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**Financial Integration and Stability
in the Age of Geo-fragmentation**

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Long-term sovereign yields under fragmentation and high debt: Global and domestic drivers

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Abstract

High debt and fragmentation amplify term premium shocks in advanced economies (AEs) but dampen them in emerging Asia (EM Asia), reflecting the dominance of anchored domestic institutional investors in EM Asia versus price-sensitive global asset managers in AEs. Using structurally-identified shocks from block-exogenous sign-restricted VARs, we document asymmetries in yield dynamics across debt and fragmentation regimes with a threshold panel local projection model. Under ordinary conditions, global risk-off shocks lower yields while term premium shocks raise yields. In AEs, 30-year yields rise more in response to term premium shocks under high debt and fragmentation than otherwise. In contrast, EM Asia yields rise by less under high debt and fragmentation than under low debt and fragmentation. This pattern reflects three channels. First, fragmentation routes pricing towards domestic institutions that cannot rotate out of duration holdings (pricing channel). Second, mechanical absorption of sovereign issuance reduces supply to global investors (absorption channel). Third, term premium shocks trigger precautionary saving among households, which institutional wrappers mechanically route into domestic long-term bonds (household-hedging channel).

JEL Codes: E43, E44, F42, H63

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1 Introduction

Ultra-long sovereign bond yields have risen markedly since 2022, with a pronounced steepening of yield curves across both advanced economies (AEs) and emerging market Asia (EM Asia) (Figure A.1). The same is observed when adjusted for both headline and core inflation (Figures A.2 and A.3). While short-term yields have reflected the normalisation of short-term interest rates, and traced closely policy cycles since 2022, the long-end of the yield curve reflected a sequence of global factors (quantitative tightening by central banks, geopolitical tensions, commodity price shocks) and domestic factors (expansionary shifts in fiscal policy amid uncertainty about growth prospects, electoral uncertainty, pension and social security reforms, changes in regulatory and liquidity frameworks, and demographic transitions).

Elevated duration risk also interacts with fiscal sustainability concerns as yields are approaching or have exceeded growth (Figure A.4). Sustained $R > G$ could compound real sovereign debt repayment burden at a time when public debt-to-GDP ratios, measured as total general government debt as a % of rolling four-quarter nominal GDP, are historically elevated in most economies (Figure A.5). Fernández-Villaverde et al. (2024)’s measure of fragmentation showed that global financial markets and trade arrangements have fragmented markedly of late (Figure A.6). Specifically, their trade fragmentation index aggregates indicators of trade openness, restrictions, and policy uncertainty in a dynamic hierarchical factor model, while their financial fragmentation index captures FDI flows, financial flow ratios, and capital controls. As these cracks continue to come to the fore, we ask whether rising fragmentation and debt accumulation could distort how the long-term yields react to global and domestic drivers.

Our findings reveal that debt and fragmentation change who prices bonds at the margin. In AEs, elevated debt and fragmentation amplify how much ultra-long-term bond yields rise in response to term premium shocks. In EM Asia, how much yields rise is instead dampened. This pattern aligns with predictions from our theoretical model. The dominance of price-sensitive global asset managers drives amplification of yield responses in AEs, while the dominance of anchored domestic institutional investors in EM Asia dampens yield responses through their inability to rotate out of duration holdings.

1.1 Literature review

This paper intersects the literature on the global financial cycle (GFCy) and cross-border macro-financial spillovers, the macroeconomic and financial determinants of the term structure, and the role of fiscal and market nonlinearities, including economic and financial fragmentation.

The literature on the GFCy emphasises the common global drivers of capital flows, asset prices, and interest rates. Empirical evidence of the role of the GFCy is mixed. Rey (2015) documented how global monetary conditions influence domestic financial markets across countries. Agrippino & Rey (2021) further showed how portfolio flows propagate shocks. However, Cerutti et al. (2019) documented empirical evidence that global factors generally explained less than a quarter of the variance in capital flows. Davis et al. (2021) instead found that two global factors explained nearly half of the variance in capital flows.

The next related field is on the term structure of interest rates. The workhorse models for estimating the yield curve stem from Nelson & Siegel (1987), Litterman et al. (1991), Svensson (1994, 1995), and Adrian et al. (2013). Annaert et al. (2013) provided a regularised regression approach to estimating the yield curve, while Nymand-Andersen (2018) discussed data and statistical considerations when estimating yield curves. King & Low (2014) provided measures of global interest rates. Izadi & Hassan (2018) and Inoguchi (2024) in turn analysed the macro determinants of the yield curve.

The last related field is on fiscal nonlinearities and cross-country spillovers. Afonso & Martins (2012) studied the effects of various types of fiscal-related shocks on the yield curve. Chudik et al. (2017) provided evidence on the impact of debt accumulation on economic growth, which leads us to further question if there are also ancillary effects on term structure determination. Fernández-Villaverde et al. (2024) documented the adverse economic and asset price impact of fragmentation shocks. Our analysis of fragmentation threshold effects on the transmission of global and domestic shocks to long-term yields looks instead at its shock intermediation role.

To ground the empirics, we combined strands of structural modelling literature. First, the term structure literature maps structural shocks to long-yield movements through a risk-price matrix (Adrian et al. (2013) and Duffee (2002)). Second, Vayanos & Vila (2021) (VV)’s segmented market model where arbitrageurs with risk tolerance that varies with market conditions absorb residual duration supply left by habitat investors. This determines how much compensation the marginal duration absorber demands as a function of supply and risk capacity. Third, heterogeneous agent New Keynesian (HANK)’s formalisation of savers and non-savers (Kaplan et al. (2018), Bilbiie (2008) and Gali et al. (2004)) pins down who the marginal bond pricer is and how their stochastic discount factor maps to macroeconomic and fiscal conditions. These strands speak to how the structure of the investor base, who prices duration at the margin and how much supply they absorb, mediates the transmission of shocks to long-term sovereign yields across different fiscal and market conditions.

1.2 Outline

Section 2 discusses the theoretical framework to guide our analysis. Section 3 will discuss the data and methodology, followed by the empirical findings in section 4. Section 5 concludes.

2 Theoretical framework

This section develops the theoretical model guiding interpretation of the empirical results.

2.1 Decomposition of long-term sovereign yields

The canonical decomposition of long-term bond yields is derived in three steps. First, we begin with the Fisher identity in equation 1, where short-term nominal returns $1 + i_{t,t+1}$ are the product of real returns and inflation (Fisher (1930)). Hence, nominal short-term rates subsume both real rates and inflation compensation. Second, the pure expectations hypothesis in equation 2 states that risk-neutral investors expect long-term nominal returns to be the geometric average of future short nominal returns (Lutz (1940)). Third, a term premium Φ_T is appended as long-term bonds persistently earn excess returns relative to rolling over short-term bonds (Campbell & Shiller (1991)), yielding the canonical decomposition in equation 3 (Adrian et al. (2013)). Long-term yields therefore decompose into expected nominal returns from rolling short-term bonds, which subsumes compensation for expected inflation via equation 1, and the term premium compensating for duration, credit, and liquidity risks.

$$\underbrace{1 + i_{t,t+1}}_{\text{Short-term nominal returns}} = \underbrace{(1 + r_{t,t+1})}_{\text{Short-term real returns}} \underbrace{(1 + \pi_{t,t+1})}_{\text{Inflation}} \quad (1)$$

$$\underbrace{1 + i_T}_{\text{Long-term nominal returns}} = \underbrace{\mathbb{E}_0 \left\{ \prod_{t=0}^{T-1} (1 + i_{t,t+1}) \right\}^{\frac{1}{T}}}_{\text{Expected nominal short-term returns}} \quad (2)$$

$$\underbrace{1 + i_T}_{\text{Long-term nominal returns}} = \underbrace{\mathbb{E}_0 \left\{ \prod_{t=0}^{T-1} (1 + i_{t,t+1}) \right\}^{\frac{1}{T}}}_{\text{Expected nominal short-term returns}} + \underbrace{\Phi_T}_{\text{Term premium}} \quad (3)$$

Assuming that nominal short-term interest rates are log-normal, a log-linearisation of equation 3 replaces the geometric average with an arithmetic mean, giving the tractable approx-

imation in equation 4, where ϕ_T denotes the corresponding log-linearised term premium.

$$\underbrace{i_T}_{\text{Long-term nominal yields}} \approx \underbrace{\mathbb{E}_0 \left\{ \frac{1}{T} \sum_{t=0}^{T-1} (i_{t,t+1}) \right\}}_{\text{Expected short-term nominal yields / risk-neutral yields}} + \underbrace{\phi_T}_{\text{Term premium}} \quad (4)$$

Yields can be taken as a function, which may not necessarily be linear, of global factors X_t^{global} (e.g., the global risk-off) and country-specific factors $X_{i,t}^{\text{domestic}}$ (e.g., fiscal, monetary, aggregate demand and supply) (equation 5).

$$i_{i,k,t} = g\left(X_t^{\text{global}}, X_{i,t}^{\text{domestic}}\right) \quad (5)$$

We can then model sovereign debt (country-level variable) and global financial / trade fragmentation (global variable) threshold effects as state-dependent amplifiers or absorbers of shocks. High sovereign debt ratio $D_{i,t}$ (measured as general government debt as a % of the four-quarter rolling sum of nominal GDP in equation 6) may increase yield sensitivity to shocks, reflecting heightened credit and rollover risk (equation 7).

$$D_{i,t} = 100 * \frac{\{\text{General Government Debt}\}_{i,t}}{\sum_{h=0}^3 \{\text{Nominal GDP}\}_{i,t-h}} \quad (6)$$

$$i_{i,k,t} = g\left(X_t^{\text{global}} \cdot \alpha_{\text{global}} \cdot d_{i,t}, X_t^{\text{domestic}} \cdot \alpha_{\text{domestic}} \cdot d_{i,t}\right), \quad d_{i,t} = \begin{cases} 0 & \text{when } D_{i,t} < D_i^{\text{Threshold}} \\ 1 & \text{when } D_{i,t} \geq D_i^{\text{Threshold}} \end{cases} \quad (7)$$

Elevated global fragmentation F_t , representing barriers in global trade and financial markets, may intensify home bias behaviour (equation 10). Fernández-Villaverde et al. (2024) estimated financial fragmentation as a latent factor in a dynamic hierarchical factor model of FDI flows, financial flow ratios, and capital controls, while trade fragmentation covers trade openness, restrictions, and trade policy uncertainty (equations 8 and 9; $\hat{\lambda}^{\text{fin}/}$ and $\hat{\lambda}^{\text{trade}/}$ are factor loadings).

$$F_t^{\text{fin}} = \hat{\lambda}_{1 \times 3}^{\text{fin}/} [\text{FDI ratio, financial flow ratio, capital controls}]'_t \quad (8)$$

$$F_t^{\text{trade}} = \hat{\lambda}_{1 \times 5}^{\text{trade}/} [\text{openness, restrictions, temp. barriers, policy uncertainty, tariff}]'_t \quad (9)$$

$$i_{i,k,t} = g\left(X_t^{\text{global}} \cdot \beta_{\text{global}} \cdot f_t, X_t^{\text{domestic}} \cdot \beta_{\text{domestic}} \cdot f_t\right), \quad f_t = \begin{cases} 0 & \text{when } F_t < F^{\text{Threshold}} \\ 1 & \text{when } F_t \geq F^{\text{Threshold}} \end{cases} \quad (10)$$

Amplification occurs when the coefficients on the state variables for debt and fragmentation α and β , respectively, are greater than 1. Dampening occurs when α and β are between 0 and 1; reversal occurs when α and β are less than 0.

2.2 A HANK-VV-ACM model of state-dependent yield dynamics

We discipline interpretation a lightweight structural model with three key mechanisms — (i) no-arbitrage bond pricing from Adrian et al. (2013) (ACM), (ii) preferred-habitat arbitrageur sector whose risk capacity varies with sovereign debt and market fragmentation from Vayanos & Vila (2021) (VV), and (iii) a heterogeneous-agent New Keynesian (HANK) household block capturing consumption-hedging motives that is adapted from Bilbiie (2008), Gali et al. (2004) and Kaplan et al. (2018).

2.2.1 Macro factors

Drawing from Adrian et al. (2013), we distil small open economy and global factors into a state vector $X_t \in \mathbb{R}^6$ that collects six factors (equation 11) — global risk-off ($x_{RO,t}$), global term premium ($x_{GTP,t}$), aggregate demand ($x_{AD,t}$), aggregate supply ($x_{AS,t}$), monetary policy ($x_{MP,t}$), and domestic term premium ($x_{DTP,t}$).

$$X_t = (x_{RO,t}, x_{GTP,t}, x_{AD,t}, x_{AS,t}, x_{MP,t}, x_{DTP,t})'_{6 \times 1} \quad (11)$$

X_t follows a VAR(1) process, where Φ is the VAR(1) transition matrix and Σ is the transmission matrix that maps the structural shocks ε_t (equation 12).

$$X_{t+1} = \Phi X_t + \Sigma \varepsilon_{t+1}, \quad \varepsilon_{t+1} \sim \mathcal{N}(0, I_6) \quad (12)$$

2.2.2 Linking bond pricing to macro factors

$$i_t = \delta_0 + \delta'_1 X_t \quad (13)$$

$\begin{matrix} 1 \times 1 & & 1 \times 1 & & 1 \times 6 & 6 \times 1 \end{matrix}$

Drawing further from Duffie & Kan (1996) and Duffee (2002), the risk-pricing matrix Λ_1 maps to the macro factors X_t (equation 14) to the excess return bondholders demand for risk exposure, summatively yielding the risk-pricing vector Λ_t at time t .

$$\Lambda_t = \Lambda_1 X_t \quad (14)$$

$\begin{matrix} 6 \times 1 & & 6 \times 66 \times 1 \end{matrix}$

The term premium arises from investors' risk aversion. The stochastic discount factor of bond investors M_{t+1} is fundamentally the time preference e^{-i_t} and the degree of risk aversion $\frac{dQ}{dP}$ (equation 15). P is the real-world probability measure of shocks ε_{t+1} from equation 12, i.e., the real data-generating process of the macro factors X_t . Q is the probability measure that would fit observed asset prices (which do not reflect risk-neutrality) suppose investors were risk-neutral, which therefore overweights adverse outcomes. $\frac{dQ}{dP}$ can be interpreted as the extent of risk aversion. Following Ang & Piazzesi (2003), the risk aversion term $\frac{dQ}{dP}$ is represented by the Radon-Nikodym derivative in equation 16.

$$M_{t+1} = e^{-i_t} \cdot \frac{dQ}{dP} \quad (15)$$

$$\frac{dQ}{dP} = \exp \left(\underbrace{-\frac{1}{2} \Lambda_t' \Lambda_t}_{\text{Normalisation term; ensures } Q \text{ is valid probability measure}} \right) \cdot \exp \left(\underbrace{-\Lambda_t' \varepsilon_{t+1}}_{\text{Tilts shock distribution by } \Lambda_t} \right) \quad (16)$$

Substituting equations 13 and 14 into equation 15 then yields the stochastic discount factor M_{t+1} , which is now a function of short-term yields i_t and also structural factors X_t scaled by the risk-pricing matrix Λ_t .

$$M_{t+1} = \exp \left(-i_t - \frac{1}{2} \Lambda_t' \Lambda_t - \Lambda_t' \varepsilon_{t+1} \right), \text{ where } \Lambda_t = \Lambda_1 X_t \quad (17)$$

Under no-arbitrage, bond prices satisfy the Euler condition in equation 18, such that bond prices today is the present value of future bond prices discounted by the stochastic discount factor from equation 17, which encapsulates the time preference and the degree of risk aversion. As the stochastic discount factor M_{t+1} is a function of Λ_t (equation 14) and therefore structural shocks ε_{t+1} (equation 17), we can link bond prices and yields with the structural shocks from equation 11.

$$P_t^{(n)} = \mathbb{E}_t[M_{t+1}P_{t+1}^{(n-1)}] \quad (18)$$

Substituting the price representation of equation 13, $P_t^{(n)} = \exp(A_n + B_n'X_t)$ where A_n and B_n are scalar coefficients, into the equation 18, followed by coefficient matching with Riccati recursions, expresses n-tenor yields $i_t^{(n)}$ in terms of risk-neutral yields and the term premium (equation 19). The term premium is jointly determined by the risk-pricing matrix Λ_1 (from equation 14), as well as the transition matrices of macro factors and shocks (Φ and Σ , respectively) (equation 12).

$$i_t^{(n)} = \underbrace{\frac{1}{n} \sum_{h=0}^{n-1} \mathbb{E}_t[i_{t+h}^{(1)}]}_{\text{risk-neutral yield}} + \underbrace{\frac{1}{n} \sum_{h=0}^{n-1} [(\Phi - \Sigma\Lambda_1)'^h - \Phi'^h] \delta_1 \cdot X_t}_{\text{term premium } \phi_t^{(n)}} \quad (19)$$

2.2.3 State-dependent risk-price matrix and arbitrageurs

The risk-price matrix Λ_1 from equation 14 governs how each shock maps to the yield curve. To generate state-dependency, we decompose Λ_1 additively into (i) an arbitrageur block, which varies with sovereign debt (d) and global market fragmentation (f), and (ii) a saver-household block, which reflects consumption-hedging motives (equation 20).

$$\Lambda_1(d, f) = \underbrace{\text{base}(d, f)}_{\substack{6 \times 6 \\ \text{VV arbitrageur block}}} \cdot \underbrace{\Lambda_1^{\text{arb}}}_{6 \times 6} + \underbrace{\Lambda_1^{\text{hh}}}_{\substack{6 \times 6 \\ \text{saver-household block}}} \quad (20)$$

In the VV framework, some investors strongly prefer specific bond maturities, e.g., pension funds needing to match long-dated liabilities or banks preferring short-term instruments. These “preferred-habitat” investors are price-insensitive at their preferred maturity, and do not arbitrage yield differentials.

Arbitrageurs step in to absorb the residual duration supply supply_factor that habitat investors left unmet. $\text{base}(d, f)$ is the price of risk per unit of duration absorbed (equation 21), which generates the term premium. Arbitrageurs also demand higher risk compensation if their risk absorption capacity $\tau_{\text{eff}}(f)$ is lower. Under high fragmentation ($f = 1$), the presence of global asset managers diminish relative to domestic asset managers, who have lower risk absorption capacity ($\tau_{\text{dom}} < \tau_{\text{glob}}$).

$$\text{base}(d, f) = \frac{\text{supply\_factor}(d)}{\tau_{\text{eff}}(f)}, \quad \tau_{\text{eff}}(f) = \begin{cases} \tau_{\text{glob}} & \text{if } f = 0 \\ \tau_{\text{dom}} \text{ where } \tau_{\text{dom}} < \tau_{\text{glob}} & \text{if } f = 1 \end{cases} \quad (21)$$

Both higher debt and fragmentation raise $\text{base}(d, f)$. Debt raises the residual duration supply left behind by habitat investors, and fragmentation routes pricing to a less risk-tolerant domestic asset managers (equation 22). A larger $\text{base}(d, f)$ amplifies the risk-price matrix for arbitrageurs Λ_1^{arb} and strengthens term-premium transmission along the yield curve. The tanh functional form ensures that the debt-to-duration supply ratio is approximately linear along most maturities, but is bounded at the extremes.

$$\text{supply\_factor}(d) = 1 + \lambda^d \tanh(k d), \text{ where } \lambda^d > 0 \quad \text{and } 0 < k < 1 \quad (22)$$

2.2.4 Reversal of debt and fragmentation threshold effects

However, the amplification effect of high debt and fragmentation can reverse when the marginal pricer of long-term bonds is an anchored domestic institutional base, and when global financial markets are fragmented ($f = 1$). By anchored, we mean a sovereign bond market dominated by domestic institutional investors (e.g., banks, insurers, and pension funds) rather than foreign investors or retail participants. Duration demand of domestic institutional investors is sized by balance-sheet constraints, regulatory requirements, and liability-matching rules. This makes them structurally different from global asset managers, who rebalances freely across markets and maturities as relative returns shift, or from retail investors, who are sensitive to headline losses. An anchored base is hence captive and price-insensitive. They absorb duration supply without requiring the yield concessions that a price-sensitive marginal investor would demand. Debt and fragmentation can dampen instead of amplify yield responses to term premium shocks through two channels.

First, pricing channel. When fragmentation routes pricing away from global asset managers towards anchored domestic institutions, effective risk tolerance at the margin rises rather than falls, as anchored domestic institutional investors cannot rotate out of duration, unlike flightier global asset managers. This is reflected in τ_{anchored} , the risk tolerance of anchored domestic institutional investors being higher than that of global asset managers τ_{glob} (equation 23). Fragmentation instead raises τ_{eff} and lowers $\text{base}(d, f)$, dampening the transmission of shocks to yields.

$$\text{base}(d, f) = \frac{\text{supply\_factor}(d)}{\tau_{\text{eff}}(f)}, \quad \tau_{\text{eff}}(f) = \begin{cases} \tau_{\text{glob}} & \text{if } f = 0 \\ \tau_{\text{anchored}} & \text{where } \tau_{\text{anchored}} > \tau_{\text{glob}} \text{ if } f = 1 \end{cases} \quad (23)$$

Second, absorption channel. The domestic institutional base absorbs new sovereign issuance mechanically, as their holdings scale with balance sheets. As anchored institutions absorb new issuance mechanically, less of the additional duration supply reaches price-sensitive global asset managers. When absorption rates are sufficiently high, net issuances reaching price-sensitive investors can fall even as gross issuance rises. This flips the sign of the supply factor λ from a positive λ^d to a negative $\lambda^{d,\text{anchored}}$ (equation 24). Rather than rising with debt, net supply on the margin falls, unlike the base case in equation 22. The tanh nonlinearity encodes the absorption ceiling. Below the ceiling, the anchored institutions absorb most of the new bond issuance and $\text{base}(d, f)$ falls with debt. Around the ceiling, marginal absorption declines and the dampening effect plateaus. Above the ceiling, excess supply that reach the price-sensitive margin then reasserts the amplification effect.

$$\text{supply\_factor}(d) = 1 + \lambda \tanh(k d), \text{ where } \lambda = \begin{cases} \lambda^d > 0 & \text{if } f = 0 \\ \lambda^{d,\text{anchored}} < 0 & \text{if } f = 1 \end{cases} \quad \text{and } 0 < k < 1 \quad (24)$$

The pricing channel raises the denominator τ_{eff} , and the absorption channel flips the numerator supply_factor from increasing to decreasing in debt (equation 22). Together they push $\text{base}(d, f)$ down and dampen the term premium transmission.

A third, reinforcing channel operates through household precautionary saving intermediated by institutional wrappers. Term premium shocks carry information about future fiscal stress and potential consumption drag, triggering precautionary saving responses. In the model, this is captured by strictly positive loadings of the short rate on the term premium factors, $\delta_{1,gtp}, \delta_{1,dtp} > 0$, which determined how much compensation saver-households demand for holding bonds through their risk-price matrix Λ_1^{hh} (from equation 20). Where pension and insurance wrappers are the dominant household savings vehicle, these additional inflows are mechanically routed into domestic long-term sovereign bonds, reinforcing the absorption channel without requiring households to actively seek duration exposure. This channel is stronger in markets where direct retail participation is low, such that domestic institutional investors intermediate most household savings.¹

¹In the minimal HANK, saver households are the marginal pricers of bonds and hand-to-mouth households

3 Data and methodology

3.1 Estimating the term premia

We estimate term premia using Adrian et al. (2013)’s methodology (ACM) for each country. All estimation steps are identical, except that zero-coupon yields are constructed by fitting a parametric yield curve, as in Svensson (1994), to observed benchmark yields at each date, rather than taken directly from Treasury zero-coupon curves. The fitted yield curve is used to interpolate zero-coupon spot rates at monthly maturities up to 30 years.

The fitted yield curve is then fed into the ACM model to estimate the term premia across all tenors up to 30 years, defined as the difference between fitted yields and their risk-neutral counterparts. Estimates suggests that the rise in long-term sovereign bond yields since 2022 largely reflected a corresponding rise in term premia (Figure 1). By 2023-24, term premia had broadly risen to pre-Global Financial Crisis (GFC) levels. This suggests that the post-2022 steepening of yield curves reflects not only higher short-term rates but also a repricing of duration risk.

3.2 Estimating the global risk-on and term premia factors

We estimate global risk-on, analogous to the global financial cycle (GFCy), and term premia factors using a two-factor model (equation 26). $\mathbf{x}_t$ denote the vector of 8 standardised financial indicators (VIX, MOVE, economic policy uncertainty (EPU), gold price growth, dollar index (DXY), and G3 average term premiums at 5-, 10-, and 30-year tenors²). $\mathbf{f}_t$ is a 2x1 vector of latent factors and $\mathbf{\Lambda}$ is the factor loading matrix. We apply Procrustes rotation to ensure that the first factor (GFCy) loads on risk indicators (VIX, MOVE, EPU, gold, DXY) while the second factor loads on term premium tenors. We also apply sign restrictions on the GFCy factor loadings to ensure economic interpretability.³

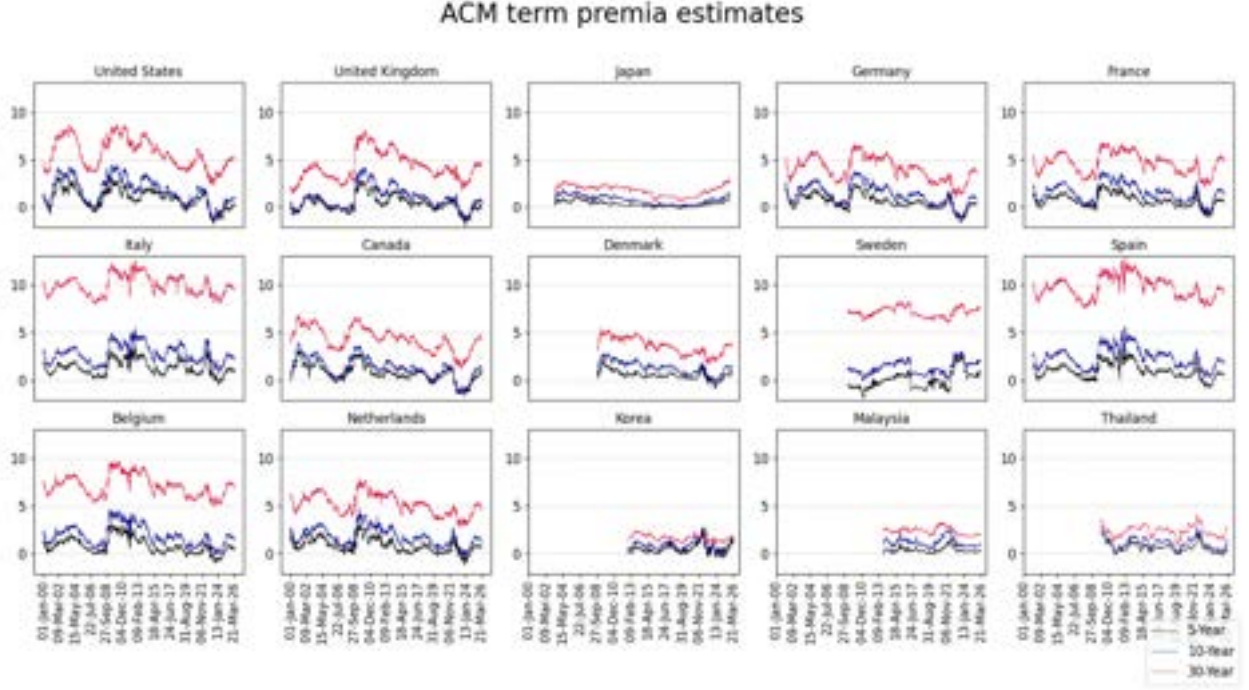
are inert. Because savers’ consumption tracks the short-rate path through their Euler equation, the risk compensation they demand for each shock is proportional to how much that shock moves the short rate, which is captured by δ_1 . This contributes a diagonal, state-independent component to Λ_1 . γ is risk aversion, σ_c is saver consumption volatility, and θ^s is the saver share. As the household block is proportional to δ_1 , it contributes zero to factors that do not enter the short rate.

$$\Lambda_1^{\text{hh}} = \text{diag}(\gamma \sigma_c \theta^s \delta_1) \quad (25)$$

²Average of the US, UK and JP ACM term premia at 5-, 10, and 30-year tenors.

³Positive loadings on VIX, MOVE, EPU, gold price, and DXY (risk-off indicators), while loadings on term premiums are not sign-restricted (primarily on the second factor). A single sign flip is used to resolve sign indeterminacy after Procrustes rotation.

Figure 1: ACM term premia estimates



$$\mathbf{x}_t = \underset{8 \times 1}{\Lambda} \underset{8 \times 2}{\mathbf{f}_t} + \underset{8 \times 1}{\varepsilon_t} \quad (26)$$

The estimated global risk-on factor shows pronounced episodic variation, with clear spikes during stress periods, e.g., the Global Financial Crisis, European debt crisis, and COVID-19 pandemic (Figure 2). The GFCy captures the common risk-off component across financial markets, distinct from the global term premium factor which reflects duration supply and quantitative easing effects.

Figure 2: Global risk-off (GFCy) and term premia factors



3.3 Global structural shock identification

We identify global structural shocks using a Vector Autoregression of p -lag order (VAR(p)) with Cholesky identification applied to US macroeconomic data (equation 27). The rationale is that the GFCy and GTPF factors themselves are constructed primarily from US financial market indicators (US term premia, VIX, MOVE, EPU, DXY), and that the US forms the bulk of international finance. $\mathbf{Y}_t$ contains GFCy, global term premium factor (GTPF), as well as country-level industrial production growth, core inflation, policy rate, M2 growth, inflation expectations, GDP growth expectations and ACM term premium. $\mathbf{B}$ contains the reduced form coefficients and $\mathbf{u}_t$ contains the reduced form errors. Lag order p is selected by minimising the Bayesian Information Criterion (BIC).

$$\mathbf{Y}_t = \mathbf{B}\mathbf{X}_t + \mathbf{u}_t \quad (27)$$

$$\text{where } \mathbf{B} = \begin{bmatrix} \boldsymbol{\mu} & \mathbf{A}_1 & \cdots & \mathbf{A}_p \end{bmatrix}, \quad \mathbf{X}_t = \begin{bmatrix} 1 \\ \mathbf{Y}_{t-1} \\ \vdots \\ \mathbf{Y}_{t-p} \end{bmatrix}$$

We impose a recursive identification scheme where (i) **GFCy shock** (risk appetite) contem-

poraneously affects all variables, and (ii) **GTPF shock** (duration supply) is orthogonal to GFCy contemporaneously, which can subsume global quantitative easing / tightening and foreign reserve reallocations (equation 28).

3.4 Local structural shock identification

We identify country-specific structural shocks for other AEs and EM Asia with a block-exogenous VAR with sign restrictions (equation 28). The sign restricted VAR framework (e.g., Uhlig (2001), Lütkepohl & Netšunajev (2014), and Baumeister & Hamilton (2015)), particularly Rubio-Ramirez et al. (2010) (RWZ)’s methodology provide a neat tool to extract structural shocks from data. Block exogeneity from equation 28 ensures that global variables cannot respond to local variables at any lag, reflecting the small open economy assumption. Essentially, the upper-right block is constrained to zero. Formally, this forces upper diagonal entries of the reduced form coefficient matrices $\mathbf{A}_i^{GL}$ that contain coefficients of global variables in equations where the explained variable is at the country level to be zero.

$$\mathbf{A}_i = \begin{bmatrix} \mathbf{A}_i^{GG} & \mathbf{A}_i^{GL} = \mathbf{0} \\ \mathbf{A}_i^{LG} & \mathbf{A}_i^{LL} \end{bmatrix} \quad (28)$$

The Cholesky factor $\mathbf{P}_{local}$ of the local variable covariance matrix is combined with an orthogonal rotation matrix $\mathbf{Q}$ chosen to satisfy the sign restrictions, which allows us back out the structural shocks $\boldsymbol{\varepsilon}_t^{local}$ from the reduced form VAR residuals $\mathbf{u}_t^{local}$ (equation 29). The sign restrictions imposed on impact responses are in Table 1. Negative demand shocks generate lower industrial production growth and inflation. Negative supply shocks generate stagflationary dynamics (negative output, positive inflation). Monetary policy tightening shocks generate contractionary effects. Domestic term premium shocks raise the ACM term premium with zero restrictions on fiscal variables.⁴ We generate $N = 1,000$ random orthogonal rotations per country, accepting those satisfying all sign restrictions and taking the median of accepted draws.

⁴The system remains 9×9 because sign restrictions achieve *partial* identification—they select which shocks are economically interpretable, but do not reduce the dimension of the structural system. A valid structural decomposition requires a full mapping between the 9 reduced-form residuals and 9 structural shocks, ensuring the implied covariance structure $\boldsymbol{\Sigma}_{local} = \mathbf{P}_{local}\mathbf{Q}\mathbf{Q}'\mathbf{P}_{local}' = \mathbf{P}_{local}\mathbf{P}_{local}'$ is preserved for all residuals. Reducing $\mathbf{Q}$ to a 9×4 submatrix would break this orthogonality and leave the remaining 5 residuals unaccounted for. The 4 shocks of interest are therefore identified by selecting the corresponding 4 rows of $\boldsymbol{\varepsilon}_t^{local}$ after the full 9×9 rotation is applied, rather than by reducing the system itself.

$$\underset{9 \times 1}{\boldsymbol{\varepsilon}_t^{local}} = (\underset{9 \times 9}{\mathbf{P}_{local}} \underset{9 \times 9}{\mathbf{Q}})^{-1} \underset{9 \times 1}{\mathbf{u}_t^{local}} \quad (29)$$

Table 1: Sign restrictions on impact responses for local structural shock identification

VAR variables	Structural shocks			
	Adverse demand	Adverse supply	Monetary tightening	Domestic term premium
Industrial production	—	—	—	free
Core inflation	—	+	—	free
Policy rate	free	free	+	0
M2	free	free	—	free
Fiscal balance	free	free	0	0
Net public debt	free	free	0	0
Inflation expectations	—	+	—	free
Growth expectations	—	—	—	free
ACM term premium	0	0	0	+

Notes: + denotes positive restriction, — negative restriction, 0 denotes zero restriction (soft zero with tolerance 0.15), and *free* indicates no restriction imposed.

Our analysis focuses on the global and domestic term premium shocks, which enter the term structure directly. The inclusion of demand, supply, and monetary policy shocks helps isolate the pure term premium components by absorbing variation that would otherwise contaminate risk-off and duration risk measures.

3.5 Threshold panel local projections

We estimate regime-dependent impulse responses using threshold panel local projections, extending the framework of Jordà (2005) and Gonçalves et al. (2024) to incorporate structurally-identified global and local shocks. The specification allows both global and domestic structural shocks to vary across debt and fragmentation regimes. The local projections framework is a flexible approach for estimating the dynamic responses of macro variables to shocks (Jordà (2005, 2023), Plagborg-Møller & Wolf (2021), and Montiel Olea et al. (2025)), including variance decomposition analysis (Gorodnichenko & Lee (2020)).

The local projections model excludes the US as global structural shocks from the block-exogenous VAR are constructed primarily from US data, which would create endogeneity concerns. AEs comprise the G6 (excluding US) plus other developed markets, while EM Asia includes Korea, Malaysia, and Thailand. International financial centres are excluded to focus on representative open economies.

The threshold panel local projections model regresses the long difference of yields $y_{i,t+h} - y_{i,t-1}$ on structural shock levels $\boldsymbol{\varepsilon}_{t-k}$ generated by the two-layered VAR framework. State dummies $\mathbb{1}_{i,t}^s$ switch regimes based on debt/fragmentation threshold crossings (equation 30). Impulse

response functions (IRFs) for shock j in regime s at horizon h is given by the coefficient $\beta_{h,0}^{s,j}$. This specification nests both debt (using net public debt-to-GDP ratios) and fragmentation thresholds (using global trade and financial fragmentation indices from Fernández-Villaverde et al. (2024)).

$$y_{i,t+h} - y_{i,t-1} = \alpha_{i,h} + \sum_{s \in \mathcal{S}} \mathbb{1}_{i,t}^s \left[\gamma_h^s + \sum_{k=0}^p \beta_{h,k}^s \boldsymbol{\varepsilon}_{t-k} + \sum_{j=1}^q \delta_{h,j}^s y_{i,t-j} \right] + u_{i,t+h} \quad (30)$$

The dependent variable enters the model as a long difference ($y_{i,t+h} - y_{i,t-1}$) as per standard practice for local projections, which reflects the cumulative effects of structural innovations on yields. However, global and domestic structural shocks enter as levels $\boldsymbol{\varepsilon}_{t-k}$ rather than first differences, given that structural shocks $\boldsymbol{\varepsilon}_t$ are already orthogonal innovations with unit variance by construction from our VAR identification procedures, eliminating further need for differencing.

Forecast error variance decomposition (FEVD) quantifies the relative importance of each global and local structural shock in shaping 30-year yields. Equation 31 decomposes the forecast error variance of yields for each debt / fragmentation regime at horizon h into the variance of each structural shock j (σ_j^2).

$$\text{FEVD}_h^{s,j} = \frac{\sum_{k=0}^h (\beta_{k,0}^{s,j})^2 \sigma_j^2}{\sum_{m=1}^M \sum_{k=0}^h (\beta_{k,0}^{s,m})^2 \sigma_m^2} \quad (31)$$

Using structural VARs and local projections in tandem offers four methodological benefits over direct estimation with a VAR. First, a panel threshold structural VAR that spans both global and domestic variables, while adhering to block exogeneity and sign restrictions, imposes severe parametric demands per debt / fragmentation regime cell. In contrast, VAR identification of structural shocks is estimated once, and only the LP response function is allowed to vary with the structural state. Second, the block exogeneity restrictions that ensure domestic shocks from small open economies do not feed back into global factors are imposed once in the VAR layer and remain intact regardless of the regime conditioning applied in the LP. In a threshold VAR, such distinctions collapse into unrestricted lag coefficients that vary freely across regimes. Third, LP-based impulse responses are consistent under lag misspecification (see Jordà (2005), Jordà (2023), Plagborg-Møller & Wolf (2021)). As shock identification and transmission estimation are separated, misspecification in the propagation dynamics does not contaminate the structural shock estimates, and vice versa. Fourth, the LP setup offers flexibility in the choice of estimation object. As the LP directly regresses the cumulative change in yields on structural shocks, the horizon- h coefficient is the cumu-

lative impulse response without recursive accumulation of period-by-period responses as one would with a VAR. Regime-specific responses are directly estimated by interacting shocks with regime indicators, rather than solving separate regime-specific VAR systems.

3.6 Data-driven threshold selection

To determine which public debt-to-GDP and global fragmentation threshold to use in the local projections model, we grid-searched over threshold candidate values τ within the central 70% of the state variable distribution (15th to 85th percentiles). The optimal threshold $\hat{\tau}$ minimises the sum of squared residuals (SSR) of the local projection equation at horizon $h = 1$ (equation 30 where $h = 1$).

$$\hat{\tau} = \arg \min_{\tau \in \mathcal{T}} \text{SSR}(\tau) \quad (32)$$

For single-threshold specifications, we evaluate $N = 50$ grid points. For joint two-dimensional threshold models (e.g., debt $\times$ fragmentation), we employ a 30×30 grid, i.e., 900 candidate combinations. The grid search accommodates both univariate threshold models (debt, trade fragmentation, or financial fragmentation) and bivariate models that allow for interactions between debt levels and fragmentation indices. This approach ensures that regime classification reflects data-supported break points rather than arbitrary divisions.

4 Findings

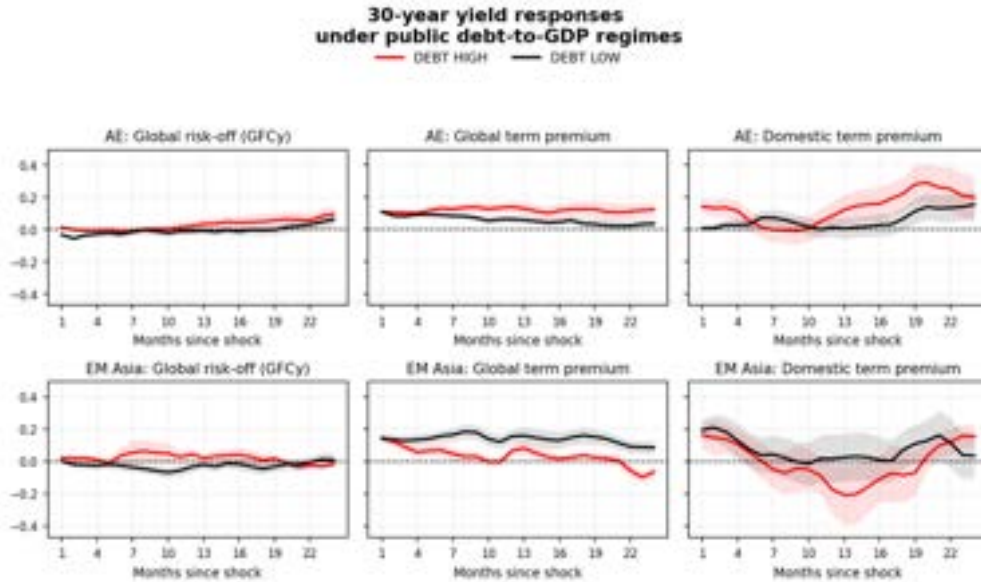
4.1 Debt and fragmentation threshold effects

Summary. Debt and fragmentation change who prices ultra-long-term bonds at the margin. In normal times, global investors flee to safety during stress, lowering yields. However, when government debt is high and global markets fragmented, this flight-to-safety breaks down. Term premium shocks, which reflect duration risk, are amplified in AEs where mobile and price-sensitive global asset managers dominate, but dampened in EM Asia where anchored domestic institutions (e.g., pension funds and insurers) cannot easily rotate out of ultra-long-term government bonds. Formally, this asymmetry reflects the pricing, absorption, and consumption-hedging channels operating through anchored domestic institutional investor bases as described in Section 2.2.4.

Baseline. In figure 3, under low debt and fragmentation, global risk-off shocks lower 30-year yields in both AEs and EM Asia, which reflects flight-to-safety dynamics. Global term premium shocks raise yields in both regions, but more persistently in EM Asia. AE yields converge back to pre-shock levels after approximately two years. Domestic term premium shocks raise yields, but the reaction is more lagged in AEs compared to EM Asia.

Debt threshold effects. Under high debt conditions, the transmission of global and domestic shocks to sovereign yields changes markedly. Global risk-off shocks no longer clearly affect 30-year yields (confidence intervals cover zero), likely reflecting the different composition of assets considered “safe” when debt sustainability concerns are elevated. High debt strengthens the reaction of 30-year yields to global term premium shocks in AEs. However, EM Asia’s reaction to global term premium shocks is dampened under high debt conditions (Figure 3). This asymmetric response reflects the theoretical mechanisms outlined in Section 2, where anchored domestic institutional investors in EM Asia provide duration absorption that dampens rather than amplifies yield responses to term premium shocks. For domestic term premium shocks, AEs’ responses strengthen under high debt, while emerging economy responses show no statistically significant difference. This pattern is consistent with the pricing and absorption channels operating through anchored domestic institutional bases in EM Asia.

Figure 3: Responses of 30Y yields under high (red) and low (black) public debt-to-GDP



Fragmentation threshold effects. Financial and trade fragmentation generate similar amplification and dampening effects as debt thresholds (Figures 4 and 5). Under high

financial fragmentation, AEs show amplified responses to global shocks, while EM Asia exhibits dampened responses. Yields also react to domestic term premium shocks in AEs with a longer lag under high fragmentation.

Figure 4: Responses of 30Y yields under high (red) and low (black) global financial fragmentation

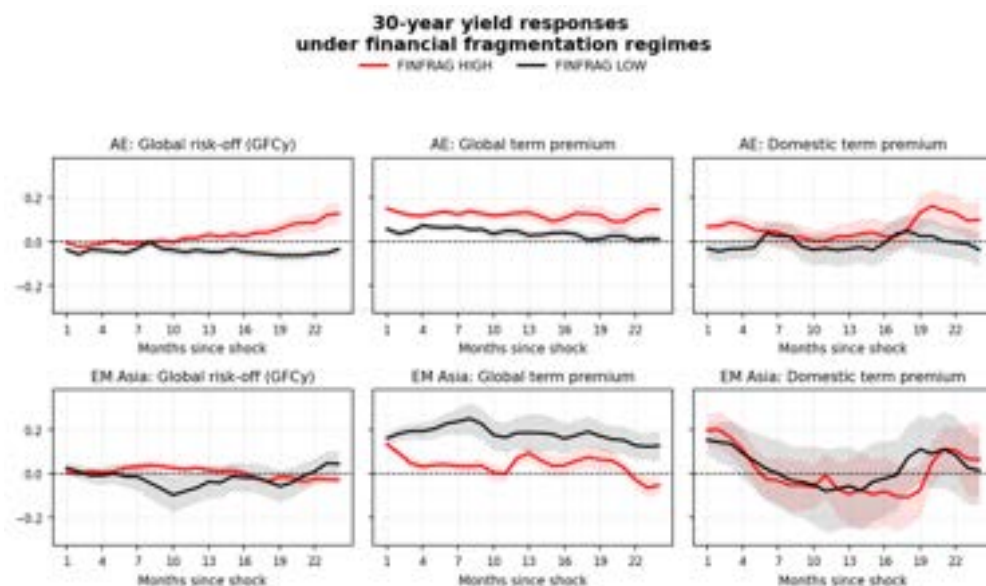
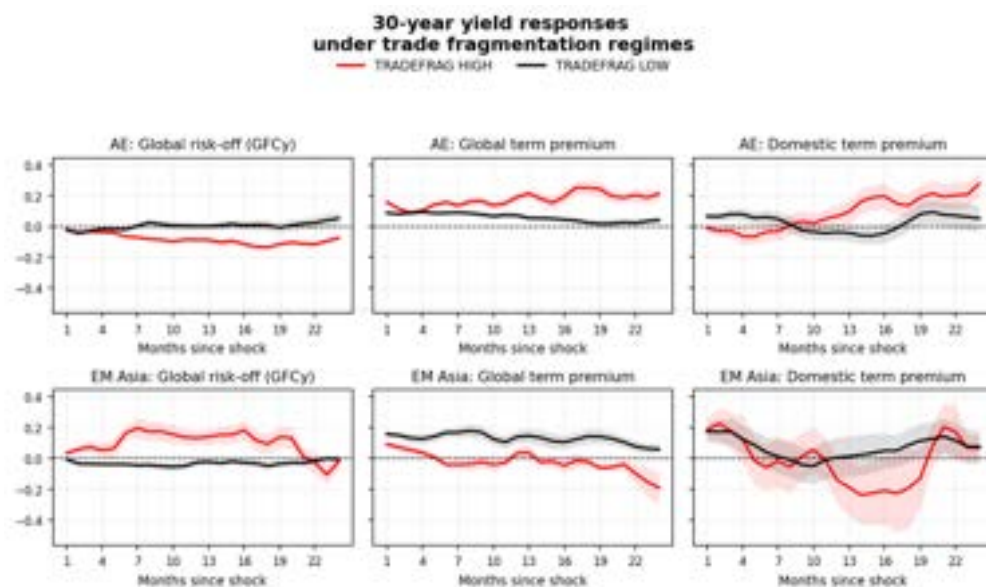


Figure 5: Responses of 30Y yields under high (red) and low (black) global trade fragmentation



4.2 Divergence in threshold effects between AEs and EM Asia

The divergence between AEs and EM Asia under debt and fragmentation thresholds reflects three channels detailed in our theoretical framework in section 2.2.4.

First, the **pricing channel**. When fragmentation routes bond pricing from global asset managers towards anchored domestic institutions, effective risk tolerance rises rather than falls, as institutional investors cannot rotate out of duration holdings.

Second, the **absorption channel**. Anchored domestic institutions absorb new sovereign issuance mechanically, reducing the net supply reaching price-sensitive global investors.

Third, the **household-hedging channel**. Term premium shocks signal fiscal stress, triggering precautionary saving flows that pension and insurance wrappers mechanically route into domestic long-term sovereign bonds, partially offsetting the arbitrageur’s negative cross-loadings on term-premium factors. This differs from Fang et al. (2025), who find that the sensitivity of sovereign yields to debt rise when price-elastic non-bank investors exit, whereas our structural model posits that investor composition shapes the sensitivity of ultra-long-term yields to term-premium shocks.

Together, these channels operate through the $\text{base}(d, f)$ function in equation 21, scaling the arbitrageur block of the risk-price matrix and governing term premium transmission in equation 20. In EM Asia, higher debt and fragmentation lower $\text{base}(\cdot)$ through both the pricing channel (raising τ_{eff}) and absorption channel (flipping the supply factor), dampening rather than amplifying transmission.

Figure 6 shows the AE case where higher debt amplifies responses relative to low debt (HD-Fragmented > LD-Fragmented) and fragmentation amplifies relative to integration (HD-Fragmented > HD-Integrated, red > black) through the standard arbitrageur channel. Figure 7 demonstrates how dominant and anchored domestic institutional investors in EM Asia dampen the impact of term premium shocks through the pricing and absorption channels. Fragmentation now dampens responses (LD-Fragmented < LD-Integrated; HD-Fragmented < HD-Integrated). Figure 8 shows how the additional household-hedging channel dampens the term premium effect on yields under high debt (LD-Fragmented > HD-Fragmented).

Figure 6: Calibrated structural model: IRFs of 30Y yields for AEs

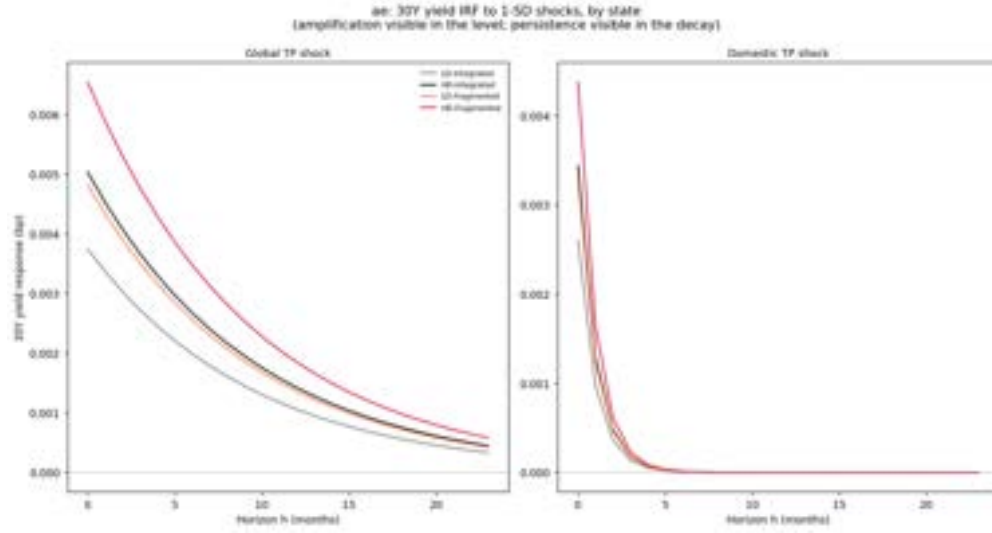


Figure 7: Calibrated structural model with institutional anchoring: IRFs of 30Y yields for EMs

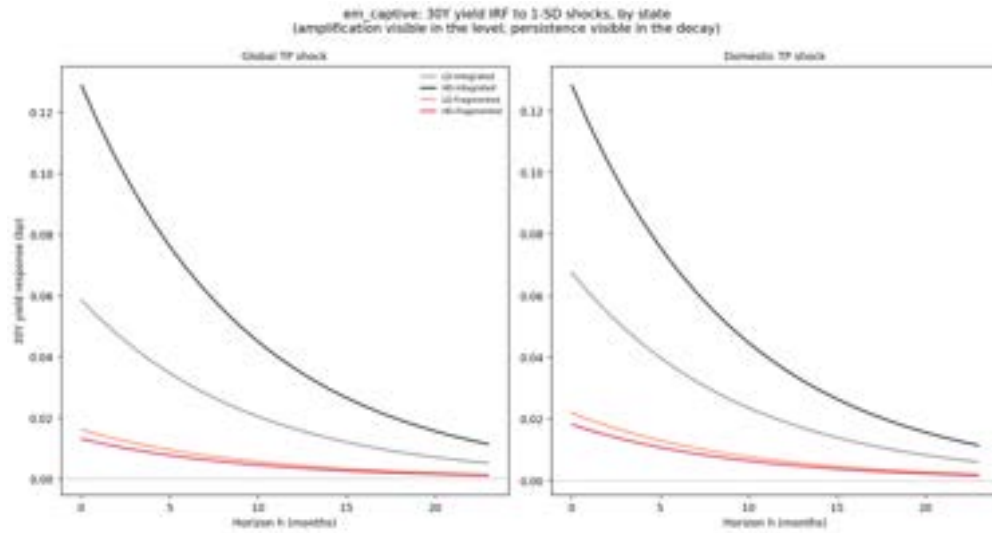
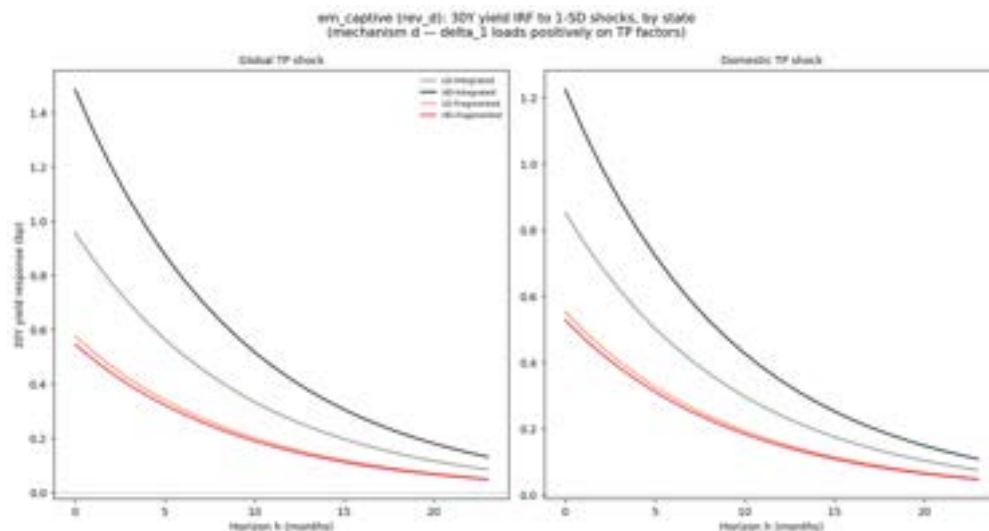


Figure 8: Calibrated structural model with institutional anchoring and consumption-hedging: IRFs of 30Y yields for EMs

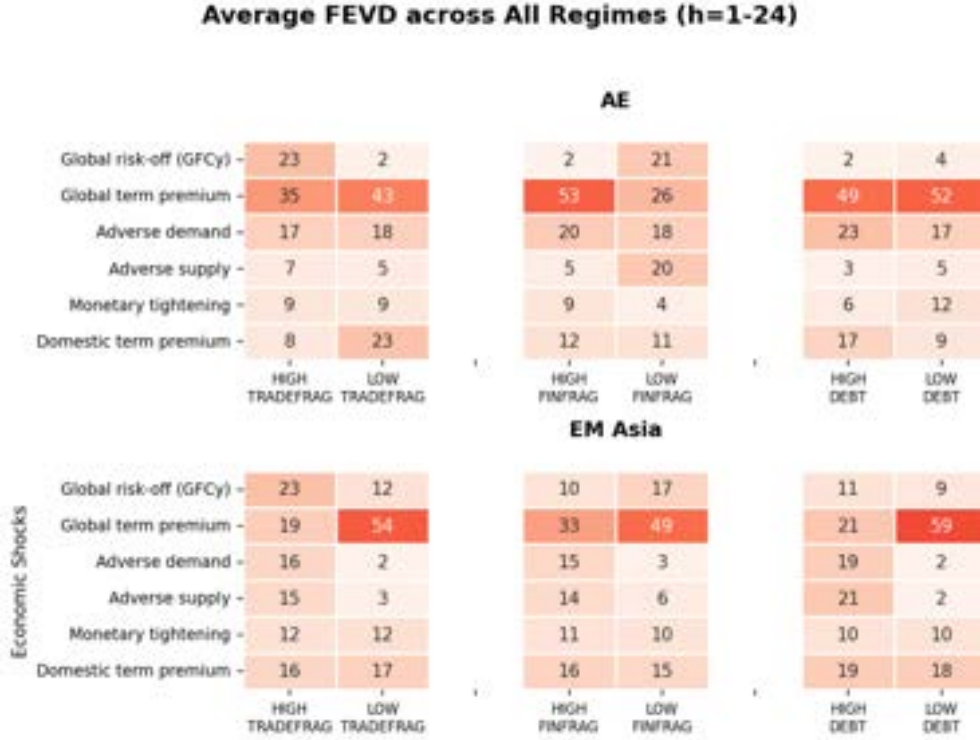


4.3 Relative importance of global and domestic shocks

FEVDs at the two-year horizon reveal how debt and fragmentation alter the relative importance of global versus domestic shocks (Figure 9). Under high debt, domestic term premium shocks gain relative importance in AEs, while global term premium effects remain stable. High financial fragmentation strengthens the global term premium factor's role. Under trade fragmentation, some of the global term premium factor's explanatory power redistributes to the risk-off factor, consistent with trade fragmentation affecting real economy linkages.

For EM Asia, the global term premium factor's role in yield variation redistributes to domestic shocks under elevated debt and fragmentation, consistent with the dampening effects identified in the impulse response analysis. This rebalancing towards domestic factors reflects the insulation provided by anchored institutional bases when global financial conditions tighten.

Figure 9: FEVD of 30Y bond yields: public debt and global fragmentation regimes



5 Conclusion

We document asymmetries in how debt and fragmentation alter shock transmission to long-term yields. Under ordinary conditions, global risk-off episodes trigger flight-to-safety flows that lower 30-year bond yields in both AEs and EM Asia, whilst global and country-specific term premium shocks raise yields. High debt and fragmentation amplify the response of 30-year yields to both global and domestic term premium shocks in AEs, but dampen the response of EM Asia yields to only global term premium shocks with no significant change for domestic shocks. Elevated debt also mutes risk-off effects, likely reflecting altered composition of safe assets globally.

Debt and fragmentation also alter the relative importance of global versus domestic drivers. In AEs, domestic shocks gain prominence under high debt whilst global shocks strengthen under fragmentation. EM Asia shows consistently increased exposure towards domestic shocks, likely reflecting anchored domestic institutional investor dominance. Trade fragmentation particularly redistributes global influence towards risk-off dynamics.

We explain this AE-EM Asia divergence with three channels that arise from dominant and anchored domestic institutional investor bases, formalised in a simplified HANK-VV-ACM

model. First, the pricing channel occurs when fragmentation routes bond pricing from global asset managers towards domestic institutions constrained by regulatory and liability-matching requirements. These institutions cannot rotate out of duration holdings, effectively raising market risk tolerance rather than lowering it. Second, the absorption channel operates when domestic institutions mechanically absorb new sovereign issuance as their balance sheets expand, reducing net supply reaching price-sensitive global investors even as gross issuance rises. Third, the household-hedging channel reflects precautionary saving responses to fiscal stress signals, where additional household saving flows are mechanically routed into domestic long-term sovereign bonds through pension and insurance wrappers, reinforcing the absorption channel without requiring households to actively seek duration exposure.

Taken together, the recent rise in term premia and ultra-long yields since 2022 reflects this interaction between global factors (quantitative tightening, geopolitical tensions, trade tensions), domestic factors (fiscal sustainability concerns, electoral cycles), and structural conditions (elevated debt, rising fragmentation). This work opens avenues for further research into the macro-behavioural foundations of regime transitions in yield dynamics, essentially grounding structural changes in fundamental shifts in market pricing behaviour. Future analysis could examine how the intermediary role of the yield curve in monetary policy transmission, including for corporate bonds, may have changed under these structural shifts, particularly as central banks navigate fragmented global markets with elevated sovereign debt burdens.

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A Additional figures

Figure A.1: Sovereign bond yields (%)

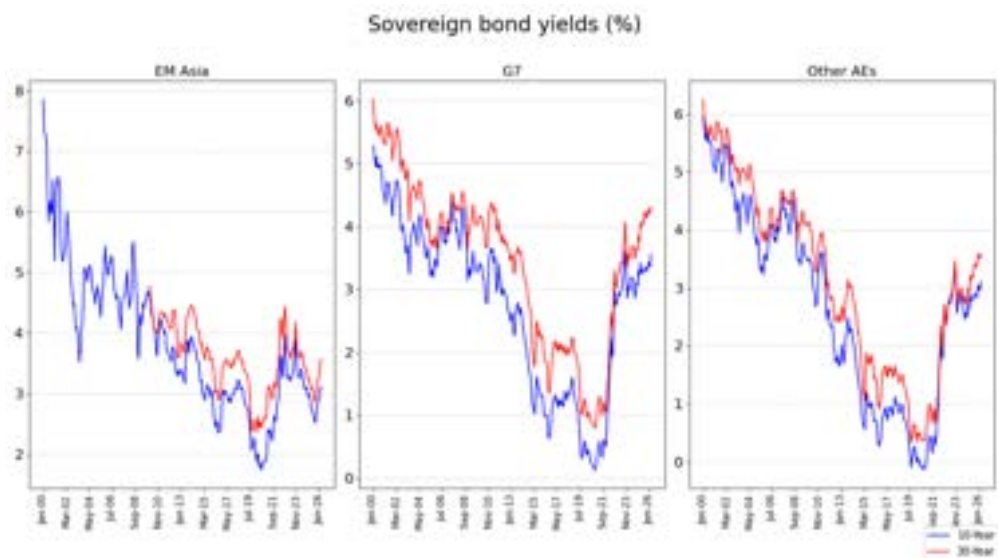


Figure A.2: Real yields (sovereign bond yields - headline inflation)

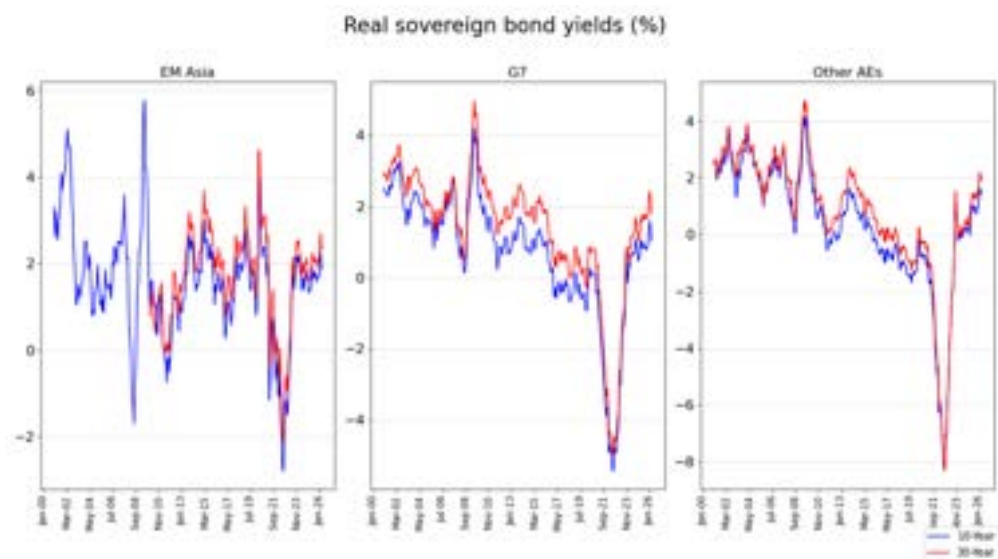


Figure A.3: Real yields (sovereign bond yields - core inflation)

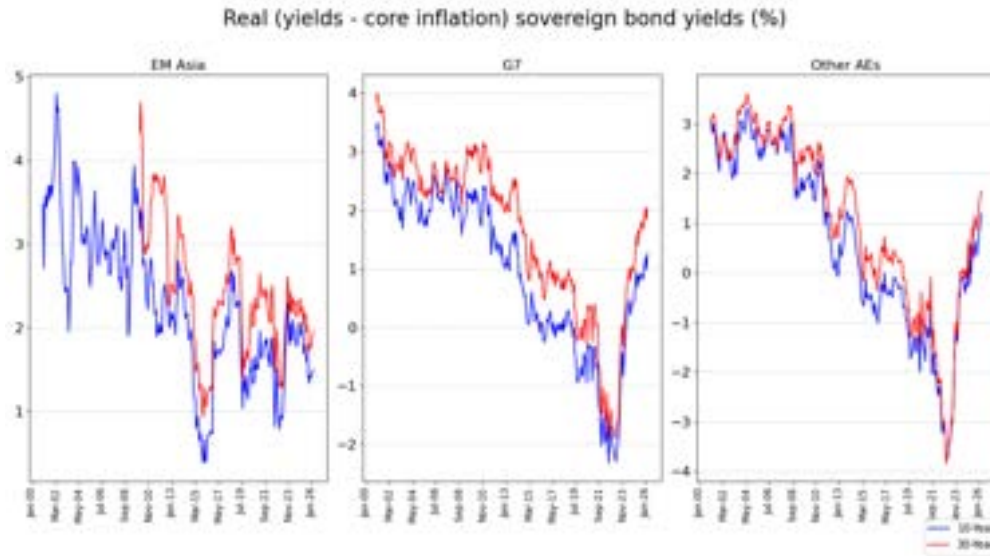


Figure A.4: G7 average R-G (difference between sovereign bond yields and nominal GDP growth)

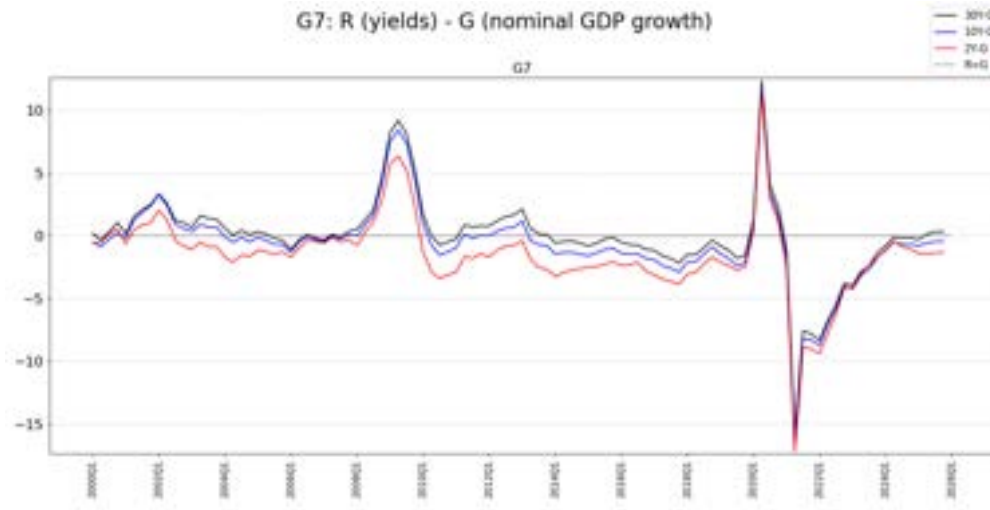


Figure A.5: Public debt (% of GDP)

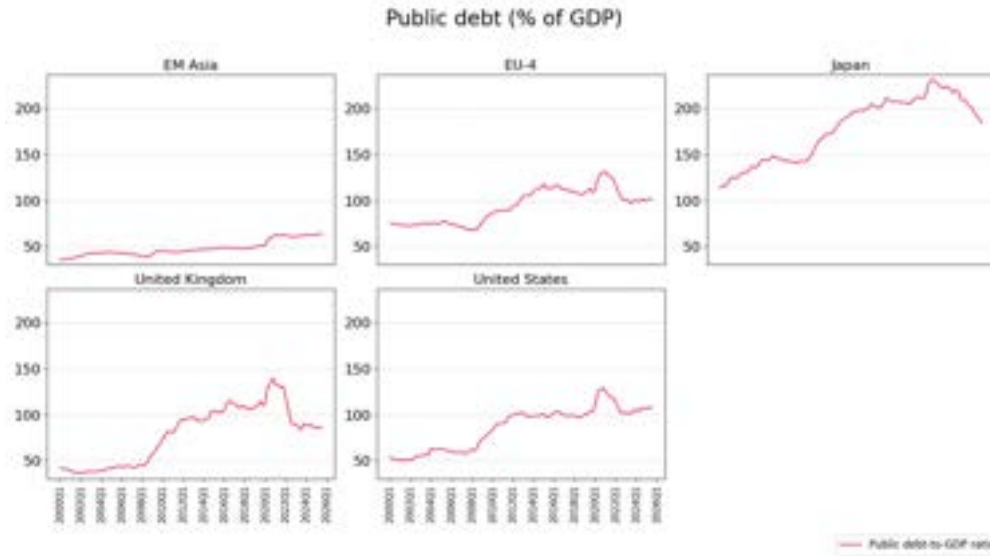
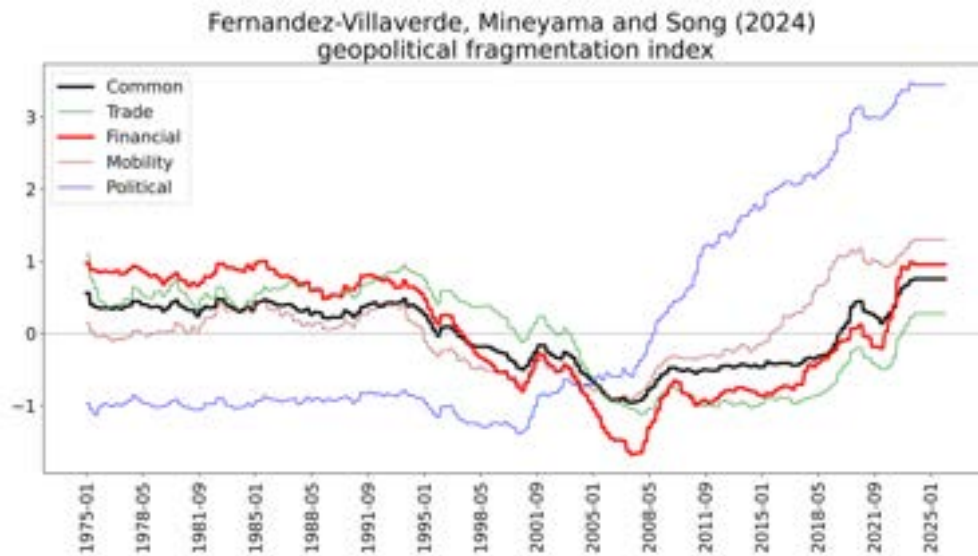


Figure A.6: Geopolitical fragmentation index



Local Factors and Return Chasing: A New Phase in Emerging Equity Markets

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PRELIMINARY

Abstract

Using granular investor-level data, this paper documents a structural shift in the drivers of global equity flows to Emerging Market Economies (EMEs) over the past two decades. We decompose the variation in flows into global (push) and country-specific (pull) components using a dynamic factor model. While global factors historically dominated, we show that local pull factors have become the main determinant of flows in the post-COVID period. Local projections further reveal a marked intensification of investor sensitivity to domestic excess returns—i.e., return chasing—with the strongest responsiveness emerging after the pandemic. We trace this shift to two channels: (i) the movement of global investors toward more concentrated, actively managed strategies (an intensive-margin adjustment), and (ii) the growing macroeconomic resilience of recipient EMEs. Together, these forces have reoriented global capital allocation toward greater responsiveness to local fundamentals, thereby enhancing the effectiveness of domestic policies in influencing cross-border capital flows.

JEL Classification: F32, G11, G15.

Keywords: Global equity flows, Emerging market, Excess returns, Fund-level data, Portfolio management, Return-chasing.

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1 Introduction

Over the past decade, a prevailing view in international finance has held that capital flows to emerging market economies (EMEs) are shaped predominantly by the global financial cycle. In this perspective, EMEs face a “Dilemma” rather than a traditional policy “Trilemma,” as global push factors—most notably US monetary policy and global risk sentiment—tend to dominate local fundamentals. As a result, domestic monetary policy is seen as having limited effectiveness in managing cross-border capital flows (Rey, 2015; Miranda-Agrippino, Nenova and Rey, 2020).

This paper challenges this prevailing consensus by considering the changing global environment and the post-COVID evolution in market dynamics. Drawing on a granular investor-level dataset, we document a structural shift in the determinants of global equity flows. While global (push) factors once played a dominant role, we show that country-specific (pull) factors have become a primary driver of capital allocation, especially in the post-COVID period. This shift signals a new phase of international financial integration, marked by increasingly sophisticated global investors who actively chase local excess returns. In so doing, their behavior reintroduces elements of price discovery and enhances policy autonomy for emerging markets.

Our analysis draws on monthly equity fund flow data from the Emerging Portfolio Fund Research (EPFR) global database. The sample spans 2004–2024 and is divided into three periods—pre-Global Financial Crisis (GFC), post-GFC, and post-COVID—to capture shifts in global liquidity conditions and the evolving resilience of EMEs.¹ Using this granular panel, we address three key questions. First, to what extent do global versus country-specific factors explain the variation in individual investor equity flows into EMEs? Second, how do these investor-level flows respond dynamically to shocks in domestic return factors across distinct macro-financial environments? Third, what mechanisms account for the evolution of these response patterns?

We begin by establishing stylized facts in valuation-adjusted equity flows using a dynamic factor model (DFM). This approach allows us to decompose the variation in equity flows into global, country-specific, and idiosyncratic components. The results reveal a pronounced shift in recent years. During the pre-GFC and post-GFC periods (2004–2021), the global common factor accounted for a substantial share of flow variation, in line with the prevailing *banking-glut* and *search-for-yield* narratives. In contrast, in the post-COVID period, the influence of country-specific factors increased sharply, explaining

¹The pre-GFC era is characterized by bank-driven credit expansion, the inter-crisis phase by market-based funding, and the post-COVID period by increased resilience in emerging markets. See Section 2.2.

16% of total flow variation and exceeding the contribution of the global factor (13%) on average across countries. This pattern, which holds for most EMEs in the sample, is particularly pronounced among high-income EMEs and the BRICS group. These findings suggest that as these markets deepen and mature, they are increasingly decoupling from the global synchronization of capital flows.

To understand the micro-foundations of this shift, we next employ panel local projections to estimate the dynamic sensitivity of active equity flows to country-specific return shocks. Our findings reveal a striking intensification of return-chasing behavior over time. Before the GFC, global investors exhibited little responsiveness to local return factors, such as rising equity prices or currency appreciation, likely reflecting market frictions and information asymmetries (Broner, Gelos and Reinhart, 2006; Portes and Rey, 2005). After the GFC, however, flow responsiveness began to strengthen gradually as the global search-for-yield environment reshaped investor incentives (Fratzscher, 2012). The shift becomes especially pronounced in the post-COVID period, during which EMEs have displayed greater macro-financial resilience. In this phase, the elasticity of flows to local stock market and exchange rate returns nearly doubled. This pattern suggests that the marginal global investor today is no longer simply responding to broad global liquidity conditions, but is actively reallocating capital toward emerging markets offering superior risk-adjusted returns.

We explore two mutually reinforcing mechanisms underlying the recent pattern of intensified return-chasing: rising investor sophistication and strengthened EME resilience. First, on the investor side, we document an intensive-margin adjustment in portfolio behavior. Global funds have progressively moved away from broad, index-tracking diversification strategies toward more concentrated portfolios. In line with theories of information acquisition (Van Nieuwerburgh and Veldkamp 2009), this increased concentration has allowed investors to process and respond to local signals more effectively. Using a balanced panel of dedicated investors, we show that the heightened sensitivity to local returns reflects a behavioral shift among sophisticated incumbents rather than a compositional change in the investor base. Second, on the recipient-country side, the responsiveness of equity flows to domestic return factors is highly state-dependent, varying systematically with economic resilience and market maturity (Hardy, Igan and Kharroubi, 2024; IMF, 2025). Improvements in macroeconomic frameworks, such as credible inflation-targeting regimes and deeper domestic financial markets, appear to have reduced the risk premia on local assets, enabling investors to assign greater weight to fundamentals. Regression results incorporating country-group heterogeneity confirm that return sensitivity is markedly higher in EMEs with stronger institutional quality, underscoring that policy

credibility is a critical precondition for attracting active, price-sensitive capital.

Our paper connects and contributes to four related strands of the international finance literature. First, we speak directly to the longstanding debate on the determinants of capital flows—specifically the push versus pull framework. A substantial body of research argues that global push factors, such as U.S. monetary policy and global risk appetite, are the primary forces driving capital flows to EMEs, often overpowering country-specific fundamentals (Calvo, Leiderman and Reinhart, 1996; Forbes and Warnock, 2012; Fratzscher, 2012). This perspective culminates in the global financial cycle hypothesis (Rey, 2015; Miranda-Agrippino et al., 2020), which posits that global asset price comovements constrain the effectiveness of domestic monetary policy in managing cross-border flows. Our findings refine this narrative in an important way. While we confirm the prominence of global factors during the pre-GFC and inter-crisis periods, we document a structural shift in the post-COVID era in which country-specific pull factors emerge as the dominant driver of capital allocation. This result aligns with recent evidence suggesting that local fundamentals, institutional frameworks, and policy credibility continue to shape capital flows—particularly in more resilient and better-managed economies (Ahmed and Zlate, 2014; Cerutti, Claessens and Rose, 2019).

Second, our findings offer additional insights for the literature on *original sin* (Eichengreen and Hausmann, 1999) and its *redux* (Hofmann, Patel and Wu, 2022; Bertaut, Bruno and Shin, 2025), viewed through the lens of global equity flows into EMEs. The shift in EME borrowing from foreign- to local-currency instruments has effectively moved currency risk from domestic borrowers to global investors (Carstens, 2019; Hofmann et al., 2022). The conventional view holds that this shift heightens the sensitivity of capital flows to exchange rate volatility, potentially amplifying instability in EMEs. We present a more nuanced interpretation, in particular for equity flows. Although we find that sophisticated investors are indeed responsive to currency risk, their sensitivity is rational and tied to price signals rather than indicative of panic or destabilizing behavior. By showing that active investors reallocate capital aggressively based on FX-adjusted returns, we highlight a mechanism through which return-sensitive flows contribute to price discovery. This, in turn, suggests that the classic *fear-of-floating* (Calvo and Reinhart, 2002) may be less warranted in the current EME environment: exchange rate flexibility can serve as an effective regulator of capital flows by altering expected returns for these sophisticated investors.

Third, we contribute to the literature on the micro-structure of international capital markets. Much of the earlier work relies on aggregate balance-of-payments data, which obscures important heterogeneity in investor behavior (Broner et al., 2006). Our study

aligns with a growing body of research that uses granular, fund-level data to illuminate the underlying mechanics of portfolio allocation (Jotikasthira, Lundblad and Ramadorai, 2012; Raddatz and Schmukler, 2012). More specifically, we extend the literature on investor heterogeneity (Koijen and Yogo, 2019; Rey, Planat, Stavrakeva and Tang, 2024) by documenting a distinct behavioral shift: the rise of return chasing among active funds. In contrast to Camanho, Hau and Rey (2022), who examine rebalancing behavior primarily in advanced economies, we show how this mechanism operates within EMEs, where historical information asymmetries and market frictions have often muted such responsiveness.

Lastly, we bridge micro-level data with macro-level factor models to quantify the relative contributions of global and country-specific forces (Förster, Jorra and Tillmann, 2014; Eller, Huber and Schuberth, 2020). Although dynamic factor models (DFMs) are widely used to study macroeconomic aggregates and financial indicators (e.g., Kose, Otrok and Whiteman, 2003; Kose, Otrok and Prasad, 2012; Miranda-Agrippino et al., 2020), they have rarely been applied to investor-level flow panels. By bringing a DFM to micro-level flows, we uncover latent country-specific drivers that are orthogonal to global conditions. This approach yields a more granular understanding of the unobserved forces shaping individual fund allocations, going beyond standard parametric regression models that rely on observable push and pull variables.

The remainder of the paper proceeds as follows. Section 2 describes the granular investor-level dataset and defines the macro-financial phases used in our analysis. Section 3 establishes the stylized facts regarding the shift from global to local drivers using a dynamic factor model. Section 4 presents the core empirical results on time-varying return sensitivity using panel local projections. Section 5 investigates the mechanisms driving this shift—investor evolution and EME resilience. Section 6 concludes.

2 Global Investor Equity Flow Data

This section details the construction of our granular investor-level dataset, defines the explanatory variables, and delineates the three macro-financial phases that structure our analysis. Also, we document some stylized facts in global equity flow data.

2.1 Data and Measurements

A central premise of our analysis is that the individual funds in our sample are atomistic relative to the aggregate market capitalization of the recipient EMEs. This allows us to treat

country-level prices as exogenous to the idiosyncratic flow decisions of any single investor, mitigating reverse causality concerns regarding the price impact of trades (Camanho et al., 2022).

Investor’s Equity Flows We construct a monthly-frequency, investor-level panel using the Emerging Portfolio Fund Research (EPFR) global database. This dataset provides monthly data on the asset allocation of individual mutual funds, including total net assets, investment destination weights, and fund type. Our baseline analysis restricts the sample to active funds. This restriction isolates discretionary portfolio rebalancing driven by information processing, excluding mechanical index tracking associated with passive funds.

We focus on funds investing in 20 major emerging market economies (EMEs).² To construct the flow variable following Kim, Park and So (2025), we first calculate the total equity holding of investor i in country c at time t :

$$\text{Equity}_{i,c,t} \equiv \sum_{a \in \mathcal{A}} \omega_{i,c,t}(a) \times \text{AUM}_{i,t}(a), \quad (1)$$

where $\text{AUM}_{i,t}(a)$ denotes the total assets under management of investor i in asset class a , and $\omega_{i,c,t}(a)$ is the portfolio weight allocated to country c .

Distinguishing active reallocation (buying/selling) from passive valuation effects is central to our measurement strategy. To isolate active investment decisions, we adjust changes in holdings for stock market index and exchange rate fluctuations:

$$R_{i,c,t+h} \equiv \text{IHS} \left(\text{Equity}_{i,c,t+h} \times \frac{\text{SP}_{c,t}^{\text{LCY}}}{\text{SP}_{c,t+h}^{\text{LCY}}} \frac{\text{FX}_{c,t}}{\text{FX}_{c,t+h}} \right) - \text{IHS}(\text{Equity}_{i,c,t}), \quad (2)$$

where $\text{SP}_{c,t}^{\text{LCY}}$ is the local currency stock price index and $\text{FX}_{c,t}$ is the exchange rate (LCY per USD). The term inside the parenthesis removes the mechanical expansion of asset value due to price appreciation, leaving only the quantity change. We apply the Inverse Hyperbolic Sine (IHS) transformation, defined as $\text{IHS}(x) = \ln(x + \sqrt{x^2 + 1})$, to accommodate zero positions and mitigate the impact of outliers in flow data.

²The sample comprises Brazil, Chile, China, Colombia, the Czech Republic, Hungary, Indonesia, India, Israel, South Korea, Mexico, Malaysia, Peru, the Philippines, Poland, Russia, Thailand, Turkey, Taiwan, and South Africa. These economies are selected based on the depth of their equity markets and the availability of consistent macroeconomic data over the 2004–2024 period.

Price Factors and Macroeconomic Variables To capture the *pull* drivers of capital flows, we compile a set of country-specific financial and macroeconomic variables. Our primary regressors are the price factors, which represent the direct financial incentives for global investors:

- **Stock Price Growth:** The log-difference of the local stock market index ($\Delta \ln SP_{c,t}^{LCY}$).
- **FX Growth:** The appreciation of the local currency against the US dollar ($\Delta \ln FX_{c,t}$).
- **US Dollar-Denominated Stock Price Growth:** The composite return/price growth for a US-based investor ($\Delta \ln SP_{c,t}^{USD} \equiv \Delta \ln SP_{c,t} - \Delta \ln FX_{c,t}$).

In addition to price factors, we control for the broader macroeconomic environment using standard pull factors: the domestic nominal interest rate, CPI inflation, industrial production growth, and changes in foreign reserves. Data are sourced from Bloomberg, the IMF International Financial Statistics (IFS), and the World Bank Global Economic Monitor. See Appendix A for the details.

2.2 Macro-Financial Phases

Following [Hardy and von Peter \(2023\)](#), we divide our sample period (2004–2024) into three distinct phases: pre-GFC, inter-crisis, and post-COVID. These periods correspond to structural shifts in the global financial cycle and the composition of capital flows. While the first two phases have been extensively examined in the literature, the last phase remains relatively underexplored.

Phase I: Pre-GFC (2004m1–2009m3). This period is characterized by bank-driven credit expansion under accommodative conditions, referred to as the global banking glut. Loose monetary conditions and light-touch regulation fueled a surge in cross-border bank lending. Capital flows to EMEs were predominantly bank-driven and highly pro-cyclical.

Phase II: Post-GFC (2009m4–2021m9). In the aftermath of the Global Financial Crisis, regulatory tightening in the banking sector and prolonged low interest rates in advanced economies triggered a "second phase of global liquidity" ([Shin, 2014](#)). Capital flows shifted toward market-based flows, replacing bank lending, as financial conditions were generally accommodative. Post-crisis regulatory tightening, in particular in banking industries, and persistent low-for-long conditions, which in turn stimulated investors' yield-seeking behavior, led to increased bond issuance by EMEs ([Erten, Korinek and Ocampo, 2021](#); [Gelos, Gornicka, Koepke, Sahay and Sgherri, 2022](#)).

Phase III: Post-COVID (2021m10–2024m12). The most recent phase marks a sharp departure from the previous decade, with a more complicated picture. On the one hand, it is characterized by extraordinary fluctuations in macro-financial conditions, reflecting surging inflation across countries and synchronized global monetary tightening. On the other hand, emerging markets, albeit not all, have shown remarkable resilience amid these disturbances, with the help of a potential structural change in global investors’ behavior and enhanced fundamentals in EMEs (IMF, 2025; Hardy et al., 2024).³ Consequently, capital flows into EMEs rebounded, reaching USD 110 billion inflows in 2023—equivalent to 0.6% of GDP for those economies (IMF, 2024). This period allows us to test whether the drivers of capital flows have structurally shifted from global liquidity cycles to local fundamentals.

2.3 Summary Statistics

Table 1 presents summary statistics at the country-month (Panel A), investor-month (Panel B), and investor-country-month (Panel C) levels. The final sample, after excluding inactive funds, comprises 162 unique investors in Phase I, 477 in Phase II, and 305 in Phase III.

Panel A of Table 1 summarizes the distribution of market-level variables, including stock index and exchange rate changes. On average, market return factor—measured as stock index growth adjusted for exchange rate depreciations—is positive across all three phases, though both the mean and median values decline over time. Stock index growth and exchange rate movements exhibit substantial cross-country and transitory variation, with large standard deviations. These reflect the inherent volatility which is typically observed in emerging markets. Notably, the period classified as Phase I, which encompasses the GFC, displays the widest dispersion and interquartile ranges across all three variables, highlighting heightened market turbulence during this phase.

Panel B describes portfolio allocations and diversification patterns at the investor level. Total investment volume in emerging markets varies considerably across funds. The mean portfolio size increased from USD 1.40 billion in Phase I to USD 1.83 billion in Phase II, before retreating to USD 1.45 billion in Phase III. In terms of diversification, investors tend to spread their holdings across multiple markets, but the average number of invested markets per investor declines over time—from 12.3 in Phase I to 9.3 in Phase III. This pattern suggests a gradual shift toward more selective or concentrated investment strategies, although changes in sample coverage over time may also partially account for

³This resilience can be attributed, at least in part, to the strengthened macroeconomic frameworks and the increased foreign exchange reserves, which together have bolstered investor confidence.

Table 1: Summary Statistics

Panel A. Country-Month Level								
	Obs.	Mean	S.D.	p10	p25	p50	p75	p90
US Dollar-denominated stock index growth (monthly %, (a) minus (b))								
Phase I	1,480	1.07	8.15	-8.26	-2.57	2.18	6.24	9.24
Phase II	3,000	0.57	6.17	-6.12	-2.61	0.88	4.01	7.26
Phase III	773	0.09	5.83	-6.05	-3.35	0.24	3.47	6.59
Stock index growth (monthly %, local currency, (a))								
Phase I	1,480	1.02	6.61	-7.17	-2.23	1.77	5.20	8.00
Phase II	3,000	0.74	4.60	-4.28	-1.68	0.91	3.22	5.64
Phase III	773	0.58	4.32	-4.24	-1.89	0.46	2.96	5.30
Exchange rate (against USD) growth (monthly %, (b))								
Phase I	1,480	-0.05	2.80	-2.91	-1.37	-0.24	0.84	2.69
Phase II	3,000	0.17	2.51	-2.46	-1.10	-0.01	1.32	2.99
Phase III	774	0.49	3.15	-2.54	-0.87	0.37	1.82	3.22

Panel B. Investor-Month Level								
	Obs.	Mean	S.D.	p10	p25	p50	p75	p90
Total investment to 20 emerging markets (USD billion)								
Phase I	7,637	1.40	3.38	0.03	0.08	0.31	1.16	3.29
Phase II	20,659	1.83	4.24	0.01	0.04	0.22	1.57	4.67
Phase III	6,545	1.45	3.45	0.01	0.04	0.18	1.14	3.86
Count of invested markets (countries) per investor								
Phase I	7,637	12.31	5.72	4.00	7.00	14.00	18.00	19.00
Phase II	20,659	10.66	6.05	2.00	5.00	11.00	16.00	19.00
Phase III	6,545	9.29	5.50	2.00	4.00	9.00	14.00	17.00

Panel C. Investor-Country-Month Level								
	Obs.	Mean	S.D.	p10	p25	p50	p75	p90
Investment to each market (USD million)								
Phase I	152,740	69.98	284.35	0.00	0.00	3.16	32.17	136.27
Phase II	413,180	91.33	412.21	0.00	0.00	0.55	26.21	164.47
Phase III	130,900	72.31	375.05	0.00	0.00	0.00	13.52	114.53
Investment to each market (USD million, excluding zero investment)								
Phase I	99,784	17.21	106.39	-78.41	-31.87	3.76	47.92	125.73
Phase II	237,109	13.79	111.77	-78.34	-32.17	-0.56	36.22	124.36
Phase III	64,721	8.39	103.16	-74.38	-27.93	-1.06	28.33	99.19
Valuation-adjusted investment growth (%)								
Phase I	146,940	0.27	22.79	-13.79	-2.57	0.00	2.93	14.42
Phase II	399,700	-0.17	19.77	-9.87	-1.17	0.00	0.50	9.02
Phase III	125,799	-0.36	18.46	-8.99	0.00	0.00	0.00	7.81
Valuation-adjusted investment growth (% , excluding zeros)								
Phase I	91,125	-1.20	26.14	-21.82	-8.05	-0.07	7.57	19.58
Phase II	215,290	-1.87	24.02	-18.29	-6.91	-0.47	5.44	14.71
Phase III	59,224	-2.25	24.06	-18.48	-7.30	-0.45	5.59	14.50

Notes: In Panel A, the growth rates of country-month variable are calculated as the log difference between periods t and $t - 1$. In Panel C, the growth rates of investor-country-month variable are computed as the difference in inverse hyperbolic sine (IHS) transformed values between t and $t - 1$. To compute statistics for valuation-adjusted investment growth (% , excluding zeros), observations with zero investments in both periods t and $t - 1$ are excluded.

this trend.

Panel C reports summary statistics at the investor–country–month level, highlighting the granular structure of portfolio allocations and the inherently lumpy, discontinuous nature of cross-border portfolio flows. Individual fund positions in specific markets are highly skewed. When limiting the sample to nonzero positions, the average investment size decreases notably in Phase III compared to earlier phases. The panel also presents valuation-adjusted investment growth rates, both including and excluding zero-investment cases. When zeros are included, the average growth rate hovers near zero across all phases; however, when excluding zeros, the average growth rate turns slightly negative. This pattern suggests that disinvestment episodes are somewhat more frequent or more pronounced than expansions within the sample period.

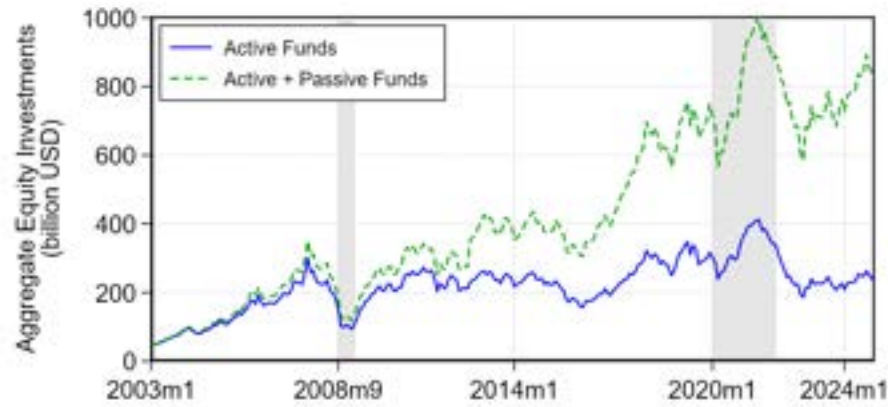
2.4 Stylized Facts: Trends and Variations

Before turning to the formal econometric analysis, we document three stylized facts regarding the evolution of global equity flows to EMEs.

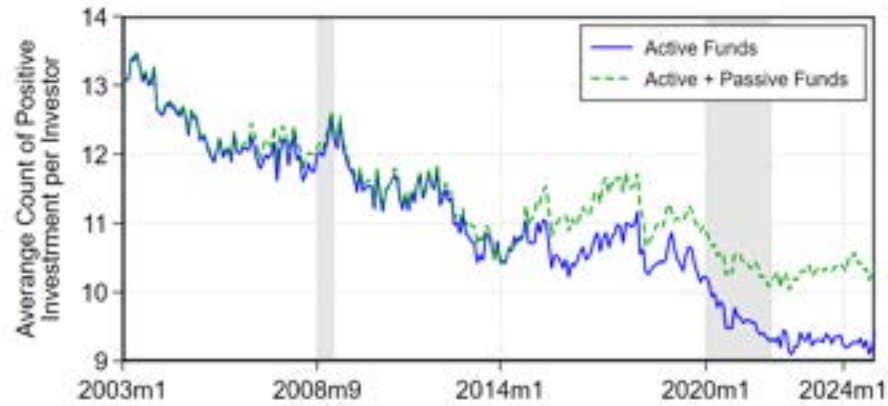
Fact 1: Divergence between Active and Passive Flows Figure 1a plots the aggregate volume of equity flows to EMEs. Consistent with the literature, total flows (active + passive; green dashed line) have grown substantially since the GFC, driven by the secular rise of index investing. In sharp contrast, flows from active funds (blue line) have remained relatively stable over the last decade. This divergence motivates our focus on active funds. By isolating active managers, we filter out the mechanical, benchmark-driven inflows associated with the passive indexing trend. This allows us to test whether the *marginal* discretionary investor is reacting to local fundamentals (*pull* factors) rather than merely riding the wave of global liquidity. However, neglecting the growing dominance of passive funds could lead to an incomplete understanding of aggregate flow dynamics and global investment patterns. To address this, we provide complementary results including both active and passive funds in Appendix B. As detailed therein, the choice of fund type does not materially alter our main empirical findings.

Fact 2: Rising Portfolio Concentration As hinted in the summary statistics (Panel C of Table 1), global portfolios have become more concentrated. Figure 1b plots the investor’s cross-sectional average number of EME destinations with positive holdings. This metric has declined from approximately 13 markets in the pre-GFC period to under 9 in the post-COVID era. Importantly, this decline occurs even as aggregate AUM remains robust. This

(a) Aggregate Equity Flows



(b) The Average Number of Positive Investment Destinations



(c) Cross-country Dispersion

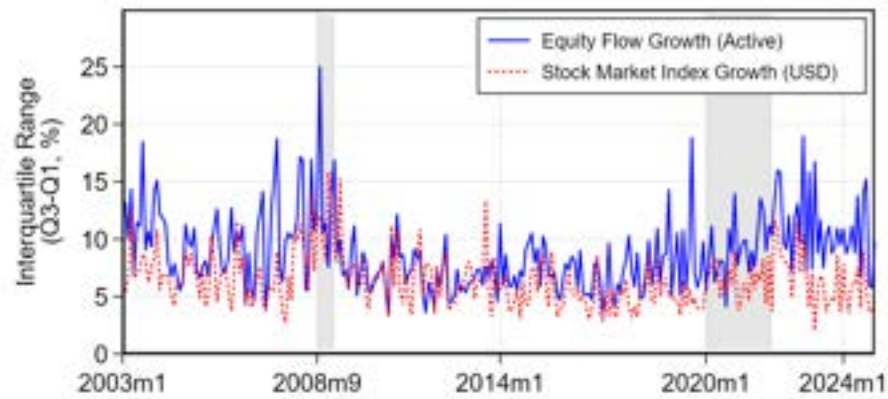


Figure 1: Global Investor Equity Flows to Emerging Equity Markets

Notes: Subfigure (a) shows the total equity investment aggregated across all investors in the EPFR dataset. Subfigure (b) display the cross-sectional average count of positive investment destinations among 20 EMEs per investor . Subfigure (c) displays the interquartile ranges (%) of country-level investment growth (aggregates equity investments across active funds) and equity market dollar-denominated price growth (stock index growth minus exchange rate growth.). All growth rates are calculated as log-differences. The shaded areas indicate the periods of the Global Financial Crisis and the COVID-19 pandemic, respectively.

pattern implies an extensive margin adjustment: investors are not exiting the asset class entirely, but rather becoming more picky, holding fewer countries with higher conviction. This concentration is a prerequisite for the return-chasing mechanism we identify later—investors can only chase returns if they actively select winners rather than holding the entire market.

Fact 3: Cross-Country Dispersion and Identification Figure 1c highlights the substantial cross-sectional heterogeneity in both flows and returns. The interquartile range of monthly flow growth (blue line) spans 4% to 25%, while the dispersion in US dollar-denominated stock market index growth (red line) ranges from 2% to 15%. Crucially, these two dispersions are positively correlated ($\rho = 0.38$ using active funds; $\rho = 0.48$ using both active and passive funds), suggesting that capital flows differentially to markets with higher excess returns relative to others or the average of emerging markets. This cross-sectional variation is the key source of our identification. In the regression analysis that follows, we employ time fixed effects to absorb all global common shocks (*push* factors). Consequently, our estimates of return-chasing are identified primarily from this variation: how a single investor reallocates capital across different EMEs in response to relative price changes (i.e., excess returns).

2.5 Correlations: The Emergence of Return Chasing

Does the sensitivity of capital flows to local returns change over time? As a precursor to our formal estimation, Figure 2 visualizes the conditional correlation between lagged dollar-denominated stock returns and aggregate equity inflows across the three phases. To construct these binned scatter plots, we first regress both flows and return factors on time and country-phase fixed effects to absorb global common shocks and time-invariant country characteristics. We then plot the residuals, ensuring the relationship is driven purely by within-phase, cross-country variation.

The results reveal a stark structural break. In the pre-GFC (Phase I) and Inter-Crisis (Phase II) periods, the relationship between the growth of country-level aggregated equity investments of all investors and one-month-lagged dollar-denominated stock market price growth is statistically indistinguishable from zero at the 10% level (correlation coefficients of -0.017 and -0.014 , respectively). This suggests that, historically, superior local market performance did not systematically attract additional active capital.

However, the post-COVID period (Phase III) exhibits a dramatic shift. As shown in the rightmost panel, the relationship turns strongly positive and statistically significant at the

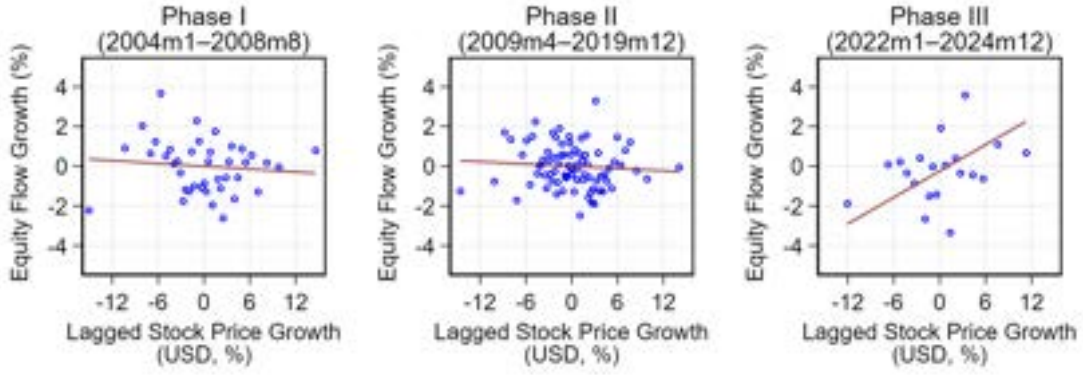


Figure 2: Equity Flows and Stock Market Indexes in 20 Emerging Market Economies

Notes: This figure displays a binned scatter plot of the association between the country’s dollar-denominated stock market index growth with a one-month lag (x-axis) and the growth of country-level aggregated equity inflows (y-axis). The number of bins is 40, 80, and 20 in Phases I, II, and III, respectively, which implies each bin has approximately 35 observations. To isolate global factors and time-invariant market characteristics, we incorporate time and destination-phase fixed effects.

1% level (correlation coefficient of 0.119). This visual evidence points to a new regime where return-chasing behavior has become a dominant driver of allocation decisions. While suggestive, these unconditional correlations do not fully account for dynamic feedback effects or control for other time-varying pull factors. The next sections formalizes this finding using a rigorous dynamic factor model and local projection framework.

3 Global and Local Factors in Global Equity Flows

Section 2 documented a stylized fact: while aggregate flows have grown, active investors have become more concentrated and selective. This suggests that the drivers of capital allocation may be shifting from broad global trends to specific local opportunities. To rigorously quantify this shift, we first employ a latent factor approach, specifically, a dynamic factor model (DFM). This framework allows us to decompose the variation in investor-level flows into a common global component (push), recipient-specific components (pull), and idiosyncratic investor shocks.

3.1 Dynamic Factor Estimation

We explore the roles of global and domestic determinants in individual equity flows by estimating latent factors from monthly investor-level equity flow data. We utilize equity flow data from 295 firms that invest across 19 emerging economies during the

sample period from 2004 to 2024.⁴ The standard DFM is employed. This framework is particularly suited for extracting latent common factors from cross-country variables, enabling a parsimonious representation of large dataset.⁵

Let $\mathbf{R}_t$ be a $N \times 1$ vector of (valuation-adjusted) equity monthly growth rates, i.e., $h = 1$ in equation (2). We assume that investor-level flows are expressed as a function of unobservable latent factors:

$$\mathbf{R}_t = \mathbf{\Lambda} \mathbf{F}_t + \boldsymbol{\xi}_t, \quad (3)$$

where $\mathbf{F}_t$ is a $K \times 1$ vector of common factors that summarize the drivers of variations across equity growth (i.e., $\mathbf{F}_t \equiv [f_{1,t}, \dots, f_{K,t}]'$), $\mathbf{\Lambda}$ is a vector of factor loadings that shape the extent to which each equity flow responds to the common factors, and $\boldsymbol{\xi}_t$ denotes a $N \times 1$ vector of idiosyncratic shocks which account for the remaining investor-specific variations. The common factors are considered to follow a VAR(p) process:

$$\mathbf{F}_t = \boldsymbol{\Phi}_1 \mathbf{F}_{t-1} + \dots + \boldsymbol{\Phi}_p \mathbf{F}_{t-p} + \boldsymbol{\varepsilon}_t, \quad (4)$$

where $\boldsymbol{\Phi}_j$ ($j = 1, \dots, p$) are $K \times K$ autoregressive coefficients, while $\boldsymbol{\varepsilon}_t$ is an error term which is normally distributed with mean zero. We set $p = 3$, enabling us to capture the dynamic persistence of capital flow cycles.

We further assume that each equity flow is a function of a global factor ($f_{g,t}$), a country-specific factor ($f_{c,t}$) and an idiosyncratic factor.

$$R_{i,c,t} = \lambda_{g,i} f_{g,t} + \lambda_{i,c} f_{c,t} + \xi_{i,c,t}. \quad (5)$$

This structure allows us to capture the differences in covariations at different aggregation levels. To this end, a global factor is loaded by all equity flows, whereas a country-specific factor is only loaded by the flows invested in country c .

The relative importance of each driver is assessed via variance decomposition. For each investor-country pair, the variance of the equity flows of investor i in country c ($R_{i,c,t}$) is decomposed as:

$$\text{var}(R_{i,c,t}) = (\lambda_{g,i})^2 \text{var}(f_{g,t}) + (\lambda_{i,c})^2 \text{var}(f_{c,t}) + \text{var}(\xi_{i,c,t}). \quad (6)$$

⁴These firm-level investments in specific economies were primarily selected to ensure a balanced dataset over the entire sample period. Notably, the number of firms per country is broadly similar, ensuring that our estimates of country-specific factors are not disproportionately influenced by a small subset of firms.

⁵Dynamic factor models work by uncovering unobservable common elements that drive the covariance or comovement of observable variables across countries. However, few prior studies have applied this framework to metrics of investor-level portfolio flows due to limited data availability.

Then, the shares of variance attributable to the global and country-specific factors are:

$$\frac{(\lambda_{g,i})^2 \text{var}(f_{g,t})}{\text{var}(R_{i,c,t})} \quad \text{and} \quad \frac{(\lambda_{i,c})^2 \text{var}(f_{c,t})}{\text{var}(R_{i,c,t})}.$$

This decomposition provides a precise metric to test our central hypothesis: has the explanatory power of country-specific "pull" factors risen relative to global "push" factors over time?

3.2 Estimation Results: The Rise of Pull Factors

Our estimation of the dynamic factor model using monthly valuation-adjusted equity flows ($R_{i,c,t}$) provides insights into the primary drivers of variations across individual investor decisions targeting emerging markets. The variance decomposition, averaged across all investor-country pairs, reveals the relative importance of the global factor, country-specific factors, and idiosyncratic components. The estimated variance contributions of global and country-specific factors are summarized in Figure 3. Further details are provided in Appendix Table A.1.⁶ Three key findings emerge, establishing a clear structural shift in the determination of global capital flows.

Consistent with the extensive literature on international capital flows emphasizing the role of global push factors (e.g., global risk appetite, US monetary policy), the global factor ($f_{g,t}$) explains a substantial portion of the overall variance in investor-level equity flows. Based on the average across 295 firm investments, the global factor accounted for 7.4 percent of total investment variation, but its role varied widely across investors (from near zero to 35 percent).⁷ This confirms that common global economic and financial conditions significantly, but heterogeneously, influence investment decisions directed towards EMEs (Rey, 2015; Miranda-Agrippino et al., 2020).

Country-specific factors ($f_{c,t}$) exhibit substantial explanatory power—comparable to that of the global factor—for the variations in investor-level equity flows. While the share varies across countries or investors, the average contribution of country-specific factors to the variance of flows is sizeable (8 percent) over 2004–2024, moderately exceeding the

⁶The main empirical results based on the dynamic factor estimation are robust to different factor model specifications (e.g., one-factor model) and alternative smaller groups of countries.

⁷Although few studies discuss the issue based on firm-level data as this paper does, the contributions of the global investment factor to investment variation reported in this section are broadly consistent with the estimates reported in other studies on business cycles, GDP, or investments on an aggregate basis. Earlier studies have reported that the global macroeconomic factor has contributed 10-20 percent to the variation in national output and investment rates, with estimates differing depending on the methodology, sample periods, country groups, and data transformations. (Kose, Otrok and Whiteman, 2008, Kose et al., 2012).

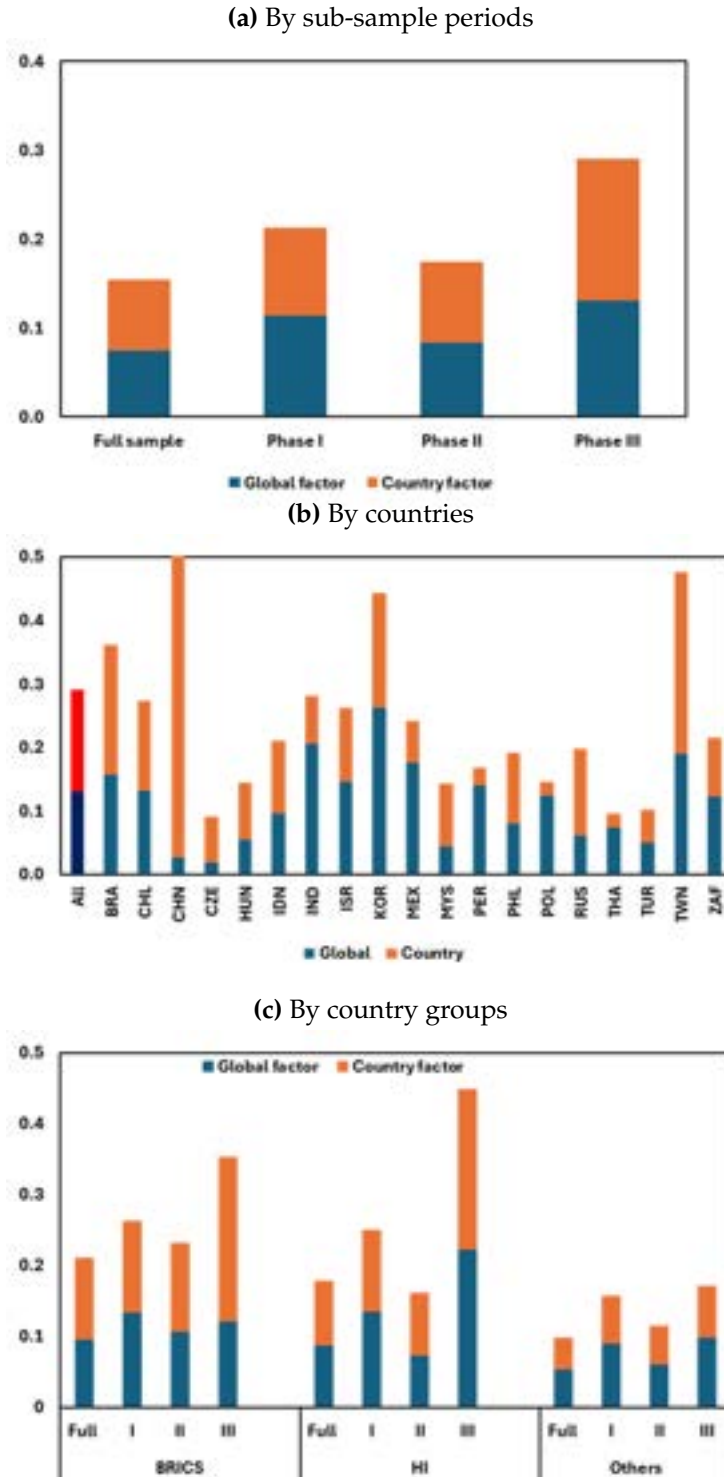


Figure 3: Variance contribution of global and country factors

Notes: The contribution of global and country-specific factors to investment variation, averaged across 295 firms in 19 countries, is analyzed across different phases (panel a), across different country groups (panel c), and across recipient countries (panel b, focusing on the Phase III period). Refer to Section 2 for details on each phase. "BRICS" indicates BRA, RUS, IND, CHN, and ZAF. "HI" indicates high-income EMEs (ISR, KOR, TWN). "Others" indicates the other 12 EMEs.

contribution of the global factor based on cross-country averages. This result underscores that EMEs are not merely passive recipients of global capital tides. Rather, pull factors or country characteristics play a vital role in attracting or deterring international equity investment at the investor level.

More interesting are the temporal changes in the role of global and country-specific factors. Overall, global investment synchronization—i.e. the combined variance contributions of global and country factors—has become increasingly significant and widespread over time. This trend is evident from model estimates across three sub-periods, as defined in Section 2: Phase I (2004m1–2009m3), Phase II (2009m4–2021m9), and Phase III (2021m10–2024m12). In the first period, the variance contribution of the global factor (11.4 percent) overshadowed that of country-specific factors (9.9 percent). This pattern reversed during the second period when country and global factors contributed 9.1 percent and 8.4 percent, respectively, to the variations in the firm-level investments. In the third phase, the roles of country-specific and global factors both expanded to 16 percent and 13 percent, respectively.

The first and second sub-sample periods encompassed major global events—such as the GFC (in 2008–09), the COVID-19 pandemic (2020), and the euro area debt crisis (early- to mid-2010s)—during which the existing literature based on the dynamic factor estimation often highlights a heightened influence of global shocks relative to more stable periods. As such, the even greater contribution of global and country-specific factors in the post-pandemic period than the two previous periods is particularly striking.⁸ This may indicate potential structural shifts in the behavior of global investment firms and/or the economic fundamentals in the countries (BIS Committee on the Global Financial System, 2021; Hardy and von Peter, 2023; Hardy et al., 2024).

This result challenges the view that EMEs are merely passive recipients of global shocks. In the post-pandemic era—characterized by synchronized global tightening—investors have not fled EMEs *en masse* (which would drive up the global factor share). Instead, they have become highly selective, causing country-specific dynamics to explain the largest share of flow variation in decades.

Finally, the contributions of global and country-specific factors are meaningfully large across all economies—explaining more than 10 percent of total variation for about one-third (two-fifths) of the 295 firms over the full sample period (post-pandemic period). During

⁸In Phase I, when the core period of the GFC (September 2008 to March 2009) is excluded, the variance contribution of global and country-specific factors moderately decreases compared to the baseline (which stands at 11.3 percent and 8.8 percent). Similarly, during the second phase, when we exclude the core pandemic period (January 2020 to August 2021), the factor shares decline to 7.9 percent and 8.6 percent, respectively, compared to 8.4 percent and 9.1 percent in the baseline.

the post-pandemic period, country-specific pull factors have played a larger role than global push factors in 11 EMEs. Although the rising importance of country-specific factors is broad-based and consistent across countries, the pattern is particularly pronounced among high-income economies (Israel, Korea, and Taiwan) and the BRICS, as summarized in panel (c) of Figure 3. Overall, global and local factors together explain a larger share of equity flows to high-income and major BRICS economies than to other EMEs. This suggests that as EME financial markets deepen, they become less tethered to global cycles and more responsive to idiosyncratic fundamentals.

The DFM analysis establishes that a structural shift has occurred: country-specific factors have become increasingly important drivers of equity flows, particularly in the post-pandemic period. However, because these factors are latent, the decomposition offers limited guidance for policymakers and market participants—it does not reveal which specific local conditions or variables are driving this heightened sensitivity. To address this limitation, Section 4 moves from latent factors to observable variables, focusing on local return-based fundamentals.

4 Market Return Factors and Global Equity Flows

Motivated by the rising importance of country-specific latent factors documented in Section 3, this section formally examines the return-chasing behavior of global investor. We employ panel local projections to estimate the dynamic sensitivity of active equity flows to observable price signals—specifically, stock market index and exchange rate movements—across our three sub-sample phases.

4.1 Empirical Strategy

The influence of push and pull factors on capital flows to emerging markets is a well-established topic in the international finance literature (Taylor and Sarno, 1997; Forbes and Warnock, 2012; Fratzscher, 2012; Rey, 2015; Goldberg and Krogstrup, 2023, and many others). Building upon existing findings with our granular investor-level data, we focus primarily on the roles played by pull factors in investment flows.

Regression Specification Using the standard local projection framework, we regress the valuation-adjusted investor-level equity flow growth between t and $t + h$ ($R_{i,c,t}$, equation 2)

on domestic return factors as follows:

$$R_{i,c,t+h} = \alpha^h \times \Delta \ln \text{SP}_{c,t}^{\text{USD}} + \sum_{l=1}^3 [\Gamma_{\text{pull},l}^h \mathbf{Pull}_{c,t-l} + \gamma_l^h \ln \text{Size}_{i,t-l}] + \delta_i^h + \delta_c^h + \delta_t^h + \varepsilon_{i,c,t}^h, \quad (7)$$

where $\Delta \ln \text{SP}_{c,t}^{\text{USD}} \equiv \Delta \ln \text{SP}_{c,t}^{\text{LCY}} - \Delta \ln \text{FX}_{c,t}$ denotes domestic stock price monthly growth ($\Delta \ln \text{SP}_{c,t}^{\text{LCY}}$) denominated in US dollars ($\Delta \ln \text{FX}_{c,t}$, exchange rate growth against US dollar), which are our main variable of interest among the return-based pull factors. A vector of other (l -th lagged) pull factors, $\mathbf{Pull}_{c,t-l}$, includes the domestic nominal interest rate at $t-l$, CPI inflation, and the growth of industrial production and foreign reserves between $t-l$ and $t-l+1$. Additionally, $\ln \text{Size}_{i,t-l}$ indicates a log of investor size at $t-l$.

The regression includes investor, country, and time fixed effects (δ_i^h , δ_c^h and δ_t^h), each serving to isolate group-specific reactions. Among them, time fixed effects (δ_t^h) control for global shocks and common time-varying influences. Accordingly, the impact of the price factor can be interpreted as that of an excess return, reflecting deviations from global average movements at each time point. This inclusion ensures that the estimated sensitivities represent the relative attractiveness of specific markets rather than general market-wide movements.⁹

In estimating equation (7), we treat country-specific return/price factors as exogenous to individual equity flows. This identification strategy relies on the plausible assumption that individual funds are atomistic relative to the aggregate market capitalization of the recipient EMEs. Consequently, while aggregate flows may influence asset prices (reverse causality), idiosyncratic flows from a single investor are unlikely to contemporaneously drive equilibrium exchange rates or stock indices (see, e.g., [Camanho et al., 2022](#)).

4.2 Regression Results: The Structural Shift in Return Sensitivity

Figure 4 illustrates the impulse responses of equity flows to a 1% increase stock market price shock, measured as the difference between domestic stock market index growth and exchange rate growth in emerging market economies. The return differentials represent ex-post arbitrage opportunities which take into account valuation changes driven by exchange rate movements ([Hau and Rey, 2006](#); [Kim, 2011](#)). Also, given the inclusion of time fixed effects (δ_t^h) in the empirical model, the estimated response to return growth can be interpreted as a reaction to excess returns—i.e., returns net of global average performance.

⁹Despite the rich set of fixed effects and control variables, a concern about reverse causality between equity flows and stock price growth could remain as capital flows can also affect domestic price factors. However, the endogeneity issue is less severe when using investor-level data, since individual investors are unlikely to generate substantial effects on market-wide prices.

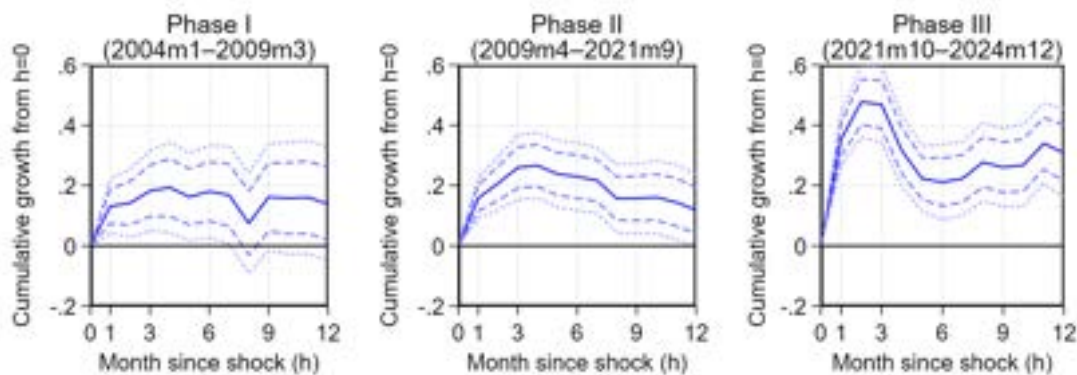


Figure 4: Equity Flow Response to Dollar-Denominated Stock Price Growth

Notes: The figure plots the predictive content of dollar-denominated stock price growth (stock market index growth minus exchange rate growth) for active fund flows of individual investors. The responses are the estimates of α^h in equation (7). The specification controls for investor, country, and time fixed effects, as well as pull factors with their three lags. The 90% and 99% confidence intervals (long- and short-dashed lines) are based on standard errors corrected for arbitrary correlation within investors. In each regression, singleton observations are dropped. The x-axis is time in months, and the y-axis is cumulative changes (growth, %).

The three charts in each panel exhibit the results for the pre-GFC (Phase I, left), post-GFC (Phase II, middle), and post-COVID (Phase III, right) samples. In addition, the long- and short-dashed lines represent the 90% and 99% confidence intervals, respectively, which are computed based on the standard errors corrected for arbitrary correlation within investors.

In emerging economies, investor-level equity flows show somewhat different responses to the excess return shocks across the three different periods. That is, global equity investors' portfolio rebalancing toward emerging equity markets varies depending upon global liquidity conditions.

Phase I (Pre-GFC): Weak Sensitivity Before (and during) the GFC (Phase I), individual equity flows exhibit positive but weak responses to the dollar denominated stock price growth shocks, reaching at most 0.2% four months after the shock. The positive responses are indicative of return-chasing of global investors in EMEs (Bekaert, Harvey and Lumsdaine, 2002; Bekaert, Harvey and Lundblad, 2007). However, the modest responses suggest that the investors' decisions were constrained by structural and market-specific factors at the time. That is, the weaker positive responsiveness of global investors, compared to the other phases, might be driven by market frictions (e.g., higher transaction costs, currency risk, policy uncertainty) or market conditions during this phase (e.g., heavy reliance on banking flows, lower liquidity, lower market depth), which overshadowed

short-run return gains (Portes and Rey, 2005; Broner et al., 2006).¹⁰

Phase II (Post-GFC): Emerging Responsiveness After the GFC (Phase II), the responses of equity flows become relatively stronger than in the previous phase. Following excess return (price growth) shocks, the equity flows increase by 0.25%, peaking around four months after the shock, before the positive responses slowly dissipate. The results reflect benign market sentiment, presumably driven by the global policy accommodation (e.g., quantitative easing and fiscal stimulus) which suppressed global risk premiums and fueled return-driven investing, commonly referred to as ‘search-for-yield’ (Rajan, 2006; Vissing-Jorgensen and Krishnamurthy, 2011; Choi and Kronlund, 2017). Improved macroeconomic policymaking and strengthened credibility within EMEs might also have played a role, making emerging equity markets more attractive to investors (Fratzscher, 2012).

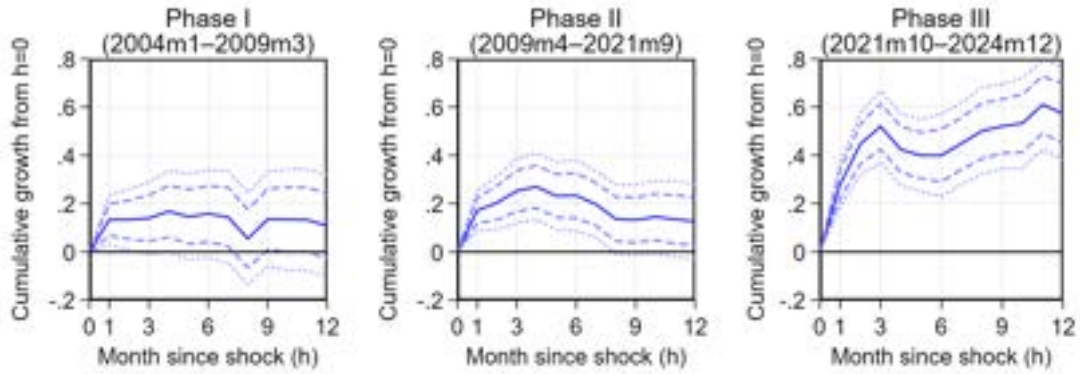
Phase III (Post-COVID): Return Chasing The post-pandemic period (right panel) marks a structural shift. The sensitivity of flows to return shocks nearly doubles compared to Phase II, rising to 0.5% within two months and remaining statistically significant and persistent. This magnitude is economically substantial: it implies that for every 10% outperformance in a local market, investors increase their allocation by 5%—a highly aggressive reallocation compared to historical norms. The peak effects during this period are also statistically different from those in the two preceding periods, as the confidence intervals (indicated by dashed lines) do not overlap. Taken together, the result confirms our central hypothesis: more active, return-chasing portfolio reallocation in the modern regime. Global investors have become highly responsive to local price signals, aggressively rewarding outperforming markets.

4.3 Decomposition: Stock Prices vs. Exchange Rates

To have a better understanding of the distinct patterns in investor-level equity flows, we further examine the impulse responses of individual equity flows to changes in constituent price factors—growth of stock price indices ($SP_{c,t}^{LCY}$, local currency unit) and exchange rates against US dollar ($FX_{c,t}$). The investor’s reactions to these (decomposed) US dollar unit

¹⁰The result also suggests how heightened uncertainty and fear of adverse selection served as a signal for investors to further retreat from equity exposure amid unstable confidence and market conditions (Bikhchandani and Sharma, 2000). Caballero and Krishnamurthy (2008) highlight the crisis-driven outflows and the breakdown of intermediation mechanisms. In addition, Camanho et al. (2022) find that higher FX volatility intensifies portfolio rebalancing, which could suggest that the elevated volatility and fear of floating in EMEs before the GFC induced risk aversion among investors.

(a) Response to Stock Market Index Growth



(b) Response to Exchange Rate Depreciation

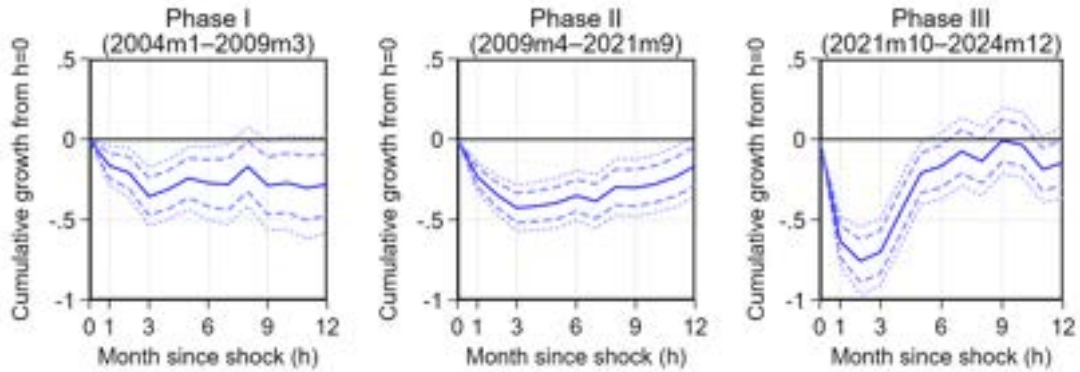


Figure 5: Equity Flow Response to Stock Market Index and Exchange Rate

Notes: The figure plots the predictive content of stock market index (panel a, local currency unit) and exchange rate growths (panel b) for active fund flows of individual investors. The responses are the estimates of α^h in equation (7). The specification controls for investor, country, and time fixed effects, as well as contemporaneous growth of other pull factors, and their two lags. The 90% and 99% confidence intervals (long- and short-dashed lines) are based on standard errors corrected for arbitrary correlation within investors. In each regression, singleton observations are dropped. The x-axis is time in months, and the y-axis is cumulative changes (growth, %).

return/price factors are estimated in a manner akin to the regression equation (7), and reported in panels (a) and (b) of Figure 5, respectively.

Following local currency stock price and exchange rate shocks, global investors exhibit patterns in EMEs that are quite consistent with their responses to changes in stock returns. That is, during the pre-GFC period, equity flows temporarily increased by 0.15% following stock price shocks. The responses became more evident and persistent in the post-GFC samples, rising by 0.25% four months after the shock. The reaction to stock price growth remarkably transitioned in the post-COVID period. Equity flows show strong positive and

persistent responses to the shock, rising by up to around 0.6%.

More interestingly, investor-level equity flows exhibit similarly distinct patterns over time in response to currency depreciation shocks, other things being constant. Currency depreciation brings about a devaluation of equity investments denominated in US dollars. Hence, from the viewpoint of global return-chasing investors, the exchange rate shock must be a negative shock, leading them to reallocate their investment portfolios accordingly (Gourinchas and Rey, 2014; Bénétrix, Lane and Shambaugh, 2015, and many others). In this regard, the exchange rate sensitivity also reflects global investors' perception of currency risks and the underdeveloped currency hedging instruments in these regions.

During the pre-GFC period, when a currency depreciates, equity flows to the emerging equity markets show negative reactions, decreasing by 0.35% three months after the shock. During the post-GFC period, equity flows decrease more strongly and persistently in response to the currency depreciation shock. Equity flows declined by around 0.45% three months after the currency depreciation shock. Furthermore, in the post-COVID period, the negative responses of equity flows to the shocks become even more pronounced, reaching around -0.75%. This heightened sensitivity to FX shocks highlights the "Original Sin Redux" channel (Hofmann et al., 2022): as global investors hold more local-currency EME assets, they become more vigilant about currency risk, actively rebalancing away from depreciating currencies to protect dollar returns.

Together, these results paint a coherent picture: the new phase of EME capital flows is characterized by sophisticated, active investors who aggressively reallocate capital based on both local equity market performance and currency dynamics.

4.4 Robustness

To ensure the validity of our main findings—specifically the structural shift toward stronger return-chasing behavior in the post-COVID period—we conduct a comprehensive set of robustness tests. These checks confirm that our results are not driven by sample selection, specific fund types, crisis outliers, or unobserved heterogeneity. Detailed results and corresponding figures are presented in Appendix B.

Inclusion of Passive Fund Flows Our baseline analysis focuses on active funds to isolate discretionary decision-making. However, given the growing market share of index investing, we re-estimate the model using the full sample of both active and passive funds. While the magnitude of the response is slightly dampened, the qualitative pattern remains robust: the structural shift in sensitivity to local returns is clearly evident in the aggregate

sample, confirming that the post-COVID shift is a market-wide phenomenon.

Extensive Margin (Zero Flows) Equity flows to EMEs often contain zeros when investors are inactive in specific markets. To ensure our results are not mechanically driven by these dormant periods, we re-estimate the model excluding observations where equity holdings remain zero. The results are qualitatively identical to the baseline but quantitatively stronger. When focusing only on active investment periods (the intensive margin), the sensitivity to stock price and exchange rate shocks is significantly larger, suggesting our baseline estimates are conservative.

Alternative Period Definitions (Excluding Crisis Spikes) Macro-financial crises often generate extreme outliers in capital flows (Choe, Kho and Stulz, 1999). To verify that our results are not driven by panic-driven capitulation during the Global Financial Crisis (GFC) or the initial COVID-19 shock, we redefine our phases to exclude these turmoil periods (2008m9–2009m3 and 2020m1–2021m12). The distinct strengthening of return-chasing behavior in Phase III remains robust even when these crisis windows are removed, indicating that the shift reflects a fundamental change in investment strategy rather than a temporary crisis response.

Strict Control for Heterogeneity Finally, we employ more granular fixed effect specifications to control for unobserved heterogeneity. We test two alternative structures: (i) *investor-country* fixed effects ($\delta_{i,c}^h$), which absorb time-invariant bilateral preferences (e.g., a specific fund’s home bias toward a specific EME), and (ii) *investor-time* fixed effects ($\delta_{i,t}^h$), which control for all time-varying investor characteristics (e.g., changing total AUM or global risk aversion). In both specifications, the impulse responses closely mirror the baseline findings. This confirms that the observed shift is driven by sensitivity to local pull factors, not by omitted variable bias related to investor-specific traits or global common shocks.

5 Mechanisms: Investor Evolution and Market Resilience

The previous sections documented a structural shift: the sensitivity of equity flows to local return shocks has strengthened markedly in the post-COVID period. In this section, we investigate the economic mechanisms driving this shift. We posit two reinforcing channels: (i) the evolution of global investors’ strategies toward greater specialization, and (ii) the enhanced macroeconomic resilience of EMEs. Motivated by these potential drivers,

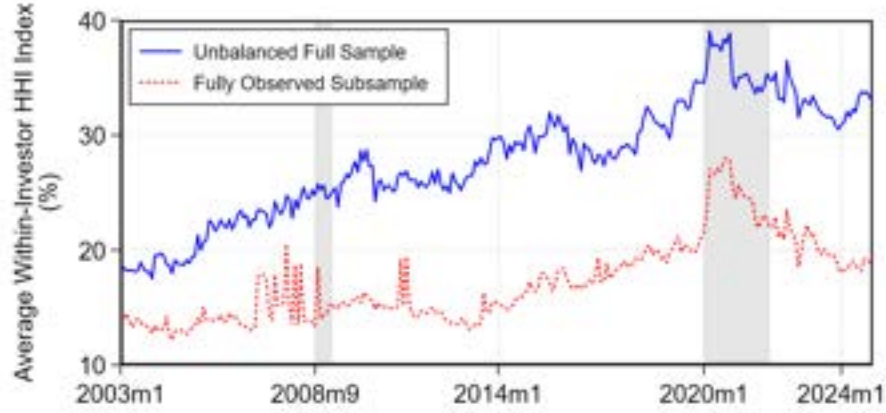


Figure 6: Within-Investor Equity Flow Concentration over Time

Notes: The figure plots the cross-sectional average of investor's HHI index of equity investment across 20 EMEs. The shaded areas indicate the periods of the Global Financial Crisis and the COVID-19 pandemic, respectively.

we further analyze flow responses with a particular focus on investor concentration and heterogeneity across income groups.

5.1 The Evolution of Investor Strategy

First, the results may reflect a rise in the sophistication of investment strategies among global institutional investors. Since the mid-2010s, global investors have increasingly adopted algorithmic and momentum-based trading, allowing them to exploit local return trends more effectively (Brogaard, Hendershott and Riordan, 2014; Boehmer, Fong and Wu, 2021; Converse, Levy-Yeyati and Williams, 2023). This trend is clearly visible in our data. As shown in Figure 1b, the number of destinations receiving positive investment per investor has declined markedly, suggesting global investors have moved away from broad "index-hugging" diversification across all EMEs.

This pattern suggests that investors are concentrating their portfolios in a narrower and more selective group of markets. To explore portfolio concentration explicitly, we introduce the Herfindahl-Hirschman Index (HHI) within investors, $\sum_c (\text{Equity}_{i,c,t} / \sum_c \text{Equity}_{i,c,t})^2$. Figure 6 plots the average concentration measure for the full sample (blue line) exhibits a clear upward trend. Theoretical literature suggests that portfolio concentration is associated with information acquisition (Van Nieuwerburgh and Veldkamp, 2009). As investors focus on fewer markets, they acquire more precise information about local fundamentals, making their capital allocation more responsive to price signals. Thus, the observed recent rising portfolio concentration can result in heightened sensitivity of investors' responsive-

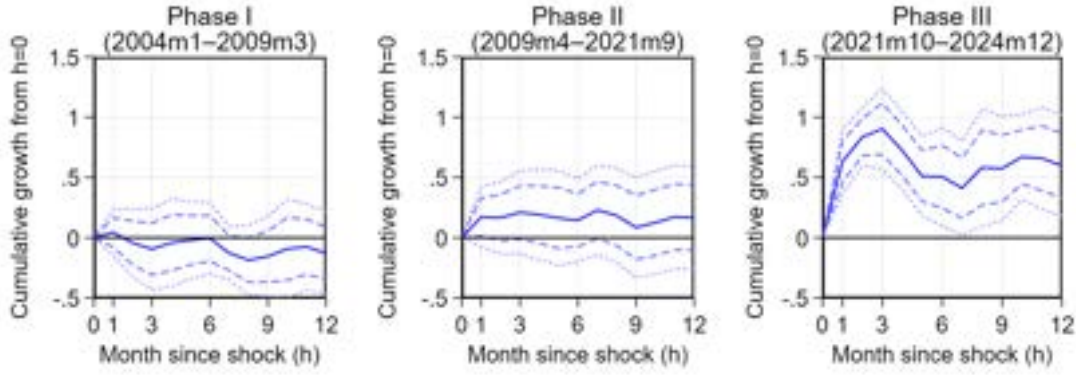


Figure 7: Balanced Sample Response to Dollar-Denominated Stock Price Growth

Notes: The figure plots the predictive content of dollar-denominated stock price growth (stock market index growth minus exchange rate growth) for active fund flows of 15 individual investors which are fully observed in the whole sample periods. The responses are the estimates of α^h in equation (7). The specification controls for investor, country, and time fixed effects, as well as pull factors with their three lags. The 90% and 99% confidence intervals (long- and short-dashed lines) are based on standard errors corrected for arbitrary correlation within investors. In each regression, singleton observations are dropped. The x-axis is time in months, and the y-axis is cumulative changes (growth, %).

ness to local conditions and fundamentals.

Testing the Intensive Margin: Dedicated Investors A potential concern is that our main result—strengthened return-chasing—stems merely from compositional shifts in the investor base (an extensive margin effect) rather than a change in investor behavior. For instance, if "tourist" (may unsuccessful) investors exited EMEs during COVID, leaving behind only sophisticated "dedicated" (may successful) investors who naturally pay closer attention to fundamentals, the aggregate return sensitivity would rise mechanically without any individual investor changing their behavior. It is therefore essential to verify that the structural shift does not simply reflect investor attrition, but instead represents a genuine shift in the investment behavior of global capital allocators.

To rule out this composition effect and isolate the behavioral (intensive-margin) shift, we re-estimate the model using a balanced panel of 15 dedicated investors who remained active in EMEs throughout the entire 2004–2024 period. Figure 7 reports the regression results for this long-horizon investor subsample. These dedicated investors exhibited little to no reaction to return factors during Phases I and II; the estimated responses are statistically indistinguishable from zero at the 10% level. In Phase III (post-COVID), however, their responses become strong, persistent, and statistically significant—with magnitudes nearly twice those obtained from the full-sample estimation in Figure 4. The

balanced-panel evidence therefore indicates that the recent increase in the sensitivity of equity flows to market price factors reflects a genuine shift in investors' emerging-market portfolio strategies (an intensive-margin response), rather than a mechanical change driven by investor entry or exit.

5.2 Macroeconomic Resilience and Policy Credibility

The second channel is the enhanced resilience of EMEs. Structural improvements in EME economic fundamentals appear to have lowered the risk perception of global investors, encouraging equity inflows in response to positive return signals. In the past when fundamentals were fragile, rising asset prices were often viewed as precursors to overheating or sudden stops (Griffin, Nardari and Stulz, 2004; Bekaert et al., 2007). However, many emerging economies have increasingly improved their policy frameworks—such as adopting credible inflation targeting and accumulating substantial foreign reserves—thereby significantly bolstering their resilience (Hardy et al., 2024; IMF, 2025).¹¹ This progress, in turn, attracts global investors as they interpret price appreciation as a valid signal of improved growth prospects rather than transitory fluctuations or bubbles. Such pattern is likely more pronounced in high-income EMEs, which are equipped with deeper financial markets and stronger institutional credibility (Levine and Schmukler, 2006; Fatum and Yamamoto, 2016).

Furthermore, global investors have become more sensitive to exchange rate fluctuations to manage their US dollar-denominated returns. As the issuance of local currency assets has increased, currency risk has shifted from borrowers to investors, compelling unhedged global funds—focused on US dollar-denominated returns—to react more actively to local currency fluctuations (referred to as 'original sin redux'; Hofmann et al., 2022; Bertaut et al., 2025).¹² Thus, the stronger return sensitivity observed in the post-COVID era is also likely driven by these sophisticated players maximizing returns.

Heterogeneity Across Countries To the extent that return-chasing behavior reflects the underlying resilience of EMEs, flow responses would exhibit heterogeneity across countries, mirroring their various degrees of resilience. To investigate this point, we

¹¹A growing body of literature documents that emerging market central banks have pursued more proactive and forceful monetary tightening than their advanced economy counterparts, in response to the post-pandemic inflationary and global financial shocks, largely due to heightened exchange rate pass-through and capital flow risks (Checo, Grigoli and Sandri, 2024; International Monetary Fund, 2023).

¹²Our results could also be related to changes in investors' overall foreign exchange exposure resulting from portfolio composition choices (Maggiori, Neiman and Schreger, 2020) and the role of exchange rate risk in segmenting international asset markets (Camanho et al., 2022).

employ country group-specific local projections to further examine the patterns of the flows in light of their fundamentals. Specifically, the baseline specification of (7) is extended to incorporate heterogeneous sensitivities to excess return shocks based on the destination country's income classification:

$$R_{i,c,t+h} = (\alpha_{\text{BRICS}}^h \mathbb{1}_{c \in \text{BRICS}} + \alpha_{\text{HighInc}}^h \mathbb{1}_{c \in \text{HighInc}} + \alpha_{\text{Others}}^h \mathbb{1}_{c \in \text{Others}}) \times \Delta \ln \text{SP}_{c,t}^{\text{USD}} + \sum_{l=1}^3 [\Gamma_{\text{pull},l}^h \mathbf{Pull}_{c,t-l} + \gamma_l^h \ln \text{Size}_{i,t-l}] + \delta_i^h + \delta_c^h + \delta_t^h + \varepsilon_{i,c,t}^h, \quad (8)$$

where α_{group}^h captures the differential sensitivity of equity flows to the excess stock return shocks for each country group. $\mathbb{1}_c$ denotes the indicator functions for the three destination country groups: BRICS, high-income emerging market economies (HighInc), and the remaining emerging market economies in our sample (Others).¹³ To account for the dynamic evolution of international investor behavior, the above local projections are estimated separately for the three phases as our benchmark.

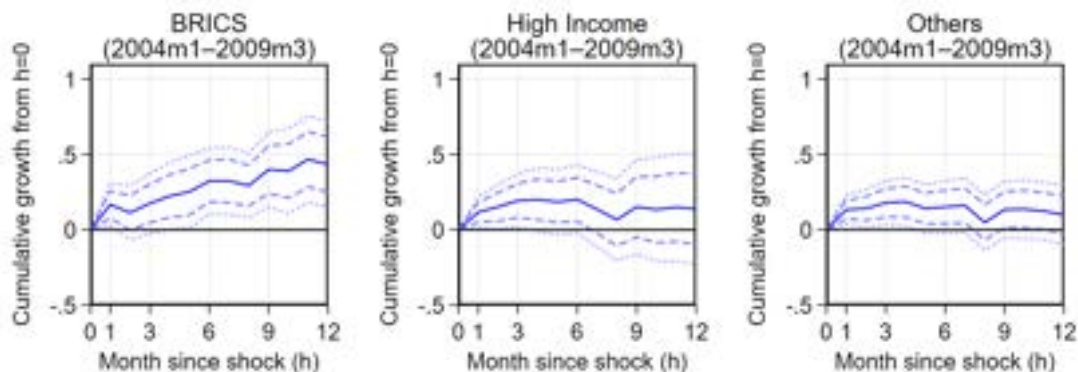
Figure 8 summarizes the impulse responses to the shocks in stock price growth across country groups. Each panel corresponds to a specific period (Phases I–III), while each column represents country group (BRICS, HighInc, and Others). The results reveal significant variation in the patterns of investment behavior depending upon the destination country group.

During the pre-GFC period (Phase I), equity flows across all three country groups display positive but weaker responses to excess stock return shocks. Among them, the positive responses of the equity flows into BRICS were relatively stronger and more persistent, gradually increasing by 0.5% 11 months after the shock. For high-income emerging economies and other EMEs, the positive flows were short-lived, with the responses quickly dissipating six or seven months following the shocks. As discussed in Section 4.2, this weak reaction of global equity flows presumably reflects the market-specific factors, including shallow market depth and the weak confidence of global investors in emerging economies at the time.

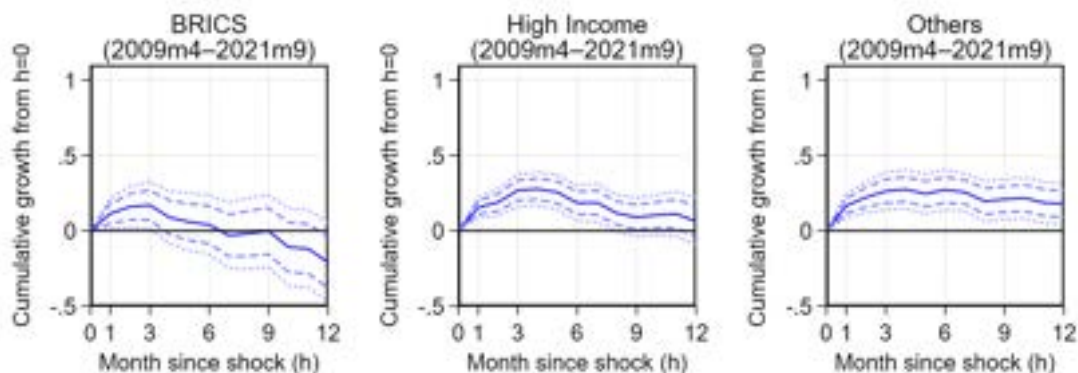
In the post-GFC period (Phase II), the equity flow sensitivities to the stock return shocks broadly were intensified except in BRICS group. In BRICS, the responses of equity flows were more transitory than those in pre-GFC period, with their significance and magnitude declining. High-income emerging markets and the other country group, however, displayed more evident positive reactions than in the pre-GFC phase. This

¹³BRICS: Brazil, China, India, Russia, South Africa. High-income: Israel, South Korea, Taiwan. Others: Chile, Colombia, the Czech Republic, Hungary, Indonesia, Malaysia, Mexico, Peru, the Philippines, Poland, Thailand, Turkey.

(a) Phase I



(b) Phase II



(c) Phase III

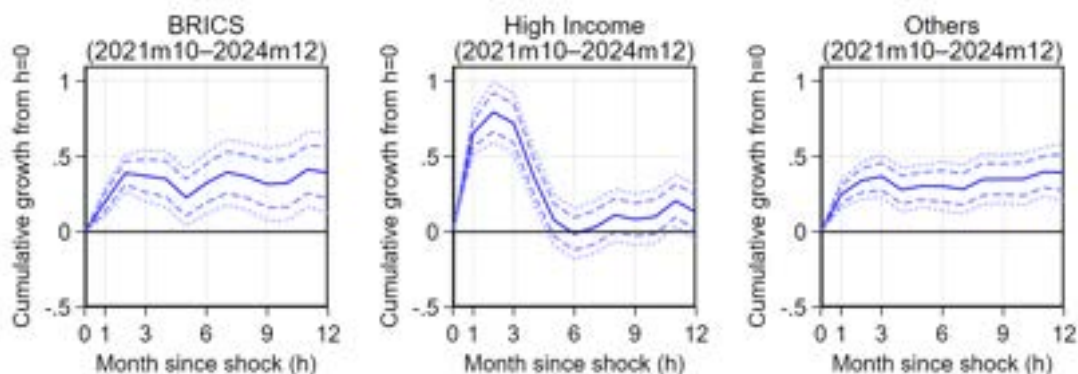


Figure 8: Equity Flow Response to Dollar-Denominated Stock Price Growth by Country Group

Notes: The figure plots the predictive content of dollar-denominated stock price growth (stock market index growth minus exchange rate growth) for active fund flows of individual investors. The responses are the estimates of α^h in equation (8). The specification controls for investor, country, and time fixed effects, as well as contemporaneous growth of other pull factors, and their two lags. The 90% and 99% confidence intervals (long- and short-dashed lines) are based on standard errors corrected for arbitrary correlation within investors. In each regression, singleton observations are dropped. The x-axis is time in months, and the y-axis is cumulative changes (growth, %).

suggests that international equity investor confidence was restored more in these country groups during the period, possibly due to favorable market conditions. These changed patterns are consistent with [Rey \(2015\)](#) and [Kalemli-Özcan \(2019\)](#), who underscore the growing influence of global financial cycles in shaping capital flows.

Finally, in the post-COVID period (Phase III), the heterogeneity became more clearly pronounced across country groups. Among them, high-income emerging economies registered a robust and persistent positive response to stock market price growth shocks, peaking at 0.8% two months after the shocks. The robust reactions for these countries are indicative of relatively stronger institutional frameworks, deeper financial markets, and closer integration with international financial markets, making them more attractive destinations for return-chasing equity flows in the aftermath of COVID-19 crisis. The equity flows into BRICS and other EMEs also exhibit clear positive responses to the shocks, but with weaker return sensitivity. This divergence reflects, at least in part, structural challenges—including uneven recovery from the pandemic crisis, constraints imposed on capital flows, or increased segmentation in the international financial system—that hindered sustained investor optimism.¹⁴

The findings reinforce the view of uneven transmission of financial shocks across income levels ([Lane and Milesi-Ferretti, 2018](#); [Eichengreen, Gupta and Masetti, 2021](#)). That is, the amplification of return-chasing patterns across phases was more pronounced in high-income countries, possibly pointing to differences in the relative attractiveness of equity investment among EMEs. Interestingly, the responses in high-income countries were quite consistent with those in advanced economies (Appendix Figure A.6).¹⁵

This finding also carries important implications for the policy design of capital flow management in EMEs. A one-size-fits-all policy approach would be inadequate; policy-makers across different EME groups may require distinct strategies to manage capital flows and bolster investors' confidence based on their specific conditions ([Basu, Boz, Gopinath, Roch and Unsal, 2025](#)).

¹⁴Geopolitical and policy-driven segmentation could also contribute to the market divergence. For instance, the imposition of financial sanctions on Russia following the Russia–Ukraine war and the strengthened regulations on foreign investment by Chinese authorities appear to have reduced return sensitivity in BRICS.

¹⁵Similar to the responses of equity flows in EMEs, those in AEs show significantly positive responses to the return shocks (Appendix Figure A.6). The 10 advanced economies include Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Spain, Switzerland, and the United Kingdom.

6 Conclusion

This paper documents a structural shift in the determination of global capital flows to EMEs. Using granular fund-level data from 2004 to 2024, we show that the drivers of equity allocations have evolved from a regime dominated by global push factors to one where local pull factors play a decisive role. Our DFM result reveals that while global liquidity conditions historically dictated capital movements, country-specific factors have become the primary source of variance in the post-COVID period. This finding is reinforced by local projection estimates, which demonstrate that the sensitivity of active equity flows to domestic excess returns has strengthened markedly, peaking in the most recent phase. Far from being passive recipients of the global financial cycle, EMEs now face a global investor base that is highly responsive to local price signals.

We trace this structural shift to two reinforcing mechanisms: the maturation of the asset class and the evolution of the investor base. On the demand side, enhanced macroeconomic resilience and credible policy frameworks in EMEs have lowered the risk premium, encouraging investors to interpret price appreciation as a signal of fundamentals rather than a prelude to a crash. On the supply side, we document a shift toward greater portfolio concentration. Global funds have moved away from broad, index-like diversification toward high-conviction strategies. Crucially, our analysis of "dedicated" investors confirms that this is an intensive-margin behavioral shift: sophisticated incumbents are actively chasing returns in resilient markets (like high-income EMEs) while discriminating against others.

This study highlights the importance of domestic factors in emerging markets amid the growing influence of global factors in understanding the decisions made by international equity investors. Hence, our findings provide several important policy implications for EME policymakers. First, even in the presence of strong global financial cycles, sound domestic fundamentals and enhanced resilience (so-called "keeping your house in order") remain paramount in managing the volatility of portfolio flows (Fischer, 1993; Ahmed and Zlate, 2014). Second, the recent shift towards more pronounced return-chasing in the post-COVID era, particularly by large investors, introduces new policy challenges. As the increasing momentum-driven flows may amplify flow volatility and economic fluctuations, policymakers in EMEs require more cautious micro-level monitoring of the equity flows and precautionary FX-related policy measures. To navigate this ever-changing environment, EMEs must be equipped with enhanced and differentiated policy toolkits (e.g., the Integrated Policy Framework as in Basu et al., 2025), thereby harnessing the benefits of portfolio flows while mitigating the associated risks.

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Appendix

A Details of Macroeconomic Data

We incorporate a wide range of *pull* factors to capture the effects of domestic price dynamics and to control for broader country-specific characteristics. For return-related factors, we include both stock prices and nominal exchange rates. Exchange rate data are primarily sourced from Bloomberg, with the exception of Russia, for which data are drawn from Bloomberg through December 2021 and from the IMF beginning January 2022.

The stock market indices employed in the analysis, retrieved from Bloomberg, are as follows:

- Brazil (IBOVESPA), Chile (IPSA), China (Shanghai SE Composite), Colombia (MSCI COLCAP), Czech Republic (PX), Hungary (BUX), India (SENSEX), Indonesia (Jakarta Composite), Israel (TA-35), Korea (KOSPI), Malaysia (FTSE Bursa Malaysia KLCI), Mexico (IPC), Peru (S&P/BVL Peru General), Philippines (PSEi), Poland (WIG), Russia (MOEX Russia), South Africa (FTSE/JSE All Share), Taiwan (TAIEX), Thailand (SET), Turkey (BIST 100)

In addition to asset prices, we incorporate a set of macroeconomic pull factors—including CPI inflation, nominal interest rates, industrial production growth, and changes in foreign reserves—to account for domestic macroeconomic conditions influencing investment decisions. CPI inflation is computed as the year-over-year change in the consumer price index. The primary source is the IMF’s International Financial Statistics (IFS), supplemented by Bloomberg in cases of missing data, as detailed below:

- Brazil (IMF), Chile (IMF until 2023m2; Bloomberg from 2023m3 onward), China (IMF), Colombia (IMF), Czech Republic (IMF), Hungary (IMF), India (IMF), Indonesia (IMF until 2023m12; Bloomberg from 2024m1 onward), Israel (IMF), Korea (IMF), Malaysia (IMF), Mexico (IMF until 2024m7; Bloomberg from 2024m8 onward), Peru (IMF), Philippines (IMF), Poland (IMF), Russia (IMF until 2022m3; Bloomberg from 2022m4 onward), South Africa (IMF), Taiwan (Bloomberg), Thailand (IMF until 2024m9; Bloomberg from 2024m10 onward), Turkey (IMF)

For nominal interest rates, we rely on money market rates, treasury bill yields, or deposit rates depending on country-specific data availability. The sources and selected rate types are as follows:

- Brazil (IMF, Money Market Rate), Chile (IMF, Money Market Rate), China (Central Bank of China, SHIBOR 3M), Colombia (IMF, Money Market Rate), Czech Republic (IMF, Money Market Rate), Hungary (IMF, Treasury Bill Rate), India (Reserve Bank of India, Treasury Bill Yield 3M), Indonesia (IMF, Deposit Rate), Israel (IMF, Treasury Bill Rate), Korea (IMF, Money Market Rate), Malaysia (IMF, Money Market Rate), Mexico (IMF, Money Market Rate), Peru (IMF, Money Market Rate), Philippines (IMF, Money Market Rate), Poland (IMF, Money Market Rate), Russia (IMF, Money Market Rate), South Africa (IMF, Money Market Rate), Taiwan (Central Bank of Taiwan, Interbank Call Loan Rate), Thailand (IMF, Money Market Rate), Turkey (Central Bank of Turkey, Weighted Average Interest Rate for Deposits)

Additionally, we include non-seasonally adjusted industrial production data (measured in U.S. dollars) obtained from the World Bank's Global Economic Monitor (GEM) database. Total foreign reserves (excluding gold, denominated in U.S. dollars) are sourced from the IMF's International Financial Statistics (IFS).

For all continuous variables, monthly growth rates are computed as the first difference of their natural logarithms.

B Robustness Checks

Active and Passive Fund Flows We first re-estimate the baseline model of (7), using a sample that includes both active and passive fund flows. Passive funds, also referred to as passive index or index-style funds, represent the benchmark-driven investments which replicate a stock market index in their portfolio composition. Thus, their performance tends to follow the performance of the market index. In contrast, active funds implement discretionary investment strategies, selecting specific stocks for their own portfolios in an effort to outperform the market average. Given such different investment strategies, active and passive funds can display different dynamics.¹⁶

Figure A.1 presents the regression results using all types of funds as the dependent variables. Panels (a)–(c) summarize the responses of investors to the changes in dollar-denominated stock price ($\Delta SP_{c,t}^{\text{USD}}$), stock market growth (local currency unit, $\Delta SP_{c,t}^{\text{LCY}}$), and exchange rate growth ($\Delta FX_{c,t}$), respectively. The estimation results with the full sample (active funds & passive funds) are broadly consistent with those using the active fund data.

Nonzero Equity Flows As discussed in Section 2, equity flows into individual emerging equity markets are often zero, especially when certain investors choose to allocate to a specific market only during particular periods. To ensure that our results are not driven by such investment patterns, we exclude observations where equity holdings remain zero due to the absence of investment, i.e., $\text{Equity}_{i,c,t+h} = \text{Equity}_{i,c,t} = 0$.

Figure A.2 presents the regression results after excluding these zero-flow observations. The results remain qualitatively consistent with our benchmark findings shown in Figures 4 and 5. Quantitatively, however, the responses are notably stronger. In panels (a) and (b), the positive investor responses to changes in dollar-denominated and local currency unit stock market growth exhibit larger magnitudes compared to the benchmark estimates. Likewise, the negative response of equity flows to exchange rate growth (panel (c)) intensifies and reaches larger absolute values more rapidly than in the benchmark results.

Alternative Phases Following Hardy and von Peter (2023), we subdivide the sample into three distinct macro-financial phases: pre-GFC, post-GFC, and post-COVID. The first phase (Phase I) spans from 2004m1 to 2009m3 and includes the GFC. The second and third phases (Phases II and III), covering 2009m4–2021m9 and 2021m10–2024m12, respectively,

¹⁶While Chari (2023) documents that passive funds are more sensitive to global shocks, Kim et al. (2025) suggest the similar investment patterns among active funds and all funds in response to global giant investors' contrarian flows (country-specific shocks).

overlap with the COVID-19 pandemic. During crisis periods—including the 1997 Asian Financial Crisis, the GFC, and the COVID-19 pandemic—numerous studies (e.g., [Choe et al., 1999](#); [Ferreruela and Mallor, 2021](#); [Kim et al., 2025](#)) have documented that investment patterns often diverge from those observed in more stable times. In light of this, it is important to assess whether our findings—particularly the weak and short-lived influence of price factors in Phases I and II—are driven by the inclusion of these crisis periods.

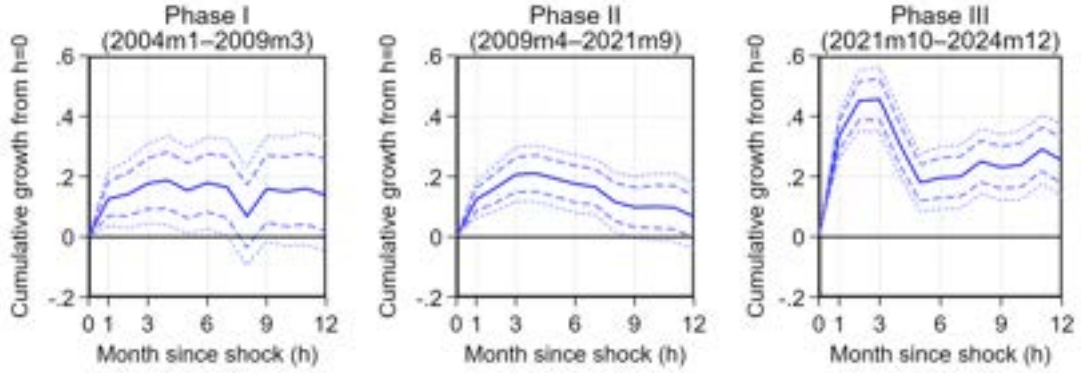
To address this, we exclude the GFC and COVID-19 periods from our sample. Specifically, we redefine Phases I, II, and III as follows: 2004m1–2008m8 for Phase I, 2009m4–2019m12 for Phase II, and 2022m1–2024m12 for Phase III. Figure [A.3](#) presents the estimation results for these three adjusted phases. The results for all Phases I, II, and III are, by and large, consistent with our benchmark estimates shown in Figures [4](#) and [5](#).

Alternative Fixed Effects Additionally, we test the robustness of our results to alternative fixed effects. In equation (7), fixed effects control for unobservable time-invariant investor characteristics separately from country-specific characteristics. However, there can be potential concerns regarding the influence of fixed effects choices on the estimated responses. We consider two alternative sets of fixed effects: (i) investor-country and time fixed effects ($\delta_{i,c}^h$ and δ_t^h), and (ii) investor-time and country fixed effects ($\delta_{i,t}^h$ and δ_c^h).

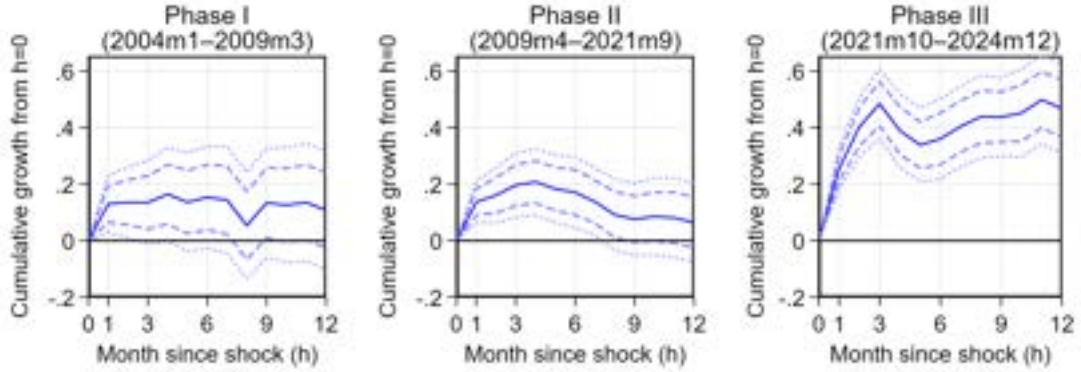
The first alternative—investor-country and time fixed effects—employs a more granular specification than our benchmark. Figure [A.4](#) presents the results using the alternative fixed effects. The impulse responses remain qualitatively and quantitatively similar to our baseline results. Hence, the results imply that controlling for potentially unique relationships between specific investors and countries does not alter the main findings associated with the distinct patterns of investor-level response to the excess return shocks across the three phases.

The second alternative set of fixed effects—investor-time and country fixed effects—is considered to control for investors’ time-varying heterogeneity more explicitly. Although our investor or investor-country fixed effects control for all time-invariant characteristics of investors, it is possible that unobserved time-varying investor characteristics, which act as an important determinant for investment flows, are not fully captured. This is particularly relevant as the benchmark specification controls only for their investment size in 20 emerging markets due to limited information provided in EPFR data. Figure [A.5](#) shows the results using investor-time fixed effects. Again, the estimated impulse responses for the three phases closely mirror the baseline findings, further corroborating the robustness of our main results.

(a) Response to Dollar-Denominated Stock Price Growth



(b) Response to Stock Market Index Growth



(c) Response to Exchange Rate Depreciation

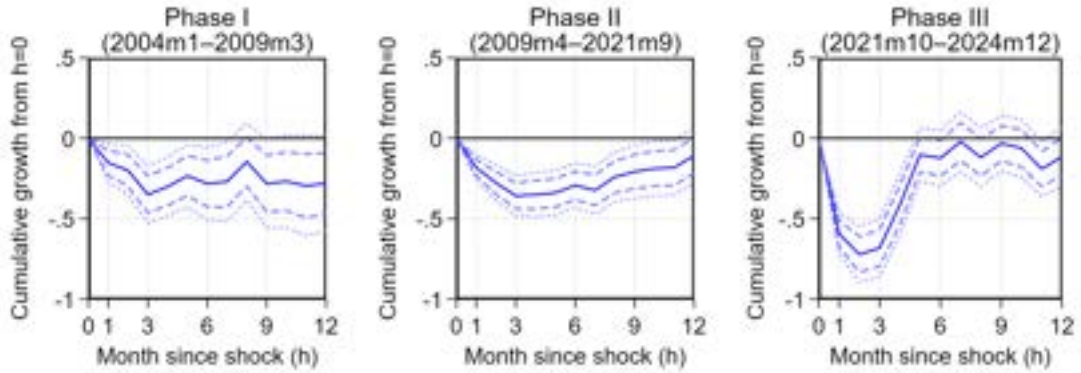
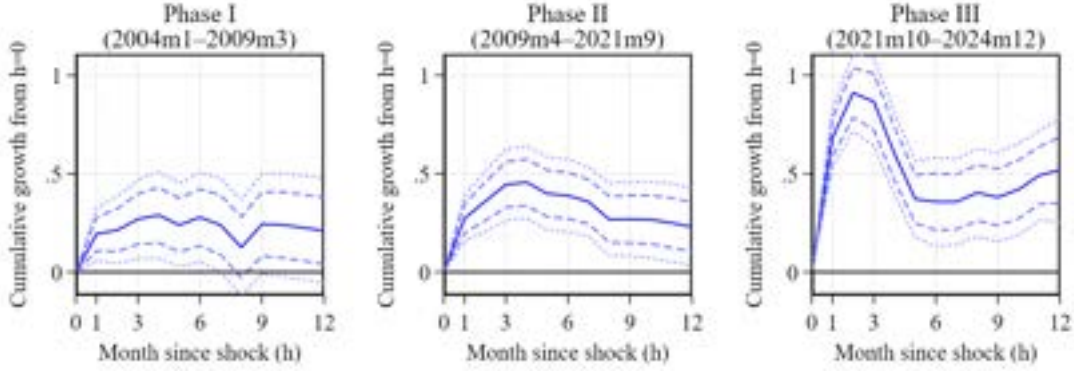


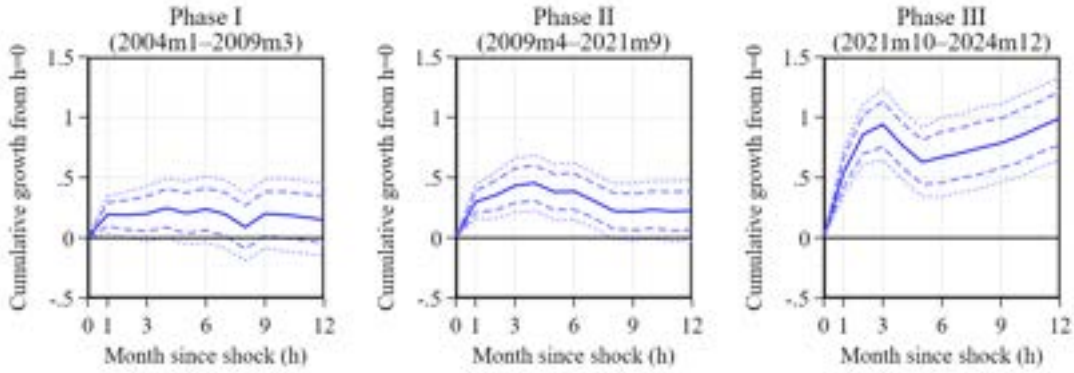
Figure A.1: Active and Passive Funds Flow Response

Notes: The figure plots the predictive content of dollar-denominated stock price growth (stock market index growth minus exchange rate growth), stock market index growth and exchange rate growth (against the US dollar) for all fund flows of individual investors. The responses are the estimates of α^h in equation (7). The specification controls for investor, country, and time fixed effects, as well as contemporaneous growth of other pull factors, and their two lags. The 90% and 99% confidence intervals (long- and short-dashed lines) are based on standard errors corrected for arbitrary correlation within investors. In each regression, singleton observations are dropped. The x-axis is time in months, and the y-axis is cumulative changes (growth, %).

(a) Response to Dollar-Denominated Stock Price Growth



(b) Response to Stock Market Index Growth



(c) Response to Exchange Rate Depreciation

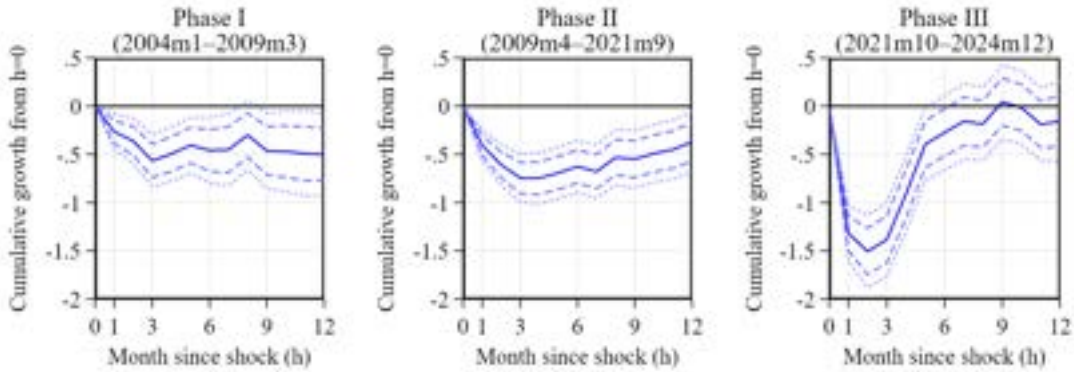
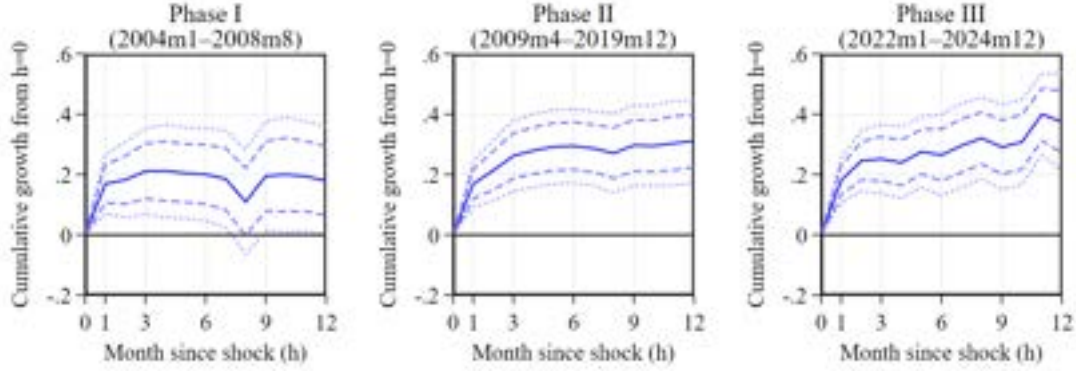


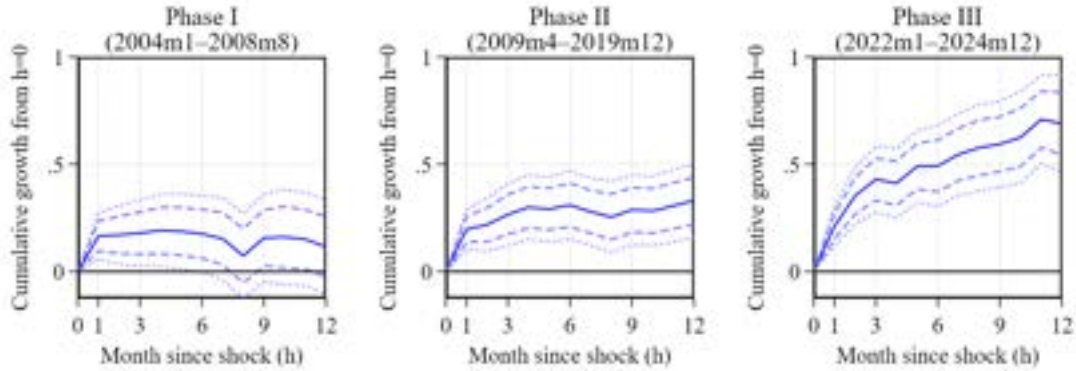
Figure A.2: Nonzero Flow Response

Notes: The figure plots the predictive content of dollar-denominated stock price growth (stock market index growth minus exchange rate growth), stock market index growth and exchange rate growth (against the US dollar) for active fund flows of individual investors excluding zero investment at t and $t + h$. The responses are the estimates of α^h in equation (7). The specification controls for investor, country, and time fixed effects, as well as contemporaneous growth of other pull factors, and their two lags. The 90% and 99% confidence intervals (long- and short-dashed lines) are based on standard errors corrected for arbitrary correlation within investors. In each regression, singleton observations are dropped. The x-axis is time in months, and the y-axis is cumulative changes (growth, %).

(a) Response to Dollar-Denominated Stock Price Growth



(b) Response to Stock Market Index Growth



(c) Response to Exchange Rate Depreciation

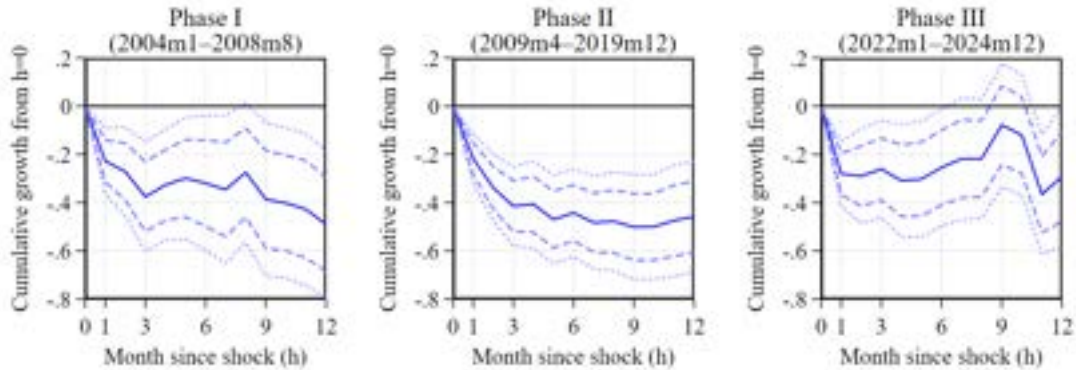
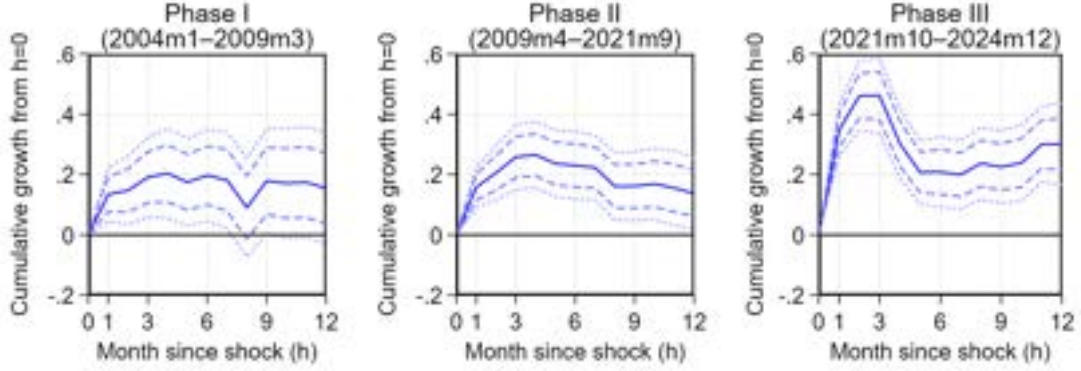


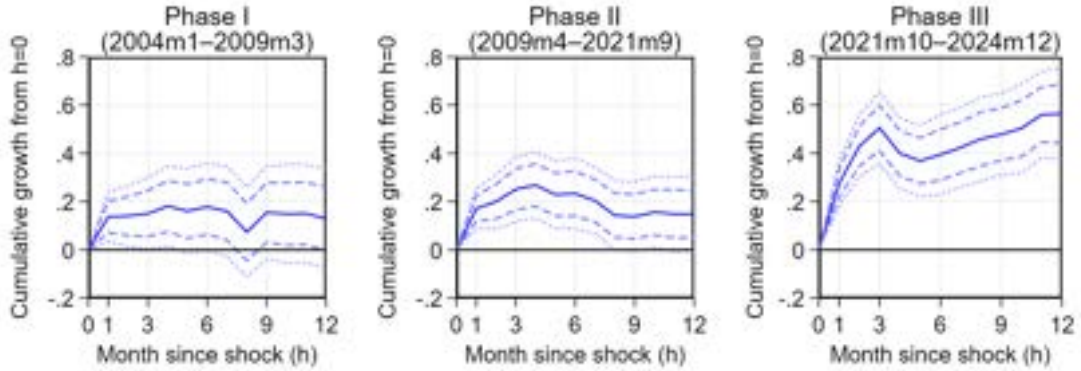
Figure A.3: Response with Alternative Phases

Notes: The figure plots the predictive content of dollar-denominated stock price growth (stock market index growth minus exchange rate growth), stock market index growth and exchange rate growth (against the US dollar) for active fund flows of individual investors with alternative definitions for the phases (excluding the global financial crisis and the COVID-19 pandemic era). The responses are the estimates of α^h in equation (7). The specification controls for investor, country, and time fixed effects, as well as contemporaneous growth of other pull factors, and their two lags. The 90% and 99% confidence intervals (long- and short-dashed lines) are based on standard errors corrected for arbitrary correlation within investors. In each regression, singleton observations are dropped. The x-axis is time in months, and the y-axis is cumulative changes (growth, %).

(a) Response to Dollar-Denominated Stock Price Growth



(b) Response to Stock Market Index Growth



(c) Response to Exchange Rate Depreciation

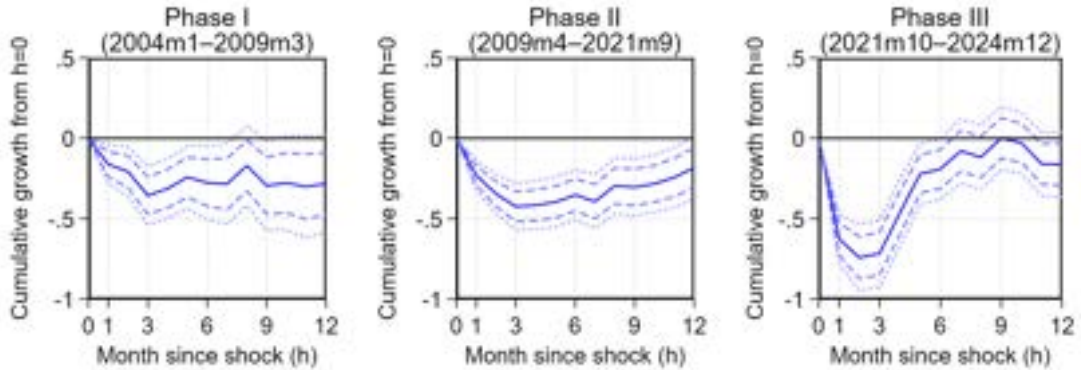
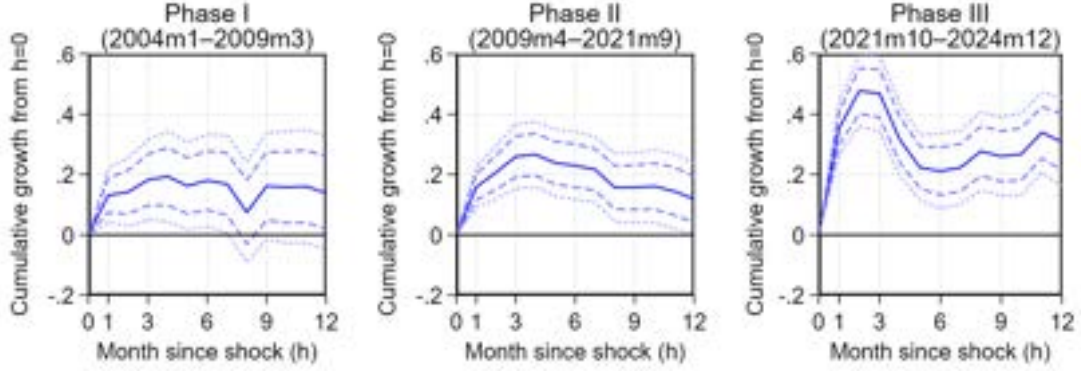


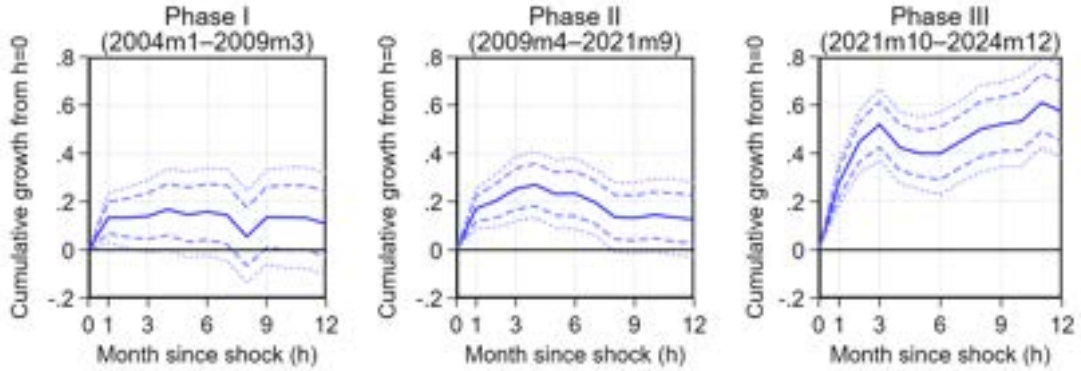
Figure A.4: Response with Investor-Country Fixed effects

Notes: The figure plots the predictive content of dollar-denominated stock price growth (stock market index growth minus exchange rate depreciation), stock market index growth, and exchange rate movements (against the U.S. dollar) for active fund flows of individual investors. The responses are the estimates of α^h in equation (7) with modified fixed effects. The specification controls for investor-country and time fixed effects, as well as pull factors with their three lags. The 90% and 99% confidence intervals (long- and short-dashed lines) are based on standard errors corrected for arbitrary correlation within investors. In each regression, singleton observations are dropped. The x-axis is time in months, and the y-axis is cumulative changes (growth, %).

(a) Response to Dollar-Denominated Stock Price Growth



(b) Response to Stock Market Index Growth



(c) Response to Exchange Rate Depreciation

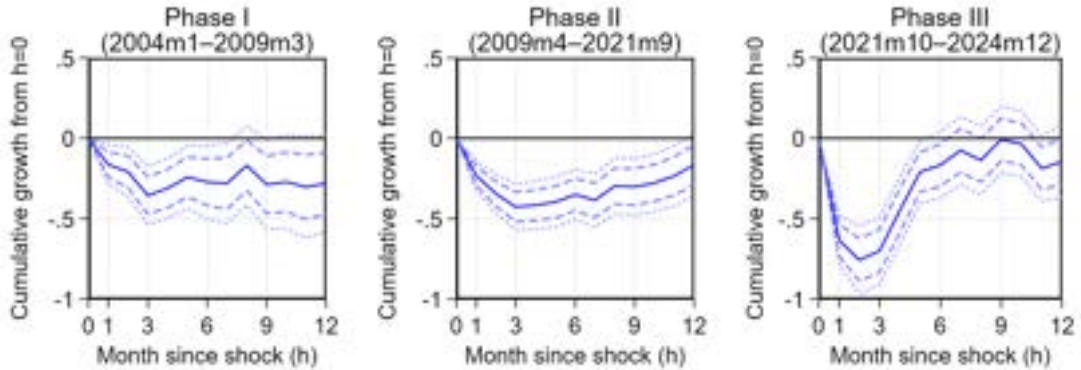


Figure A.5: Response with Investor-Time Fixed effects

Notes: The figure plots the predictive content of dollar-denominated stock price growth (stock market index growth minus exchange rate depreciation), stock market index growth, and exchange rate movements (against the U.S. dollar) for active fund flows of individual investors. The responses are the estimates of α^h in equation (7) with modified fixed effects. The specification controls for country and investor-time fixed effects, as well as pull factors with their three lags. The 90% and 99% confidence intervals (long- and short-dashed lines) are based on standard errors corrected for arbitrary correlation within investors. In each regression, singleton observations are dropped. The x-axis is time in months, and the y-axis is cumulative changes (growth, %).

C Additional Figures and Tables

Table A.1: Variance Contribution of Global and Country Factors

Sample period Factor	2004m1–2024m12		2004m1–2009m3		2009m4–2021m9		2021m10–2024m12	
	Global	Country	Global	Country	Global	Country	Global	Country
All countries	0.07	0.08	0.12	0.10	0.08	0.09	0.13	0.16
BRA	0.17	0.11	0.22	0.09	0.18	0.16	0.16	0.21
CHL	0.05	0.05	0.60	0.06	0.04	0.04	0.13	0.14
CHN	0.06	0.24	0.12	0.24	0.08	0.21	0.03	0.53
CZE	0.03	0.03	0.10	0.07	0.05	0.01	0.02	0.07
HUN	0.04	0.04	0.11	0.10	0.05	0.05	0.05	0.09
IDN	0.05	0.06	0.10	0.05	0.06	0.06	0.10	0.11
IND	0.08	0.07	0.09	0.09	0.10	0.07	0.21	0.07
ISR	0.02	0.01	0.02	0.02	0.01	0.06	0.15	0.12
KOR	0.11	0.09	0.18	0.14	0.09	0.09	0.26	0.18
MEX	0.08	0.04	0.11	0.10	0.10	0.08	0.18	0.07
MYS	0.02	0.01	0.04	0.07	0.02	0.01	0.04	0.10
PER	0.04	0.04	0.05	0.03	0.07	0.04	0.14	0.03
PHL	0.02	0.03	0.01	0.05	0.04	0.03	0.08	0.11
POL	0.10	0.04	0.20	0.06	0.09	0.04	0.12	0.02
RUS	0.09	0.06	0.12	0.16	0.10	0.07	0.06	0.14
THA	0.04	0.04	0.06	0.02	0.05	0.06	0.07	0.02
TUR	0.05	0.11	0.14	0.15	0.06	0.13	0.05	0.05
TWN	0.07	0.10	0.10	0.11	0.07	0.09	0.19	0.29
ZAF	0.09	0.04	0.14	0.05	0.08	0.06	0.12	0.09

Notes: This table summarizes the variance contributions of global and country-specific factors, which are estimated based on 2-factor dynamic factor model of 295 firm-level investment.

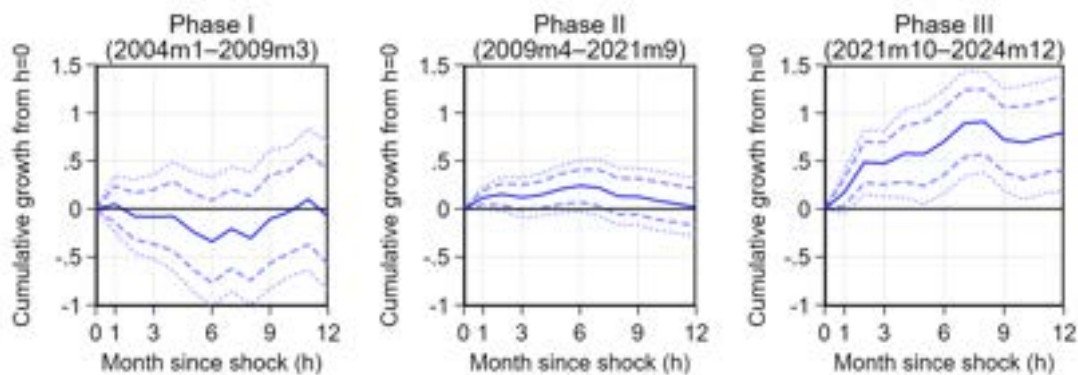


Figure A.6: Advanced Economies: Response to Dollar-Denominated Stock Price Growth

Notes: The figure plots the predictive content of dollar-denominated stock price growth (stock market index growth minus exchange rate growth) for individual investors. The responses are the estimates of α^h in equation (7). The specification controls for investor, country, and time fixed effects, as well as pull factors with their three lags. The 90% and 99% confidence intervals (long- and short-dashed lines) are based on standard errors corrected for arbitrary correlation within investors. In each regression, singleton observations are dropped. The x-axis is time in months, and the y-axis is cumulative changes (growth, %). The 10 advanced economies include Australia, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Switzerland, and United Kingdom.

Assessing the benefits of international portfolio diversification: the case of EMEs in the era of geo-economic fragmentation

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Abstract

This study assesses the benefits of international portfolio diversification for emerging market economies (EMEs) amid rising risks of geo-economic fragmentation. Analysing the risk-adjusted returns as measured by an annualized Sharpe ratio of optimised international stock market portfolios for 20 EMEs from 2014 to 2024, we find that unrestricted investments from EMEs to global equity markets enhance the average risk-adjusted returns by 0.31 compared to a domestic portfolio average of 0.13. This result underscores the importance of opening access to foreign investments for EME investors to maximise diversification benefits. However, we find that rising geo-economic fragmentation could reduce such gains. Restrictions on investments in countries with the largest geopolitical distances from the sampled EMEs, as indicated by low bilateral correlations in UN General Assembly voting outcomes, could reduce the gains by 70%, reducing the Sharpe ratio improvement to 0.09. This reflects a reduced ability to mitigate their exposure to domestic institutional risks, such as those associated with domestic political risks and business environments. Nevertheless, we find that even under such constraints, EME investors could still achieve some diversification benefits by investing in peers with smaller geopolitical distance, particularly those that have more developed financial markets and fewer similarities in terms of their risk profile.

¹ The authors thank Eric Wong and an anonymous reviewer for comments. This paper represents the views of the authors, which are not necessarily the views of the Hong Kong Monetary Authority, Hong Kong Academy of Finance Limited, or Hong Kong Institute for Monetary and Financial Research. The above-mentioned entities except the authors take no responsibility for any inaccuracies or omission contained in the paper.

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1. Introduction

Understanding the benefits of international portfolio diversification (referred to as “international diversification” thereafter) is essential for both investors and policymakers. For investors, it provides a strategic way to reduce risks from domestic market fluctuations and improve potential returns by investing in foreign markets. For policymakers, recognizing these benefits can help develop strategies that encourage domestic investors to explore international opportunities, thereby diversifying their risk exposure.

Building on Markowitz (1952)’s modern portfolio theory, the literature has long acknowledged the benefits of international portfolio diversification, beginning with the early works by Grubel (1968), Levy and Sarnat (1970) and Lessard (1973). However, most previous studies have primarily examined this issue from the perspective of advanced economies (AEs), with relatively less focus on emerging market economies (EMEs). As demonstrated by Driessen and Laeven (2007) in a cross-country analysis, the benefits of investing abroad could be greater for investors in EMEs, especially for those facing high country risk. In addition to greater risk exposure, equity markets in EMEs are generally smaller and less diversified than those in AEs, further necessitating risk diversification through international investments. Moreover, EMEs often face capital restrictions that limit their potential gains from international diversification. Together, these factors warrant a deeper understanding of the benefits of international diversification for EMEs.

Assessing the benefits of international diversification is particularly relevant in the current environment amid rising risks of geo-economic fragmentation. Geo-economic fragmentation may limit opportunities for international risk diversification. For EMEs, these restrictions can be especially detrimental as they constrain the potential gains from international diversification. This could exacerbate macro-financial volatility over the long term and increase countries’ vulnerability to adverse shocks (International Monetary Fund, 2023). Therefore, from the perspective of financial stability, it is essential to gain a better understanding of the effects of geo-economic fragmentation on the benefits of international diversification for EMEs.

In this context, this study offers a fresh assessment of the international portfolio diversification benefits for EMEs, with a specific focus on the potential impacts of geo-economic fragmentation. To address these critical issues, this study poses four key questions that guide our analysis:

1. What are the benefits of international portfolio diversification for EMEs?
2. How does geo-economic fragmentation affect these benefits?
3. What drives the impact of geo-economic fragmentation?
4. How can EMEs enhance diversification benefits in the light of geo-economic fragmentation?

The first question aims to provide evidence on how EMEs can potentially benefit from international diversification. The second and third questions seek to assess the impact of geo-economic fragmentation and identify the underlying causes of these impacts. Finally, having identified the negative consequences posed by geo-economic fragmentation, the last question outlines a strategy that EMEs can employ to maximize their diversification benefits in this challenging environment.

By analyzing the risk-adjusted returns (annualized Sharpe ratio) of ex-ante optimized international stock market portfolios using Markowitz’s (1952) mean-variance optimization framework for 20 EMEs from 2014 to 2024, we find that unrestricted investments from EMEs to global equity markets would enhance average risk-adjusted returns by 0.31 compared to a

domestic portfolio average of 0.13, underscoring the importance of open access to foreign investments for EME investors in maximizing diversification benefits.

However, we find that rising geo-economic fragmentation could reduce such gains. Restrictions on investments in countries with the largest geopolitical distances from the sampled EMEs, as indicated by low bilateral correlations in UN General Assembly voting outcomes, a measure widely used by major international organisations such as the International Monetary Fund, the Bank for International Settlements and the European Central Bank,³ could reduce the gains by 70%, dropping the Sharpe ratio improvement to 0.09. A comparison of the country risk profile of the sampled EMEs with their foreign peers indicates that excluding country peers with the largest geopolitical distances from the international equity portfolio primarily reduces the ability of sampled EMEs to mitigate their exposure to domestic institutional risk, such as those associated with domestic political and business environments. Nevertheless, we find that even under such constraints, EME investors could achieve diversification benefits by investing in peers with smaller geopolitical distance, particularly those with more developed financial markets and lower risk profile similarity.

This study contributes to the literature in two ways. First, it adds to the discussion on the negative impacts of geo-economic fragmentation on international diversification benefits. Previous research, such as that by Okuda and Tsuruga (2024), has shown significant losses for G7 countries when restricted to trading only with geopolitical allies. This study examines the issue from an EMEs perspective, demonstrating that these economies could also incur considerable losses in their ability to achieve international portfolio diversification if faced with overseas investment restrictions stemming from geopolitical conflicts.

Secondly, by comparing the country risk profile of the sampled EMEs with those of their foreign counterparts, we identify the factors contributing to the estimated reduction in diversification benefits when peers with largest geopolitical distance are excluded from foreign investment options. Previous studies, such as those by Cosset and Suret (1995), De Santis et al. (1999), and Attig et al. (2023), provide evidence of various country-specific risks that can explain the benefits of international portfolio diversification. Building on their findings, this study identifies a channel through which geo-economic fragmentation may restrict EMEs' ability to diversify portfolio risks through international investments.

This paper is structured as follows: The next section reviews the literature. Section 3 discusses the methodology and data. Section 4 presents the results, while Section 5 reports the results of robustness tests. The final section concludes.

2. Literature review

This study relates to two strands of literature. First, it links to the vast literature on the benefits of international diversification. Since the introduction of modern portfolio theory by Markowitz (1952), which suggests that portfolio risk can be reduced by diversifying into assets whose returns are not perfectly correlated, early studies such as Grubel (1968), Levy and Sarnat (1970), and Lessard (1973) have demonstrated the benefits of diversifying into foreign equity markets that have a low correlation with the domestic market. Subsequent studies shed further light on the choices of cross-country diversification, focusing mainly on the benefits of investing in EMEs as a way to reduce portfolio risk (e.g. Errunza and Padmanabhan (1988); Bailey and Stulz (1990); Harvey (1995); Bekaert and Urias (1996); DeFusco et al. (1996); Kohlers et al. (1998); Li et al. (2003); Berger et al. (2011); Switzer and Tahaoglu (2015)), though there are also studies that caution against the benefits of doing so in view of rising inter-market

³ See examples such as International Monetary Fund (2023), the Bank for International Settlements (2024) and the European Central Bank (2024).

correlation.⁴ Meanwhile, several studies attempt to emphasise the contribution of cross-country diversification by comparing the contribution from industrial diversification (e.g., Meric and Meric (1989); Heston and Rouwenhorst (1994); Griffin and Karolyi (1998)). However, as acknowledged by Driessen and Laeven (2007), most studies examine the issue from the perspective of U.S. investors or those from the advanced economies, rather than from EMEs. To contribute on this aspect, Driessen and Laeven (2007) investigate how the benefits of international portfolio diversification differ across countries, and find that the benefits of investing abroad are largest for investors in developing countries, in particular those facing higher country risk. Using a dynamic copula approach, Christoffersen et al. (2012) show that although diversification benefits have lessened in the case of developed markets, the case for emerging markets remains strong.

Several studies have sought to explain the sources of international diversification benefits. Discussion is based around the idea that some risks are country-specific and unsystematic, and thus diversifiable. By including foreign countries with a different risk profile than domestic markets, international investors can reduce their overall risk exposure while enhancing potential returns in their investment portfolios. Errusza and Losq (1987) discuss four categories of country-specific risk that can be diversified through international investments: currency risk (including exchange rate volatility and purchasing power risk), political risk (such as explicit barriers to capital flows, taxes, expropriation, and exchange controls, referred to as “institutional risk” in this paper⁵), investment risk, and the risks associated with a country's stage of development (including size, liquidity, and regulation). In line with this, Cosset and Suret (1995) find significant diversification gains from including politically risky countries in an international portfolio, which they show to reduce overall portfolio risk. Meanwhile, De Santis et al. (1999) demonstrate that neglecting differences in currency risk can prevent international investors from fully realizing the benefits of risk reduction and return enhancement in optimized portfolio strategies. In contrast to the above studies that focus on individual risk factors, Attig et al. (2023) examine the issue by considering the relationship between seven country risk factors (political, market, economic, financial, inflation, legal, and credit risk) and the country risk component of firms’ stock returns. They show that the benefits of international diversification primarily arise from the mitigation of local market, political, and inflation risks.

This study relates to the ongoing debate regarding the financial stability impact of geo-economic fragmentation. Rising geopolitical tensions in recent years have heightened concerns about global economic and financial fragmentation (International Monetary Fund, 2023), which could lead to reduced cross-border capital flows or abrupt reallocations of capital.⁶ This limits the opportunities for international diversification and makes countries more vulnerable to adverse shocks, particularly for economies with less developed financial systems or inadequate external buffers to absorb negative consequences. In this context, Catalan and Tsuruga (2023) utilize a gravity model to demonstrate that an increase in geopolitical distance between a source and a recipient country is associated with a reduction in both bilateral cross-border portfolio investment and bank claims. Similarly, Okuda and Tsuruga (2024) apply a two-country open-

⁴ Studies such as Lin et al. (1994), Longin and Solnik (1995), Freimann (1998), Goetzmann et al. (2005), Hong et al. (2007), Carrieri et al. (2007), Pukthuanthong and Roll (2009) and Han et al., (2017) have documented an increase in cross-country correlations amid increasing integration of international markets, implying a potential reduction of international diversification benefits over time.

⁵ The alternative term is used to avoid confusion with geo-economic fragmentation that is examined in the paper, which considers the broader international context and interactions between countries that can lead to instability or conflict. In contrast, the institutional risk referred to in this study focuses on the internal political or business environment of a specific country.

⁶ An increase in geopolitical tensions could also affect financial instability indirectly through a real channel triggered by restrictions on international trade and technology transfer and by disruptions to supply chains and commodity markets. This outcome could adversely affect international trade and economic growth and generate inflationary pressures. These factors could, in turn, adversely affect the liquidity and profitability of nonfinancial corporations, generating credit risks for banks and undermining macro-financial stability (International Monetary Fund, 2023).

economy model to G7 countries and find that restricting trade to geopolitical allies increases the volatility of asset prices, resulting in a loss of diversification benefits. While Okuda and Tsuruga (2024) have quantified the potential losses for AEs, to the best of our knowledge, there has yet to be a study assessing the potential losses for EMEs.

Overall, while the literature provides substantial evidence on the benefits and sources of international diversification, there is less evidence supporting its relevance to EMEs, which potentially have a lot to gain from such diversification. Moreover, the extent to which, and how, geo-economic fragmentation diminishes these benefits for EMEs remains unexplored. Using stock market returns from 2014 to 2024, this study finds that there are substantial benefits to international portfolio diversification for EMEs. We show how these benefits are reduced when investments options are restricted, which is relevant in the current context of ongoing threats of geo-economic fragmentation.

3. Methodology and Data

Methodology

Assessing the benefits of international diversification – a portfolio optimisation approach

To assess the benefits of international diversification, we employ the classical mean-variance portfolio optimization framework developed by Markowitz (1952). This framework aims to identify the optimal portfolio allocation by maximizing expected returns while minimizing return variance. In our analysis, we apply this framework to determine the optimal country weighting that maximizes the Sharpe ratio of an international stock market portfolio, represented by the following objective function:

$$\text{Maximize: } \textit{Sharpe Ratio} = \frac{E(R_p) - R_f}{\sigma_p}$$

$$\text{Subject to: } w_d \geq q \text{ and } \sum_{i=1}^n w_i = 100\% - q$$

In our objective function above, $E(R_p)$ represents the expected return of the optimized portfolio, calculated as a weighted sum of expected returns from an “investable universe” that consists of n foreign countries and the domestic market. The weights allocated to each market are denoted by w_i for the foreign countries and w_d for the domestic country. σ_p and R_f represent the standard deviation of the portfolio return and the risk-free rate, respectively. The Sharpe ratio is calculated as the portfolio return (above the risk-free rate) divided by its standard deviation.

The constraint statement suggests that investors can freely allocate their portfolio weights among any foreign country in the investable universe and the domestic market, subject to a minimum allocation of $q\%$ in the domestic market. This constraint reflects a realistic scenario where investors may have a home bias (Lewis (1999); Gorman and Jorgensen (2002); Chan et al. (2005); Smimou (2014)) or are subject to regulatory requirements. In our baseline analysis, we set q at 25%. In the robustness section, we demonstrate that our results are consistent with a more restrictive or relaxed assumption.

Using this optimization framework, we identify the optimal international stock market portfolio allocation for each sample country and compute the corresponding portfolio Sharpe ratio. To lower the risk of overestimating diversification benefits, we implement an ex-ante analysis

(Cosset and Suret, 1995) using a dynamic adjustment strategy similar to Goyal and Welch (2003). The strategy involves using rolling windows of “in-sample” historical stock market returns to determine ex-ante portfolio weighting for subsequent “out-of-sample” window.⁷ Finally, we calculate the difference between the Sharpe ratio of the ex-ante optimized portfolio and that of the domestic market index, with a positive difference indicating a net benefit to international diversification.

In contrast to Cosset and Suret (1995), who divide the full sample window into two for their ex-ante analysis, the rolling window approach enables us to generate a time series of ex-ante optimized portfolio Sharpe ratios over an extended time frame. Adjusting portfolio composition over time also mimics a more realistic portfolio allocation process where investors consider changes in market conditions and dynamically adjust their portfolios. After testing various combinations, we set the length of the in-sample and out-of-sample period in our baseline analysis at seven and two years, respectively.⁸

Assessing the impacts of geo-economic fragmentation – an exclusion approach

As discussed in the introduction, one channel through which geo-economic fragmentation can reduce the benefits of international diversification is by limiting foreign investment options available to investors, thereby restricting the return-risk trade-off. To explore this channel, we re-run the portfolio optimization while restricting the countries in the investable universe. We base the exclusions on countries' bilateral geopolitical distances. Among the possible information available to quantify geopolitical relations between countries⁹, the United Nations General Assembly voting data is the most common information used for bilateral geopolitical relations research. Specifically, this study uses ideal point distance proposed by Bailey et al. (2017), which has been widely used by major international organisations such as the International Monetary Fund, the Bank for International Settlements, and the European Central Bank. The measure, available over time and for any country pair, captures the yearly average agreement between countries' foreign policies based on their voting behaviour in the United Nations General Assembly.¹⁰ Smaller values for the ideal point distance indicate a closer geopolitical alignment. By comparing the optimised portfolio Sharpe ratio from the “restricted” investable universe (referred to as “restricted” scenarios) with that from the “full” universe (referred to as “no restriction” scenario), we can assess the impact of geo-economic fragmentation on international diversification benefits.

⁷ For simplicity, our calculation assumes that the portfolio is reconstructed at the beginning of each new rolling window based on the ex-ante determined optimised weights, without re-adjustment afterwards to stick with the optimised weightings during the rest of the window. Under this assumption, transaction costs would only be incurred at the first month of each rolling window. As a result, their impact on the estimated portfolio returns are likely minimal and, therefore, not incorporated in our baseline estimates. Nevertheless, we have considered an additional case in which a 1% transaction cost is imposed in the calculation of optimised portfolio returns, and the differences with our baseline estimates are minimal as expected. The results are not reported for brevity.

⁸ With our data sample starting from 2007, historical return from 2007 to 2013 is used to calculate the optimised weight for calculating the portfolio performance for 2014 to 2015, historical return from 2009 to 2015 to determine the portfolio weights for 2016 to 2017, and so forth. As a result, a time series of optimised Sharpe ratio from 2014 to June 2024 is derived for our assessment. The results are robust to slight alterations to the lengths of both windows.

⁹ Other proxies of geopolitical alignment that are being considered in literature include the ATOP dataset by Leeds et al. (2002), which covers 789 military agreements from 1815 to 2018 and the Global Treaty Database by Broner et al. (2025), which covers approximately 78,000 bilateral and multilateral treaties between 1800 to 2020.

¹⁰ Based on the observed UN votes, Bailey et al. (2017) adopt an ordered logit model to estimate a time varying measure of each country's foreign political preferences or “ideal points”. They show that these ideal points estimate better separate signal from noise in identifying foreign policy shifts, have greater face validity, allow for better intertemporal comparisons, are less sensitive to shifts in the UN' agenda, and are strongly correlated with measures of liberalism. The (symmetric) distance between two countries in each year is then computed as the absolute value of the difference between the respective foreign political preferences.

Chart 1 presents the analytical framework. First, for each EME under examination, we categorize its foreign country peers into four equal groups, namely “most distant”, “distant”, “close” and “closest” in descending order of geopolitical distance from that country.¹¹ The four-tiers categorisation follows Bosone and Stamato (2024), which examines the impact of geo-economic fragmentation on cross-border trade flows. Then, we sequentially exclude each group from the investable universe, starting with “most distant” countries, followed by “distant” and “close” countries, ultimately retaining only “closest” countries. After each exclusion, we reformulate the ex-ante optimized international portfolio with countries that remain in the “restricted” investable universe and calculate the Sharpe ratio. If geo-economic fragmentation reduces international diversification benefits, the optimized portfolio Sharpe ratio under the “restricted” investable universe (i.e., “restricted” scenarios) would be lower than that under the full investable universe (i.e., “no restriction” scenario). By sequentially excluding more countries from the investable universe, the approach in Chart 1 allows us to analyse the effects of increasing geo-economic fragmentation.

Data

Our analysis examines international diversification for 20 EMEs which, alongside 25 AEs, that form the “full” investable universe of 45 countries (Annex Table 1). The 45 countries are chosen based on market size and historical data availability, which together represent 89% of global stock market capitalization. We use MSCI national stock market indices to measure stock market returns and calculate portfolio Sharpe ratios in U.S. dollar terms. As we will show in the robustness section, the findings remain consistent when the Sharpe ratios are measured in the local currency of sampled EMEs. We use 3-month U.S. Treasury bill rates as a proxy for the risk-free rate. Considering data availability, our analytical sample covers monthly data from January 2014 to June 2024.¹²

4. Results and discussions

1. What are the benefits of international portfolio diversification for EMEs?

Chart 2 presents a scatter plot of the time-averaged optimized portfolio Sharpe ratio under the “no restriction” scenario for each sampled EME. To illustrate the benefits of international diversification, the Sharpe ratio of the domestic market index for each sampled EME is also displayed. The results indicate that incorporating foreign stock markets into the investment portfolio significantly enhances the portfolio Sharpe ratio of the sampled EMEs. Specifically, Table 1 shows that the average Sharpe ratio of the internationally optimized stock market portfolios for the sampled EMEs is 0.43, reflecting a statistically significant improvement of 0.31 over the average Sharpe ratio of 0.12 for their domestic market indices. Additionally, Table 1 reveals that this improvement arises from both increased portfolio returns and reduced volatility, underscoring the comprehensive benefits of international stock diversification for EMEs during the sample period.

2. How does geo-economic fragmentation affect these benefits?

Chart 3 presents the results for the sampled EMEs using the analytical framework in Chart 1. To illustrate the evolution of the benefits of international diversification under different

¹¹ Considering the total of 45 countries in the full investable universe (see the Data section), there would be 11 foreign country peers in each of the four groups. In applying dynamic adjustment strategy, the compositions of their “most distant”, “distant”, “close” and “closest” countries for each sampled EMEs would be updated over time based on the observed bilateral distance during each “in-sample” window.

¹² This takes into account earlier historical data used for ex-ante portfolio optimisation. See footnote 6 for details.

“restricted” scenarios, we present the estimates in two steps. First, Panel A depicts the optimized portfolio Sharpe ratio for each scenario over the Sharpe ratio of domestic market indices. These figures represent the overall benefits of international diversification obtained from each scenario, with a positive value indicating net benefits. Second, Panel B plots the estimated benefits of international diversification for each “restricted” scenario over the “no restriction” scenario. A negative value indicates a loss of international diversification benefits due to restrictions on the investable universe.

Panel B of Chart 3 shows that geo-economic fragmentation results in a loss of diversification benefits for our sampled EMEs, as evidenced by a concentration of negative values. Furthermore, the effect appears to follow a convex relationship, with the most pronounced impact occurring when the first group of foreign country peers—specifically, the “most distant” countries—is excluded (our “exclude most distant” scenario). Our estimates indicate that excluding “most distant” countries reduce international diversification benefits by an average of 70%, from 0.31 to just 0.09 relative to the Sharpe ratio of domestic market indices. The amount of the average reduction is statistically significant at the 1% level. However, when the investable universe is further restricted all the way to include only “closest” countries, the diversification benefits are estimated to decrease by an additional 15% only. Collectively, our estimates suggest a substantial negative impact of geo-economic fragmentation on international diversification benefits, with most of the losses stemming from the exclusion of “most distant” countries.

Despite the negative impact of geo-economic fragmentation, diversifying into a “restricted” set of foreign stock markets can still offer advantages for the sampled EMEs (Panel A of Chart 3).

¹³ Even in the most restrictive scenario, where only “closest” countries remain in the investable universe, the ex-ante optimized Sharpe ratio is still, on average, 30% higher than the Sharpe ratio based on domestic market indices for the sampled EMEs.¹⁴

To reinforce the finding that the exclusion of “most distant” countries is the main contributor to the observed reduction in international diversification benefits, we re-ran the ‘restricted’ scenario by altering the first group of countries excluded from the “full” investable universe. Specifically, instead of excluding the “most distant” countries as laid out in Chart 1, we now exclude “distant,” “close,” or “closest” countries in the first step. Chart 4 reveals that excluding “most distant” countries lead to a much larger reduction in diversification benefits compared to excluding other peer groups. Such a contrast emphasizes the importance of diversifying into “most distant” countries to maximize diversification benefits for EMEs. This underscores the potential challenges posed by geo-economic fragmentation, where investments in countries with greater geopolitical differences may face increased restrictions, impacting diversification strategies.

We conclude this section by examining the temporal dimension of the reduction in diversification benefits under the “exclude most distant” scenario. The time series plot in Chart 5 illustrates that the negative impact persists over time, particularly over longer horizons. Specifically, on a 24-month rolling basis (represented by the orange line in Chart 5), excluding

¹³ It is worth noting that the estimated benefits of international diversification for certain sampled EMEs under the more restricted scenarios are estimated to be negative (i.e. the spots in the negative region in Panel B of Chart 3), which can be expected given the consideration of ex-ante optimised portfolio Sharpe ratio. Considering ex-ante optimised portfolio Sharpe ratio under the “no restriction” scenario is mostly positive for the sampled EMEs, the results reflect further how the “restricted” investable universe can undermine the gains from international diversification. It is worth noting that the estimated benefits under all “restricted” scenarios would all become positive if we consider the ex-post optimised portfolio Sharpe ratio instead.

¹⁴ The average Sharpe ratio of the ex-ante optimised portfolios in this scenario is 0.15, compared to 0.12 of domestic market indices. The difference is also statistically significant.

"most distant" countries results in a lower average ex-ante Sharpe ratio than the "no restriction" scenario across the sampled EMEs in 97% of the rolling windows, compared to 79% at a 12-month horizon (indicated by the blue line).

3. What drives the impact of geo-economic fragmentation?

Cosset and Suret (1995) show that a portfolio including both politically risky and stable countries can achieve a better risk-return trade-off than one consisting solely of stable countries. Their findings highlight two key considerations for diversification. First, it is optimal to include countries with varying risk levels. While investing in low-risk countries may reduce overall risk, it also limits potential growth. A mix of high and low-risk countries should therefore be chosen to enhance the return-risk trade-off. Second, the correlation of countries' risk exposures is crucial. If countries have highly correlated risk exposures, their returns are likely to move together, limiting diversification benefits.

To identify the drivers behind the observed reduction in diversification benefits when "most distant" countries are excluded, we compare the absolute level differences and absolute correlations across six dimensions: institutional, financial, economic, inflation, market, and currency risk (Annex Table 2). These factors are commonly regarded as a diversifiable risk in literature (e.g., Errunza and Padmanabhan, 1988; Cosset and Suret, 1995; De Santis et al., 1999; Attig et al., 2023).¹⁵ Chart 6 illustrates these comparisons, showing significant disparities in institutional risk between the sampled EMEs and their "most distant" country peers, as indicated by larger absolute differences and lower absolute correlations compared to the other three peer groups. Such a pattern is not observed in other risk factors. This suggests that excluding "most distant" countries likely restricts opportunities to diversify institutional risk, which in turn diminishes the international diversification benefits.

We conduct three tests to validate the above findings. First, we follow Attig et al. (2023) by regressing the country risk component of stock market returns on the above six risk factors. The estimation results, as reported in Table 2, indicate a positive association between institutional risk and the country-specific component of stock market returns, after controlling for other risk factors.¹⁶ This finding aligns with the results obtained by Attig et al. (2023),¹⁷ which argues that for investors to effectively mitigate the institutional risk exposure in their portfolios, they should allocate funds across countries with varying levels of institutional risk. This interpretation is consistent with our result. Furthermore, given that all regression variables in Table 2 are standardized with zero mean and unity variance, the fact that institutional risk has the largest estimation coefficient confirms the importance of this factor in driving stock market returns that affect the benefits from international diversification.

Second, we examine the relationship between i) the reduction in diversification benefits from a "no restriction" to an "exclude most distant" scenario and ii) the average absolute correlation of institutional risk between the sampled EMEs and their "most distant" peers, using a simple cross-sectional regression. Table 3 reports a statistically significant negative relationship between the two, indicating that the reduction is more pronounced for EMEs if they have a lower average absolute correlation in institutional risk with their "most distant" countries. This aligns with our earlier prediction that diversification benefits are expected to be higher when the risk measure of two countries is less correlated.

¹⁵ We only consider the time-varying risk factors covered by Attig et al. (2023), but not the static ones like legal risk.

¹⁶ The estimated coefficient for most of the other risk factors are also positive and statistically significant, consistent with Attig et al. (2023).

¹⁷ Attig et al. (2023) extract the country risk component using firm-level stock returns and find a positive association between the level of a country's institutional risk and the level of the country risk component in stock market returns

Third, we repeat the scenario analysis in Chart 4, but by categorizing country peers based on their absolute differences or correlations in institutional risk with sampled EMEs, instead of their geopolitical distance. Chart 7 shows that the reduction in diversification benefits is greatest when excluding peers with a larger disparity in institutional risk, re-affirming the relevance of a country's institutional risk in international portfolio diversification.

Together, the results of the three tests help to validate the relevance of disparities in institutional risk, both in terms of level differences and correlations, in explaining the negative impact of excluding "most distant" countries on international diversification benefits.

4. How can EMEs enhance diversification benefits in the light of geo-economic fragmentation?

Our earlier analysis shows that geo-economic fragmentation can undermine the gains from international diversification. However, it also indicates that opportunities for diversification remain, even when the sampled EMEs can only invest in peers that do not belong to the "most distant" countries. This raises an important question: how can the sampled EMEs enhance their international diversification benefits in this context?

To address this issue, we conducted an analysis aimed at identifying a general strategy to maximize the diversification benefits of investing in peers that are not considered "most distant" countries to the sampled EMEs ("non-most distant peers"). Our approach involves comparing the estimated diversification benefits when the international equity portfolio is concentrated in each of the four sub-groups of such peers. These sub-groups are formed based on similarity i) in risk profile with the sampled EMEs and ii) the level of financial market development (see below elaboration or Chart 8). If these criteria are relevant for maximizing diversification benefits, we expect to observe significant changes in the estimated benefits as we transition across the four sub-groups.

To create the four sub-groups, we first divide the "non-most distant" peers into two groups based on their similarity in country risk profiles with the sampled EMEs.¹⁸ This categorization is essential, as the similarity in risk profile between domestic and foreign country peers significantly influences diversification benefits. We anticipate greater diversification benefits when the portfolio is concentrated in peers with a larger difference in their risk profile (lower similarity) as compared with the domestic market.

Next, we further divide the two groups of "non-most distant" peers obtained in the first step into two further sub-groups based on their level of financial market development. This criterion is important because one objective for EMEs in diversifying abroad is to achieve stability that may not be attainable by investing solely in domestic markets. Thus, we hypothesize that investing in "non-most distant" peers with relatively more developed financial markets will yield greater benefits.¹⁹ To assess a country's level of financial market development, we utilize the Financial Markets Index proposed by Svirydenka (2016).²⁰

¹⁸ For each non-most distant peer of a sampled EMEs, we infer the similarity of country risk profile based on the average ranking based on i) absolute difference in level and ii) correlation of the six country risk measures with respect to that EMEs. Average ranking across risk factors and measures is considered given their differences in magnitude.

¹⁹ Wand et al. (2017) show that countries with more developed financial markets tend to have lower aggregate volatility, while Demir (2025) finds that stock market development has a unidirectional positive influence on long-term economic growth.

²⁰ Financial Markets Index measures the level of stock market and debt market development in a country based on their depth, access and efficiency. The index range from 0 to 1 with 1 (0) denoting most (least) developed.

Chart 9 presents the results. As expected, when faced with restrictions on investing in “most distant” countries, diversifying the portfolio towards other peers with more developed financial markets and a less similar risk profile yields the greatest diversification benefits (second column of Chart 9), with the estimated benefits comparable to our “exclude most distant” scenario (i.e., the optimal results from allocating to all 33 “non-most distant” countries, first column). This is followed by peers with more developed financial markets and more similar risk profiles (third column). Conversely, investing in less financially developed peers generally results in smaller diversification benefits and greater negative tail risks (fourth and fifth column), particularly when these peers share more similar risk profiles with the sampled EMEs (fifth column).

By decomposing the Sharpe ratio into its return and volatility components, Chart 10 further illustrates that diversifying towards “non-most distant” peers with more developed financial markets can achieve a significantly lower volatility in portfolio returns. This finding aligns with the previously discussed advantages of diversifying into more developed financial markets. Overall, the results underscore the importance of diversifying into foreign peers with more developed financial markets and a less similar risk profile, when the sampled EMEs face constraints in international diversification options due to geo-economic fragmentation.

5. Robustness tests

We conduct four tests to verify that the negative impacts of geo-economic fragmentation are robust under alternative assumptions in the optimization exercise. Specifically, we consider i) an optimised portfolio Sharpe ratio in the local currency of sampled EMEs instead of the US dollar to remove any currency effects (e.g., Driessen and Laeven (2007); Lotfi et al. (2024)); ii) an alternative portfolio optimisation approach, by minimizing portfolio volatility instead of mean-variance optimisation (Cosset and Suret (1995)); iii) the imposition of trading frictions in portfolio optimisation, specifically short-selling constraints (e.g., De Roon et al. (2001); Driessen and Laeven (2007)) and iv) alternative assumptions about the minimum domestic asset allocation, by setting q at 50% (i.e., more restrictive constraint) or 0% (i.e. removing the constraint outright) instead of 25%.

Chart 11 reports the changes in diversification benefits (compared with a ‘no restriction’ scenario) arising from the exclusion of “most distant” countries under these different alternative assumptions. As in our baseline results, a reduction in diversification benefits is consistently observed among the sampled EMEs, although the magnitude of the estimated reduction varies.^{21,22} Overall, our results confirm that the negative impact of geo-economic fragmentation are robust to alternative assumptions in the optimisation exercise.

We also verify the robustness of our baseline results by exploring an alternative approach to country peer categorisation. Specifically, our baseline analysis uses the relative bilateral geopolitical distance from a given EME to divide its peers into four equal groups. While this ensures a sufficient number of country peers in each group for portfolio optimization purposes, it may label an EME as having a “most distant,” even if it is geopolitically close to all other countries, due to the use of relative geopolitical distance within a given EME only.

²¹ For instance, in setting the minimum domestic allocation (q) at 50%, the estimated reduction in international benefits is smaller than that observed with a lower q (25% or 0%). The overall international diversification benefits are bounded to be smaller with a larger minimum domestic allocation, and so do the potential reduction in benefits under the “restricted” scenario.

²² The reductions in diversification benefits due to the exclusion of other country peer groups (i.e., “distant”, “close,” or “closest”) remain notably smaller than that of “most distant” countries, consistent with the baseline results (Chart 4). The detailed estimates are not reported for brevity.

To address this concern, we consider an alternative approach using geopolitical distance in an “absolute” sense. In particular, we classify the peers of each sampled EME into “most distant”, “distant”, “close” or “closest” countries based on the relative ranking concerning all bilateral geopolitical distances involving the 20 sampled EMEs. This takes into account the overall distribution of bilateral geopolitical distance among all sampled EMEs, reducing potential misclassifications due to the use of relative distance within an EME as discussed above. However, one drawback to this approach is that it could result in an uneven split of country peers in the peer groups, leading to cases where the portfolio optimiser may fail to find a solution due to the number of country peers in a particular group being too small. Taking into account this constraint, only 18 EMEs are included in this robustness analysis.

Chart 12 reports the results using the alternative country peer group categorisation approach. The results are generally consistent with our baseline findings, indicating that geo-economic fragmentation does indeed lead to a loss of diversification benefits for the sampled EMEs. In Chart 13, we re-ran the “restricted” scenario by altering which group of countries was excluded first from the “full” investable universe. Specifically, we exclude “distant,” “close,” or “closest” countries in the initial step as we did in Chart 4. The results confirm that excluding “most distant” countries leads to a much larger reduction in diversification benefits compared to excluding other peer groups. Overall, our results suggest that our findings are robust to the use of either “relative” or “absolute” geopolitical distance in classifying the country peers.

6. Conclusions

In conclusion, this study highlights the significant benefits that international portfolio diversification can offer EMEs. However, our analysis reveals that excluding country peers with large geopolitical distance from foreign investment options can substantially diminish these benefits. A closer examination of the risk profile of sampled EMEs in relation to their peers indicates that this constraint primarily limits their ability to mitigate exposure to domestic institutional risks, thereby reducing the gains from international diversification. Nonetheless, our findings suggest that there may be benefits from diversification for EMEs investors under this situation, particularly through investments in other peers with more developed financial markets and a lower risk profile similarity.

Overall, our study underscores the importance of providing EME investors with access to foreign investments to maximize diversification benefits. However, persistent threats of geo-economic fragmentation may impede their capacity to fully capitalize on the potential gains from diversification. If this situation materializes, it could weaken their resilience to economic shocks and undermine financial stability.

From a financial stability perspective, while policymakers in EMEs can implement measures to promote greater access to international markets for domestic investors, they must also safeguard their economies from the adverse effects of geo-economic fragmentation on the stability of the domestic financial system. This could involve establishing contingency plans to mitigate risks associated with sudden geopolitical shifts, including building adequate capital and liquidity buffers against shocks (International Monetary Fund, 2023).

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Chart 1: Analytical framework for assessing the impact of geo-economic fragmentation

This chart illustrates the framework for assessing the impact of geo-economic fragmentation. First, for each country under examination, we categorize its foreign country peers of into four equal groups in descending order of geopolitical distance from that country. Then, we sequentially exclude each group from the investable universe, starting with “most distant” countries, ultimately retaining only “closest” countries. After each exclusion, we reformulate the optimized international portfolio using the “restricted” investable universe and calculate its Sharpe ratio, and compare with that under the “no restriction” scenario.

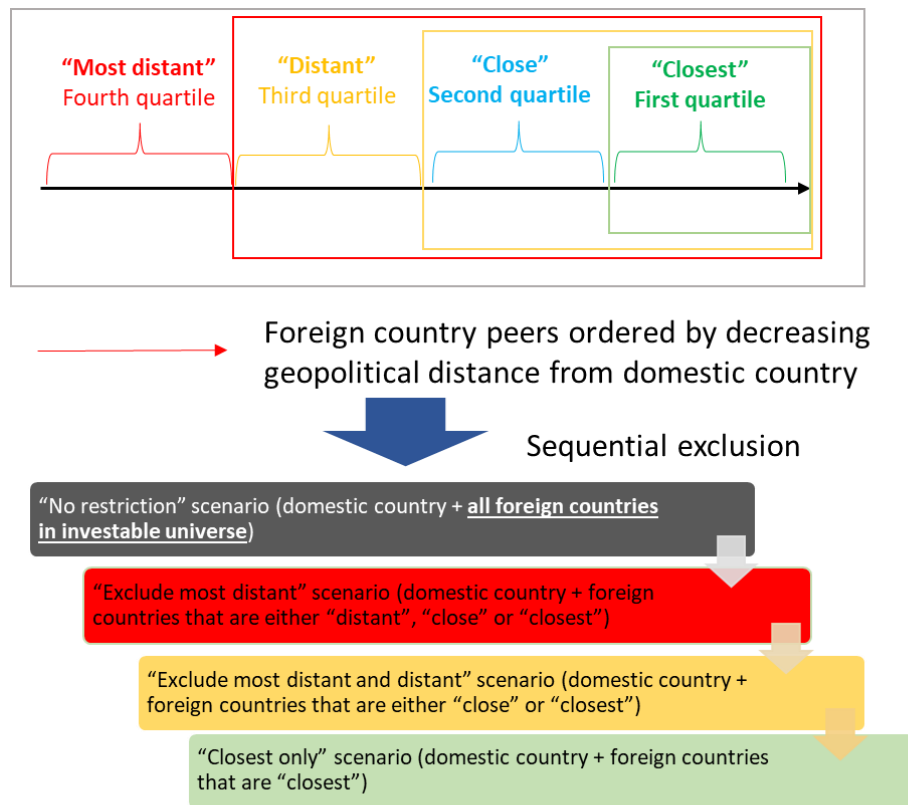


Chart 2: Ex-ante optimised portfolio Sharpe ratio under “no restriction” scenario

This chart depicts, for the 20 sampled EMEs, the time-averaged Sharpe ratio for their domestic indices and the ex-ante optimized international stock market portfolio under the "no restriction" scenario as laid out in the *Methodology* section. Each dot on the chart represents a sampled EME. The time-averaged figures cover the period from January 2014 to June 2024. The horizontal lines of the box plot (from top to bottom) denote the 1.5 times interquartile range above the 75th percentile, 75th percentile, median, 25th percentile, and 1.5 times interquartile range below the 25th percentile respectively.

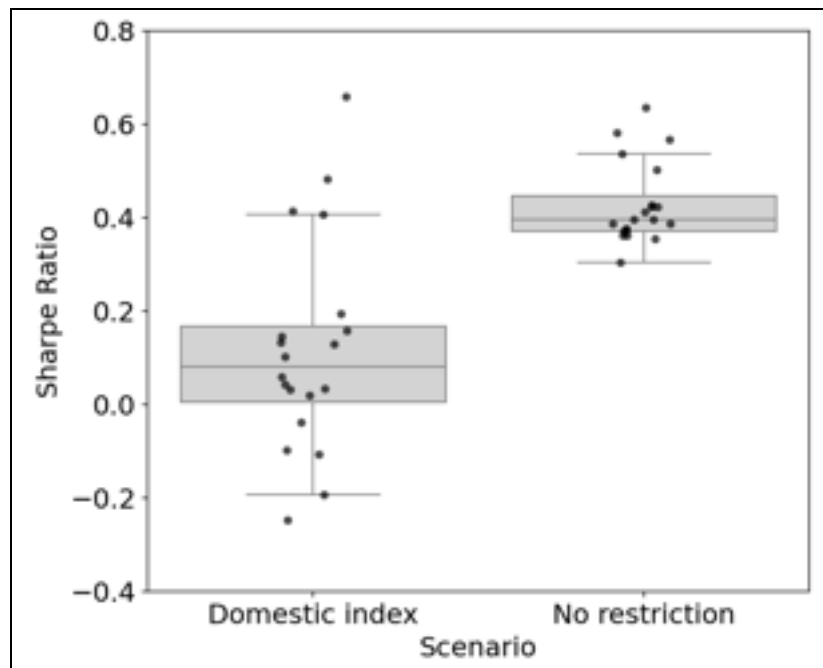


Chart 3: Ex-ante optimised portfolio Sharpe ratio under various “restriction” scenarios

Panel A plots the time-average optimized portfolio Sharpe ratios for 20 sampled EMEs under each scenario, expressed as an excess over the Sharpe ratio of domestic market indices. Panel B depicts the estimated change in optimised portfolio Sharpe ratio for each “restricted” scenario, specifically “exclude most distant”, “exclude most distant and distant”, and “closest only” as defined in Chart 1, over the “no restriction” scenario. Each dot on the chart represents a sampled EME. The time-averaged figures cover the period from January 2014 to June 2024. The horizontal lines of the box plot (from top to bottom) denote the 1.5 times interquartile range above the 75th percentile, the 75th percentile, median, 25th percentile, and 1.5 times interquartile range below the 25th percentile respectively.

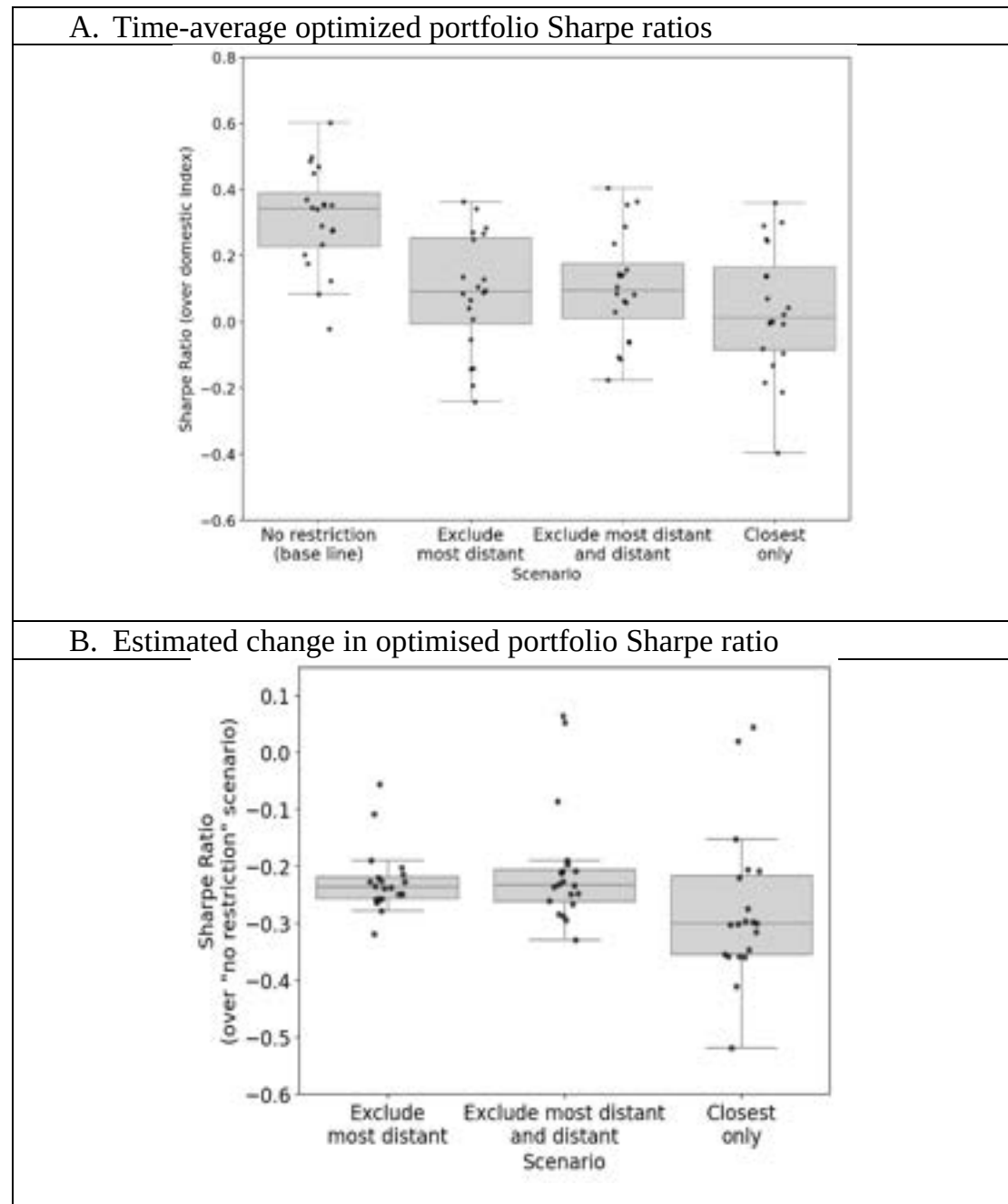


Chart 4: Ex-ante optimized portfolio Sharpe ratios with alternative exclusion of peer country groups in the first step

This chart depicts the estimated change in the time-averaged optimized portfolio Sharpe ratio from the “no restriction” scenario, when one of the peer country groups (“most distant”, “distant”, “close” or “closest”) is excluded from the “full” investable universe for portfolio optimisation. Each dot on the chart represents a sampled EME. The time-averaged figures cover the period from January 2014 to June 2024. The horizontal lines of the box plot (from top to bottom) denote the 1.5 times interquartile range above the 75th percentile, the 75th percentile, median, 25th percentile, and 1.5 times interquartile range below the 25th percentile respectively.

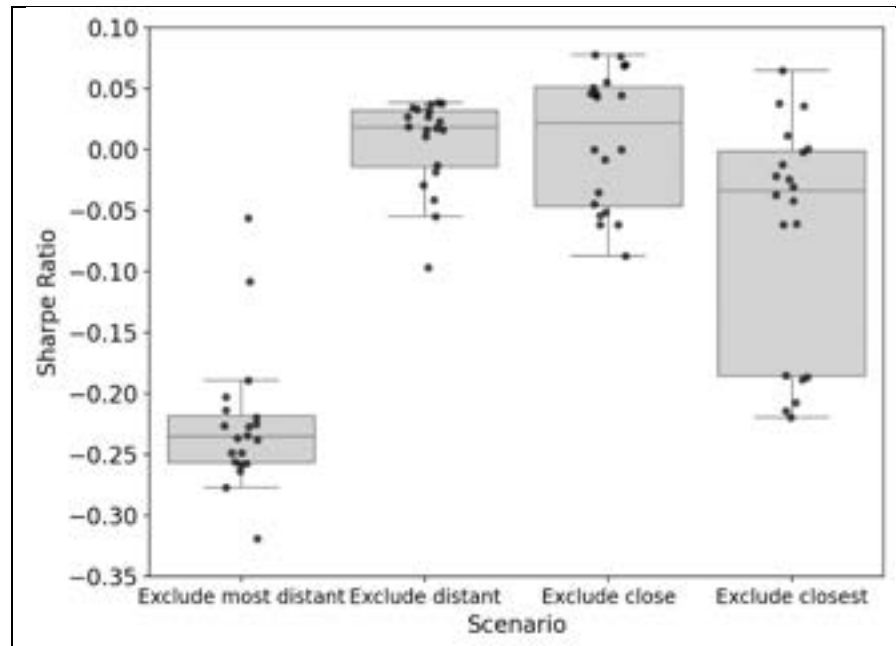


Chart 5: Time series of ex-ante optimised portfolio Sharpe ratio under the “exclude most distant” scenario

This chart depicts the time series of the average estimated change in optimised monthly portfolio Sharpe ratio from “no restriction” to “exclude most distant” scenario across the sampled EMEs. To calculate the monthly Sharpe ratio, the annualised risk-adjusted monthly return is divided by the annualised volatility over the entire time period. The blue line denotes the 12-months rolling average while the orange line represents the 24-months rolling average.

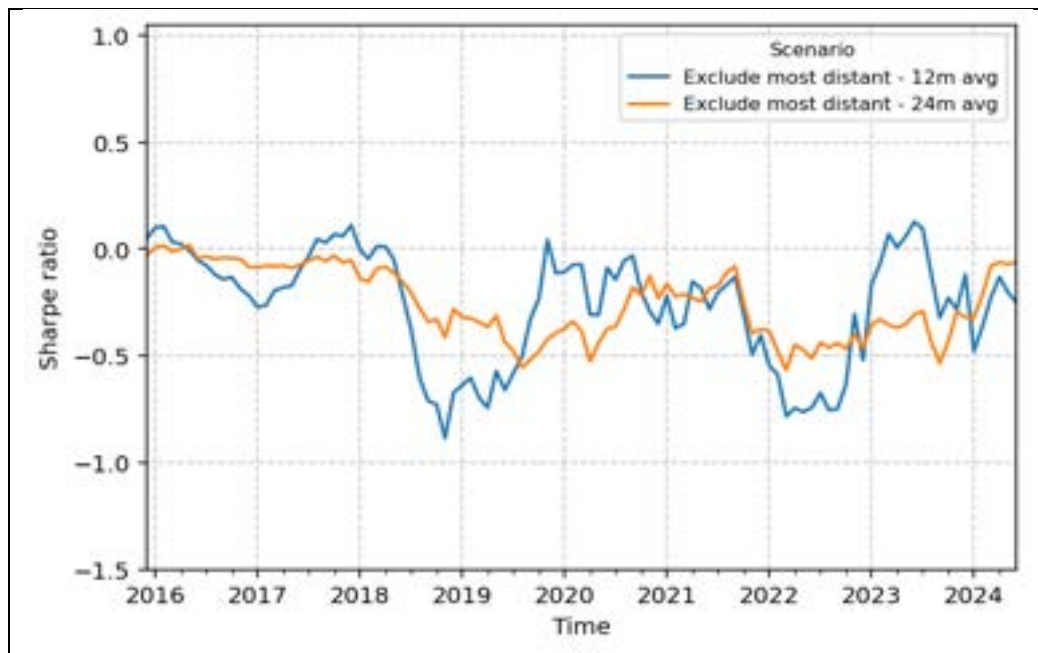
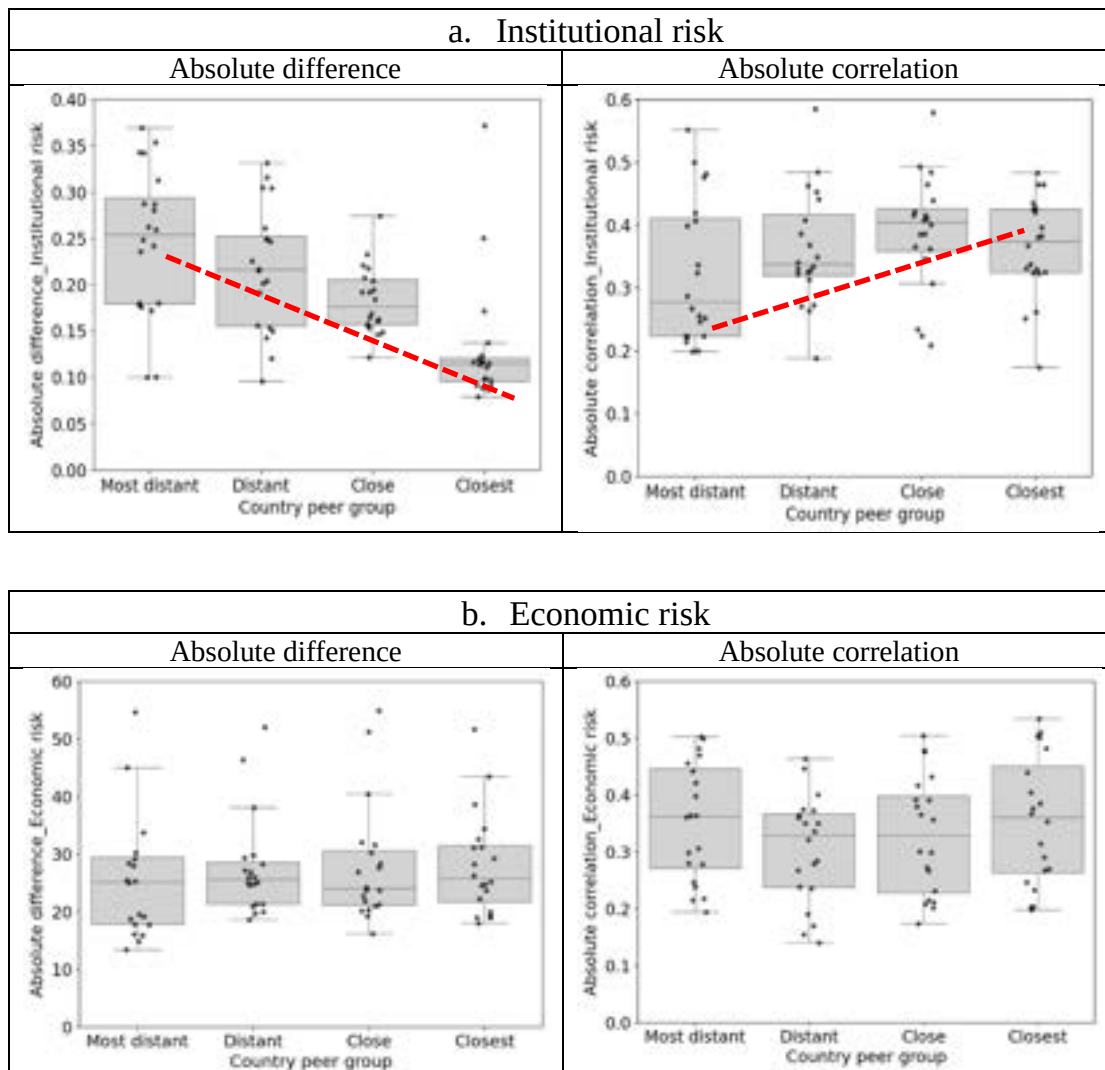
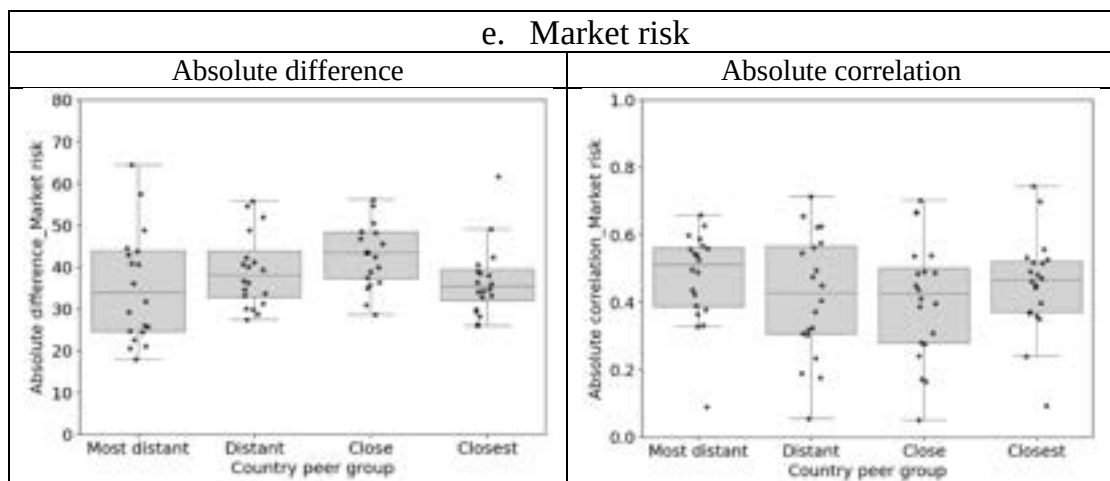
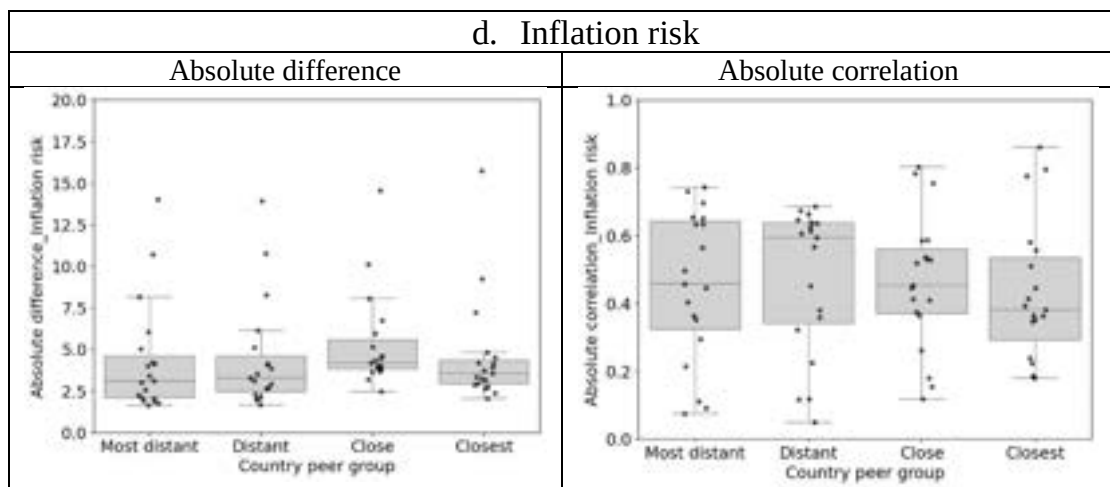
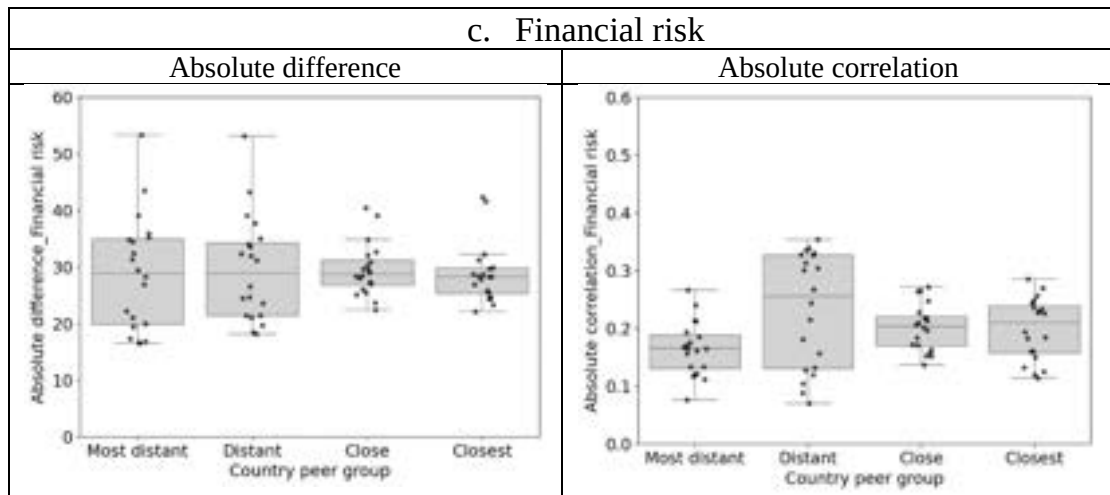


Chart 6: Comparison of countries' risk profiles

This chart displays the distribution of the time-averaged absolute difference and absolute pairwise correlation among six risk factors (Annex Table 2) between the sampled EMEs and their country peers. Each dot on the chart shows the average values within a particular peer group (i.e. most distant, distant, close or closest) in relation to a sampled EME. The horizontal lines of the box plot (from top to bottom) denote the 1.5 times interquartile range above the 75th percentile, the 75th percentile, median, 25th percentile, and 1.5 times interquartile range below the 25th percentile respectively.





f. Currency risk

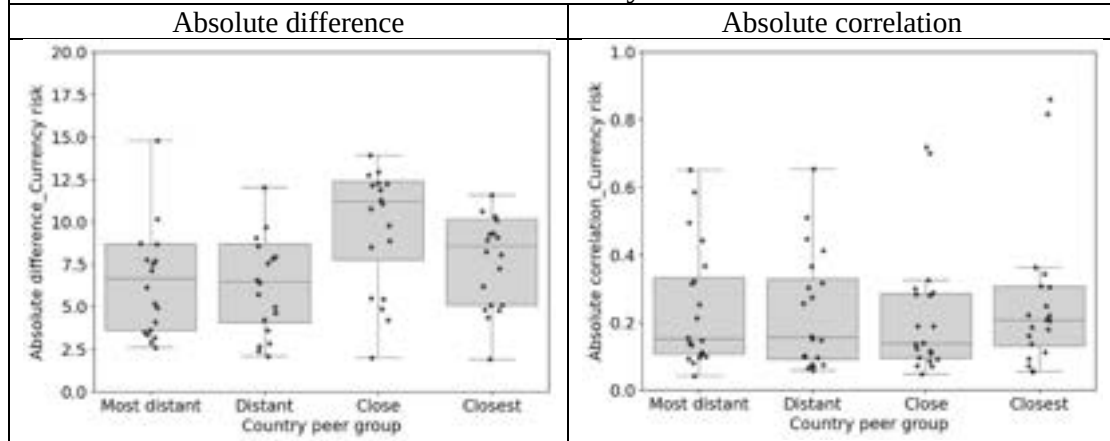


Chart 7: Estimated changes in international diversification benefits with exclusion of peer countries by their disparities in the institutional risk with sampled EMEs

This chart depicts the estimated change in the optimized portfolio Sharpe ratio (relative to the “no restriction” scenario) when each of the four equal groups of foreign country peers is removed from the “full” investable universe. These groups are categorized based on their absolute difference (panel A) or absolute correlation (panel B) in institutional risk profiles with each sampled EME. “Excluding the 1st quartile” refers to omitting the group of foreign country peers with the smallest absolute difference (panel A) or absolute correlation (panel B) in institutional risk compared to the sampled EME, and vice versa for the “excluding the 4th quartile” scenario. The horizontal lines of the box plot (from top to bottom) denote the 1.5 times interquartile range above the 75th percentile, the 75th percentile, median, 25th percentile, and 1.5 times interquartile range below the 25th percentile respectively.

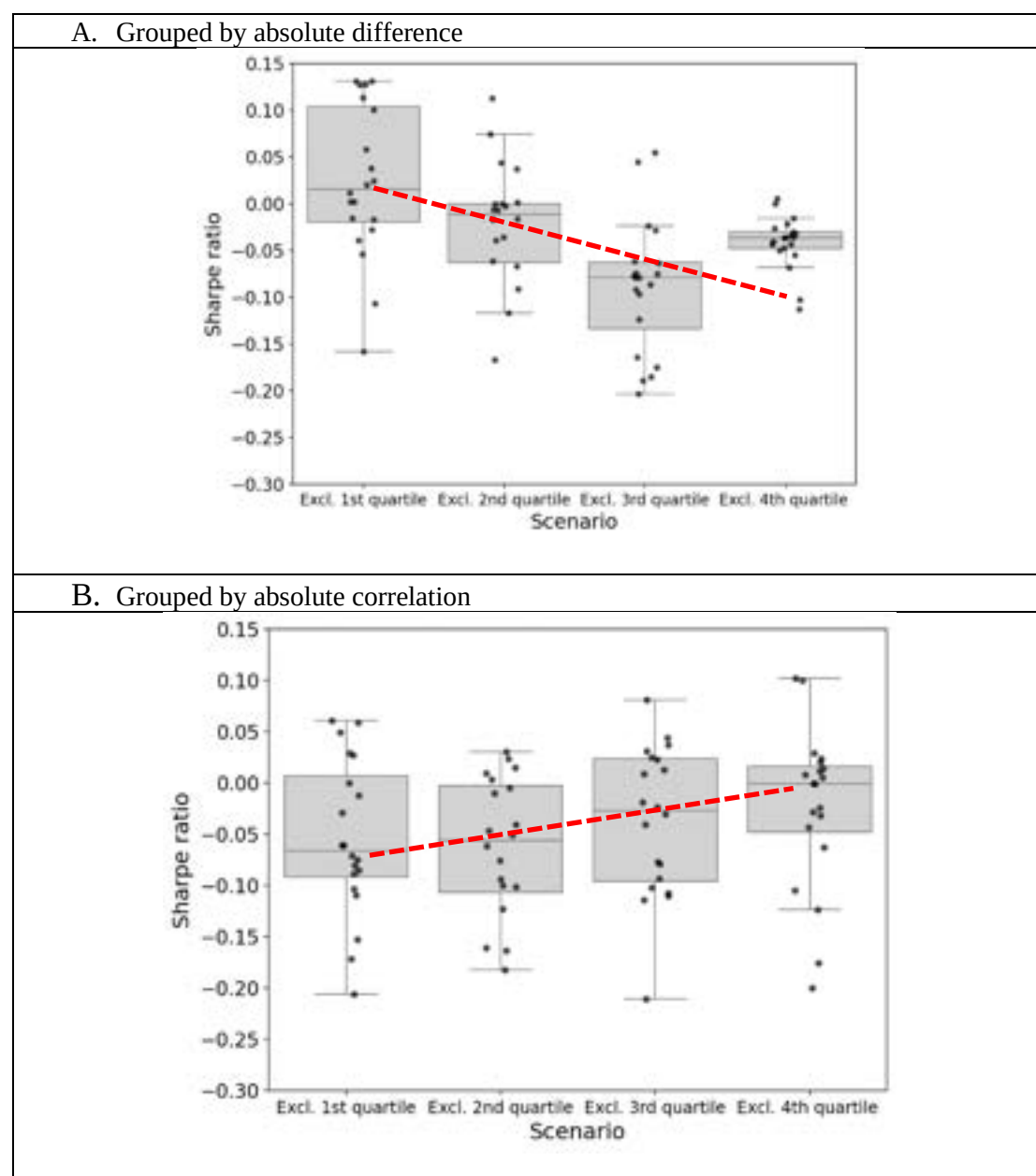


Chart 8: Analytical framework for assessing the optimal strategy for investing in "non-most distant" peers

This chart illustrates the framework for assessing the optimal strategy for investing in “non-most distant” peers. First, for each country under examination, we divide the “non-most distant” peers (i.e. 33 countries that are not “most distant” peers to a given EMEs) by into 2 groups based on the similarity of their country risk profile with the sampled EMEs (see footnote 15). Then, we further divide each group into two subgroups according to their level of Financial Markets Index. After dividing the groups, we reformulate the optimized international portfolio by only considering the countries in a given peer group and estimate the ex-ante optimised portfolio Sharpe ratio for comparison.

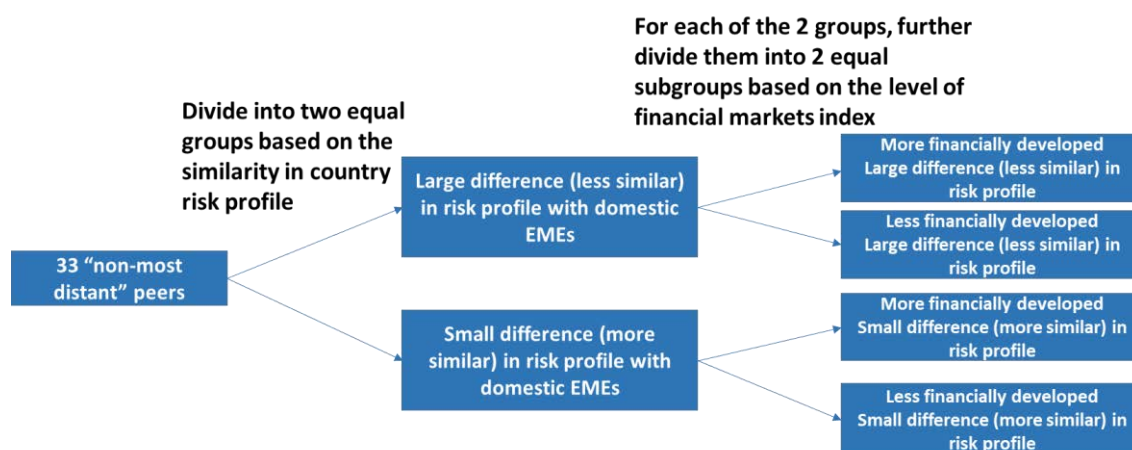


Chart 9: Ex-ante optimised portfolio Sharpe ratio under different strategies for investing in “non-most distant” peers

This chart plots the time-average optimized portfolio Sharpe ratios for 20 sampled EMEs under each scenario, expressed as an excess over the Sharpe ratio of domestic market indices. It depicts the estimated change in optimised portfolio Sharpe ratio for the “exclude-most distant” scenario as defined in Chart 1 and the scenarios of investing in each sub-group of “non-most distant” peers, specifically “Less similar risk more financially developed”, “More similar risk more financially developed”, “Less similar risk less financially developed” and “More similar risk less financially developed” as defined in Chart 8. Each dot on the chart represents a sampled EME. The time-averaged figures cover the period from January 2014 to June 2024. The horizontal lines of the box plot (from top to bottom) denote the 1.5 times interquartile range above the 75th percentile, the 75th percentile, median, 25th percentile, and 1.5 times interquartile range below the 25th percentile respectively.

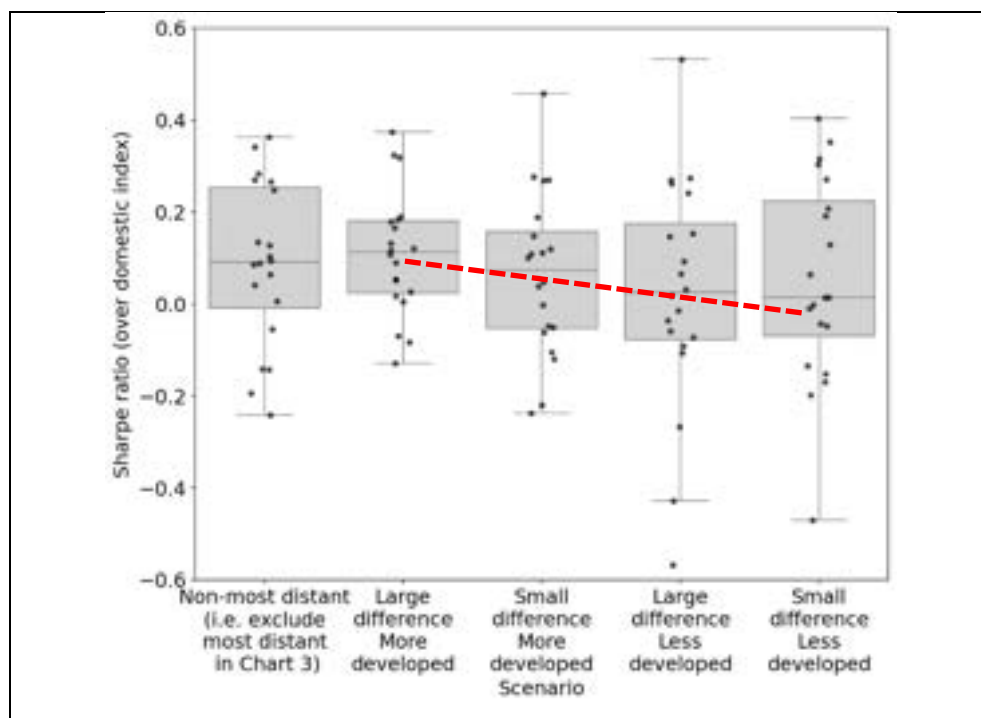


Chart 10: Ex-ante optimised portfolio return and return volatility under different strategies for investing in “non-most distant” peers

This chart plots the time-average optimized portfolio Sharpe ratios for 20 sampled EMEs under each scenario, decomposed into the return (panel A) and volatility (panel B) component, for the “exclude most distant” scenario as defined in Chart 1 and the scenarios of investing in each sub-group of “non-most distant” peers, specifically “Less similar risk more financially developed”, “More similar risk more financially developed”, “Less similar risk less financially developed” and “More similar risk less financially developed” as defined in Chart 8. Each dot on the chart represents a sampled EME. The time-averaged figures cover the period from January 2014 to June 2024. The horizontal lines of the box plot (from top to bottom) denote the 1.5 times interquartile range above the 75th percentile, the 75th percentile, median, 25th percentile, and 1.5 times interquartile range below the 25th percentile respectively.

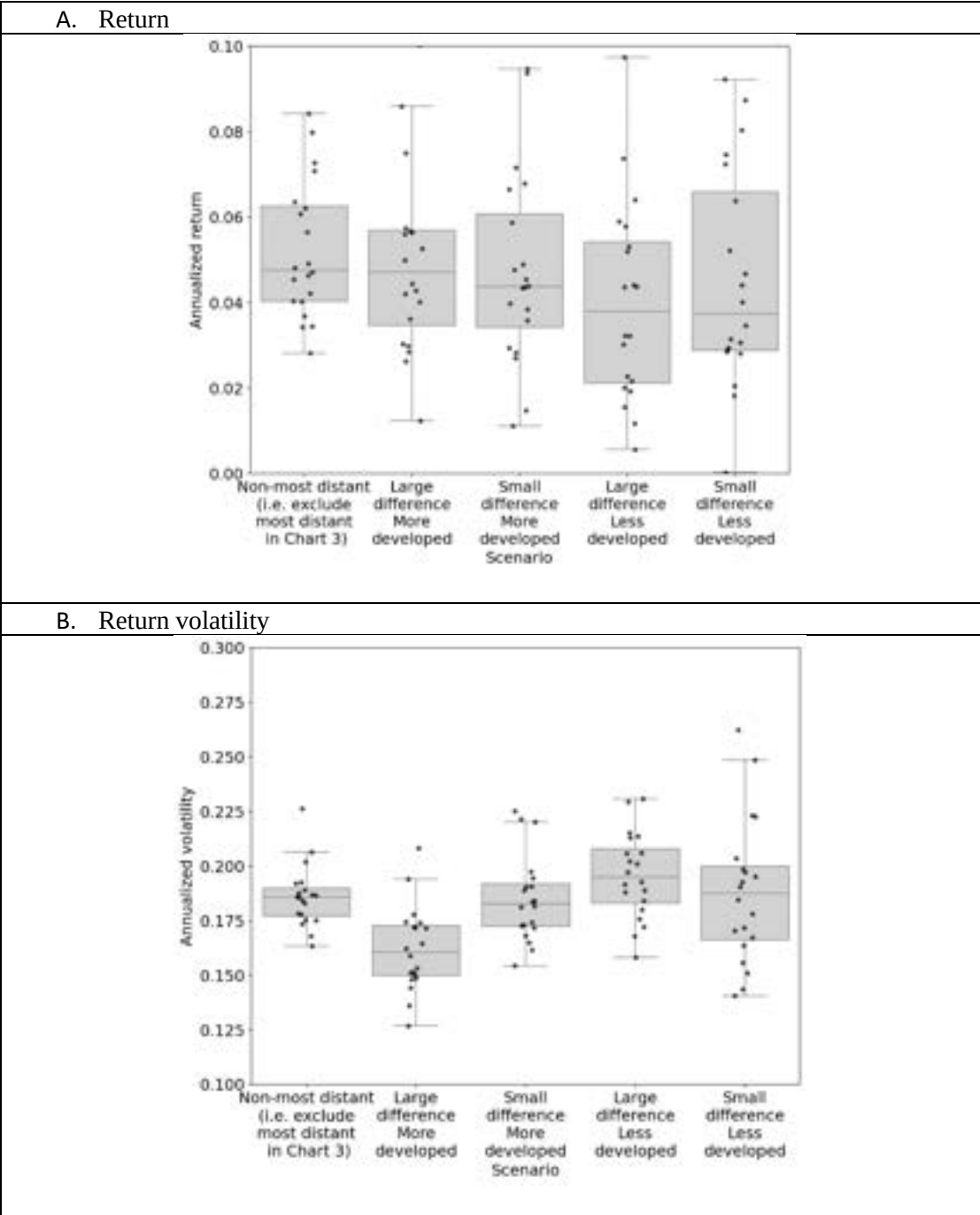


Chart 11: Estimated changes in international diversification benefits under the “exclude most distant” scenario with alternative assumptions in the optimization exercise

This chart reports the estimated change in optimised portfolio Sharpe ratio from the “no restriction” scenario to “exclude most distant” scenario under various alternative assumptions to optimisation exercise. The “local currency” case refers to measuring the optimised portfolio Sharp ratio in the local currency of the sampled EMEs. The “minimizing vol” refers to conducting portfolio optimisation by minimizing the portfolio’s variance (instead of maximizing mean-variance ratio). The “short-sell restri” refers to imposing an additional restriction of non-negative weighting to the optimisation exercise in Equation 1. The “ $\geq 50\%$ domestic” and “ $\geq 0\%$ domestic” refer to setting parameter q in Equation 1 at 50 and 0, respectively. The horizontal lines of the box plot (from top to bottom) denote the 1.5 times interquartile range above the 75th percentile, the 75th percentile, median, 25th percentile, and 1.5 times interquartile range below the 25th percentile respectively.

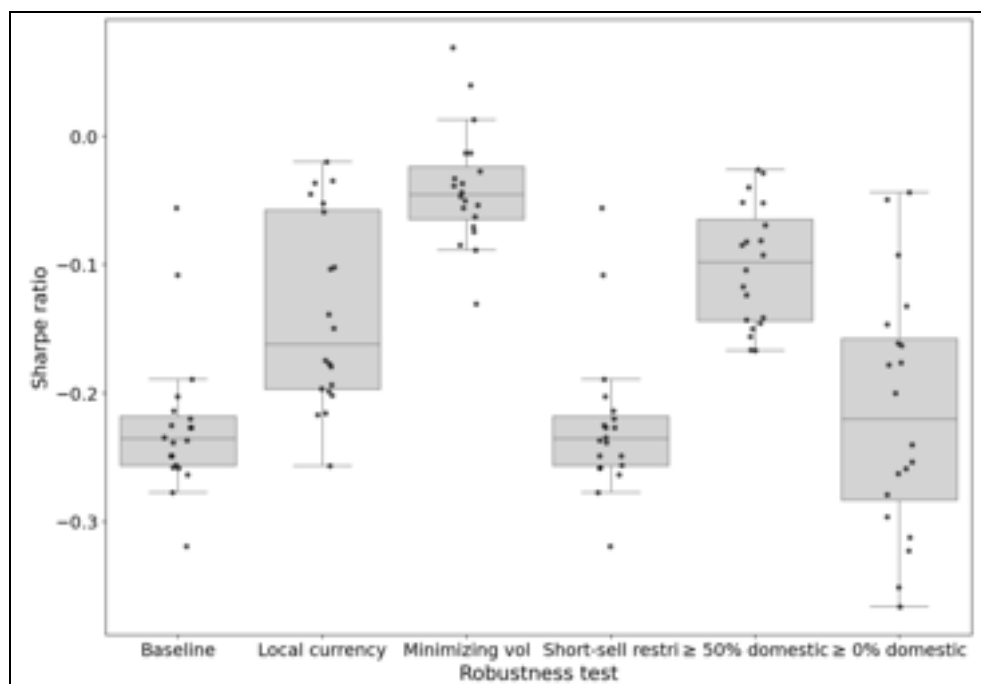


Chart 12: Ex-ante optimised portfolio Sharpe ratio under various “restriction” scenarios with alternative country peer grouping using absolute geopolitical distance

Panel A plots the time-average optimized portfolio Sharpe ratios for 18 sampled EMEs under each scenario, expressed as an excess over the Sharpe ratio of domestic market indices, based on the alternative country peer grouping using the absolute geopolitical distance. Panel B depicts the estimated change in optimised portfolio Sharpe ratio for each “restricted” scenario, specifically “exclude most distant”, “exclude most distant and distant”, and “closest only” as defined in Chart 1, over the “no restriction” scenario, based on the alternative country grouping assumption. Each dot on the chart represents a sampled EME. The time-averaged figures cover the period from January 2014 to June 2024. The horizontal lines of the box plot (from top to bottom) denote the 1.5 times interquartile range above the 75th percentile, the 75th percentile, median, 25th percentile, and 1.5 times interquartile range below the 25th percentile respectively.

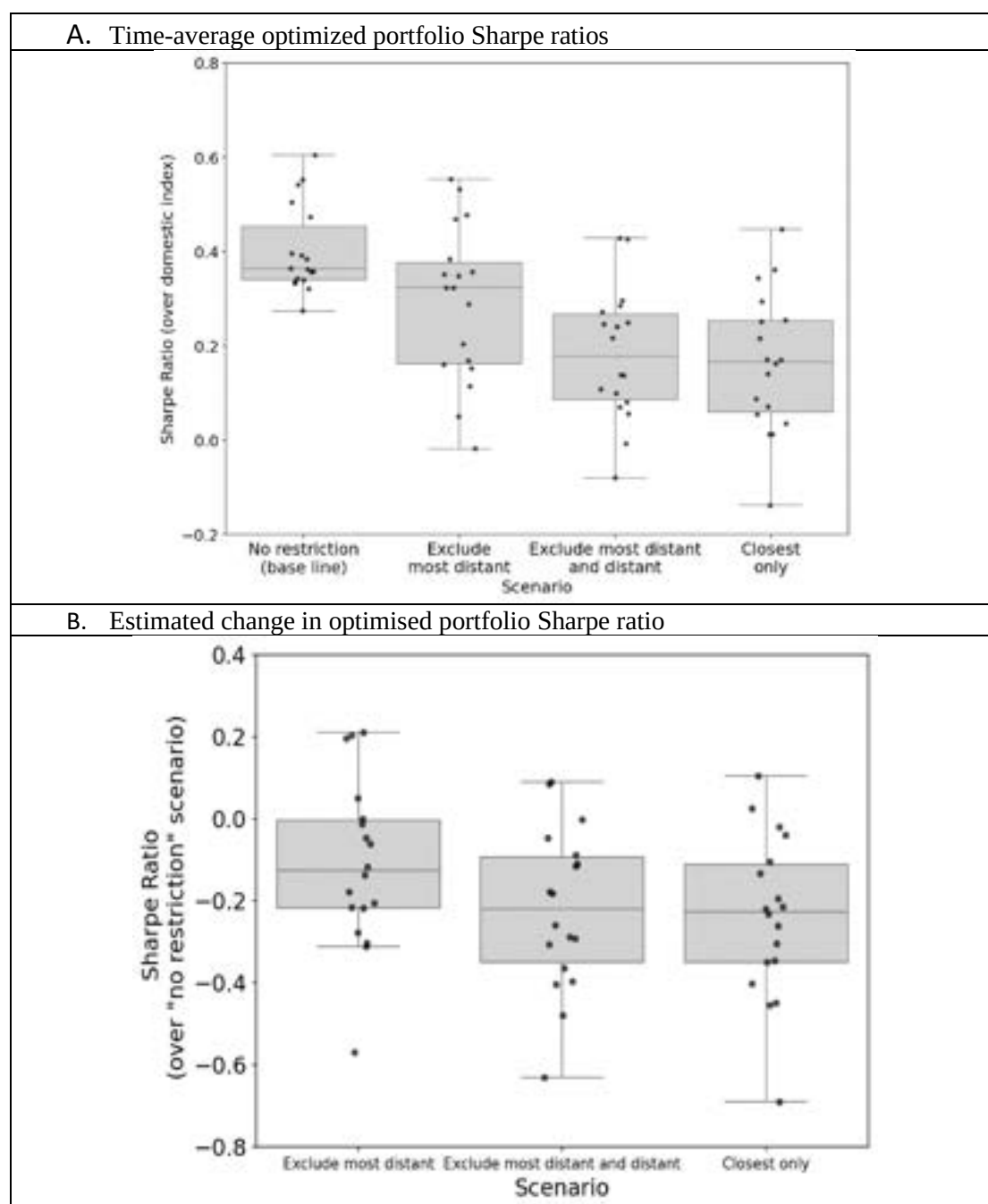


Chart 13: Ex-ante optimized portfolio Sharpe ratios with alternative exclusion of peer country groups in the first step under alternative country peer grouping using absolute geopolitical distance

This chart depicts the estimated change in the time-averaged optimized portfolio Sharpe ratio from the “no restriction” scenario, when one of the peer country groups (“most distant”, “distant”, “close” or “closest”) is excluded from the “full” investable universe for portfolio optimisation under alternative country peer grouping using absolute geopolitical distance. Each dot on the chart represents a sampled EME. The time-averaged figures cover the period from January 2014 to June 2024. The horizontal lines of the box plot (from top to bottom) denote the 1.5 times interquartile range above the 75th percentile, the 75th percentile, median, 25th percentile, and 1.5 times interquartile range below the 25th percentile respectively.

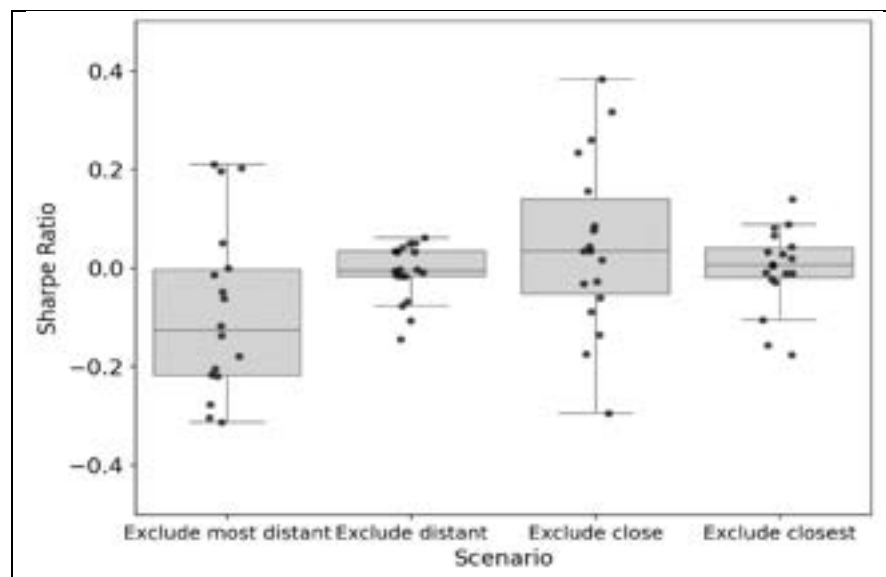


Table 1: Breakdowns of ex-ante optimised portfolio Sharpe ratio under “no restriction” scenario

Scenario	Domestic portfolio	No restriction
Annualised portfolio return	4.8%	8.6%
Annualised standard deviation	26.0%	16.7%
Annualised Sharpe ratio	0.12	0.43

Table 2: Estimated relationship between country component of stock market return and country risk factors

This table reports the estimated relationship between the idiosyncratic component of country equity returns and six country risk factors (see Annex Table 2) using a two-way fixed effect panel regression model for 19 EMEs.²³ The idiosyncratic component is derived as the regression residual from a two-factors dynamic factor model of EME country stock market returns. Following Attig et al. (2023), the absolute value of the residual is used, where a larger positive value indicates a greater deviation from the common factors of sampled EMEs’ country equity returns. Following Attig et al. (2023), the model also controls for country openness (trade-to-GDP ratio) and stock market concentration (Herfindahl-Hirschman Index of sectoral stock market capitalization). The monthly data spans from January 2009 to December 2023. All variables are standardized into zero mean and unity variance before estimation. ***, **, and * indicate the estimated coefficients are statistically significant at 1%, 5%, and 10%, respectively.

Independent variable:	Dependent variable: Idiosyncratic component of country equity return
Institutional risk	0.12**
Economic risk	0.11***
Financial risk	0.05*
Inflation risk	0.08***
Market risk	0.10***
Currency risk	0.05
Stock market concentration	0.01
Trade openness	-0.07
Month fixed effect	Yes
Country fixed effect	Yes
Number of observations	180
Adjusted R-squared	0.12

²³ Argentina is not included in the regression estimation due to extreme values in the inflation risk measure.

Table 3: Estimated relationship between loss in diversification benefits under “exclude most distant” scenario and the disparity in the institutional risk between sampled EMEs and their “most distant” country peers

Note: The above table reports the estimated coefficient of cross-sectional regression model for 19 sampled EMEs.²⁴ The dependent variable is the reduction in optimised portfolio Sharpe ratio from “no restriction” to “exclude most distant” scenario, with a positive value denoting larger reduction. The independent variables include the average absolute correlation in and absolute level difference in institutional risk of sampled EMEs with their respective “most distant” country peers as categorized by their geopolitical distance (Chart 1). All variables are standardized into zero mean and unity variance before estimation. ***, **, and * indicate the estimated coefficients are statistically significant at 1%, 5%, and 10%, respectively.

Independent variable:	Dependent variable: Reduction in optimised portfolio Sharpe ratio from “no restriction” to “exclude most distant” scenario
Average absolute correlation of institutional risk with most distant countries	-0.29**
Average absolute level difference in institutional risk with most distant countries	0.03
Number of observations	19
Adjusted R-squared	0.15

²⁴ Kazakhstan is excluded from the estimation because it contains an outlier value in the estimation dataset.

Annex

Table 1: List of countries

This Table list the 20 EMEs covered in the analysis, and the 25 AEs for forming the investable universe, making it a total of 45 countries.

20 EMEs for analysis	25 AEs for forming the investable universe	
Argentina	Australia	Japan
Brazil	Austria	Netherlands
Chile	Belgium	New Zealand
China	Canada	Norway
Colombia	Czech Republic	Portugal
Egypt	Denmark	Singapore
India	Finland	South Korea
Indonesia	France	Spain
Kazakhstan	Germany	Sweden
Malaysia	Greece	Switzerland
Mexico	Ireland	United Kingdom
Pakistan	Israel	United States
Peru	Italy	
Philippines		
Poland		
Qatar		
Romania		
South Africa		
Thailand		
Türkiye		

Table 2: Country risk measures

Risk measure	Definition	Source
Institutional risk	Country's Political Risk Index (PRI) compiled by the International Country Risk Guide (ICRG) and sourced from the World Bank. The PRI assesses the political risk by assigning risk points to 12 political risk components, including government stability, internal conflict, external conflict, military in politics, religious tensions, ethnic tensions, and bureaucracy quality.	International Country Risk Guide (ICRG) and World Bank
Economic risk	Country's Economic Risk Index (ERI) compiled by Bloomberg, with regards to a country's risk in economic activity, fiscal performance, external balance and foreign exposure	Bloomberg
Financial risk	Country's Financial Risk Index (ERI) compiled by Bloomberg, with regards to a country's risk in credit, equity and foreign exchange markets.	Bloomberg
Inflation risk	Measured by the year-on-year change of country's Consumer Price Index.	International Monetary Fund
Market risk	The conditional standard deviation of the stock market return using GARCH(1,1) process.	Bloomberg
Currency risk	The conditional standard deviation of US dollar exchange rate using GARCH(1,1) process.	Bloomberg

Explosive Depreciations and the Global Dollar Cycle: Evidence from the GSADF Test in East and Southeast Asia

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Abstract

This paper examines whether episodes of explosive depreciation in East and Southeast Asian currencies should be interpreted as currency-specific instability or as the regional manifestation of the global dollar cycle. Using the generalized supremum augmented Dickey–Fuller (GSADF) test of [Phillips et al. \(2015\)](#), we analyze U.S.-dollar exchange rates for ten Asian economies over 2006–2025 under three benchmark definitions: the raw bilateral rate, a PPP-adjusted misalignment measure, and a DXY-adjusted measure. We find recurrent explosive episodes across the region, with broad clustering during the 2015–2017 U.S. monetary normalization cycle and again in 2022 under the raw and PPP-based measures. However, this clustering weakens sharply after DXY adjustment, especially in the windows spanning the main regional depreciation waves. These results indicate that much of the apparent explosiveness in bilateral U.S.-dollar exchange rates reflects common dollar-driven regional pressure rather than simultaneous episodes of currency-specific instability. Once broad dollar movements are removed, the remaining late-sample evidence is much narrower and concentrated mainly in JPY and, more briefly, KRW. More broadly, the paper shows that benchmark construction fundamentally shapes GSADF-based inferences about exchange-rate explosiveness.

Keywords: Exchange Rate; Explosive Depreciation; Dollar Cycle; GSADF test

JEL Classification: C12; F31

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1 Introduction

Recent years have witnessed repeated episodes of broad-based currency depreciation across East and Southeast Asia, most visibly during the 2015–2016 U.S. monetary normalization cycle and again during the sharp dollar upswing of 2022. Such episodes are often discussed currency by currency, with emphasis on domestic macroeconomic fundamentals, policy credibility, or country-specific vulnerabilities. Yet their timing raises a broader interpretive question. When several Asian currencies weaken sharply against the U.S. dollar within a relatively narrow window, should these movements be understood as distinct episodes of currency-specific instability or as the regional manifestation of a common external force? The distinction matters for both empirical interpretation and policy. A region-wide episode driven mainly by common dollar conditions calls for a different reading, and potentially a different policy response, than simultaneous domestic crises across multiple economies.

A broad literature on the global financial cycle suggests that this distinction is first-order. Work on U.S. monetary policy, global risk conditions, and dollar dominance implies that bilateral U.S.-dollar exchange rates may embed a sizable common component associated with broad dollar conditions (Rey, 2015, Bruno and Shin, 2015, Miranda-Agrippino and Rey, 2020, Gopinath et al., 2020). If so, statistical evidence of explosiveness in raw bilateral exchange rates need not map cleanly into currency-specific instability. What appears, in bilateral terms, as a cluster of separate depreciation episodes may instead reflect common regional exposure to the global dollar cycle.

East and Southeast Asia provides a particularly informative setting in which to examine this issue. The ten economies in our sample span a wide range of exchange-rate arrangements, from relatively freely floating currencies such as the Japanese yen and Korean won, through various forms of managed floating, to the crawl-like arrangements of the Chinese yuan and Vietnamese dong and the basket-based framework of the Singapore dollar (Ilzetzi et al., 2019). This institutional heterogeneity reduces the plausibility of a single domestic explanation for region-wide exchange-rate pressure. At the same time, the region has repeatedly experienced clustered depreciations against the U.S. dollar during periods of broad dollar strength. That combination of cross-country heterogeneity and recurrent regional synchronization makes Asia-10 a natural laboratory for distinguishing between common dollar-driven movements and

residual currency-specific dynamics.

This paper examines whether recent depreciation episodes in Asian currencies exhibit signs of statistical explosiveness and, if so, how those episodes should be interpreted once broad dollar movements are explicitly taken into account. We apply the generalized supremum augmented Dickey–Fuller (GSADF) test of [Phillips et al. \(2015\)](#) to the currencies of ten East and Southeast Asian economies over 2006–2025. The GSADF framework is well suited to this setting because exchange-rate pressure need not take the form of a single sustained episode; explosive dynamics may instead arise in recurrent, short-lived bursts separated by partial reversals. Our empirical strategy compares GSADF evidence across three measures of exchange-rate displacement: the raw nominal bilateral rate, a PPP-adjusted misalignment measure, and a measure adjusted for fluctuations in the U.S. Dollar Index (DXY). This design makes it possible to trace how the incidence and synchronization of explosive episodes change once relative-price movements and, more importantly, the common dollar component are filtered out. Our baseline adopts a no-drift specification so that persistent depreciations are not absorbed mechanically by a deterministic component.

The paper is motivated by a gap between two strands of the literature that have rarely been brought together explicitly. On one side, recursive ADF and GSADF studies have provided increasingly sophisticated tools for detecting explosive exchange-rate behavior, but most applications continue to evaluate explosiveness using raw bilateral U.S.-dollar exchange rates. On the other side, the global financial cycle literature implies that those same bilateral rates contain a strong common component associated with broad dollar conditions. The resulting tension is straightforward but important: if the benchmark series itself embeds a powerful common external force, then GSADF detections based on that series may overstate the extent of currency-specific instability. Existing work has not systematically examined how exchange-rate explosiveness inferences change when the benchmark is redefined to remove broad dollar movements. This paper addresses that omission directly.

We find recurrent episodes of statistically explosive depreciation across the region, but their interpretation depends crucially on benchmark choice. The raw bilateral measure exhibits its broadest clustering during the 2015–2017 normalization cycle, whereas the PPP-based measure records its sharpest regional burst in 2022. By contrast, regional clustering weakens markedly after DXY adjustment. The attenuation is especially clear in the two windows that bracket the main region-wide depreciation

waves. Over 2013–2019, explosive currency-months fall from 242 in the raw bilateral measure to 43 in the PPP-based measure and to 38 in the DXY-adjusted measure. Over 2020–2025, they fall from 143 in the raw bilateral measure and 117 in the PPP-based measure to 34 after DXY adjustment. Taken together, these patterns indicate that much of the broad, synchronized depreciation observed across East and South-east Asia is better understood as the regional manifestation of the global dollar cycle than as a common wave of currency-specific instability.

This paper makes three contributions. First, it offers a substantive reinterpretation of exchange-rate explosiveness in Asia by showing that much of the apparent region-wide clustering in bilateral U.S.-dollar exchange rates reflects common dollar-driven regional pressure rather than simultaneous episodes of currency-specific instability. Second, it delineates the boundary of that interpretation. Once broad dollar movements are removed, the later-sample evidence is no longer region-wide but concentrated mainly in JPY and, more briefly, KRW, pointing to a much narrower residual set of country-specific mechanisms. Third, it shows that benchmark construction fundamentally shapes GSADF-based inference in exchange-rate applications. Relative to recursive ADF studies on raw bilateral U.S.-dollar rates, including [Bettendorf and Chen \(2013\)](#) and [Hu and Oxley \(2017\)](#), the paper demonstrates that inferences about the timing, breadth, and persistence of explosive episodes depend materially on whether broad dollar movements are explicitly removed.

The policy implication follows directly from this reinterpretation. If synchronized explosive depreciations mainly reflect common dollar shocks, the relevant policy margin is not to treat each bilateral depreciation wave as a separate domestic crisis requiring level defense. Rather, the emphasis should fall on resilience to global tightening through reserve adequacy, FX liquidity management, hedging capacity, and macroprudential buffers that slow the transmission of external dollar shocks to domestic balance sheets and financial conditions.

The remainder of the paper is organized as follows. Section [2](#) reviews the related literature. Section [3](#) describes the exchange-rate dynamics for Asian currencies. Section [4](#) presents the empirical methodology. Section [5](#) reports the empirical results, including robustness checks. Section [6](#) concludes.

2 Related Literature

This paper relates to two strands of the literature: the empirical detection of explosive dynamics in exchange rates using recursive unit root tests, and the broader literature on the global financial cycle and the international role of the U.S. dollar. The paper’s contribution lies in bringing these two literatures into direct conversation through the interpretation of benchmark-sensitive GSADF evidence.

The first strand concerns recursive testing for explosiveness. [Phillips et al. \(2011\)](#) develop the supremum ADF (SADF) procedure, while [Phillips et al. \(2015\)](#) extend it to the generalized supremum ADF (GSADF) framework by allowing both the start and endpoint of the recursive estimation window to vary, thereby improving power against multiple short-lived explosive episodes separated by periods of mean reversion. This extension is especially relevant for exchange rates, where pressure often emerges in recurrent bursts rather than in a single uninterrupted episode. Applications to exchange rates include [Bettendorf and Chen \(2013\)](#), who study the sterling–dollar rate and show that evidence of explosiveness becomes less straightforward to interpret once economically meaningful benchmarks are considered, and [Hu and Oxley \(2017\)](#), who apply the GSADF framework to a broader set of G10 and emerging-market currencies and show that evidence of exchange-rate bubbles is more pronounced in some emerging-market cases than in mature G10 currencies, while also depending on specification choices. More recent work has emphasized inference under time-varying volatility. [Phillips and Shi \(2020\)](#) propose a wild-bootstrap implementation of the PSY procedure designed to mitigate the effects of unconditional heteroskedasticity and to account for the multiplicity issue inherent in recursive testing. Despite these advances, most exchange-rate applications still test explosiveness using raw bilateral U.S.-dollar exchange rates, so detected explosiveness is typically interpreted at the currency level even when the underlying series may contain a substantial common dollar component.

The second strand emphasizes precisely that common component. [Rey \(2015\)](#) argues that U.S. monetary policy and global risk appetite generate a global financial cycle that synchronizes capital flows, leverage, and asset prices across countries. [Miranda-Agrippino and Rey \(2020\)](#) document a dominant global factor in risky asset returns closely linked to U.S. monetary conditions, while [Bruno and Shin \(2015\)](#) identify dollar-denominated bank lending as an important transmission channel through

which U.S. monetary tightening is propagated internationally. [Gopinath et al. \(2020\)](#) further show that the dollar’s role as the dominant invoicing and pricing currency gives dollar fluctuations systemic reach well beyond bilateral trade relationships. Taken together, these studies imply that bilateral U.S.-dollar exchange rates are not merely currency-specific relative prices; they also embed broad movements in global dollar conditions.

The present paper contributes to these literatures by bringing benchmark choice to the center of interpretation. Rather than treating explosiveness detected in bilateral U.S.-dollar exchange rates as directly informative about currency-specific instability, it evaluates how that inference changes once two alternative filters are applied: a PPP-based adjustment for relative-price movements and, more importantly, a DXY-based adjustment for the common dollar factor. In this respect, the paper is closest in spirit to [Bettendorf and Chen \(2013\)](#), which emphasizes the importance of economically meaningful benchmarks, but it extends that insight to a regional panel of Asian currencies and links it directly to the global dollar cycle literature. The central issue is therefore not simply whether explosive depreciation can be detected, but how detected explosiveness should be interpreted once benchmark construction becomes more economically informative.

3 Exchange Rate Dynamics and Stylized Facts in East and Southeast Asia

Section 2 highlighted that bilateral U.S.-dollar exchange rates may reflect both currency-specific dynamics and a strong common dollar component. Before turning to the formal GSADF tests, this section documents the main descriptive regularities in the Asia-10 sample. The objective is not to infer explosiveness from visual inspection alone, but to establish the empirical patterns that motivate the subsequent econometric analysis. In particular, the discussion focuses on the extent of regional comovement with broad dollar cycles, whether recent depreciation pressures are exceptional or instead part of a recurrent pattern, and the extent to which cross-country differences reflect persistence rather than amplitude alone. [Figure 1](#) presents the full-sample regional pattern over 2006–2025, while [Figures 2 and 3](#) compare bilateral

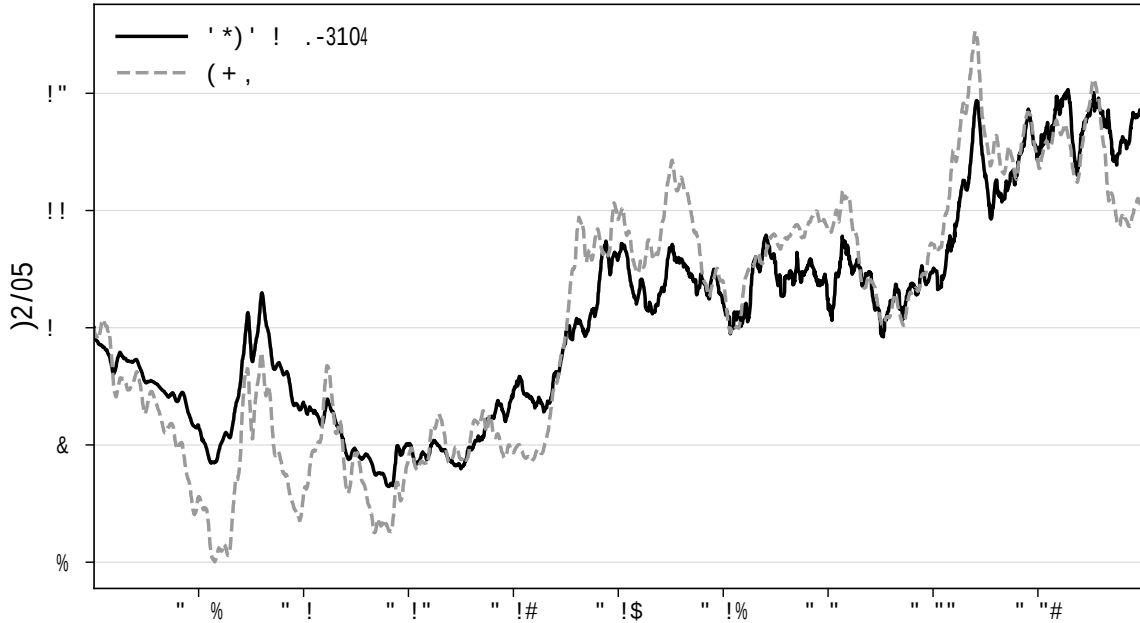
dynamics and depreciation persistence across 2013–2019 and 2020–2025.¹

Figure 1 plots an equal-weighted Asia-10 currency basket against the U.S. Dollar Index (DXY) using daily data rebased to January 3, 2006 = 100 and smoothed with a 20-business-day moving average. Two features stand out. First, the Asia-10 basket co-moves closely with the dollar index over the full sample, with a level correlation of 0.94 over 2006–2025, indicating that regional exchange-rate movements contain a substantial common component. The correspondence is especially visible during the 2015–2016 dollar upswing associated with the early phase of Federal Reserve normalization, and again during the sharp tightening episode of 2022. In both cases, broad dollar appreciation coincides with synchronized weakening of Asian currencies against the U.S. dollar. This pattern is consistent with the global financial cycle view, under which U.S. monetary conditions and global risk sentiment generate common financial fluctuations across open economies (Rey, 2015, Bruno and Shin, 2015, Miranda-Agrippino and Rey, 2020). Second, the relationship is strong but not mechanical. After the late-2022 peak, the DXY retraces part of its rise, yet the Asia-10 basket remains elevated relative to its pre-tightening level through much of the remaining sample. This incomplete reversal suggests that global dollar conditions are an important, but not exhaustive, part of the story.

Figure 2 turns from the regional aggregate to cross-country dynamics. To preserve readability while capturing the main regional depreciation waves emphasized later in the GSADF results, the figure is split into two panels: Panel (a) covers 2013–2019 and Panel (b) covers 2020–2025. This split shows that broad-based Asian currency weakness is not unique to the most recent years. In Panel (a), most currencies display a noticeable upward shift—that is, depreciation against the U.S. dollar—around 2015–2016, but the amplitudes differ materially across economies. Regional pressure emerged earlier during the 2013 Taper Tantrum, when the Indonesian rupiah and Japanese yen weakened by 17.3% and 11.3% against the dollar, respectively, within a few months of the Federal Reserve’s first tapering signal, while the Malaysian ringgit

¹These two windows are chosen to bracket the two major region-wide depreciation waves that dominate the full-sample pattern: the taper-tantrum/normalization cycle centered on 2015–2016 and the post-pandemic tightening cycle centered on 2022. Starting the first window in 2013 captures the initial regional stress following the Federal Reserve’s taper signal, while ending it in 2019 leaves sufficient post-episode observations to assess the degree of retracement prior to the pandemic shock. The 2020–2025 window then provides a natural counterpart for the subsequent tightening cycle. This partition also anticipates the formal evidence reported in Section 5, where synchronized explosive depreciation is most prevalent around 2016 and 2022.

Figure 1: Asia-10 Currency Basket and the U.S. Dollar Index (DXY)



Notes: Daily series are rebased to January 3, 2006 = 100. The Asia-10 basket is the equal-weighted average of bilateral USD exchange-rate indices for China, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand, and Vietnam, computed on common trading days (balanced panel). A 20-business-day moving average is applied to emphasize persistent comovement. Higher values indicate either a stronger U.S. dollar (DXY) or a weaker Asia-10 currency basket against the U.S. dollar.

and Philippine peso also registered initial pressure of 6.9% and 7.5%. Depreciation intensified through the 2015–2016 normalization cycle, with the DXY reaching a cycle peak of 102.0 in December 2016. Over the 2013–2019 window as a whole, Malaysia and Indonesia record particularly large cumulative increases, whereas Japan and Korea display sharp mid-window run-ups that are only partly sustained. Thailand and Taiwan, by contrast, show more limited end-of-period depreciation despite visible interim stress. The 2013–2019 episode is therefore best viewed as a region-wide but heterogeneous depreciation wave.

Panel (b) of Figure 2 shows that the 2020–2025 period contains an even more synchronized regional run-up, concentrated around 2022. Nearly all currencies weaken against the dollar as global inflation pressures and aggressive U.S. monetary tightening strengthen the dollar cycle. Yet the post-shock trajectories diverge substantially. The Japanese yen displays by far the largest and most persistent depreciation over the period, ending the sample 42.7% above its January 2020 level. The Korean won and

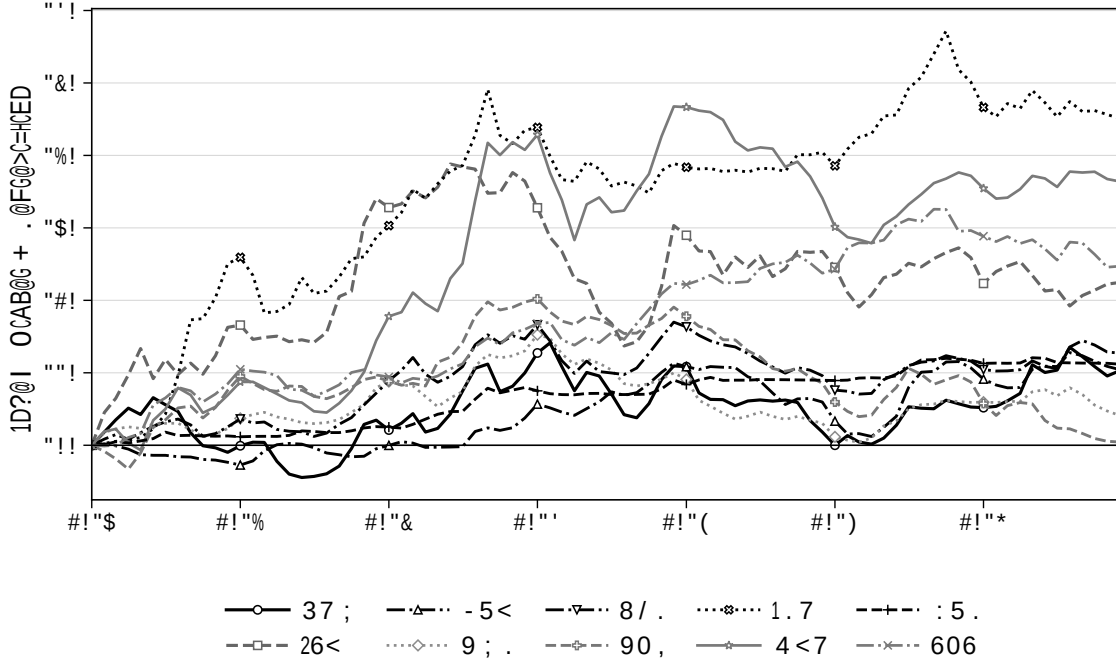
Indonesian rupiah also remain markedly weaker at the end of the sample, with cumulative depreciations of 25.7% and 21.7%, respectively. By contrast, the Thai baht and Malaysian ringgit experience substantial interim weakness but more pronounced subsequent retracement, while the Singapore dollar is distinctive in eventually ending the sample 4.5% stronger than its January 2020 benchmark despite a visible depreciation phase around 2022. These differences are substantively important because currencies may share the same regional shock yet differ sharply in the extent to which that shock is absorbed, reversed, or propagated over time.

Figure 3 summarizes the distinction between amplitude and persistence more directly by comparing, for each currency and each subperiod, the end-of-period cumulative depreciation with the maximum cumulative depreciation reached at any point within the same window. In the 2013–2019 window, several currencies exhibit sizable peak–end gaps, indicating that exchange-rate pressure intensified during the 2015–2016 episode but was at least partly reversed thereafter. This pattern is especially visible for Thailand, Taiwan, and Japan, where the within-window peak depreciation of 20.2%, 15.3%, and 38.8%, respectively, exceeds the end-of-period change of 0.5%, 4.1%, and 22.5% by a non-trivial margin. By contrast, Malaysia, Indonesia, and the Philippines end the 2013–2019 period noticeably weaker than at the start of the window, with end-of-period cumulative depreciations of 36.4%, 45.1%, and 24.7%, implying that a larger share of their depreciation was carried through to the end of the subperiod. Thus, even within a common regional wave, some currencies display temporary stress while others exhibit more durable repricing.

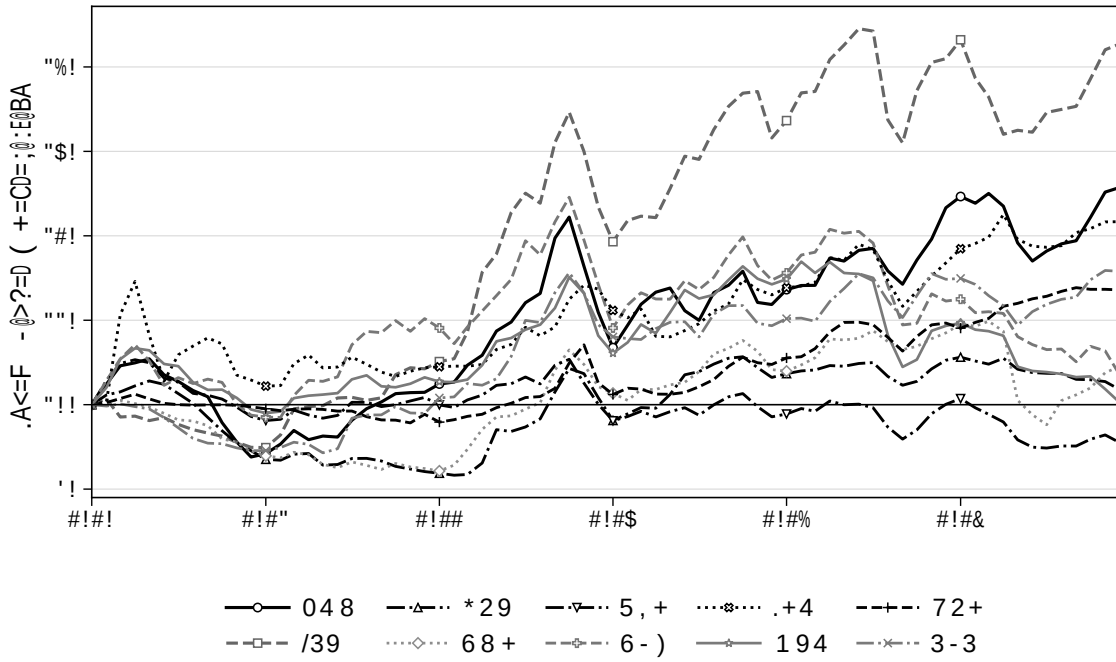
The contrast is sharper in the 2020–2025 window. Japan combines a very large cumulative depreciation of 42.7% with a negligible peak–end gap of 1.8 percentage points, indicating that most of the depreciation persisted rather than being rapidly unwound. Korea and Indonesia show a similar, though less extreme, pattern, with peak–end gaps of 0.0 and 0.8 percentage points, respectively. By contrast, Thailand and Malaysia display much larger peak–end gaps of 21.0 and 16.7 percentage points: both currencies undergo substantial depreciation during the 2022 episode, yet a meaningful part of that weakness is subsequently reversed. The Singapore dollar is again an informative benchmark case. Its peak level of 5.4% above the January 2020 baseline indicates that it was not insulated from the regional dollar shock, but its end-of-period change of -4.5% shows that the shock was ultimately more than offset over the remainder of the sample. Taken together, Figure 3 suggests that the main

Figure 2: Asia-10 Bilateral Exchange-Rate Indices against the U.S. Dollar

(a) 2013–2019



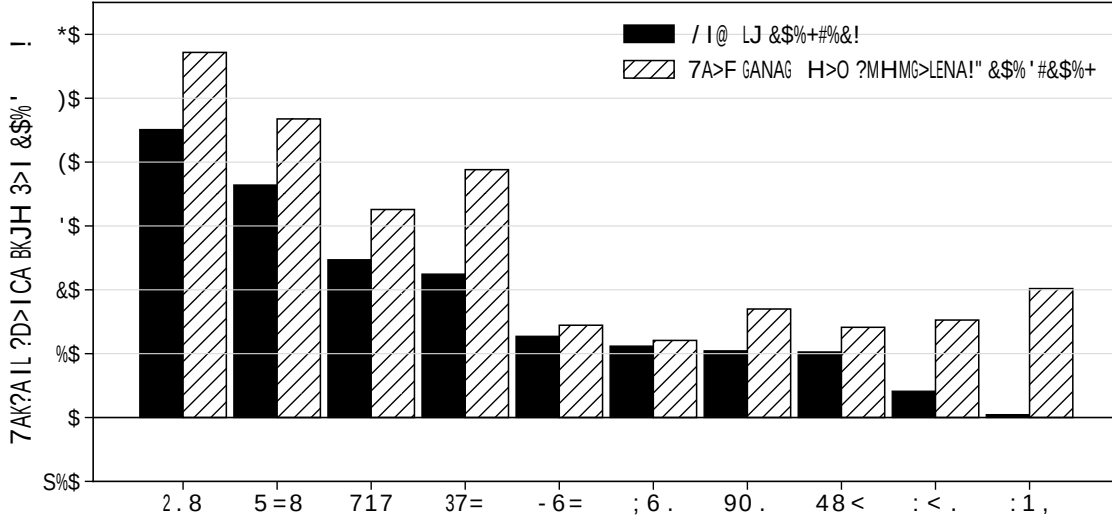
(b) 2020–2025



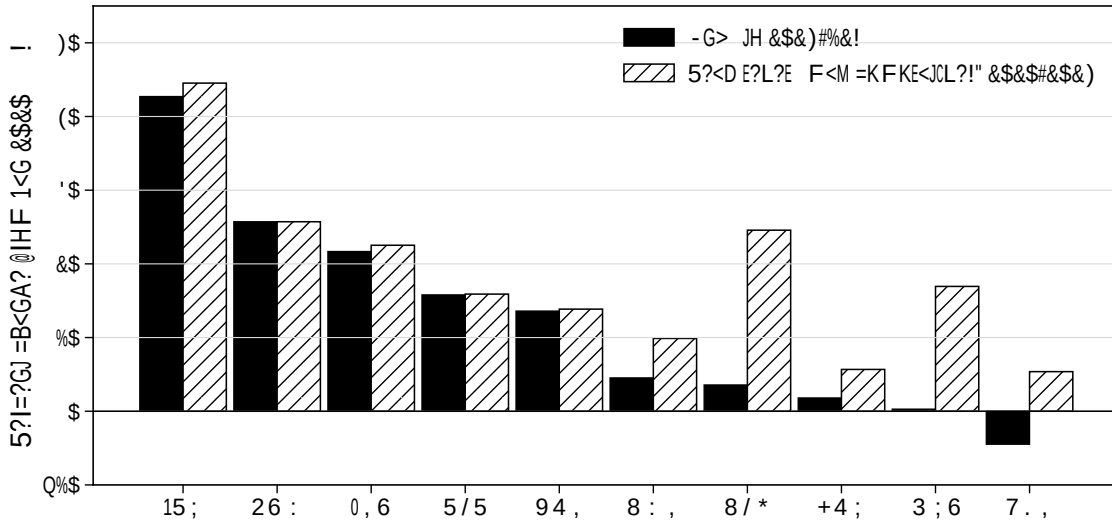
Notes: Monthly averages of bilateral nominal exchange rates (local currency units per U.S. dollar) are converted into index form. In panel (a), each series is rebased to January 2013 = 100; in panel (b), each series is rebased to January 2020 = 100. Formally, $I_{i,t} = 100 \times \bar{S}_{i,t} / \bar{S}_{i,0}$, where the base month 0 is panel-specific. Higher values indicate depreciation against the U.S. dollar.

Figure 3: Cumulative and Peak Depreciation of Asia-10 Currencies against the USD

(a) 2013–2019



(b) 2020–2025



Notes: Based on monthly averages. In panel (a), solid bars report the cumulative percent change from January 2013 to December 2019, while hatched bars report the maximum cumulative depreciation reached at any point during 2013–2019, both relative to January 2013. In panel (b), solid bars report the cumulative percent change from January 2020 to December 2025, while hatched bars report the maximum cumulative depreciation reached at any point during 2020–2025, both relative to January 2020. Negative values indicate net appreciation relative to the panel-specific base month.

cross-country difference lies not merely in the amplitude of depreciation at the height of stress, but in the persistence of those movements once the immediate dollar shock subsides.

Taken together, the three figures point to three stylized facts. First, East and Southeast Asian bilateral exchange rates contain a strong common component linked to broad dollar movements. Second, visually salient regional depreciation waves are not confined to the post-pandemic period; a comparable, though not identical, cluster is also evident around 2015–2016. Third, the currencies differ not only in the amplitude of depreciation but also in its persistence, with Japan, Korea, and Indonesia standing out as cases of more durable weakness in the later window, while others exhibit larger partial reversals. These descriptive patterns are suggestive of episodic, synchronized, but heterogeneous deviations in exchange-rate dynamics.

At the same time, visual inspection alone cannot determine whether these run-ups constitute statistically identifiable episodes of right-tailed explosiveness or merely large but ultimately stationary adjustments to common external shocks, nor can it reveal how much of the apparent instability in raw bilateral exchange rates reflects currency-specific factors as opposed to the common dollar cycle. These issues require formal testing. The next section therefore introduces the GSADF framework used to test the raw bilateral exchange rate, the PPP-based misalignment measure, and the DXY-adjusted measure for episodic explosiveness and to date the corresponding episodes across the Asia-10.

4 Empirical Methodology

4.1 Exchange Rates, Fundamentals, and Explosive Dynamics

We allow the nominal exchange rate to contain an explosive deviation from a benchmark value. Following the standard asset-pricing framework, the exchange rate can be decomposed as

$$s_t = s_t^f + e_t \tag{1}$$

where s_t denotes the logarithm of the nominal exchange rate, s_t^f represents the equilibrium exchange rate determined by economic fundamentals, and e_t is a residual component that may display explosive behavior.

The residual component is assumed to follow

$$e_t = (1 + \rho)e_{t-1} + \varepsilon_t \quad (2)$$

where $\rho > 0$ and ε_t is an error. Under this specification, the residual component follows an explosive autoregressive process, with an autoregressive root greater than unity. As a result, the observed exchange rate may exhibit locally explosive behavior over some subsamples.

In what follows, however, the term *statistical explosiveness* is used in a deliberately statistical rather than structural sense. A GSADF rejection identifies temporary right-tailed explosiveness in the observed exchange-rate series or in a benchmark-adjusted deviation from fundamentals; it does not, by itself, distinguish among speculative expectations, policy-regime shifts, discrete administrative devaluations, or other mechanisms that may also generate locally explosive behavior. For that reason, the empirical objective of the paper is to detect and date episodes of *statistical explosiveness* and then interpret their sensitivity to alternative benchmark definitions.

The specification of the benchmark component s_t^f depends on the economic benchmark used in the analysis. In this paper we consider three alternative specifications. First, s_t^f can be treated as a constant, in which case the nominal exchange rate itself is tested for explosive dynamics. Second, s_t^f is defined by price differentials between the domestic economy and the United States, consistent with the purchasing power parity (PPP) framework. Third, s_t^f incorporates a common dollar factor proxied by the U.S. Dollar Index (DXY), which captures broad dollar movements and the external financial environment shared by all bilateral exchange rates in the sample.

To make these alternatives operational, let $S_{i,t}$ denote the bilateral nominal exchange rate (local currency units per U.S. dollar), P_t^{US} the U.S. price index, $P_{i,t}$ the domestic price index, and DXY_t the U.S. Dollar Index. We then examine three variables:

$$x_{i,t}^N = \log S_{i,t}, \quad (3)$$

$$x_{i,t}^{PPP} = \log S_{i,t} + \log P_t^{US} - \log P_{i,t}, \quad (4)$$

$$x_{i,t}^{DXY} = \log S_{i,t} - \log DXY_t. \quad (5)$$

The raw nominal rate $x_{i,t}^N$ captures bilateral depreciation against the U.S. dollar in

its most direct form. The PPP-based measure $x_{i,t}^{PPP}$ evaluates exchange-rate pressure relative to a relative-price benchmark, while the DXY-adjusted measure $x_{i,t}^{DXY}$ isolates exchange-rate pressure relative to the global dollar cycle rather than merely against the dollar in absolute terms. This three-way comparison is central to the empirical design: if apparent explosiveness in the raw or PPP-based measure weakens materially once DXY_t is removed, the evidence points to a dominant common dollar factor rather than to a purely idiosyncratic currency-specific mechanism.

4.2 The GSADF Test

To examine whether exchange rate movements exhibit episodically explosive behavior, we employ the generalized supremum augmented Dickey–Fuller (GSADF) test developed by [Phillips et al. \(2015\)](#). The procedure is well suited to the present application because exchange-rate pressure need not take the form of a single sustained episode; instead, it may arise in recurrent bursts separated by partial corrections. Recursive right-tailed tests are designed to detect and date such episodic departures from unit-root behavior. The empirical strategy interprets those detections across benchmark definitions. Rather than treating every rejection in a raw bilateral exchange rate as direct evidence of a currency-specific source of explosiveness, we examine whether the timing and duration of detected episodes survive progressively stricter benchmark adjustments.

Let x_t denote the time series variable of interest at time t . In the baseline specification, a rise in x_t corresponds to a depreciation of the domestic currency against the U.S. dollar. Following the recursive ADF framework, we estimate

$$\Delta x_t = d_{r_1, r_2} + \beta_{r_1, r_2} x_{t-1} + \sum_{j=1}^k \psi_{j, r_1, r_2} \Delta x_{t-j} + \varepsilon_t, \quad (6)$$

over subsamples indexed by the fractional window $[r_1, r_2]$, where $0 \leq r_1 < r_2 \leq 1$. The null hypothesis is a unit root, $H_0 : \beta_{r_1, r_2} = 0$, against the right-tailed alternative of local explosiveness, $H_1 : \beta_{r_1, r_2} > 0$. For each estimation window, the corresponding right-tailed ADF statistic is denoted by $ADF_{r_1}^{r_2}$. Because an increase in each benchmark variable corresponds to a stronger U.S. dollar or a weaker domestic currency, the right-tailed alternative is directly aligned with the notion of explosive depreciation.

Two deterministic specifications are considered. In the baseline *no-drift* specifica-

tion, $d_{r_1, r_2} = 0$. In the alternative *drift* specification, $d_{r_1, r_2} = \alpha_{r_1, r_2}$ is estimated freely. This distinction is economically important in exchange-rate applications because including a constant can make the right-tailed test more conservative by absorbing part of a gradual upward shift that might otherwise contribute to explosive detection (Hu and Oxley, 2017). For transparency, the baseline results are reported under the no-drift specification, while drift-inclusive results are used to assess whether the paper’s central inference remains robust across benchmark definitions.

The GSADF statistic generalizes the SADF test by allowing both the starting point and the endpoint of the recursive window to vary, rather than fixing the initial observation at the beginning of the sample.² The resulting GSADF statistic is given by

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ r_1 \in [0, r_2 - r_0]}} \{ADF_{r_1}^{r_2}\}. \quad (7)$$

For episode dating, we use the backward SADF sequence,

$$BSADF_{r_2}(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} \{ADF_{r_1}^{r_2}\}, \quad (8)$$

and date an episode as beginning when the *BSADF* statistic first exceeds its corresponding pointwise critical value and as ending when it subsequently falls below that threshold. In the empirical implementation, the paper focuses on positive episodes because the object of interest is explosive depreciation, and the minimum episode duration is set to one month.

The GSADF procedure is designed to identify locally explosive behavior, and the economic interpretation therefore turns on how detections change across the three benchmark variables. The discussion in Section 5 accordingly places greatest weight on the pattern of attenuation across benchmarks.

4.3 Data and Model Specification

The empirical analysis focuses on bilateral nominal exchange rates against the U.S. dollar for ten East and Southeast Asian economies: China, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Thailand, Taiwan, and Vietnam. Daily

²The SADF test of Phillips et al. (2011) is nested as the special case in which the recursive window always begins at the start of the sample.

exchange rate data are obtained from Bloomberg and converted to monthly frequency by taking monthly averages. The sample period spans January 2006 to December 2025. The exchange rate variable is defined as the logarithm of the domestic currency price of one U.S. dollar, so that an increase in the series corresponds to a depreciation of the domestic currency.

The benchmark variables in equations (4) and (5) are constructed on the same monthly calendar as the exchange-rate data. The PPP-based series uses the domestic CPI and the U.S. CPI to proxy the relative-price component, yielding a real-misalignment measure $\log(S_{i,t}P_t^{US}/P_{i,t})$. The DXY-adjusted series is defined as $\log S_{i,t} - \log DXY_t$, where DXY_t corresponds to the ICE U.S. Dollar Index obtained from Bloomberg. All constituent series are converted to monthly averages prior to construction.

The GSADF test is implemented with a parsimonious no-lag structure ($k = 0$) in the recursive ADF regressions. As noted by [Bettendorf and Chen \(2013\)](#), overfitting the lag order may reduce the power of right-tailed unit root tests and distort their finite-sample size. The minimum window size follows the data-dependent rule of [Phillips et al. \(2015\)](#),

$$m_0 = \left\lfloor \left(0.01 + \frac{1.8}{\sqrt{T}} \right) T \right\rfloor, \quad (9)$$

where T is the total number of monthly observations. For the full 2006–2025 sample of $T = 240$ months, this yields $m_0 = 36$ months. Baseline critical values are obtained using the wild-bootstrap procedure proposed by [Phillips and Shi \(2020\)](#), which is designed to lessen the effects of unconditional heteroskedasticity and to account for the multiplicity problem in recursive testing. Monte Carlo critical values are retained for appendix material and robustness comparisons, but the tables and figures in the main text are anchored to the no-drift, no lag, and wild-bootstrap design.

As described above, the main text emphasizes the no-drift, no lag, and wild-bootstrap baseline; a later robustness subsection within Section 5 reports drift-inclusive results, alternative lag choices, and the no-drift Monte Carlo benchmark. The central empirical claim is that synchronized explosiveness is prominent in the raw and PPP-based measures around the main dollar-tightening episodes, but attenuates materially once the DXY component is removed.

4.4 Benchmark-Based Interpretation Strategy

The paper’s interpretation strategy relies on benchmark variation. The GSADF test is applied to the same currency under three benchmark definitions, and differences in episode timing and duration are used to infer whether detected explosiveness primarily reflects raw bilateral depreciation, relative-price misalignment, or the common dollar factor. The first comparison is between the raw nominal rate and the PPP-based measure. If explosiveness appears in both, the evidence is less likely to be an artifact of nominal bilateral scaling alone. The second, and more important, comparison is between the raw or PPP-based measure and the DXY-adjusted measure. If an episode is prominent in $x_{i,t}^N$ or $x_{i,t}^{PPP}$ but weakens materially in $x_{i,t}^{DXY}$, the evidence points to a broad dollar shock common to many bilateral rates. If, by contrast, explosiveness survives DXY adjustment, the residual episode is more plausibly associated with country-specific or regional forces that lie beyond the common dollar cycle.

This strategy also helps discipline the interpretation of mechanically strong detections in raw nominal rates. In some currencies, especially under managed or crawling arrangements, a long sequence of positive monthly changes in the raw bilateral rate may produce lengthy detections under no-drift specifications. Such findings are still informative, but they should not automatically be read as evidence of a country-specific explosive depreciation episode. For that reason, the discussion in Section 5 places greatest weight on patterns that are economically interpretable across benchmarks: synchronized explosiveness around common dollar-tightening episodes in the raw and PPP-based measures, substantial attenuation after DXY adjustment, and a narrower set of residual episodes that remain after the common dollar component is removed.

Accordingly, the key empirical question for the next section is not whether some explosive-looking episodes can be found in the Asia-10 sample. Rather, it is whether the broad synchronization documented in Section 3 continues to appear once one moves from the raw bilateral rate to benchmark-adjusted measures. The next section applies this benchmark-based framework to the Asia-10 sample and evaluates the resulting episode patterns across the three benchmark definitions.

5 Main Results

5.1 Baseline Episode Dating and Regional Synchronization

Figure 4 presents the main empirical results of the paper by summarizing the timing of explosive depreciation episodes across the 10 East and Southeast Asian currencies identified using the GSADF procedure. Each shaded cell indicates a month in which the corresponding currency is classified as exhibiting locally explosive depreciation under the baseline specification. Unless otherwise noted, the results in this section refer to the baseline no-drift, no lag design with wild-bootstrap critical values. The figure reports results under three alternative specifications of the benchmark variable: the nominal exchange rate itself, the PPP-based misalignment measure, and the misalignment measure adjusted for movements in the U.S. dollar index (DXY).

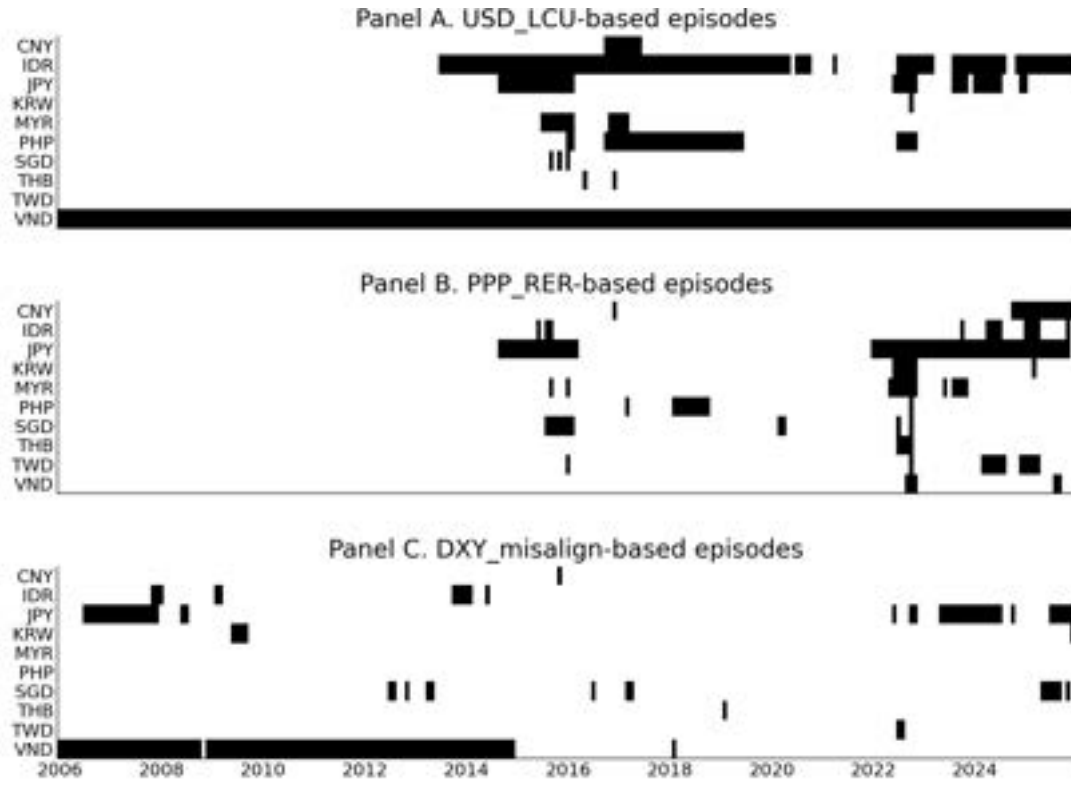
A striking feature of Figure 4 is the recurrence of synchronized explosive episodes around major dollar-tightening phases. In the raw USD/LCU block, synchronization rises sharply during the 2015–2017 normalization cycle, reaching six currencies in January and December 2016, and rises again to five currencies in October 2022. In the PPP-based block, the mid-2010s cluster is more limited, peaking at four currencies, but the 2022 burst is markedly sharper and broader, reaching eight currencies in October 2022. The DXY-adjusted block, by contrast, remains much sparser in both episodes. The figure therefore suggests that region-wide explosive depreciation is not purely idiosyncratic: it is episodic, synchronized, and closely aligned with broad external pressure.

5.2 Attenuation after DXY Adjustment

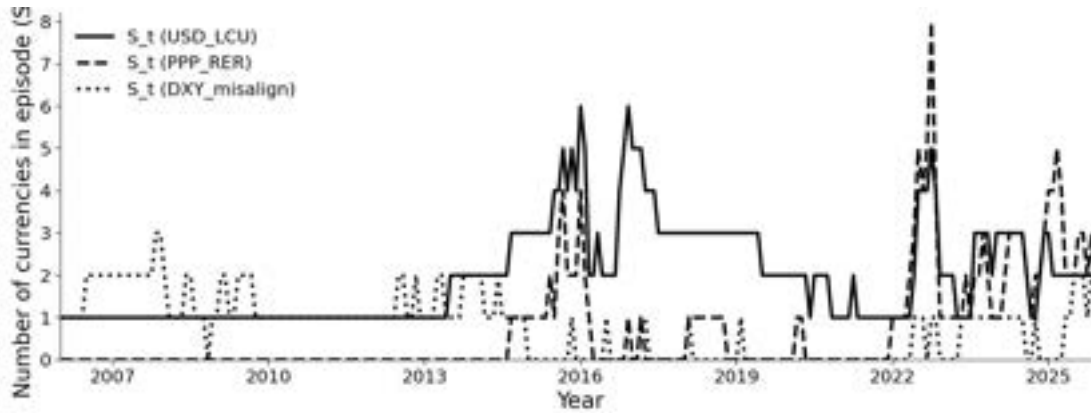
Regional synchronization weakens materially once the broad dollar cycle is removed. The visual attenuation in Figure 4 is complemented by the period-by-period incidence statistics in Table 1. The table combines the information previously separated across aggregate and country-level summaries and reports explosive currency-months for each currency, benchmark, and sample window.

Figure 4: Explosive Depreciation Episodes (Baseline: No Drift)

(a) By Currencies



(b) Number of Currencies in Episodes



Notes: A shaded cell indicates that the currency is classified as being in an explosive episode in that month under the baseline GSADF specification (no drift, wild-bootstrap critical values). Within each subfigure, the first block corresponds to the nominal USD/LCU measure, the second to the PPP-based misalignment measure, and the third to the DXY-adjusted measure.

Table 1: Explosive Currency-Months by Benchmark and Sample Period under the Baseline WB Specification

Currency	2006–2025			2013–2019			2020–2025		
	Raw	PPP	DXY	Raw	PPP	DXY	Raw	PPP	DXY
CNY	9 (3.8)	16 (6.7)	1 (0.4)	9 (10.7)	1 (1.2)	1 (1.2)	0 (0.0)	15 (20.8)	0 (0.0)
IDR	124 (51.7)	13 (5.4)	11 (4.6)	78 (92.9)	3 (3.6)	6 (7.1)	46 (63.9)	10 (13.9)	0 (0.0)
JPY	37 (15.4)	66 (27.5)	45 (18.8)	18 (21.4)	19 (22.6)	0 (0.0)	19 (26.4)	47 (65.3)	25 (34.7)
KRW	1 (0.4)	7 (2.9)	5 (2.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.4)	7 (9.7)	1 (1.4)
MYR	13 (5.4)	14 (5.8)	0 (0.0)	13 (15.5)	2 (2.4)	0 (0.0)	0 (0.0)	12 (16.7)	0 (0.0)
PHP	40 (16.7)	11 (4.6)	0 (0.0)	35 (41.7)	10 (11.9)	0 (0.0)	5 (6.9)	1 (1.4)	0 (0.0)
SGD	3 (1.3)	11 (4.6)	14 (5.8)	3 (3.6)	7 (8.3)	5 (6.0)	0 (0.0)	4 (5.6)	6 (8.3)
THB	2 (0.8)	4 (1.7)	1 (0.4)	2 (2.4)	0 (0.0)	1 (1.2)	0 (0.0)	4 (5.6)	0 (0.0)
TWD	0 (0.0)	13 (5.4)	2 (0.8)	0 (0.0)	1 (1.2)	0 (0.0)	0 (0.0)	12 (16.7)	2 (2.8)
VND	240 (100.0)	5 (2.1)	108 (45.0)	84 (100.0)	0 (0.0)	25 (29.8)	72 (100.0)	5 (6.9)	0 (0.0)
Total	469 (19.5)	160 (6.7)	187 (7.8)	242 (28.8)	43 (5.1)	38 (4.5)	143 (19.9)	117 (16.3)	34 (4.7)

Notes: Each entry reports explosive currency-months, with the corresponding within-period share in parentheses, under the baseline GSADF specification (no drift, no lag, wild-bootstrap critical values at the 95% level). For individual currencies, denominators are 240 months for 2006–2025, 84 months for 2013–2019, and 72 months for 2020–2025. In the total row, denominators are the corresponding counts of currency-month observations (2,400; 840; and 720). Detailed dated episodes for each benchmark variable and period are reported in Appendix Tables [A1–A3](#).

Table 1 shows that the attenuation result is clearest in the two windowed comparisons that bracket the main regional depreciation waves. Over 2013–2019, explosive currency-months fall from 242 in the raw measure to 43 in the PPP-based measure and to 38 in the DXY-adjusted measure. The sharp raw-to-PPP compression in that window suggests that much of the mid-2010s regional pressure operated through bilateral dollar strength rather than through a persistent region-wide real-misalignment signal. Over 2020–2025, by contrast, PPP adjustment leaves 117 explosive currency-months before DXY adjustment reduces the count to 34. In other words, the post-pandemic tightening wave contains a broader real-depreciation component than the mid-2010s episode, but much of its regional comovement still collapses once the common dollar factor is removed. This pattern is also visible in the synchronization index: during the 2022 tightening wave, the raw and PPP-based panels reach five and eight simultaneous currencies, respectively, whereas the DXY-adjusted index never exceeds one during calendar year 2022.

By contrast, the full 2006–2025 aggregate must be interpreted more carefully. Although the raw measure still produces the most detections (469 currency-months), the full-sample DXY-adjusted total (187) exceeds the PPP total (160). That inversion is driven overwhelmingly by VND, with a smaller contribution from SGD, rather than by a broad region-wide residual wave after DXY adjustment. PPP adjustment and DXY adjustment are not nested filters: the former removes relative-price differentials, whereas the latter removes the common dollar factor. Under more managed or basket-based exchange-rate paths, these two filters need not reduce detections in the same order. For that reason, the attenuation result across benchmarks is most informative when attention is focused on the two regional-depreciation windows highlighted in Section 3, rather than on an undifferentiated full-sample total that mixes distinct historical regimes.

Even within 2020–2025, attenuation is not confined to the initial 2022 shock. In March 2025, the PPP-based measure records five currencies simultaneously in explosive episodes, whereas the DXY-adjusted measure records none. More generally, the DXY-adjusted synchronization index never exceeds two currencies in any month of the 2020–2025 window. Purging the common dollar factor therefore removes not only the most obvious late-2022 cluster but also later bursts that would otherwise appear more regionally synchronized under the PPP benchmark.

Taken together, these comparisons indicate that much of the broad regional explo-

siveness visible in raw bilateral exchange rates and, in the later sample, in PPP-based exchange rates reflects the regional transmission of the global dollar cycle rather than a common wave of country-specific instability.

5.3 Country-Level Heterogeneity across Periods

The wide layout of Table 1 also makes clear that attenuation is strongly currency- and period-specific. In 2013–2019, the DXY-adjusted residual set is concentrated mainly in VND (25 months), IDR (6), and SGD (5), whereas the JPY cluster visible in the raw and PPP-based measures during 2014–2016 disappears once the common dollar factor is removed. Residual detections in VND and SGD should, however, be interpreted more cautiously than residual detections in more market-determined bilateral rates. Vietnam’s exchange-rate arrangement is classified by the IMF as de facto crawl-like and de jure managed floating, while Singapore’s monetary framework is centered on a trade-weighted S\$NEER basket-band-crawl system rather than on a bilateral U.S.-dollar peg ([International Monetary Fund, 2025](#), [Monetary Authority of Singapore, 2025](#)). In that setting, residual detections in VND and SGD need not carry the same interpretation as residual detections in freely floating currencies such as JPY or KRW.

The post-2020 residual map is very different. In 2020–2025, CNY, IDR, MYR, PHP, THB, and VND record zero DXY-adjusted months; KRW and TWD record only 1 and 2 months, respectively; SGD records 6; and JPY alone accounts for 25 DXY-adjusted months. The later-sample residual evidence is therefore not region-wide. It is concentrated overwhelmingly in the yen, with only very short-lived signals elsewhere. This is precisely why the 2020–2025 attenuation result is so informative: the broad regional synchronization visible in the raw and PPP-based panels collapses to a much narrower and more uneven residual set once the dollar factor is removed.

5.4 Late-2025 Residual Episodes

The most recent residual cluster is thin. Over 2025 Q4, the baseline DXY-adjusted set is JPY, KRW, and SGD, but these currencies do not carry the same empirical weight. JPY is present from July through December 2025 and dominates the later-sample residual evidence. KRW appears only in December 2025 under the baseline design. SGD is episodic and drops out once either a drift term or lag augmentation

is introduced. Given Singapore’s basket-based exchange-rate regime, the short-lived SGD signal is best read as a transient bilateral residual rather than as evidence of an independent late-sample episode.

For JPY, a plausible interpretation is that the residual episode reflects Japan-specific monetary-normalization frictions rather than the common dollar cycle. The Bank of Japan raised its policy rate to 0.75 percent in December 2025, but also stressed that real short-term interest rates remained significantly negative and that accommodative financial conditions were still being maintained (BOJ, 2026, pp. 9–10). In this setting, yen weakness can persist even after the common dollar component is removed, producing a residual DXY-adjusted signal that is both economically interpretable and statistically persistent.

For KRW, the evidence is thinner but not obviously random. The Bank of Korea has explicitly linked the divergence between the USD/KRW rate and the DXY in late 2025 to unusually strong resident overseas equity-investment demand and to expectations that the won would remain relatively weaker than peer currencies (BOK, 2026), while the U.S. Treasury highlighted public-pension diversification outflows and judged the won’s weakness difficult to reconcile with Korea’s strong fundamentals (U.S. Treasury, 2026, pp. 34–36). The brief KRW residual is therefore better read as a Korea-specific capital-flow and expectations episode than as part of a renewed region-wide dollar wave.

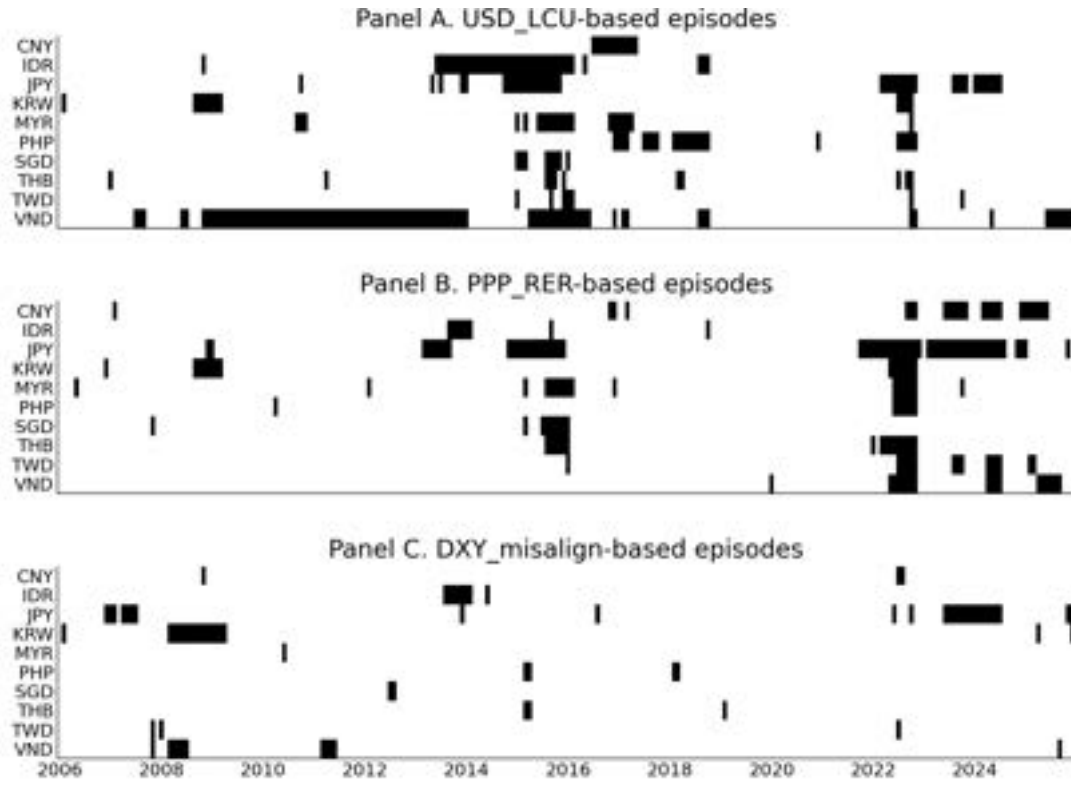
5.5 Robustness Checks

Drift-Inclusive Specification. As a robustness exercise, we re-estimate the GSADF tests by allowing for a deterministic intercept term in the recursive ADF regression while retaining the wild-bootstrap critical values. Figure 5 reports episode dating under this drift-inclusive specification.

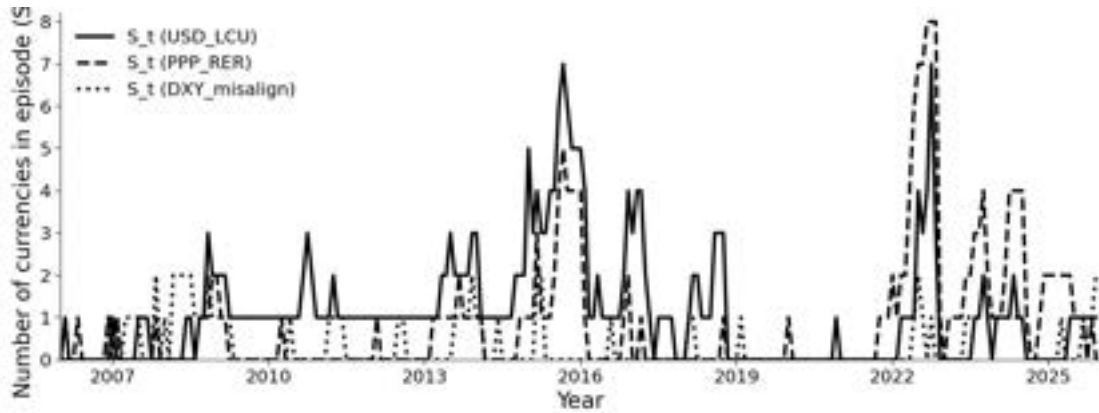
Allowing for an intercept does not simply thin all detections mechanically; instead, it changes what the test counts as explosive. Relative to the baseline wild-bootstrap design, raw nominal detections fall sharply—from 469 to 269 currency-months in the full sample and from 143 to 46 in 2020–2025—while DXY-adjusted detections also decline, from 187 to 79 in the full sample and from 34 to 24 in 2020–2025. PPP-based detections, however, rise modestly from 160 to 192 in the full sample and from 117 to 121 in 2020–2025, while peak synchronization remains 8 in the later window. The

Figure 5: Explosive Depreciation Episodes (Robustness: Drift-Inclusive)

(a) By Currencies



(b) Number of Currencies in Episodes



Notes: The figure reports drift-inclusive GSADF results with wild-bootstrap critical values. Within each subfigure, the first block corresponds to the nominal USD/LCU measure, the second to the PPP-based misalignment measure, and the third to the DXY-adjusted measure.

distinction reflects what the intercept absorbs. In the raw nominal rate, a drift term captures part of a slow and persistent bilateral depreciation crawl, so long one-sided movements no longer cross the explosive threshold unless they accelerate beyond that average trend. In the PPP-based measure, by contrast, relative-price adjustment has already stripped out part of that low-frequency drift. The intercept therefore removes less additional trend than in the raw series, while the remaining real-misalignment bursts around 2022 are short and sharp enough to remain detectable. In the present application, the drift-inclusive threshold is also lower than under the no-drift baseline, so some borderline PPP episodes cross the right-tailed threshold even as long nominal crawls are filtered out. This is why raw nominal detections fall sharply whereas PPP-based detections rise modestly.

Alternative Lag Lengths and Monte Carlo Critical Values. Table 2 summarizes peak synchronization across periods under the remaining alternative specifications.

Two results stand out. First, lag augmentation under wild-bootstrap critical values dramatically thins the PPP-based signal. In 2020–2025, the peak PPP synchronization falls from 8 under the baseline to 1 at lag 1 and remains only 1 at lag 3; in 2013–2019 it falls from 4 to 1 and 2, respectively. This suggests that much of the broad PPP-based co-occurrence is concentrated in low-order dynamics and is sensitive to richer short-run filtering. Economically, adding lags partials out more short-run serial correlation and uses degrees of freedom, so short synchronized bursts are less likely to cross the explosive threshold once richer short-run dynamics are admitted. The DXY-adjusted panel, by contrast, remains sparse throughout: its peak synchronization is 2 in the baseline later window, 1 at lag 1, and 2 at lag 3.

Second, switching from wild-bootstrap to Monte Carlo critical values densifies detections across all three sample windows. Peak synchronization rises to 7, 8, and 4 in the full sample and to 7, 8, and 4 in 2020–2025 for the raw, PPP-based, and DXY-adjusted measures, respectively. This does not imply that wild-bootstrap critical values are always more conservative in general. Rather, the wild-bootstrap and Monte Carlo procedures generate different critical-value surfaces once heteroskedasticity and recursive multiple testing are taken into account. In the present no-drift, no-lag application, the wild-bootstrap values are more conservative than the Monte Carlo values, so fewer months cross the explosive threshold. Importantly, however, the later-sample residual ranking is not overturned: JPY remains present in 2025 Q4

Table 2: Peak Synchronization across Sample Periods under Alternative Specifications

Specification	2006–2025			2013–2019			2020–2025		
	Raw	PPP	DXY	Raw	PPP	DXY	Raw	PPP	DXY
Baseline WB (no lag)	6	8	3	6	4	2	5	8	2
Drift WB (no lag)	7	8	2	7	5	2	7	8	2
No drift WB (lag 1)	3	1	2	3	1	0	1	1	1
No drift WB (lag 3)	3	2	3	3	2	1	2	1	2
No drift MC (no lag)	7	8	4	7	6	3	7	8	4

Notes: Entries report the maximum number of currencies simultaneously classified as explosive within each period. WB denotes wild-bootstrap critical values and MC denotes Monte Carlo critical values.

under all four alternative specifications considered, KRW survives the drift-inclusive wild-bootstrap and lag 3 wild-bootstrap variants, and SGD does not.

Taken together, the robustness exercises reinforce the same substantive conclusion. What varies across deterministic specifications, lag choices, and critical-value procedures is the exact density of detected episodes. What remains stable is that, in the windows centered on the main regional depreciation waves, the raw and PPP-based measures display much broader synchronization than the DXY-adjusted measure. The robustness exercises therefore strengthen the paper’s central inference: the synchronized depreciation episodes observed across East and Southeast Asia are driven predominantly by the global dollar cycle rather than by a common wave of country-specific instability.

6 Conclusion

This paper examines whether recurrent depreciation episodes in East and Southeast Asian currencies should be interpreted as separate episodes of currency-specific instability or as the regional manifestation of common dollar shocks. Using the GSADF test of [Phillips et al. \(2015\)](#), we study ten Asian currencies against the U.S. dollar over 2006–2025 under three benchmark definitions: the raw bilateral rate, a PPP-based misalignment measure, and a DXY-adjusted measure.

Three conclusions stand out. First, much of the apparent region-wide explosiveness in bilateral U.S.-dollar exchange rates is better understood as the regional

manifestation of the global dollar cycle than as a common wave of currency-specific instability. The key evidence is the sharp attenuation after DXY adjustment. Over 2013–2019, explosive currency-months fall from 242 in the raw measure to 43 in the PPP-based measure and to 38 in the DXY-adjusted measure; over 2020–2025, they fall from 143 in the raw measure and 117 in the PPP-based measure to 34 after DXY adjustment. During calendar year 2022, the raw and PPP-based panels reach peaks of five and eight simultaneous currencies, respectively, whereas the DXY-adjusted index never exceeds one. These comparisons indicate that a substantial share of the broad regional clustering observed in bilateral rates reflects common dollar-driven pressure.

Second, once broad dollar movements are removed, the remaining late-sample evidence is much narrower. The residual detections are concentrated mainly in JPY and, more briefly, KRW rather than in a renewed region-wide wave. These residual episodes should therefore be read as defining the boundary of the dollar-cycle interpretation rather than overturning it. The common dollar factor explains much of the broad regional synchronization, but it does not exhaust all remaining variation. The empirical focus consequently shifts from a putative region-wide episode to a smaller set of country-specific residual cases that warrant separate investigation.

Third, benchmark construction fundamentally shapes GSADF-based inference in exchange-rate applications. Explosive episodes are not identified independently of the benchmark against which exchange-rate pressure is measured; alternative benchmark definitions materially change their apparent timing, breadth, and persistence. For exchange-rate applications, benchmark choice is therefore part of the economic interpretation rather than a secondary robustness detail.

The policy implication follows directly. If synchronized explosive depreciations mainly reflect common dollar shocks, the relevant policy margin is not to treat each bilateral depreciation wave as a separate domestic crisis requiring level defense. Rather, the emphasis should fall on resilience to global tightening through reserve adequacy, FX liquidity management, hedging capacity, and macroprudential buffers that slow the transmission of external dollar shocks to domestic financial conditions. More broadly, the results suggest that analyses of regional exchange-rate stress should first separate common dollar movements from residual country-specific pressure before drawing conclusions about domestic vulnerability. Future research can build on this result by linking the remaining residual episodes to specific policy regimes, capital-flow structures, and regional spillover channels.

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A Appendix

Appendix Tables [A1–A3](#) report detailed baseline dated episodes for each benchmark variable and for each of the three sample windows emphasized in the main text. For ease of comparison, the appendix tables are organized by sample window, with Panel A reporting the raw nominal USD/LCU measure, Panel B the PPP-based measure, and Panel C the DXY-adjusted measure.

Appendix Figure [A1](#) collects the currency-level GSADF episode plots. Each panel corresponds to one currency and, within each page, the left-hand plots report the no-drift baseline while the right-hand plots report the drift-inclusive wild-bootstrap robustness. Appendix Figures [A2–A4](#) reserve space for the robustness heatmaps and synchronization graphs under the no-drift WB lag-1, no-drift WB lag-3, and no-drift MC no-lag specifications, respectively.

Table A1: Detailed Baseline Episodes, 2006–2025 — Panel A. Raw Nominal USD/LCU Measure

Currency	Months	Share (%)	Dated episodes
CNY	9/240	3.8	2016M10–2017M06 (9)
IDR	124/240	51.7	2013M07–2020M05 (83); 2020M07–2020M10 (4); 2021M04–2021M04 (1); 2022M07–2023M03 (9); 2023M08–2024M08 (13); 2024M11–2025M12 (14)
JPY	37/240	15.4	2014M09–2016M02 (18); 2022M06–2022M11 (6); 2023M08–2023M11 (4); 2024M01–2024M07 (7); 2024M12–2025M01 (2)
KRW	1/240	0.4	2022M10–2022M10 (1)
MYR	13/240	5.4	2015M07–2016M02 (8); 2016M11–2017M03 (5)
PHP	40/240	16.7	2016M01–2016M02 (2); 2016M10–2019M06 (33); 2022M07–2022M11 (5)
SGD	3/240	1.3	2015M09–2015M09 (1); 2015M11–2015M11 (1); 2016M01–2016M01 (1)
THB	2/240	0.8	2016M05–2016M05 (1); 2016M12–2016M12 (1)
TWD	0/240	0.0	
VND	240/240	100.0	2006M01–2025M12 (240)
Total	469/2400	19.5	

Notes: Baseline GSADF date-stamping uses the no-drift, no lag, wild-bootstrap specification at the 95% level. Episode dates are clipped to the corresponding sample window.

Table A1: Detailed Baseline Episodes, 2006–2025 — Panel B. PPP-Based Measure

Currency	Months	Share (%)	Dated episodes
CNY	16/240	6.7	2016M12–2016M12 (1); 2024M10–2025M12 (15)
IDR	13/240	5.4	2015M06–2015M06 (1); 2015M08–2015M09 (2); 2023M10–2023M10 (1); 2024M04–2024M07 (4); 2025M01–2025M04 (4); 2025M11–2025M11 (1)
JPY	66/240	27.5	2014M09–2016M03 (19); 2022M01–2025M11 (47)
KRW	7/240	2.9	2022M06–2022M11 (6); 2025M03–2025M03 (1)
MYR	14/240	5.8	2015M09–2015M09 (1); 2016M01–2016M01 (1); 2022M05–2022M11 (7); 2023M06–2023M06 (1); 2023M08–2023M11 (4)
PHP	11/240	4.6	2017M03–2017M03 (1); 2018M02–2018M10 (9); 2022M10–2022M10 (1)
SGD	11/240	4.6	2015M08–2016M02 (7); 2020M03–2020M04 (2); 2022M07–2022M07 (1); 2022M10–2022M10 (1)
THB	4/240	1.7	2022M07–2022M10 (4)
TWD	13/240	5.4	2016M01–2016M01 (1); 2022M10–2022M10 (1); 2024M03–2024M08 (6); 2024M12–2025M04 (5)
VND	5/240	2.1	2022M09–2022M11 (3); 2025M08–2025M09 (2)
Total	160/2400	6.7	

Notes: Baseline GSADF date-stamping uses the no-drift, no lag, wild-bootstrap specification at the 95% level. Episode dates are clipped to the corresponding sample window.

Table A1: Detailed Baseline Episodes, 2006–2025 — Panel C. DXY-Adjusted Measure

Currency	Months	Share (%)	Dated episodes
CNY	1/240	0.4	2015M11–2015M11 (1)
IDR	11/240	4.6	2007M11–2008M01 (3); 2009M02–2009M03 (2); 2013M10–2014M02 (5); 2014M06–2014M06 (1)
JPY	45/240	18.8	2006M07–2007M12 (18); 2008M06–2008M07 (2); 2022M06–2022M06 (1); 2022M10–2022M11 (2); 2023M05–2024M07 (15); 2024M10–2024M10 (1); 2025M07–2025M12 (6)
KRW	5/240	2.1	2009M06–2009M09 (4); 2025M12–2025M12 (1)
MYR	0/240	0.0	
PHP	0/240	0.0	
SGD	14/240	5.8	2012M07–2012M08 (2); 2012M11–2012M11 (1); 2013M04–2013M05 (2); 2016M07–2016M07 (1); 2017M03–2017M04 (2); 2025M05–2025M09 (5); 2025M11–2025M11 (1)
THB	1/240	0.4	2019M02–2019M02 (1)
TWD	2/240	0.8	2022M07–2022M08 (2)
VND	108/240	45.0	2006M01–2008M10 (34); 2008M12–2014M12 (73); 2018M02–2018M02 (1)
Total	187/2400	7.8	

Notes: Baseline GSADF date-stamping uses the no-drift, no lag, wild-bootstrap specification at the 95% level. Episode dates are clipped to the corresponding sample window.

Table A2: Detailed Baseline Episodes, 2013–2019 — Panel A. Raw Nominal USD/LCU Measure

Currency	Months	Share (%)	Dated episodes
CNY	9/84	10.7	2016M10–2017M06 (9)
IDR	78/84	92.9	2013M07–2019M12 (78)
JPY	18/84	21.4	2014M09–2016M02 (18)
KRW	0/84	0.0	
MYR	13/84	15.5	2015M07–2016M02 (8); 2016M11–2017M03 (5)
PHP	35/84	41.7	2016M01–2016M02 (2); 2016M10–2019M06 (33)
SGD	3/84	3.6	2015M09–2015M09 (1); 2015M11–2015M11 (1); 2016M01–2016M01 (1)
THB	2/84	2.4	2016M05–2016M05 (1); 2016M12–2016M12 (1)
TWD	0/84	0.0	
VND	84/84	100.0	2013M01–2019M12 (84)
Total	242/840	28.8	

Notes: Baseline GSADF date-stamping uses the no-drift, no lag, wild-bootstrap specification at the 95% level. Episode dates are clipped to the corresponding sample window.

Table A2: Detailed Baseline Episodes, 2013–2019 — Panel B. PPP-Based Measure

Currency	Months	Share (%)	Dated episodes
CNY	1/84	1.2	2016M12–2016M12 (1)
IDR	3/84	3.6	2015M06–2015M06 (1); 2015M08–2015M09 (2)
JPY	19/84	22.6	2014M09–2016M03 (19)
KRW	0/84	0.0	
MYR	2/84	2.4	2015M09–2015M09 (1); 2016M01–2016M01 (1)
PHP	10/84	11.9	2017M03–2017M03 (1); 2018M02–2018M10 (9)
SGD	7/84	8.3	2015M08–2016M02 (7)
THB	0/84	0.0	
TWD	1/84	1.2	2016M01–2016M01 (1)
VND	0/84	0.0	
Total	43/840	5.1	

Notes: Baseline GSADF date-stamping uses the no-drift, no lag, wild-bootstrap specification at the 95% level. Episode dates are clipped to the corresponding sample window.

Table A2: Detailed Baseline Episodes, 2013–2019 — Panel C. DXY-Adjusted Measure

Currency	Months	Share (%)	Dated episodes
CNY	1/84	1.2	2015M11–2015M11 (1)
IDR	6/84	7.1	2013M10–2014M02 (5); 2014M06–2014M06 (1)
JPY	0/84	0.0	
KRW	0/84	0.0	
MYR	0/84	0.0	
PHP	0/84	0.0	
SGD	5/84	6.0	2013M04–2013M05 (2); 2016M07–2016M07 (1); 2017M03–2017M04 (2)
THB	1/84	1.2	2019M02–2019M02 (1)
TWD	0/84	0.0	
VND	25/84	29.8	2013M01–2014M12 (24); 2018M02–2018M02 (1)
Total	38/840	4.5	

Notes: Baseline GSADF date-stamping uses the no-drift, no lag, wild-bootstrap specification at the 95% level. Episode dates are clipped to the corresponding sample window.

Table A3: Detailed Baseline Episodes, 2020–2025 — Panel A. Raw Nominal USD/LCU Measure

Currency	Months	Share (%)	Dated episodes
CNY	0/72	0.0	
IDR	46/72	63.9	2020M01–2020M05 (5); 2020M07–2020M10 (4); 2021M04–2021M04 (1); 2022M07–2023M03 (9); 2023M08–2024M08 (13); 2024M11–2025M12 (14)
JPY	19/72	26.4	2022M06–2022M11 (6); 2023M08–2023M11 (4); 2024M01–2024M07 (7); 2024M12–2025M01 (2)
KRW	1/72	1.4	2022M10–2022M10 (1)
MYR	0/72	0.0	
PHP	5/72	6.9	2022M07–2022M11 (5)
SGD	0/72	0.0	
THB	0/72	0.0	
TWD	0/72	0.0	
VND	72/72	100.0	2020M01–2025M12 (72)
Total	143/720	19.9	

Notes: Baseline GSADF date-stamping uses the no-drift, no lag, wild-bootstrap specification at the 95% level. Episode dates are clipped to the corresponding sample window.

Table A3: Detailed Baseline Episodes, 2020–2025 — Panel B. PPP-Based Measure

Currency	Months	Share (%)	Dated episodes
CNY	15/72	20.8	2024M10–2025M12 (15)
IDR	10/72	13.9	2023M10–2023M10 (1); 2024M04–2024M07 (4); 2025M01–2025M04 (4); 2025M11–2025M11 (1)
JPY	47/72	65.3	2022M01–2025M11 (47)
KRW	7/72	9.7	2022M06–2022M11 (6); 2025M03–2025M03 (1)
MYR	12/72	16.7	2022M05–2022M11 (7); 2023M06–2023M06 (1); 2023M08–2023M11 (4)
PHP	1/72	1.4	2022M10–2022M10 (1)
SGD	4/72	5.6	2020M03–2020M04 (2); 2022M07–2022M07 (1); 2022M10–2022M10 (1)
THB	4/72	5.6	2022M07–2022M10 (4)
TWD	12/72	16.7	2022M10–2022M10 (1); 2024M03–2024M08 (6); 2024M12–2025M04 (5)
VND	5/72	6.9	2022M09–2022M11 (3); 2025M08–2025M09 (2)
Total	117/720	16.3	

Notes: Baseline GSADF date-stamping uses the no-drift, no lag, wild-bootstrap specification at the 95% level. Episode dates are clipped to the corresponding sample window.

Table A3: Detailed Baseline Episodes, 2020–2025 — Panel C. DXY-Adjusted Measure

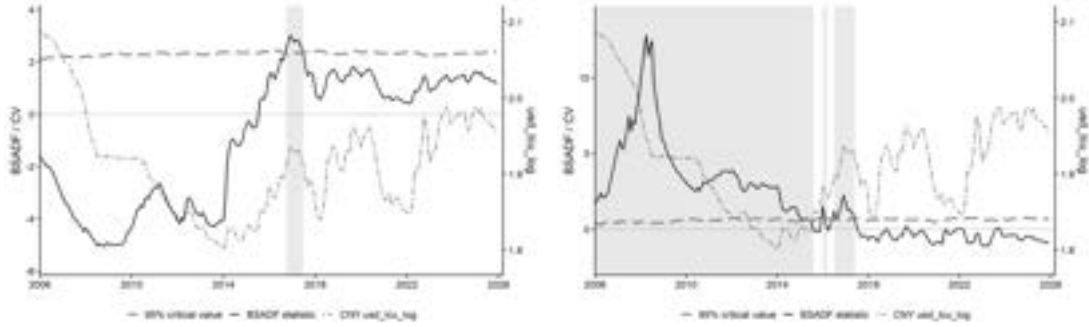
Currency	Months	Share (%)	Dated episodes
CNY	0/72	0.0	
IDR	0/72	0.0	
JPY	25/72	34.7	2022M06–2022M06 (1); 2022M10–2022M11 (2); 2023M05–2024M07 (15); 2024M10–2024M10 (1); 2025M07–2025M12 (6)
KRW	1/72	1.4	2025M12–2025M12 (1)
MYR	0/72	0.0	
PHP	0/72	0.0	
SGD	6/72	8.3	2025M05–2025M09 (5); 2025M11–2025M11 (1)
THB	0/72	0.0	
TWD	2/72	2.8	2022M07–2022M08 (2)
VND	0/72	0.0	
Total	34/720	4.7	

Notes: Baseline GSADF date-stamping uses the no-drift, no lag, wild-bootstrap specification at the 95% level. Episode dates are clipped to the corresponding sample window.

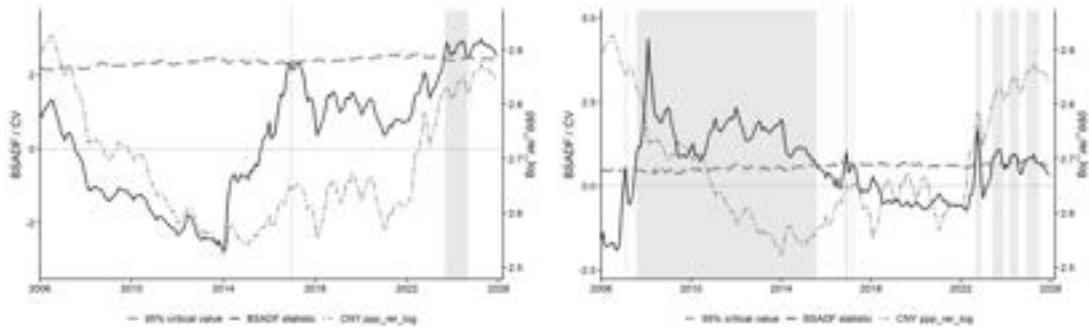
Appendix Figure A1 reports the currency-level GSADF episode plots. The ten currency pages are treated as panels of a single appendix figure for compact presentation.

Figure A1: Currency-Level GSADF Episode Plots — Panel A. Chinese yuan

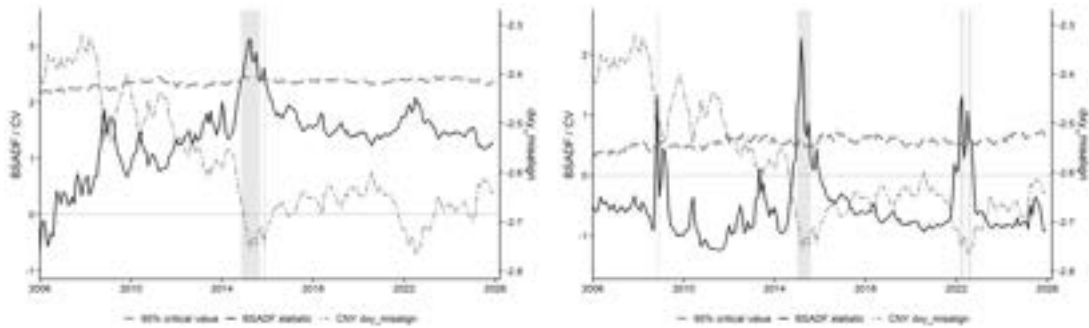
(a) LCU-based Episodes



(b) PPP-based Episodes



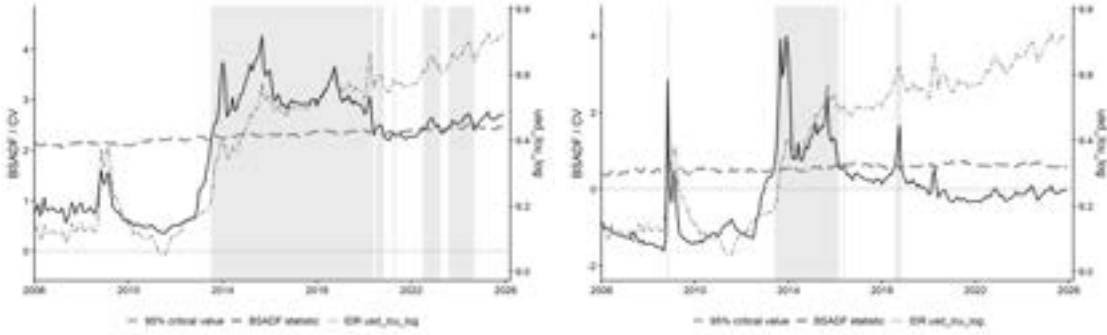
(c) DXY-misalignment Episodes



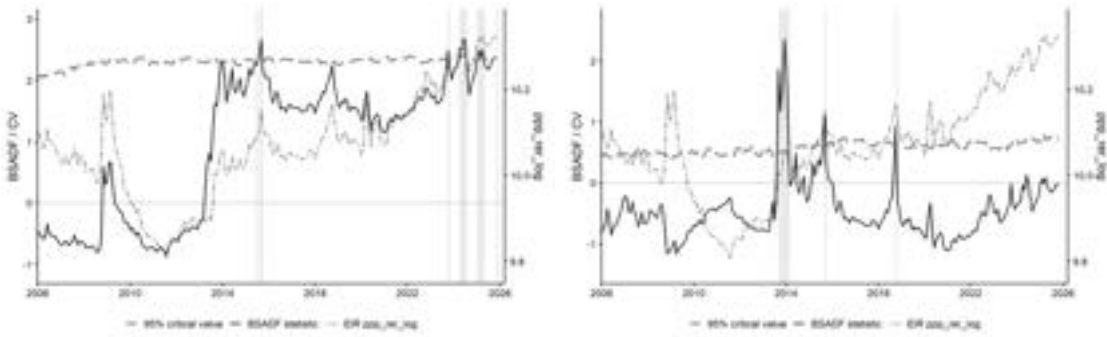
Notes: Left (right) figure reports the no-drift baseline (drift-inclusive robustness) using wild-bootstrap critical values under the common no lag design.

Figure A1: Panel B. Indonesian rupiah

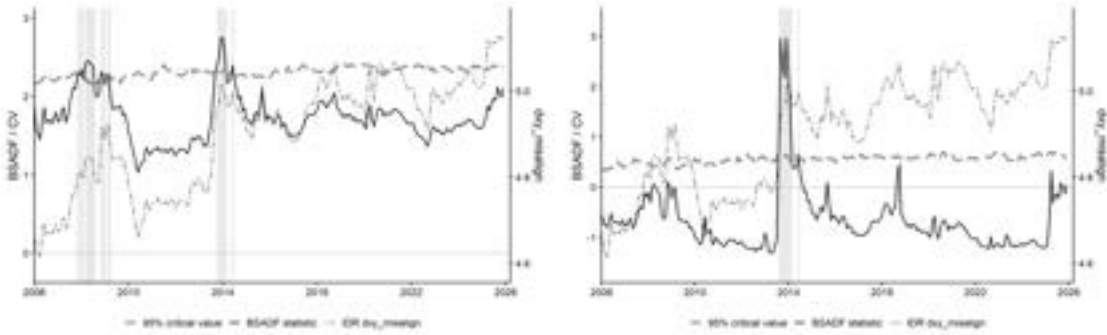
(a) LCU-based Episodes



(b) PPP-based Episodes



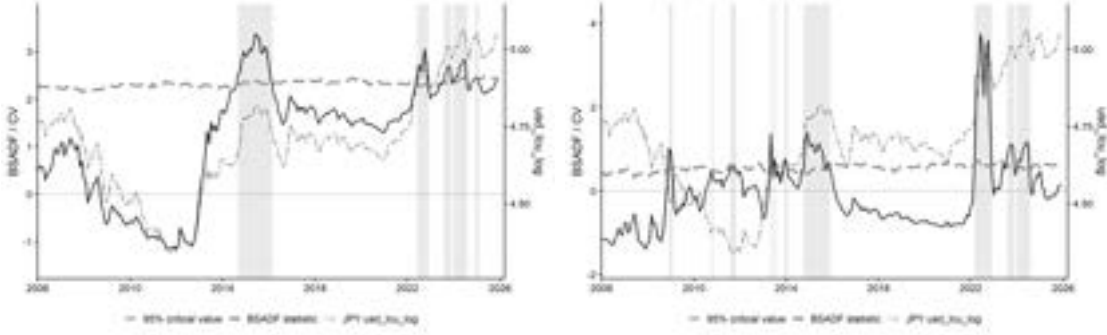
(c) DXY-misalignment Episodes



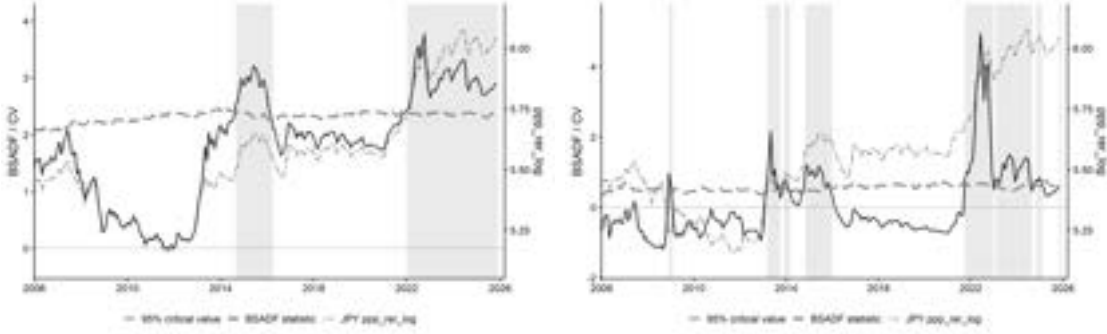
Notes: Left (right) figure reports the no-drift baseline (drift-inclusive robustness) using wild-bootstrap critical values under the common no lag design.

Figure A1: Panel C. Japanese yen

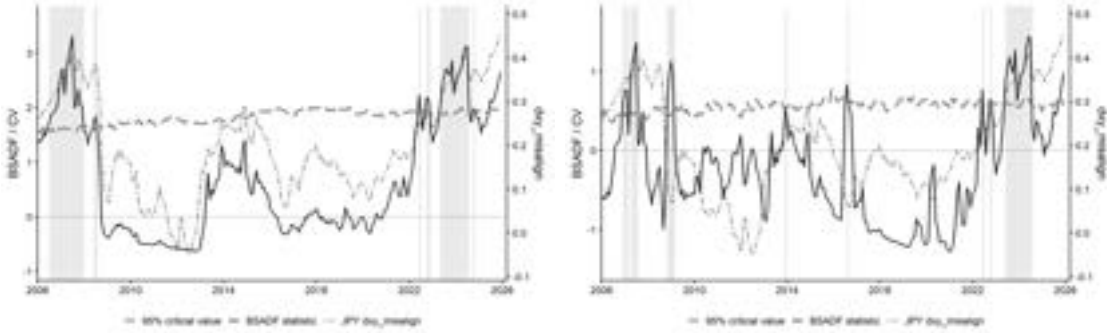
(a) LCU-based Episodes



(b) PPP-based Episodes



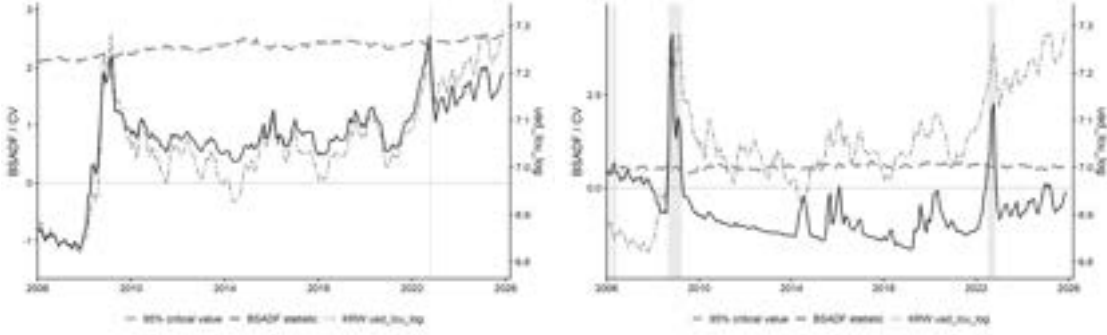
(c) DXY-misalignment Episodes



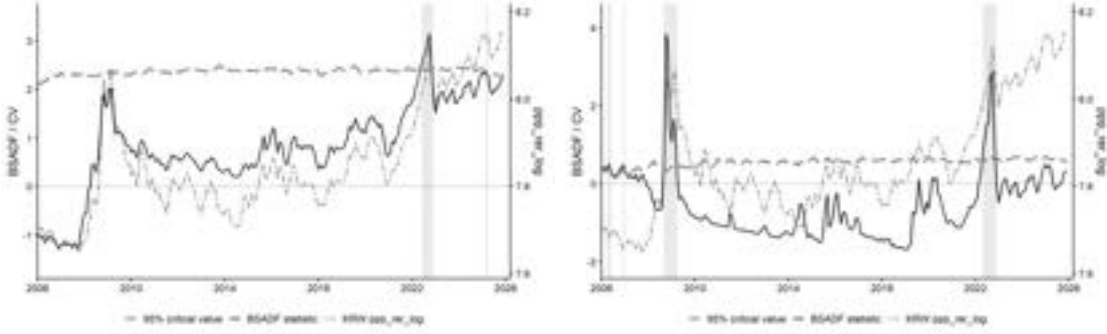
Notes: Left (right) figure reports the no-drift baseline (drift-inclusive robustness) using wild-bootstrap critical values under the common no lag design.

Figure A1: Panel D. Korean won

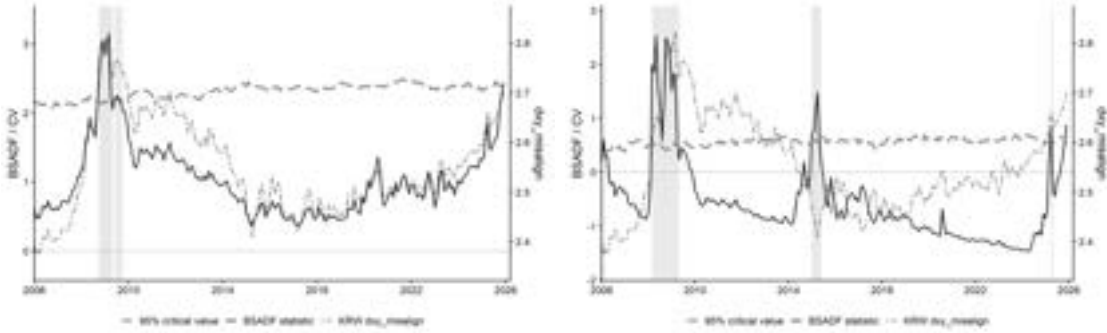
(a) LCU-based Episodes



(b) PPP-based Episodes



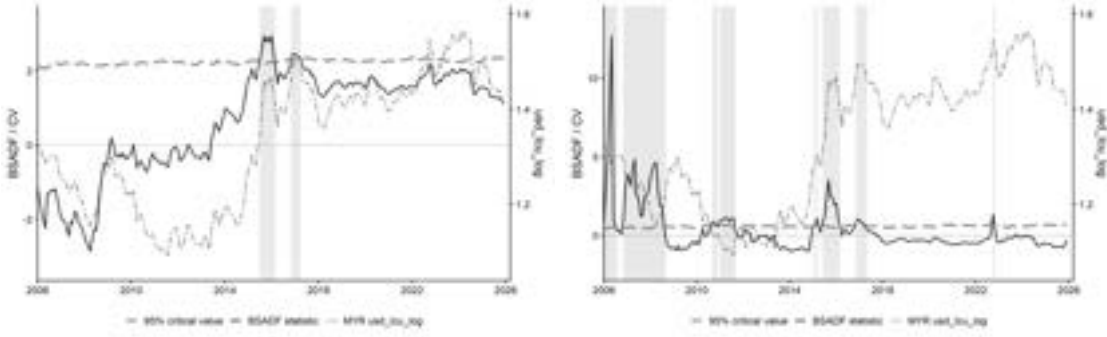
(c) DXY-misalignment Episodes



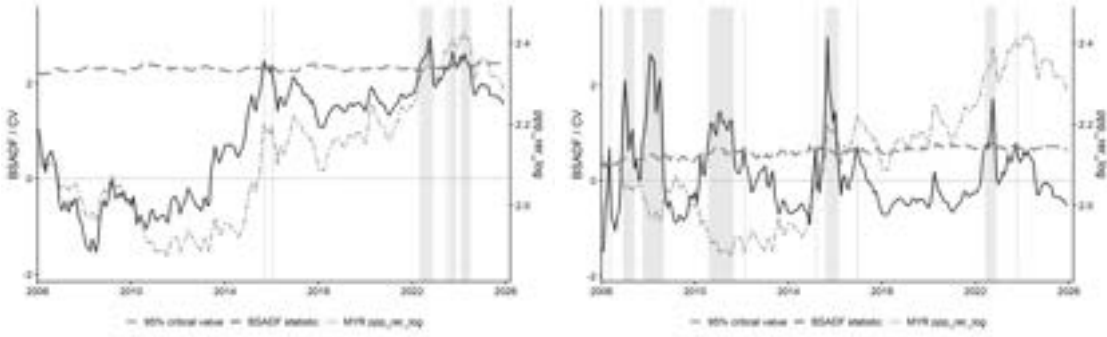
Notes: Left (right) figure reports the no-drift baseline (drift-inclusive robustness) using wild-bootstrap critical values under the common no lag design.

Figure A1: Panel E. Malaysia ringgit

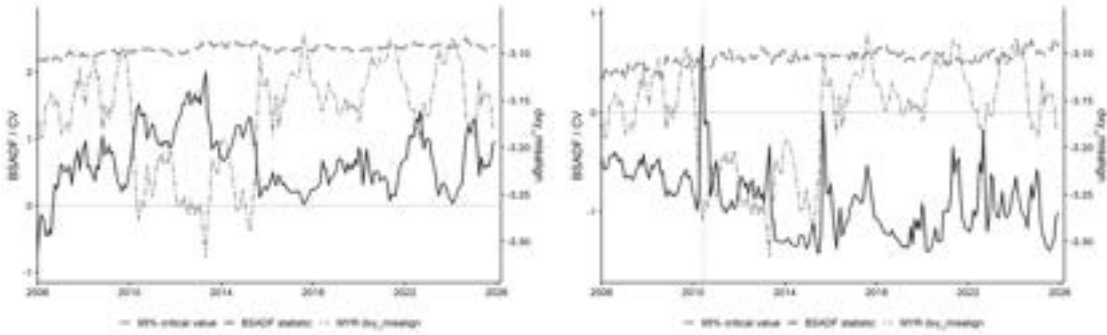
(a) LCU-based Episodes



(b) PPP-based Episodes



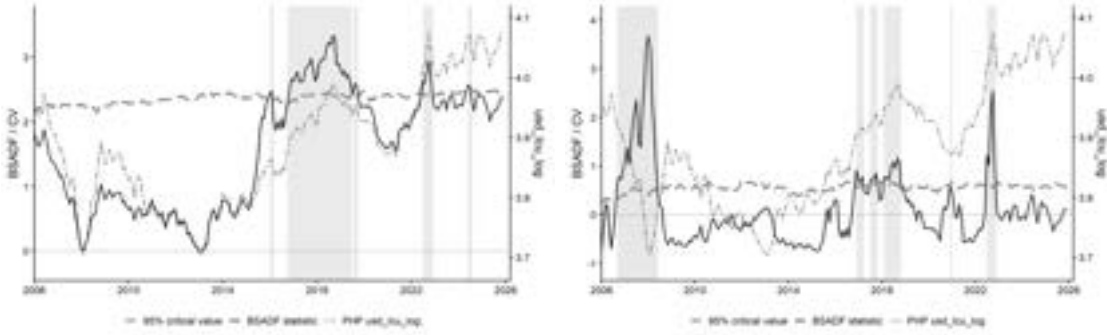
(c) DXY-misalignment Episodes



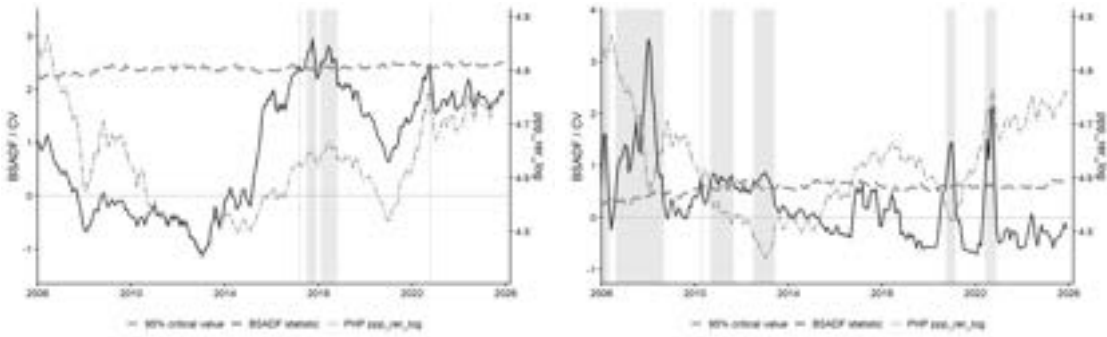
Notes: Left (right) figure reports the no-drift baseline (drift-inclusive robustness) using wild-bootstrap critical values under the common no lag design.

Figure A1: Panel F. Philippine peso

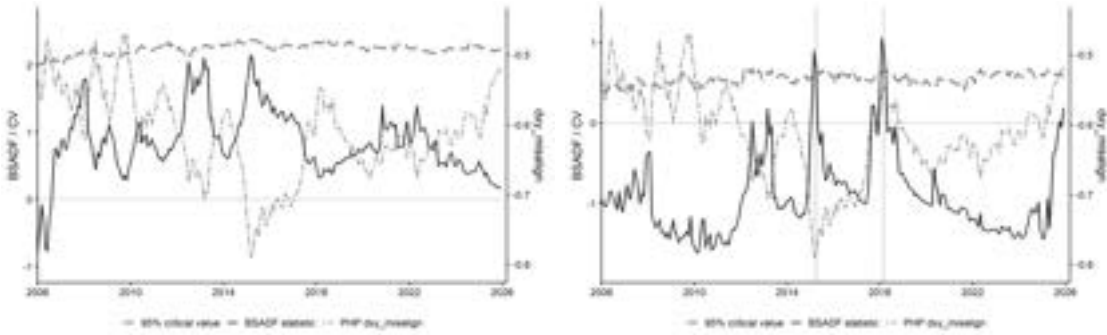
(a) LCU-based Episodes



(b) PPP-based Episodes



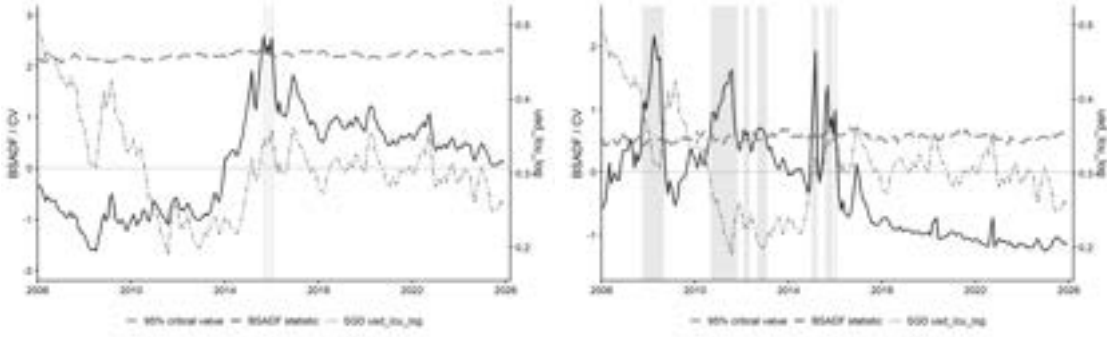
(c) DXY-misalignment Episodes



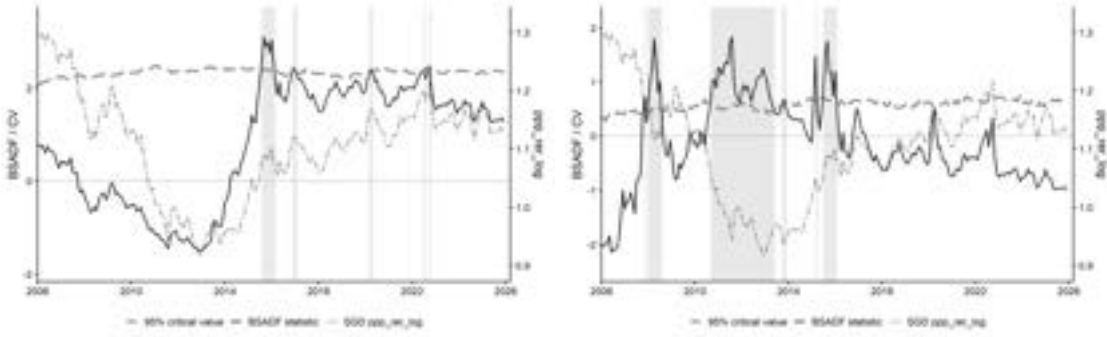
Notes: Left (right) figure reports the no-drift baseline (drift-inclusive robustness) using wild-bootstrap critical values under the common no lag design.

Figure A1: Panel G. Singapore dollar

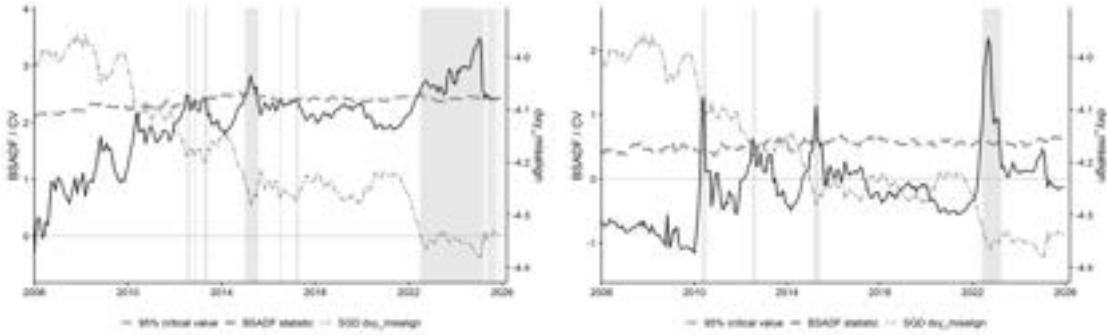
(a) LCU-based Episodes



(b) PPP-based Episodes



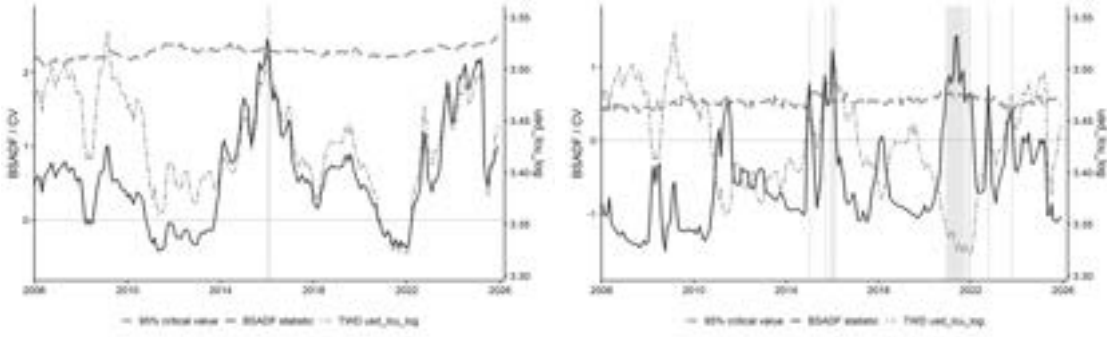
(c) DXY-misalignment Episodes



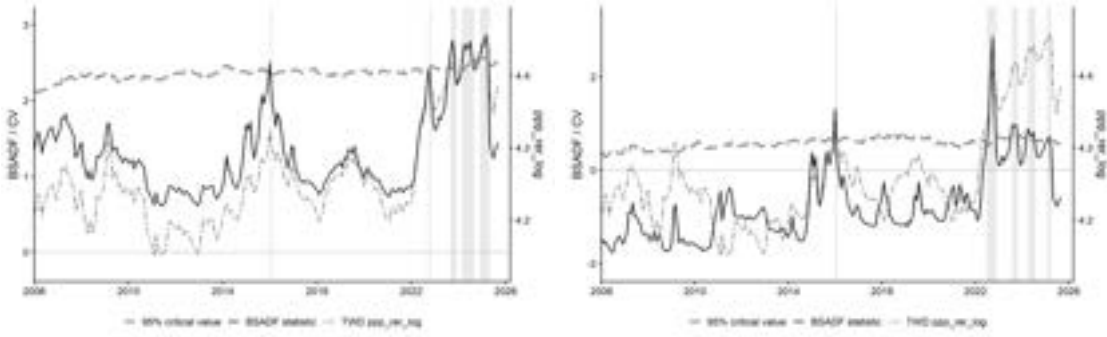
Notes: Left (right) figure reports the no-drift baseline (drift-inclusive robustness) using wild-bootstrap critical values under the common no lag design.

Figure A1: Panel H. Taiwan dollar

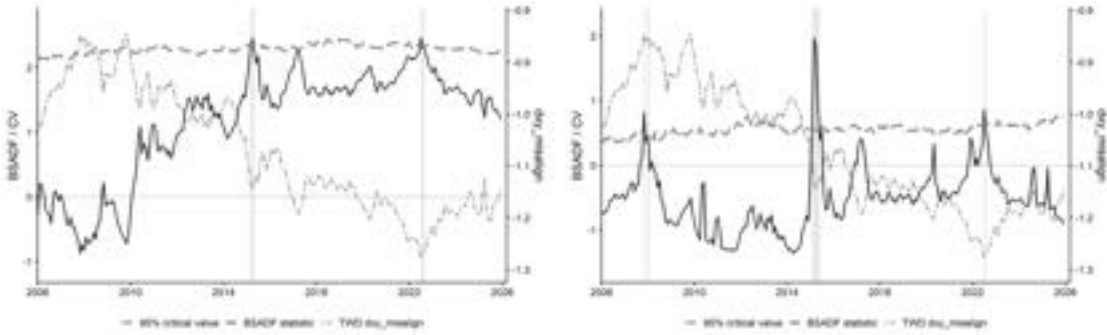
(a) LCU-based Episodes



(b) PPP-based Episodes



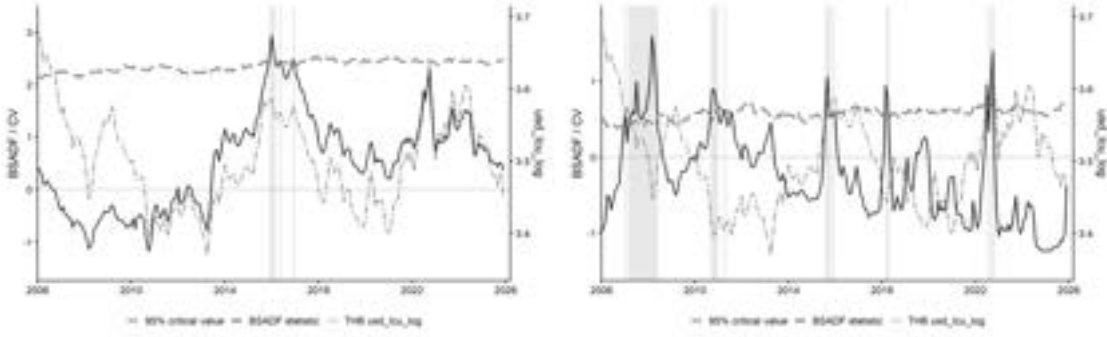
(c) DXY-misalignment Episodes



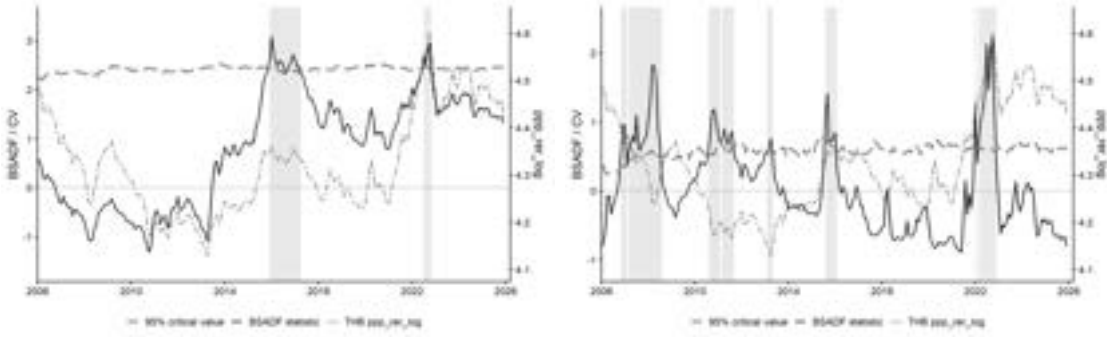
Notes: Left (right) figure reports the no-drift baseline (drift-inclusive robustness) using wild-bootstrap critical values under the common no lag design.

Figure A1: Panel I. Thai baht

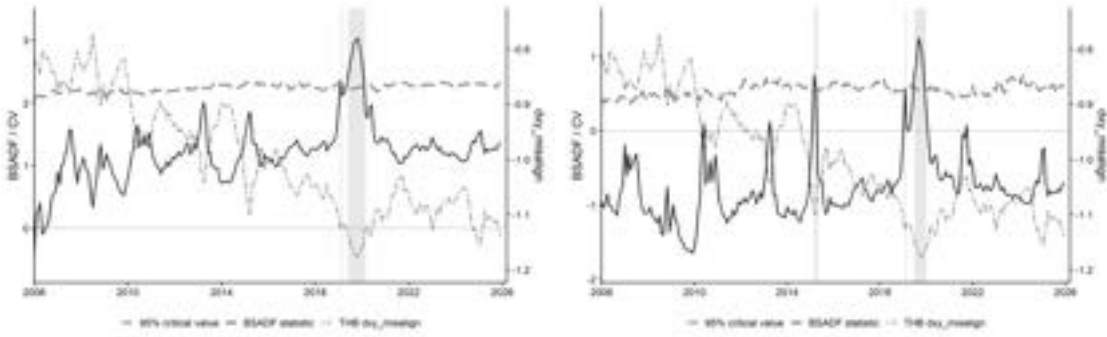
(a) LCU-based Episodes



(b) PPP-based Episodes



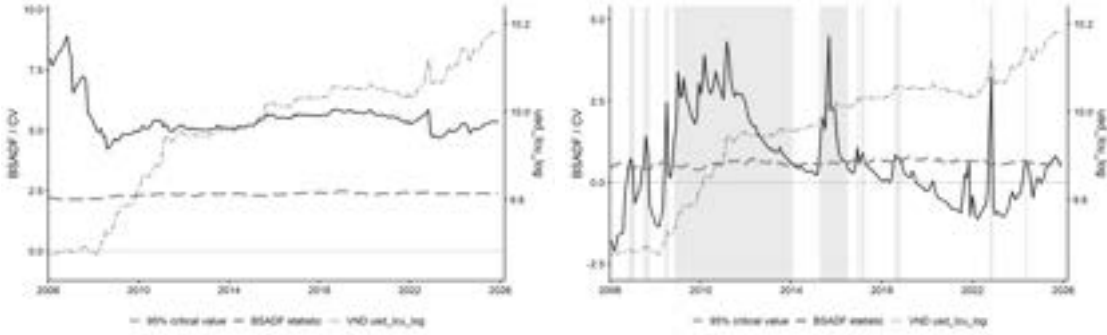
(c) DXY-misalignment Episodes



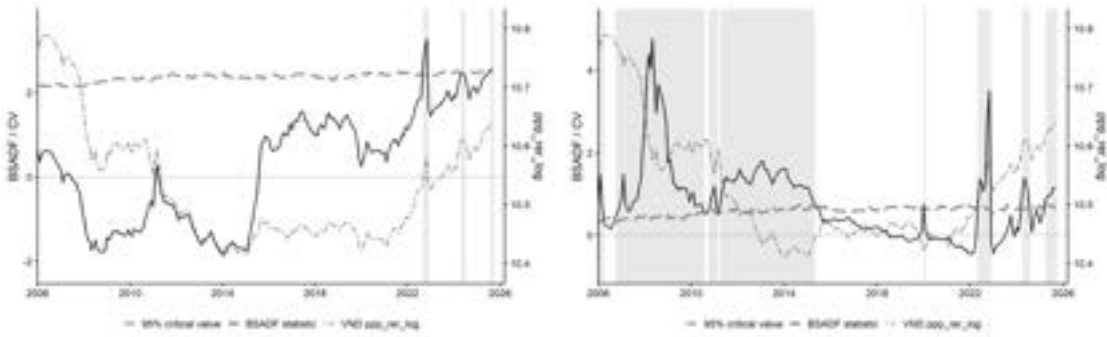
Notes: Left (right) figure reports the no-drift baseline (drift-inclusive robustness) using wild-bootstrap critical values under the common no lag design.

Figure A1: Panel J. Vietnamese dong

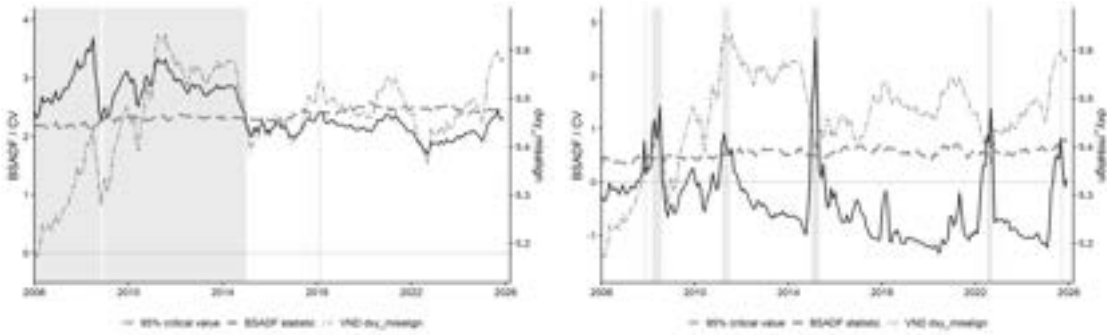
(a) LCU-based Episodes



(b) PPP-based Episodes



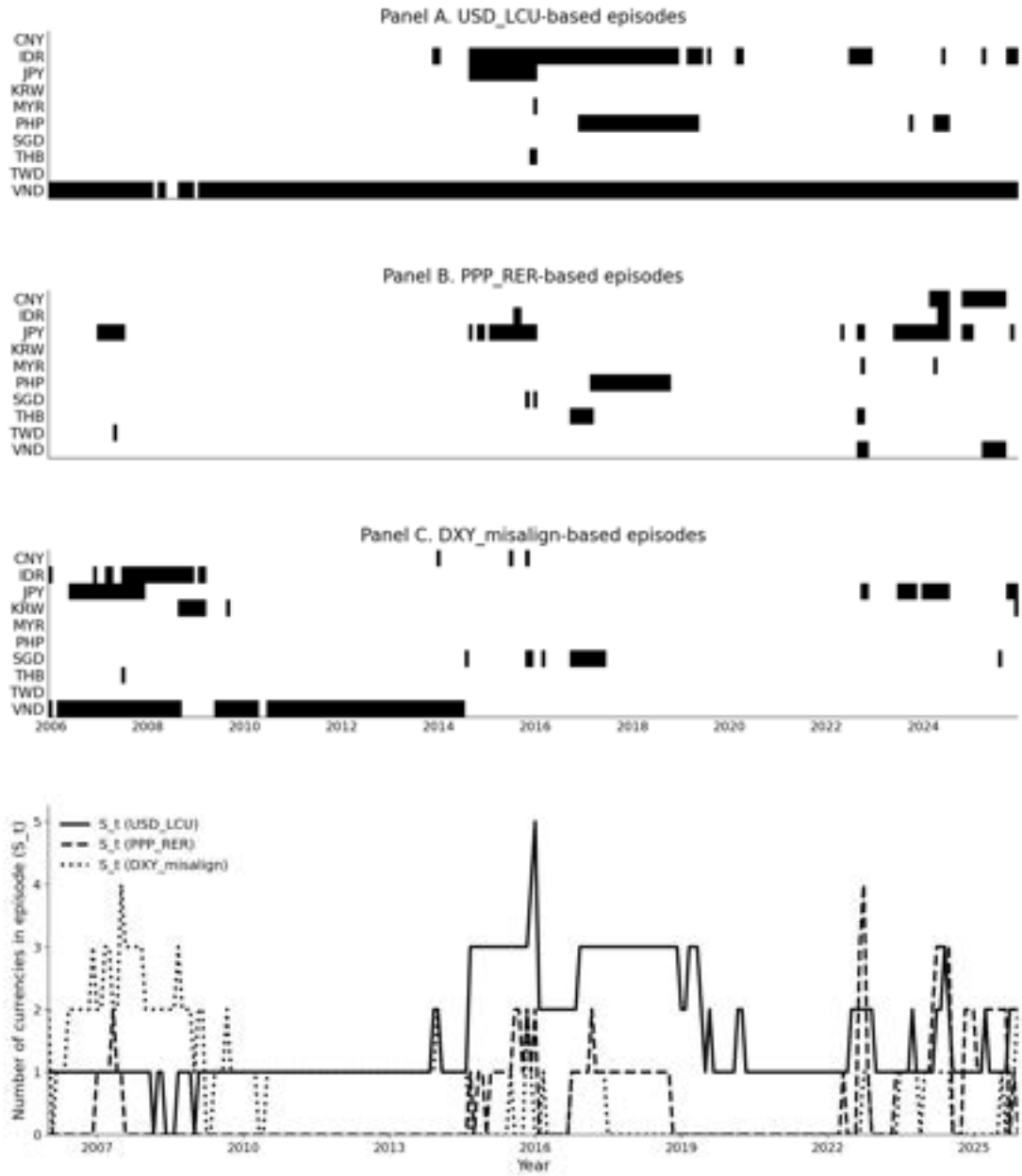
(c) DXY-misalignment Episodes



Notes: Left (right) figure reports the no-drift baseline (drift-inclusive robustness) using wild-bootstrap critical values under the common no lag design.

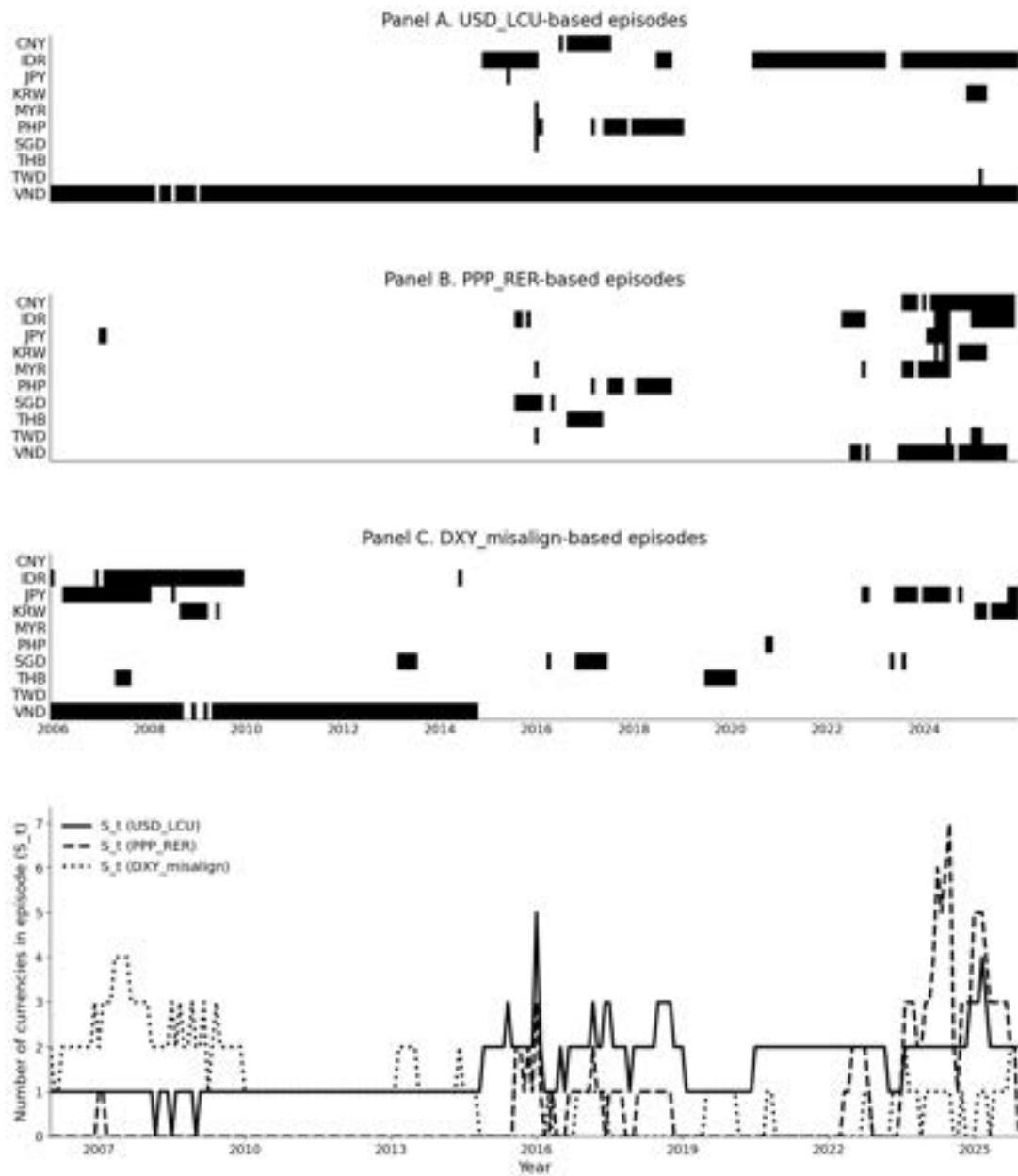
Appendix Figures A2–A4 are reserved for the robustness heatmaps and synchronization graphs discussed in Section 5.5. The corresponding image files can be inserted directly by replacing the placeholders below.

Figure A2: Robustness Heatmap and Synchronization — No Drift, WB, Lag 1



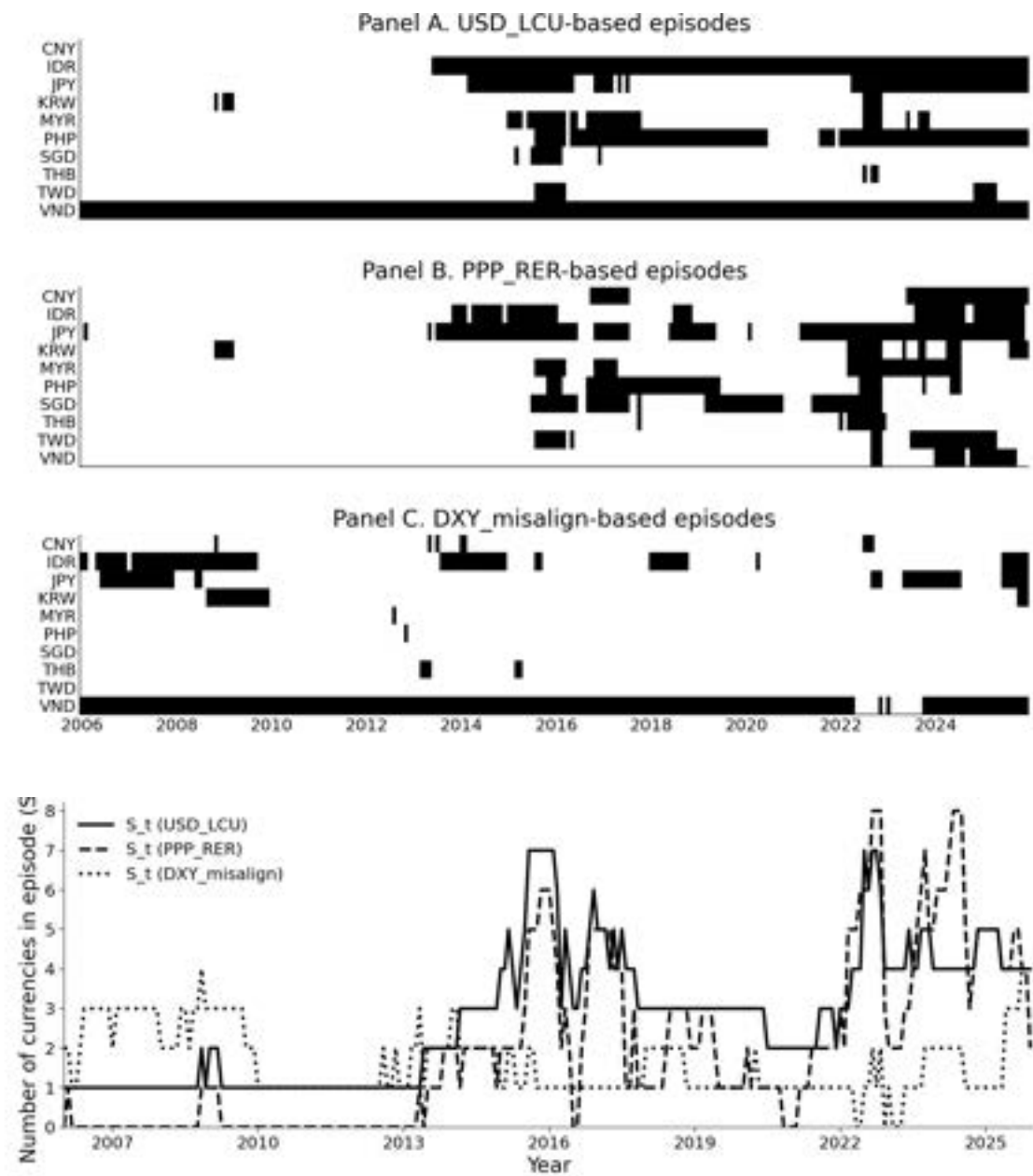
Notes: Replace the two placeholder boxes with the no-drift, WB, lag-1 heatmap and synchronization images.

Figure A3: Robustness Heatmap and Synchronization — No Drift, WB, Lag 3



Notes: Replace the two placeholder boxes with the no-drift, WB, lag-3 heatmap and synchronization images.

Figure A4: Robustness Heatmap and Synchronization — No Drift, MC, No Lag



Notes: Replace the two placeholder boxes with the no-drift, MC, no-lag heatmap and synchronization images.

Demystifying Trade Patterns In A Fragmenting World

Tatjana Schulze and Weining Xin

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Demystifying Trade Patterns In A Fragmenting World
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ABSTRACT: So-called “connector” countries have been argued to benefit from the US-China trade tensions, given their rising share in US imports. This paper draws an important distinction between trade reallocation—countries increase domestic production to substitute for declining Chinese exports to the US—and trade rerouting—countries serve as one-stop place for transshipment of Chinese exports to the US. Leveraging granular data on trade and FDI flows and global input-output linkages, focusing on six Asian countries, we first document that the connector role of these countries may reflect their growing domestic markets and Chinese supply chain reconfiguration, beyond trade rerouting from China to the US. We then zoom in on value-added components and deploy a synthetic control approach to disentangle trade reallocation from trade rerouting. While the evidence remains elusive for five of the six countries, Vietnam appears to have benefited from trade reallocation, with increased domestic content in its exports to the US in strategic sectors, instead of facilitating significant transshipment of Chinese exports to the US. Such domestic production expansion also helped increase domestic content in Vietnam’s exports to the rest of the world, and may be partly due to Chinese firms relocating to Vietnam through greenfield FDI. Despite potential short-term gains, trade reallocation increases connector countries’ vulnerability to geoeconomic fragmentation with losses to all countries in the long run.

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WORKING PAPERS

Demystifying Trade Patterns In A Fragmenting World

Prepared by Tatjana Schulze and Weining Xin¹

¹ We thank Chadi Abdallah, Jacqueline Deslauriers, Corinne Delechat, Rupa Duttagupta, Michael Gorbanyov, Ashique Habib, Ken Kashiwase, Jeff Kearns, Emmanouil Kitsios, Paulo Medas, Roman Merga, Lorenzo Rotunno, John Spray, Krishna Srinivasan, and participants in several IMF seminars for helpful comments. The views expressed in this paper are those of the authors and do not necessarily reflect those of the IMF, its Executive Board, or its Management. All mistakes herein are ours.

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1 Introduction

Since the advent of the US-China trade tensions, there has been a growing debate on the impact of rising barriers to trade on global and bilateral trade patterns.¹ Geoeconomic fragmentation poses losses to all countries in the medium to long term, but may lead to different trade dynamics among countries in the short-term. Especially those that rely on an export-oriented growth model, are open to global trade and investment, and are deeply integrated into global supply chains may be able to withstand trade tensions more effectively. So called “connector” countries have been argued to benefit from bridging the gap between trade blocs, for example, increasing exports to the US as they substitute for declining US sourcing from China, while at the same time increasing their imports from China (Fajgelbaum et al., 2021; Alfaro and Chor, 2023; Dahlman and Lovely, 2023; Freund et al., 2023; Utar et al., 2023; Gopinath et al., 2024). However, it is not clear (i) whether such connector countries are indeed serving as a bridge, as the increasing imports from China may reflect other factors such as growing domestic markets that Chinese firms tap into; and (ii) even if such “bridging the gap” effects exist, through which channels they operate. Two possible channels include:

- *Trade reallocation*: connector countries produce more goods domestically to export to the US—with rising domestic value added—as the US shifts away from China, likely using intermediate inputs imported from China.
- *Trade rerouting*: connector countries serve as a one-stop place for Chinese exports to the US with minimal to no domestic value added—in the extreme case through transshipment—to circumvent trade barriers, especially for products identified as having strategic importance, e.g., electronics and chemicals.

Separating these channels is important. While both trade reallocation and rerouting increase connector countries’ vulnerability to shocks from further fragmentation, including from lower global growth, trade reallocation could benefit the domestic economy at least in the short-term as it increases domestic production for exports. Conversely, trade rerouting involves minimal to no domestic production activities and may result in harmful countervailing trade restrictions. Leveraging granular trade and FDI data as well as a multi-region input-output database, this paper provides a nuanced assessment of the changing trade patterns since 2018 by disentangling these two channels, with a focus on a sample of six Asian emerging markets, namely, India, Indonesia, Malaysia, Philippines,

¹See for example Aiyar et al., 2023; Alfaro and Chor, 2023; Blanga-Gubbay and Rubínová, 2023; Freund et al., 2023; World Trade Organization, 2023; Gopinath et al., 2024.

Thailand, and Vietnam, which have been argued to have benefited from the US-China trade tensions.

First, we document that the positive correlation between these countries' imports from China and exports to the US may reflect other forces at play, such as their growing domestic markets and Chinese supply chain reconfiguration, and thus does not necessarily suggest their connector roles in bridging the gap between China and the US. Notably, several countries have seen an increase in their shares in Chinese imports, including India, Malaysia, and Vietnam. This suggests that Chinese firms may be relocating some of their production abroad to these countries, for example, due to their lower labor costs, and importing back the processed products for further processing and exports. In addition, the six Asian countries have seen an increase in their shares in Chinese abroad-absorbed value added,² which points towards the role of growing domestic markets and domestic demand in providing opportunities for market penetration by Chinese exporters. Hence, countries' growing domestic markets and Chinese supply chain reconfiguration may explain these countries' rising imports from China beyond mere trade rerouting. Consequently, there may not be a direct link between these countries' increasing exports to the US and their rising imports from China.

Second, we then dive into the value-added content of bilateral trade flows, by utilizing a multi-region input-output database and constructing two value-added measures in a country's exports to the US: (i) the share of domestic value added, and (ii) the share of Chinese value added. We use a synthetic control approach to estimate the effect of US-China trade tensions on these measures, especially for strategic sectors including *electrical and machinery sector* and *petroleum, chemical and non-metallic mineral products sector* that have been most affected by the US-China trade tensions and specifically US tariffs on Chinese exports.³ Compared to the synthetic counterfactual, a higher share of domestic value added in a country's exports to the US would suggest evidence of trade reallocation, i.e., there is an increase in domestic production and more domestic content is embedded in the country's exports to the US, as the US shifts away from China. On the other hand, a lower share of Chinese value added in a country's exports to the US would suggest no evidence of trade rerouting *on a significant scale*. Otherwise it would have increased as Chinese exports are re-exported to the US with minimal to no domestic value added.

²A country's share in Chinese abroad-absorbed value added is the value added of Chinese production absorbed by this country's domestic final demand as a share of the total value added from Chinese production that is absorbed abroad by final demand.

³We follow the IMF [2023 April World Economic Outlook](#) to map strategic sectors with the 26 sectors in the multi-region input-output database. Given the aggregate sector definitions in the multi-region input-output database, precise mapping with the strategic sectors identified in International Monetary Fund ([2023](#)) which uses SEC 3 definitions and subsectors of ISIC code 20 is not possible.

The results suggest that among the six countries of interest, Vietnam appears to have benefited from the trade reallocation effect during 2018-2022—significantly increasing its domestic value added and reducing Chinese value added in its strategic sector exports to the US—rather than trade rerouting from China to circumvent tariffs. Specifically, for strategic sectors, Vietnam has seen a statistically significant increase in the share of domestic value added in its exports to the US, 6 and 7 percentage points higher than its synthetic counterfactual in 2018, for *electrical and machinery sector* and *petroleum, chemical and non-metallic mineral products sector*, respectively, and 10 and 12 percentage points higher in 2022. This suggests that Vietnam has increased domestic production of its strategic sectors’ exports and thus been able to embed more domestic content in its exports to the US. To eliminate potential confounding factors that affect not only strategic sectors but also non-strategic sectors (e.g. pandemic lockdowns disrupting supply chains, economy-wide structural reforms which increase productivity), we replicate the analysis for the non-strategic manufacturing sector and find that the increase in the share of domestic value added in Vietnam’s non-manufacturing sectors’ exports to the US is more muted and importantly, not statistically significant until 2021. Such difference between strategic and non-strategic sectors suggests that the significant increase in the share of domestic value added in strategic sectors’ exports to the US can be attributed to the US-China trade tensions. On the other hand, Vietnam has seen a statistically significant decline in the share of Chinese value added in its strategic sectors’ exports to the US, suggesting no evidence of trade rerouting from China to the US to circumvent tariffs on a significant scale.

Moreover, extending the analysis of domestic value added in Vietnam’s export to *the world*, we show that Vietnam has been able to export more domestic content not only to the US but also globally, though the effects on the latter are slightly smaller and take longer to become statistically significant. This could suggest that, beyond increasing its domestic content in bilateral exports to the US, Vietnam managed to expand its domestic production capacity to capture a larger share in the global market.

Third, extending the analysis to FDI by examining the cumulative number of greenfield FDI projects that commit Chinese capital to Vietnam, we find that Vietnam attracted more greenfield FDI projects in strategic sectors from China after 2018, which is likely one of the reasons behind the scaling up of domestic production of its exports: Chinese firms relocate their production, or accelerate the relocation process that started before due to higher domestic labor costs, to Vietnam against the backdrop of increasing tariffs on China imposed by the US. Notably, this supply chain reconfiguration through FDI may not be exclusive to Chinese firms as FDI inflows to Vietnam from other countries, including the US, Japan, and Korea, also significantly increased at the same time.

Taken together, Vietnam appears to have benefited from the trade reallocation effect by increasing its domestic production—partly supported by Chinese FDI capital but also by its favorable structural characteristics—and therefore has been able to embed more domestic content in its exports to the US and the rest of the world, especially in strategic sectors. Meanwhile, the evidence suggests that Vietnam has not served as a one-stop place allowing China to reroute its exports to the US to circumvent tariffs on a significant scale.

As for the other five Asian countries, the impacts of the US-China trade tensions are elusive. Malaysia is estimated to have seen a positive but not statistically significant effect on the share of domestic value added in its strategic sector exports to the US, while other countries are estimated to have seen negative and not statistically significant effects (except for Thailand). In terms of the trade rerouting effect, Malaysia is estimated to have seen a negative (but not statistically significant) effect on the share of Chinese value added in its exports to the US for strategic sectors. Other countries have seen small positive and statistically significant effects on the share of Chinese value added in its exports for strategic sectors. However, this does not suggest evidence of trade rerouting as the increasing share of Chinese value added in these countries' strategic sector exports could well reflect their increasing supply chain integration with China through backward linkages, which would lead to a higher share of Chinese value added in its exports.⁴

In sum, this paper provides a nuanced assessment of changing global trade patterns against the backdrop of increasing geoeconomic fragmentation, by zooming in on so-called connector countries, delving into the value-added component of trade flows, and distinguishing between trade reallocation and trade rerouting effects. The connector role of these countries is not as clear-cut with limited evidence that they are indeed bridging the gap between trade blocs. Moreover, the connector role is likely to have been achieved through trade reallocation rather than trade rerouting, which could benefit the connector country, at least in the short term, as it boosts domestic production and potentially attracts more inward FDI flows.

Related Literature. This paper contributes to three strands of literature. First, it draws an important distinction between trade reallocation and trade rerouting. The literature on the impacts of the US-China trade tensions on global trade has primarily focused on reconfiguration of supply chains and reallocation of global trade (Fajgelbaum et al., 2021; Alfaro and Chor, 2023; Grossman et al., 2024; Freund et al., 2023). Despite the growing anecdotal discussion of rerouting, there have been few analyses disentangling trade rerouting from trade reallocation empirically in the context of the US-China trade tensions. Hayakawa and Sudsawasdi (2024) study the impacts of Thailand's introduction

⁴For example, Foxconn began assembling top-end Apple iPhones in India in 2019 (Reuters, 2018).

of a watchlist to curb the rerouting of Chinese goods to the US and EU in 2019. They find that the watchlist did not significantly affect Thailand’s imports of high-risk goods from China, while it led to an increase in those goods’ exports to the US but a decrease in exports to the EU. Iyoha et al. (2024) examine at the product and firm level whether trade rerouting increased via Vietnam due to the US-China trade tensions. They find that the level of aggregation significantly affects the assessment: a significantly larger share of Vietnamese exports to the US is identified as subject to rerouting at the product level than at the firm level. These results also highlight the challenges in understanding trade rerouting and disentangling it from trade reallocation based on aggregate trade patterns. To our best knowledge, this paper is the first to disentangle the trade rerouting effect from the trade reallocation effect by examining value-added components of trade flows.

Second, we contribute to the recent literature on the emergence of connector countries in the context of geoeconomic fragmentation. Several studies propose the emergence of connector countries by looking at the association between the change in their inward linkages with China—measured by their shares in Chinese exports or outward FDI—and the change in their outward linkages with the US—measured by their shares in US imports (Alfaro and Chor, 2023, Dahlman and Lovely, 2023, Freund et al., 2023, Utar et al., 2023, Gopinath et al., 2024). We enrich the analysis by first looking at other potential forces at play, including China’s production relocation and supply chain reconfiguration, and connector countries’ growing domestic markets. These factors are not necessarily associated with connector countries bridging the gap between trade blocs. Second, we examine through which channels the connector role is achieved by differentiating between trade reallocation and trade rerouting. In addition, there are a growing number of studies zooming in on Vietnam, to study the impacts of the US-China trade tensions on its domestic economy, including labor markets (Mayr-Dorn et al., 2023; Rotunno et al., 2024), structural change (Nguyen and Lim, 2023), FDI flows (Xue, 2023), and environmental progress (Kahn et al., 2024). While the positive impact of the US-China trade tensions on Vietnam’s domestic economy found in these papers is consistent with our main finding that Vietnam has benefited from trade reallocation rather than trade rerouting, this paper offers empirical evidence to support trade reallocation while rejecting the trade rerouting hypothesis. This paper also provides a cross-country comparison, by comparing Vietnam with other Asian emerging countries that are also argued to have benefited from the US-China trade tensions, and finds that the evidence of trade reallocation in other countries is elusive.

Third, our paper also relates to the literature on trade barrier circumvention through rerouting. The existing literature mainly uses trade data at different aggregation levels

without examining the value added components, with much of the evidence based on correlations. Fisman et al. (2008) find that China was more likely to import goods through Hong Kong if it had higher import tariffs on the rest of the world, and argue that this indirect trade was partly due to tariff evasion. Stoyanov (2012) provide evidence of tariff evasion by showing that goods with greater preferential treatment under the Canada-US Free Trade Agreement were more likely to be transshipped through the US to Canada. Rerouting from China to the US has been examined in the context of quotas and anti-dumping duties. Rotunno et al. (2013) find a high correlation between African countries' imports from China and exports to the US for apparel products for which African countries have duty- and quota-free access to the US market through the African Growth and Opportunity Act (AGOA). Rotunno and Vézina (2015) show that the US in-bond system of imports may be used by firms to illegally avoid trade barriers, which involves declaring Chinese exports bound for Mexico but diverting them to the US market while in transit. Liu and Shi (2019) find an increase in the correlation between Chinese imports and US exports in third countries for products that are subject to US anti-dumping duties on Chinese products. Iyoha et al. (2024) estimate the causal response of rerouting to the tariffs imposed during the US-China trade tensions using a difference-in-difference approach based on both product-level and firm-level data. However, looking at trade flows, without examining the value added components, may overstate the extent of rerouting if there are unobserved value-added activities, even within a product code. Our approach, using multi-region input-output linkages to construct value added-related measures and synthetic control counterfactuals, allows us to estimate the causal impact of the US-China trade tensions on the extent of trade rerouting versus trade reallocation.

The remainder of the paper is organized as follows: Section 2 documents stylized facts related to the geoeconomic fragmentation and connector countries, including an analysis of other potential factors behind countries' increasing imports from China. Section 3 presents the main empirical methodology and the data sources. Section 4 presents the main empirical results, alongside validation analysis. Finally, Section 5 concludes.

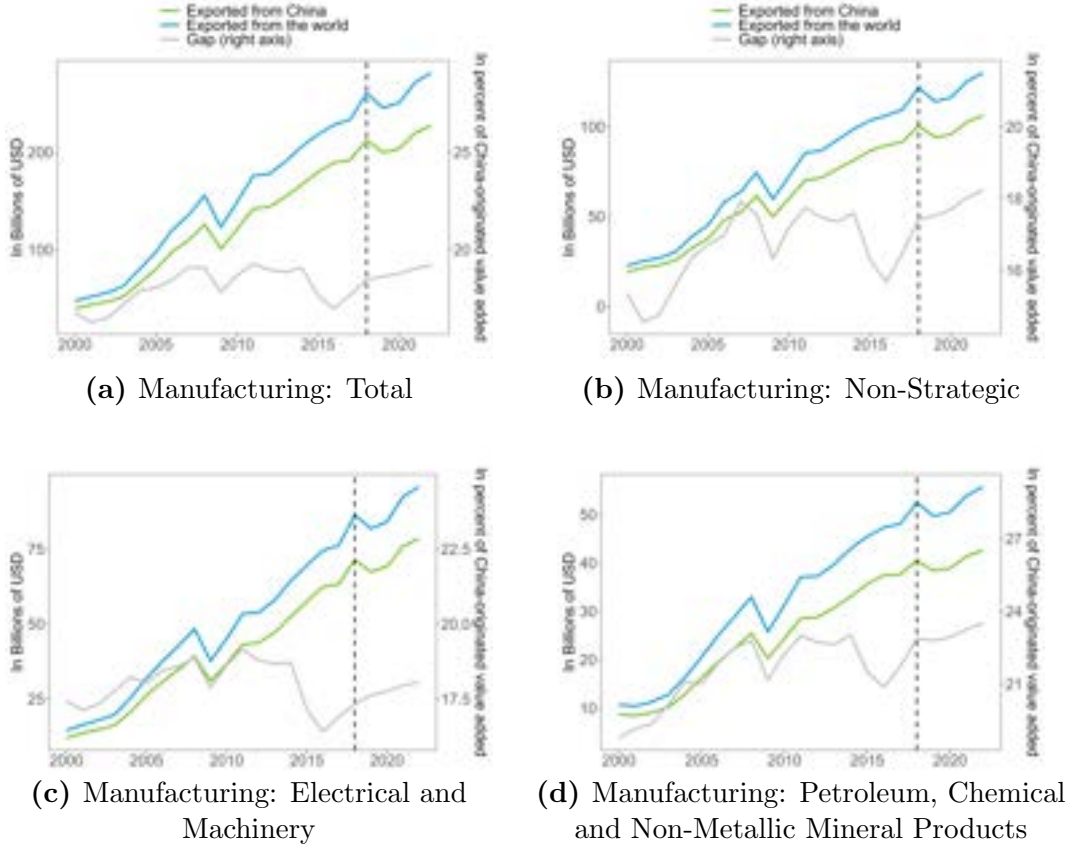
2 Stylized Facts

We first document the evolution of Chinese value added in US imports and to what extent it has been exported through other countries before analyzing the connector role of six Asian countries of interest: India, Indonesia, Malaysia, Philippines, Thailand, and Vietnam.

Chinese value added has been increasingly exported to the US through other countries,

not only in strategic sectors but also more broadly for the overall manufacturing sector. Figure 1 plots the Chinese value added in US imports that is exported from the world (including China itself) versus the value added that is exported directly from China, and the gap as a share of the total Chinese value added in US imports, for the overall manufacturing sector (panel (a)), non-strategic sectors (panel (b)), and strategic sectors including electrical and machinery (panel (c)) and petroleum, chemical, and non-metallic mineral products (panel (d)).

Figure 1: Value Added Originated in and Exported from China in US Imports



Notes: Panel (a)-(d) plot Chinese value added that is exported either from China or other countries (the blue lines) versus Chinese value added that is exported only from China (the orange lines) on the left axis and the gap between the two as a share of the total Chinese value added on the right axis, for the overall manufacturing sector, the non-strategic sectors, and strategic sectors include electrical and machinery and petroleum, chemical, and non-metallic mineral products, respectively. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Since China's accession to the WTO in 2001, an increasing share of its value added has been exported through other countries, which is likely due to its integration into the

global value chain through forward linkages, i.e., supplying intermediate goods to other countries for production and exports. However, the increasing trend plateaued after the Global Financial Crisis, before starting to decline in 2015 and reaching its trough in 2016. Since 2017, it has started to increase again, not only in strategic sectors, but also in non-strategic sectors and for the overall manufacturing sector.

The recent upward trend may be argued as evidence of Chinese exports having been channeled through other countries to the US to circumvent tariffs for strategic sectors. However, the broad-based increase—not only in strategic sectors but also non-strategic sectors—suggests that the trend may also reflect Chinese firms’ production relocation and supply chain reconfiguration. For example, Chinese firms may be increasingly supplying intermediate products and relocating low-value added production, such as assembly and packaging, abroad to countries with lower labor costs, as labor costs in China increase and China strives to move up the value chain.⁵

While the literature has coined the emergence of connector countries based on the positive correlation between their shares in Chinese exports and US imports, the link between these countries’ increasing exports to the US and imports from China is not clear. Following Gopinath et al. (2024), Figure 2 first plots the change in a country’s share in US imports against the change in its share in Chinese exports, between 2013-17 and 2018-22 for non-aligned countries (panel (a)).⁶ We then augment the analysis by also looking at the change in a country’s share in Chinese imports (panel (b)) and the change in its share in Chinese abroad-absorbed value added (panel (c)), between 2013-17 and 2018-22, against the change in its share in Chinese exports. A country’s share in Chinese abroad-absorbed value added is the value added of Chinese production absorbed by this country’s domestic final demand (consumption and investment), as a share of the total value added from Chinese production that is absorbed abroad by the global final demand. It therefore serves as an indicator of the amount of Chinese exported value added that is absorbed within a country’s domestic economy as opposed to going into the production of exported goods, and thus a measure of the size of the country’s domestic market in absorbing Chinese exports.

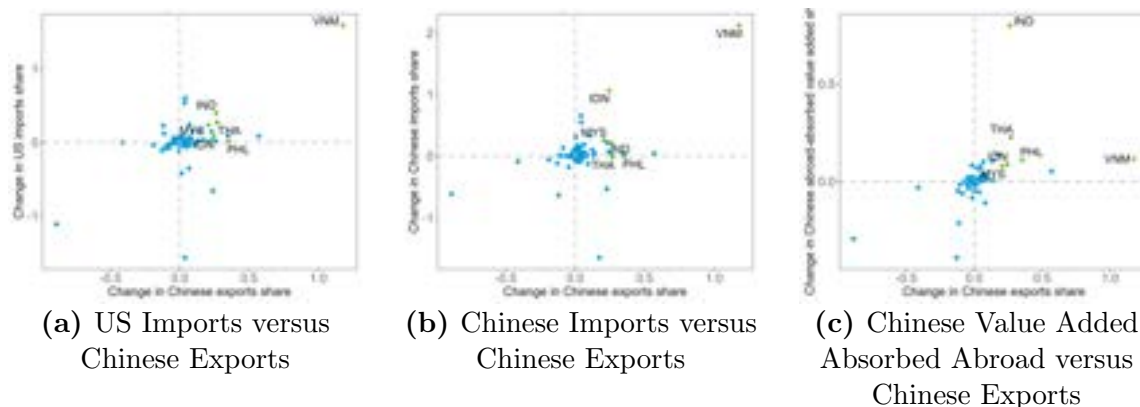
As documented in many studies, India, Malaysia, Thailand, and Vietnam have seen both an increase in their shares in Chinese exports and an increase in their shares in US imports (panel (a)), which has been argued as evidence of their roles as connector countries between China and the US, i.e., facilitating the rerouting of Chinese exports to

⁵For example, the ‘Made in China 2025’ initiative, launched in 2015, aims to raise the domestic content of core materials.

⁶We follow the definition in Gopinath et al. (2024) on blocs. All six Asian countries of interest in this paper are therefore considered as non-aligned countries.

the US.

Figure 2: Change in the Share of Non-Aligned Countries in US Imports, Chinese Imports, and Chinese Abroad-Absorbed Value Added versus Change in the Share of Chinese Exports



Notes: Panel (a)-(c) plot changes in three measures of market shares of non-aligned countries, including the share in US imports (panel (a)), the share in Chinese imports (panel (b)), and the share in Chinese abroad-absorbed value added (panel (c)), between 2013-17 and 2018-22, against change in the share in Chinese exports. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: BACI Database (Gaulier and Zignago, 2010), The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

However, there could be other forces at play which may break the direct link between the two. First, as shown in Panel (b), India, Indonesia, Malaysia, and Vietnam have also seen an increase in their shares in Chinese imports at the same time as they see an increase in their shares in Chinese exports. This would suggest evidence of Chinese firms relocating some of their production to these countries, for example, due to their lower labor costs,⁷ and importing back the processed products. As such, increasing imports from China that reflect Chinese firms relocating production abroad is not necessarily associated with trade rerouting due to the US-China trade tensions. Second, as shown in Panel (c), all six Asian countries have seen an increase in the size of their domestic markets—measured by their shares in Chinese abroad-absorbed value added—at the same time as they have seen an increase in their shares in Chinese exports. This would suggest that the increase in their shares in Chinese exports may well reflect these countries' growing domestic markets and thus increasing demand and absorption of exports from China. As such, increasing imports from China that reflect these countries' growing domestic markets are again not

⁷For example, Le and Tran-Nam (2018) find that the high level of FDI inflows into Vietnam could be explained mainly by its relatively skilled workforce, combined with low wages as compared to neighboring countries in the region. Luo et al. (2022) study the determinants of Japanese divestment in China and find that higher minimum wages raise the probability of divestment.

necessarily associated with trade rerouting due to the US-China trade tensions. Zooming in onto strategic sectors yields similar results (see Appendix B).

In sum, despite the increasing share of Chinese value added that has been exported to the US through other countries, there is no evidence based on trade flows that Chinese exports are rerouted through other countries to the US. Moreover, the connector role of some economies in the interest of this paper—argued based on the association between their increasing shares in Chinese exports and the US imports since 2018—could reflect other forces at play, beyond trade rerouting from China to the US through these economies as a result of the US-China trade tensions. These forces include structural factors such as Chinese firms relocating production abroad to these countries and these economies’ growing domestic demand for Chinese exports.

3 Data and Methodology

In this section, we first describe the empirical methodology and then discuss the data and sample.

Methodology. We deploy the synthetic control approach proposed in Abadie et al. (2010). Simply put, for the observation of interest, we construct a synthetic counterfactual which is a weighted average of the other observations in the sample, based on the matching of pretreatment characteristics, so that this synthetic counterfactual provides a more appropriate comparison than any other single observation. The synthetic control approach works well with aggregate macro data when no single unit alone may provide a good comparison for the unit affected by the intervention, for example, if no single unit satisfies the “parallel pretreatment trend” assumptions. In our case, we employ it to examine the effect of the US-China trade tensions since 2018, and set the treatment period as years from 2018 onwards. We focus on India, Indonesia, Malaysia, Thailand, Philippines, and Vietnam, a group of Asian countries that are argued to have benefited from the US-China trade tensions and geoeconomic fragmentation more generally.

To disentangle the trade reallocation effect from the trade rerouting effect, we examine two value-added measures that are constructed from a multi-region input-output database (see below): (i) the share of domestic value added in a country-sector’s exports to the US and (ii) the share of Chinese value added in a country-sector’s exports to the US. Two hypotheses are tested:

Hypothesis I: *There has been trade reallocation resulting from the US-China trade*

tensions, leading the country to produce more goods domestically to export to the US as the US shifts away from China, i.e.,

$$\frac{\text{Domestic Value Added}_{t,outcome}}{\text{Total exports to US}_{t,outcome}} > \frac{\text{Domestic Value Added}_{t,counterfactual}}{\text{Total exports to US}_{t,counterfactual}} \quad (1)$$

To test this hypothesis, we examine the dynamics of the share of domestic value added in a country's exports to the US. A higher share of domestic value added in a country's strategic sector exports to the US relative to the synthetic control counterfactual, with statistical significance, would suggest that the country has seen trade reallocation resulting from the US-China trade tensions and has actually benefited from it, as it has led to more domestic production and more domestic content embedded in its exports.

Hypothesis II: *There has been **significant** trade rerouting resulting from the US-China trade tensions, i.e., importing Chinese goods and re-exporting them to the US with minimal to no domestic value added.*

To test this hypothesis, let

$$Y_t^{counterfactual} \equiv \frac{\text{Chinese Value Added}_{t,counterfactual}}{\text{Total exports to US}_{t,counterfactual}} \quad (2)$$

be the share of Chinese value added in a country's exports to the US in the counterfactual control group *absent any trade rerouting* in the treatment year t . Compare this counterfactual ratio to the outcome ratio, that is the *actual* observed share of Chinese value added in the country's exports to the US, defined as

$$Y_t^{outcome} \equiv \frac{\text{Chinese Value Added}_{t,counterfactual} + \Delta_t}{\text{Total exports to US}_{t,counterfactual} + \Delta_t + \epsilon_t} \quad (3)$$

where Δ_t represents the *additional* value added of Chinese products *resulting from the US-China trade tensions* that is exported to the country and embedded in the country's exports to the US, and ϵ_t represents the *additional* domestic value that is added to Chinese imports that go into exports to the US (e.g. think of Δ_t and ϵ_t as jointly entering a firm's production function).

If ϵ_t is zero or sufficiently small compared to Δ_t , then for any Δ_t

$$Y_t^{outcome} > Y_t^{counterfactual}. \quad (4)$$

In the case of trade rerouting with minimal to no domestic value added, we have $\epsilon_t \rightarrow 0$, i.e. the additional domestic value added is zero or sufficiently small compared to the Chinese value added Δ_t . As a result, the observed share of Chinese value added is larger than the counterfactual. Equivalently, a rejection of the inequality (4) would suggest that ϵ_t is not sufficiently small compared to Δ_t , indicating the trade rerouting has not happened *on a significant scale*.

Operationally, in the synthetic control approach, compared to the synthetic counterfactual, a lower share of Chinese value added, with statistical significance, would provide evidence to *reject* the inequality (4) and thus the hypothesis, suggesting that trade rerouting has not happened *on a significant scale*.

Importantly however, a higher share of Chinese value added, even if statistically significant, does not necessarily suggest evidence of trade rerouting, as it could reflect a country’s increasing supply chain integration with China, in particular through backward linkages, which would lead to a higher share of Chinese value added in the country’s exports to the US.⁸

We follow the IMF [2023 April World Economic Outlook](#) to map strategic sectors with the 26 sectors in the multi-region input-output database, which include (i) electrical and machinery, and (ii) petroleum, chemical and non-metallic mineral products.⁹ Matching characteristics in the synthetic control approach include the value-added measures from 2010 to 2017 to capture the pretreatment trend, nominal GDP in US dollar based on purchasing power parity in 2010 and 2015 to capture the size of the economy, and exports of goods as a share of GDP in 2010 and 2015 to capture the level of trade openness.¹⁰

To evaluate the statistical significance of our estimates, we use placebo tests, following Abadie and Gardeazabal (2003), Bertrand et al. (2004), and Abadie et al. (2010). For each country of interest, we run placebo studies by applying the synthetic control method to all other countries (excluding China and the US, and other countries in the interest of this paper). If the placebo studies create gaps of magnitude similar to the one estimated for the country of interest, this suggests that there is no significant evidence to support trade reallocation effect or reject trade rerouting effect of the US-China trade tensions. If, on the other hand, the placebo studies show that the gaps estimated for the country is unusually large (when it is positive) or small (when it is negative) relative to the gaps for

⁸A special case of trade rerouting involves illegally changing the origin or the value-added composition of a product. Input-output tables would not capture such artificial practices. We therefore caveat that we assume accurate measurement of the value added of exports through input-output tables.

⁹Given the aggregate sector definitions in the multi-region input-output database, precise mapping with the strategic sectors identified in the International Monetary Fund (2023) which uses SEC 3 definitions and subsectors of ISIC code 20 is not possible.

¹⁰Both the nominal GDP in US dollar based on purchasing power parity and exports of goods as a share of GDP are from the *IMF World Economic Outlook Database*.

all other countries, e.g., in the top or bottom decile of the distribution, this suggest that there is significant evidence to support trade reallocation effect or reject trade rerouting effect of the US-China trade tensions. As such, a $10^{th} - 90^{th}$ percentile range is constructed based on the distribution of the estimated effects of all countries excluding those with a mean squared prediction error (MSPE) during the pretreatment period of more than five times the MSPE of the country at hand, i.e., the placebo test distribution. An estimated effect is therefore statistically significant at the 90 percent confidence level if it is outside the constructed $10^{th} - 90^{th}$ percentile range.

Data. We use the Eora26 Global Supply Chain database which consists of a multi-region input-output table (MRIO) model, covering 189 countries and 26 sectors and spanning the period from 1990 to 2022 (see Appendix A for details on the sample).¹¹ Leveraging this input-output table database, we construct value-added measures that enables us to examine the value-added component of country-sector pairs' exports as mentioned above.

We also use the Orbis Cross-Border Investment database provided by Bureau van Dijk to examine the dynamics of greenfield FDI projects, such as a company setting up (or expanding) a physical presence in a foreign market. This database provides detailed project-level information, such as sourcing country, destination country, project industry, date of announcement, current status, committed capital expenditure, etc. Due to the lack of information on the disbursement of committed capital, we examine the dynamics of and the effect on the cumulative number of projects which were announced between 2003 and 2022 in strategic sectors and non-strategic manufacturing sectors. We focus only on projects of which the latest status is either completed or announced.

4 Empirical Results

In this section, we first present the empirical results that test the hypotheses of trade reallocation and trade rerouting effects, and then zoom in on specific country cases by augmenting the trade analysis with FDI data.

¹¹Other input-output databases, e.g. ADB MRIO, OECD TiVA, are also commonly used. We deploy the Eora database as it covers a particularly large set of countries which allows for a larger pool to draw from in constructing the synthetic counterfactual.

4.1 Has there been trade reallocation?

Recall that, to test the hypothesis whether there has been trade reallocation resulting from the US-China trade tensions, we examine the share of domestic value added in a country's exports to the US. Compared to the synthetic counterfactual, a higher share of domestic value added in a country's exports to the US, with statistical significance, would suggest that the country has seen trade reallocation and has actually benefited from it, as it has boosted domestic production of exports.

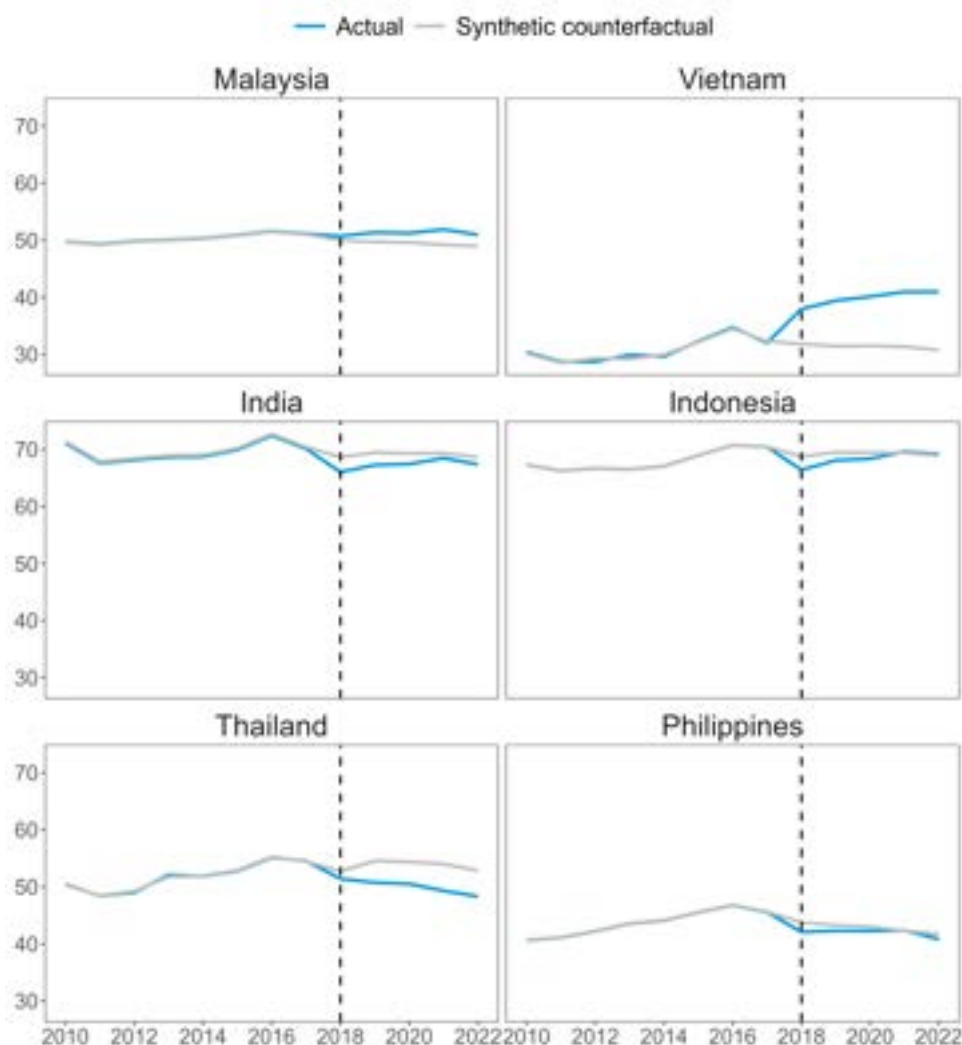
For the electrical and machinery sector as shown in Figure 3, Malaysia and Vietnam have seen a higher share of domestic value added in their exports to the US after the onset of the US-China trade tensions, as compared to their synthetic counterfactuals. Specifically, Malaysia would have seen its share of domestic value added declining since 2018 if there were no US-China trade tensions, but instead the share has been relatively stable since then. Vietnam has seen an increasing share of domestic value added since 2018, rising above 40 percent, while the counterfactual shows a gradual decline. On the other hand, all other countries of interest, namely, India, Indonesia, Philippines, and Thailand, have exhibited a lower share of domestic value added than their synthetic counterfactuals.

Figure 4 shows the estimated effect on the share of domestic value added in the countries' electrical and machinery exports to the US, calculated as the gap between the actual values and the synthetic counterfactuals, and the 10th–90th percentile range of the placebo test distribution. Results show that, while both Malaysia and Vietnam see positive effects, only Vietnam displays statistically significant effects since 2018. Specifically, Vietnam has seen its share of domestic value added increase by 6 percentage points in 2018, accumulating to more than 10 percentage points in 2022. For all other countries that have negative effects, none of those are statistically significant at the 90 percent confidence level, except for Thailand.

For petroleum, chemical and non-metallic mineral products, similar results hold: Malaysia and Vietnam have seen positive effects on the domestic content of their exports to the US, with a higher share of domestic value added in their exports to the US compared to their synthetic counterfactuals, but the positive effects are only statistically significant in Vietnam. Vietnam has seen its share of domestic value added increase by 7 percentage points in 2018, which has accumulated to almost 12 percentage points in 2022. On the other hand, all other countries in the sample display negative but not statistically significant effects on the domestic content of their exports to the US (see more details in Appendix C).

These results show that, for strategic sectors that include electrical and machinery, and

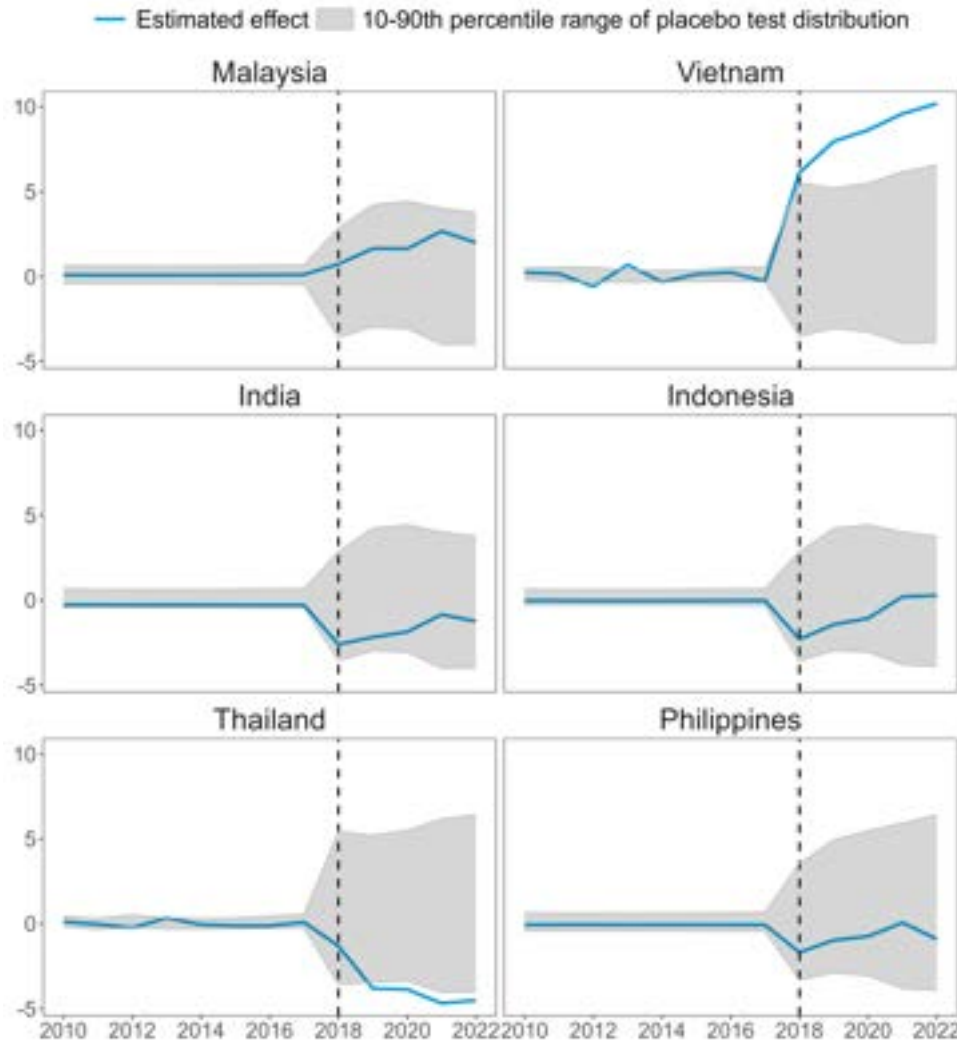
Figure 3: Share of Domestic Value Added in the Country's Exports to the US, Electrical and Machinery (In Percent)



Notes: For each country, the figure plots the actual (the blue lines) and the synthetic counterfactual (the grey lines) share of domestic value added in the country's exports to the US, for electrical and machinery sector. The synthetic counterfactuals are constructed based on a weighted average of the share of domestic value added in other countries' exports to the US for the same sector, excluding the six countries of interest in this paper. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Figure 4: Estimated Effect on the Share of Domestic Value Added in the Country's Exports to the US, Electrical and Machinery (In Percentage Points)



Notes: For each country, the figure plots the estimated effect on the share of domestic value added in the country's exports to the US, for electrical and machinery sector (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of the country in study. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged. Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

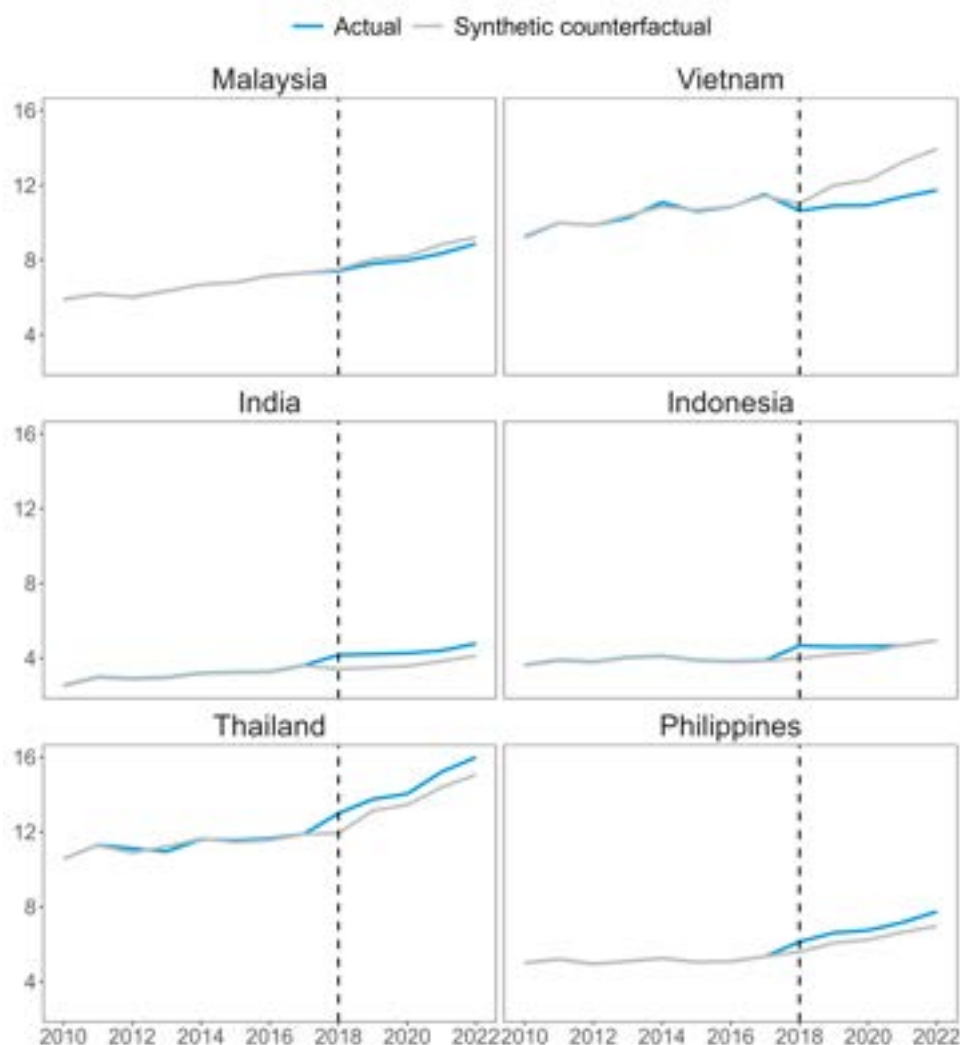
petroleum, chemical and non-metallic mineral products, among the countries in the sample, Vietnam has seen a positive and statistically significant effect on the domestic content of its exports to the US, while the other countries do not exhibit any statistically significant effects. Combining these results, it suggests that Vietnam has benefited from the trade reallocation effect, as the US shifts away its sourcing from China, which has boosted its domestic production of exports for strategic sectors, reflected in increasing domestic content of its exports. On the other hand, other countries in the sample haven't seen any statistically significant effects on the domestic content of their exports to the US.

4.2 Has there been trade rerouting?

Recall that, to test the hypothesis whether there has been significant trade rerouting resulting from the US-China trade tensions, we examine the share of Chinese value added in a country's exports to the US for strategic sectors. Compared to the synthetic counterfactual, a lower share of Chinese value added, with statistical significance, would provide evidence to *reject* the hypothesis, suggesting that trade rerouting has not happened on a significant scale. On the other hand, even a higher share of Chinese value added with statistical significance does not necessarily suggest evidence of trade rerouting as it could reflect a country's increasing supply chain integration with China, particularly through backward linkages, which would lead to a higher share of Chinese value added in the country's exports to the US.

For electrical and machinery sector as shown in Figure 5, Malaysia and Vietnam have seen lower share of Chinese value added in their exports to the US since 2018, as compared to their synthetic counterfactuals. On the other hand, India, Indonesia, Thailand, and Philippines have seen higher share of Chinese value added in their exports to the US. Looking at the estimated effects and their statistical significance as shown in Figure 6, Malaysia and Vietnam have seen negative effects on the share of Chinese value added in their exports to the US, with those of Vietnam statistically significant at 90 percent confidence level from 2019 onwards. In other countries who have seen positive effects, the effects are statistically significant in India, Thailand, and Philippines during 2018-22, and in Indonesia during 2018-19 only. Similar results are found for petroleum, chemical and non-metallic mineral products that Vietnam has seen a negative and statistically significant effect on the share of Chinese value added in its exports to the US, while other countries except India have seen negative but not statistically significant effects (see more details in Appendix D).

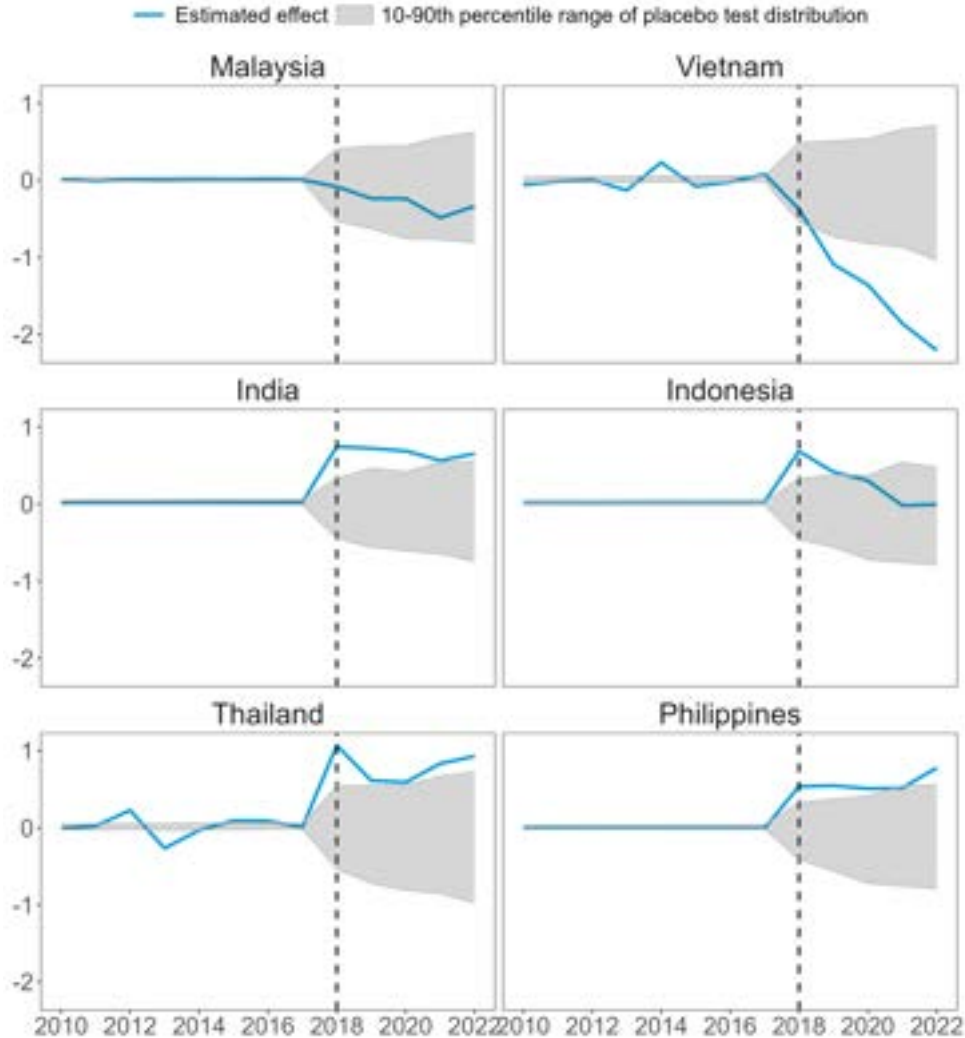
Figure 5: Share of Chinese Value Added in the Country's Exports to the US,
Electrical and Machinery
(In Percent)



Notes: For each country, the figure plots the actual (the blue lines) and the synthetic counterfactual (the grey lines) share of Chinese value added in the country's exports to the US, for electrical and machinery sector. The synthetic counterfactuals are constructed based on a weighted average of the share of Chinese value added in other countries' exports to the US for the same sector, excluding the six countries of interest in this paper. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Figure 6: Estimated Effect on the Share of Chinese Value Added in the Country's Exports to the US, Electrical and Machinery (In Percentage Points)



Notes: For each country, the figure plots the estimated effect on the share of Chinese value added in the country's exports to the US, for electrical and machinery sector (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of the country in study. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged. Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

These results provide evidence to *reject* the null hypothesis that there has been significant trade rerouting through Vietnam, as it has seen statistically significant negative effects on the Chinese value added in its strategic sector exports to the US. In other words, trade rerouting has not happened as a result of the US-China trade tensions through Vietnam on a significant scale. It is also important to note that, the inability to reject the hypothesis for other countries does not suggest evidence of trade rerouting, as noted above that the positive effects on the share of Chinese value added in these countries' exports to the US could reflect their increasing supply chain integration with China. For example, these effects could reflect that major manufacturers relocated part of their production from China to these countries, in particular assembly and packaging that would source inputs from China but enable them to export to the US, such as that Foxconn began assembling top-end Apple iPhones in India in 2019 (Reuters, [2018](#)).

Taken together, results from the two value added-based measures suggest that, among countries of interest in the paper, Vietnam has seen trade reallocation effect as US shifts away from China and reconfigures its supply chains towards Vietnam, instead of trade rerouting from China to circumvent tariffs. As such, Vietnam has benefited from the trade reallocation effect which has boosted its domestic production and increased the domestic content embedded in its exports to the US. On the other hand, the effects—either trade reallocation or trade rerouting—in other countries is elusive.

4.3 The Case of Vietnam

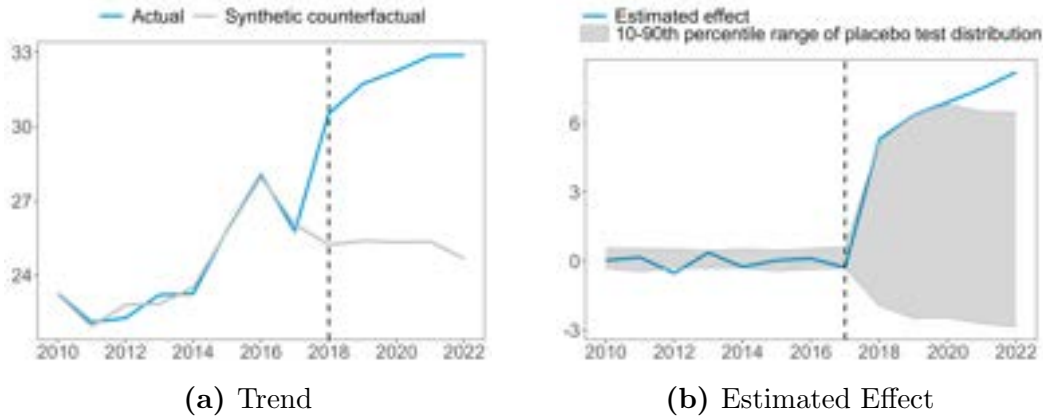
The results above suggest that Vietnam appears to have benefited from trade reallocation as a result of the US-China trade tensions, which has boosted its domestic production and thus increased the domestic content of its exports to the US in strategic sectors. Zooming in on Vietnam, we further examine (i) to what extent Vietnam's exports to the rest of the world (beyond the US) have been affected and (ii) whether part of the reason behind the scaling up of domestic production is related to Chinese firms' reallocation to Vietnam, by examining the FDI dynamics.

4.3.1 Effect on Domestic Content Exported to the World

A natural question building on the positive effect on domestic value added found in Vietnam's exports to the US is whether Vietnam has boosted domestic production for exporting not only to the US, but also to the rest of the world. If so, this suggests that Vietnam has been able to reap more benefits from the US-China trade tensions

than simply gaining from trade reallocation between China and US. We answer this by applying the analysis on the share of domestic value added to that in Vietnam’s *total* exports to the world.

Figure 7: Share of Domestic Value Added in Vietnam’s Exports to the World, Electrical and Machinery
(In Percent)



Notes: Panel (a) plot the actual (the blue line) and the synthetic counterfactual (the grey line) share of domestic value added in Vietnam’s exports to the world, and Panel (b) plots the estimated effect (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of the country in study, for electrical and machinery sector. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors’ calculations.

Figure 7 shows the actual and synthetic counterfactual trends (panel (a)) and the estimated effect (panel (b)) for the electrical and machinery sector. Vietnam has seen the share of domestic value added in its electrical and machinery exports to the world increase since the US-China trade tensions, by 5 percentage points in 2018 and 8 percentage points by the end of 2022. While these effects are slightly smaller than those on Vietnam’s electrical and machinery exports to the US (6 and 10 percentage points in 2018 and 2022, respectively), they are still statistically significant at 90 percent level, although the estimates are very close to the 90th-percentile threshold during 2018–20. These positive and statistically significant effects suggest that Vietnam has been able to export more domestic content not only to the US, as a result of the US-China trade tensions, but also to the rest of the world—otherwise the gross effects would be much smaller given that its exports to the rest of the world are about 70 percent of Vietnam’s total exports.

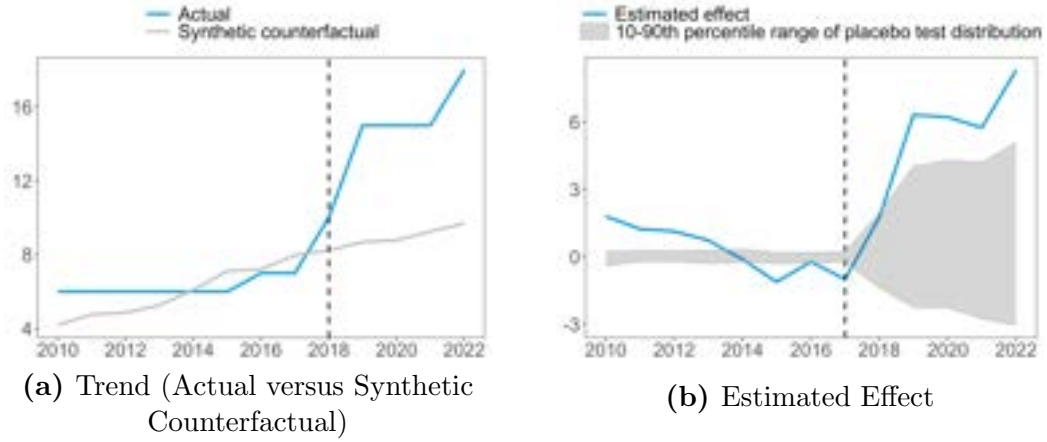
4.3.2 The FDI Channel

To examine whether part of the reason behind the scaling up of domestic production in Vietnam is related to Chinese firms' reallocation to Vietnam, we replicate the synthetic control analysis for the cumulative number of greenfield FDI projects that commit Chinese capital to Vietnam since 2003, the year when data in the Orbis Cross-Border Investment Database becomes available. While the database also has information on the value of committed capital, there is no information on the disbursement status or schedule. As a result, we choose to use the number of projects.

Figure 8 shows the actual and synthetic counterfactual trends (panel (a)) and the estimated effect (panel (b)) for the electrical and machinery sector. Results show that Vietnam has seen a positive and statistically significant effect on FDI inflows from China in the electrical and machinery sector since 2019: it has six more greenfield FDI projects that commit Chinese capital to Vietnam than its synthetic counterfactual cumulatively by 2019, and eight more by 2022. We note that the pre-2018 trend is not perfectly matched, likely due to the volatile nature of the number of greenfield FDI projects—for example, during 2010 and 2017, there are only projects in 2016 in Vietnam—but the average match during 2010 and 2017 is relatively good with mean squared prediction error around 1, which underpins the validity of the estimated effect to some extent.

Combining the results on the share of domestic value added and the number of greenfield FDI projects for Vietnam, it suggests that part of the reasons behind Vietnam's increasing domestic production and thus increasing domestic content in its exports to the US and the rest of the world could be that Chinese firms relocate their production to Vietnam through greenfield FDI for exports. These FDI projects do not only serve the mere purpose of producing products in Vietnam for exporting to the US, but also boost Vietnam's domestic production capacity more broadly and therefore enable it to export more domestic content to the entire world. In addition, tariffs on Chinese exports may also induce non-Chinese firms in China to relocate their production to countries with competitive production costs like Vietnam. Due to the lack of information on the ultimate ownership of these FDI projects, we caution that the effects on FDI could include those from Chinese firms and non-Chinese firms in China. Moreover, the supply chain reconfiguration through FDI may not be exclusive to China as FDI inflows to Vietnam from other countries, including the US, Japan, and Korea, also significantly increased at the same time. While the analysis covers only greenfield FDI investment, FDI inflows into existing businesses for expanding production capacity and mergers and acquisitions could further underpin the attractiveness of Vietnam, along with its high level of education and quality of labor, to foreign investors.

Figure 8: Cumulative Number of Greenfield FDI Projects that Commit Chinese Capital to Vietnam
Electrical and Machinery



Notes: Panel (a) plot the actual (the blue line) and the synthetic counterfactual (the grey line) of the cumulative number of greenfield FDI projects that commit Chinese capital to Vietnam for electrical and machinery sector since 2003. The synthetic counterfactuals are constructed based on a weighted average of the cumulative number of greenfield FDI projects that commit Chinese capital to other countries for the same sector since 2023, excluding Vietnam. Dashed vertical indicates the year 2018 when the US-China trade tensions started. Panel (b) plots the estimated effect on the cumulative number of greenfield FDI projects that commit Chinese capital to Vietnam for electrical and machinery sector since 2003 (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of Vietnam.

Sources: The Orbis Cross-border Investment Database and authors' calculations.

Taken together, these channels are different from trade rerouting in which Vietnam only serves as one-stop place to allow Chinese exports to be re-exported to the US with minimal to no domestic value added.¹² Instead, trade reallocation through FDI helps boost Vietnam's domestic production, enabling it to export more domestic content to the world, and could prove to be more beneficial if there are positive spillovers from FDI firms to domestic firms, as evidence in other countries suggests (Ahn et al., 2024).

The question remains what factors explain the distinct impact of the US-China trade tensions on Vietnam relative to other Asian emerging markets. Several possible reasons to reallocate a significant volume of trade and FDI, and to reconfigure supply chains towards one connector country relative to another could explain the evidence presented in this paper, including these countries' growing domestic markets and their favorable labor costs. While identifying the precise country characteristics is beyond the scope of this paper, it is worth noting that greater openness to global trade and investment,

¹²Few cases of Chinese FDI abroad resulted in US rulings on anti-dumping and countervailing duties, alleging transshipment via third countries with minimal to no domestic value added to circumvent tariffs (e.g. in the solar industry). The evidence of such practices however applied only to isolated cases rather than being evidence of broad-based trade rerouting, and resulting remedial actions were firm-specific rather than affecting all exporters of the affected product.

along with more efficient financial markets, can foster the role as a connector. Vietnam in particular stands out as a candidate connector country partly due to its successful structural transformation boosted by early FDI reforms in the 1980s, its accession to the World Trade Organization (WTO) in 2007, further structural reforms (e.g. on labor markets and state-owned enterprises), FDI incentives in the 2010s, several free trade agreements, supported by a young population, relatively high educational outcomes and female labor force participation, political stability, and geographic proximity to China, which also substantially reduces transportation costs. These factors turned Vietnam into a favorable destination for FDI in Southeast Asia that long preceded the US-China trade tensions and continued afterwards.

4.4 Discussions

One threat to the identification could arguably stem from the impact of potential confounding factors that affect not only strategic sectors but also non-strategic sectors, for example, lockdowns during the Covid-19 pandemic which disrupt supply chains and countries' production capacity, and economy-wide structural reforms which increase productivity. To address this, we replicate the analysis for non-strategic manufacturing sector, that is, calculating the average share of domestic value added in a country's exports to the US across all non-strategic manufacturing sectors and examining whether there have been any effects on the share of domestic value added in a country's non-strategic manufacturing exports to the US. Results in Appendix C show that the positive effects on Vietnam's non-manufacturing sectors are more muted and importantly, not statistically significant until 2022, suggesting that Vietnam has not seen statistically significant effects on the domestic content of its non-strategic manufacturing exports to the US, in contrast with the positive and statistically significant effects on strategic sectors throughout the period of 2018-22. Such difference between strategic and non-strategic sectors helps address potential confounding factors that affect all manufacturing sectors, and thus suggests that the positive and statistically significant effects on strategic sectors can be attributed to the US-China trade tensions. Moreover, two features of our research design mitigate these concerns. First, the Covid-19 pandemic spans only the later half of our post-treatment period, with the bulk of the significant evidence already captured in the unaffected years 2018-2019. Second, to the extent that the pandemic represented a global shock and lockdowns occurred simultaneously in many countries, pandemic-related supply chain reconfiguration would affect all countries in the synthetic control group in a similar manner without confounding effects on the relative distribution of value added in exports. Similar to the trade reallocation effect, the positive and statistically significant effects on FDI are only observed in strategic sectors but not in the non-strategic man-

ufacturing sectors (see Appendix G for results on petroleum, chemical and non-metallic mineral products sector and non-strategic manufacturing sectors).

A similar argument could be drawn with respect to concerns about the effects from the US-China trade tensions on other countries, challenging the validity of including some countries in the synthetic control group. Arguably, the US-China trade tensions, while rippling through markets globally, did not significantly upend all countries' trade relationships and lead to a reconfiguration of supply chains in every country, as found in many studies (e.g. Gopinath et al., 2024 among others). Notwithstanding, Appendix E presents the top countries—with the largest weights that add up to 70 percent—used in constructing the synthetic counterfactual for each country in the sample. The country lists suggest that other frequently mentioned connector countries, such as Mexico and Poland, do not receive large weights when constructing the synthetic counterfactuals. Moreover, all countries (except the six Asian countries in the sample, and China and the US) are included in constructing the 10th – 90th percentile range of the placebo test distribution. This strengthens our key finding that the effect on Vietnam still remains statistically significant, even when including some other countries in the synthetic control group which may have been affected by US tariffs and may also have seen positive effects on the share of domestic value added in their exports to the US.

One may also argue that there may be other structural factors in these countries (e.g. a relative increase in labor costs) driving the change in domestic value added or Chinese value added in gross exports that occurred around the time of the US-China trade tensions. An increase in the domestic input costs in China may increase incentives for rerouting of goods by Chinese firms while such an increase in the connector countries may be reflected as an increasing share of domestic value added in their exports. This could challenge the interpretation of domestic and Chinese value added as sufficient to test our hypotheses of trade reallocation and rerouting. However, as shown in the results, the share of value added (either domestic or Chinese) is slow-moving. With the pre-treatment matching characteristics including the dynamics of the variable of interest in almost one decade as well as the economy and exports sizes, structural factors such as significant increases in domestic input costs or productivity growth should already be accounted for when constructing the synthetic counterfactuals. In addition, as mentioned before, failure to reject the trade rerouting hypothesis could still reflect Chinese firms' incentive to relocate their production to the connector country to benefit from favorable structural characteristics rather than mere transshipment. Finally, some structural drivers among the countries in our sample and in the counterfactual long preceded the US-China trade tensions as part of a slower-moving structural transformation of countries towards manufacturing and services.

5 Conclusion

This paper provides a nuanced distinction of *trade reallocation* and *trade rerouting* in explaining changing trade patterns since the onset of US-China trade tensions, by zooming in on six Asian connector countries' trade and FDI flows as well as input-output linkages. First, the connector role—that has been argued based on inward linkages with China through imports and outward linkages with the US through exports—does not necessarily establish the bridging role of these countries between the trade blocs, and could well reflect Chinese firms' relocation of production abroad and reconfiguration of supply chains, as well as these economies' growing domestic markets. Second, examining the value-added content of bilateral trade, Vietnam appears to have benefited from trade reallocation as a result of the US-China trade tensions during 2018-2022. Vietnam's domestic production of strategic sector exports to the US has scaled up, which is reflected in an increasing share of domestic value added embedded in its exports to the US for strategic sectors. Conversely, there is no evidence of Vietnam facilitating trade rerouting—or transshipment—of Chinese exports on a significant scale, as it has seen a lower share of Chinese value added in its strategic sector exports to the US. Moreover, the positive effects on domestic value added are also found in Vietnam's strategic sectors' exports to the rest of the world. At the same time, Vietnam has seen an increase in the committed inward FDI from China in its strategic sectors. Taken together, it suggests that the connector role of Vietnam has manifested through trade reallocation as the US shifts away from China and reconfigures its supply chains towards Vietnam while China shifts production to Vietnam by setting up more factories in Vietnam through FDI—likely not only because of tariffs imposed by the US but also to take advantage of lower labor costs—which has led to a scale-up of domestic production of strategic sector products and more domestic content embedded in Vietnam's exports, not only to the US but also to the rest of the world. The evidence of either the trade reallocation or trade rerouting effect in the other five Asian countries is elusive.

The benefits of rising trade and FDI flows to the *domestic* sector, however, remain unclear. Benefits of geoeconomic fragmentation-related inflows may come from boosting trade activity in the FDI sector and from translating into value added to the domestic sector, including through higher employment and wages, technological spillovers, and deepening of domestic firms' global value chain integration. For example, studies on the US-China trade tensions in 2018-2019 find positive labor market effects in districts more exposed to US-China tariffs (Mayr-Dorn et al., 2023; Rotunno et al., 2024). At the same time, Vietnam's “dual economy”, or disconnect between activities in the domestic and FDI sectors, weighs on the technological diffusion and productivity spillovers that could boost domestic firm potential.

Fragmentation also risks clouding connector countries' prospects. In relative terms and in the short term, non-aligned countries that maintain open trade relationships to all countries may stand to suffer the least from geoeconomic fragmentation (Aiyar et al., [2023](#); Bolhuis et al., [2023](#); Cerdeiro et al., [2021](#); Góes and Bekkers, [2022](#)). However, such countries, usually those with an export-oriented growth strategy that are well-integrated into the global supply chain, would be more vulnerable to adverse shocks resulting from an intensification of geoeconomic fragmentation, such as disruptive movements in commodity prices, unexpected shifts in protective trade policies, and an overall decline in external demand from a shrinking global economy. In the long run, all countries stand to lose from geoeconomic fragmentation.

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Appendices

Appendix A Country and Sector Sample

The appendix presents the sample of country in Table 1 and the 26 sectors in the Eora Global Supply Chain database in Table 2.

Table 1: Sample of Country by Income Group

Advanced Economies	Emerging Market and Middle-Income Economies	Low Income Developing Countries
Andorra	Aruba	Afghanistan
Australia	Angola	Burundi
Austria	Albania	Benin
Belgium	United Arab Emirates	Burkina Faso
Canada	Argentina	Bangladesh
Switzerland	Armenia	Bhutan
Cyprus	Antigua and Barbuda	Central African Republic
Czech Republic	Azerbaijan	Côte d'Ivoire
Germany	Bulgaria	Cameroon
Denmark	Bahrain	Democratic Republic of the Congo
Spain	Bahamas, The	Congo, Republic of
Estonia	Bosnia and Herzegovina	Djibouti
Finland	Belarus	Eritrea
France	Belize	Ethiopia
United Kingdom	Bolivia	Ghana
Greece	Brazil	Guinea
Hong Kong SAR	Barbados	Gambia, The
Ireland	Brunei Darussalam	Honduras
Iceland	Botswana	Haiti
Israel	Chile	Kenya
Italy	China	Kyrgyz Republic
Japan	Colombia	Cambodia
Korea	Cabo Verde	Lao P.D.R.
Lithuania	Costa Rica	Liberia
Luxembourg	Dominican Republic	Lesotho
Latvia	Algeria	Moldova
Macao SAR	Ecuador	Madagascar
Malta	Egypt	Mali
Netherlands	Fiji	Myanmar
Norway	Gabon	Mozambique
New Zealand	Georgia	Mauritania
Portugal	Guatemala	Malawi
Singapore	Guyana	Niger
San Marino	Croatia	Nigeria
Slovak Republic	Hungary	Nicaragua
Slovenia	Indonesia	Nepal
Sweden	India	Papua New Guinea
Taiwan Province of China	Iran	Rwanda
	Iraq	Senegal
	Jamaica	Sierra Leone
	Jordan	Somalia
	Kazakhstan	São Tomé and Príncipe
	Kuwait	Chad

Lebanon	Togo
Libya	Tajikistan
Sri Lanka	Tanzania
Morocco	Uganda
Maldives	Uzbekistan
Mexico	Vietnam
North Macedonia	Yemen
Montenegro, Rep. of	Zambia
Mongolia	Zimbabwe
Mauritius	
Malaysia	
Namibia	
Oman	
Pakistan	
Panama	
Peru	
Philippines	
Poland	
Paraguay	
Qatar	
Romania	
Russia	
Saudi Arabia	
El Salvador	
Serbia	
Suriname	
Eswatini	
Seychelles	
Syria	
Thailand	
Turkmenistan	
Trinidad and Tobago	
Tunisia	
Turkey	
Ukraine	
Uruguay	
Venezuela	
Vanuatu	
Samoa	
South Africa	

Table 2: Sectors in the Eora Global Supply Chain Database

Sector
Agriculture
Fishing
Mining and Quarrying
Food and Beverages
Textiles and Wearing Apparel
Wood and Paper
Petroleum, Chemical and Non-Metallic Mineral Products
Metal Products
Electrical and Machinery
Transport Equipment
Other Manufacturing
Recycling
Electricity, Gas and Water
Construction
Maintenance and Repair
Wholesale Trade
Retail Trade
Hotels and Restaurants
Transport
Post and Telecommunications
Financial Intermediation and Business Activities
Public Administration
Education, Health and Other Services
Private Households
Others
Re-export and Re-import

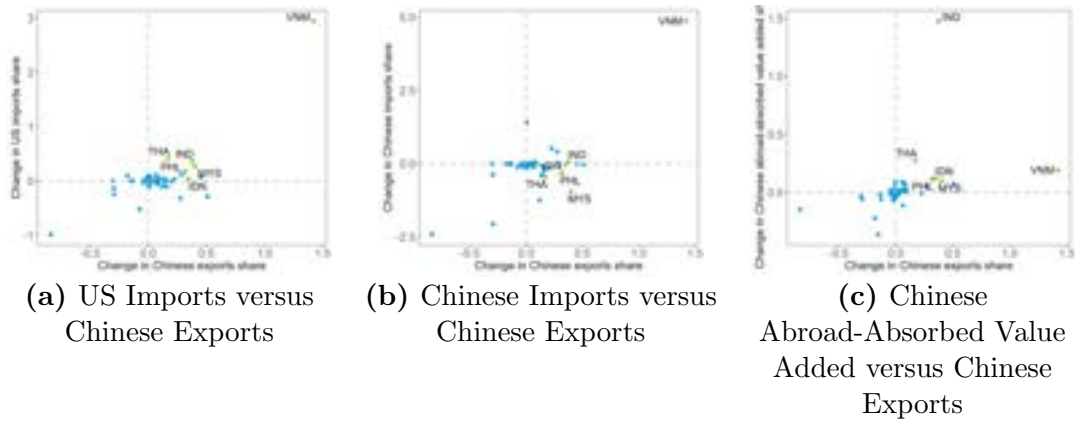
This appendix presents additional stylized facts on the association between change in a country's share in the US imports, in Chinese imports, in Chinese abroad-absorbed value added, and change in a country's share in Chinese exports, for strategic sectors including (i) electrical and machinery (Figure 9) and (ii) petroleum, chemical and non-metallic mineral products (Figure 10).

Figure 1 consists of three scatter plots, (a), (b), and (c), each showing the relationship between changes in a specific variable and the change in Chinese exports share. The x-axis for all plots is 'Change in Chinese exports share' ranging from -0.3 to 0.3. The y-axis for all plots is 'Change in [variable] value added' ranging from -2 to 3.

- (a) US Imports versus Chinese Exports: The y-axis is 'Change in US imports value added'. Data points are clustered around the x-axis, with a slight positive correlation. Labeled points include 'RC', 'CN', 'TH', 'AL', and 'VNM'.
- (b) Chinese Imports versus Chinese Exports: The y-axis is 'Change in Chinese imports value added'. Data points are clustered around the x-axis, with a slight positive correlation. Labeled points include 'RC', 'TH', 'CN', 'AL', 'VNM', and 'TA'.
- (c) Chinese Value Added Absorbed Abroad versus Chinese Exports: The y-axis is 'Change in Chinese value added absorbed abroad value added'. Data points are clustered around the x-axis, with a slight positive correlation. Labeled points include 'RC', 'TH', 'CN', 'AL', 'VNM', and 'TA'.

Sources: BACI Database (Gaulier and Zignago, 2010), The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Figure 10: Change in the Share in US Imports, Chinese Imports, and Chinese Abroad-Absorbed Value Added versus Change in the Share of Chinese Exports Petroleum, Chemical and Non-Metallic Mineral Products



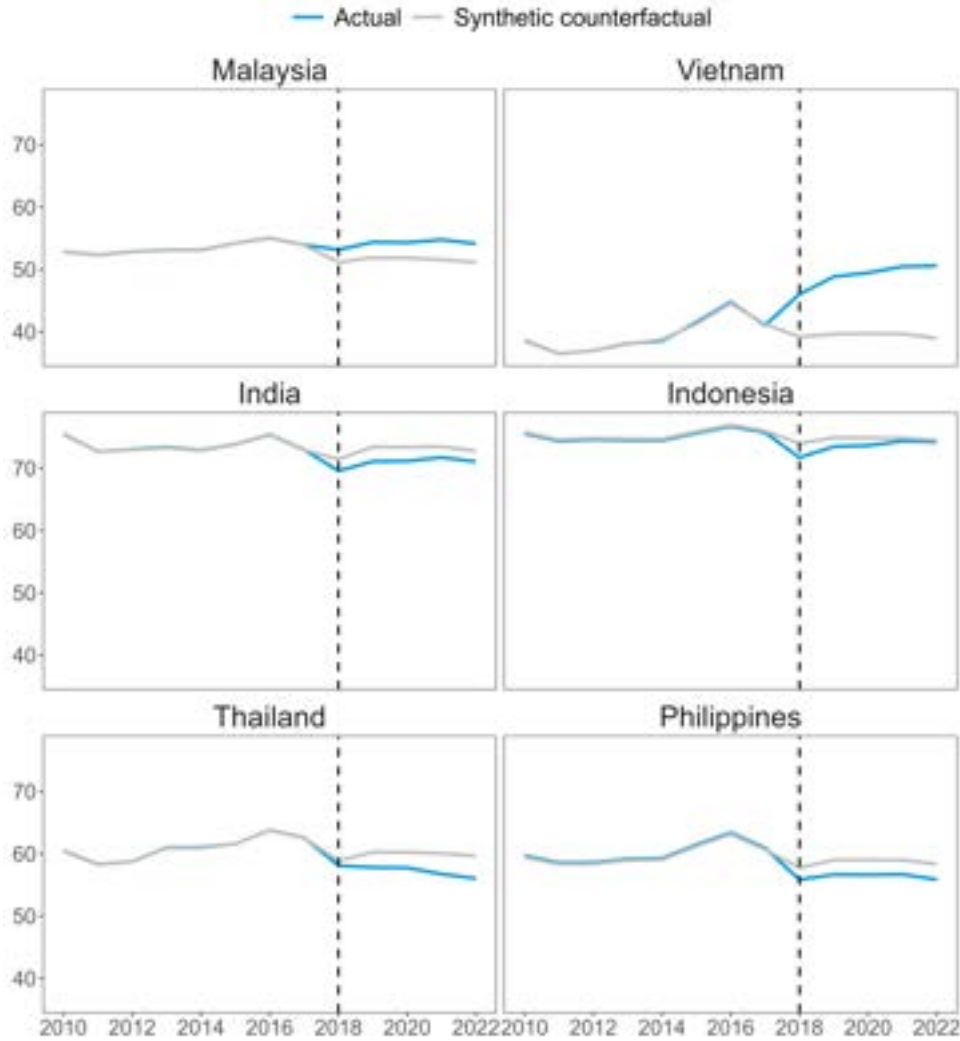
Notes: Panel (a)-(c) plot changes in three measures of market shares, including the share in US imports (panel (a)), the share in Chinese imports (panel (b)), and the share in Chinese abroad-absorbed value added (panel (c)), between 2013-17 and 2018-22, against change in the share in Chinese exports, for nonaligned countries. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: BACI Database (Gaulier and Zignago, 2010), The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Appendix C Additional Empirical Results on the Share of Domestic Value Added in Exports

The appendix presents empirical results for petroleum, chemical and non-metallic mineral products, and non-strategic manufacturing products, including (i) the dynamics - both the actual values and the synthetic counterfactuals - of the share of domestic value added in a country's exports to the US, and (ii) the estimated effects.

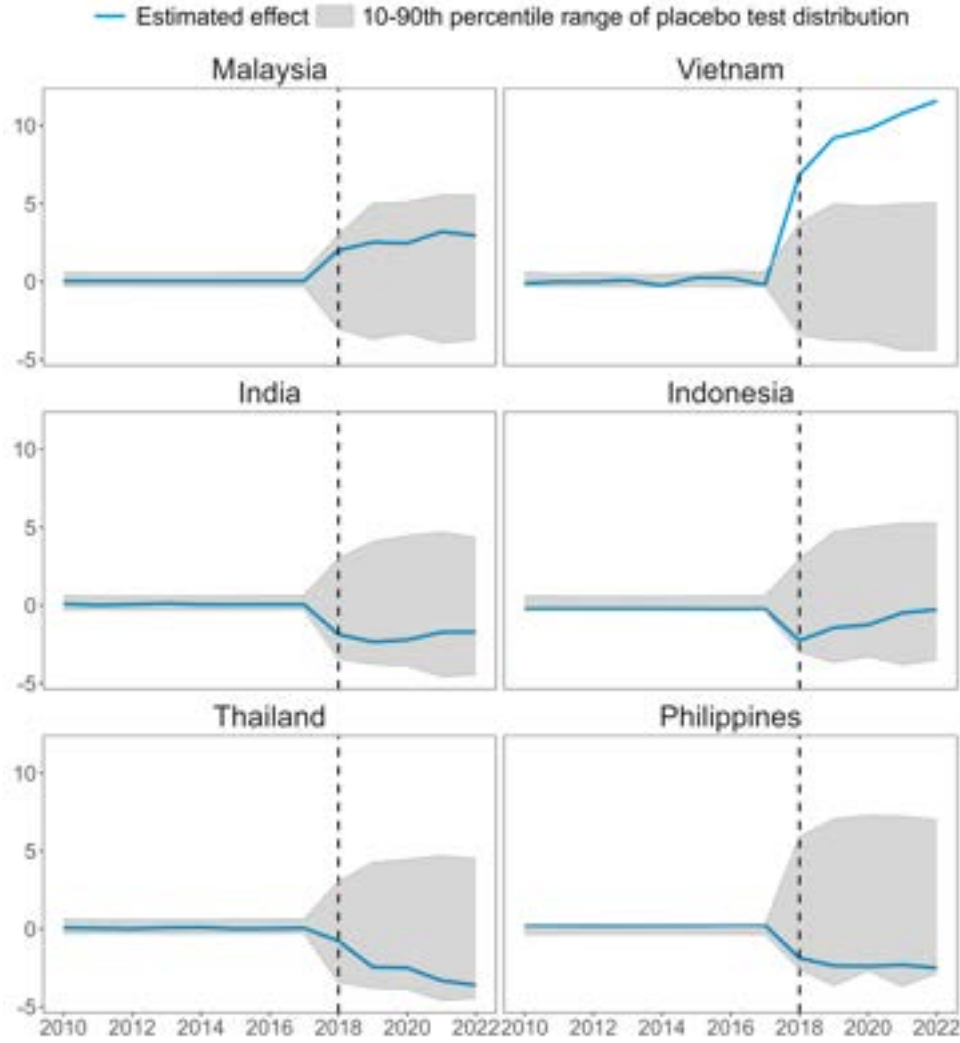
Figure 11: Share of Domestic Value Added in the Country's Exports to the US,
Petroleum, Chemical and Non-Metallic Mineral Products
(In Percent)



Notes: For each country, the figure plots the actual (the blue lines) and the synthetic counterfactual (the grey lines) share of domestic value added in the country's exports to the US, for petroleum, chemical and non-metallic mineral products sector. The synthetic counterfactuals are constructed based on a weighted average of the share of domestic value added in other countries' exports to the US for the same sector, excluding the six countries of interest in this paper. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

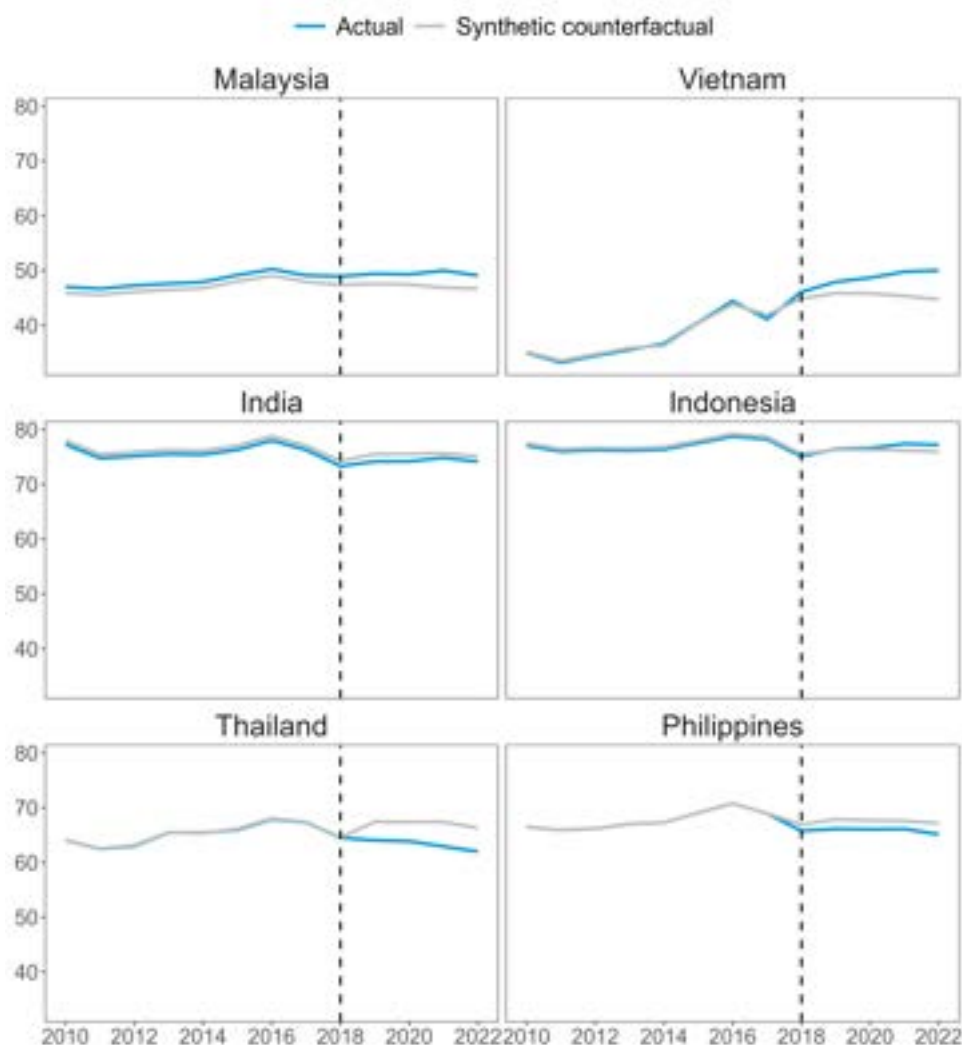
Figure 12: Estimated Effect on the Share of Domestic Value Added in the Country's Exports to the US, Petroleum, Chemical and Non-Metallic Mineral Products (In Percentage Points)



Notes: For each country, the figure plots the estimated effect on the share of domestic value added in the country's exports to the US, for petroleum, chemical and non-metallic mineral products sector (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of the country in study.ashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

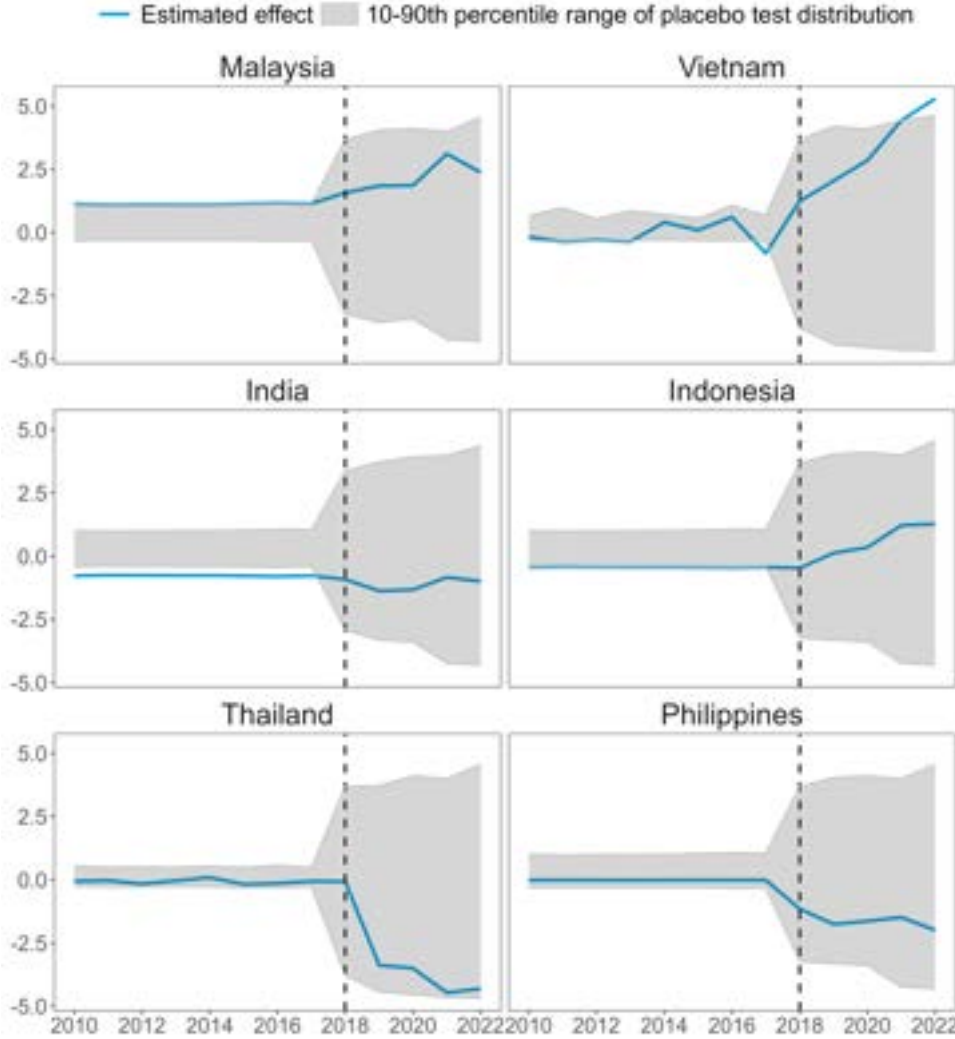
Figure 13: Share of Domestic Value Added in the Country's Exports to the US,
Non-Strategic Manufacturing Products
(In Percent)



Notes: For each country, the figure plots the actual (the blue lines) and the synthetic counterfactual (the grey lines) share of domestic value added in the country's exports to the US, for non-strategic manufacturing sectors. The synthetic counterfactuals are constructed based on a weighted average of the share of domestic value added in other countries' exports to the US for the same sector, excluding the six countries of interest in this paper. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Figure 14: Estimated Effect on the Share of Domestic Value Added in the Country's Exports to the US, Non-Strategic Manufacturing Products (In Percentage Points)

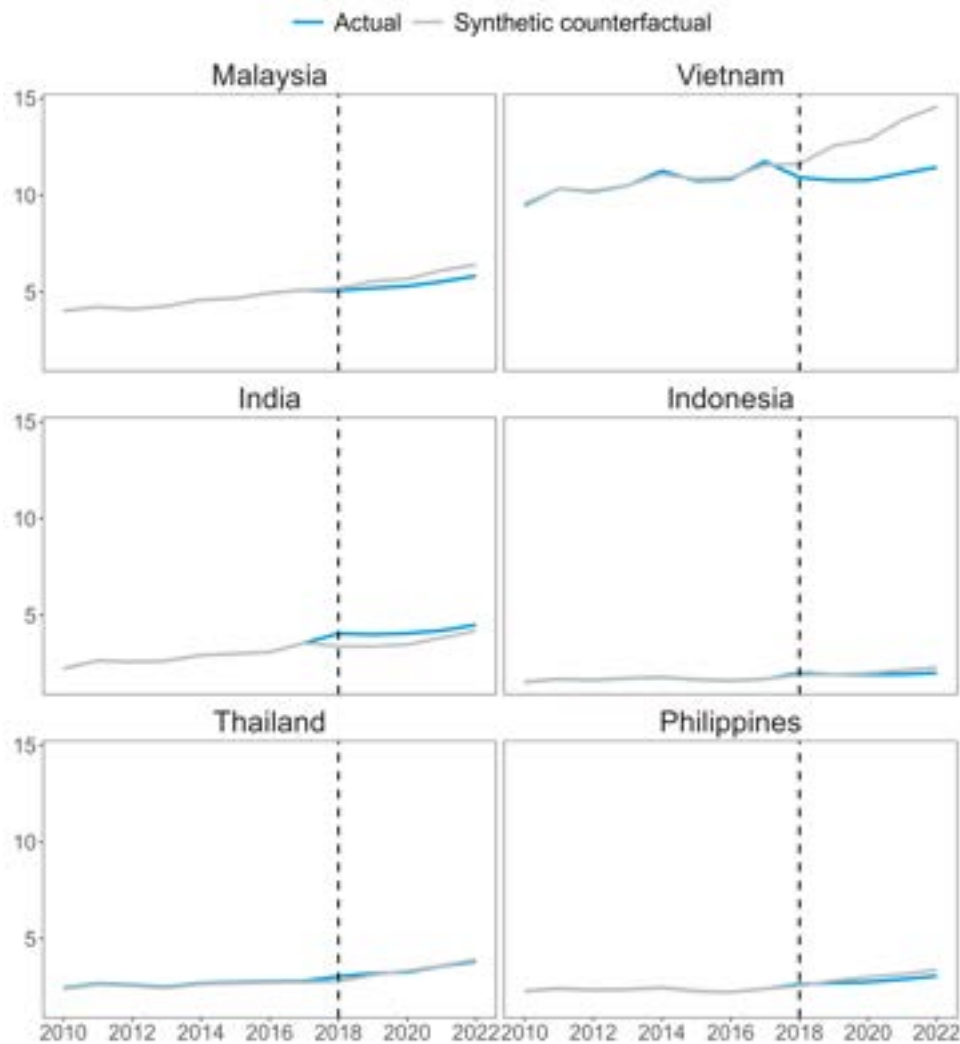


Notes: For each country, the figure plots the estimated effect on the share of domestic value added in the country's exports to the US, for non-strategic manufacturing sectors (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of the country in study. A dashed vertical line indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged. Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Appendix D Additional Empirical Results on the Share of Chinese Value Added in Exports

The appendix presents empirical results for petroleum, chemical and non-metallic mineral products, and non-strategic manufacturing products, including (i) the dynamics - both the actual values and the synthetic counterfactuals - of the share of Chinese value added in a country's exports to the US, and (ii) the estimated effects.

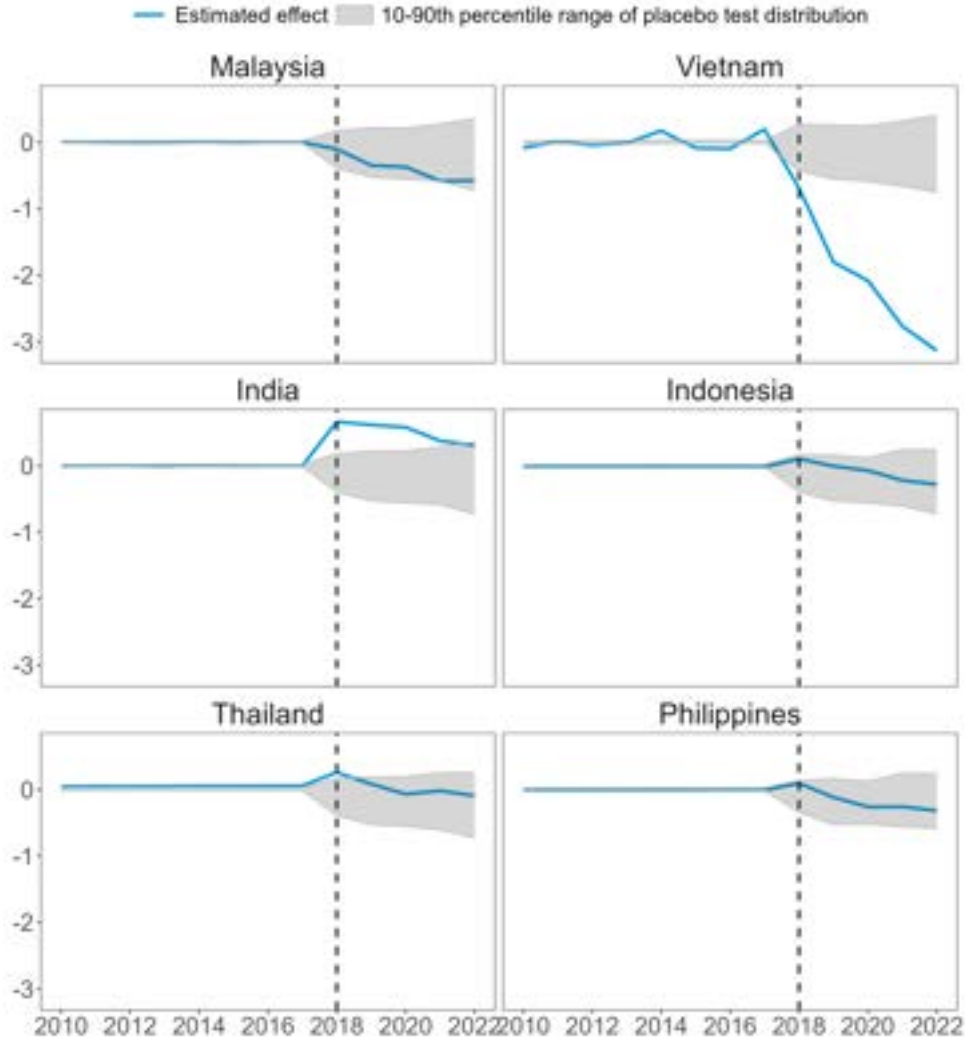
Figure 15: Share of Chinese Value Added in the Country's Exports to the US,
Petroleum, Chemical and Non-Metallic Mineral Products
(In Percent)



Notes: For each country, the figure plots the actual (the blue lines) and the synthetic counterfactual (the grey lines) share of Chinese value added in the country's exports to the US, for petroleum, chemical and non-metallic mineral products sector. The synthetic counterfactuals are constructed based on a weighted average of the share of Chinese value added in other countries' exports to the US for the same sector, excluding the six countries of interest in this paper. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

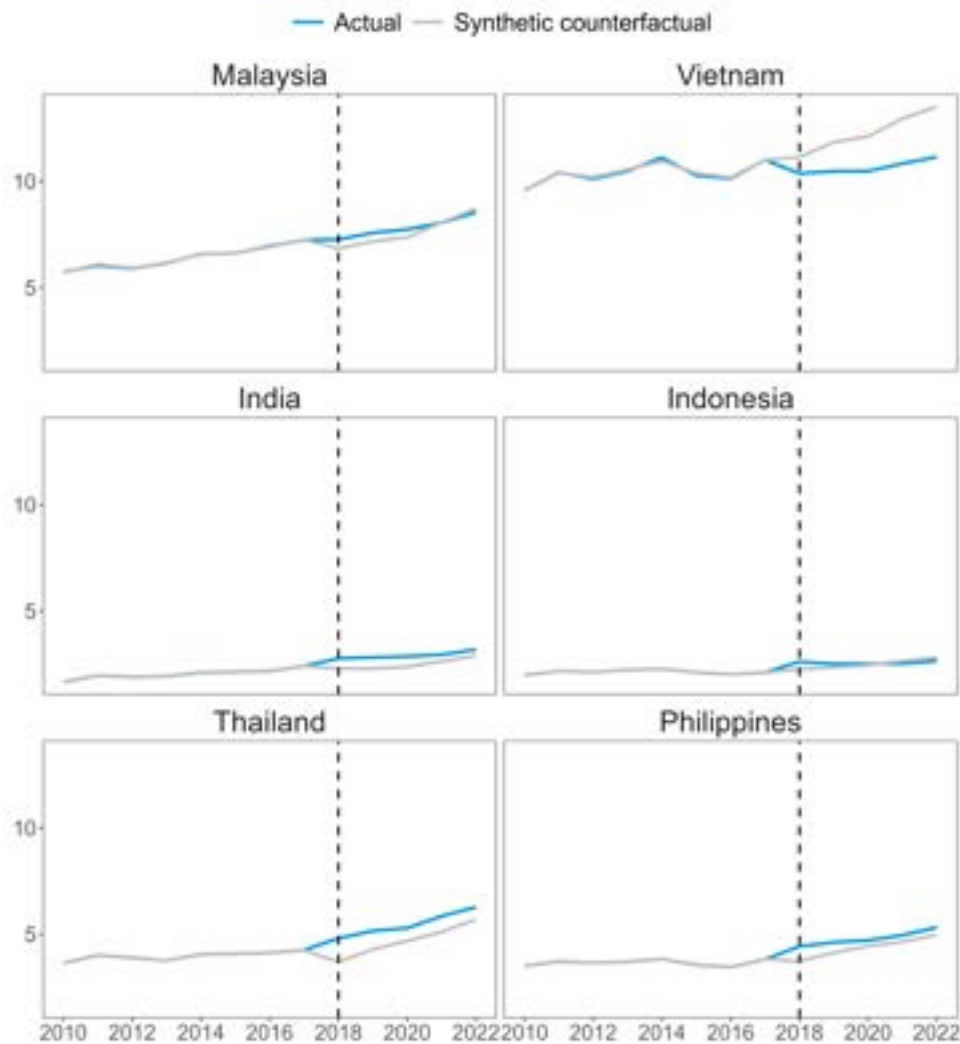
Figure 16: Estimated Effect on the Share of Chinese Value Added in the Country's Exports to the US, Petroleum, Chemical and Non-Metallic Mineral Products (In Percentage Points)



Notes: For each country, the figure plots the estimated effect on the share of domestic value added in the country's exports to the US, for petroleum, chemical and non-metallic mineral products sectors (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of the country in study. dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

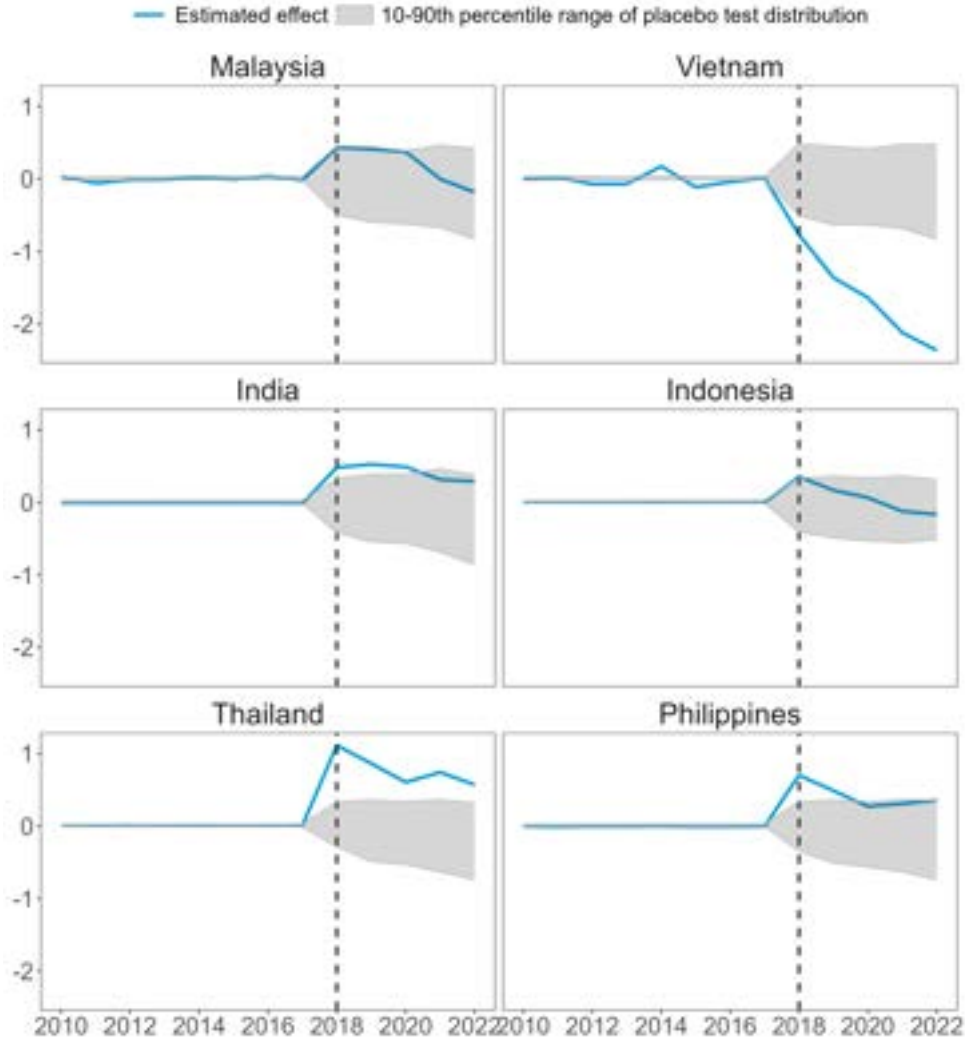
Figure 17: Share of Chinese Value Added in the Country's Exports to the US,
Non-Strategic Manufacturing Products
(In Percent)



Notes: For each country, the figure plots the actual (the blue lines) and the synthetic counterfactual (the grey lines) share of Chinese value added in the country's exports to the US, for non-strategic manufacturing sector. The synthetic counterfactuals are constructed based on a weighted average of the share of Chinese value added in other countries' exports to the US for the same sector, excluding the six countries of interest in this paper. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Figure 18: Estimated Effect on the Share of Chinese Value Added in the Country's Exports to the US, Non-Strategic Manufacturing Products (In Percentage Points)



Notes: For each country, the figure plots the estimated effect on the share of domestic value added in the country's exports to the US, for non-strategic manufacturing sectors (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of the country in study. A vertical dashed line indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged. Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Appendix E List of Countries Used in Constructing Synthetic Counterfactuals

The appendix presents the list of countries used in constructing the synthetic counterfactuals for the share of domestic value added (Table 3 - 5) and for the share of Chinese value added (Table 6 - 8), with the largest weights that add up to 70 percent.

Table 3: List of Top Countries Used in Constructing the Synthetic Counterfactual for the Share of Domestic Value Added, Electrical and Machinery

Rank	Indonesia	India	Malaysia	Philippines	Thailand	Vietnam
1	United Arab Emirates	Suriname	Guyana	Seychelles	Singapore	Luxembourg
2	Burundi	Yemen	Myanmar	Guyana	Maldives	Hungary
3	Côte d'Ivoire	Uzbekistan	Singapore	Hong Kong SAR	Seychelles	
4	Brunei Darussalam	Myanmar		Singapore		
5	Bahrain	Serbia				
6	Benin					
7	New Zealand					
8	Bulgaria					
9	Peru					
10	Bolivia					
11	Brazil					
12	Oman					
13	Trinidad and Tobago					
14	Pakistan					
15	Central African Republic					
16	Chad					
17	Russia					
18	Norway					
19	Cameroon					
20	Angola					
21	South Africa					
22	Mozambique					
23	Qatar					
24	Iran					
25	Egypt					
26	Algeria					
27	Kuwait					
28	Nepal					
29	United Kingdom					
30	Ecuador					
31	Australia					
32	Mauritius					
33	Congo, Republic of					
34	Belarus					
35	Malawi					
36	Tanzania					
37	Colombia					
38	Switzerland					
39	Panama					
40	Myanmar					

Notes: Each column lists the countries used in constructing the synthetic counterfactual for each country in the sample, with the largest weights that add up to 70 percent.

Sources: authors' calculations.

Table 4: List of Top Countries Used in Constructing the Synthetic Counterfactual for the Share of Domestic Value Added, Petroleum, Chemical and Non-Metallic Mineral Products

Rank	Indonesia	India	Malaysia	Philippines	Thailand	Vietnam
1	Panama	Serbia	Hungary	Austria	Seychelles	Seychelles
2	South Africa	Myanmar	Angola	Togo	Korea	Lithuania
3	New Zealand		Hong Kong SAR	United Arab Emirates		Luxembourg
4	Singapore		Netherlands	Mauritania		
5	Hungary		Ireland	Armenia		
6	Oman		Norway	Haiti		
7	Taiwan Province of China		Mozambique	Montenegro, Rep. of		
8	Spain		Sweden	Zambia		
9	Mozambique		Switzerland	Senegal		
10	Norway		Luxembourg	Romania		
11	Congo, Republic of		Myanmar	Djibouti		
12	Tunisia		Malawi	Argentina		
13	Kuwait		Congo, Republic of	Cambodia		
14	Tanzania		Belarus	Madagascar		
15	Belarus		Lithuania	Germany		
16	Malawi		Guyana	Tunisia		
17	Luxembourg		Singapore	Ecuador		
18	Switzerland		Taiwan Province of China	Denmark		
19	Myanmar			Nepal		
20	Pakistan			Bulgaria		
21				Ghana		
22				Mexico		
23				Poland		
24				Kenya		
25				Tanzania		
26				Iceland		
27				Nigeria		
28				Cyprus		
29				Mauritius		
30				Switzerland		
31				Croatia		
32				Egypt		
33				Gambia, The		
34				Cabo Verde		
35				Portugal		
36				Panama		
37				Democratic Rep. of Congo		
38				Seychelles		
39				Bahamas, The		
40				Belarus		
41				Luxembourg		
42				Guyana		
43				United Kingdom		
44				Uzbekistan		

Notes: Each column lists the countries used in constructing the synthetic counterfactual for each country in the sample, with the largest weights that add up to 70 percent.

Sources: authors' calculations.

Table 5: List of Top Countries Used in Constructing the Synthetic Counterfactual for the Share of Domestic Value Added, Non-Strategic Manufacturing Products

Rank	Indonesia	India	Malaysia	Philippines	Thailand	Vietnam
1	Nigeria	Pakistan	Korea	Haiti	Maldives	Luxembourg
2	Myanmar	Morocco	Singapore	Switzerland	Seychelles	Montenegro, Rep. of
3		Myanmar		Macao SAR		
4				Belarus		
5				United Kingdom		
6				Guyana		
7				Pakistan		
8				Seychelles		
9				Egypt		

Notes: Each column lists the countries used in constructing the synthetic counterfactual for each country in the sample, with the largest weights that add up to 70 percent.

Sources: authors' calculations.

Table 6: List of Top Countries Used in Constructing the Synthetic Counterfactual for the Share of Chinese Value Added, Electrical and Machinery

Rank	Indonesia	India	Malaysia	Philippines	Thailand	Vietnam
1	Nigeria	Lesotho	Germany	Moldova	Moldova	Hong Kong SAR
2	Belarus	Kyrgyz Republic	Singapore	Egypt	Yemen	Djibouti
3	Congo, Republic of			Hong Kong SAR	Hong Kong SAR	
4	Cambodia			Belarus		
5	Iran					
6	Panama					

Notes: Each column lists the countries used in constructing the synthetic counterfactual for each country in the sample, with the largest weights that add up to 70 percent.

Sources: authors' calculations.

Table 7: List of Top Countries Used in Constructing the Synthetic Counterfactual for the Share of Chinese Value Added, Petroleum, Chemical and Non-Metallic Mineral Products

Rank	Indonesia	India	Malaysia	Philippines	Thailand	Vietnam
1	Central African Republic	Ghana	Belarus	Cyprus	Seychelles	Hong Kong SAR
2	Mozambique	Lesotho	United Arab Emirates	Macao SAR	Germany	Djibouti
3	Belarus	Djibouti	Germany	Uzbekistan		
4	Myanmar			Nepal		
5	Russia			Nigeria		
6	Chad			Belarus		
7	Macao SAR					
8	Tajikistan					
9	Cambodia					
10	Panama					
11	Botswana					
12	Nepal					
13	Nigeria					
14	Malawi					

Notes: Each column lists the countries used in constructing the synthetic counterfactual for each country in the sample, with the largest weights that add up to 70 percent.

Sources: authors' calculations.

Table 8: List of Top Countries Used in Constructing the Synthetic Counterfactual for the Share of Chinese Value Added, Non-Strategic Manufacturing Products

Rank	Indonesia	India	Malaysia	Philippines	Thailand	Vietnam
1	Angola	Pakistan	Mauritius	Belarus	United Arab Emirates	Hong Kong SAR
2	Switzerland	Czech Republic		Egypt	Seychelles	Mongolia
3	Georgia	Suriname			Djibouti	
4	Guatemala	Jamaica				
5	Brazil	Mauritius				
6	Qatar	Ghana				
7	Mozambique	Lesotho				
8	Myanmar	Germany				
9	Oman	Yemen				
10	Croatia	Madagascar				
11	Panama	Guyana				
12	Congo, Republic of	Uzbekistan				
13	Botswana	Djibouti				
14	Macao SAR	Morocco				
15	Chad	Serbia				
16	Iran	Montenegro, Rep. of				
17	Namibia					
18	Tanzania					
19	Belarus					
20	Nigeria					

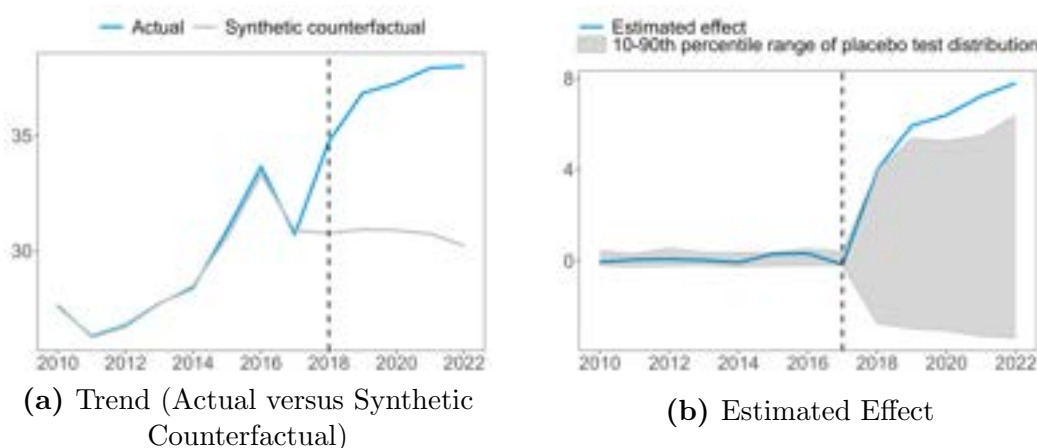
Notes: Each column lists the countries used in constructing the synthetic counterfactual for each country in the sample, with the largest weights that add up to 70 percent.

Sources: authors' calculations.

Appendix F Additional Empirical Results on the Share of Domestic Value Added in Vietnam's Exports to the World

The appendix presents empirical results for petroleum, chemical and non-metallic mineral products, and non-strategic manufacturing products, including (i) the dynamics - both the actual values and the synthetic counterfactuals - of the share of domestic value added in Vietnam's exports to the world, and (ii) the estimated effects.

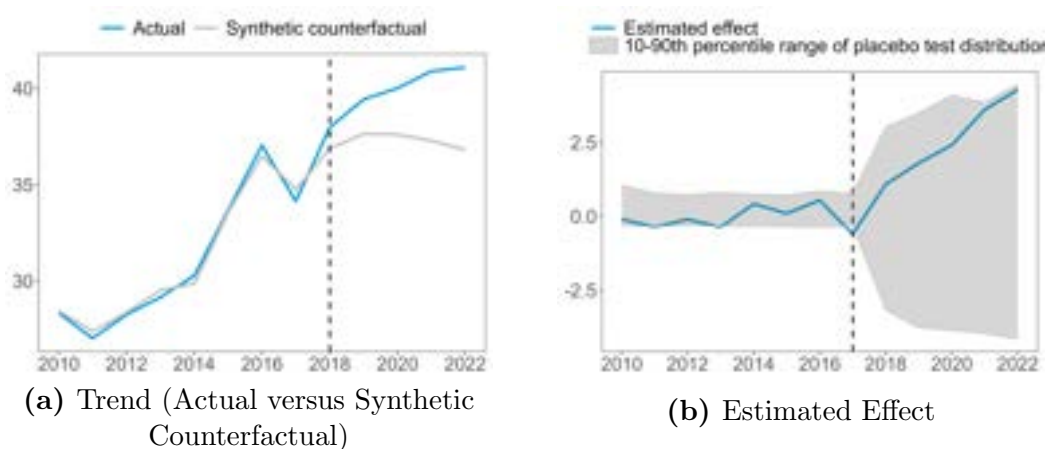
Figure 19: Share of Domestic Value Added in Vietnam's Exports to the World, Petroleum, Chemical and Non-Metallic Mineral Products (In Percent)



Notes: Panel (a) plot the actual (the blue line) and the synthetic counterfactual (the grey line) share of domestic value added in Vietnam's exports to the world, and Panel (b) plots the estimated effect on the share of domestic value added in Vietnam's exports to the world (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of the country in study, for petroleum, chemical and non-metallic mineral products. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Figure 20: Share of Domestic Value Added in Vietnam's Exports to the World, Non-Strategic Manufacturing Products (In Percent)



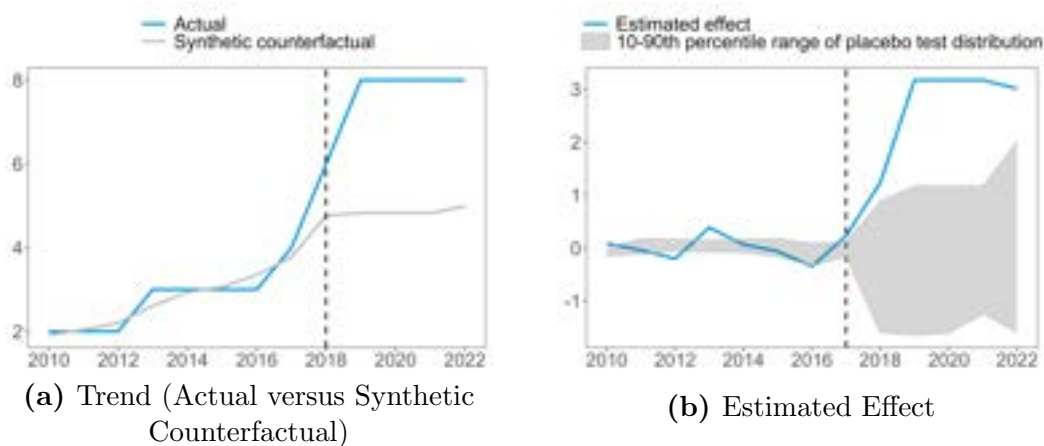
Notes: Panel (a) plot the actual (the blue line) and the synthetic counterfactual (the grey line) share of domestic value added in Vietnam's exports to the world, and Panel (b) plots the estimated effect on the share of domestic value added in Vietnam's exports to the world (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of the country in study, for non-strategic manufacturing products. Dashed vertical indicates the year 2018 when the US-China trade tensions started. To account for a visible seam between 2015 and 2016 data in the Eora Global Supply Chain Database due to a structural break in the database methodology (see Eora Global Supply Chain Database (2024)), value added measures from 2016 onwards are adjusted so that the adjusted 2016 value is equal to the linearly-extrapolated value based on data during 2010 and 2015 while the post-2016 trend is kept unchanged.

Sources: The Eora Global Supply Chain Database (Lenzen et al., 2012, Lenzen et al., 2013), Aslam et al. (2017), and authors' calculations.

Appendix G Additional Empirical Results on the Number of Greenfield FDI Projects

The appendix presents empirical results for petroleum, chemical and non-metallic mineral products, and non-strategic manufacturing products, including (i) the dynamics - both the actual values and the synthetic counterfactuals - of the cumulative number of greenfield FDI projects that commit Chinese capital in Vietnam, and (ii) the estimated effects.

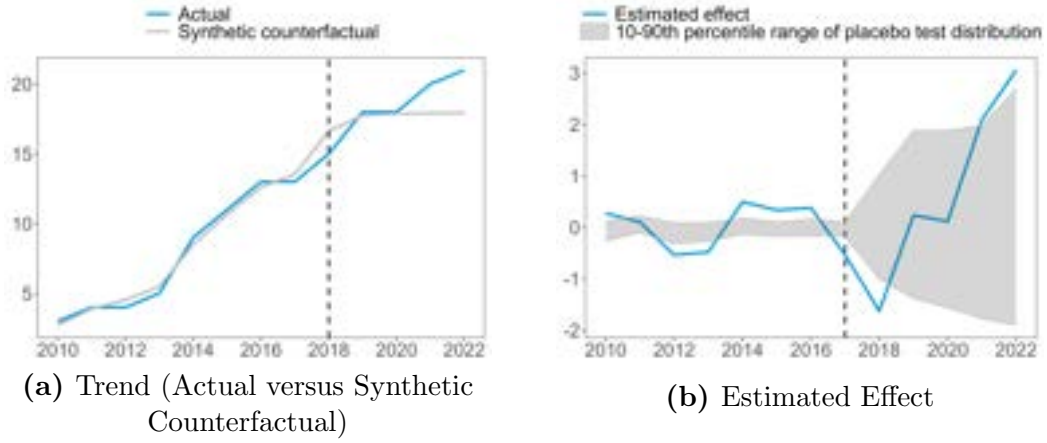
Figure 21: Cumulative Number of Greenfield FDI Projects that Commit Chinese Capital to Vietnam
Petroleum, Chemical and Non-Metallic Mineral Products



Notes: Panel (a) plot the actual (the blue line) and the synthetic counterfactual (the grey line) of the cumulative number of greenfield FDI projects that commit Chinese capital to Vietnam for petroleum, chemical and non-metallic mineral product sector since 2003. The synthetic counterfactuals are constructed based on a weighted average of the cumulative number of greenfield FDI projects that commit Chinese capital to other countries for the same sector since 2023, excluding Vietnam. Dashed vertical indicates the year 2018 when the US-China trade tensions started. Panel (b) plots the estimated effect on the cumulative number of greenfield FDI projects that commit Chinese capital to Vietnam for electrical and machinery sector since 2003 (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of Vietnam.

Sources: The Orbis Cross-border Investment Database and authors' calculations.

Figure 22: Cumulative Number of Greenfield FDI Projects that Commit Chinese Capital to Vietnam
Non-Strategic Manufacturing Sector



Notes: Panel (a) plot the actual (the blue line) and the synthetic counterfactual (the grey line) of the cumulative number of greenfield FDI projects that commit Chinese capital to Vietnam for non-strategic manufacturing sector since 2003. The synthetic counterfactuals are constructed based on a weighted average of the cumulative number of greenfield FDI projects that commit Chinese capital to other countries for the same sector since 2023, excluding Vietnam. Dashed vertical indicates the year 2018 when the US-China trade tensions started. Panel (b) plots the estimated effect on the cumulative number of greenfield FDI projects that commit Chinese capital to Vietnam for electrical and machinery sector since 2003 (the blue lines) and the 10th – 90th percentile range of the placebo test distribution excluding countries that have pretreatment (before 2018) mean squared prediction error (MSPE) of more than five times the MSPE of Vietnam.

Sources: The Orbis Cross-border Investment Database and authors' calculations.



PUBLICATIONS

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Supply Chain Pressures, Trade Openness, and Inflation Dynamics: The Role of Trade Vulnerability in ASEAN-5 Economies

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ABSTRACT

This paper examines how global supply-chain disruptions transmit to domestic inflation in ASEAN-5 economies, focusing on the roles of structural trade vulnerability and global volatility regimes. Using panel local projections, we find that inflation responses to global supply-chain pressure shocks are hump-shaped and peak after several quarters. Trade openness alone does not significantly amplify inflation responses, while pass-through is larger in economies with greater exposure to imported intermediate inputs and stronger during periods of elevated global trade volatility. To interpret these patterns, we develop a regime-switching two-country New Keynesian dynamic stochastic general equilibrium (NK-DSGE) model in which a vulnerability parameter governs the pass-through of global logistics stress into firms' marginal costs and shock volatility switches between low- and high-volatility regimes. The model generates state-dependent stagflationary dynamics—rising inflation alongside contractions in output, investment, and net exports—that are qualitatively consistent with the empirical evidence. These findings suggest that trade vulnerability, rather than trade openness per se, is a key determinant of inflation responses to global supply disruptions, with implications for how policymakers identify sources of external inflation vulnerability and assess the role of supply-chain structure in shaping inflation risks.

Keywords: Global supply chains; Inflation dynamics; Trade vulnerability; DSGE models; Local projections.

JEL Classification: E31, F41, E32, F44.

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[†]The views expressed in this paper are solely those of the author and do not necessarily reflect the views of AMRO or its management. All errors and omissions are the sole responsibility of the author.

1 INTRODUCTION

Recent global events have highlighted the macroeconomic importance of supply-chain disruptions. The COVID-19 pandemic, shipping bottlenecks, geopolitical tensions, and shifts in global logistics conditions have generated substantial volatility in global supply conditions and production networks (Benigno et al. (2022); di Giovanni et al. (2022)). These disruptions have been associated with inflationary pressures across both advanced and emerging economies, raising concerns about how external supply shocks propagate to domestic prices and economic activity (Finck and Tillmann (2023); Gordon and Clark (2023); Acharya et al. (2023)). For ASEAN-5 economies, this issue is particularly salient. The region is deeply integrated into global production networks and relies heavily on imported intermediate goods, external demand, and maritime logistics. Moreover, recent research suggests that global supply-chain disruptions have had uneven macroeconomic impacts across ASEAN+3 economies, reflecting differences in exposure to transportation service shortages and supply-chain linkages during the pandemic (Tang, 2022).

A key distinction emerging from recent inflation episodes is that trade openness alone does not fully capture vulnerability to global cost shocks. While more open economies are mechanically exposed to external developments, recent evidence suggests that global supply-chain disruptions contributed materially to post-pandemic inflation dynamics beyond aggregate demand factors (Gordon and Clark, 2023). However, the transmission of external shocks depends not only on the volume of trade but also on structural features of production networks, including reliance on imported intermediate inputs, sectoral input–output linkages, supplier concentration, and logistical constraints (di Giovanni et al., 2022). When firms face higher imported input costs and supply constraints, they may pass part of these costs on to consumers, amplifying inflationary pressures—a pattern documented across European economies (Binici et al., 2024) and during the broader post-pandemic inflation episode (Gordon and Clark, 2023). These considerations suggest that vulnerability to global supply-chain pressure (GSCP) shocks reflects structural characteristics of production networks beyond trade openness alone. This distinction is relevant for interpreting inflation dynamics in open economies and for designing appropriate macroeconomic policy responses.

Existing studies have examined the aggregate inflationary effects of supply-chain disruptions in advanced and European economies (Gordon and Clark, 2023; Acharya et al., 2023) and across ASEAN+3 economies Tang (2022). However, the joint role of structural trade vulnerability and global volatility regimes in shaping the pass-through of such disruptions has received relatively limited attention, particularly for ASEAN-5 economies.

This study addresses this gap through two complementary components: an empirical analysis based on panel local projections and a structural investigation using a two-country New Keynesian DSGE model. Rather than focusing on trade fragmentation, decoupling, or tariff shocks, the analysis centers on GSCP shocks that capture disruptions in shipping costs, logistics bottlenecks,

and international production networks, proxied using the Global Supply Chain Pressure Index (GSCPI) proposed by [Benigno et al. \(2022\)](#). The key contribution lies in combining reduced-form panel evidence with a DSGE framework that explicitly incorporates imported-input cost channels and regime-switching volatility to examine how structural trade vulnerability and global supply conditions shape the transmission of GSCP shocks.

To characterize cross-country exposure to such disruptions, we incorporate measures of trade openness alongside a Global Trade Vulnerability Index (GTVI), which captures structural dependence on imported intermediate inputs, trade linkages, and sensitivity to external cost shocks. These variables are combined with macroeconomic time series—including inflation, exchange rates, import prices, and global cost indicators—with output gaps and policy variables added in richer specifications to estimate inflation impulse responses to GSCP shocks.

The local-projection approach of [Jordà \(2005\)](#) is particularly well suited to this setting because it allows flexible estimation of dynamic responses without imposing strong structural restrictions. Interaction terms and regime-specific analysis can be readily incorporated within this framework. In particular, the empirical specification allows the inflationary effects of GSCP shocks to vary across high- and low-volatility regimes, reflecting the observation that global supply disruptions often cluster during periods of heightened uncertainty.

The empirical analysis suggests three main patterns. First, GSCP shocks generate hump-shaped inflation responses that peak after approximately three to five quarters. Second, trade openness alone does not appear to systematically amplify pass-through once structural vulnerability and macroeconomic controls are included. Third, the inflationary effects tend to be larger and more persistent during periods of elevated volatility, particularly in structurally exposed economies, although these regime-specific patterns should be interpreted as indicative given the underlying estimation uncertainty. These patterns help motivate and discipline the structural model developed in the second part of the paper.

The second component develops a two-country New Keynesian DSGE model with regime-switching GSCP shock volatility to provide a structural interpretation of the empirical findings. The model features a GSCP-driven shipping-cost wedge that raises import prices and enters firms' marginal costs through an imported-input cost channel, alongside exchange-rate dynamics captured by a reduced-form Uncovered Interest Parity (UIP)-type specification. Trade openness operates through import intensity and external leakage, shaping quantitative exposure to foreign inputs, while a vulnerability parameter scales the pass-through of global supply disruptions into domestic marginal costs. GSCP shocks are modeled as persistent disturbances whose volatility switches between low- and high-volatility regimes according to a two-state Markov chain. This specification is motivated by the local projection estimates, which suggest that inflation responses differ across periods of global supply stress, although the LP evidence alone cannot identify the specific regime-switching structure adopted here.

Within this framework, supply-chain disruptions raise marginal costs and inflation, trigger endogenous monetary tightening, and generate contractions in output, consumption, and investment. The model also produces external adjustment dynamics, including exchange-rate depreciation at longer horizons and an initial deterioration in net exports that partially reverses as the weaker currency shifts expenditure toward domestic goods.¹ Lastly, the regime-switching structure generates state-dependent responses in which the same shock produces larger and more persistent inflation under high-volatility regimes—a pattern that is qualitatively consistent with the hump-shaped dynamics observed in the empirical analysis, although the model does not aim to quantitatively match those responses.

By integrating the empirical LP evidence with structural DSGE simulations, the analysis provides a complementary perspective on how global supply-chain disruptions may propagate through production costs, monetary policy responses, and external adjustment channels. The combined results are consistent with the view that inflationary spillovers depend not only on trade openness but also on the interaction between import intensity, structural vulnerability, and the volatility regime of global supply conditions. This framework offers a tentative explanation for why economies with similar degrees of trade openness may experience different inflation outcomes, and suggests that supply-chain structure may influence exposure to external inflationary pressures in ASEAN-5 economies. Establishing this relationship more firmly, nevertheless, would require formal estimation of the structural model and broader empirical validation across a wider set of economies.

The remainder of the paper is structured as follows. Section 2 presents the local projection framework. Section 3 develops the DSGE model. Section 4 discusses the combined findings, and Section 5 concludes.

2 LOCAL PROJECTIONS METHOD

The empirical analysis draws on quarterly panel data for the ASEAN-5 economies—Indonesia, Malaysia, the Philippines, Thailand, and Singapore—spanning Q1 2008 to Q2 2025, sourced from CEIC. The sample period covers several major episodes of external and supply-chain stress, including the global crisis of 2008–2009, the COVID-19 pandemic disruptions of 2020–2021, and the post-pandemic shipping bottlenecks of 2021–2022, thereby providing variation across both high- and low-volatility episodes. However, the limited number of economies and the relatively short subsample within each regime warrant caution in interpreting the regime-specific estimates.

The empirical analysis examines how inflation in ASEAN-5 economies responds to unexpected global trade-disruption shocks, with particular attention to two transmission channels emphasized in the structural model: trade openness as a potential leakage or dampening mechanism, and trade vulnerability as a factor that may amplify the inflationary effects of global supply-chain

¹The extent of this recovery, however, depends on calibration, and the reduced-form treatment of the exchange rate limits the structural richness of this channel.

disturbances. The empirical strategy relies on the panel local projection framework of [Jordà \(2005\)](#), which provides flexible horizon-specific impulse responses without imposing strong restrictions on the underlying data-generating process and allows heterogeneity in transmission to be captured through interaction terms and regime-specific specifications.

Let i index countries, t denote time, and $h = 0, 1, \dots, H$ the forecast horizon, the baseline local projection specification is

$$\begin{aligned} \pi_{i,t+h} - \pi_{i,t-1} = & \alpha_h + \beta_{h,0} z_t^{\text{gscp}} + \beta_{h,1} TO_{i,t-1} + \beta_{h,2} GTVI_{i,t-1}^{TVP} \dots \\ & + \beta_{h,3} z_t^{\text{gscp}} \times TO_{i,t-1} + \beta_{h,4} z_t^{\text{gscp}} \times GTVI_{i,t-1}^{TVP} + \Gamma'_h X_{i,t-1} + \mu_{i,h} + \varepsilon_{i,t,h}, \end{aligned} \quad (1)$$

where $\pi_{i,t}$ denotes CPI inflation, z_t^{gscp} is the global trade-disruption innovation,² $TO_{i,t-1}$ measures trade openness, and $GTVI_{i,t-1}^{TVP}$ is a time-varying index of trade vulnerability derived from the global trade vulnerability factor.³ The control vector $X_{i,t-1}$ includes lagged inflation, output growth, exchange-rate changes, commodity prices, and other domestic or global macroeconomic indicators. Country fixed effects $\mu_{i,h}$ capture persistent cross-country differences, while time fixed effects are excluded to preserve identification of the common global shock.⁴ This specification allows the direct inflationary effect of global trade disruptions to vary with structural exposure. The coefficient $\beta_{h,0}$ captures the average cost-push effect of the shock, $\beta_{h,3}$ reflects how openness modifies the transmission of the shock, and $\beta_{h,4}$ captures the amplification associated with trade vulnerability.

To allow for state-dependent transmission, the specification is extended to incorporate volatility regimes in global trade conditions. Let D_t^H denote an indicator that equals one during periods of elevated volatility in GSCP and zero otherwise. The regime-dependent specification becomes

$$\begin{aligned} \pi_{i,t+h} - \pi_{i,t-1} = & \alpha_h + \beta_{h,0} z_t^{\text{gscp}} + \beta_{h,1} TO_{i,t-1} + \beta_{h,2} GTVI_{i,t-1}^{TVP} \dots \\ & + \beta_{h,3} z_t^{\text{gscp}} \times TO_{i,t-1} + \beta_{h,4} z_t^{\text{gscp}} \times GTVI_{i,t-1}^{TVP} + \beta_{h,5} z_t^{\text{gscp}} \times D_t^H + \beta_{h,6} z_t^{\text{gscp}} \times TO_{i,t-1} \times D_t^H \dots \\ & + \beta_{h,7} z_t^{\text{gscp}} \times GTVI_{i,t-1}^{TVP} \times D_t^H + \Gamma'_h X_{i,t-1} + \mu_{i,h} + \varepsilon_{i,t,h}, \end{aligned} \quad (2)$$

which allows both the baseline shock effect and its interaction with openness and vulnerability to

²The global supply-chain shock is obtained as the standardized residual from an autoregressive (AR) or AR-X model of the GSCPI. The AR-X specification may include global industrial production and financial market volatility (VIX) to isolate unexpected supply-chain disturbances. Lag selection follows the Bayesian Information Criterion (BIC). Because z_t^{gscp} is a generated regressor, the reported standard errors do not account for first-stage estimation uncertainty; however, given that the GSCPI is constructed from a large number of underlying series and the AR model is estimated over a long time series, the attenuation bias from this source is likely small relative to the signal in the innovation ([Pagan, 1984](#)).

³Appendix A provides a detailed description of the time-varying parameter factor-augmented vector autoregression (TVP-FAVAR) framework, data construction, factor extraction, and filtering procedure used to obtain the time-varying GTVI measure.

⁴Global commodity prices, world oil prices, and financial conditions are included as controls in the richer specifications to partial out other common global factors without absorbing the shock of interest.

vary across volatility regimes. In this formulation, $\beta_{h,5}$ captures the additional inflationary impact of global trade disruptions during high-volatility periods, while $\beta_{h,6}$ and $\beta_{h,7}$ capture how openness and vulnerability modify this regime-dependent transmission.

The implied horizon- h impulse responses for a country with openness level to and vulnerability level g can be expressed as

$$\begin{aligned}\text{IRF}_\pi(h \mid to, g, \sigma_{\text{low}}) &= \beta_{h,0} + \beta_{h,3}to + \beta_{h,4}g, \\ \text{IRF}_\pi(h \mid to, g, \sigma_{\text{high}}) &= \beta_{h,0} + \beta_{h,3}to + \beta_{h,4}g + \beta_{h,5} + \beta_{h,6}to + \beta_{h,7}g.\end{aligned}$$

Comparing these responses across regimes allows an assessment of whether inflationary effects are systematically stronger during periods of heightened global trade disruption and whether such amplification is unique in economies with higher trade vulnerability.

Local projections are estimated separately for each horizon $h = 0, 1, \dots, 8$ quarters. Inference relies on two alternative variance estimators reported throughout the analysis. The first uses heteroskedasticity-robust (HC) standard errors clustered at the country level, which account for within-country serial correlation over time. The second uses Driscoll–Kraay (DK) standard errors as a robustness check; the DK estimator allows for both serial correlation and cross-sectional dependence across countries and is particularly relevant here because the common global shock may induce contemporaneous correlation in inflation dynamics across ASEAN-5 economies. Where the two sets of confidence intervals diverge materially, the DK-based intervals are treated as the more conservative benchmark.

Impulse responses are computed under three alternative control configurations. The baseline specification includes lagged inflation and lagged values of z_t^{gscp} to remove predictable serial dependence in the dependent variable prior to estimation. Alternative specification 1 augments this with domestic macroeconomic controls—the output gap, real exchange-rate changes, and additional lags of inflation—to account for domestic cyclical conditions that may covary with the shock. Alternative specification 2 further adds global commodity price inflation, oil price inflation, and changes in the monetary policy rate to capture external cost pressures and endogenous policy responses. These global controls are included in levels rather than as fixed effects so as not to absorb the common variation in z_t^{gscp} that provides identification, consistent with the time-fixed-effects exclusion discussed above.

3 DSGE MODEL OVERVIEW

The second part of the project develops a nonlinear DSGE model that studies how global supply chain disruptions transmit to domestic inflation, and how this transmission depends on trade openness and external vulnerability. The interaction terms used in the empirical local projection (LP) specification mirror the model’s structural experiments: the model is simulated under al-

ternative degrees of openness (import intensity), trade vulnerability (pass-through of global trade frictions into domestic marginal costs), and regime-specific GSCP volatility. The mapping allows the empirical impulse responses to be interpreted within a coherent structural framework, and the model-based impulse responses provide a disciplined decomposition of the underlying channels.

The DSGE model is a two-country New Keynesian economy with a Home (H) and a Foreign (F) block. In each country, infinitely-lived representative households supply labor and consume; firms operate under monopolistic competition and face Rotemberg-type price adjustment costs; and the monetary authority sets the nominal interest rate according to a Taylor-type rule. Technology follows a nonstationary stochastic trend, and capital evolves according to a standard accumulation equation with investment adjustment costs a la [Christiano et al. \(2005\)](#).

The two economies are linked through (1) a trade/leakage block in which Home net exports depend on relative output and on domestic absorption (capturing leakage that is stronger in more open economies), and (2) an exchange-rate block featuring a persistent risk premium.⁵ The novel element of the model is GSCP, which is modeled as an iceberg-type shipping-cost wedge on imported intermediate inputs. This wedge raises the effective price of imported inputs and acts as a cost-push disturbance, with its pass-through amplified by a vulnerability parameter that may introduce nonlinearities in the transmission of global supply disruptions.

3.1 HOUSEHOLDS Households in country $i \in \{H, F\}$ maximize expected lifetime utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[\log(c_{i,t}) - \chi_0 \frac{h_{i,t}^{1+\chi}}{1+\chi} \right],$$

where $c_{i,t}$ is consumption, $h_{i,t}$ is labor, $\beta \in (0, 1)$ is the subjective discount factor, $\chi_0 > 0$ scales the disutility of labor, and χ is the inverse Frisch elasticity of labor supply. Optimality with respect to labor supply yields

$$\frac{w_{i,t}}{c_{i,t}} = \chi_0 h_{i,t}^{\chi}, \quad (3)$$

where $w_{i,t}$ is the real wage. The optimality condition for nominal one-period bonds, taking into account nonstationary technology growth, is

$$1 = \beta E_t \left[\frac{R_{i,t}}{\pi_{i,t+1}} \frac{c_{i,t}}{\pi_{i,t+1}^Z c_{i,t+1}} \right], \quad (4)$$

⁵In the present framework, imported goods enter the economy primarily as intermediate inputs used in domestic production rather than as final consumption goods. Consequently, global supply-chain disruptions affect inflation mainly through firms' marginal costs via the imported-input price channel. This modeling choice reflects the focus of the analysis on production-network disruptions—such as shipping bottlenecks and logistics costs—that primarily raise the cost of intermediate inputs rather than directly altering household consumption baskets. Abstracting from imported consumption goods therefore helps isolate the cost-push mechanism emphasized in the empirical analysis.

where $R_{i,t}$ is the gross nominal interest rate, $\pi_{i,t}$ is gross CPI inflation, and $\pi_{i,t}^Z$ is the gross growth rate of technology.

3.2 TECHNOLOGY, PRODUCTION, AND CAPITAL

3.2.1 TECHNOLOGY AND MARKUP PROCESSES Each country features a cost-push (markup) process and a nonstationary technology process. The country-specific elasticity of substitution across differentiated goods, $\eta_{i,t}$, evolves as:

$$\log \eta_{i,t} = (1 - \rho_\eta) \log \eta + \rho_\eta \log \eta_{i,t-1} + \sigma_\eta \varepsilon_{i,t}^\eta,$$

where $\eta > 1$ is the steady-state elasticity, ρ_η is the persistence parameter, σ_η is the standard deviation of the cost-push innovation, and $\varepsilon_{i,t}^\eta$ is an i.i.d. shock.

Technology is nonstationary and follows

$$\log \pi_{i,t}^Z = (1 - \rho_z) \log \mu + \rho_z \log \pi_{i,t-1}^Z + \sigma_z \varepsilon_{i,t}^z,$$

where μ is the steady-state gross technology growth factor.

3.2.2 PRODUCTION Output in country i is produced by monopolistically competitive firms using capital and labor with a Cobb-Douglas technology:

$$y_{i,t} = k_{i,t-1}^\nu h_{i,t}^{1-\nu},$$

where $k_{i,t-1}$ is the beginning-of-period capital stock and $\nu \in (0, 1)$ is the capital share. Imported intermediate inputs do not enter the production function directly in the implementation; instead, global supply-chain disruptions affect production costs through the delivered import price wedge and the marginal cost channel described below. The marginal products are

$$\text{MPL}_{i,t} = (1 - \nu) \frac{y_{i,t}}{h_{i,t}}, \quad \text{MPK}_{i,t} = \nu \frac{y_{i,t}}{k_{i,t-1}}.$$

3.2.3 CAPITAL ACCUMULATION AND INVESTMENT ADJUSTMENT COSTS Capital evolves according to

$$k_{i,t} = (1 - \delta) \frac{k_{i,t-1}}{\pi_{i,t}^Z} + i_{i,t} \left[1 - \frac{\varphi}{2} \left(\frac{i_{i,t}}{i_{i,t-1}} - 1 \right)^2 \right].$$

Let $q_{i,t}$ denote Tobin's Q . The Euler equation for capital is⁶

$$q_{i,t} = \beta E_t \left[\frac{c_{i,t}}{c_{i,t+1}} \frac{1}{\pi_{i,t+1}^Z} \left(q_{i,t+1}(1 - \delta) + \text{MPK}_{i,t+1} \frac{w_{i,t+1}}{\text{MPL}_{i,t+1}} \right) \right],$$

and the first-order condition for investment is given by

$$1 = q_{i,t} \left[1 - \frac{\varphi}{2} \left(\frac{i_{i,t}}{i_{i,t-1}} - 1 \right)^2 - \varphi \left(\frac{i_{i,t}}{i_{i,t-1}} - 1 \right) \frac{i_{i,t}}{i_{i,t-1}} \right] \dots \\ + \beta E_t \left[\frac{c_{i,t}}{c_{i,t+1}} q_{i,t+1} \varphi \left(\frac{i_{i,t+1}}{i_{i,t}} - 1 \right) \left(\frac{i_{i,t+1}}{i_{i,t}} \right)^2 \right]. \quad (5)$$

3.3 FIRMS: IMPORTED INPUTS, GSCP SHIPPING WEDGE, AND MARGINAL COST

3.3.1 COST MINIMIZATION WITH IMPORTED INTERMEDIATES This subsection provides a firm-side cost-minimization problem that rationalizes (1) the delivered import price $p_{i,t}^m$ in marginal cost, and (2) the interpretation of ω_{nx} as an import-intensity (openness/exposure) parameter. Because the model implementation uses a parsimonious reduced-form closure $m_{i,t} = \omega_{nx} y_{i,t}$, we first present a microfounded static problem in which imported intermediates enter variable production costs with a constant cost share, and then state the approximation that maps to the implemented equations.

Technology with a variable-input requirement. Fix a country $i \in \{H, F\}$. For a given output level $y_{i,t}$ and predetermined capital stock $k_{i,t-1}$, a representative firm chooses labor $h_{i,t}$ and imported intermediate inputs $m_{i,t}$ to satisfy

$$y_{i,t} = k_{i,t-1}^\nu \left[\mathcal{V}(h_{i,t}, m_{i,t}) \right]^{1-\nu},$$

where $\mathcal{V}(\cdot, \cdot)$ is a variable-input aggregator combining labor and imported intermediates. We adopt a Cobb-Douglas form

$$\mathcal{V}(h_{i,t}, m_{i,t}) = h_{i,t}^{1-\xi_m} m_{i,t}^{\xi_m}, \quad \xi_m \in (0, 1),$$

so that the static problem implies a constant expenditure share ξ_m on imported intermediates. In the model implementation, ξ_m corresponds to the imported-input cost intensity parameter.

⁶Note that a standard model with labor as the sole variable input, cost minimization implies $w_{i,t}/\text{MPL}_{i,t} = mc_{i,t}$, so the two expressions coincide. In the present model, however, real marginal cost depends on both the wage and the delivered import price $p_{i,t}^m$ through equation (8), so that $w_{i,t}/\text{MPL}_{i,t} \neq mc_{i,t}$ in general. The expression here reflects the reduced-form implementation, in which imported intermediate requirements per unit output are held constant at $m_{i,t} = \omega_{nx} y_{i,t}$. Under this approximation, the import-cost margin is absorbed into the delivered price wedge and marginal cost is recovered from the Phillips curve block rather than from the capital Euler equation directly. A fully microfounded treatment would replace $w_{i,t+1}/\text{MPL}_{i,t+1}$ with $mc_{i,t+1}$ as derived in equation (8), and would require solving for the optimal factor mix endogenously at each date. We leave this extension for future work.

Define the required composite variable input

$$v_{i,t} \equiv \mathcal{V}(h_{i,t}, m_{i,t}) = \left(\frac{y_{i,t}}{k_{i,t-1}^\nu} \right)^{\frac{1}{1-\nu}},$$

so that the variable-input constraint can be written as $v_{i,t} = h_{i,t}^{1-\xi_m} m_{i,t}^{\xi_m}$.

Static cost-minimization problem. Let $w_{i,t}$ denote the real wage and $p_{i,t}^m$ the real delivered price of imported intermediates. Conditional on $(k_{i,t-1}, y_{i,t})$, the firm solves

$$\min_{h_{i,t}, m_{i,t}} w_{i,t} h_{i,t} + p_{i,t}^m m_{i,t} \quad \text{s.t.} \quad h_{i,t}^{1-\xi_m} m_{i,t}^{\xi_m} = v_{i,t}.$$

The first-order conditions imply the conditional factor demand

$$\frac{m_{i,t}}{h_{i,t}} = \frac{\xi_m}{1 - \xi_m} \frac{w_{i,t}}{p_{i,t}^m}, \quad (6)$$

so that an increase in the delivered import price $p_{i,t}^m$ (e.g. due to GSCP) induces substitution away from imported intermediates toward labor.

Unit cost of the composite input. For the Cobb-Douglas production function, the minimized cost of producing one unit of $v_{i,t}$ is

$$UC_{i,t}^V = \frac{w_{i,t}^{1-\xi_m} (p_{i,t}^m)^{\xi_m}}{(1 - \xi_m)^{1-\xi_m} \xi_m^{\xi_m}},$$

so that total variable cost is

$$VC_{i,t} = UC_{i,t}^V v_{i,t} = UC_{i,t}^V \left(\frac{y_{i,t}}{k_{i,t-1}^\nu} \right)^{\frac{1}{1-\nu}}.$$

Holding $k_{i,t-1}$ fixed, the real marginal cost is then,

$$mc_{i,t} \equiv \frac{\partial VC_{i,t}}{\partial y_{i,t}} = \frac{UC_{i,t}^V}{1 - \nu} \left(\frac{y_{i,t}}{k_{i,t-1}^\nu} \right)^{\nu/(1-\nu)} k_{i,t-1}^{-\nu} \quad (7)$$

Taking logs yields the explicit decomposition

$$\log mc_{i,t} = (1 - \xi_m) \log w_{i,t} + \xi_m \log p_{i,t}^m + \frac{\nu}{1 - \nu} \log y_{i,t} - \frac{\nu}{1 - \nu} \log k_{i,t-1} + \text{constant}, \quad (8)$$

where the constant collects terms that are fixed in steady state, including $-\log(1 - \nu)$ and the Cobb-Douglas share constants in the unit cost function. Equation (8) shows that the delivered import price enters marginal cost with elasticity ξ_m .

Mapping to the implemented exposure closure. Under the fully microfounded problem, the import share varies endogenously with $p_{i,t}^m$ through the optimality condition above. For tractability, the implementation adopts the reduced-form approximation

$$m_{i,t} = \omega_{nx} y_{i,t}, \quad (9)$$

which can be interpreted as an approximation around a steady state in which imported-intermediate requirements per unit output are approximately constant. Under (9), trade openness ω_{nx} primarily governs exposure through quantities and the trade/leakage block, while the delivered import price $p_{i,t}^m$ captures the exogenous cost push from GSCP.

Implication for GSCP pass-through. Given the iceberg mapping

$$\log p_{i,t}^m = \gamma_{\text{ship}}(1 + \phi_{nx})^{\vartheta_\phi} z_t^{\text{gscp}},$$

the GSCP elasticity of marginal cost is

$$\frac{\partial \log mc_{i,t}}{\partial z_t^{\text{gscp}}} = \xi_m \gamma_{\text{ship}}(1 + \phi_{nx})^{\vartheta_\phi}.$$

Here, z_t^{gscp} denotes the GSCP shock, interpreted as an exogenous disturbance capturing fluctuations in global logistics conditions such as shipping costs, port congestion, and transportation bottlenecks. The parameter γ_{ship} governs how strongly logistics disruptions translate into higher delivered prices of imported intermediates, while ξ_m represents the share of imported intermediate inputs in firms' production costs and therefore determines the sensitivity of marginal costs to import-price changes. These parameters describe the mapping from global logistics stress to production costs and are held fixed in the simulations.

Cross-simulation heterogeneity is instead introduced through ϕ_{nx} , which provides a parsimonious measure of external vulnerability consistent with the empirical role of the GTVI. A higher ϕ_{nx} implies that a given GSCP disturbance generates a larger import-cost wedge and stronger pass-through to firms' marginal costs. The curvature parameter ϑ_ϕ governs the nonlinearity of this amplification and is kept fixed in the baseline simulations so that differences across scenarios primarily reflect differences in vulnerability.

Through this mechanism, ϕ_{nx} determines how strongly global logistics stress affects marginal costs and inflation through the Rotemberg Phillips curve. In addition, ϕ_{nx} influences the respon-

siveness of net exports to relative output, so that higher values capture economies that are more sensitive along both the cost pass-through and trade-adjustment channels.

3.4 PRICE SETTING AND NEW KEYNESIAN PHILLIPS CURVE Firms in each country set prices subject to Rotemberg adjustment costs. Let $\pi_{i,t}$ denote gross inflation and π^* be the steady-state inflation target. The Rotemberg cost is

$$C_{i,t}^{\text{price}} = \frac{\kappa}{2} \left(\pi_{i,t} - \pi_{i,t-1}^\alpha (\pi^*)^{1-\alpha} \right)^2 y_{i,t},$$

where κ is the adjustment cost parameter and α controls indexation to past inflation. The Rotemberg Phillips curve can be written as

$$0 = (1 - \eta_{i,t}) + \eta_{i,t} mc_{i,t} - \kappa \left(\pi_{i,t} - \pi_{i,t-1}^\alpha (\pi^*)^{1-\alpha} \right) \pi_{i,t} \dots \\ + \beta \kappa E_t \left[\left(\pi_{i,t+1} - \pi_{i,t}^\alpha (\pi^*)^{1-\alpha} \right) \pi_{i,t+1} \frac{C_{i,t}}{C_{i,t+1}} \frac{y_{i,t+1}}{y_{i,t}} \right],$$

where $mc_{i,t}$ is real marginal cost. From the equation, we can see that GSCP shocks directly raise $mc_{i,t}$ through the delivered import price wedge and thereby generate inflationary pressure.

3.5 MONETARY POLICY In each country $i \in \{H, F\}$, the central bank sets the nominal interest rate according to a Taylor-type rule with interest-rate smoothing:

$$\frac{R_{i,t}}{R_i^{\text{ss}}} = \left(\frac{R_{i,t-1}}{R_i^{\text{ss}}} \right)^\rho \left(\frac{\pi_{i,t}}{\pi^*} \right)^{\psi(1-\rho)} \exp(\sigma_r \varepsilon_{i,t}^R).$$

Here $R_{i,t}$ denotes the gross nominal interest rate set by the central bank in country i , and R_i^{ss} is its steady-state level. The parameter ρ captures interest-rate smoothing, implying that policy adjusts gradually over time. Inflation $\pi_{i,t}$ is measured relative to the inflation target π^* , and the parameter ψ governs the strength of the policy response to inflation deviations. The term $\varepsilon_{i,t}^R$ represents an exogenous monetary policy shock, with σ_r determining its volatility.

3.6 EXCHANGE RATE DYNAMICS AND RISK PREMIUM (REDUCED FORM) Let s_t denote the (log) nominal exchange rate and rp_t a (log) risk premium component. The risk premium follows:

$$rp_t = \rho_q rp_{t-1} + \sigma_q \varepsilon_t^q,$$

and the exchange rate satisfies

$$s_t = \rho_s s_{t-1} + \phi_s (R_{H,t} - R_{F,t}) + rp_t.$$

where s_t represents the logarithm of the nominal exchange rate, defined as the price of foreign currency in terms of domestic currency. The term rp_t captures the risk premium that reflects deviations from UIP, such as changes in investors' risk perceptions, financial market conditions, or capital flow pressures. It follows a first-order autoregressive process, where ρ_q measures its persistence and σ_q determines the volatility of the shock ε_t^q . The exchange rate equation allows the exchange rate to depend on its own past value, governed by the persistence parameter ρ_s , and on the nominal interest rate differential between the Home and Foreign economies. The parameter ϕ_s measures the sensitivity of the exchange rate to this interest rate differential. This specification can be interpreted as a reduced-form UIP-type relationship in which exchange rate movements reflect both interest rate differentials and a persistent risk premium component.

3.7 GLOBAL SUPPLY CHAIN PRESSURE (GSCP) AND TRADE/LEAKAGE LINKAGES Global supply chain pressure follows an exogenous AR(1) process with regime-switching volatility:⁷

$$z_t^{\text{gscp}} = \rho_{z^{\text{gscp}}} z_{t-1}^{\text{gscp}} + \sigma_{z^{\text{gscp}}}(s_t) \varepsilon_t^{\text{gscp}}, \quad (10)$$

where $\varepsilon_t^{\text{gscp}}$ is i.i.d. $\mathcal{N}(0, 1)$ and the shock volatility depends on the latent regime $s_t \in \{L, H\}$:

$$\sigma_{z^{\text{gscp}}}(s_t) = \begin{cases} \sigma_{z^{\text{gscp}}}^L & \text{if } s_t = L \text{ (low-volatility regime),} \\ \sigma_{z^{\text{gscp}}}^H & \text{if } s_t = H \text{ (high-volatility regime),} \end{cases} \quad (11)$$

with $\sigma_{z^{\text{gscp}}}^L < \sigma_{z^{\text{gscp}}}^H$. The regime s_t evolves as a two-state Markov chain with transition probabilities

$$\Pr(s_t = H \mid s_{t-1} = L) = p_{LH}, \quad \Pr(s_t = L \mid s_{t-1} = H) = p_{HL}. \quad (12)$$

The unconditional probability of the high-volatility regime is $\pi_H = p_{LH}/(p_{LH} + p_{HL})$. The low-volatility shock standard deviation $\sigma_{z^{\text{gscp}}}^L$ is calibrated to the sample standard deviation of the GSCPI innovation during tranquil periods, while $\sigma_{z^{\text{gscp}}}^H$ is calibrated to the standard deviation during episodes of elevated global supply-chain stress, consistent with the rolling-volatility regime classification used in the local projection analysis.

International linkages are captured by a reduced-form behavioral equation for Home net exports:

$$NX_{H,t} = (y_{F,t} - y_{H,t}) + \lambda_{\text{leak}} \omega_{nx} (y_{H,t} - c_{H,t} - i_{H,t}),$$

with $NX_{F,t} = -NX_{H,t}$. The first term captures a relative-activity component: Home net exports

⁷The GSCP disturbance is modeled in this way to capture the persistence typically observed in global logistics disruptions. Supply-chain bottlenecks tend to evolve gradually and dissipate over several quarters rather than appearing as purely transitory shocks. The AR(1) specification therefore provides a parsimonious approximation to the persistence observed in the GSCPI innovations used in the empirical analysis.

rise when Foreign output expands relative to Home output, reflecting stronger external demand. The second term captures an absorption/leakage component. When domestic output exceeds private absorption, the surplus is partly directed outward. The parameter $\lambda_{\text{leak}} > 0$ governs the sensitivity of net exports to the gap between output and domestic absorption, capturing the propensity of the economy to translate excess domestic production into external trade rather than domestic use. The parameter ω_{nx} scales this leakage by trade openness, so that more open economies direct a larger share of any output–absorption gap toward the external sector.

3.8 RESOURCE CONSTRAINTS The aggregate resource constraint imposes market clearing in each economy, describing how total output is allocated between private absorption and other uses. In each country, output can be used for consumption and investment, while resources may also be absorbed by price adjustment costs arising from nominal rigidities. In addition, the external sector contributes through net exports. For the Home country, the aggregate resource constraint is

$$c_{H,t} + i_{H,t} = y_{H,t} - \frac{\kappa}{2} (\pi_{H,t} - \pi_{H,t-1}^\alpha (\pi^*)^{1-\alpha})^2 y_{H,t} + \omega_{nx} NX_{H,t},$$

and for the Foreign country,

$$c_{F,t} + i_{F,t} = y_{F,t} - \frac{\kappa}{2} (\pi_{F,t} - \pi_{F,t-1}^\alpha (\pi^*)^{1-\alpha})^2 y_{F,t} + \omega_{nx} NX_{F,t}.$$

In these equations, the first term on the right-hand side therefore reflects the total production available in the economy and the second term captures the resource cost associated with nominal price adjustment under Rotemberg pricing. Firms face quadratic costs when adjusting prices away from their previous inflation dynamics. The parameter κ governs the magnitude of these adjustment costs, while $\pi_{i,t}$ denotes the gross inflation rate. Inflation dynamics incorporate partial indexation to past inflation, represented by the parameter α , and anchoring to the steady-state inflation target π^* . When inflation deviates from this indexed benchmark, firms incur adjustment costs that absorb real resources and therefore reduce the amount of output available for consumption and investment.

The final term reflects the contribution of the external sector. $NX_{i,t}$ denotes net exports, defined as exports minus imports for country i . The parameter ω_{nx} scales the contribution of net exports to domestic absorption and captures the degree of trade openness in the economy. The net-exports equation and the resource constraint serve distinct roles and jointly determine equilibrium absorption and trade flows. The resource constraint is a market-clearing identity: given $NX_{H,t}$, it pins down the level of domestic absorption consistent with goods market equilibrium. The net-exports equation is a behavioral relationship: given absorption ($c_{H,t} + i_{H,t}$), it describes how trade flows respond to relative output and domestic leakage. Together, the two equations simultaneously determine $NX_{H,t}$ and ($c_{H,t} + i_{H,t}$) in equilibrium, analogously to how a goods-market clearing condition and a trade-balance equation jointly determine output and net exports in a standard

open-economy model.

4 RESULTS AND DISCUSSION

This section presents empirical impulse response estimates from the local-projection (LP) framework alongside structural impulse responses from the DSGE model. The LP results provide reduced-form evidence on the inflationary effects of global trade-disruption shocks across alternative specifications and volatility regimes, while the DSGE simulations offer a structural interpretation of the transmission mechanisms underlying these empirical findings. Figures 2-7 report the LP-based responses, whereas Figure 8 presents the corresponding DSGE regime-switching impulse responses.

4.1 BASELINE IMPULSE RESPONSES Figures 2-4 present the response of inflation to a GSCP shock under the baseline and progressively richer specifications. The baseline specification includes the shock and its interactions with trade openness and the trade vulnerability measure, without additional macroeconomic controls. Alternative specification 1 augments this setup with standard domestic controls—namely inflation persistence, the output gap, real exchange rate changes, and trade openness dynamics—while alternative specification 2 further incorporates global cost-push and policy variables, including world commodity prices, oil prices, and changes in the monetary policy rate.

Across all specifications, the impulse responses display a hump-shaped pattern: inflation rises gradually after the shock, peaks after roughly three to five quarters, and then declines slowly. This dynamic profile is consistent with staggered price adjustment and gradual pass-through from external supply disruptions to domestic prices. The delayed peak is consistent with propagation through upstream cost channels, though the LP framework does not identify which specific channels—production networks, import prices, or intermediate inputs—are most operative.

The overall shape and timing of the responses remain stable as additional domestic and global controls are introduced. The inclusion of output gap dynamics, exchange rate movements, and global price factors does not materially alter the trajectory of the impulse responses. This stability suggests that the estimated inflationary effect is not substantially confounded by the domestic cyclical conditions and global cost factors considered here, lending credibility to the supply-shock interpretation, though identification limitations inherent to the LP approach should be kept in mind.

The interaction terms shed light on cross-country heterogeneity in transmission. Trade openness alone does not significantly amplify the inflation response once controls are included; the interaction between the shock and trade openness is small and statistically indistinguishable from zero across specifications. Trade vulnerability plays a more prominent role: economies that are structurally more exposed to global trade disruptions tend to exhibit stronger and more persistent inflationary responses to the same shock, consistent with the view that reliance on imported intermediate

goods, concentrated trade structures, or logistical bottlenecks can intensify domestic inflationary pressures. These interaction effects are, however, estimated with considerable uncertainty and should be interpreted with caution.

These findings are broadly consistent with recent evidence that global supply-chain disruptions contributed to inflationary pressures through cost-push channels during the post-pandemic period (e.g., [Gordon and Clark \(2023\)](#); [Acharya et al. \(2023\)](#)). Related work also highlights the role of imported input costs and production-network linkages in transmitting global supply shocks to domestic prices ([Binici et al. \(2024\)](#)). The present results complement this literature by suggesting that the inflationary effects of supply disruptions depend not only on trade openness but also on structural trade vulnerability and exposure to global logistics conditions in supply-chain-integrated economies.

The figures also report confidence intervals based on both heteroskedasticity-consistent (HC) and Driscoll-Kraay (DK) standard errors. Because DK standard errors account for both cross-sectional dependence and serial correlation in panel settings, they tend to provide more conservative inference than HC standard errors, though this is not guaranteed in every application. The close similarity between HC- and DK-based intervals is consistent with cross-country correlation and residual dependence not materially distorting inference in this setting, though it does not rule out their presence entirely. The qualitative conclusions regarding the shape and timing of the inflation response appear broadly robust across alternative inference methods.

4.2 REGIME-SPECIFIC IMPULSE RESPONSES Figures 5–7 present the impulse responses of inflation to a GSCP shock across high- and low-volatility regimes of the GSCPI. The regimes are defined based on the rolling volatility of the estimated trade-disruption innovation, allowing the transmission of shocks to vary depending on the stability of global trade conditions. In contrast to the full-sample analysis, these regime-specific estimates rely on heteroskedasticity-consistent (HC) standard errors, as the subsample dimension makes Driscoll-Kraay (DK) corrections less reliable.

Across specifications, an asymmetry is apparent between the two regimes. Under high-volatility conditions, inflation responses tend to be larger and more persistent, consistent with the notion that trade disruptions propagate more forcefully when global supply chains are already under stress. By contrast, in low-volatility periods the responses are generally muted and often statistically indistinguishable from zero, indicating limited pass-through of isolated trade disturbances when global logistics conditions remain stable. This pattern is broadly consistent across the baseline and richer specifications: the qualitative differences between high- and low-volatility regimes persist as domestic macroeconomic dynamics and global cost-push factors are sequentially added, suggesting that the regime asymmetry is not substantially explained by the controls included in the richer specifications. Given the limited number of countries and the relatively short subsample in each regime, however, these estimates should be interpreted as indicative rather than definitive.

The interaction terms provide further, albeit tentative, insight into heterogeneity in transmission. Trade openness does not appear to systematically amplify inflation responses within either regime once controls are included. Trade vulnerability plays a potentially more important role: economies with higher structural exposure to global trade disruptions tend to exhibit larger inflationary responses during high-volatility periods, consistent with heightened sensitivity to supply-chain bottlenecks and import cost pressures. The interaction effects may, however, be imprecisely estimated within regimes, and the confidence bands overlap substantially across specifications.

Overall, the regime-specific results are consistent with the baseline findings and highlight a state-dependent dimension of shock transmission: GSCP shocks appear more inflationary when they occur during periods of elevated supply-chain volatility, and this pattern may be amplified in structurally exposed economies, consistent with recent evidence that the inflationary effects of global supply disruptions intensify during episodes of elevated supply-chain stress (e.g., [Gordon and Clark \(2023\)](#); [Acharya et al. \(2023\)](#)). The uncertainty surrounding the interaction estimates, however, warrants caution in drawing strong conclusions about the precise role of trade vulnerability within each regime, and these patterns are best understood as motivating evidence for the structural interpretation developed in the DSGE section.

4.3 DSGE IMPULSE RESPONSES AND STRUCTURAL INTERPRETATION To complement the empirical LP estimates, Figure 8 reports impulse responses from the regime-switching DSGE model. The model is calibrated to Indonesian macroeconomic conditions using standard quarterly parameters summarized in Table 2.⁸

The simulations distinguish two structural dimensions. First, the model allows the global supply-chain shock to occur under low and high volatility regimes, capturing periods of relatively stable versus highly disrupted global logistics conditions. Second, the degree of trade vulnerability is varied through the parameter ϕ_{nx} , which governs the sensitivity of domestic production costs to imported intermediate inputs. The low-vulnerability calibration corresponds to $\phi_{nx} = 0.2$, while the high-vulnerability calibration corresponds to $\phi_{nx} = 0.9$.⁹ The persistence and magnitude of the global supply-chain disturbance are estimated using the empirical Global Supply Chain Pressure Index (GSCPI). When the empirical shock used in the local projection analysis is constructed as the standardized AR residual, its variance is normalized to unity. The DSGE shock magnitude is

⁸A caveat on scope: the DSGE model is calibrated to Indonesian macroeconomic conditions while the LP estimates pool evidence across ASEAN-5 economies, introducing an interpretive asymmetry. The structural parameters— ω_{nx} , ϕ_{nx} , and the Taylor rule coefficients—reflect Indonesia’s specific trade structure and monetary policy regime, which differ across the panel economies. The model should therefore be interpreted as providing a stylized structural interpretation of the transmission mechanism rather than a quantitatively precise representation of the panel-average response. A fully heterogeneous calibration across countries is left for future work.

⁹These calibration values are chosen for illustrative purposes in the model simulations and are not estimated from data. Rather, they are selected to represent two stylized degrees of external exposure—low and high vulnerability—in order to illustrate how differences in trade exposure and reliance on imported inputs may affect the transmission of global supply chain shocks.

therefore scaled to match the empirical impulse-response magnitude, ensuring that the simulated process reproduces both the persistence and unconditional volatility of observed global supply-chain disturbances.

The model generates a contraction in real economic activity following the supply-chain shock, with the magnitude varying substantially across calibrations. Output, consumption, investment, and labor hours decline on impact or in the periods immediately following the shock and recover gradually over subsequent periods. The contraction is larger when the economy is both highly vulnerable to imported inputs and exposed to a high-volatility shock, as illustrated by the comparison across calibrations in Figure 8. Investment exhibits the largest decline among the real variables, particularly under the high-vulnerability calibration, reflecting the sensitivity of forward-looking capital accumulation to increases in expected production costs and compressed future profitability. These dynamics arise because higher global trade costs raise firms' marginal production costs, dampening output and reducing household real income through lower wages and returns to capital.

While the model produces hump-shaped inflation dynamics similar to those estimated in the LP analysis, the simulated response tends to peak somewhat earlier. The difference reflects the structural transmission in the model, in which higher imported-input costs affect firms' marginal costs immediately, whereas the empirical interaction estimates may exhibit more gradual dynamics across economies. The hump-shaped inflation response reflects the cost-push nature of the disturbance and through the Rotemberg price-adjustment mechanism, these higher production costs are partially passed through to consumer prices. Furthermore, consistent with the real-side responses, the increase in inflation is more pronounced under the high-volatility regime and the high trade-vulnerability calibration, as shown in Figure 8.

The central bank responds endogenously to these inflationary pressures by raising the policy interest rate when inflation rises above target, consistent with the Taylor-rule-type monetary policy framework. As a result, the policy rate increases in the early periods following the shock and gradually declines as inflation pressures ease and the economy moves back toward its steady state. The temporary tightening of monetary conditions contributes to the contraction in real activity and moderates the persistence of the inflationary response, though the relative contribution of monetary policy to inflation dynamics is not formally decomposed within the model.

External-sector dynamics vary across calibrations. Net exports decline on impact following the shock, with the deterioration larger and more persistent when trade vulnerability is high. This pattern is consistent with the increase in import costs that raises the value of imported intermediates used in domestic production, though the precise accounting of the trade balance response is not formally decomposed within the model. The nominal exchange rate depreciates with a lag of several periods, with a stronger depreciation under the high-volatility regime and high-vulnerability calibration. Although monetary policy tightens in response to inflation, the exchange rate continues to depreciate over the medium horizon, suggesting that cost-pressure and external-balance effects

offset the appreciation pressure from higher interest rates under these calibrations; however, the relative magnitudes of these forces are not formally identified. Over time, the weaker exchange rate is consistent with a gradual expenditure shift toward domestic goods, which may moderate import demand and support a partial recovery in net exports, though the extent of this recovery depends on calibration and the reduced-form treatment of the exchange rate limits the structural richness of this channel.

In summary, the structural simulations produce dynamics consistent with stagflationary pressures, characterized by rising inflation alongside declining real activity following global supply-chain disruptions. These effects are larger when the economy is highly dependent on imported intermediate inputs and when the shock occurs in a high-volatility environment, as illustrated by the comparison across calibrations in Figure 8. The results suggest that trade structure and supply-chain exposure may play a role in shaping macroeconomic vulnerability to global cost shocks, though establishing this more firmly would require formal model estimation and a broader cross-country analysis beyond the single-country calibration presented here.

5 CONCLUDING REMARKS

This paper examines how global supply-chain disruptions transmit to domestic inflation and how this transmission depends on trade openness and structural vulnerability in global value chains. Using a panel local projection framework complemented by a two-country NK-DSGE model with regime-switching shock volatility, the analysis provides both reduced-form evidence and a structural interpretation of the inflationary effects of GSCP shocks.

The empirical results reveal several patterns. GSCP shocks generate delayed and hump-shaped inflation responses, with economically meaningful effects emerging at medium horizons. The timing is consistent with gradual pass-through operating through production costs, imported intermediate inputs, and nominal rigidities rather than immediate price adjustment, though the LP framework does not identify which of these channels is most operative. Trade openness alone does not systematically amplify inflationary pressures once domestic and global controls are considered; the interaction between openness and the GSCP shock is small and statistically indistinguishable from zero across specifications. Economies that are more structurally exposed to disruptions in global value chains tend to exhibit stronger and more persistent inflationary responses to the same GSCP shock, particularly during periods of elevated global trade volatility, though these interaction effects are estimated with considerable uncertainty and should be interpreted with caution.

The DSGE model offers a structural interpretation of these patterns by distinguishing the roles of trade openness, structural vulnerability, and global volatility regimes in shaping inflation transmission from supply-chain disruptions. In the model, trade openness primarily influences quantities and external adjustment through import intensity and trade leakage, whereas structural vulnerability governs the extent to which global logistics stress passes through to delivered import

prices and firms’ marginal costs. This distinction is broadly consistent with the empirical results, in which openness alone does not systematically amplify inflation responses while greater vulnerability tends to amplify them in the simulations, though the model is calibrated rather than estimated and the mapping between simulated and empirical responses is qualitative rather than quantitative. The regime-switching structure introduces state dependence: when global logistics conditions are relatively stable, supply-chain shocks generate modest and short-lived inflation responses, whereas in high-volatility regimes the same disturbance produces larger and more persistent increases in marginal costs and inflation—a pattern that reflects different shock propagation dynamics across regimes rather than nonlinearity in the strict sense.

The simulations also illustrate broader macroeconomic adjustments that are less directly visible in reduced-form estimates. Higher imported input costs raise firms’ marginal costs, trigger an endogenous monetary policy tightening, and dampen output, consumption, and investment, producing dynamics that are qualitatively consistent with stagflationary pressures, though no formal comparison of magnitudes with observed episodes is made. External-sector responses—including exchange-rate depreciation and an initial deterioration in net exports—vary with both trade vulnerability and the prevailing volatility regime, consistent with the channels described above. Over time, the weaker exchange rate is consistent with a gradual expenditure shift toward domestic goods and a partial recovery in net exports, though the extent of this recovery depends on calibration and horizon, and the reduced-form treatment of the exchange rate limits the structural richness of this channel. What these simulations suggest, more broadly, is that inflation responses to supply-chain disruptions may partly reflect structural characteristics of production networks and imported-input dependence, rather than trade intensity alone—a mechanism that is plausible given the model structure, though formal estimation would be needed to assess how well the framework accounts for the empirical patterns quantitatively, and a broader cross-country analysis would be required to assess its generality beyond the single-country calibration presented here.

While the model provides insights into the transmission of global supply-chain disruptions, several caveats should be noted. First, the DSGE framework is calibrated rather than formally estimated. Calibration helps maintain transparency and consistency with the empirical local-projection evidence, but estimating the model would allow a more systematic assessment of parameter uncertainty and shock dynamics, and would permit a quantitative evaluation of how well the framework accounts for the empirical impulse responses. In addition, the parameter capturing trade vulnerability (ϕ_{nx}) is specified in a relatively reduced-form way. It serves as a tractable proxy for structural exposure to global production networks—such as reliance on imported intermediate inputs, supplier concentration, and logistics frictions—but a richer microfounded treatment could better capture how these channels operate in practice, particularly given that the current calibration is specific to Indonesia and may not generalise to the other ASEAN-5 economies in the panel.

A further limitation is that the model abstracts from heterogeneity in monetary policy regimes.

Allowing the policy response to inflationary cost-push shocks to vary across more hawkish versus more accommodative regimes could provide additional insights into how policy credibility and reaction strength influence the inflationary consequences of global supply disruptions. Incorporating such regime variation may also improve the model's ability to replicate state-dependent responses suggested by the data, though whether it would do so in practice would depend on estimation and identification. Extending the framework in this direction represents a natural next step for future work.

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A CONSTRUCTION OF THE GLOBAL TRADE VULNERABILITY INDEX (GTVI)

This appendix documents the procedure used to construct a country’s Global Trade Vulnerability Index (GTVI) for each ASEAN-5 economies to be used in the LP estimation.¹⁰ The GTVI is extracted as the first time-varying common factor from a large set of economic indicators that proxy the country’s exposure and sensitivity to global fragmentation and supply-chain pressure. The methodology follows a Time-Varying Parameter Factor-Augmented Vector Autoregression (TVP-FAVAR) in the spirit of [Koop and Korobilis \(2013\)](#).

A.1 DATA PREPARATION We compile quarterly data from CEIC. Variables include external trade indicators, GVC-related measures, financial exposures, and domestic macroeconomic indicators. The treatment of the raw data proceeds in three stages:

1. Seasonal Adjustment. All series are seasonally adjusted in levels using the SEATS procedure from the X-13ARIMA-SEATS framework. For each variable x_t , the raw series is passed to the SEATS decomposition, which applies an ARIMA-based model-based seasonal filter (as opposed to simple deterministic quarterly dummies) and returns the seasonally adjusted component,

$$\tilde{x}_t = x_t^{\text{SA, SEATS}},$$

where the seasonal pattern is removed through the signal extraction algorithm described in [Burman \(1980\)](#) and [Dagum and Bianconcini \(2016\)](#). The advantage of SEATS over deterministic regressions is that the seasonal pattern is allowed to vary stochastically over time and is jointly estimated with the ARIMA model for the underlying series. The SEATS-adjusted $\tilde{x}_t$ is then used as the input for subsequent stationarity testing and transformations. The seasonal adjustment was implemented via the X-13 Toolbox for seasonal filtering constructed by [Lengwiler, 2025](#), which interfaces with the U.S. Census Bureau’s X-13ARIMA-SEATS software for SEATS decomposition ([U.S. Census Bureau, 2020](#)).

2. Stationarity Transformation. Each seasonally adjusted variable is tested for a unit root (ADF test). If non-stationary:
 - (a) for indicators measured in percent or diffusion indices, we take first differences

$$\Delta x_t = x_t - x_{t-1};$$

- (b) for non-percent variables we take log differences when the level is strictly positive,

$$\Delta x_t = 100 \times (\log x_t - \log x_{t-1}),$$

¹⁰We use Indonesia as an example.

otherwise we use first differences.

Stationary series are kept in levels.

3. Alignment, Imputation, and Standardization. After transformation, all series are aligned to the available sample. Missing interior values are filled using forward- and backward-replacement for numerical stability. Finally, all variables are standardized:

$$z_{i,t} = \frac{x_{i,t} - \bar{x}_i}{s_i}.$$

Let the resulting balanced dataset be the $T \times N$ standardized panel Z_t .

A.2 MODEL SPECIFICATION: TVP-FAVAR We partition the set of observable variables into:

$$Y_t = (y_{1,t}, y_{2,t}, y_{3,t})' \quad (\text{macro block}),$$

$$X_t = Z_t \setminus Y_t \quad (\text{GVC and financial exposure block}).$$

The goal is to extract a latent factor capturing the country's vulnerability to GSCP. The measurement equation is

$$\begin{pmatrix} Y_t \\ X_t \end{pmatrix} = \Lambda_t \begin{pmatrix} Y_t \\ F_t \end{pmatrix} + e_t, \quad (13)$$

where F_t is the latent factor (the GTVI), Λ_t are time-varying loadings, and $e_t \sim N(0, V_t)$. The state equation for the factor-augmented VAR is

$$\begin{pmatrix} Y_t \\ F_t \end{pmatrix} = B_t \begin{pmatrix} Y_{t-1} \\ F_{t-1} \end{pmatrix} + u_t, \quad (14)$$

with $u_t \sim N(0, Q_t)$ and B_t evolving according to a random walk:

$$B_t = B_{t-1} + \nu_t, \quad \Lambda_t = \Lambda_{t-1} + \eta_t.$$

Stochastic volatilities V_t and Q_t follow exponentially weighted moving-average (EWMA) processes governed by forgetting factors $\ell_1, \ell_2, \ell_3, \ell_4$.

A.3 ESTIMATION Estimation proceeds in three steps:

1. Initialization via PCA. Principal components of X_t provide initial estimates of the factors, F_t^{PC} , and associated loadings Λ^{PC} .
2. Static and Quasi-Dynamic Factor Estimates. We obtain [Doz et al. \(2011\)](#) estimates by running a Kalman filter and smoother with fixed loadings and covariance parameters derived

from PCA.

3. TVP-FAVAR Estimation. The dynamic factor structure is estimated using the time-varying parameter FAVAR framework of [Koop and Korobilis \(2013\)](#), implemented with the original MATLAB routines made available by Dimitris Korobilis.¹¹ For each period t , the measurement loadings Λ_t , VAR coefficient matrices B_t , idiosyncratic error covariance V_t , and factor shock covariance Q_t evolve according to random-walk state equations with exponentially weighted moving-average (EWMA) innovations.

Given $(\Lambda_t, B_t, V_t, Q_t)$, the latent factor sequence F_t is extracted via a Kalman smoother. Parameters and factors are updated iteratively until convergence. The Global Trade Vulnerability Index (GTVI) is defined as the first estimated factor:

$$\text{GTVI}_t \equiv F_t.$$

To ensure correct orientation, the sign of F_t is chosen such that its correlation with a reference exposure variable (e.g., short-term external debt of banks) is positive. Finally, the GTVI is standardized to have mean zero and unit variance.

A.4 INTERPRETATION The GTVI summarizes how a country’s macro-financial system comoves with GVC-sensitive variables and external exposures in a fully time-varying environment. Higher values indicate periods when the country is more vulnerable to global supply-chain fragmentation, external shocks, or policy-driven trade pressures. Because all loadings and VAR coefficients evolve over time, the GTVI captures structural changes in the country’s integration with global value chains.

A.5 EXAMPLE: DEVELOPING A GTVI FOR INDONESIA The construction of the GTVI is described in detail in this section, while the underlying variables are summarized in Table 1. As can be seen in Figure 1, the index exhibits sharp declines during the global financial crisis and the COVID-19 pandemic.

A.5.1 VARIABLES AND DATA The construction of Indonesia’s Global Trade Vulnerability Index (GTVI) draws on a set of macroeconomic, external, real-sector, and financial variables that together capture the multiple channels through which global fragmentation pressures may affect the domestic economy. Indonesia’s vulnerability is inherently multidimensional: it reflects not only direct trade exposure to major partners such as China and the United States, but also the structure of its manufacturing base, reliance on imported intermediate goods, external financing conditions, and

¹¹The code used for TVP-FAVAR estimation, including functions for Kalman filtering, smoothing, and time-varying covariance updates, is available at <https://sites.google.com/site/dimitriskorobilis/matlab/forecasting-tvp-favar>.

sensitivity to global uncertainty or supply-chain disruptions. By combining these indicators into a single composite factor using data-driven statistical methods, the GTVI summarizes the common cyclical component in these series as a measure of Indonesia’s exposure to global trade risks over time.

Trade indicators form a central pillar of the GTVI. The export share to China and import share sourced from China measure the economy’s bilateral economic dependence, which is relevant given China’s role as a key export market for natural resources and a critical supplier of industrial inputs. Imports of raw materials and intermediate goods provide a more structural measure of Indonesia’s participation in global value chains (GVCs), where disruptions to cross-border production networks may have material effects on domestic manufacturing output. These trade-side indicators allow the GTVI to reflect both the scale and the composition of Indonesia’s external linkages.

Alongside trade exposure, the GTVI incorporates indicators of financial and external resilience. Short-term external debt of the banking sector captures rollover risk and vulnerability to shifts in global risk sentiment. Foreign exchange reserves (in months of import coverage) measure the economy’s ability to absorb external shocks, while the current account balance provides information on external funding needs. Movements in the real effective exchange rate (REER) capture competitiveness pressures and the impact of global monetary conditions. Together, these variables are intended to reflect the macro-financial channels through which global fragmentation may tighten domestic liquidity, weaken the exchange rate, or reduce financial stability, though the index summarises their common variation rather than identifying each channel separately.

Real-sector indicators, including manufacturing value added and industrial production indices for GVC-intensive subsectors (electrical machinery, machinery and equipment, chemicals, and basic metals), are included to reflect the structure of Indonesia’s production network. These industries rely heavily on foreign inputs and multinational supply chains; fluctuations in their activity may therefore provide signals of external supply disruptions or policy-driven fragmentation. Including these variables is intended to help the GTVI capture real-economy manifestations of global shocks, to the extent that such effects are reflected in the common factor.

Global uncertainty indicators further enrich the index. Trade Policy Uncertainty Indices (TPUI) for China and the United States reflect uncertainty stemming from tariff policy, export controls, and geopolitical tensions. Incorporating these measures allows the “with-global-indices” version of the GTVI to reflect external sources of uncertainty more directly. A parallel version of the index excluding these global variables provides a robustness check, isolating the contribution of Indonesia’s own structural conditions.

The final GTVI is generated using three alternative factor-extraction approaches: (1) static principal components analysis (PCA); (2) the quasi-dynamic factor model of [Doz et al. \(2011\)](#), which corrects the PCA for measurement error and serial correlation; and (3) a fully time-varying parameter FAVAR (TVP-FAVAR) model following [Koop and Korobilis \(2013\)](#), which allows factor

loadings and shock transmission mechanisms to evolve smoothly over time. Despite differences in methodology, all three approaches produce broadly similar GTVI series, as shown in Figure ??, suggesting that the extracted vulnerability signal is not highly sensitive to the choice of factor method, though this convergence does not by itself validate the index as a measure of true underlying vulnerability.

A.5.2 RESULTS AND DISCUSSION Figure 1 illustrates that Indonesia’s GTVI is countercyclical and responsive to global stress episodes. The most pronounced declines occur during the 2008-2009 global financial crisis and the onset of the COVID-19 pandemic in early 2020, when all three GTVI versions exhibit a sharp and synchronized deterioration. These patterns are consistent with the broad-based nature of both episodes, which affected trade flows, manufacturing supply chains, external financing conditions, and global uncertainty simultaneously, though the index captures their common statistical footprint rather than identifying each channel separately.

During 2014-2019, the GTVI exhibits relatively moderate fluctuations, broadly consistent with a period of more stable external conditions, though intermittent U.S.-China trade tensions are visible in the series. Beginning around 2017, the GTVI gradually rises, a pattern that coincides with heightened global trade-policy uncertainty and emerging disruptions to technology and supply-chain linkages. This pattern becomes more pronounced in 2018-2019 as trade tensions escalate, though the index cannot isolate the contribution of these specific factors from other concurrent developments.

In the post-pandemic recovery period (2021-2023), the GTVI improves but remains more volatile than in the pre-COVID era, consistent with elevated GSCP, commodity price swings, and shifting monetary conditions during this period. By 2024-2025, the GTVI stabilizes but remains above its pre-2018 levels, suggesting that the structural and macro-financial conditions captured by the index have not fully returned to their earlier configuration, though whether this reflects a permanent shift in Indonesia’s exposure to global fragmentation is beyond what the index alone can establish.

Overall, the GTVI provides a summary measure of the common variation in Indonesia’s trade-related vulnerability indicators over time. The broad agreement across PCA, Doz et al. (2011)-factor, and TVP-FAVAR estimates suggests that the extracted signal is not highly sensitive to the choice of factor method, lending some confidence to its use as an interaction term in the LP analysis. Its interpretation should nonetheless remain descriptive—as a data-driven composite index rather than a structural measure of true underlying vulnerability.

Table 1: Variables Used in Constructing the Global Trade Vulnerability Index (GTVI), Indonesia

Variable	Unit	Description
Real GDP	IDR billion	Gross domestic product, constant prices.
GDP deflator	Index	GDP deflator index.
Short-term interest rate	Percent (% p.a.)	Monetary policy rate (quarterly average).
Exports to China/Total exports	Percent (%)	Share of total exports to China.
Imports from China/Total imports	Percent (%)	Share of total imports from China.
Imports: raw materials and intermediates	USD million	Imports of raw and intermediate inputs used in domestic production.
FX reserves	Months	International reserves measured in months of import coverage.
Current account balance	Percent of GDP	Current account surplus/deficit relative to GDP.
Real effective exchange rate (REER)	Index	Real effective exchange rate; an increase indicates real appreciation.
Import price index (USD)	Index	Index of import prices denominated in USD.
GDP manufacturing industry	IDR billion	Gross value added of Indonesia's manufacturing sector.
IPI: electrical machinery	Index	Industrial production index for electrical machinery and equipment.
IPI: machinery and equipment	Index	Industrial production index for machinery and equipment.
IPI: chemicals	Index	Industrial production index for chemical products.
IPI: basic metals	Index	Industrial production index for basic metal manufacturing.
Exports: non-oil and gas	USD million	Exports of non-oil and gas goods.
Exports: manufactured products	USD million	Exports of manufactured goods.
TPUI China	Index	Trade Policy Uncertainty Index of China.
TPUI US	Index	Trade Policy Uncertainty Index of the United States.



Figure 1: **Global Trade Vulnerability Index (GTVI), Indonesia: Static PCA, Doz et al. (2011), and TVP-FAVAR Estimates.** The figure compares three alternative estimates of the GTVI: (1.) the Static PCA series is obtained as the first principal component of the standardized data matrix, (2.) the [Doz et al. \(2011\)](#) series is the quasi-maximum likelihood dynamic factor estimate using a Kalman smoother, and (3.) the TVP-FAVAR series follows the time-varying parameter FAVAR framework of [Koop and Korobilis \(2013\)](#). All indices are standardized to mean zero and unit variance.

Table 2: Baseline DSGE calibration for Indonesia (quarterly frequency)

Param.	Value	Interpretation	Source/Data
<i>Household and price-setting</i>			
β	0.99	Discount factor	Standard; implies $\approx 4\%$ annual real rate
π^*	$1.025^{1/4}$	Inflation target (3% yoy)	Bank Indonesia target (sample average)
μ	$1.045^{1/4}$	Trend productivity growth (4.5% yoy)	BPS data
η	6	Elasticity of substitution (markup $\approx 20\%$)	Standard NK literature
κ	60	Rotemberg adjustment cost	Calibrated; NKPC slope = $(\eta - 1)/\kappa \approx 0.08$
α	0.5	Inflation indexation	Calibrated; standard range [0.3, 0.7]
<i>Monetary policy</i>			
ψ	1.33	Taylor rule inflation response	Juhro et al. (2023)
ρ	0.75	Interest rate smoothing	Juhro et al. (2023)
σ_r	0.54	Monetary policy shock std.	Juhro et al. (2023)
<i>Production and capital</i>			
ν	0.33	Capital share	Penn World Tables; standard
δ	0.025	Depreciation rate (10% yoy)	Standard NK-DSGE literature
φ	4	Investment adjustment cost	Christiano et al. (2005)
<i>Trade and vulnerability</i>			
ω_{nx}	0.25	Trade openness/import intensity	World Bank; Indonesia imports/GDP
ϕ_{nx}	0.20	Trade vulnerability (baseline)	Calibrated
λ_{leak}	0.20	Leakage/absorption strength	Calibrated
<i>Global supply chain pressure</i>			
$\rho_{z^{gscp}}$	0.8562	GSCP persistence	Estimated, AR(1) on GSCPI (Q1 2008-Q2 2025)
γ_{ship}	0.06	GSCP $\rightarrow$ import-price wedge	Calibrated
ξ_m	0.20	Imported intermediate input share	OECD TiVA/WIOD, Indonesia
ϑ_ϕ	2	Vulnerability convexity	Calibrated
<i>Other shocks</i>			
ρ_z	0.75	Technology shock persistence	Standard
σ_z	0.01	Technology shock std.	Standard
ρ_η	0.75	Cost-push shock persistence	Standard
σ_η	0.01	Cost-push shock std.	Standard

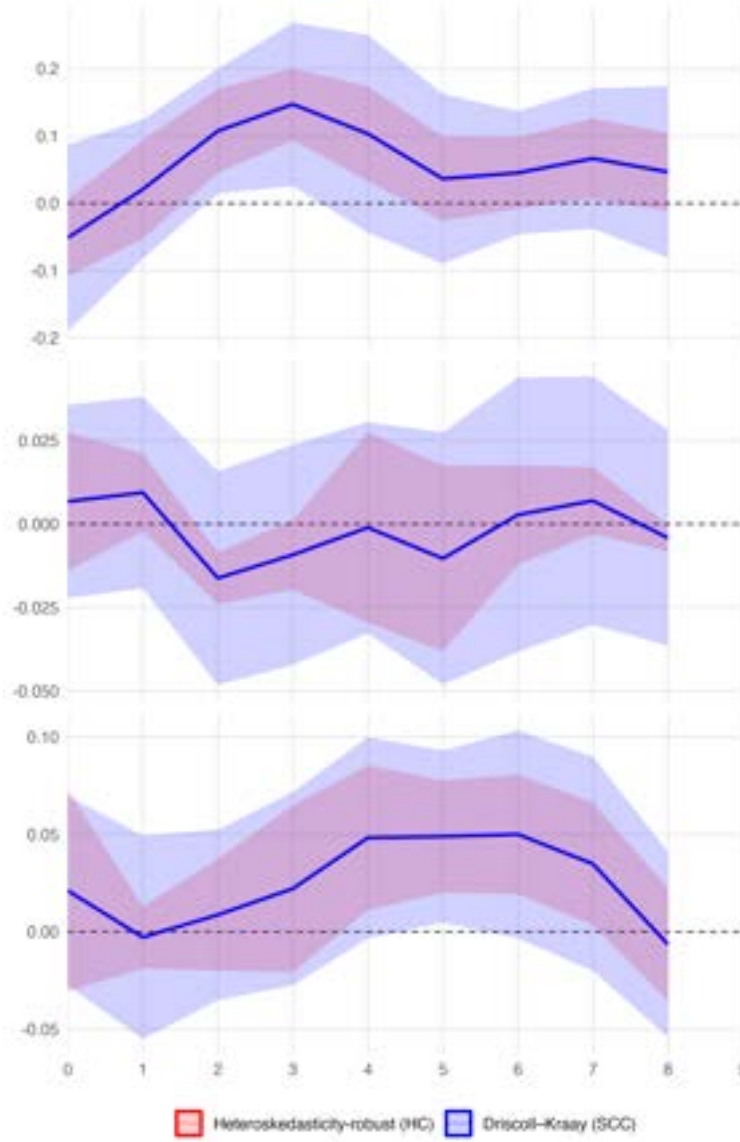


Figure 2: Impulse responses to a GSCP shock (baseline specification). The baseline model includes the shock interacted with trade openness (TO) and trade vulnerability (GTVI) but excludes additional macroeconomic controls. The top panel reports the response of inflation to the GSCP shock, the middle panel shows the response to the interaction between the shock and trade openness (shock $\times$ TO), and the bottom panel shows the response to the interaction between the shock and trade vulnerability (shock $\times$ GTVI). Shaded areas denote 90% confidence intervals.

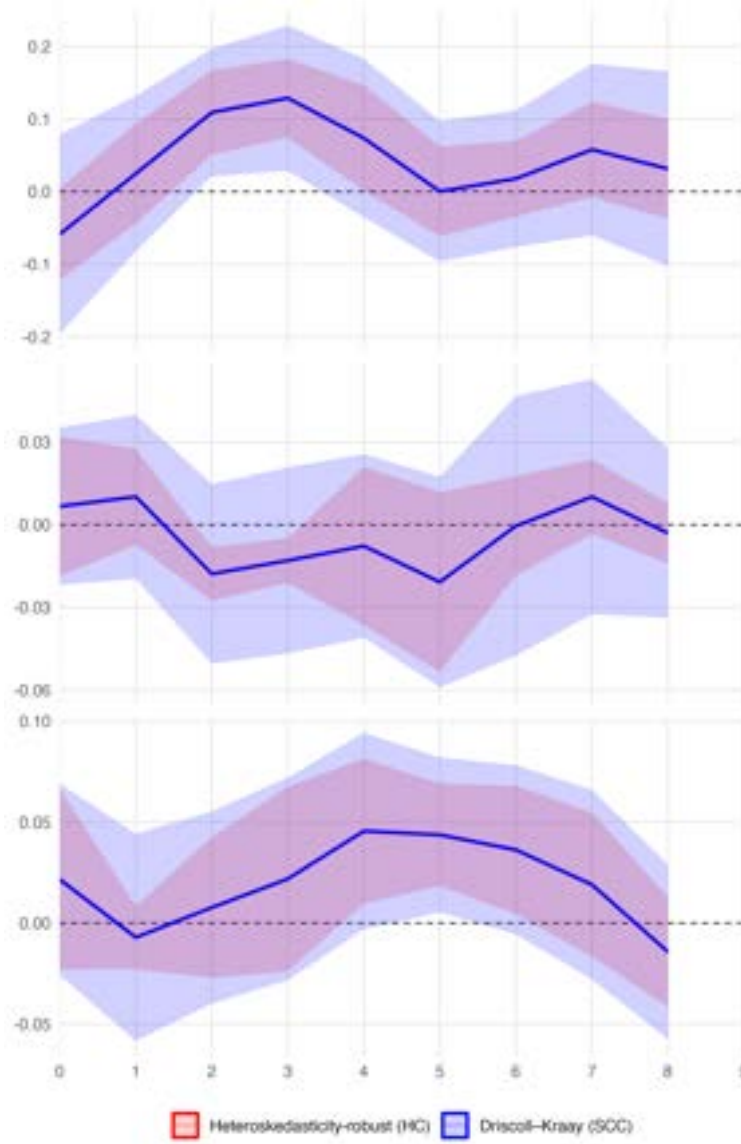


Figure 3: Impulse responses to a GSCP shock (alternative specification 1). This specification adds standard macroeconomic controls, including inflation persistence, output gap, real exchange rate changes, and trade openness dynamics, in addition to the interaction terms with TO and GTVI. The top panel reports the response of inflation to the GSCP shock, the middle panel shows the response to the interaction between the shock and trade openness (shock $\times$ TO), and the bottom panel shows the response to the interaction between the shock and trade vulnerability (shock $\times$ GTVI). Shaded areas denote 90% confidence intervals.

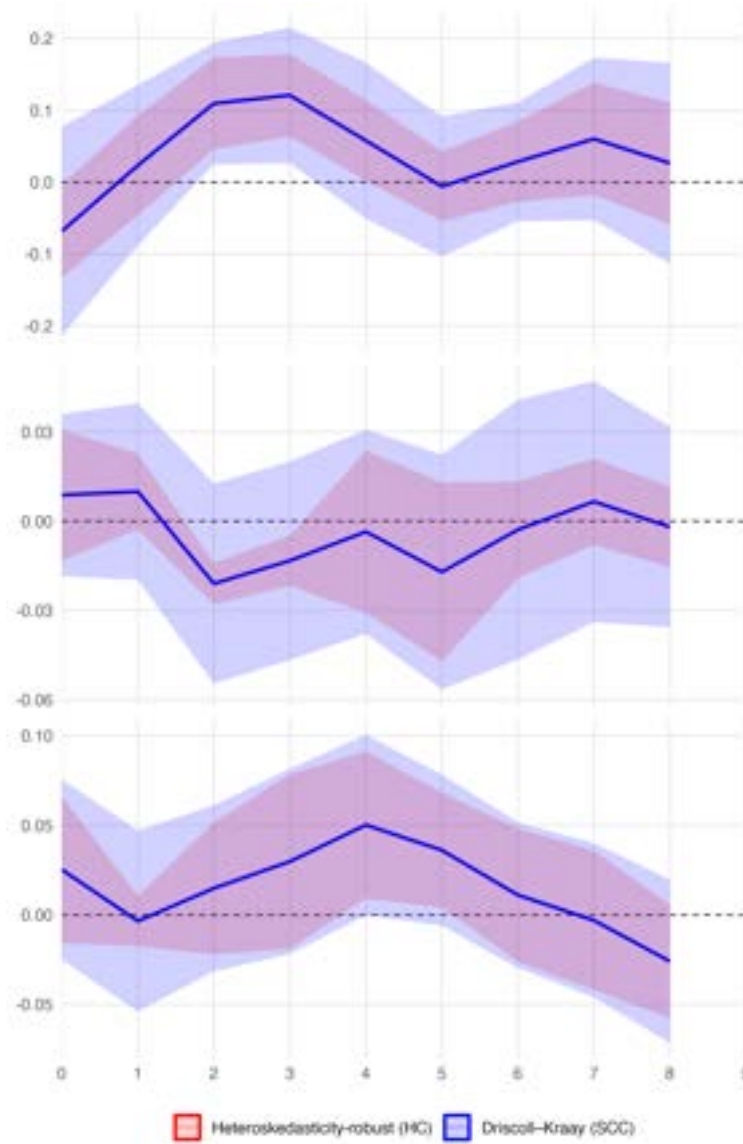


Figure 4: Impulse responses to a GSCP shock (alternative specification 2). This extended specification further includes global cost-push and policy controls (commodity prices, oil prices, and monetary policy rate changes), alongside TO and GTVI interaction terms. The top panel reports the response of inflation to the GSCP shock, the middle panel shows the response to the interaction between the shock and trade openness ($\text{shock} \times \text{TO}$), and the bottom panel shows the response to the interaction between the shock and trade vulnerability ($\text{shock} \times \text{GTVI}$). Shaded areas denote 90% confidence intervals.

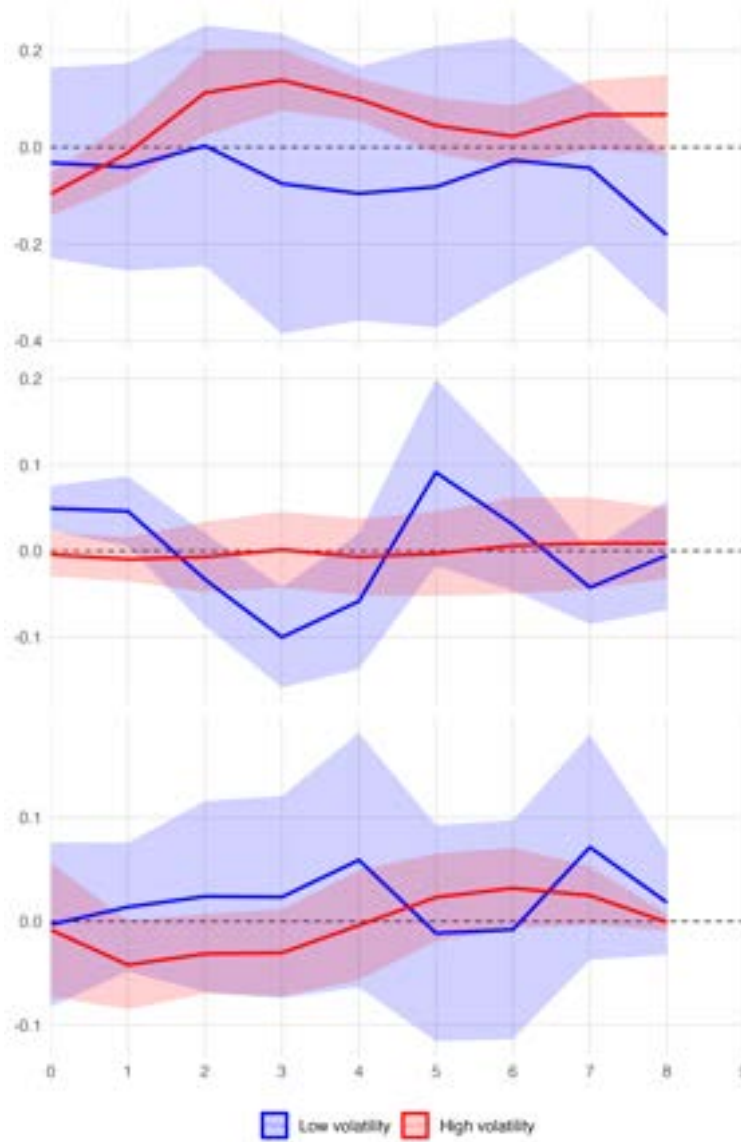


Figure 5: Impulse responses to a GSCP shock under high- versus low-volatility regimes (baseline specification). The regimes are defined based on the volatility of the GSCPI. The baseline specification excludes additional macroeconomic controls but includes interactions with TO and GTVI. The top panel reports the response of inflation to the GSCP shock, the middle panel shows the response to the interaction between the shock and trade openness (shock $\times$ TO), and the bottom panel shows the response to the interaction between the shock and trade vulnerability (shock $\times$ GTVI). Confidence intervals are computed using heteroskedasticity-consistent (HC) standard errors.

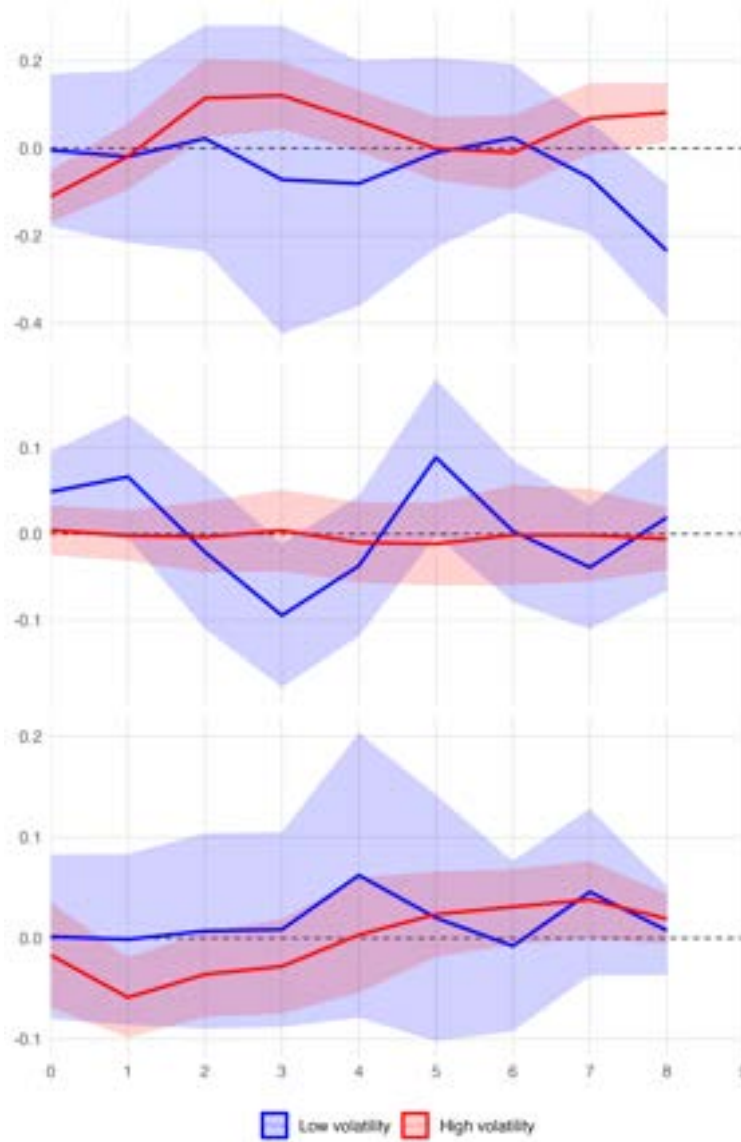


Figure 6: Impulse responses to a GSCP shock under high- versus low-volatility regimes (alternative specification 1). This specification includes standard domestic macroeconomic controls while allowing the response to vary with TO and GTVI. The top panel reports the response of inflation to the GSCP shock, the middle panel shows the response to the interaction between the shock and trade openness (shock $\times$ TO), and the bottom panel shows the response to the interaction between the shock and trade vulnerability (shock $\times$ GTVI). Confidence intervals are computed using heteroskedasticity-consistent (HC) standard errors.

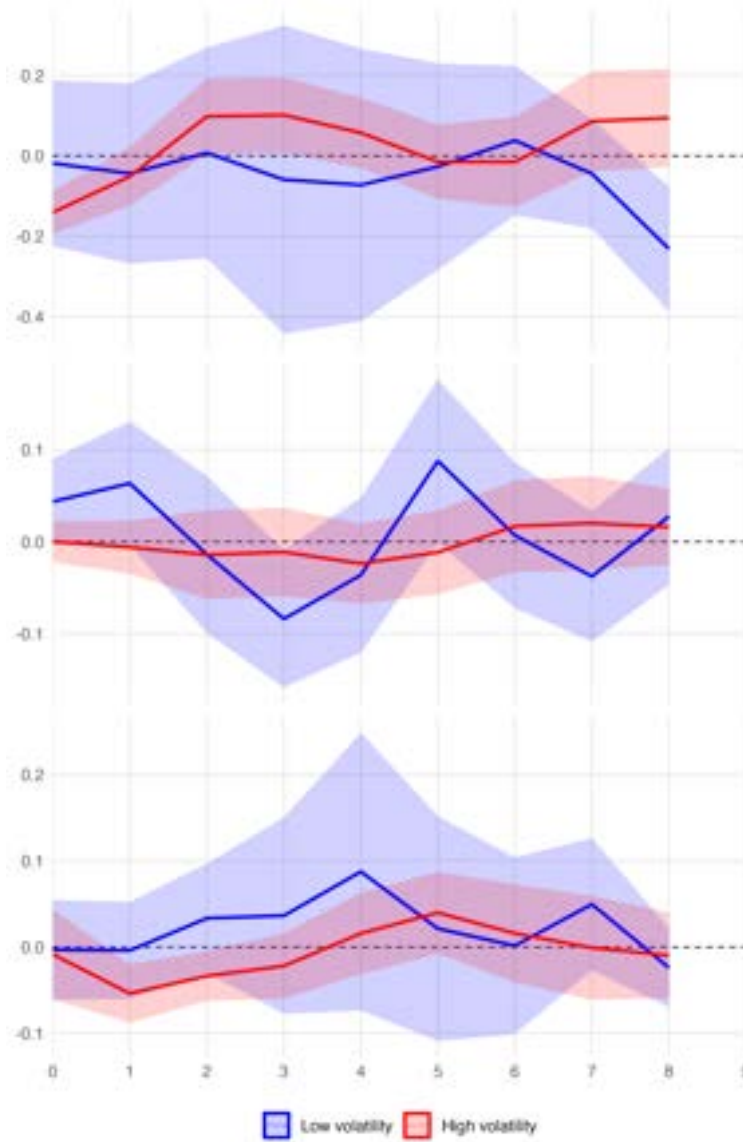


Figure 7: Impulse responses to a GSCP shock under high- versus low-volatility regimes (alternative specification 2). This extended specification incorporates additional global price and policy controls, allowing the transmission of trade disruptions to differ across volatility regimes. The top panel reports the response of inflation to the GSCP shock, the middle panel shows the response to the interaction between the shock and trade openness (shock $\times$ TO), and the bottom panel shows the response to the interaction between the shock and trade vulnerability (shock $\times$ GTVI). Confidence intervals are computed using heteroskedasticity-consistent (HC) standard errors.

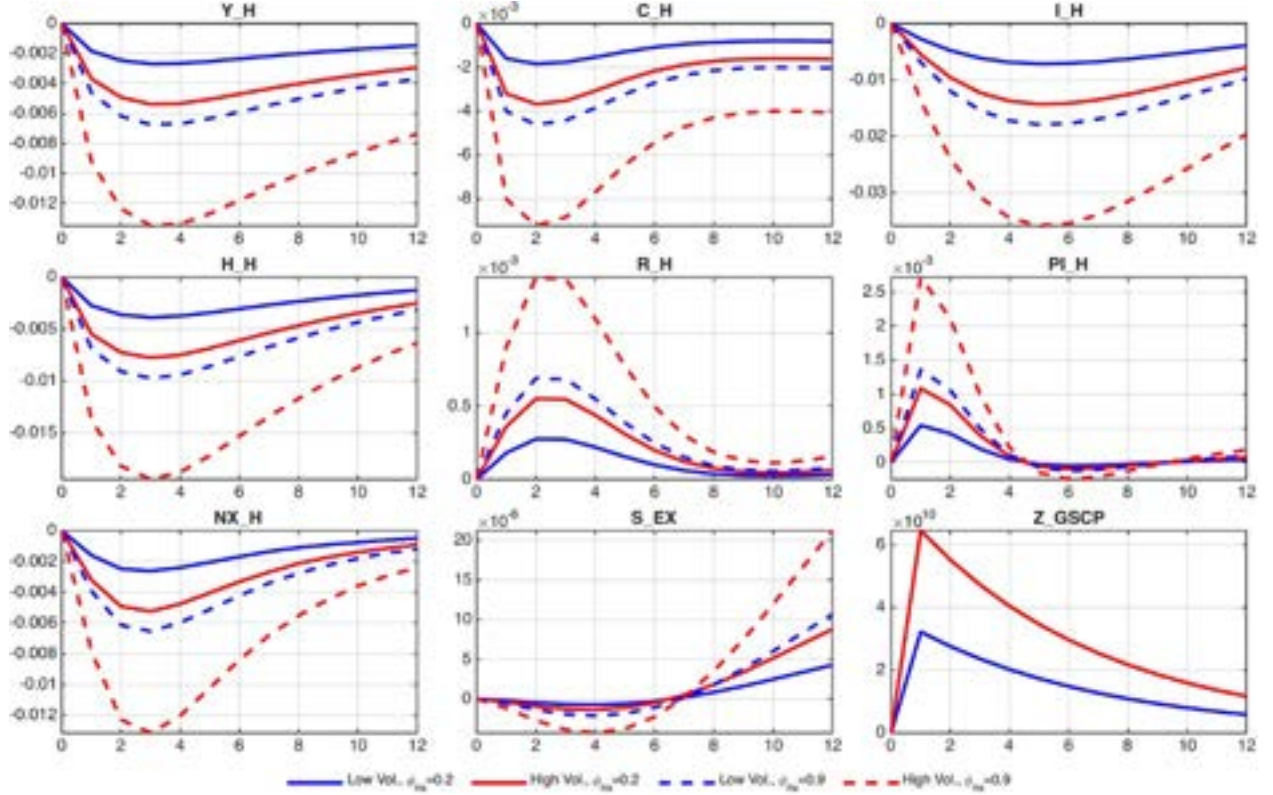


Figure 8: Impulse responses to a GSCP shock under low- and high-volatility regimes. Blue (red) lines denote low (high) GSCP volatility. Solid lines correspond to the baseline trade vulnerability calibration ($\phi_{nx} = 0.2$), while dashed lines represent higher trade vulnerability ($\phi_{nx} = 0.9$). Responses are expressed as deviations from steady state. The GSCP shock captures global supply-chain disruptions that raise import costs and propagate to domestic inflation, real activity, external balances, and exchange-rate dynamics through trade and cost channels.



Building Resilience in the Geoeconomic Fragmentation: The Role of MFI Transitions to Banks in Cambodia's Financial Development

Chhorn Dina, Muth Sumontheany, and Houy Sivly

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Acronyms and abbreviations

ABC	Association of Banks in Cambodia
AC	Agricultural Cooperative
ACLEDA	The Association of Local Economic Development Agencies
AMRET	Amret Microfinance Institution
AR1	First-order Serial Correlation
AR2	Second-order Serial Correlation
CB	Commercial Banks
CBC	Credit Bureau Cambodia
Coef	Coefficient
CRS	Congressional Research Service
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
IDLO	International Development Law Organization
IFS	International Financial Statistics
IMF	International Monetary Fund
INEF	Institute for Development and Peace
KHQR	Khmer Quick Response Code
LOLC	LOLC (Cambodia) PLC
MDI	Microfinance Deposit-taking Institution
MFI	Microfinance Institution
MSMEs	Micro, Small, and Medium Enterprises
NBC	National Bank of Cambodia
NGO	Non-Governmental Organisation
NPLs	Non-performing Loans
ODA	Official Development Assistance
OLS	Ordinary least squares
PAR	Portfolio At Risk
PPP	Purchasing Power Parity
PRASAC	Programme de Réhabilitation et d'Appui au Secteur Agricole du Cambodge
RGC	Royal Government of Cambodia
SB	Specialized Banks
SE	Standard Error
US	United States of America
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
USD	US Dollars
WITS	World Integrated Trade Solution
WUI	World Uncertainty Index

Executive summary

In a geoeconomic fragmentation, Cambodia's financial sector faces the challenge of enhancing inclusion while safeguarding stability. The transition of microfinance institutions (MFIs) into banks marks possibly a significant step toward resilience, offering opportunities to expand credit access and absorb external shocks.

Analysing panel data from 120 financial institutions (2013-2023), the core objective of this research is to assess the impact of MFIs transitioning to banks on Cambodia's financial development in a fragmented world. The specific objectives include:

- (1) *Analysing the implications of MFIs transitioning to banks for financial inclusion and financial risk in Cambodia; and*
- (2) *Investigating the role of these transitions in promoting economic resilience, particularly in a world characterised by the geo-economic fragmentation.*

From the estimated results of the models, we suggest the following hypothesis based on two distinct time periods. *During the pre-pandemic phase*, loan access, an indicator of financial inclusion, is primarily driven by the persistence of prior loan access. Non-performing loans (NPLs), an indicator of financial risk, are significantly influenced by lagged NPLs, economic growth, and the size of financial institutions in terms of assets and equity, highlighting the potential for over-lending during economic booms. Notably, NPLs declined during this period, largely due to the positive effects of transitioning MFIs to banks. *In the post-pandemic period*, the landscape has shifted. NPLs rose due to the adverse impacts of the global pandemic. However, MFI transitioning into banks helped mitigate these effects. While global uncertainty correlates with reduced NPLs, likely reflecting more conservative lending, it did not significantly impact loan access. Importantly, transformed institutions expanded their branch networks more than their non-transformed counterparts, which became more pronounced during the post-pandemic recovery period. Our hypothesis is that financial institutions that transitioned are more responsive to global uncertainty, suggesting heightened sensitivity to both risk and opportunity in a fragmented international environment.

Policy recommendations for strengthening financial resilience in Cambodia amidst global geoeconomic fragmentation must include a balanced approach to financial inclusion and risk management. Given the persistence of high NPLs, there must be enhanced regulatory oversight through stress testing, onsite inspections, and resolution mechanisms. Better credit assessments should be enforced to ensure loan quality, thereby prioritising productive loans over non-productive lending. Accelerating the establishment of a deposit insurance system would enhance financial stability while reducing dependency on volatile foreign capital by prioritising domestic capital mobilisation. Additionally, encouraging mergers and acquisitions can improve institutional efficiency and resilience, though transitioning MFIs into banks should be driven by sustainable growth rather than regulatory pressures. The role commercial banks play in microcredit should be limited to prevent redundancy with MFIs.

Key detailed findings from the estimated results are summarised in the table below.

Model A: Effect of MFIs transitioning to banks on loan accessibility	• The results suggest financial inclusion was driven primarily by prior access to financial services, indicating a self-reinforcing dynamic. • No strong evidence that institutional or macroeconomic factors (equity-asset ratio, profitability, GDP growth, lending rates) significantly improve loan access. • Post-transition to bank status does not clearly increase loan accessibility, raising doubts about whether regulatory upgrading alone widens outreach. • No significant interaction between institutional transition and the post-COVID period on loan access. • Geoeconomic or macro shocks (e.g., lending rate changes) have minimal effect on loan accessibility.
Model B: Effect of geoeconomic fragmentation on loan accessibility	• World Uncertainty Index (WUI) shows weak influence on access to loans, indicating external uncertainty does not strongly disrupt financial inclusion. • Institutional transformation and global fragmentation do not independently drive financial outreach, suggesting other domestic or behavioural factors are more critical.
Model C: Effect of MFIs transitioning to banks on NPLs	• Transitioning MFIs to banks significantly reduces NPLs, reflecting stronger regulation, improved risk control, and enhanced oversight. • Post-transition * post-pandemic interaction indicates upgraded institutions were more resilient to COVID-19 shocks. • Post-pandemic period led to higher NPLs, highlighting persistent borrower distress. • Positive relationship between economic growth and NPLs suggests risk of over-lending during booms. • Historical NPL levels strongly predict future NPLs, stressing the need for early intervention. • Larger institutions tend to face higher NPLs due to wider risk exposure. • Higher equity-assets ratio may be associated with riskier lending behaviour, requiring stronger prudential supervision.
Model D: Effect of geoeconomic fragmentation on NPLs	• Transitioning MFIs to banks remains important in enhancing financial stability under global uncertainty. • Interaction of transition and WUI reveals that upgraded institutions show greater resilience during global shocks. • Negative WUI coefficient suggests institutions adopt more cautious lending during uncertainty, reducing NPLs.
Model E: Effect of MFIs transitioning to banks on the number of branches of financial institutions	• Transformed institutions expand branch networks more aggressively than non-transformed MFIs. • Expansion is especially strong post-pandemic, indicating institutional upgrading supports both stability and growth.
Model F: Effect of geoeconomic fragmentation on the number of branches of financial institutions	• Global uncertainty exerts a modest influence on institutional expansion. • Transformed institutions are more sensitive and responsive to international risk dynamics, suggesting higher strategic awareness and adaptability.

1. Introduction

In a world where economic ties are growing deeper yet more fragile, Cambodia's increasing integration into global economy brings new opportunities while also presenting potential risks that may challenge its efforts to enhance financial inclusion and maintain stability, particularly in the context of rising geoeconomic fragmentation. The risk of geoeconomic fragmentation has become increasingly evident. Since the 2007-08 global financial crisis (GFC), a series of global events have accelerated divisions across the world, including Brexit, US-China trade tensions, the COVID-19 pandemic, the Russia-Ukraine war, and other ongoing conflicts. Additionally, China's GDP, measured by purchasing power parity (PPP), surpassed that of the US in 2013, further intensifying global economic pressures (see, CRS 2015; Aiyar, Presbitero, and Ruta 2023; Aiyar et al 2023).

Geoeconomic fragmentation has significantly impacted international trade, technology, and financial systems by disrupting global flows of goods, capital, and labour while increasing trade restrictions. Aiyar et al. (2023) highlights that fragmentation increases challenges in trade and technology, reduces cross-border labour efficiency, hinders innovation, exacerbates demographic issues, and restricts external financing options, thus decreasing economic development. Jean (2024) explains that geopolitical tensions and strategic competition among great powers increasingly shape the global economy, driving fragmentation through trade and industrial policies. Similarly, Norring (2024) underlines rising challenges in global trade and finance as globalisation retreats, trade growth slows, and global value chains shift from efficiency-driven to resilience-focused frameworks.

Geoeconomic decoupling also poses significant challenges for Cambodia due to its close economic ties with China and the US, its largest import and export partners, respectively (WITS 2022). Globally, trade tensions and protectionist policies between the world's two greatest economies have disrupted trade flows, foreign direct investment (FDI), and capital markets. Such actions have slowed China's economic growth and reduced Cambodia's growth prospects (Aiyar et al. 2023). Cambodia's reliance on China as its largest bilateral donor, lender, investor, and trading partner increases these risks (Menon 2023). In addition, Cambodia's financial sector faces the dual challenge of enhancing inclusion and maintaining stability in a fragmented global economy. This highlights the country's dependence on foreign capital inflows, particularly official development assistance (ODA) and FDI, both of which make the economy vulnerable to external shocks. The lack of domestic fundraising platforms, such as a bond market or a strong stock exchange, deepens this reliance. While foreign direct investment into Cambodia's banking sector has supported fund mobilisation, the economy remains vulnerable to shifts in investor sentiment and external conditions that may affect the stability and sustainability of these inflows (see, Aiba 2023; Aiyar et al 2023).

In recent years, Cambodia's financial sector has undergone significant changes as MFIs transition into banks, particularly during the post-pandemic period. Notable organisations that have made this transition include Sathapana Microfinance Plc, which became a commercial bank in 2012 after its acquisition by Japan's Maruhan Bank, and Prasac MFI Plc, which transitioned in 2023 after it was acquired by South Korea's KB Kookmin Bank for USD1 billion (Amarthalingam 2023). In a bid to expand its overseas business, Bank SinoPac announced plans to acquire Amret Plc, a leading financial institution in Cambodia, in 2024 further underscoring foreign

investors' growing interest in Cambodia's financial sector (Sinopac 2024). These transitions hold the potential to reshape the country's financial landscape by promoting financial stability, economic resilience, and greater access to credit for households and businesses. While the transition offers significant opportunities for improving financial resilience, it is not without risks, especially, since this transformation is occurring within a context of increasing global economic fragmentation.

Similarly, academic literature on this topic highlights mixed results of such transitions. Transitioning MFIs into banks can enhance financial resilience by increasing credit availability and reducing dependency on foreign capital, improving efficiency, rising economies of scale in large banks, and promoting banks' performance in response to external shocks (see, Bárcenas, Barreiro, and Pagliacci 2016; Allen and Liu 2007; Mitchell and Onvural 1996; Shaffer and David 1991; Kolari and Zardkoohi 1991; Baltensperger 1972; Benston 1972). However, the process is not without challenges. Risks include mission drift, increased regulatory burdens, and operational inefficiencies. Studies suggest that the commercialisation of microfinance may undermine social objectives, leaving vulnerable groups underserved. Additionally, stricter regulatory and capital requirements can negatively impact smaller MFIs, potentially leading to financial instability (see, for example, Hermes, Lensink, and Meesters 2011; Cull, Demirgüç-Kunt, and Morduch 2009; Simper 1999). This study aims to explore how the transition of MFIs into banks contributes to Cambodia's financial development and resilience in a fragmented global environment.

The core objective of this study is to assess how MFIs transitioning to banks impacts Cambodia's financial development. The specific objectives include:

- Analysing the implications of MFIs transitioning to banks for financial inclusion and financial risk in Cambodia.
- Investigating the role these transitions play in promoting economic resilience, particularly in a world characterised by geoeconomic fragmentation.

The paper is structured as follows: Section 2 reviews the relevant literature. Section 3 outlines the methodology employed. Section 4 presents the empirical findings, while Section 5 concludes with policy implications and recommendations for strengthening financial resilience in Cambodia.

2. Literature review

2.1. Geoeconomic fragmentation and its implications

What had been a risk of geoeconomic fragmentation has recently become more certain. After the 2007-2008 global financial crisis, many global events occurred that further deepened global divisions, including Brexit, US-China trade conflicts, the COVID-19 pandemic, the Russia-Ukraine war, and other ongoing conflicts. China's GDP surpassed that of the US in 2013 when measured using PPP (CRS 2015), which has also created significant pressure. According to Aiyar et al. (2023, 4),

After decades of increasing global economic integration, the world is facing the risk of fragmentation. A shallow and uneven recovery from the GFC was followed by Brexit, US-China trade tensions, and a growing number of military conflicts. The post-GFC era has seen a levelling-off of global flows of goods and capital, and a surge in trade restrictions. The COVID-19 pandemic and Russia's invasion of Ukraine have further tested international relations and increased scepticism about the benefits of globalization.

Shekhar and Anna (2023) explained that while the direction of globalisation remains uncertain, the world is likely to become more multi-polar amidst the risk of runaway geoeconomic fragmentation. Geoeconomic fragmentation impacts various sectors, particularly international trade, technology, and the financial system, by disrupting global flows of goods and capital and increasing trade restrictions. The possibility of a more fragmented global economy, with deeply divided global supply chains and financial systems, is growing. Aiyar et al. (2023, 16) the world is facing the risk of policy-driven geoeconomic fragmentation (GEF suggested that:

Geo-economic fragmentation is likely to affect the global economy through several other channels, amplifying the impact from trade and technology fragmentation. For example, rising barriers to cross-border labour flows could reduce efficiency, hinder innovation and technological diffusion and worsen adverse demographic trends. The fragmentation could hinder cross-border capital flows, reducing the options for external financing and impeding economic development.

Jean (2024, 4) explained that “it has become received wisdom to consider the world economy as increasingly shaped by forces of fragmentation, resulting from geopolitical tensions and strategic competition between great powers, including through trade and industrial policies.” Norring (2024) underscored the growing turbulence in global trade and finance due to geopolitical tensions and the shift from efficiency-driven global value chains to resilience-focused frameworks. Norring (2024, 1) explained additionally that the “world is witnessing growing turbulence stemming from geopolitics and a tangible threat of economic disintegration. There are some indications of globalization in retreat, international trade growth slowing down and a transition from optimizing efficiency of global value chains towards ensuring their resilience.”

The geoeconomic fragmentation impacts economies closely linked to Cambodia, particularly China as Cambodia’s largest import source and the US as Cambodia’s largest export partner (WITS 2022). Globally, China remains the centre of global trade, while the US serves as the hub for FDI (Hudecz et al. 2024). Ongoing protectionist measures and countermeasures between the world’s two greatest economies have increased trade tensions (Aiyar et al. 2023). Since the beginning of the trade war and the implementation of COVID-related restrictions in China, the country’s economic growth has significantly slowed. This slowdown brings uncertainties that disrupt global trade flows, FDI, and capital markets, all of which also reduce Cambodia’s growth prospects. These risks are further emphasised for Cambodia because China is its largest bilateral donor, lender, investor, and trading partner (Menon 2023).

In a fragmented global economy, Cambodia’s financial sector development has also faced the challenge of enhancing inclusion while safeguarding stability. Aiba (2023) stated Cambodia’s reliance on foreign capital inflows, like ODA and FDI, makes its economy vulnerable to external shocks, especially due to unstable bank inflows. According to Aiba (2023, 4-5):

Cambodia is a highly open economy, and the Cambodian government has adopted a liberal stance toward foreign investment and trade, leading to huge capital inflows. Most capital inflows are in the form of ODA, FDI, and other investments. Although capital inflows into banks are primarily FDI, they are not entirely stable as they remain sensitive to changes in foreign investors’ sentiment and external conditions. Thus, a high dependency on foreign funding as a result of borrowing or deposits is likely to make the entire economy vulnerable to external shocks.

The study also highlighted the significant lack of domestic fundraising platforms in Cambodia, which makes the country to continue relying on foreign capital. This dependency exposes the Cambodian economy to external financial fluctuations and vulnerabilities. Aiba (2023, 5) suggested that:

In the case of Cambodia, recent capital flows are volatile and the main driver is inflows into the banking sector. The banking sector plays a pivotal role in fund mobilization in Cambodia, since there is no other formal financial market functioning in the country: there is no bond market, and although a stock exchange market was opened in 2011, only five companies were listed as of 2017.

The effect of geoeconomic fragmentation is also potentially linked to interest rates, exchange rates, and inflation in Cambodia due to its multifaceted impact on supply-chain disruptions and foreign direct investment (FDI). Emerging market and developing economies are highly vulnerable to FDI relocation, which creates additional uncertainty (see, for example, IMF 2023). This scenario is likely to have an impact on the Cambodian national currency “Riel”, higher borrowing costs due to international capital flow restriction, and instable inflation due to fluctuation of Cambodia’s trade, especially from China and the US, which are key players in the geopolitical divide.

At the country and financial institutional levels, the rise of geoeconomic fragmentation also affects financial services and increases risks for financial institutions within a given country. Aiyar et al. (2023, 3) explained:

An increase in geopolitical tensions with major partner countries could cause a sudden reversal of cross-border capital flows, with the impact being notably larger for emerging and developing economies. These patterns could pose macro-financial stability risks through an increase in banks’ funding costs, a decline in their profitability, and lower credit provision to the private sector.

Aiyar, Presbitero, and Ruta (2023) also examined the implications of macro-financial volatility, emphasising the need for diversification strategies to mitigate potential risks. They argued that “financial fragmentation could exacerbate macro-financial volatility in the longer term by reducing international risk diversification opportunities in the face of adverse domestic and external shocks.”

2.2. Development of MFIs and its role in Cambodian financial sector

2.2.1. History of MFIs in Cambodia

Cambodia’s microfinance sector was first introduced in the early 1990s. It was initially developed by non-governmental organisation (NGO) following the Paris Peace Accords in 1991. NGOs played a critical role in providing rehabilitation and reconstruction work for the poor, particularly refugees. At the initial stage, the Royal Government of Cambodia (RGC) prioritised developing rural finance to reduce poverty and foster economic growth, especially in agriculture. Over time, NGOs shifted their focus to microfinance as a mechanism for poverty reduction and economic development, retaining their focus in rural areas where banking services were inaccessible (NBC 2007).

Early in the 1990s, preliminary microfinance programmes were supported by international organisations like the United Nations (UN), particularly the United Nations International Children’s Emergency Fund (UNICEF), the United States Agency for International Development

(USAID), and the World Bank. Initial efforts focused on converting local initiatives into village banks that provided emergency aid and small loans, which laid the foundation for the sector. Key players like The Association of Local Economic Development Agencies (ACLEDA) and the EU Commission Programme de Réhabilitation et Appui au Secteur Agricole du Cambodge (PRASAC) transitioned from development programs to registered MFIs, enabling large-scale financial inclusion in rural areas. By the mid-1990s, MFIs such as AMRET, LOLC, and Sathapana Bank expanded their operations by offering loans nationwide and establishing dense networks to serve underserved communities, further transforming Cambodia's financial landscape (see details in Bliss 2022). The microcredit delivery includes individual loans, solidarity groups, village banks, and self-help groups (IDLO 2008, 2).

In the 2000s, the NBC began regulating and licensing MFIs to formalise their operations. This marked the transformation of many NGOs into licensed or registered MFIs. The NBC introduced the *Law on Banking and Financial Institutions* (1999) and the *Prakas on Registration and Licensing of Microfinance Institutions* (2000) to provide a legal framework for licensing MFIs as formal financial entities (see NBC 1999 and NBC 2000). Under the Prakas, large MFIs were required to obtain a license, medium-sized MFIs were only required to register, and small MFIs were exempt from registration (NBC 2000). Vada (2010) referred to this period as the commercialisation phase of microfinance. The first MFI to take action was ACLEDA. By the end of 1999, ACLEDA had an outstanding portfolio of USD13.7 million, which represented a 37 percent increase from the previous year (Mot 2010).

According to NBC (2007, 4), “for the first time in 2000, the NBC issued regulations on the classification of MFIs, classifying all MFIs into three categories according to the level of their operations with different criteria for being licensed and registered.” According to ABC (2024), financial institutions were classified into three categories: full commercial banks (minimum USD13 million paid-up capital), specialised banks (minimum USD2.5 million paid-up capital), and licensed/registered MFIs. As stated by NBC (2007, 9), “Of the 15 commercial banks, one bank has transformed from an NGO operating microfinance into a specialized bank and at last, a commercial bank (ACLEDA Bank). ACLEDA Bank has the largest network all over the country, in the cities and in remote areas of the countryside. ACLEDA Bank provides both commercial banking and rural financial services.”

The MFI sector has since continued to grow. Its growth has aligned with Cambodia's strong economic performance, averaging an over 7 percent GDP growth rate over the past three decades. Many MFIs have been established, and some have evolved into specialised and commercial banks. In 2006, Cambodian microfinance grew remarkably. There were 17 licensed MFIs, 26 registered rural credit operators, and around 60 NGOs freely operating in the whole country (NBC 2007, 3). By the end of 2011, the banking sector in Cambodia consisted of 31 commercial banks, of which 22 were local incorporated banks and 9 foreign bank branches, 7 specialised banks, including one state-owned bank, 32 licensed MFIs where 7 eligible to collect customer deposits, and 29 registered MFIs (NBC 2011, 1).

Today, Cambodia's banking system operates under a two-tier structure. The public sector is represented by the NBC, while the private sector includes commercial banks, specialised banks, MFIs, and NGOs engaged in rural credit activities (NBC 2024). The NBC Annual Report 2023 (NBC 2023, 27) showed that “as of December 2023, Cambodia's banking system consisted of 58 commercial banks, 9 specialised banks, 4 microfinance deposit-taking institutions, 83 microfinance non-deposit-taking institutions, 114 rural credit institutions, 16 leasing institutions, 6 third-party processors, 33 payment service institutions, 1 credit bureau, 5 representative offices and 2,915 money changers.”

The COVID-19 pandemic accelerated the growth of Cambodia's digital finance landscape, particularly in the domain of payment systems. The expansion of the NBC's Bakong system and KHQR (Khmer QR code) has become central to the country's post-pandemic financial recovery. According to ADB (2019, 7), "the NBC launched the operational phase of Bakong, a key element in the e-commerce infrastructure, and completed the first phase of its enhancement to incorporate a large-value payment system with the functionalities of a real-time gross settlement system (e.g., credit transfer, transaction and information requests, and settlements and statistics reporting)."

2.2.2. Characteristics of Cambodian borrowers and rising concern about NPLs

During the 2000s, Cambodia's financial sector experienced significant reforms aimed at increasing financial inclusion and strengthening the banking system. In fact, the government declared 2006 the "Year of Microfinance," which led to the rapid expansion of MFIs, particularly in rural areas. According to NBC (2006), since the start of the year, several seminars and workshops on microfinance have been organised to enhance the operational efficiency of MFIs, raise public awareness, and broaden access to financial services. The authorities remain fully committed to promoting and strengthening these institutions.

In the 2010s, Cambodia saw substantial progress in financial inclusion due to a growing microfinance sector and improved banking services. By 2013, MFIs accounted for 10 percent of the banking sector's total assets and served approximately 2.4 million customers. According to NBC (2013, iii),

Although poverty fell more than 1 percent, the alleviation of poverty is still a priority of the RGC. Improving the access of both the poor and small and medium enterprises to formal financial services is a principal component of the Government's strategy for reducing poverty. To support this policy, the NBC continued to foster the development of sound MFIs. The total assets of MFIs, which currently serve about 2.4 million customers, rose to about 10 percent of the total assets of the banking sector.

The number of deposit and credit accounts grew significantly as public confidence in financial institutions increased. The *Prakas on Credit Reporting* was passed in May 2011, and Credit Bureau Cambodia (CBC) was officially launched on 19 March 2012 (CBC 2024). The establishment of a credit bureau enhanced credit risk management and transparency, contributing to relatively low NPL ratios.

The 2020s brought transformative changes as digital financial services were adopted and there was a heightened focus on sustainable finance. By 2023, financial inclusion was significantly advanced through platforms such as the Bakong system and KHQR, which facilitated digital payments and e-commerce. Numbers of deposit accounts rose to 18.9 million, and credit accounts reached 3.9 million (NBC 2023, ix). However, the rising number of NPLs became a concern, especially in the post-pandemic period. NBC (2023, ix) found that the NPL ratio rose 5.4 percent and 6.7 percent for the banking and microfinance sectors, respectively, which they attributed to the realisation of loan restructuring measures and slow credit growth. The NBC responded by strengthening regulations to manage credit risks and maintain financial stability.

2.2.3. Effects of microfinance on Cambodia's financial development

Studies on the effects of MFIs on Cambodia's development remain mixed. There are three main schools of thought: positive, negative, and conditional, where the effects vary based on specific

circumstances. Within the positive school of thought, the literature highlights microfinance's significant contributions to financial inclusion, poverty alleviation, and economic development in Cambodia. In fact, IDLO (2008) found that microfinance played a pivotal role in bridging the gap between formal financial services and rural communities, particularly in the post-conflict period. By the early 2000s, microfinance had transitioned from scattered donor-funded initiatives to a structured financial sector underpinned by regulatory frameworks. The rapid expansion of MFIs facilitated economic reconstruction and entrepreneurship, particularly among low-income households. The availability of small loans with high repayment rates enabled micro-entrepreneurs to smooth consumption, invest in productive assets, and improve overall economic resilience. Aiba (2024) further emphasised that despite commercialisation trends, microfinance remains crucial in advancing financial access and supporting sustainable development. However, to prevent mission drift, policymakers must ensure a balance between financial sustainability and social impact through strengthened regulations, particularly by promoting rural outreach and prioritising poverty alleviation.

The sector's positive impact on the country's financial development extends beyond credit provision to fostering financial sector integration and broader economic participation. Roth et al. (2017) found that microfinance significantly improved agricultural productivity and self-employment, particularly among poorer households. Credit access allowed rural farmers to invest in essential inputs such as fertilisers, irrigation, and mechanisation, leading to substantial gains in paddy production and income. The study also found that women disproportionately benefited from microcredit, as it provided opportunities to engage in self-employment activities, improving household financial stability. Green et al. (2023) supported these findings, emphasising that microfinance has deepened financial access for many Cambodian households, creating opportunities for economic mobility. Pimhidzai et al. (2019) further highlighted that microfinance led to a shift from informal moneylenders to formal credit sources, reducing borrowing costs and expanding economic opportunities. The increased participation in microfinance resulted in higher household spending on agriculture and entrepreneurship, contributing to poverty reduction. These findings underscore the role microfinance plays in fostering economic inclusion and financial empowerment, particularly when structured within a sustainable regulatory framework.

The negative school of thought sees microfinance linked to growing financial vulnerabilities despite its positive contributions. Such vulnerabilities include over-indebtedness, aggressive lending practices, and financial distress among borrowers. Bylander (2014) while these loans provide immediate financial relief, they also compel borrowers into cycles of labour migration to meet repayment obligations, exposing them to economic instability and risks of failed migration. Additionally, the lack of comprehensive credit information limits MFIs' ability to accurately assess borrowers' repayment capacities, exacerbating financial distress. The study also pointed out that many loans, originally intended for microenterprise support, are increasingly used to fund migration-related expenses, further diverting microfinance away from its initial poverty-alleviation mission. Seng (2018) illustrated the risks associated with loan misallocation and unsustainable debt burdens. While microcredit has enabled some households to invest in income-generating activities, a substantial proportion of borrowers rely on loans for non-productive expenses, such as daily consumption and emergencies. High-interest rates and excessive loan amounts relative to income have plunged many borrowers into cycles of debt, often requiring them to take out additional informal loans to meet repayment obligations. Guermond et al. (2022) extended this critique by highlighting the commodification of rural livelihoods. Many Cambodian farmers rely on microloans for climate adaptation and agricultural inputs. However, the rising costs of farming and lack of state support have forced

them into unsustainable debt cycles. By 2021, the average microfinance loan size exceeded Cambodia's GDP per capita, placing severe financial strain on rural households.

Green et al. (2023) found that microfinance's increasing commercialisation has deepened socio-economic vulnerabilities, often prioritising financial performance over social impact. Their study highlighted the prevalence of "debt juggling," where borrowers manage repayments by taking additional loans, often from high-interest informal lenders. This pattern is exacerbated by strict repayment schedules and the use of land-based collateral, which has led to land dispossession and worsening financial insecurity. Bateman (2024) the role of land tenure soon attracted the attention of the international development community as a neoliberal-oriented theory of change rooted in the possession and use of private individual land titles by the poor. One of the central mechanisms proposed by de Soto was a three-step process that involves the poor (1 reinforced this critique, arguing that Cambodia's microfinance model has prioritised profit maximisation over poverty alleviation. The widespread reliance on land titles as collateral has led to aggressive lending and forced asset sales, placing borrowers at heightened risk of financial loss. While the sector was initially designed to empower small entrepreneurs, its shift toward commercialisation has compromised its original mission and has raised urgent questions about the long-term sustainability of microfinance as a development tool.

Finally, the mixed school of thought sees the impact of microfinance in Cambodia as highly context-dependent, with its benefits and obstacles varying based on borrower circumstances and the regulatory environment. Chhorn (2019) found that while microfinance has contributed to poverty reduction, particularly in structured development programs, its broader welfare impact remains insignificant. While access to microcredit has improved household income levels, particularly for those engaged in agricultural cooperatives, systemic issues—high interest rates, non-productive use of loans, over-indebtedness, often landless customers, and intergenerational migration—have offset many potential benefits. Additionally, the rapid commercialisation of MFIs has created concerns about mission drift, where profit-driven lending practices overshadow social objectives. The introduction of an 18 percent interest rate cap on microfinance loans in 2017 exemplifies these policy dilemmas. While the cap reduced borrowing costs for some, it also restricted access to smaller loans, thereby pushing some borrowers back toward informal moneylenders. Bliss (2022) further underscored this duality by highlighting both the transformative and exploitative dimensions of microfinance. On the one hand, expanded credit access has enabled rural households to invest in small businesses, agriculture, and housing improvements, driving economic growth. On the other hand, the aggressive lending practices of some MFIs, particularly those reliant on land as collateral, have placed borrowers at risk of losing their most valuable assets. Over-indebtedness remains a pressing concern. In fact, many borrowers prioritise loan repayments over essential household expenditures, leading to reduced food security and limited spending on healthcare and education. Despite high repayment rates, the human cost of these repayments, including forced land sales and labour migration, raises ethical and policy questions about the true effectiveness of microfinance as a poverty alleviation tool.

The broader implications of microfinance's mixed impact suggest that targeted reforms are necessary to maximise benefits while mitigating risks. Pimhidzai et al. (2019) recommended a combination of financial literacy programs, consumer protection mechanisms, and digital financial innovations to improve microfinance's effectiveness. The transition from informal to formal credit sources has been a major achievement, but it has also introduced new risks, such as rising debt-to-income ratios and financial exclusion due to regulatory constraints. In this regard, the development of an independent financial information provider, such as the

Credit Bureau of Cambodia (CBC), has played an important role in addressing information asymmetry. For instance, they have provided credit reporting services that allow lenders to assess borrower risk more accurately and thus reduce the likelihood of over-indebtedness and promote financial stability. In addition, ensuring that microfinance remains an inclusive and sustainable development tool requires balancing financial sector growth with social objectives. Strengthening borrower protections, introducing flexible repayment structures, and promoting diversified financial instruments beyond credit alone can help ensure that microfinance fulfils its potential as a tool for equitable economic growth rather than a driver of financial distress.

2.3. MFIs transitioning to banks and its implications

In recent years, Cambodia's financial sector has undergone significant transformations. Notably among these changes has been the transition of many MFIs into commercial banks. While this transition is still in its early stages, there has been a noticeable increase in such developments during the post-pandemic period, highlighting differences between the pre- and post-pandemic periods. The forces driving this transition can be attributed to various factors: economic profitability and market influences.

Several MFIs have transitioned to banks in the past 15 years, and we present a few examples of such transitions here. In 2012, Sathapana Microfinance Plc, one of the largest MFIs in Cambodia, transformed into a commercial bank. This move followed the acquisition of a 95.1 percent stake by Japanese-owned Maruhan Bank. Sathapana became the second MFI to make this transition, following ACLEDA in 2009 (May 2016). Subsequently, in 2020, two more financial institutions transitioned into commercial banks. Ly Hour Microfinance Institution became SBI LY HOUR Bank, a joint venture between Ly Hour Microfinance Institution and SBI Holdings Inc. Similarly, Hattha Kaksekar Limited, a former MFI, successfully transitioned into Hattha Bank Plc in August 2020, following its acquisition by Bank of Ayudhya (Krungsri), a Thai commercial bank. In 2023, Prasac MFI Plc, Cambodia's largest MFI, also became a commercial bank after its complete acquisition by KB Kookmin, one of South Korea's top five largest banks, for an accumulated sum of USD1 billion. The new entity, known as KB Prasac Bank Plc, is a merger between Prasac, which had nearly USD4.8 billion in assets as of 31 December 2022, and Kookmin Bank Cambodia Plc (Amarthalingam 2023). In May 2024, Bank SinoPac announced its plans to acquire Amret Plc, one of the leading financial institutions in Cambodia. This acquisition is expected to enable Bank SinoPac to extend its overseas network and exert more positive influence on sustainable finance. As of 31 December 2023, Amret had 150 operating branches in 24 provinces across Cambodia, with total assets of approximately USD2 billion. Bank SinoPac will acquire 80 percent of the equity of Amret in the first tranche for approximately USD435 million, followed by two further tranches of 10 percent each, at the end of the first year and second year, respectively (Sinopac 2024).

As MFIs transitioned into commercial banks, they also influenced a sector heavily reliant on foreign capital, which, in turn, has impacted the development of the country's financial sector. Aiba (2024) emphasised that recent developments in the microfinance sector have attracted significant capital investment. Concurrently, there has been an increase in the number of MFIs acquired by domestic and foreign private investors, particularly commercial banks. The study found that these acquisitions have contributed to increases in the loan portfolios of MFIs and a shift in their credit allocation from rural to urban areas. Thus, changes in ownership and organisational structures through acquisitions by commercial investors could potentially cause mission drift among MFIs. Aiba (2023, 5) also explained:

In the Cambodian banking sector, foreign-owned banks are also allowed to operate, as there are no restrictions on foreign ownership of a subsidiary, a branch, or a representative office. Subsidiaries and branches are permitted to engage in full banking activities. For subsidiaries, a foreign owner could have 100 percent of its shares, and could acquire the shares of an existing local bank. There is no difference in prudential regulation between locally-owned banks and foreign-owned banks.

The nature and characteristics of MFIs and banks differ in terms of loan sizes, capital structures, regulatory requirements, and service offerings. Aiba (2023, 5) emphasised:

The Cambodian banking sector is composed of three types of financial institutions: commercial banks, specialized banks, and MFIs which include both Microfinance Deposit-Taking Institutions (MDIs) and non-deposit-taking MFIs. Commercial banks are allowed to provide all financial services, while the regulations governing them are most strict in terms of capital and reserve requirements. Specialized banks can be engaged in only one type of financial service, such as settlement network or loan provision to the agricultural sector as well as to MSMEs. MFIs are aimed at providing financial services for the poor, with restrictions on the amount of each loan grant, but are not permitted to take deposits from customers. On the other hand, MDIs are permitted to take deposits from customers and thus offer broader services such as accepting deposits, providing savings accounts and offering microloans. As of 2017, commercial banks dominate almost 85 percent of total assets in the Cambodian banking sector, while MFIs cover the remaining 15 percent. Specialized banks have less than 1 percent of total assets in the entire banking sector.

However, the roles of MFIs and banks in Cambodia are likely mixed because of the evolution of loan sizes and resulting loan restructuring, in addition to the rising number of borrowers. Additionally, the loan sizes of some MFI borrowers are comparable to those of commercial and specialised banks. Aiba (2024) suggested that acquisition cases have led to increases in loan portfolios of MFIs, both in terms of loan amounts and the number of borrowers. This supports the claim that loan size evolution and restructuring have impacted the roles MFIs and banks play in Cambodia's financial sector. According to Aiba (2024, 1), "the acquisition cases have contributed to increases in the loan portfolios of MFIs and a shift in MFIs' credit allocation from rural to urban areas after acquisition. Thus, changes in ownership and organizational structures through acquisition by commercial investors could more or less cause mission drift among MFIs."

The positive implications of MFIs transitioning to banks are centred around increased efficiency, larger economies of scale, larger firm size, higher banking concentration, and improved performance in response to external shocks (see Allen and Liu 2007; Baltensperger 1972; Bárcenas, Barreiro, and Pagliacci 2016; Benston 1972; Kolari and Zardkoohi 1991; Mitchell and Onvural 1996; and Shaffer and David 1991). The role of financial institutions in mitigating external shocks has been explored in studies across the world. In their study of how Latin American banks of varying sizes respond to financial turbulence, Bárcenas, Barreiro, and Pagliacci (2016) found that larger banks maintain deposits and even improve profitability during adverse shocks, though this increase largely comes from non-lending activities rather than traditional lending. Despite a temporary drop in operating efficiency and a reduction in lending, large banks benefit from local currency depreciation in their investment strategies. However, this profitability boost does not necessarily lead to greater financial stability; instead, large banks accumulate more liquid assets and shift resources towards mortgage credit.

In addition, commercial banks that emerged from MFIs can play a pivotal role in strengthening the financial sector by increasing credit availability, reducing dependence on foreign capital,

and fostering domestic investments in critical sectors. Mitchell and Onvural's (1996) study "Economies of Scale and Scope at Large Commercial Banks" analysed cost efficiency in large commercial banks using a Fourier flexible cost function, encompassing the translog form as a subset. Their findings provided limited evidence of economies of scale and scope in large banks. In addition, in their analysis of US commercial banks during 1981, 1983, and 1985, Kolari and Zardkoohi (1991) observed that evidence is found that cost curves were downward sloping in these years. Moreover, the largest banks tended to have the greatest scale economies, implying that large banks have an operating cost advantage over smaller banks. Similarly, Shaffer and David (1991) suggested that there may be cost incentives or benefits associated with expansion or consolidation among large regional banks, including interstate operations.

While transitioning MFIs to banks offers significant opportunities for enhancing the financial sector, it is not without risks. One major concern is the potential dilution of MFIs' original mission to serve low-income and rural populations. In fact, studies such as Simper (1999) and Hermes, Lensink, and Meesters (2011) suggested that the commercialisation of microfinance may lead to mission drift, where institutions prioritise profitability over social objectives, potentially leaving vulnerable groups underserved. This could exacerbate financial exclusion for the very populations MFIs were designed to support. Another critical risk is the increased regulatory burden on institutions undergoing this transition, especially since commercial banks are subject to stricter regulatory and capital requirements than MFIs. As highlighted by Cull, Demirgüç-Kunt, and Morduch (2009), the compliance costs and operational complexities of becoming a commercial bank can strain the capacity of smaller MFIs, leading to operational inefficiencies or even failure.

3. Methodology and data

3.1. Data

To build the panel dataset, we compiled reports on microfinance from the NBC between 2013 and 2021. Annexe A1 lists the information available in these reports. We then structured the data into a panel format with yearly observations for each institution. Next, we identified financial institutions that transitioned to commercial or specialised banks by consulting their websites and relevant news articles. The transitioned MFIs' data are recorded under the microfinance category up until their final year as MFIs. From the year of transition onward, each MFI's information is included in the bank category. To capture the full timeline, we continued to extract reports for these institutions under the bank category after their transition. Finally, we linked the two datasets to create a comprehensive panel that includes MFIs that have not transitioned, those that have not yet transitioned, and those up to and including their transition to banks.

To further enrich the dataset, we incorporated time-fixed macroeconomic variables, such as the GDP growth rate (sourced from the National Institute of Statistics), the lending rate (sourced from the International Financial Statistics - IFS), and the WUI.

The final dataset comprises an unbalanced panel of 806 observations between 2013 and 2023 that covers 120 distinct institutions (see Annexe A2).

3.2. Model specification

To analyse the main effects of the MFIs' transition and the impact of global uncertainty from geopolitical economic fragmentation on the financial inclusion and financial risk, we specify two regression models:

$$\text{Log loan}_{it} = \alpha + \beta \text{Log loan}_{it-1} + \gamma \text{Post transition}_{it} + \delta \text{Log WUI}_t + \mu Z_{it} + y_t + \varphi_i + \mu_{it} \quad (1)$$

$$\text{NPL ratio}_{it} = \alpha + \beta \text{NPL ratio}_{it-1} + \gamma \text{Post transition}_{it} + \delta \text{Log WUI}_t + \mu Z_{it} + y_t + \varphi_i + \mu_{it} \quad (2)$$

The two model specifications have the following variables:

- Log loan_{it} are NPL ratio_{it} the outcome variables which are used to proxy respectively the financial inclusion and the financial risk, the focus of our analysis.
- Log loan_{it-1} and NPL ratio_{it-1} are the lagged outcome variables and are included as regressors to account for their persistence effects due to financial indicator nature.
- $\text{Post transition}_{it}$ is the dummy variable equal to 1 if an institution has transited to bank in year t and 0 otherwise.
- Log WUI_t is the logarithm of world uncertainty index in year t .
- Z_{it} are the control variables. They include variables such as net profit as a percentage of assets, equity-asset ratio and log of asset.
- φ_i is the institution-fixed effect of controlling unobserved cross-institution heterogeneity.
- y_t are the time-fixed effect variables. They include GDP growth rate and lending rates (macroeconomic factors) and year dummy variables.
- ε_{it} : Error term representing unobserved factors.

In addition to analysing the main effects of MFIs' transition and global geoeconomic fragmentation, we also aimed to examine the interaction between these two factors and their impact on financial inclusion and financial risk. Therefore, we introduced two additional model specifications as follows:

$$\text{NPL ratio}_{it} = \alpha + \beta \text{NPL ratio}_{it-1} + \zeta \text{Post transition}_{it} * \text{Log WUI}_{it} + \mu Z_{it} + y_t + \varphi_i + \mu_{it} \quad (3)$$

$$\text{Log loan}_{it} = \alpha + \beta \text{Log loan}_{it-1} + \zeta \text{Post transition}_{it} * \text{Log WUI}_{it} + \mu Z_{it} + y_t + \varphi_i + \mu_{it} \quad (4)$$

We then proceeded with a correlation test between the regressors and found evidence of high collinearity among some of them (see Annexe A3). In particular, we found the log of assets to be highly correlated with the equity-to-asset ratio, while some year dummy variables exhibited high correlation with macroeconomic variables such as the GDP growth rate. Consequently, the log of assets and the year dummy variables were dropped from the model. Annexe A4 describes the variables used and their sources. Our final model specifications for the main effects and interaction effects for both outcome variables were as follows:

$$\begin{aligned} \text{NPL ratio}_{it} = & \alpha + \beta \text{NPL ratio}_{it-1} + \gamma \text{Post transition}_{it} + \delta \text{Log WUI}_{it} + \theta \text{Equity asset ratio}_{it} \\ & + \vartheta \text{Net profit as percentage of asset}_{it} + \iota \text{Economic growth}_t + \kappa \text{Lending rate}_t + \varphi_i + \mu_{it} \end{aligned} \quad (5)$$

$$\begin{aligned} \text{Log loan}_{it} = & \alpha + \beta \text{Log loan}_{it-1} + \gamma \text{Post transition}_{it} + \delta \text{Log WUI}_{it} + \theta \text{Equity asset ratio}_{it} \\ & + \vartheta \text{Net profit as percentage of asset}_{it} + \iota \text{Economic growth}_t + \kappa \text{Lending rate}_t + \varphi_i + \mu_{it} \end{aligned} \quad (6)$$

$$\begin{aligned} \text{NPL ratio}_{it} = & \alpha + \beta \text{NPL ratio}_{it-1} + \zeta \text{Post transition}_{it} * \text{Log WUI}_{it} + \theta \text{Equity asset ratio}_{it} \\ & + \vartheta \text{Net profit as percentage of asset}_{it} + \iota \text{Economic growth}_t + \kappa \text{Lending rate}_t + \varphi_i + \mu_{it} \end{aligned} \quad (7)$$

$$\begin{aligned} \text{Log loan}_{it} = & \alpha + \beta \text{Log loan}_{it-1} + \zeta \text{Post transition}_{it} * \text{Log WUI}_{it} + \theta \text{Equity asset ratio}_{it} \\ & + \vartheta \text{Net profit as percentage of asset}_{it} + \iota \text{Economic growth}_t + \kappa \text{Lending rate}_t + \varphi_i + \mu_{it} \end{aligned} \quad (8)$$

3.3. Estimation strategy

In this section, we explain and demonstrate the application of different panel data estimation techniques to assess the robustness of the results. For simplicity, we refer to our model based on the simple specification below:

$$y_{it} = \alpha + \beta y_{it-1} + \gamma X_{it} + z_t + \varphi_i + \mu_{it} \text{ or (9)}$$

$$y_{it} = \alpha + \beta y_{it-1} + \gamma X_{it} + z_t + \varepsilon_{it} \text{ (10)}$$

Where y_{it} is the outcome variables (the NPL loan ratio and the log of loan of the financial institution), X_{it} is a vector of explanatory variable, z_t is the time-specific effect that captures shocks; and ε_{it} is the error term composed of φ_i , time-invariant institution-specific fixed effects, and μ_{it} which is considered to be independent and evenly distributed with zero mean and constant variance.

The dynamic panel model violated the orthogonality condition as the lagged dependent variable (y_{it-1}) depending on ε_{it-1} , which is a function of ε_{it} . As a result, it caused bias in dynamic, panel data estimation, which only goes away as t tends to infinity.

To remove the institution fixed effect, we deducted from the equation to get:

$$\Delta y_{it} = \beta \Delta y_{it-1} + \gamma \Delta X_{it} + \Delta z_t + \Delta \mu_{it} \text{ (11)}$$

As Δy_{it-1} includes μ_{it-1} , a component of $\Delta \mu_{it}$, then the pooled Ordinary least squares (OLS) estimator would yield a biased result as Δy_{it-1} correlates with $\Delta \mu_{it}$.

To circumvent this problem, the difference Generalized Method of Moments (GMM) estimator was developed by assuming that the error terms were serially uncorrelated in Equation (9). The level of y_{it} lagged two periods or more can be used as valid instruments for Equation (11). This is because $y_{i(t-2)}$ and earlier values are correlated with $\Delta y_{i(t-1)}$, but not with $\Delta \mu_{it}$. Assuming that the X_{it} are predetermined in the sense that X_{it} and μ_{it} are uncorrelated, but X_{it} may be correlated with μ_{it-1} and earlier errors, x_{it} lagged one period or more are also used as valid instruments. Thus, the accompanying moment conditions are:

$$E[y_i(t-2) \Delta \mu_{it}] = 0 \text{ for } t = 1, 2, 3 \dots T$$

$$E[x_i(t-1) \Delta \mu_{it}] = 0 \text{ for } t = 1, 2, 3 \dots T$$

However, other studies have found the two-step estimator to be downwardly biased when applied to situations with a small sample over time. To overcome these limitations, the system GMM estimator was developed by using lagged first differences as instrumental variables to combine first-difference and level regressions. The system estimator addressed the issue of weak instruments by employing a more robust set of instrumental variables, resulting in greater efficiency.

To derive these additional conditions, we assumed that the panel effect is not correlated with the initial observable difference in the dependent variable. We expressed these additional moment conditions as follows:

$$E[\Delta y_i(t-1) \mu_{it}] = 0 \text{ for } t = 1, 2, 3 \dots T$$

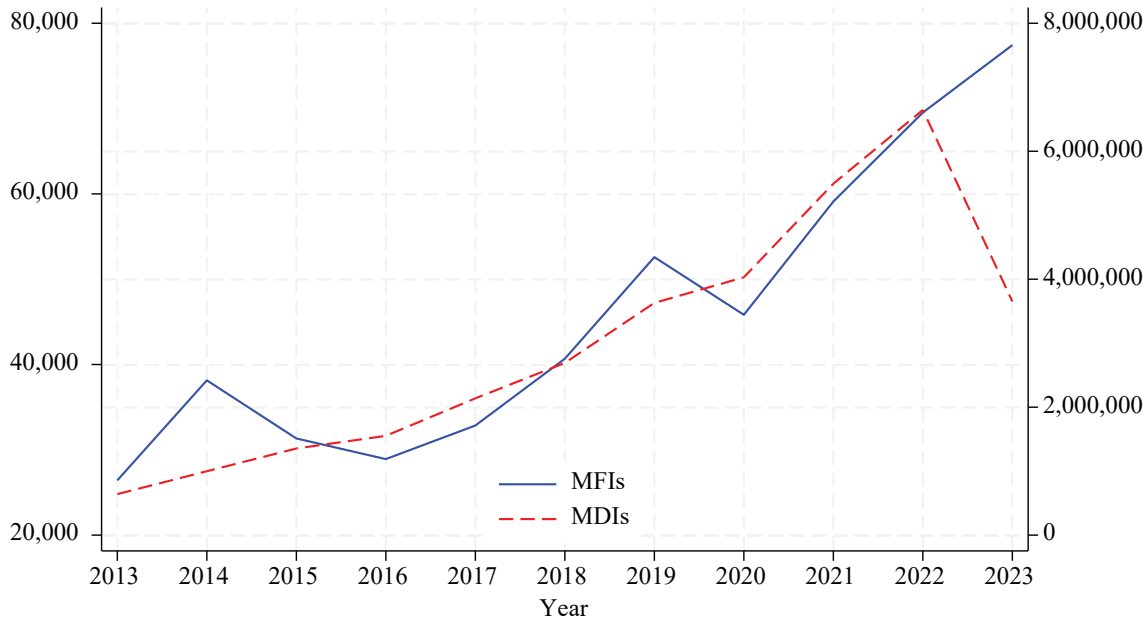
$$E[\Delta x_i(t-1) \mu_{it}] = 0 \text{ for } t = 1, 2, 3 \dots T$$

While the GMM estimator is effective in addressing endogeneity in dynamic panel models, its effectiveness depends heavily on instrument validity, sample size, and model specification. Therefore, robust tests are crucial for evaluating the consistency of the GMM estimator. The first test is the Sargan test of overidentifying restrictions, which assesses the validity of the instruments used in the model. If the null hypothesis is not rejected, it indicates that the instruments are valid and that the model is correctly specified. The second test is the Arellano-Bond test for residual serial correlation. For first-order serial correlation (AR1), the null hypothesis should be rejected, confirming its presence. However, for second-order serial correlation (AR2), the null hypothesis should not be rejected, confirming its absence.

3.4. Observing variables’ trending

The data from 2013 to 2023 on various aspects of Cambodia’s microfinance sector revealed important trends and insights into the sector’s growth, challenges, and transformation. Overall, Cambodia’s microfinance sector has experienced significant growth driven by rising demand for financial inclusion. However, the sector also faces challenges proxied by rising NPLs amid the geoeconomic fragmentation. Some MFIs’ transition to banks reflected a maturing financial landscape with an increasing appeal for foreign investors. The increased NPL ratios observed in prior analyses further underscore the sector’s exposure to borrower defaults, economic volatility, and regulatory impacts. This financial strain is likely to continue impacting profitability and operational stability. Moving forward, the sector’s resilience will depend on effective risk management, improved regulatory compliance, and strategic adjustments to navigate profitability challenges and maintain stability.

Figure 1: Loans provided by MFIs and MDIs, 2013 to 2023



Source: Authors’ elaboration.

Note: MDIs = Microfinance Deposit-taking Institutions; MFIs = Microfinance Institutions.

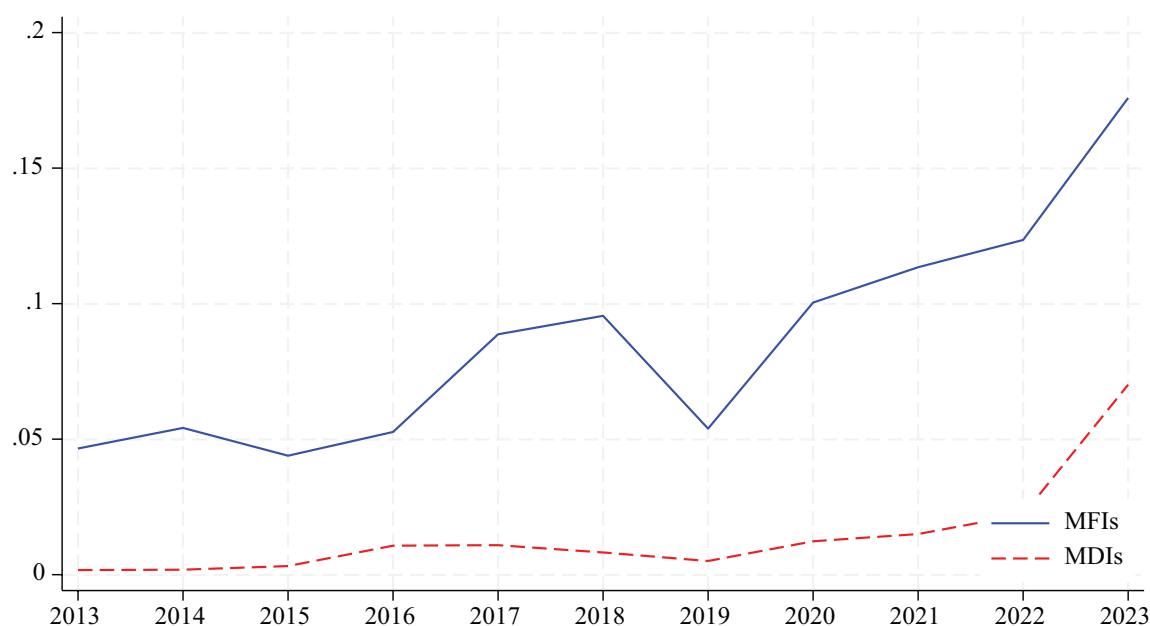
A. Cambodia’s financial development inclusion and stability

Figure 1 illustrates the trends in the mean of loans provided by MFIs and the microfinance MDIs in Cambodia between 2013 and 2023. From 2013 to 2016, both MFIs and MDIs showed relatively moderate growth in their loan averages. However, between 2017 and 2021, the mean loan amounts for MFIs grew more rapidly, particularly after 2019. MDIs also displayed growth, though at a slightly slower rate than that of MFIs. The trend suggests that MFIs’ lending

capabilities strengthened over this period, possibly due to increased financial inclusion, widened operational capacities, or a rise in small loan demand. In 2022, both MFIs and MDIs reached their highest recorded loan means. Yet, in 2023, MDI loans declined sharply, which may have been driven by the transformation of one MDI into a commercial bank. MFIs continued their growth trend that same year.

Figure 2 illustrates the NPL ratio for MDIs and MFIs in Cambodia from 2013 to 2023. The NPL ratio for MFIs shows significant fluctuation over the period, with a notable increase from 2019 to 2023 and peaking in 2023. After a brief decline in 2019, the ratio began to rise again from 2020 onward. By 2023, the MFIs' NPL ratio had reached its highest point. This upward trend indicates growing challenges in loan performance within the MFI sector. Such challenges are likely due to economic slow-down factors that may have impacted borrowers' ability to repay their loans. The sharp increase in NPLs after 2020 suggests that MFIs have become increasingly vulnerable, potentially due to their exposure to higher-risk borrowers or the economic impact of the COVID-19 pandemic and other shocks. By contrast, MDIs have maintained relatively low and stable NPL ratios throughout the observed period, especially between 2013 and 2019 when the ratio remained close to 1 percent. However, MDIs' NPL ratios gradually rose from 2020 onward, reaching over 5 percent in 2023. Although the NPL ratio for MDIs remains significantly lower than that of MFIs, the steady increase suggests that MDIs are also feeling the effects of broader economic pressures. Their relatively slower rise in NPL ratios compared to MFIs might indicate that MDIs are better equipped to manage risk or provide to a less vulnerable borrower base.

Figure 2: NPL loan ratio in Cambodia, 2013 to 2023



Source: Authors' elaboration.

Note: MDIs = Microfinance Deposit-taking Institutions; MFIs = Microfinance Institutions.

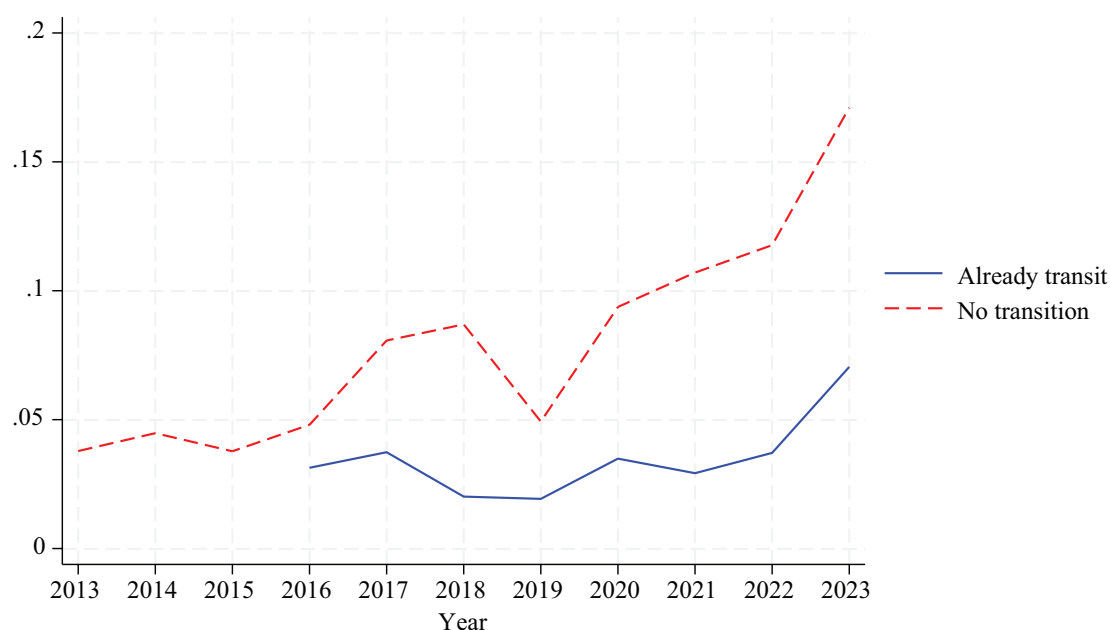
The upward trend in NPL ratios for both MFIs and MDIs after 2020 points to systemic pressures on Cambodia's microfinance sector. This trend likely reflects macroeconomic challenges such as slower economic growth, inflation, and increasing household debt burdens, all of which have strained borrowers' ability to meet their loan obligations. The steep rise in NPLs for MFIs may indicate that this segment of the financial sector is more exposed to risk. On the other hand, with only four institutions in 2023, MDIs seem to have more robust risk management

practices, though they are by no means immune to broader economic pressures. These trends highlight the need for careful monitoring and potential policy intervention to prevent further deterioration in the financial health of the microfinance sector.

Figure 3 presents the average NPL ratio in Cambodia between 2013 and 2023 by comparing two categories of MFIs: *already transitioning* (MFIs that have transitioned to banks in the referenced year) and *no transition* (MFIs that have not undergone the transition in the referenced year). The analysis revealed important trends across these categories. First, MFIs that had not transitioned to banks showed the highest and most volatile average NPL ratios over the period. The NPL ratio for this group began to increase notably after 2016. The upward trend accelerated after 2020, peaking sharply in 2023 at over 15 percent. Such a sharp increase indicates severe deterioration in loan performance. This may reflect structural weaknesses in MFIs that have not transitioned, as they likely face higher exposure to credit risks or borrower defaults, especially in the wake of external economic shocks like the COVID-19 pandemic.

Second, the MFIs that had already transitioned to banks exhibited a more stable movement in the NPL ratio. Before 2022, the NPL ratio remained low, below 5 percent. By 2023, the NPL ratio for this group reached above 5 percent. Although the ratio was still lower than the *no transition* group, it is still indicative of rising challenges. This suggests that while transitioning to banks might offer some protection against severe credit risks, it does not entirely shield these institutions from broader economic pressures affecting borrowers.

Figure 3: Average NPL loan ratio in Cambodia, 2013 to 2023



Source: Authors' elaboration.

The sharp rise in NPL ratios post-2020, particularly for MFIs that had not transitioned to banks, underscores the heightened vulnerability of these institutions to economic challenges, which were likely exacerbated by the COVID-19 pandemic and other financial pressures. MFIs that have already transitioned to banks show a somewhat mitigated risk, as reflected in their lower NPL ratios compared to the non-transitioned group. However, the continuous rise in NPLs even for these transitioned institutions suggests that economic shocks affect all segments of the financial sector, albeit to varying degrees.

B. Transition from MFIs to banks in Cambodia

Figure 4: Number of MDIs, MFIs and the transitioned banks in Cambodia, 2013 to 2023

Year	MDIs	MFIs	CB	SB
2013	7	29	0	0
2014	7	32	0	0
2015	8	45	0	0
2016	7	62	2	1
2017	7	69	2	1
2018	7	73	3	1
2019	7	75	3	1
2020	6	73	5	1
2021	5	72	6	1
2022	5	82	6	1
2023	4	83	7	1

Source: Authors' elaboration.

Note: MDIs = Microfinance Deposit-taking Institutions; MFIs = Microfinance Institutions; CB = Commercial Banks; SB = Specialized Banks.

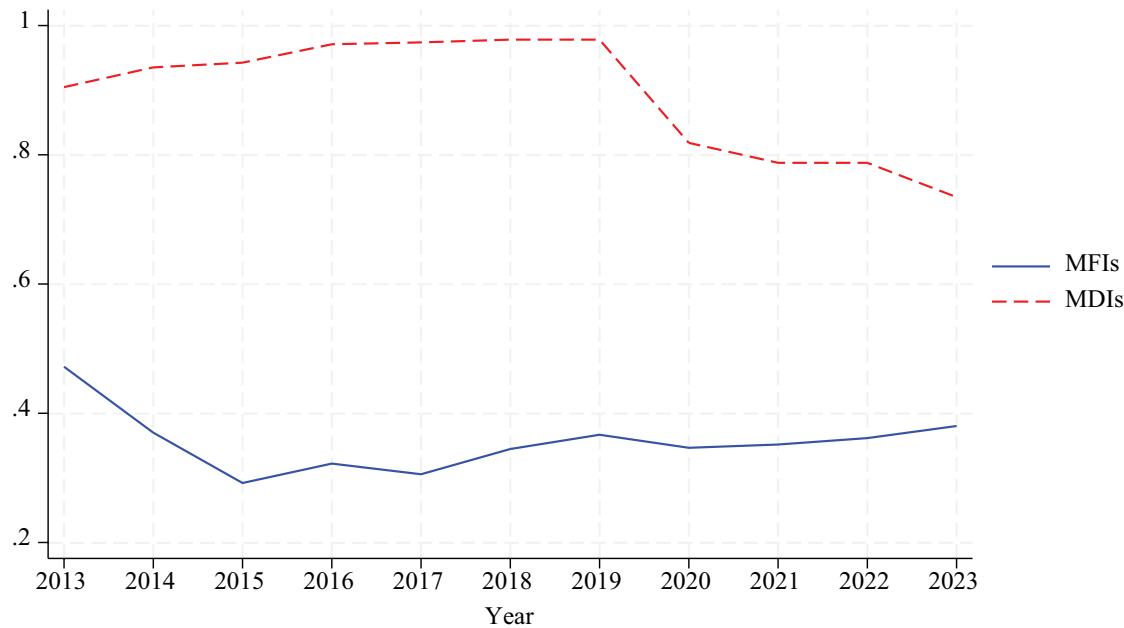
Figure 4 illustrates the number of MDIs, MFIs, and the transitioned banks in Cambodia from 2013 to 2023. In 2013, there were 7 MDIs and only 29 MFIs. The number of MDIs remained fairly stable between 2013 and 2020, fluctuating between 6 and 8 institutions annually. However, starting in 2020, the number of MDIs noticeably declined, dropping to just 4 institutions by 2023. This downward trend suggests consolidation within the sector, driven by MDIs transitioning into banks and specialised banks. Between 2013 and 2023, there were a total of 8 transition cases, 7 of which involved MFIs/MDIs transitioning into banks, while 1 involved an MFIs/MDIs transitioning into a specialised bank. This growth reflects a maturing financial sector in Cambodia, where some MFIs and MDIs have successfully transitioned into banks. This trend signals the development of a more regulated and stable banking environment as institutions scale up to meet broader financial needs in the country. On the other hand, MFIs have seen steady growth over this same period, increasing from 29 institutions in 2013 to 83 in 2023. The consistent rise of MFIs, particularly after 2016, highlights the growing demand for microfinance services in Cambodia, especially in underserved regions. However, this rapid expansion could also pose risks since it may lead to challenges in maintaining loan quality and institutional stability, as evidenced by rising NPL ratios in the sector.

Figure 5 presents the foreign share of ownership in MDIs and MFIs in Cambodia from 2013 to 2023. The foreign share refers to the proportion of foreign ownership or investment in these institutions over time. Two distinct trends are observable for MDIs and MFIs. For MDIs, the foreign share remained consistently high, hovering around 80-85 percent between 2013 and 2022. This consistently high foreign share indicates the dominant presence of foreign ownership in this segment. Furthermore, such stability suggests that foreign investors have maintained a strong interest in MDIs, which likely reflects the perception of MDIs as relatively stable, regulated, and attractive investment opportunities within Cambodia's financial sector.

However, between 2020 and 2023, the foreign share in MDIs declined noticeably, dropping to approximately 73 percent in 2023. Though this drop may reflect the effect of the transformation of two MDIs into commercial banks during this period and not be a significantly negative

indicator. In contrast, the foreign share in MFIs showed a slight upward trajectory. Starting at approximately 30 percent in 2015, the foreign share steadily increased over the years, reaching 36 percent in 2019. This upward trend reflects growing foreign interest and investment in the MFI sector, likely driven by the expanding microfinance market in Cambodia and the potential for high returns in a developing economy. However, since 2020, the foreign share in MFIs stabilised, remaining below 40 percent through 2023. The stabilisation of foreign investment in MFIs might suggest that the market is reaching a saturation point or that investors are becoming more cautious, possibly due to concerns over rising NPLs or regulatory risks within the sector.

Figure 5: Foreign share, 2016 to 2023

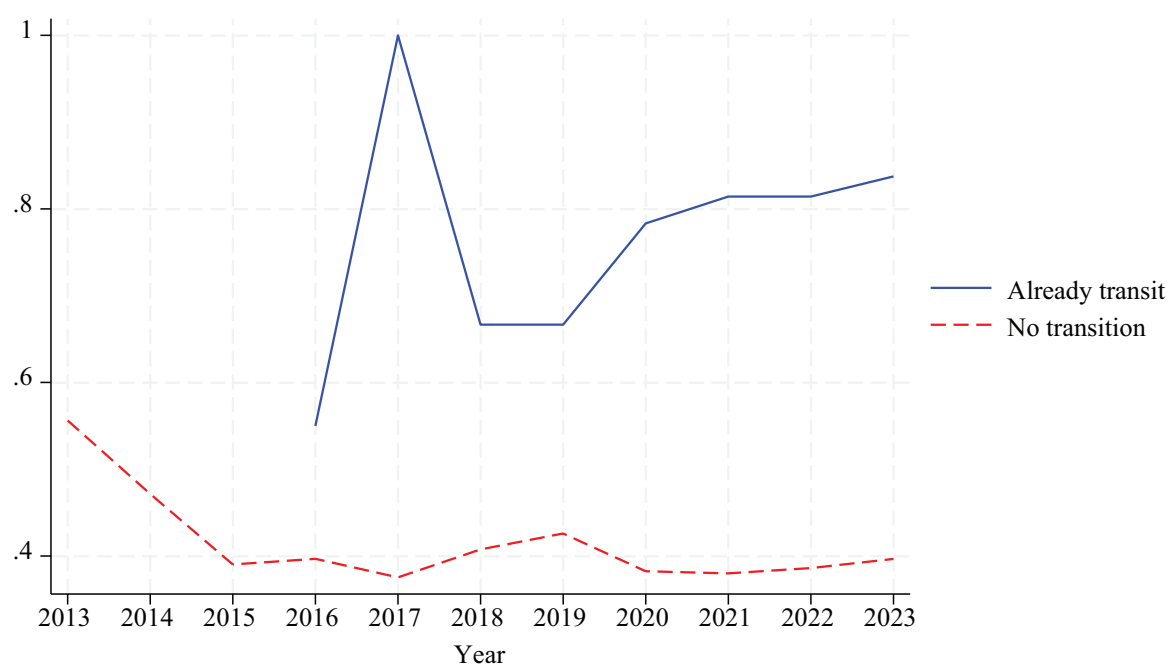


Source: Authors’ elaboration.
 Note: MDIs = Microfinance Deposit-taking Institutions; MFIs = Microfinance Institutions.

Figure 6 displays the average foreign share of ownership in two categories of MFIs (those that transitioned to banks and those that did not transit) between 2013 and 2023. First, MFIs that transitioned to banks have a much higher share of foreign ownership compared to those that did not. Since 2017, the majority of these transitioned MFIs have been owned by foreign investors, with foreign ownership consistently above 60 percent. By 2021, this share stabilised at around 80 percent, demonstrating a strong and steady reliance on foreign backing. For non-transitioned MFIs, the level of foreign ownership is lower but still significant. While the level of foreign ownership is more moderate, it has remained steady over time, reaching an average of about 40 percent by 2023.

This data highlights an important insight: financial institutions in Cambodia are heavily reliant on foreign ownership and capital inflows, regardless of whether they have transitioned to banks or not. This may also reveal a broader macroeconomic trend that the banking industry has become a key player in attracting international capital, possibly due to strong macroeconomic stability and regulatory frameworks that favour foreign investment. The difference may lie in the degree of dependence, with transitioned MFIs relying even more on foreign investments to sustain their operations.

Figure 6: Average foreign share, 2013 to 2023

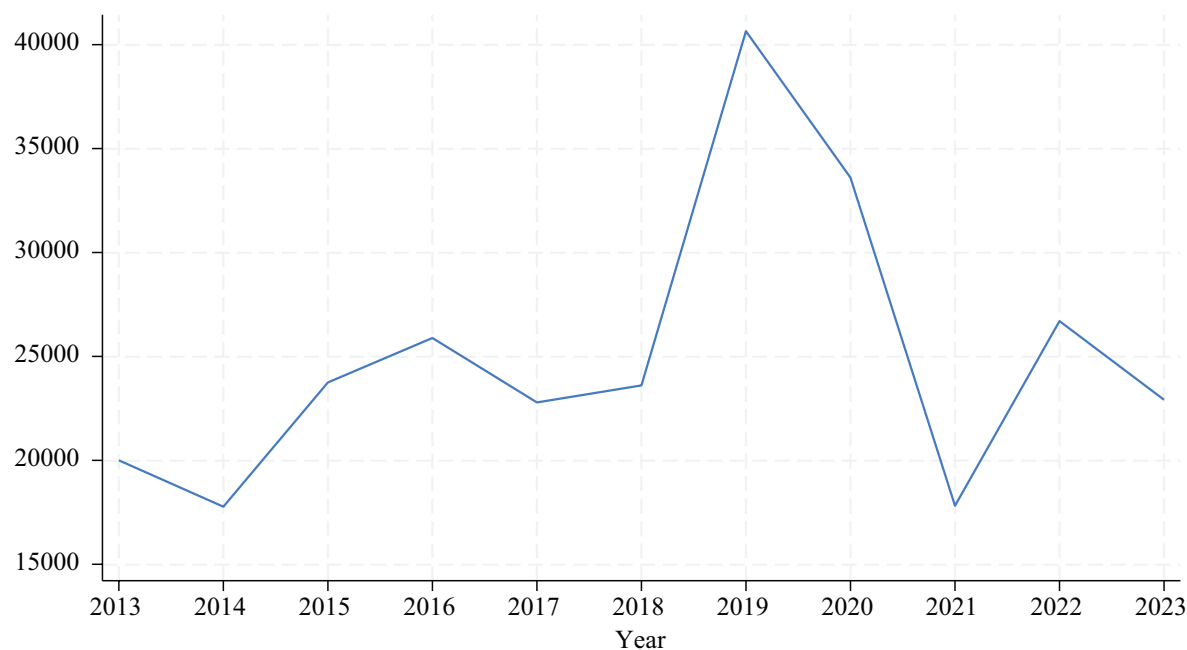


Source: Authors' elaboration.

Figure 7 shows the WUI from 2013 to 2023, representing fluctuations in global uncertainty over the period. The WUI appears to vary significantly, with peaks around specific years, which may reflect global events that heightened economic and political uncertainty.

C. Global economic fragmentation

Figure 7: Global World Uncertainty Index, 2013 to 2023



Source: Authors' elaboration.

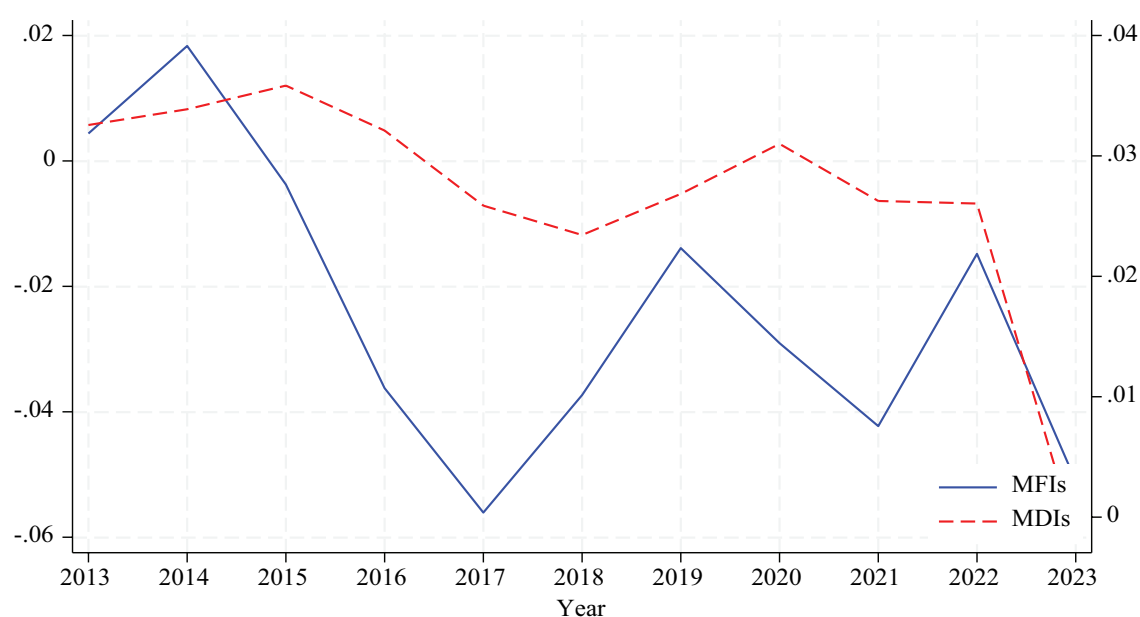
From 2013 to 2015, the index was relatively stable with values fluctuating between 20,000 and 25,000. A gradual increase followed with notable peaks in 2019 when the index reached its highest level at around 40,000. This peak likely corresponds to the COVID-19 pandemic, which caused unprecedented uncertainty in global markets. After 2020, the index declined somewhat but remained above pre-2019 levels, suggesting that the residual effects of the pandemic, alongside other geopolitical and economic issues, continued to contribute to heightened uncertainty.

High global uncertainty, as indicated by peaks in the WUI, likely has significant implications for Cambodia's financial development. Cambodia is an open, developing economy, and fluctuations in global uncertainty can impact it through various channels, such as investment flows and FDI. In summary, heightened levels of global uncertainty, as depicted by the WUI, may slow Cambodia's financial development through reduced investments, credit constraints, and economic volatility. Managing these impacts requires strategic planning and policy adjustments to bolster resilience against external shocks.

D. Institutional financial variables

Figure 8 illustrates the net profit as a share of assets for MDIs and MFIs in Cambodia between 2016 and 2023. This metric reflects the profitability of each type of institution relative to their total assets and provides insight into the financial efficiency and profitability trends within the microfinance sector. For MDIs, the net profit as a share of assets was initially high in 2016 at over 3 percent, indicating strong profitability relative to their asset base. However, after this initial peak, the ratio slightly declined, stabilising between 2.5 percent and 3 percent between 2017 and 2022. The stability during this period suggests that MDIs were able to maintain a relatively consistent profit level in proportion to their assets, likely due to steady revenue streams and efficient asset management. However, in 2023, there was a notable drop in profitability to below 2 percent, indicating a sharp decline in returns relative to assets. This decrease may reflect increased operational challenges, such as higher loan defaults, regulatory impacts, or reduced demand for MDI services, which may have put pressure on profit margins.

Figure 8: Net profit as share of asset, 2013 to 2023



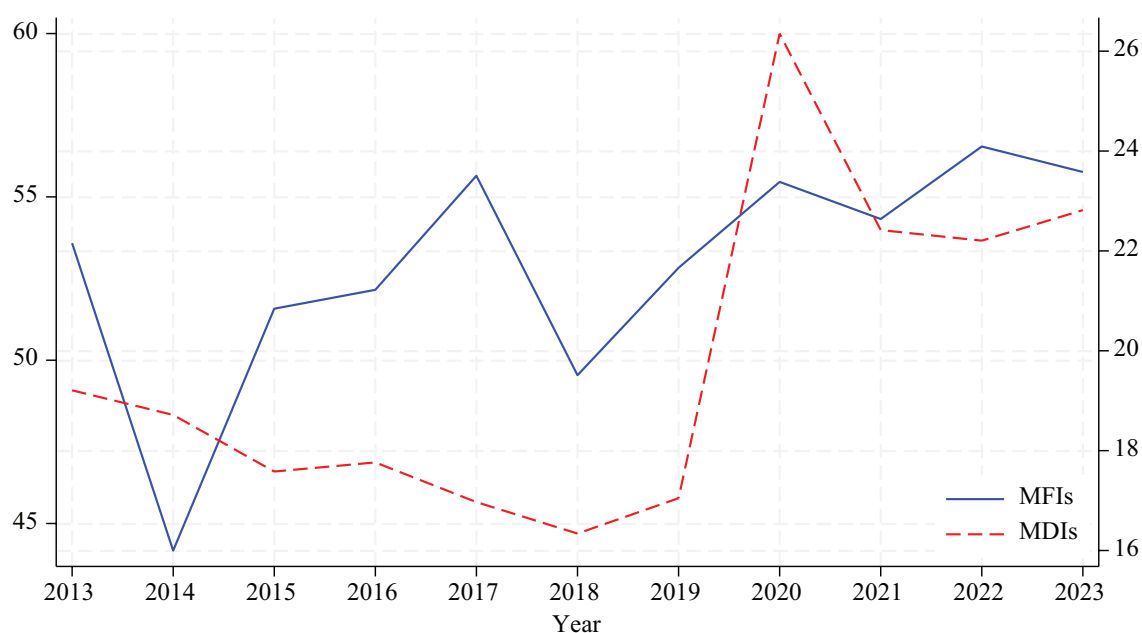
Source: Authors' elaboration.

Note: MDIs = Microfinance Deposit-taking Institutions; MFIs = Microfinance Institutions.

In contrast, MFIs showed a downward trend in net profit as a share of assets throughout the same period. Starting at approximately -4 percent in 2016, the profitability of MFIs relative to assets decreases steadily over the years, reaching around -5 percent in 2023. This continuous decline suggests that MFIs have faced increasing profitability challenges, potentially due to rising operational costs, increased competition, or a higher risk profile among borrowers that affects loan repayment rates. The downward trajectory indicates that MFIs may be struggling to maintain profitability at the same pace as their asset growth, illuminating possible inefficiencies or difficulties in scaling operations sustainably.

The trends in net profit as a share of assets highlights the differing financial pressures and performance between MDIs and MFIs. MDIs maintained a relatively stable profit level over most of the period, suggesting better financial resilience and asset management. However, the sharp decline in 2023 indicates emerging challenges that have affected profitability and potentially signal a need for strategic adjustments. On the other hand, MFIs have seen a consistent decline in profitability relative to assets, which could reflect ongoing challenges in maintaining financial sustainability amidst growth. The steady drop may suggest that MFIs are increasingly struggling with operational efficiency, profitability, or both.

Figure 9: Equity asset ratio, 2016 to 2023



Source: Authors' elaboration.

Note: MDIs = Microfinance Deposit-taking Institutions; MFIs = Microfinance Institutions.

Figure 9 illustrates the mean equity-asset ratio over time for MFIs and MDIs in Cambodia from 2013 to 2023. The equity-asset ratio is an important indicator of financial stability by measuring the proportion of an institution's assets financed by equity rather than debt. In this scenario, higher ratios indicate stronger financial resilience.

First, the equity-asset ratio for MFIs fluctuates significantly over the period. Starting at approximately 53 percent in 2013, the ratio declined sharply in 2014 to around 44 percent. This drop suggests a temporary reduction in the equity buffer of MFIs, which may reflect higher debt financing or an expansion in assets outpacing equity growth. Between 2015 and 2017, the ratio stabilised and gradually increased, indicating improved financial resilience as MFIs likely focused on strengthening their equity positions. A noticeable peak occurred in 2022 when the equity-asset ratio for MFIs rose sharply to around 57 percent, which signalled

a strong equity base relative to assets. However, this was followed by a slight decline in 2023. Despite the fluctuations, the ratio consistently remained above 50 percent after 2016, which reflects a strong equity position and consistent equity management practices.

Second, MDIs appeared more stable but exhibited a structural break in their equity-asset ratio. Starting at 19 percent in 2013, the ratio gradually declined to around 16 percent in 2018. However, it increased sharply in 2020 to roughly 26 percent and has maintained levels above 20 percent ever since. The abrupt jump in 2020 was due to a composition effect, as one MFI¹ with higher equity-asset ratio converted to an MDI, thereby pulling up the average equity-asset ratio in the overall MDIs category. In addition, this gradual improvement suggests that MDIs have been bolstering their equity positions, likely in response to regulatory requirements or market conditions that demand stronger financial buffers.

The steady upward trend in MDIs' equity-asset ratio contrasts with the more volatile pattern seen in MFIs, indicating that MDIs may have more consistent equity management strategies and a less variable financial structure. The smaller fluctuations in MDIs' equity-asset ratios suggest greater operational stability compared to MFIs. The equity-asset ratios for both MFIs and MDIs reflect broader trends in financial resilience within Cambodia's microfinance sector. MFIs, with their higher and more volatile ratios, indicate a reliance on equity financing but face fluctuations that may reflect market pressures, asset expansion, or changes in operational strategies. By contrast, MDIs show a more measured and steady improvement in their equity-asset ratios that reflect a more conservative approach to financial management.

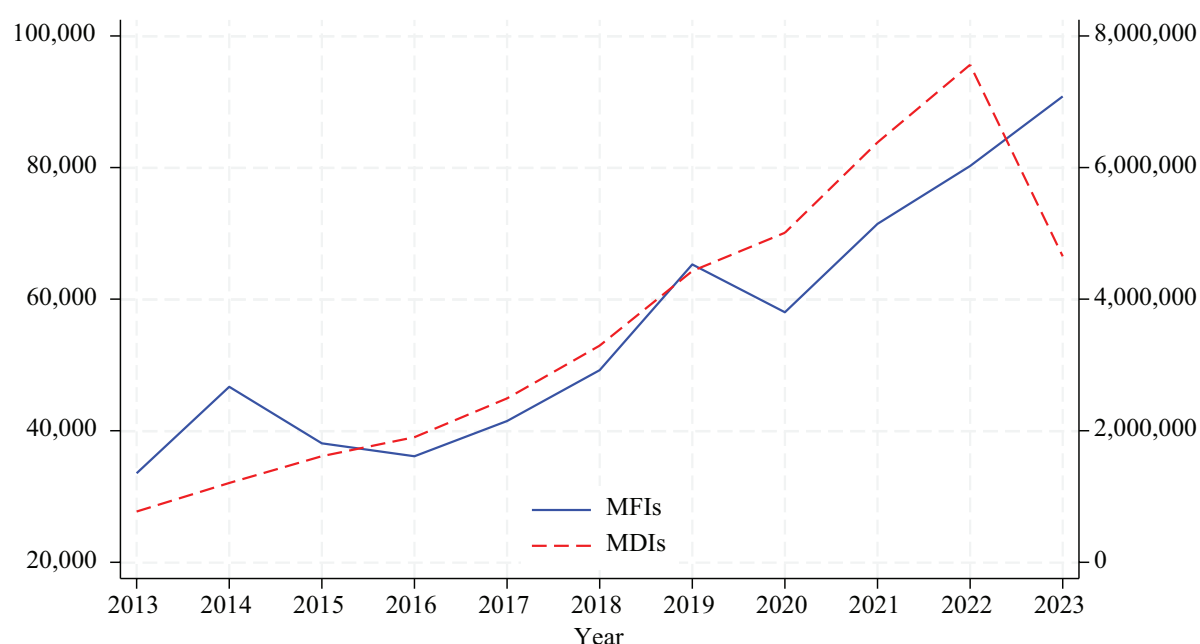
From a policy perspective, the higher equity-asset ratios for MFIs suggest stronger short-term financial buffers, which are critical for institutions serving higher-risk, underserved populations. However, the volatility in MFIs' ratios raises concerns about long-term sustainability and their ability to maintain resilience during economic downturns. For MDIs, the consistent improvement in equity-asset ratios indicates that these institutions are strengthening their financial foundations, which may enhance their ability to transition to more complex financial operations, such as commercial banking.

Figure 10 illustrates the total assets of MDIs and MFIs in Cambodia between 2013 and 2023, and shows distinct growth trends for each category over time. The average assets of MDIs grew substantially from 2013 to 2022. Starting at a low value in 2013, MDI assets rose sharply each year, and peaked by 2022. This rapid increase highlights the expansion and growing importance of MDIs within Cambodia's financial sector, likely driven by increased deposits, expanded lending, and strong investor confidence in these institutions. However, after peaking in 2022, the total assets of MDIs dropped significantly in 2023.

By contrast, the total assets of MFIs exhibited a more modest and consistent growth trend. Starting from a much lower base in 2016, the total assets of MFIs increased gradually over the years, and reached a peak by 2023. This steady growth suggests that MFIs have been able to expand their asset base, albeit at a slower pace compared to MDIs. The gradual increase reflects the continued demand for microfinance services among low-income borrowers and in underserved areas. However, MFIs may face more limitations in asset accumulation due to regulatory constraints or higher risk exposure.

1 Mohanokor Microfinance Institution Plc (MFI) transitioned to Mohanokor Microfinance Deposit-taking Institution Plc. (MDI) after receiving a Deposit License from the National Bank of Cambodia on 17 July 2020.

Figure 10: Total assets, 2016 to 2023



Source: Authors' elaboration.

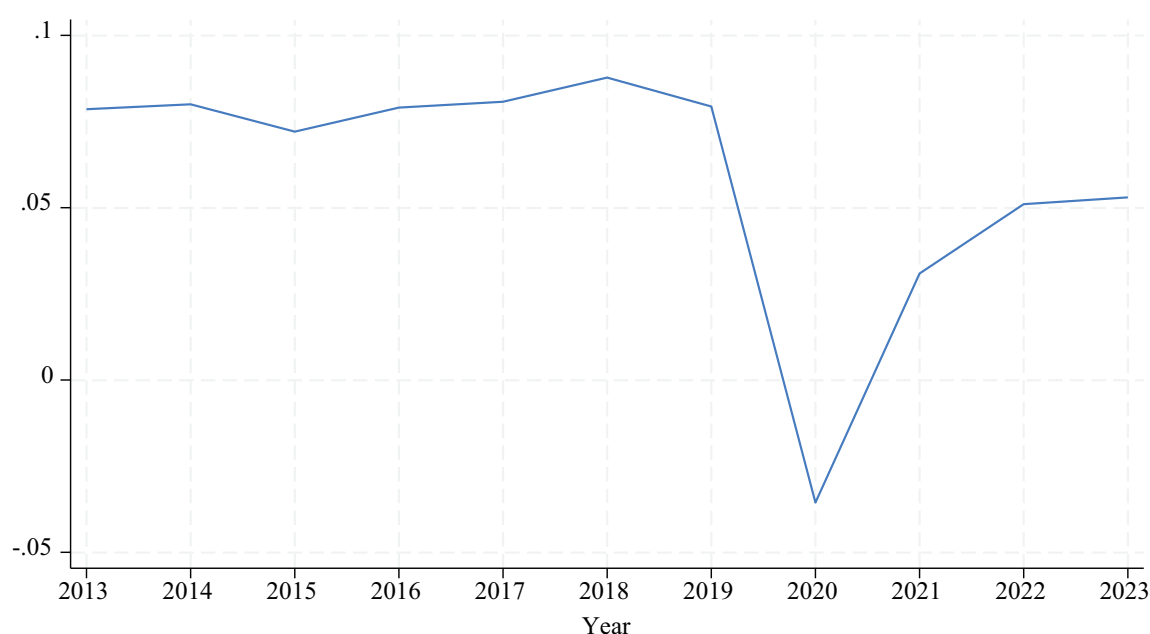
Note: MDIs = Microfinance Deposit-taking Institutions; MFIs = Microfinance Institutions.

E. Macroeconomic variables

Figure 11 describes Cambodia's economic growth rate from 2013 to 2023, and shows fluctuations in the annual growth rate over this period. The data reveals a trend of stable growth in the early years, a significant economic contraction during the COVID-19 pandemic, and a gradual recovery afterwards. From 2013 to 2019, Cambodia's economy experienced robust and stable growth with annual rates consistently remaining around 7 percent or higher. This period of high economic growth was driven by strong performance in key sectors, including garment manufacturing, tourism, construction, and agriculture. Cambodia's integration into global trade networks and FDI further fuelled its economic expansion. The stability during this time reflects effective economic policies and a favourable global economic environment that supported Cambodia's export-driven economy.

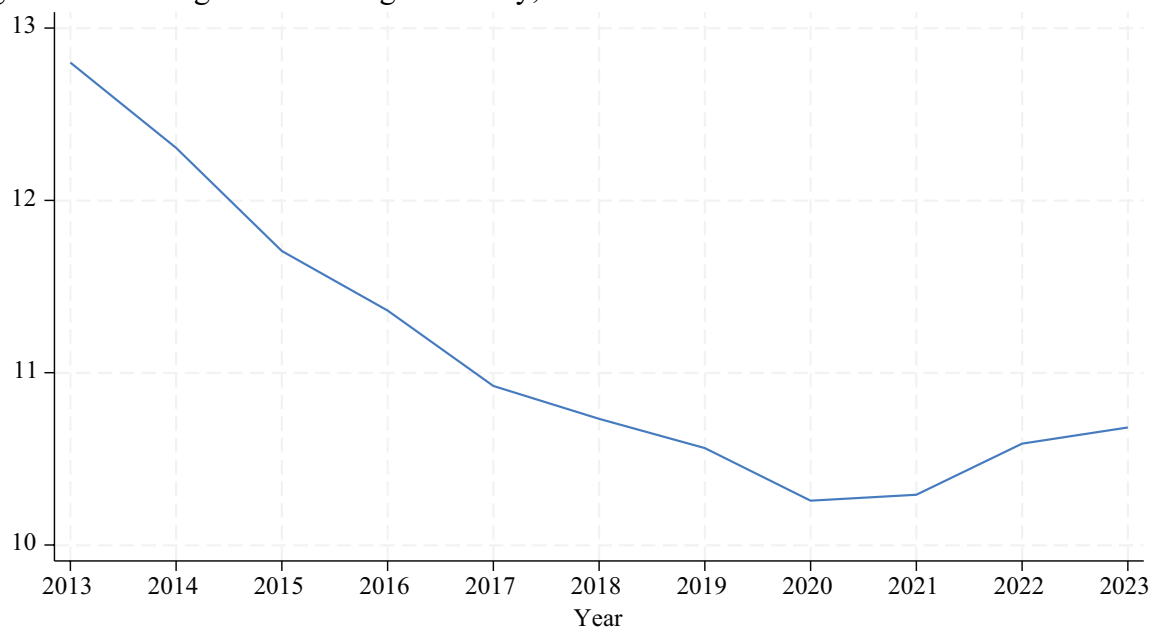
In 2020, Cambodia's economic growth rate experienced a sharp contraction, dropping below zero percent for the first time in the period analysed. This significant decline was primarily due to the global disruptions caused by the COVID-19 pandemic. Key sectors such as tourism, garment exports, and construction faced severe setbacks due to lockdowns, reduced international demand, and supply chain disruptions. The contraction reflects Cambodia's high dependency on external trade and investment, which made the economy particularly vulnerable to global economic shocks. From 2021 onward, Cambodia's economic growth began to recover, although at a slower pace compared to the pre-pandemic years. Growth rates stabilised between 4 and 6 percent by 2023, which indicates a gradual return to economic activity. The recovery has likely been supported by a rebound in tourism, the resumption of construction projects, and continued FDI inflows. However, the slower recovery rate compared to the pre-2020 period suggests lingering challenges, such as global economic uncertainty, inflationary pressures, and disrupted supply chains.

Figure 11: GDP growth, 2013 to 2023



Source: Authors' elaboration.

Figure 12: Lending rate for foreign currency, 2013 to 2023



Source: Authors' elaboration.

Figure 12 depicts the lending rate for foreign currency loans in Cambodia between 2013 and 2023, and highlights a clear downward trend over the decade with stabilisation and a slight rebound in the later years. Between 2013 and 2020, lending rates declined steadily, starting at approximately 13 percent in 2013 and dropping to around 10.26 percent in 2020. This consistent reduction can be attributed to increased competition among financial institutions, improved macroeconomic stability, and policy efforts to promote access to affordable credit. Lower rates during this period likely encouraged borrowing for business expansion and household consumption, supporting economic growth.

However, from 2021 onward, lending rates began to rise gradually and reached approximately 10.68 percent by 2023. This upward trend reflects post-pandemic recovery pressures, inflation, and rising operational costs for financial institutions. The slight increase also suggests that institutions adjusted lending rates to reflect global monetary tightening and changes in funding conditions. The overall trend indicates a significant reduction in borrowing costs over the decade, fostering greater financial inclusion and economic activity. However, the recent uptick in lending rates highlights emerging challenges, such as inflationary pressures and heightened global uncertainty, which may impact the affordability of foreign currency loans in Cambodia. This development underscores the need for continued monitoring of lending rates and their implications for financial accessibility and economic resilience.

4. Empirical findings

4.1. Effect of MFI-to-Banks and geoeconomic fragmentation on Cambodia's financial inclusion

Table 1 presents the results of a dynamic panel model using the GMM estimator to analyse the effect of MFI-to-Bank transitions and global geoeconomic fragmentation on financial inclusion in Cambodia, measured by access to loans. The GMM approach uses the same specification strategy. Diagnostic tests confirm the model's validity: the Arellano-Bond test indicates no significant second-order autocorrelation, and the Hansen test suggests that the instruments used are valid and not over-identified. This econometric framework allows for robust estimation of causal relationships while controlling for time-invariant heterogeneity and dynamic persistence in access to loans.

The coefficient for lagged access to loans is positive and significant (0.7272, $p = 0.045$ in Step 1; 0.9486, $p = 0.000$ in Step 2), indicating strong persistence in financial inclusion. This suggests that higher levels of access to loans in the past positively influence future access. Besides this, other explanatory variables show no significant coefficients. The equity-asset ratio is negative but insignificant (-0.0101, $p = 0.463$ in Step 1; -0.0028, $p = 0.789$ in Step 2). The coefficient for profitability is negative and insignificant (-0.0543, $p = 0.953$ in Step 1; -0.9260, $p = 0.385$ in Step 2). The post-transition variable is positive but insignificant (0.9084, $p = 0.378$ in Step 1). The post-pandemic variable is negative but insignificant (-0.2102, $p = 0.186$ in Step 1). The interaction term is negative and insignificant (-0.9104, $p = 0.573$ in Step 1; 0.1794, $p = 0.827$ in Step 2). The coefficient for economic growth is negative and insignificant (-0.0343, $p = 0.734$ in Step 1; -0.1225, $p = 0.938$ in Step 2). The lending rate for foreign currency loans is negative and insignificant (-0.0343, $p = 0.734$ in Step 1; 0.0772, $p = 0.441$ in Step 2).

The findings, on the one hand, suggest that the strong persistence observed in lagged access to loans is a good predictor for the current value. The insignificant impact of the post-transition variable raises questions about whether transitioning MFIs to banks has any relationship with loan. While banks benefit from stronger regulatory frameworks and expanded operational capacity, these advantages may not translate into greater accessibility for underserved populations. Similarly, the lack of significant interaction between post-transition and post-pandemic suggests that institutional transformations did not substantially mitigate the challenges posed by the pandemic in terms of loan accessibility. Global uncertainty, coupled with lending rates and macroeconomic factors, also appears to have minimal impact on access to loans, reflecting a disconnect between external economic conditions and domestic financial inclusion efforts.

Model A. Effect of MFI-to-Banks on access to loan

Table 1: Effect of MFI-to-Banks on access to loan

Independent variables	Dependent variable: Access to loan					
	Step 1 main effect			Step 2 interaction effect		
	Coef	SE	P Value	Coef	SE	P Value
Lag access to loan	0.7272	0.3628	0.0450	0.9486	0.2636	0.0000
Equity-asset ratio	-0.0101	0.0137	0.4630	-0.0028	0.0106	0.7890
Net profit as a percentage of assets	-0.0544	0.9290	0.9530	-0.9260	1.0664	0.3850
Post transition	0.9085	1.0300	0.3780			
Post pandemic	-0.2102	0.1589	0.1860			
Post transition * post pandemic				0.1794	0.8231	0.8270
Economic growth	-0.9105	1.6162	0.5730	-0.1223	1.5702	0.9380
Lending rate foreign currency	-0.0343	0.1009	0.7340	0.0772	0.1002	0.4410
Constant	3.9964	4.8898	0.4140	0.0409	3.9487	0.9920
Wald Test	100,627			117,935		
Arellano-Bond test for AR (1) Test z =	-1.2100			-1.32		
Pr > z =	0.2280			0.187		
Arellano-Bond test for AR (2) Test z =	0.1100			0.72		
Pr > z =	0.9110			0.472		
Sargan Test: chi2(15) =	31.88			22.8		
Prob > chi2 =	0.007			0.088		
Hansen Test: chi2(15) =	21.53			24.79		
Prob > chi2 =	0.121			0.053		
Difference Hansen Tests	Valid and exogenous			Valid and exogenous		
Number of obs	685			685		
Number of groups	115			115		
Number of instruments	23			22		

Source: Authors' elaboration.

Note: To account for macro-financial disruptions triggered by the COVID-19 pandemic, we include a binary variable, Post-pandemic, coded as 1 for the period 2021-2023 and 0 otherwise. This variable is intended to capture structural changes in the operating environment of financial institutions following the pandemic, including shifts in credit conditions, portfolio quality, and institutional behaviour. For example, as shown in Figure 3, the post-pandemic years in Cambodia were marked by elevated NPLs. This specification is applied to all other models. Coef = coefficient; SE = Standard error.

Model B. Effect of geoeconomic fragmentation on access to loan

Table 2 presents the results from a dynamic panel model using the GMM estimator to assess the effects of MFI-to-Bank transitions and global fragmentation (proxied by WUI) on Cambodia's financial inclusion, measured by access to loans. GMM is applied the same way as previous models by using interaction terms such as post-transition * WUI. Diagnostic tests, including the Arellano-Bond test for autocorrelation and the Hansen test for instrument validity, confirm the model's appropriateness, with no significant second-order autocorrelation and valid instrument specification.

The sign and significant level are almost the same as previous estimations, which the coefficient for lagged access to loans is positive and significant (0.8816, $p = 0.054$ in Step 1; 0.9211, $p = 0.000$ in Step 2), indicating strong persistence in financial inclusion. Moreover, the interaction term post-transition * WUI is positive but insignificant (0.2962, $p = 0.895$ in Step 1; 0.0328, p

= 0.632 in Step 2), suggesting that the combined effect of transitioning institutions and global uncertainty has a limited impact on loan. This result implies that while institutional transitions improve operational capacity, they may not strongly counteract the challenges posed by global fragmentation.

Table 2: Effect of geoeconomic fragmentation on access to loan

<i>Independent variables</i>	<i>Dependent variable: Access to loan</i>					
	Step 1 main effect			Step 2 interaction effect		
	Coef	SE	P Value	Coef	SE	P Value
Lag access to loan	0.8816	0.4572	0.0540	0.9212	0.2588	0.0000
Equity-asset ratio	-0.0039	0.0191	0.8390	-0.0034	0.0102	0.7360
Net profit as a percentage of assets	-0.4599	1.4024	0.7430	-0.9035	1.1118	0.4160
Post transition	0.4497	1.2860	0.7270			
Log WUI	0.4274	0.3454	0.2160			
Post transition * log WUI				0.0328	0.0685	0.6320
Economic growth	0.2962	2.2504	0.8950	-1.4391	2.4393	0.5550
Lending rate foreign currency	0.1001	0.1762	0.5700	0.2581	0.3292	0.4330
Constant	-3.8048	10.5766	0.7190	-1.5372	3.2729	0.6390
Wald Test	114,662			108,350		
Arellano-Bond test for AR (1) Test z =	-1.1700			-1.35		
<i>Pr</i> > z =	0.2410			0.178		
Arellano-Bond test for AR (2) Test z =	0.4800			0.61		
<i>Pr</i> > z =	0.6280			0.542		
Sargan Test: chi2(15) =	28.99			22.57		
<i>Prob</i> > chi2 =	0.016			0.068		
Hansen Test: chi2(15) =	19.45			23.08		
<i>Prob</i> > chi2 =	0.194			0.059		
Difference Hansen Tests	Valid and exogenous			Valid and exogenous		
Number of obs	685			685		
Number of groups	115			115		
Number of instruments	23			21		

Source: Authors' elaboration.

Note: Coef = coefficient; SE = Standard error.

The findings similarly highlight how lagged loan value serve as a good predictor for the current loan value. However, the lack of significant effects for institutional characteristics, such as equity-asset ratio and profitability, suggests that these factors alone do not determine the loan value that the bank loan out to customers. The absence of a significant impact from post-transition implies that transitioning from MFIs to banks does not directly increase nor decrease loan amounts. This may reflect a focus on regulatory compliance and risk management during transitions rather than explicit efforts to increase inclusion. Similarly, the limited effect of global uncertainty suggests that external economic fragmentation may not directly impede financial access, but it also highlights missed opportunities for financial institutions to innovate during periods of uncertainty. Overall, these results indicate limited evidence of significant relationships between institutional transitions, world uncertainty, and access to loans and institutional and external macroeconomic factors are not sufficient to drive financial inclusion.

4.2. Effect of MFI-to-Banks and geoeconomic fragmentation on Cambodia's financial stability

Table 3 presents the results of a dynamic panel model using the GMM estimator to examine the effect of MFI-to-bank transitions on financial stability, proxied by the NPLs in Cambodia. GMM is suitable for addressing endogeneity in panel data models by using lagged variables as instruments. The model includes lagged NPL loans as a dependent variable to capture persistence in NPL levels, while controlling for institution-specific characteristics (e.g., equity-asset ratio, net profit as a percentage of assets), macroeconomic factors (e.g., economic growth), and interaction terms (e.g., post-transition and post-pandemic periods).

Model C. Effect of MFI-to-Banks on NPL

Table 3: Effect of MFI-to-Banks on NPL

<i>Independent variables</i>	<i>Dependent variable: NPL</i>					
	Step 1 main effect			Step 2 interaction effect		
	Coef	SE	P Value	Coef	SE	P Value
Lag NPL loan	0.1577	0.0818	0.0540	0.2054	0.0954	0.0310
Log asset	0.0541	0.0246	0.0280	0.0690	0.0350	0.0480
Equity-asset ratio	0.0021	0.0010	0.0300	0.0027	0.0015	0.0790
Net profit as a percentage of assets	-0.0930	0.1083	0.3900	-0.1347	0.1791	0.4520
Post transition	-0.1983	0.0779	0.0110			
Post pandemic	0.0472	0.0193	0.0140			
Post transition * post pandemic				-0.2525	0.1210	0.0370
Economic growth	0.4165	0.1521	0.0060	0.0102	0.1339	0.9390
Lending rate foreign currency	-0.0018	0.0118	0.8770	-0.0054	0.0147	0.7160
Constant	-0.6417	0.3932	0.1030	-0.7595	0.5748	0.1860
Wald Test	80.65			80.65		
Arellano-Bond test for AR (1) Test z						
=	-1.6700			-1.88		
Pr > z =	0.0950			0.059		
Arellano-Bond test for AR (2) Test z						
=	-1.8400			-1.49		
Pr > z =	0.0660			0.137		
Sargan Test: chi2(15) =	51.34			77.38		
Prob > chi2 =	0.001			0.00		
Hansen Test: chi2(15) =	27.49			31.02		
Prob > chi2 =	0.236			0.122		
Difference Hansen Tests	Valid and exogenous			Valid and exogenous		
Number of obs	806			806		
Number of groups	120			120		
Number of instruments	32			32		

Source: Authors' elaboration.

Note: NPL = Nonperforming Loan; Coef = coefficient; SE = Standard error.

Diagnostic tests, including the Arellano-Bond test for serial correlation and the Hansen test for over-identification restrictions, were used to evaluate the validity of instruments and model specification. The results indicate the absence of second-order serial correlation ($p > 0.05$ for AR(2)) and robustness of instruments (Hansen p -value > 0.05), confirming the reliability of the estimates.

The interpretation of the coefficients for the key variables provides critical insights into the dynamics of NPLs in Cambodia. The Lag NPL Loan variable is positive and significant (0.1577, $p = 0.054$ in Step 1; 0.2054, $p = 0.031$ in Step 2), indicating that past NPL levels are strong predictors of future NPLs. This persistence highlights the importance of addressing existing loan performance issues to prevent their spillover into subsequent periods. The Log Asset variable is also positive and significant (0.0540, $p = 0.028$ in Step 1; 0.0690, $p = 0.048$ in Step 2), suggesting that larger institutions tend to have higher NPL levels. This may result from their exposure to a broader and potentially riskier loan portfolio and underscores the need for tailored risk management strategies in larger institutions.

The equity-asset ratio is positive and significant (0.0020, $p = 0.03$ in Step 1; 0.0027, $p = 0.049$ in Step 2), implying that institutions with higher equity relative to assets may also face slightly elevated NPL levels. This finding could indicate that such institutions are leveraging their equity for riskier lending activities, requiring improved prudential oversight. In contrast, net profit as a percentage of assets is negative and insignificant (-0.0930, $p = 0.39$ in Step 1; -0.1347, $p = 0.452$ in Step 2), suggesting that profitability does not play a significant role in reducing NPLs, which is contrary to expectations. This may reflect the complex relationship between profitability and loan performance, potentially influenced by other factors such as operational efficiency or market conditions.

The post-transition variable is negative and significant (-0.1982, $p = 0.011$ in Step 1; -0.2524, $p = 0.037$ in Step 2), indicating that the transition from MFIs to banks leads to a reduction in NPLs. This is likely due to stronger regulatory oversight, improved governance, and enhanced risk management practices post-transition. However, the post-pandemic variable is positive and significant (0.0471, $p = 0.014$ in Step 1), reflecting the lingering economic impact of COVID-19, which elevated NPL levels due to borrowers' reduced repayment capacities. Importantly, the interaction term post-transition * post-pandemic is negative and significant (-0.2524, $p = 0.037$ in Step 2), suggesting that institutions that transitioned to banks were better equipped to mitigate the pandemic's adverse effects, showcasing the resilience benefits of these transitions.

Finally, economic growth is positive and significant (0.4165, $p = 0.006$ in Step 1), indicating that periods of higher economic growth are associated with elevated NPL levels, possibly due to overexpansion of credit during growth phases. On the other hand, the lending rate for foreign currency is negative but insignificant (-0.0012, $p = 0.877$ in Step 1; -0.0053, $p = 0.716$ in Step 2), suggesting that changes in foreign currency lending rates have minimal direct effects on NPLs. This result may imply that lending rates are not the primary driver of loan performance but could instead interact with other factors such as credit risk and borrower profiles.

On the one hand, one significant implication of these results is that the negative and significant coefficient of the post-transition variable demonstrates that transitioning MFIs to banks strengthens financial stability by reducing NPLs. This finding aligns with the expectation that transitioned institutions benefit from enhanced regulatory oversight, better risk management, and stronger financial frameworks. The interaction term (post-transition * post-pandemic) further supports this conclusion, as these institutions were more resilient to the economic

shocks of the pandemic, likely due to their improved operational structures. This underscores the importance of regulatory support and institutional transformation in bolstering financial resilience. In addition, the resilience observed among transitioned institutions suggests that such transformations can buffer financial systems against external shocks.

On the other hand, the post-pandemic variable highlights the lasting impact of global economic disruptions on Cambodia's financial sector. The significant increase in NPLs during this period reflects borrowers' continued struggles with repayment amid economic uncertainty. The positive association between economic growth and NPLs suggests the potential for over-lending during economic booms, emphasising the need for cautious credit expansion policies.

In summary, the findings highlight the critical role of MFI-to-bank transitions in strengthening Cambodia's financial stability. The results underscore the need for continued institutional reforms, enhanced regulatory oversight, and resilience-building measures to safeguard financial stability in an increasingly uncertain global environment.

Model D. Effect of geoeconomic fragmentation on NPL

Table 4: Effect of geoeconomic fragmentation on NPL

<i>Independent variables</i>	<i>Dependent variable: NPL</i>					
	Step 1 main effect			Step 2 interaction effect		
	Coef	SE	P Value	Coef	SE	P Value
Lag NPL loan	0.1956	0.0828	0.0180	0.2055	0.0890	0.0210
Log asset	0.0697	0.0274	0.0110	0.0728	0.0275	0.0080
Equity-asset ratio	0.0026	0.0011	0.0220	0.0027	0.0012	0.0280
Net profit as a percentage of assets	-0.1142	0.1205	0.3430	-0.1087	0.1483	0.4630
Post transition	-0.2348	0.0996	0.0180			
Log WUI	-0.0527	0.0180	0.0030			
Post transition * WUI				-0.0238	0.0085	0.0050
Economic growth	-0.0173	0.1278	0.8920	0.0804	0.2175	0.7120
Lending rate foreign currency	-0.0089	0.0196	0.6490	-0.0053	0.0247	0.8300
Constant	-0.1823	0.5775	0.7520	-0.7971	0.5430	0.1420
Wald Test	55.79			62.43		
Arellano-Bond test for AR (1) Test z =	-1.8500			-1.84		
<i>Pr > z</i> =	0.0640			0.066		
Arellano-Bond test for AR (2) Test z =	-1.5400			-1.46		
<i>Pr > z</i> =	0.1230			0.145		
Sargan Test: chi2(15) =	60.04			59.58		
<i>Prob > chi2</i> =	0.000			0.000		
Hansen Test: chi2(15) =	33.24			25.96		
<i>Prob > chi2</i> =	0.077			0.253		
Difference Hansen Tests	Valid and exogenous			Valid and exogenous		
Number of obs	806			806		
Number of groups	120			120		
Number of instruments	32			30		

Source: Authors' elaboration.

Note: NPL = Nonperforming Loan; Coef = coefficient; SE = Standard error.

The analysis presented in Table 4 employs a dynamic panel data approach using the GMM estimator to explore the effects of MFI-to-bank transitions and global fragmentation on Cambodia's financial stability, proxied by NPLs. This method applied the same specification strategy as the previous model by using the interaction terms (e.g., post-transition * WUI). Diagnostic tests, including the Arellano-Bond test for autocorrelation and the Hansen test for instrument validity, were used to confirm the appropriateness of the model. The Hansen test indicates robust instrument validity ($p > 0.05$), while the Arellano-Bond test suggests no second-order autocorrelation.

The interpretation of coefficients provides key insights into the factors influencing NPLs in Cambodia. The sign and significant level are almost the same as previous estimations. The lag NPL loan variable is positive and significant (0.1956, $p = 0.018$ in Step 1; 0.2055, $p = 0.021$ in Step 2). The log asset variable is positive and significant (0.0696, $p = 0.011$ in Step 1; 0.0727, $p = 0.007$ in Step 2). The equity-asset ratio is also positive and significant (0.0020, $p = 0.02$ in both steps). Net profit as a percentage of assets is negative but insignificant (-0.1141, $p = 0.540$ in Step 1; -0.1087, $p = 0.463$ in Step 2). Other variables, such as economic growth and lending rate (foreign currency), are insignificant in both steps, suggesting limited direct effects on NPL levels. Economic growth (0.0803, $p = 0.712$ in Step 2) appears to have a marginal positive association with NPLs, while lending rate changes (-0.0053, $p = 0.830$ in Step 2) do not show a meaningful impact. These findings suggest that structural and institutional factors play a more prominent role in shaping NPL dynamics compared to macroeconomic or monetary conditions.

The post-transition variable is negative and significant (-0.2347, $p = 0.011$ in Step 1), indicating that transitioning MFIs to banks leads to a reduction in NPLs. Similarly, the Log WUI is negative and significant (-0.0526, $p = 0.003$ in Step 1) suggesting that higher global uncertainty correlates with reduced NPLs. This counterintuitive result may reflect tightened lending practices or increased risk aversion during periods of heightened uncertainty. The interaction term post-transition * WUI is also negative and significant (-0.0238, $p = 0.005$ in Step 2), highlighting that transitioned institutions are better equipped to navigate the adverse effects of global uncertainty and reflecting their enhanced resilience.

The findings underscore the importance of transitioning MFIs to banks in order to strengthen financial stability. The significant negative coefficient for the post-transition variable suggests that transitioning institutions benefit from improved governance, risk management, and regulatory compliance, leading to reduced NPL levels. Additionally, the interaction term (post-transition * WUI) highlights the resilience benefits of these transitions during periods of heightened global uncertainty. This demonstrates that institutional transformation is a key strategy for enhancing the stability of Cambodia's financial sector. The negative and significant coefficient for WUI indicates that global uncertainty correlates with reduced NPLs, likely reflecting conservative lending practices during uncertain periods. However, this result requires further exploration, as it may depend on the specific channels through which uncertainty influences financial institutions. The interaction term (post-transition * WUI) further supports the notion that transitioned institutions are better equipped to navigate fragmented global conditions, highlighting the role of institutional strength in mitigating external shocks. The persistence of NPLs, as indicated by the lagged NPL variable, underscores the need for sustained monitoring and early intervention strategies to prevent NPLs from escalating.

4.3. Robustness checks: Financial institutions' branches as a financial inclusion

To measure financial inclusion at the institutional level, this study employs the *aggregate reported loan amount*. While the total loan volume provides insight into the scale and reach

of credit provision, it does not necessarily reflect the geographic accessibility or service availability of financial institutions, particularly for underserved populations. In the literature, Beck, Demirguc-Kunt, and Martinez Peria (2007) used the number of bank branches and the number of ATMs to characterise access to and use of banking services across countries.

We suggest, therefore, using the other complementary indicator: the *number of branches of financial institutions*. The number of branches serves as a robust proxy for physical access to financial services, especially in developing economies where digital penetration remains uneven. A greater branch density per capita or per geographic area often signals enhanced financial outreach, enabling more individuals and MSMEs to interact with the formal financial system. This indicator is especially relevant in Cambodia, where rural and remote populations face both logistical and informational barriers to accessing finance. Despite the rise of mobile banking and digital platforms, physical infrastructure continues to matter for trust-building, documentation, and compliance, especially for first-time borrowers or savings clients.

Model E. Effect of MFI-to-Banks on number of branches

Table 5: Effect of MFI-to-Banks on number of branches

<i>Independent variables</i>	<i>Dependent variable: Total branches</i>					
	Step 1 main effect			Step 2 interaction effect		
	Coef	SE	P Value	Coef	SE	P Value
Lag total branches	-0.0025	0.0057	0.6660	-0.0088	0.0063	0.1590
Equity-asset ratio	-0.0150	0.0086	0.0830	-0.0227	0.0060	0.0000
Net profit as a percentage of assets	1.2804	1.9884	0.5200	1.1508	0.4731	0.0150
Post transition	3.3284	0.7046	0.0000			
Post pandemic	-0.3373	0.1965	0.0860			
Post transition * post pandemic				3.9761	0.8881	0.0000
Economic growth	-7.6778	1.4519	0.0000	-4.7126	1.3047	0.0000
Lending rate foreign currency	1.5362	0.2497	0.0000	1.8190	0.2714	0.0000
Constant	-13.3527	2.4556	0.0000	-16.2624	2.7994	0.0000
Wald Test	1,030.94			444.37		
AR (1) Test z =	-1.0800			-0.08		
Pr > z =	0.2810			0.94		
AR (2) Test z =	-1.7800			-1.93		
Pr > z =	0.0750			0.053		
Sargan Test: chi2(15) =	7.93			22.55		
Prob > chi2 =	0.047			0.094		
Hansen Test: chi2(15) =	4.06			31.9		
Prob > chi2 =	0.255			0.007		
Difference Hansen Tests	Valid			Valid		
Number of obs	647			647		
Number of groups	109			109		
Number of instruments	11			22		

Source: Authors' elaboration.

Note: Coef = coefficient; SE = Standard error.

Table 5 evaluates how the transformation from MFIs to banks influences branch expansion in Cambodia's financial sector. The key finding is the statistically significant and positive effect of the *post transition* dummy (coef = 3.3284, $p < 0.001$), indicating that institutions that have transitioned tend to expand their branch networks more than their non-transformed counterparts. This effect is further amplified during the post-pandemic recovery period, as shown by the highly significant interaction term *post transition * post pandemic* (coef = 3.9761, $p < 0.001$). This suggests that transformation enhances resilience and expansion capability in the face of macro shocks like COVID-19.

Equity-asset ratio became significant in the interaction model ($p < 0.001$), implying that well-capitalised institutions were better positioned to scale operations post-transition. Similarly, profitability and lending in foreign currency become influential only when interactions are considered, reflecting differentiated behaviour under changing macro-financial conditions. The lagged branch variable is insignificant, suggesting weak persistence in branch expansion decisions. Model diagnostics (Hansen test $p = 0.255$; AR(2) $p = 0.075$) confirm the validity of the dynamic panel estimation.

Model F. Effect of geoeconomic fragmentation on number of branches

Table 6: Effect of geoeconomic fragmentation on number of branches

<i>Independent variables</i>	<i>Dependent variable: Total branches</i>					
	Step 1 main effect			Step 2 interaction effect		
	Coef	SE	P Value	Coef	SE	P Value
Lag total branches	-0.0031	0.0052	0.5520	-0.00376	0.00528	0.4760
Equity-asset ratio	-0.0189	0.0069	0.0060	-0.01921	0.00707	0.0070
Net profit as a percentage of assets	1.0582	0.8082	0.1900	0.90841	0.78650	0.2480
Post transition	3.1466	0.6157	0.0000			
Log WUI	0.2154	0.0951	0.0230			
Post transition * log WUI				0.31767	0.06278	0.0000
Economic growth	-4.9730	1.0942	0.0000	-4.96723	1.11705	0.0000
Lending rate foreign currency	1.7383	0.2650	0.0000	1.73462	0.27099	0.0000
Cons	-17.7123	2.9504	0.0000	-15.45571	2.69060	0.0000
Wald Test	1,463.52			1,274.72		
AR (1) Test z =	-0.9400			-0.46		
Pr > z =	0.3480			0.644		
AR (2) Test z =	-1.7200			-2.01		
Pr > z =	0.0860			0.045		
Sargan Test: chi2(15) =	83.77			78.11		
Prob > chi2 =	0.000			0.000		
Hansen Test: chi2(15) =	25.69			25.8		
Prob > chi2 =	0.001			0.001		
Difference Hansen Tests	Valid			Valid		
Number of obs	647			647		
Number of groups	109			109		
Number of instruments	16			15		

Source: Authors' elaboration.

Note: Coef = coefficient; SE = Standard error.

Table 6 investigates how geoeconomic fragmentation, proxied by the log of the WUI, affects branch expansion among Cambodian financial institutions. The main effect of WUI is marginally significant ($p = 0.023$), suggesting that rising global uncertainty modestly influences institutional expansion. However, the interaction term *post transition* * *log WUI* is highly significant (coef = 0.31767, $p < 0.001$), indicating that financial institutions which have transitioned from MFIs to banks are significantly more sensitive to global uncertainty. This implies that transformed entities are more responsive, either in risk or opportunity, to shifts in the international economic environment.

While the direct effect of post-transition alone is positive but insignificant, the interaction model reveals how WUI amplifies the post-transition effect. The equity-asset ratio and lending rate in foreign currency remained significant, thereby emphasising capital structure and market pricing as key drivers. Economic growth continues to be a robust and negative predictor, aligning with the countercyclical expansion tendency of financial institutions. Although the Sargan test raises minor concerns about instrument overidentification ($p = 0.000$), the Hansen test confirms instrument validity ($p = 0.001$). Overall, findings underscore that financial institutions' expansion strategies are shaped not only by domestic structural changes but also by exposure to global economic fragmentation, particularly for upgraded entities.

5. Conclusion

This study underscores the critical importance of promoting financial inclusion and financial risk in Cambodia's financial sector amidst a global geoeconomic fragmentation. The transition of MFIs into banks has likely proven to be a significant step toward building resilience, enhancing access to credit, and mitigating external economic shocks.

For the *pre-pandemic period*, our study found that financial inclusion was driven primarily by the persistence of prior access to financial services, which indicates a self-reinforcing dynamic. Financial risk, measured through NPLs, demonstrated a downward trend driven by the transition of MFIs. However, rising NPLs are also significantly influenced by lagged NPLs, economic growth, and the size of financial institutions in terms of assets and equity, which highlights the potential for over-lending during economic booms.

During the *post-pandemic period*, our findings suggest the financial landscape became more challenging. NPLs increased during this period due to the adverse impacts of the global pandemic, though NPLs decline during this period, largely due to the positive effects of transitioning MFIs to banks. While global uncertainty correlates with reduced NPLs, likely reflecting more conservative lending, it did not significantly impact loan access. Importantly, transformed institutions expanded their branch networks more than their non-transformed counterparts, with this effect becoming more pronounced during the post-pandemic recovery. Additionally, financial institutions that have transitioned are more responsive to global uncertainty, suggesting heightened sensitivity to both risk and opportunity in a fragmented international environment.

Based on these findings, the authors provide the following policy recommendations:

- The model reveals the strong persistence of past NPLs that could determine the current NPL. As a result, prudent measures should be a priority. Strengthening bank supervision through stress testing exercises, onsite inspections, and preparing resolution arrangements for the high NPLs through loan restructuring are options to address this issue. Such measures will ensure that financial institutions remain resilient in the face of economic uncertainty, especially in a geoeconomic fragmentation.

- While expanding financial inclusion remains crucial, maintaining a balance between access to finance and risk management is equally important. The post-pandemic rise in NPLs highlights the need for better credit assessment practices to verify borrower credibility. Financial institutions should focus on promoting productive loans that support business expansion and investment rather than non-productive lending. Ensuring that borrowers have the financial capacity to repay loans will contribute to the long-term sustainability of the financial sector.
- Given the rising NPL levels, it is essential to fast-track the implementation of a deposit insurance scheme to further strengthen financial system stability and maintain depositor confidence. A well-structured deposit insurance system can help prevent panic-driven bank runs and enhance public trust in the financial sector, particularly during economic downturns. Establishing this mechanism promptly will reinforce financial resilience and protect depositors from potential losses.
- Over-reliance on foreign capital inflows presents a long-term vulnerability for Cambodia's financial sector. The potential for sudden capital withdrawals poses external risks that could disrupt economic stability. To mitigate this, policymakers should focus on promoting domestic capital mobilisation by developing local funding platforms. Encouraging domestic investment and fostering a self-sustaining financial ecosystem will reduce dependency on volatile foreign capital and ensure a more stable economic environment.
- The evidence of MFIs transitioning to banks and its relation in reducing NPLs, even in the uncertain context, demonstrates that it is worth considering encouraging consolidation in the financial sector through mergers and acquisitions. In particular, mergers and acquisitions can help maintain the sector's survival and improve efficiency while ensuring financial inclusion of low-income and rural populations. Well-managed consolidation efforts can help improve economies of scale, strengthen governance frameworks, and ensure long-term sectoral stability.
- Transitioning MFIs into banks should be guided by sustainable growth strategies rather than be driven by regulatory pressures or institutional distress. While the transition can enhance financial resilience and expand credit access, it should be encouraged only when MFIs demonstrate strong financial health and growth potential. Policymakers should ensure that such transitions are well-planned, with appropriate regulatory support to facilitate a smooth and beneficial transformation.
- The role of commercial banks in providing microcredits should be reassessed to prevent unnecessary overlaps with MFIs. While this study does not include disaggregated loan-size data, policy literature and stakeholder discussions have highlighted growing overlaps in the provision of microcredit by commercial banks and MFIs. To safeguard the financial system's inclusivity and specialisation, future regulatory dialogues should consider exploring clearer institutional definitions, particularly in terms of client targeting, product structuring, and risk assessment. As some commercial banks expand their retail outreach, it is important to ensure that MFIs continue to serve their core low-income and rural client base without being crowded out. This recommendation is intended as a strategic consideration for future policy inquiry rather than a direct finding from the panel analysis and should be revisited when borrower-level or loan-size-segmented data become available.

Our study has some limitations. First, due to the unavailability of granular data, we do not have access to loan data at the customer level. Consequently, relying on aggregate loan amounts by institution may not be an ideal indicator for measuring financial access (i.e., access to loans). Future research could address this limitation by incorporating more detailed, customer-level data. In addition, while the model effectively captures key relationships, the insignificant role of profitability and lending rates raises questions about whether additional variables, such as sectoral risk exposure and borrower characteristics, might better explain variations in NPLs. Additionally, the study employs the WUI to represent uncertainty over time, which we hypothesise is, to some extent, a result of global fragmentation. Future research could benefit from using a variety of indices to further explore and validate the real impact of global geo-economic fragmentation.

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Annexes

Annexe A1: Reports of NBC on microfinance

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1	Comparative Report on Total Assets
2	Report on Registered Equity Ratio
3	Balance Sheet Report
4	Report on Asset and Inactive Asset Ratios (%)
5	Profit-Loss Report
6	Net Profit Report
7	Comparative Report on Total Deposits
8	Deposit Report by Account Type
9	Total Loans and Non-Performing Loans Report
10	Total Loans by Business Type Report
11	Loans by Business Type Report
12	Loan-to-Deposit Ratio Report
13	Report on Number of Branches and Operational Areas of MFIs
14	Staff Number Report
-

Source: Authors' elaboration.

Annexe A2: List of financial institutions

No.	Name	No.	Name	No.	Name
1	AMK	41	Golden Cash	81	RAFCO
2	AMZ	42	Grow	82	Rolya
3	ANAKUT	43	Hattha Kaksekar	83	Royal Microfinance
4	Active People	44	Hattha Bank Plc.	84	SAMIC
5	Aeon	45	Idemitsu Saison	85	SAWAD RUNG REUNG FINANCE (CAMBODIA) PLC
6	Amatak	46	Intean Poalroath Rongroeurng	86	Sabay Credit
7	Amret	47	JACCS	87	Sachak
8	Angkor ACE Star Credits	48	JC Finance	88	Sahaka
9	Apple Finance	49	JET's Cash Box	89	Sahakrinpheap
10	Farmer Union Development Fund	50	Prasac	90	Samaky
11	Atom Capital	51	KB Prasac Bank Plc.	91	Sambat
12	BAMC Finance	52	KEY Microfinance	92	Samporn Samakum Sahakreas Thuntoch neung matjum Kampuchea Plc.
13	BAYON Credit	53	Khemarak Microfinance Institution	93	Samrithisak Microfinance Limited
14	BNKC	54	Khmer Capital	94	Sathapana Limited
15	BORIBO	55	Kongkea Capital	95	Sathapana Bank Plc.
16	Baitang Microheranhvatho	56	LBP	96	Seilanithih
17	Bamboo Finance	57	LCH	97	Serey Oudom
18	CAM Capital	58	LED	98	Side Hustle
19	CBIRD	59	LOLC	99	Sixty Six
20	CMK	60	LY HOUR	100	Soksan
21	Cambodia Labour Care	61	Leng Navatra	101	Sonatra
22	Camma	62	MET PP Finance	102	Srey Oudom
23	Century Cambo Development	63	MIA	103	Sunny
24	Cellcard	64	Mango	104	T&Go
25	Chailease Royal Finance	65	Maxima	105	TBB
26	Chamroeun	66	Mohanokor	106	Taca
27	Chokchey	67	Mother Financial Japan	107	Thaneakea Phum
28	City Microfinance	68	Niron	108	Thida Srisawad
29	Collective Win	69	NongHyup	109	Trop Khnhom

30	Corich Microfinance	70	Oro	110	Vithey Microfinance
31	Delta Microfinance	71	PG Development	111	Vivath Golden
32	EAP	72	Kredit Microfinance	112	Vision fund
33	EAST Micro	73	Phillip Bank Plc.	113	Green Central Microfinance
34	Evergreen Microfinance	74	Piphup Thmey	114	Welcome Finance
35	Family Microfinance	75	Ponleu Chaktomuk	115	Woori Finance
36	Farmer Finance	76	Prasethpheap	116	WB Finance
37	Fist Finance	77	Prime	117	Woori Bank (Cambodia) Plc.
38	Funan Microfinance	78	Prince	118	Malis
39	Futaba Microfinance	79	Propey Microfinance	119	YCP
40	GB Microfinance	80	Queen Finance	120	YLP

Source: Authors' elaboration.

Annexe A3: Autocorrelation of the dependent variable “NPL Loan Ratio”

LAG AC	PAC	Q	Prob>Q
1 0.6403	0.6630	5.8621	0.0155
2 0.1284	-0.3219	6.124	0.0468
3 -0.1044	-0.0384	6.319	0.0971
4 -0.2006	.	7.1414	0.1286
5 -0.2367	.	8.4769	0.1318
6 -0.1851	.	9.4569	0.1495
7 -0.1664	.	10.447	0.1646
8 -0.2014	.	12.381	0.1350
9 -0.1343	.	13.67	0.1346
10 -0.0396	.	13.895	0.1779
. restore			

Source: Authors' elaboration.

Note: The Ljung-Box Q-test at lag 1 is highly significant ($p = 0.0155$), confirming strong autocorrelation with a high coefficient (0.6630). At lag 2, the autocorrelation weakens, and beyond lag 2, it is insignificant. Thus, we include only the first lag in our dynamic panel regression model.

Annexe A4: Variables description

Variable	Description	Source
<i>NPL ratio</i>	Non-performing loan as percentage of total loan. NBC classifies the loan status in 5 categories: normal, special mention, substandard, doubtful and loss. Loan is considered as non-performing loan when it falls into the third category or higher (late payment for more than 31 and 90 days respectively for short-term and long-term loan)	NBC
<i>Log loan</i>	Aggregate reported loan amount (institution-level, in log value)	NBC
<i>Log total branches</i>	Total branches of financial institutions (institution-level, in log value)	NBC
<i>Log asset</i>	Aggregate asset amount (institution-level, in log value)	NBC
<i>Equity-asset Ratio</i>	Ratio of equity to asset (institution-level, in log value)	NBC
<i>Net profit as a percentage of assets</i>	Ration of net profit to asset (institution-level, in log value)	NBC
<i>Post transition</i>	Dummy variable with the value of 1 indicating an MFI/MDI transited to bank for a certain referenced period	MFI/MDI's websites, news article
<i>Log World Uncertainty Index (WUI)</i>	The World Uncertainty Index is a measure that tracks uncertainty across the globe by text mining the country reports of the Economist Intelligence Unit.	World Uncertainty Index
<i>Economic growth</i>	Real GDP growth rate (using newly rebased 2014 GDP data)	NIS
<i>Lending Rate Foreign Currency</i>	Lending rate for USD	International Financial Statistic

Source: Authors' elaboration.

Annexe A5: Effect of MFI-to-Banks on access to loan: Step 1 main effect

Access to loan as dependent variable	Coefficient	std. err.	P Value
Lag access to loan	0.7272127	0.3628396	0.045
Equity-asset ratio	-0.0100932	0.0137406	0.463
Net profit as a percentage of assets	-0.0543849	0.9290021	0.953
Post transition	0.9084678	1.029997	0.378
Post pandemic	-0.2102169	0.1588787	0.186
Post transition * post pandemic			
Economic growth	-0.9104825	1.616164	0.573
Lending rate foreign currency	-0.0343263	0.1009216	0.734
Cons	3.996352	4.889831	0.414
Number of obs = 685			
Time variable: Year	Number of groups = 115		
Number of instruments = 23	Obs per group: min = 1		
Wald chi2(7) = 100626.97	Avg = 5.96		
Prob > chi2 = 0.000	Max = 10		
Instruments for first differences equation			
GMM-type (missing=0, separate instruments for each period unless collapsed)			
L(2/10).Netprofitaspercentageofasse collapsed			
L(1/8).lag_NPL_Loan collapsed			
Instruments for levels equation			
Standard			
post_transit1 Post_pandemic EquityAssetRatio Growth			
LendingRateForeignCurrency			
_cons			
Arellano-Bond test for AR(1) in first differences: z = -1.21 Pr > z = 0.228			
Arellano-Bond test for AR(2) in first differences: z = 0.11 Pr > z = 0.911			
Sargan test of overid. restrictions: chi2(15) = 31.88 Prob > chi2 = 0.007			
(Not robust, but not weakened by many instruments.)			
Hansen test of overid. restrictions: chi2(15) =			
(Robust, but weakened by many instruments.)			
Difference-in-Hansen tests of exogeneity of instrument subsets:			
gmm(lag_NPL_Loan, collapse eq(diff) lag(1 8))			
Hansen test excluding group: chi2(7) = 9.54 Prob > chi2 = 0.216			
Difference (null H = exogenous): chi2(8) = 11.99 Prob > chi2 = 0.152			
gmm(Netprofitaspercentageofasse, collapse eq(diff) lag(2 .))			
Hansen test excluding group: chi2(6) = 7.41 Prob > chi2 = 0.284			
Difference (null H = exogenous): chi2(9) = 14.12 Prob > chi2 = 0.118			
iv(post_transit1 Post_pandemic EquityAssetRatio Growth LendingRateForeignCurrency, eq(level))			
Hansen test excluding group: chi2(10) = 10.17 Prob > chi2 = 0.426			
Difference (null H = exogenous): chi2(5) = 11.37 Prob > chi2 = 0.045			

Source: Authors' elaboration.

Annexe A6: Effect of MFI-to-Banks on access to loan: Step 2 interaction effect

Access to loan as dependent variable	Coefficient	std. err.	P Value
Lag access to loan	0.9485758	0.2635763	0.000
Equity-asset ratio	-0.0028416	0.0106047	0.789
Net profit as a percentage of assets	-0.9260044	1.066355	0.385
Post transition			
Post pandemic			
Post transition * post pandemic	0.1794148	0.8230927	0.827
Economic growth	-0.1222539	1.570201	0.938
Lending rate foreign currency	0.077218	0.1002379	0.441
Cons	0.0408582	3.948663	0.992
Number of obs = 685			
Time variable: Year	Number of groups = 115		
Number of instruments = 22	Obs per group: min = 1		
Wald chi2(6) = 117934.50	Avg = 5.96		
Prob > chi2 = 0.000	Max = 10		
Instruments for first differences equation			
GMM-type (missing=0, separate instruments for each period unless collapsed)			
L(2/10).Netprofitaspercentageofasse collapsed			
L(1/8).lag_NPL_Loan collapsed			
Instruments for levels equation			
Standard			
Post_transit1_Post_Pandemic EquityAssetRatio Growth			
LendingRateForeignCurrency			
_cons			
Arellano-Bond test for AR(1) in first differences: z = -1.32 Pr > z = 0.187			
Arellano-Bond test for AR(2) in first differences: z = 0.72 Pr > z = 0.472			
Sargan test of overid. restrictions: chi2(15) = 22.80 Prob > chi2 = 0.088			
(Not robust, but not weakened by many instruments.)			
Hansen test of overid. restrictions: chi2(15) = 24.79 Prob > chi2 = 0.053			
(Robust, but weakened by many instruments.)			
Difference-in-Hansen tests of exogeneity of instrument subsets:			
gmm(lag_NPL_Loan, collapse eq(diff) lag(1 8))			
Hansen test excluding group: chi2(7) = 10.11 Prob > chi2 = 0.183			
Difference (null H = exogenous): chi2(8) = 14.68 Prob > chi2 = 0.066			
gmm(Netprofitaspercentageofasse, collapse eq(diff) lag(2 .))			
Hansen test excluding group: chi2(6) = 9.23 Prob > chi2 = 0.161			
Difference (null H = exogenous): chi2(9) = 15.55 Prob > chi2 = 0.077			
iv(Post_transit1_Post_Pandemic EquityAssetRatio Growth LendingRateForeignCurrency, eq(level))			
Hansen test excluding group: chi2(11) = 18.83 Prob > chi2 = 0.064			
Difference (null H = exogenous): chi2(4) = 5.95 Prob > chi2 = 0.203			

Source: Authors' elaboration.

Annexe A7: Effect of fragmented world on access to loan: Step 1 main effect

Access to loan as dependent variable	Coefficient	std. err.	P Value
Lag access to loan	0.8815658	0.457163	0.054
Equity-asset ratio	-0.0038743	0.0191158	0.839
Net profit as a percentage of assets	-0.459897	1.402398	0.743
Post transition	0.4496843	1.286035	0.727
Log WUI	0.4273762	0.3453904	0.216
Post transition * log WUI			
Economic growth	0.2961972	2.2504	0.895
Lending rate foreign currency	0.100067	0.1762358	0.57
Cons	-3.804787	10.57661	0.719
Number of obs = 685			
Time variable: Year	Number of groups = 115		
Number of instruments = 23	Obs per group: min = 1		
Wald chi2(7) = 114661.70	Avg = 5.96		
Prob > chi2 = 0.000	Max = 10		
Instruments for first differences equation			
GMM-type (missing=0, separate instruments for each period unless collapsed)			
L(2/10).Netprofitaspercentageofasse collapsed			
L(1/8).lag_NPL_Loan collapsed			
Instruments for levels equation			
Standard			
post_transit1 log_WUI EquityAssetRatio Growth LendingRateForeignCurrency			
_cons			
Arellano-Bond test for AR(1) in first differences: z = -1.17 Pr > z = 0.241			
Arellano-Bond test for AR(2) in first differences: z = 0.48 Pr > z = 0.628			
Sargan test of overid. restrictions: chi2(15) = 28.99 Prob > chi2 = 0.016			
(Not robust, but not weakened by many instruments.)			
Hansen test of overid. restrictions: chi2(15) = 19.45 Prob > chi2 = 0.194			
(Robust, but weakened by many instruments.)			
Difference-in-Hansen tests of exogeneity of instrument subsets:			
gmm(lag_NPL_Loan, collapse eq(diff) lag(1 8))			
Hansen test excluding group: chi2(7) = 8.30 Prob > chi2 = 0.307			
Difference (null H = exogenous): chi2(8) = 11.15 Prob > chi2 = 0.193			
gmm(Netprofitaspercentageofasse, collapse eq(diff) lag(2 .))			
Hansen test excluding group: chi2(6) = 6.06 Prob > chi2 = 0.417			
Difference (null H = exogenous): chi2(9) = 13.39 Prob > chi2 = 0.146			
iv(post_transit1 log_WUI EquityAssetRatio Growth LendingRateForeignCurrency, eq(level))			
Hansen test excluding group: chi2(10) = 16.37 Prob > chi2 = 0.090			
Difference (null H = exogenous): chi2(5) = 3.08 Prob > chi2 = 0.688			

Source: Authors' elaboration.

Annexe A8: Effect of fragmented world on access to loan: Step 2 interaction effect

Access to loan as dependent variable	Coefficient	std. err.	P Value
Lag access to loan	0.9211907	0.258751	0.000
Equity-asset ratio	-0.0034326	0.0101995	0.736
Net profit as a percentage of assets	-0.9034536	1.111829	0.416
Post transition			
Log WUI			
Post transition * WUI	0.0327547	0.0684566	0.632
Economic growth	-1.439091	2.439316	0.555
Lending rate foreign currency	0.2580543	0.3291814	0.433
Cons	-1.537175	3.272946	0.639
Number of obs = 685			
Time variable: Year	Number of groups = 115		
Number of instruments = 21	Obs per group: min = 1		
Wald chi2(6) = 108350.15	Avg = 5.96		
Prob > chi2 = 0.000	Max = 10		

Instruments for first differences equation

GMM-type (missing=0, separate instruments for each period unless collapsed)

L(2/10).Netprofitaspercentageofasse collapsed

L(1/8).lag_NPL_Loan collapsed

Instruments for levels equation

Standard

Post_transit1_1_WUI EquityAssetRatio

Growth

_cons

Arellano-Bond test for AR(1) in first differences: z = -1.35 Pr > z = 0.178

Arellano-Bond test for AR(2) in first differences: z = 0.61 Pr > z = 0.542

Sargan test of overid. restrictions: chi2(14) = 22.57 Prob > chi2 = 0.068

(Not robust, but not weakened by many instruments.)

Hansen test of overid. restrictions: chi2(14) = 23.08 Prob > chi2 = 0.059

(Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:

gmm(lag_NPL_Loan, collapse eq(diff) lag(1 8))

Hansen test excluding group: chi2(6) = 7.35 Prob > chi2 = 0.289

Difference (null H = exogenous): chi2(8) = 15.73 Prob > chi2 = 0.046

gmm(Netprofitaspercentageofasse, collapse eq(diff) lag(2 .))

Hansen test excluding group: chi2(5) = 6.27 Prob > chi2 = 0.281

Difference (null H = exogenous): chi2(9) = 16.81 Prob > chi2 = 0.052

iv(Post_transit1_1_WUI EquityAssetRatio Growth, eq(level))

Hansen test excluding group: chi2(11) = 20.57 Prob > chi2 = 0.038

Difference (null H = exogenous): chi2(3) = 2.51 Prob > chi2 = 0.474

Source: Authors' elaboration.

Annexe A9: Effect of MFI-to-Banks on NPL: Step 1 main effect

NPL Loan as dependent variable	Coefficient	std. err.	P Value
Lag NPL loan	0.1576913	0.0817631	0.054
Log asset	0.0540582	0.0246009	0.028
Equity-asset ratio	0.0020706	0.0009528	0.03
Net profit as a percentage of assets	-0.0930021	0.1082591	0.39
Post transition	-0.1982775	0.077908	0.011
Post pandemic	0.0471611	0.0192717	0.014
Post transition * post pandemic			
Economic growth	0.4165082	0.1520918	0.006
Lending rate foreign currency	-0.0018284	0.0117986	0.877
Cons	-0.6416615	0.3931911	0.103
Number of obs = 806	Obs per group: min = 1		
Time variable: Year	Wald chi2(8) = 80.65		
Number of groups = 120	avg = 6.72		
Number of instruments = 32	Prob > chi2 = 0.000 max = 11		

Instruments for first differences equation

GMM-type (missing=0, separate instruments for each period unless collapsed)

L(2/10).(Netprofitaspercentageofasse log_asset) collapsed

L(1/8).lag_NPL_Loan collapsed

Instruments for levels equation

Standard

post_transit1 Post_pandemic EquityAssetRatio Growth

LendingRateForeignCurrency

_cons

Arellano-Bond test for AR(1) in first differences: z = -1.67 Pr > z = 0.095

Arellano-Bond test for AR(2) in first differences: z = -1.84 Pr > z = 0.066

Sargan test of overid. restrictions: chi2(23) = 51.34 Prob > chi2 = 0.001

(Not robust, but not weakened by many instruments.)

Hansen test of overid. restrictions: chi2(23) = 27.49 Prob > chi2 = 0.236

(Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:

gmm(lag_NPL_Loan, collapse eq(diff) lag(1 8))

Hansen test excluding group: chi2(15) = 14.10 Prob > chi2 = 0.518

Difference (null H = exogenous): chi2(8) = 13.39 Prob > chi2 = 0.099

gmm(Netprofitaspercentageofasse log_asset, collapse eq(diff) lag(2 .))

Hansen test excluding group: chi2(5) = 8.42 Prob > chi2 = 0.135

Difference (null H = exogenous): chi2(18) = 19.07 Prob > chi2 = 0.388

iv(post_transit1 Post_pandemic EquityAssetRatio Growth LendingRateForeignCurrency, eq(level))

Hansen test excluding group: chi2(18) = 23.33 Prob > chi2 = 0.178

Difference (null H = exogenous): chi2(5) = 4.16 Prob > chi2 = 0.527

Source: Authors' elaboration.

Annexe A10: Effect of MFI-to-Banks on NPL: Step 2 interaction effect

NPL Loan as dependent variable	Coefficient	std. err.	P Value
Lag NPL loan	0.2054055	0.0954146	0.031
Log asset	0.0690309	0.0349708	0.048
Equity-asset ratio	0.0027223	0.001548	0.079
Net profit as a percentage of assets	-0.1346851	0.1791217	0.452
Post transition			
Post pandemic			
Post transition * post pandemic	-0.2524679	0.1210475	0.037
Economic growth	0.0101699	0.1338708	0.939
Lending rate foreign currency	-0.0053593	0.0147359	0.716
Cons	-0.7595101	0.5748288	0.186
Number of obs = 806	Obs per group: min = 1		
Time variable: Year	Wald chi2(8) = 80.65		
Number of groups = 120	Avg = 6.72		
Number of instruments = 32	Prob > chi2 = 0.000		
	Max = 11		
GMM-type (missing=0, separate instruments for each period unless collapsed)			
L(2/10).(Netprofitaspercentageofasse log_asset) collapsed			
L(1/8).lag_NPL_Loan collapsed			
Instruments for levels equation			
Standard			
Post_transit1_Post_Pandemic EquityAssetRatio Growth			
LendingRateForeignCurrency			
_cons			
Arellano-Bond test for AR(1) in first differences: z = -1.88 Pr > z = 0.059			
Arellano-Bond test for AR(2) in first differences: z = -1.49 Pr > z = 0.137			
Sargan test of overid. restrictions: chi2(23) = 77.38 Prob > chi2 = 0.000			
(Not robust, but not weakened by many instruments.)			
Hansen test of overid. restrictions: chi2(23) = 31.02 Prob > chi2 = 0.122			
(Robust, but weakened by many instruments.)			
Difference-in-Hansen tests of exogeneity of instrument subsets:			
gmm(lag_NPL_Loan, collapse eq(diff) lag(1 8))			
Hansen test excluding group: chi2(15) = 20.27 Prob > chi2 = 0.162			
Difference (null H = exogenous): chi2(8) = 10.74 Prob > chi2 = 0.217			
gmm(Netprofitaspercentageofasse log_asset, collapse eq(diff) lag(2 .))			
Hansen test excluding group: chi2(5) = 7.38 Prob > chi2 = 0.194			
Difference (null H = exogenous): chi2(18) = 23.64 Prob > chi2 = 0.167			
iv(Post_transit1_Post_Pandemic EquityAssetRatio Growth LendingRateForeignCurrency, eq(level))			
Hansen test excluding group: chi2(19) = 26.42 Prob > chi2 = 0.119			
Difference (null H = exogenous): chi2(4) = 4.59 Prob > chi2 = 0.332			

Source: Authors' elaboration.

Annexe A11: Effect of fragmented world on NPL: Step 1 main effect

NPL Loan as dependent variable	Coefficient	std. err.	P Value
Lag NPL loan	0.1955686	0.0828393	0.018
Log asset	0.0696644	0.0274395	0.011
Equity-asset ratio	0.0026252	0.0011449	0.022
Net profit as a percentage of assets	-0.1141629	0.1204504	0.343
Post transition	-0.234776	0.0995914	0.018
Log WUI	-0.0526597	0.0180178	0.003
Post transition * WUI			
Economic growth	-0.0172974	0.1278451	0.892
Lending rate foreign currency	-0.0089255	0.0196306	0.649
Cons	-0.1822655	0.5775094	0.752
Number of obs = 806			
Time variable: Year	Number of groups = 120		
Number of instruments = 32	Obs per group: min = 1		
Wald chi2(8) = 55.79	Avg = 6.72		
Prob > chi2 = 0.000	Max = 11		
Instruments for first differences equation			
GMM-type (missing=0, separate instruments for each period unless collapsed)			
L(2/10).(Netprofitaspercentageofasse log_asset) collapsed			
L(1/8).lag_NPL_Loan collapsed			
Instruments for levels equation			
Standard			
post_transit1 log_WUI EquityAssetRatio Growth LendingRateForeignCurrency			
_cons			
Arellano-Bond test for AR(1) in first differences: z = -1.85 Pr > z = 0.064			
Arellano-Bond test for AR(2) in first differences: z = -1.54 Pr > z = 0.123			
Sargan test of overid. restrictions: chi2(23) = 60.04 Prob > chi2 = 0.000			
(Not robust, but not weakened by many instruments.)			
Hansen test of overid. restrictions: chi2(23) = 33.24 Prob > chi2 = 0.077			
(Robust, but weakened by many instruments.)			
Difference-in-Hansen tests of exogeneity of instrument subsets:			
gmm(lag_NPL_Loan, collapse eq(diff) lag(1 8))			
Hansen test excluding group: chi2(15) = 23.38 Prob > chi2 = 0.076			
Difference (null H = exogenous): chi2(8) = 9.86 Prob > chi2 = 0.275			
gmm(Netprofitaspercentageofasse log_asset, collapse eq(diff) lag(2 .))			
Hansen test excluding group: chi2(5) = 4.65 Prob > chi2 = 0.461			
Difference (null H = exogenous): chi2(18) = 28.60 Prob > chi2 = 0.054			
iv(post_transit1 log_WUI EquityAssetRatio Growth LendingRateForeignCurrency, eq(level))			
Hansen test excluding group: chi2(18) = 18.92 Prob > chi2 = 0.397			
Difference (null H = exogenous): chi2(5) = 14.32 Prob > chi2 = 0.014			

Source: Authors' elaboration.

Annexe A12: Effect of fragmented world on NPL: Step 2 interaction effect

NPL Loan as dependent variable	Coefficient	std. err.	P Value
Lag NPL loan	0.2054600	0.0889605	0.021
Log asset	0.0727528	0.0275477	0.008
Equity-asset ratio	0.0026923	0.001222	0.028
Net profit as a percentage of assets	-0.1086875	0.1482577	0.463
Post transition			
Log WUI			
Post transition * WUI	-0.0238497	0.008548	0.005
Economic growth	0.0803533	0.2174845	0.712
Lending rate foreign currency	-0.0053035	0.0246957	0.83
Cons	-0.7970536	0.5429637	0.142
Number of obs = 806			
Time variable: Year	Number of groups = 120		
Number of instruments = 30	Obs per group: min = 1		
Wald chi2(7) = 62.43	Avg = 6.72		
Prob > chi2 = 0.000	Max = 11		
Instruments for first differences equation			
GMM-type (missing=0, separate instruments for each period unless collapsed)			
L(2/10).(Netprofitaspercentageofasse log_asset) collapsed			
L(1/8).lag_NPL_Loan collapsed			
Instruments for levels equation			
Standard			
Post_transit1_1_WUI EquityAssetRatio Growth			
_cons			
Arellano-Bond test for AR(1) in first differences: z = -1.84 Pr > z = 0.066			
Arellano-Bond test for AR(2) in first differences: z = -1.46 Pr > z = 0.145			
Sargan test of overid. restrictions: chi2(22) = 59.58 Prob > chi2 = 0.000			
(Not robust, but not weakened by many instruments.)			
Hansen test of overid. restrictions: chi2(22) = 25.96 Prob > chi2 = 0.253			
(Robust, but weakened by many instruments.)			
Difference-in-Hansen tests of exogeneity of instrument subsets:			
gmm(lag_NPL_Loan, collapse eq(diff) lag(1 8))			
Hansen test excluding group: chi2(14) = 17.05 Prob > chi2 = 0.254			
Difference (null H = exogenous): chi2(8) = 8.91 Prob > chi2 = 0.350			
gmm(Netprofitaspercentageofasse log_asset, collapse eq(diff) lag(2 .))			
Hansen test excluding group: chi2(4) = 5.04 Prob > chi2 = 0.283			
Difference (null H = exogenous): chi2(18) = 20.92 Prob > chi2 = 0.283			
iv(Post_transit1_1_WUI EquityAssetRatio Growth, eq(level))			
Hansen test excluding group: chi2(19) = 23.27 Prob > chi2 = 0.226			
Difference (null H = exogenous): chi2(3) = 2.69 Prob > chi2 = 0.442			

Source: Authors' elaboration.

Annexe A13: Effect of MFI-to-Banks on number of branches: Step 1 main effect

Total branch as dependent variable	Coefficient	std. err.	P Value
Lag total branch	-0.0025	0.0057	0.6660
Equity-asset ratio	-0.0150	0.0086	0.0830
Net profit as a percentage of assets	1.2804	1.9884	0.5200
Post transition	3.3284	0.7046	0.0000
Post pandemic	-0.3373	0.1965	0.0860
Post transition * post pandemic			
Economic growth	-7.6778	1.4519	0.0000
Lending rate foreign currency	1.5362	0.2497	0.0000
Cons	-13.3527	2.4556	0.0000
Number of obs = 647			
Time variable : Year	Number of groups = 109		
Number of instruments = 11	Obs per group: min = 1		
Wald chi2(7) = 1030.94	Avg = 5.94		
Prob > chi2 = 0.000	Max = 10		

Instruments for first differences equation

GMM-type (missing=0, separate instruments for each period unless collapsed)

L(2/3).Netprofitaspercentageofasse collapsed

L(1/3).lag_total_branch collapsed

Instruments for levels equation

Standard

post_transit1 Post_pandemic EquityAssetRatio Growth

LendingRateForeignCurrency

_cons

Arellano-Bond test for AR(1) in first differences: z = -1.08 Pr > z = 0.281

Arellano-Bond test for AR(2) in first differences: z = -1.78 Pr > z = 0.075

Sargan test of overid. restrictions: chi2(3) = 7.93 Prob > chi2 = 0.047

(Not robust, but not weakened by many instruments.)

Hansen test of overid. restrictions: chi2(3) = 4.06 Prob > chi2 = 0.255

(Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets:

gmm(lag_total_branch, collapse eq(diff) lag(1 3))

Hansen test excluding group: chi2(0) = 0.00 Prob > chi2 = .

Difference (null H = exogenous): chi2(3) = 4.06 Prob > chi2 = 0.255

gmm(Netprofitaspercentageofasse, collapse eq(diff) lag(23))

Hansen test excluding group: chi2(1) = 0.02 Prob > chi2 = 0.898

Difference (null H = exogenous): chi2(2) = 4.04 Prob > chi2 = 0.132

Source: Authors' elaboration.

Annexe A14: Effect of MFI-to-Banks on number of branches: Step 2 interaction effect

Total branch as dependent variable	Coefficient	std. err.	P Value
Lag total branch	-0.00883	0.00627	0.1590
Equity-asset ratio	-0.02268	0.00598	0.0000
Net profit as a percentage of assets	1.15084	0.47311	0.0150
Post transition			
Post pandemic			
Post transition * post pandemic	3.97615	0.88808	0.0000
Economic growth	-4.71256	1.30472	0.0000
Lending rate foreign currency	1.81904	0.27137	0.0000
Cons	-16.26243	2.79936	0.0000
Number of obs = 647			
Time variable : Year	Number of groups = 109		
Number of instruments = 22	Obs per group: min = 1		
Wald chi2(6) = 444.37	Avg = 5.94		
Prob > chi2 = 0.000	Max = 10		
Instruments for first differences equation			
GMM-type (missing=0, separate instruments for each period unless collapsed)			
L(2/10).Netprofitaspercentageofasse collapsed			
L(1/8).lag_total_branch collapsed			
Instruments for levels equation			
Standard			
Post_transit1_Post_Pandemic EquityAssetRatio Growth			
LendingRateForeignCurrenc _cons			
Arellano-Bond test for AR(1) in first differences: z = -0.08 Pr > z = 0.940			
Arellano-Bond test for AR(2) in first differences: z = -1.93 Pr > z = 0.053			
Sargan test of overid. restrictions: chi2(15) = 22.55 Prob > chi2 = 0.094			
(Not robust, but not weakened by many instruments.)			
Hansen test of overid. restrictions: chi2(15) = 31.90 Prob > chi2 = 0.007			
(Robust, but weakened by many instruments.)			
Difference-in-Hansen tests of exogeneity of instrument subsets:			
gmm(lag_total_branch, collapse eq(diff) lag(1 8))			
Hansen test excluding group: chi2(7) = 3.39 Prob > chi2 = 0.847			
Difference (null H = exogenous): chi2(8) = 28.51 Prob > chi2 = 0.000			
gmm(Netprofitaspercentageofasse, collapse eq(diff) lag(2 .))			
Hansen test excluding group: chi2(6) = 25.01 Prob > chi2 = 0.000			
Difference (null H = exogenous): chi2(9) = 6.89 Prob > chi2 = 0.649			
iv(Post_transit1_Post_Pandemic EquityAssetRatio Growth LendingRateForeignCurrency, eq(level))			
Hansen test excluding group: chi2(11) = 13.17 Prob > chi2 = 0.283			
Difference (null H = exogenous): chi2(4) = 18.73 Prob > chi2 = 0.001			

Source: Authors' elaboration.

Annexe A15: Effect of fragmented world on number of branches: Step 1 main effect

Total branch as dependent variable	Coefficient	std. err.	P Value
Lag total branch	-0.0031	0.0052	0.5520
Equity-asset ratio	-0.0189	0.0069	0.0060
Net profit as a percentage of assets	1.0582	0.8082	0.1900
Post transition	3.1466	0.6157	0.0000
Log WUI	0.2154	0.0951	0.0230
Post transition * log WUI			
Economic growth	-4.9730	1.0942	0.0000
Lending rate foreign currency	1.7383	0.2650	0.0000
Cons	-17.7123	2.9504	0.0000
Number of obs = 647			
Time variable : Year	Number of groups = 109		
Number of instruments = 16	Obs per group: min = 1		
Wald chi2(7) = 1463.52	Avg = 5.94		
Prob > chi2 = 0.000	Max = 10		

Instruments for first differences equation

GMM-type (missing=0, separate instruments for each period unless collapsed)

L(2/4).Netprofitaspercentageofasse collapsed

L(1/5).lag_total_branch collapsed

Instruments for levels equation Standard

EquityAssetRatio post_transit1 log_WUI Growth LendingRateForeignCurrency _cons

GMM-type (missing=0, separate instruments for each period unless collapsed)

DL.Netprofitaspercentageofasse collapsed. D.lag_total_branch collapsed

Arellano-Bond test for AR(1) in first differences: z = -0.94 Pr > z = 0.348

Arellano-Bond test for AR(2) in first differences: z = -1.72 Pr > z = 0.086

Sargan test of overid. restrictions: chi2(8) = 83.77 Prob > chi2 = 0.000

(Not robust, but not weakened by many instruments.)

Hansen test of overid. restrictions: chi2(8) = 25.69 Prob > chi2 = 0.001

(Robust, but weakened by many instruments.)

Difference-in-Hansen tests of exogeneity of instrument subsets: GMM instruments for levels

Hansen test excluding group: chi2(6) = 17.48 Prob > chi2 = 0.008

Difference (null H = exogenous): chi2(2) = 8.21 Prob > chi2 = 0.017

gmm(lag_total_branch, collapse lag(15))

Hansen test excluding group: chi2(2) = 3.47 Prob > chi2 = 0.176

Difference (null H = exogenous): chi2(6) = 22.21 Prob > chi2 = 0.001

gmm(Netprofitaspercentageofasse, collapse lag(2 4))

Hansen test excluding group: chi2(4) = 11.48 Prob > chi2 = 0.022

Difference (null H = exogenous): chi2(4) = 14.21 Prob > chi2 = 0.007

iv(EquityAssetRatio post_transit1 log_WUI Growth LendingRateForeignCurrency, eq(level))

Hansen test excluding group: chi2(3) = 5.80 Prob > chi2 = 0.122

Difference (null H = exogenous): chi2(5) = 19.89 Prob > chi2 = 0.001

Source: Authors' elaboration.

Annexe A16: Effect of fragmented world on number of branches: Step 2 interaction effect

Total branch as dependent variable	Coefficient	std. err.	P Value
Lag total branch	-0.00376	0.00528	0.4760
Equity-asset ratio	-0.01921	0.00707	0.0070
Net profit as a percentage of assets	0.90841	0.78650	0.2480
Post transition			
Log WUI			
Post transition * WUI	0.31767	0.06278	0.0000
Economic growth	-4.96723	1.11705	0.0000
Lending rate foreign currency	1.73462	0.27099	0.0000
Cons	-15.45571	2.69060	0.0000
Number of obs = 647			
Time variable : Year	Number of groups = 109		
Number of instruments = 15	Obs per group: min = 1		
Wald chi2(6) = 1274.72	Avg = 5.94		
Prob > chi2 = 0.000	Max = 10		
Instruments for first differences equation			
GMM-type (missing=0, separate instruments for each period unless collapsed)			
L(2/4).Netprofitaspercentageofasse collapsed			
L(1/5).lag_total_branch collapsed			
Instruments for levels equation Standard			
EquityAssetRatio Post_transit1_1_WUI Growth LendingRateForeignCurrency _cons			
GMM-type (missing=0, separate instruments for each period unless collapsed)			
DL.Netprofitaspercentageofasse collapsed. D.lag_total_branch collapsed			
Arellano-Bond test for AR(1) in first differences: z = -0.46 Pr > z = 0.644			
Arellano-Bond test for AR(2) in first differences: z = -2.01 Pr > z = 0.045			
Sargan test of overid. restrictions: chi2(8) = 78.11 Prob > chi2 = 0.000			
(Not robust, but not weakened by many instruments.)			
Hansen test of overid. restrictions: chi2(8) = 25.80 Prob > chi2 = 0.001			
(Robust, but weakened by many instruments.)			
Difference-in-Hansen tests of exogeneity of instrument subsets: GMM instruments for levels			
Hansen test excluding group: chi2(6) = 18.29 Prob > chi2 = 0.006			
Difference (null H = exogenous): chi2(2) = 7.51 Prob > chi2 = 0.023			
gmm(lag_total_branch, collapse lag(1 5))			
Hansen test excluding group: chi2(2) = 2.78 Prob > chi2 = 0.248			
Difference (null H = exogenous): chi2(6) = 23.01 Prob > chi2 = 0.001			
gmm(Netprofitaspercentageofasse, collapse lag(2 4))			
Hansen test excluding group: chi2(4) = 10.79 Prob > chi2 = 0.029			
Difference (null H = exogenous): chi2(4) = 15.01 Prob > chi2 = 0.005			
iv(EquityAssetRatio Post_transit1_1_WUI Growth LendingRateForeignCurrency, eq(level))			
Hansen test excluding group: chi2(4) = 7.95 Prob > chi2 = 0.093			
Difference (null H = exogenous): chi2(4) = 17.85 Prob > chi2 = 0.001			

Source: Authors' elaboration.

Annexe A17: Correlation matrix

	Lag NPL loan	Log asset	Equity~o	Netpr~et	Log_WUI	Growth	Lendin~y	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Lag NPL loan	1																	
Log asset	-0.222	1																
Equity asset ratio	0.131	-0.483	1															
Net profit-asset	-0.191	0.281	0.079	1														
Log WUI	-0.050	0.024	0.029	0.015	1													
Growth	0.044	-0.063	-0.045	0.013	-0.208	1												
Lending rate	0.065	-0.088	-0.064	0.073	-0.375	0.510	1											
2013	0.130	-0.044	-0.014	0.046	-0.205	0.134	0.624	1										
2014	-0.036	-0.013	-0.067	0.065	-0.325	0.149	0.481	-0.049	1									
2015	0.015	-0.032	-0.021	0.043	-0.061	0.116	0.324	-0.057	-0.060	1								
2016	-0.047	-0.059	-0.014	-0.013	0.041	0.198	0.218	-0.068	-0.071	-0.083	1							
2017	-0.049	-0.043	0.022	-0.054	-0.133	0.224	0.010	-0.071	-0.074	-0.087	-0.103	1						
2018	-0.022	-0.013	-0.033	-0.019	-0.087	0.298	-0.088	-0.074	-0.077	-0.090	-0.107	-0.112	1					
2019	-0.001	0.027	-0.001	0.029	0.698	0.222	-0.179	-0.075	-0.078	-0.092	-0.108	-0.114	-0.118	1				
2020	-0.079	0.028	0.025	0.000	0.420	-0.878	-0.337	-0.074	-0.077	-0.091	-0.107	-0.113	-0.117	-0.119	1			
2021	0.013	0.046	0.008	-0.026	-0.488	-0.241	-0.317	-0.074	-0.077	-0.090	-0.107	-0.112	-0.116	-0.118	-0.117	1		
2022	0.036	0.035	0.036	0.027	0.095	-0.053	-0.174	-0.079	-0.082	-0.096	-0.114	-0.120	-0.124	-0.125	-0.125	-0.124	1	
2023	0.066	0.035	0.028	-0.056	-0.138	-0.034	-0.122	-0.079	-0.082	-0.097	-0.114	-0.120	-0.125	-0.126	-0.125	-0.125	-0.133	1

Source: Authors' elaboration.

Note: NPL = Nonperforming Loan; Equity~o = Equity asset ratio; Netpr~et = Net profit-asset; Lendin~y = Lending rate.

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Designing Retail and Wholesale CBDC Architectures for Cross-Border Payments

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Abstract

This paper develops a structural macroeconomic framework to evaluate the optimal design of Central Bank Digital Currencies (CBDCs) for cross-border payments. Integrating household payment choices, institutional liquidity management, and central bank welfare optimization, we systematically compare Automated Market Makers (AMM), Dealer-based intermediation, and Multilateral Netting. We highlight three key findings. First, capacity-constrained CBDC platforms generate a micro-structural “crowding-out” effect, where exogenous retail demand inadvertently forces institutional wholesale flows into legacy correspondent channels. Second, CBDC programmability induces a macro-policy substitution: central banks optimally deploy precision AML/KYC regulation to curb illicit capital flight, effectively minimizing reliance on distortionary capital controls. Finally, we map the dominance regions of each architecture. While Multilateral Netting extracts a massive “symmetry dividend” under balanced macroeconomic flows, it faces a steep welfare cliff under structural imbalances, rendering AMM and Dealer mechanisms strictly superior for asymmetric corridors.

Keywords: Retail CBDC; Wholesale CBDC; Cross-Border Payment

JEL Classification: E42; E58; F33; G28.

1 Background

Central bank digital currencies (CBDCs) are increasingly viewed as a promising solution not only for enhancing domestic payment systems but also for addressing long-standing inefficiencies in cross-border transactions. Broadly, there are two types of CBDCs under development: *retail CBDCs*, which are designed for use by the general public to improve payment convenience and promote financial inclusion, and *wholesale CBDCs*, which are issued for use by financial institutions to facilitate interbank settlement and cross-border flows. As of April 2026, there are 81 retail CBDC initiatives, 43 wCBDC projects, and 33 cases where the model has yet to be determined.¹

1.1 Retail CBDCs and Cross-Border Payments

Retail CBDCs have the potential to transform small-value cross-border remittances. This is particularly crucial for developing economies, where remittance inflows have surpassed Foreign Direct Investment (FDI) as the largest external source of income, projected to reach \$690 billion by 2025 (Monterroso & Vilan, 2025). By offering a direct digital channel, retail

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¹Source: <https://www.atlanticcouncil.org/cbdctracker/>

CBDCs could reduce dependency on costly money transfer operators (MTOs) and lower fees, which averaged 5.6% on a \$200 transfer via MTOs as of Q2 2024.²

However, retail CBDCs also face serious design and adoption challenges. These include privacy concerns, interoperability of digital wallets across jurisdictions, compliance with foreign exchange controls, and public misconceptions. For example, the rollout of China's e-CNY encountered skepticism partly due to confusion with cryptocurrency wallets and perceptions of lower convenience relative to platforms like WeChat Pay and Alipay.³ Recent research has focused on the determinants of rCBDC such as e-HKD. The primary factors influencing user willingness include privacy, settlement speed, customer support, ease of payment and the adoption by merchants (Dordal i Carreras, Kawaguchi, JIN, & Guo, 2025).

1.2 Wholesale CBDCs and Cross-Border Settlement

By contrast, wCBDCs offer a pathway for modernizing high-value cross-border interbank payments. They provide central banks with greater control over liquidity, settlement finality, and compliance. For countries exposed to geopolitical risks or sanctions, wCBDCs are also seen as a more resilient alternative to reliance on correspondent banking and SWIFT networks (Ye, 2025a).

Several cross-border wCBDC initiatives have already been launched, often coordinated by the BIS Innovation Hub. Table 1 summarizes some of the key projects, highlighting differences in system architecture, access models, FX mechanisms, and governance structures. These platforms often pursue bilateral or multilateral interoperability, aiming to reduce reliance on long correspondent banking chains and minimize pre-funding in nostro/vostro accounts.

²Source: https://remittanceprices.worldbank.org/sites/default/files/rpw_main_report_and_annex_q224.pdf, accessed July 5, 2025.

³Privacy concerns have similarly stalled discussions in the United States. To address the inconvenience of opening the standalone e-CNY app for payments, China has integrated e-CNY into WeChat Pay via a dedicated banner on the payment code page. In 2026, China entered the "e-CNY 2.0" stage, characterized by the integration of the CBDC into commercial banks' balance sheets as M1. Under this framework, banks are permitted to pay interest on e-CNY holdings, which are further protected by deposit insurance (Ye & Rengifo, 2026). These institutional shifts are expected to effectively rectify public misconceptions regarding rCBDC.

Table 1: Major Cross-border CBDC Projects and Key Design Challenges

Project	Countries/Regions	Tech Features	Objective	Status / Challenges
mBridge	China Mainland, HK SAR, UAE, Thailand, Saudi Arabia	Multilateral DLT (mBridge Ledger)	Direct cross-border wCBDC transfers, bypass SWIFT	MVP 2024; BIS withdrew Oct 2024 amid BRICS-sanctions concerns; geopolitical governance
Agorá	UK (BoE), Japan, France/Eurosystem, Korea, Mexico, Switzerland	Unified ledger with tokenized deposits + wCBDC; smart contracts	Tokenized cross-border wholesale payments via public-private partnership	41 private firms (Visa, JPMorgan, SWIFT, etc.); NY Fed withdrew Jan 2025 amid US executive order
Dunbar	Singapore, Australia, Malaysia, South Africa, BIS	Shared multi-CBDC platform (Corda, Quorum prototypes)	Direct multi-CBDC settlement on shared platform	Concluded 2022; access models, governance
Jura	France, Switzerland, BIS	DLT (Corda) + tokenized assets, dual-notary signing	Cross-border DvP and PvP for wCBDC	Concluded 2021; FX mechanism, access
Mariana	France, Switzerland, Singapore, BIS	AMM-based FX on public blockchain (DeFi-style)	Joint trading and settlement of wCBDCs via AMMs	Concluded 2023; AMM vs. dealer trade-offs
Mandala	Phase 1: Australia, Singapore, Korea, Malaysia + BIS; Phase 2 (Nov 2025) added France, India, Kuwait, Philippines	Distributed compliance with ZKPs and MPC; tested with Mariana wCBDC and SWIFT	Programmable compliance-by-design for cross-border transactions	Phase 1 PoC completed Oct 2024; Phase 2 active since Nov 2025; expanding scalability and digital asset compliance
Icebreaker	Israel, Norway, Sweden, BIS	Hub-and-spoke retail CBDC interlinking	Retail cross-border CBDC payments via FX providers	Concluded 2023; technical feasibility
Rialto	France, Italy, Malaysia, Singapore, BIS	Interlinked instant payment systems + tokenized wCBDC + AMM-based FX layer	Retail cross-border payments with real-time FX and central bank money settlement	PoC concluded Dec 2025; addresses FX and settlement frictions; multiple intermediaries remain a concern

1.3 Design Questions

Rather than evaluating individual pilot projects, this paper focuses on the normative question of how to design both retail and wholesale CBDCs for cross-border payments. We develop a unified analytical framework to explore critical trade-offs in four key dimensions: system architecture (efficiency vs. resilience), access and participation, FX conversion mechanisms, and multilateral governance. This framework aims to guide current and future platform choices to achieve secure, efficient, and inclusive cross-border digital currency systems.

2 Literature Review

CBDCs have increasingly moved to the forefront of policy discussions as potential solutions to the high costs and settlement delays endemic to the traditional correspondent banking system. While alternative instruments—such as stablecoins and central bank currency swaps—have been proposed to enhance cross-border efficiency, they face fundamental limitations: stablecoins generally fail to meet critical monetary criteria including singleness, elasticity, and robust safeguards against illicit finance (Bank for International Settlements, 2025), while currency swaps are inherently bilateral and temporary (Perez-Saiz & Zhang, 2023). By contrast, CBDCs are increasingly regarded as a more sovereign-controlled, systemic, and enduring approach to modernizing cross-border payment infrastructures.⁴

Despite this growing policy momentum, academic research specifically addressing CBDCs in cross-border settings remains limited. The existing literature can be broadly organized along three dimensions that correspond to the core contributions of this paper: (i) the absence of a formal welfare comparison across alternative FX settlement architectures; (ii) the lack of an integrated framework for retail–wholesale CBDC interactions; and (iii) the underexplored relationship between CBDC programmability and the optimal mix of compliance regulation and capital controls.

2.1 Architecture Selection: Institutional Explorations without Formal Welfare Analysis

Several cross-border wholesale CBDC pilots have been launched under the BIS Innovation Hub, each exploring distinct architectural paradigms. Project mBridge leverages a multilateral distributed ledger to disperse operational risks and enhance resilience against technical failures or geopolitical interventions, albeit at the cost of increased coordination overhead. Project Mariana emphasizes transactional efficiency through AMM-based FX pools with largely off-chain settlement, whereas Project Mandala focuses on decentralizing compliance verification to alleviate regulatory bottlenecks. More recently, Project

⁴To illustrate the scale mismatch between crypto-based and traditional channels, as of 2024 the total market capitalization of crypto assets stood at approximately \$2.5 trillion, compared with an estimated \$196.4 trillion in global cross-border payment flows (Cerutti, Firat, & Hengge, 2025).

Rialto explores interlinked instant payment systems with automated FX layers for retail cross-border payments.

However, these institutional explorations remain largely descriptive. Each project report evaluates a single architecture in isolation, without providing a formal welfare comparison across alternative mechanisms. Durfee, Maniff, and Slattery (2023) further argue that from a strict payment settlement perspective, introducing a novel form of central bank liability may not be essential to support such technological platforms. Looking ahead, legal hurdles and interoperability challenges are likely to pose more formidable constraints for wCBDC implementation than the underlying technology itself (Athanassiou, 2020).

A related and critical concern is the management of settlement risk. Whether operating under Payment-versus-Payment (PvP) or Delivery-versus-Payment (DvP) mechanisms, settlement risk inevitably persists; for context, the global scale of FX settlement risk reached \$2.2 trillion in 2022 (Glowka & Nilsson, 2022). Automated market makers (AMMs) have been proposed in several CBDC pilots to facilitate frictionless FX conversion (Gogol, Messias, Schlosser, Kraner, & Tessone, 2023). However, lessons from the institutional FX spot market suggest that traditional dealer markets, combined with prime brokerage arrangements, may provide superior liquidity risk management under large-scale capital flows (Fink, Maag, & Wehrli, 2025). Meanwhile, Lee, Martin, and Müller (2022) caution that indiscriminately adopting strict PvP structures may not always be welfare-enhancing, as instantaneous settlement can undermine liquidity optimization by precluding multilateral netting and increasing CBDC pre-positioning requirements.

This body of work highlights a fundamental gap: while the technological properties of individual architectures have been documented, no existing study provides a unified framework to formally characterize under what macroeconomic conditions each architecture—AMM, Dealer-based intermediation, or Multilateral Netting—is socially optimal. This paper addresses this gap directly, which map the dominance regions of each architecture as a function of structural flow characteristics and planner preferences.

2.2 Retail and Wholesale CBDCs: Parallel Literatures without Interaction

The academic literature on retail and wholesale CBDCs has developed along largely separate tracks. On the retail side, existing studies have primarily examined implications for domestic monetary policy (Abad, Nuño, & Thomas, 2024; Minesso, Mehl, & Stracca, 2022; Tapking, Vlassopoulos, & Caccia, 2024; Zhou, 2024), the financial stability risks arising from deposit disintermediation (Niepelt, 2024; Ozili, 2023; Ye, 2025b), and optimal design frameworks to maximize social welfare (Agur, Ari, & Dell’Ariccia, 2022; Paul, Ulate, & Wu, 2025). When cross-border dimensions are incorporated, the literature predominantly focuses on technical parameters such as access, communication protocols, currency conversion, compliance, and settlement processes (Reslow, Soderberg, & Tsuda, 2024). Research on wholesale CBDCs, meanwhile, remains largely confined to the policy reports discussed above.

Crucially, no existing work models the endogenous interaction between retail and

wholesale CBDC flows when both share a common FX liquidity pool. In practice, dual-tier CBDC platforms—where households transact via retail channels and financial institutions settle through wholesale channels on the same underlying infrastructure—create capacity externalities. As retail adoption grows, it may saturate the platform’s economic capacity, crowding out the very institutional participants vital for large-value cross-border settlements. This crowding-out mechanism is absent from the existing literature, which either analyzes retail CBDCs in a domestic context (Chiu, Davoodalhosseini, Jiang, & Zhu, 2023; Paul et al., 2025) or evaluates wholesale settlement in isolation from household payment choices.

Our model explicitly incorporates this interaction by specifying a shared friction function in which the total platform volume—the sum of retail household flows and wholesale institutional flows—jointly determines congestion costs.

2.3 Compliance, Capital Controls, and CBDC Programmability

A third strand of the literature addresses the interplay between privacy, compliance, and capital flow management in digital currency systems. Capponi, Lee, and Zhu (2025) demonstrate that unconditional anonymity in CBDC-based cross-border payments can incentivize illicit activity and ultimately degrade social welfare. Existing CBDC proposals typically rely on tiered transparency or regulated intermediaries, which inevitably expose sensitive transaction data to varying degrees. Duffie, Veneris, and Olowookere (2025) propose embedding privacy-preserving compliance mechanisms directly into ledgers through zkKYC certificates (Pauwels, 2021) and smart contracts that automatically generate suspicious activity reports (SARs). A related approach by Aldasoro, Frost, Lim, Perez-Cruz, and Shin (2025) constructs an AML compliance score and classifies entities using predetermined thresholds, with a particular focus on the off-ramp stage.

Separately, the literature on capital controls (Erten, Korinek, & Ocampo, 2021) has analyzed the welfare costs of restricting cross-border capital flows, but without considering how CBDC programmability might alter the optimal policy mix. While the broader literature, such as IMF (2020), offers a macro-financial perspective using stylized adoption scenarios, and central bank pilots like Phase II of the e-HKD project emphasize asset tokenization and programmability (Hong Kong Monetary Authority, 2025), the formal analysis of how programmable compliance substitutes for blunt capital controls remains unexplored.

This paper integrates both dimensions into a single welfare optimization. We characterize the optimal AML/KYC intensity as an interior solution that balances the marginal benefit of curbing illicit capital flight against the direct cost of excluding marginalized populations and the indirect cost of depressing legitimate transaction volumes. Our quantitative results demonstrate that CBDC programmability enables central banks to rely on precision regulation rather than distortionary capital controls, a macro-policy substitution that, to our knowledge, has not been formally derived in the existing literature.

2.4 Contribution

The papers most closely related to ours are (Chiu et al., 2023; Parra-Polania & Martinez-Ventura, 2026; Paul et al., 2025), all of which develop structural macroeconomic models of CBDC design. However, these studies focus exclusively on closed-economy settings, analyzing the impact of retail CBDCs on bank intermediation and monetary policy transmission. They do not address the cross-border dimension—the choice among alternative FX settlement architectures, the interaction between retail and wholesale tiers, or the role of capital controls—which is the central concern of our paper. Agur et al. (2022) considers optimal CBDC design in a welfare framework but abstracts from cross-border settlement mechanics entirely.

This paper fills these gaps by developing a unified structural framework that integrates household payment choices, institutional liquidity management, and central bank welfare optimization in an open-economy setting. By doing so, we formally map how the interplay between settlement efficiency, systemic resilience, domestic bank disintermediation, and capital flight determines the socially optimal CBDC architecture for different country archetypes.

3 Models

This section develops a framework to model the optimal choice of CBDC design for cross-border payments. The economy comprises three key agents: central banks, households, and financial institutions. The central bank of the issuing country seeks to maximize domestic social welfare. A complete summary of notation used throughout the paper is provided in Appendix 2.

3.1 Central Bank’s Objective

The primary objective of the central bank is to design a CBDC that facilitates cross-border payments for its residents and firms. While CBDCs can serve multiple policy purposes, as discussed in Section I, this paper focuses exclusively on their role in cross-border transactions. The model integrates payment allocation, FX market clearing, liquidity management by financial institutions, and a regulatory optimization problem encompassing system architecture, access policies, AML stringency, and capital control intensity.

Households and firms derive utility from consumption financed through payment systems, which may involve cross-border transactions requiring foreign currency. Payments face settlement frictions, liquidity costs, and FX transaction costs. Banks hold liquidity buffers to satisfy settlement needs under uncertainty.

Let α denote the centralization index of the payment system architecture, where higher α implies a more centralized system with lower communication delays. Let β represent the degree of access openness, i.e., the inclusion of non-bank entities in CBDC usage, γ measure AML/KYC intensity, and κ reflect the tightness of capital controls.

A decentralized equilibrium consists of households' payment choices, banks' liquidity buffer decisions, and FX prices e that clear markets, given the policy vector $\{\alpha, \beta, \gamma, \kappa\}$.

The central bank seeks to maximize a dynamic welfare objective that balances settlement efficiency function $\mathcal{E}(\cdot)$, systemic resilience cost function $\mathcal{R}(\cdot)$, leakage risk function $\mathcal{L}(\cdot)$, and financial inclusion function $\mathcal{I}(\cdot)$:

$$\max_{\{\alpha, \beta, \gamma, \kappa\}} \mathbb{E}_t \sum_{t=0}^{\infty} \rho_c^t \begin{bmatrix} \phi_1 & \phi_2 & \phi_3 & \phi_4 \end{bmatrix} \cdot \begin{bmatrix} \mathcal{E}_t(\alpha, \beta, \Psi) \\ -\mathcal{R}_t(\alpha) \\ -\mathcal{L}_t(\beta, \gamma, \kappa) \\ \mathcal{I}_t(\beta, \gamma, \kappa) \end{bmatrix} \quad (1)$$

where ρ_c captures the discount factor and ϕ represents the central bank's preference weights. Several remarks on functional form are in order.

In equation (1), the settlement efficiency component $\mathcal{E}(\alpha, \beta, \Psi)$ takes the form:

$$\mathcal{E}_t(\alpha, \beta, \Psi) = \mu \ln(1 + e^{-\eta D_t(\alpha; \Psi)}) + \Omega_t(\Psi, \alpha, \beta, M_{F,t}, M_{H,t}), \quad (2)$$

where

$$\Omega_t(\Psi, \alpha, \beta, M_{F,t}, M_{H,t}) = \begin{cases} \omega \beta^{1-\epsilon} - \tau(M_{F,t} + M_{H,t})^2, & \text{if } \Psi = \text{AMM-based} \\ \omega \alpha^{1-\epsilon} - \theta(M_{F,t} - M_{H,t})^2, & \text{if } \Psi = \text{Dealer} \\ \omega \frac{2 \min(M_{F,t}, M_{H,t})}{M_{F,t} + M_{H,t}} - \chi(M_{F,t} - M_{H,t})^2 & \text{if } \Psi = \text{Multilateral Netting} \end{cases}$$

In this specification, the parameter $\mu > 0$ captures the marginal social value of reducing settlement delays, η represents the sensitivity of settlement efficiency to communication delays, and $D(\alpha, \Psi)$ represents communication delays that decrease with greater system centralization, with the $\ln(\cdot)$ term capturing diminishing marginal efficiency gains from reducing such delays. We define M_F and M_H as the total demand for cross-border settlement flows denominated in the foreign and home currencies, respectively. To capture inherent differences in settlement latency across architectures, we generalize the delay function to $D(\alpha; \Psi) = d_\Psi(1 - \alpha)$, where d_Ψ is a mechanism-specific multiplier. We set $d_{\text{AMM}} = 1.2$, reflecting the additional on-chain confirmation and smart contract execution delays inherent in decentralized AMM settlement; $d_{\text{Dealer}} = 1.0$ (the benchmark); and $d_{\text{Netting}} = 0.8$, capturing the batch processing efficiencies of multilateral netting cycles, which consolidate multiple bilateral obligations into a single net settlement, thereby reducing the effective number of messages and confirmation steps required.

When the FX mechanism employs an AMM⁵ structure, efficiency takes the form

$$\Omega_t(\Psi, \alpha, \beta, M_{F,t}, M_{H,t}) = \omega\beta^{1-\epsilon} - \tau(M_{F,t} + M_{H,t})^2,$$

where ω is the weight of retail participation in AMM liquidity. Liquidity deepens with broader retail access β , reflecting crowding-in effects typical of decentralized liquidity pools. τ acts as the AMM slippage cost parameter. Slippage costs rise quadratically with the aggregate FX order size, highlighting that while small-value transactions enhance pool depth, large trades face increasing marginal costs.

In the dealer-based FX setup, liquidity is supplied by institutional dealer balance sheets. Settlement efficiency improves with greater system centralization α as a more unified infrastructure reduces latency in price discovery and order routing across dealer networks.

$$\Omega_t(\Psi, \alpha, \beta, M_{F,t}, M_{H,t}) = \omega\alpha^{1-\epsilon} - \theta(M_{F,t} - M_{H,t})^2$$

The term $\omega\alpha^{1-\epsilon}$ captures this concave benefit, using the same functional form and parameters as the AMM specification to maintain comparability. Transaction costs depend on order flow imbalances $(M_{F,t} - M_{H,t})^2$, with θ summarizing the inverse of market depth.

Finally, under multilateral netting arrangements, efficiency is modeled as

$$\Omega_t(\Psi, \alpha, \beta, M_{F,t}, M_{H,t}) = \omega \frac{2 \min(M_{F,t}, M_{H,t})}{M_{F,t} + M_{H,t}} - \chi(M_{F,t} - M_{H,t})^2.$$

The first term represents the efficiency gain derived from flow symmetry, microfounded in Appendix B from a model of bilateral obligation cancellation. The balance ratio falls within $[0, 1]$. When cross-border flows are completely balanced, the system achieves a maximum benefit of ω . Notably, netting achieves this benefit without requiring policy distortions—it does not rely on high retail access β (avoiding deposit substitution risks) nor high centralization α (avoiding geopolitical risks). The second term is the squared residual position after netting, which equals the flow imbalance. The parameter χ governs the cost per unit of residual imbalance, with $\chi < \theta$ reflecting the superior netting efficiency of coordinated multilateral settlement relative to bilateral dealer intermediation.

In equation (1), $\mathcal{R}(\alpha)$ represents the resilience cost, capturing the degree of distributed ledger and centralization in the application of CBDC on cross-border payments:

$$\mathcal{R}(\alpha) = \underbrace{\lambda_1(1-\alpha)^T}_{\text{Technological Risk}} + \underbrace{\lambda_2\alpha^G}_{\text{Geopolitical Risk}} \quad (3)$$

In equation (3), λ_1 measures the weight the central bank assigns to technological re-

⁵AMMs have gained increasing attention since the emergence of decentralized exchanges such as Uniswap. Unlike traditional dealer-based order book structures, AMMs determine the exchange rates between token x and token y directly via smart contracts. For example, in Uniswap v2, the swap ratio is governed by the constant product AMM: $x \cdot y = k$, where k is a constant. For further discussion, see (Mohan, 2022; Xu, Paruch, Cousaert, & Feng, 2023). The technical discussion about how AMM can be applied to CBDCs through layer 2 is from (Gogol et al., 2023).

silience. The term $(1 - \alpha)^T$ captures how decentralization influences technical vulnerability. A more decentralized system reduces single-point-of-failure risks but may introduce synchronization and governance complexities. λ_2 reflects the importance of geopolitical resilience in the planner's welfare objective. A higher parameter G indicates higher susceptibility to sanctions or network partition risks. Therefore, this formulation allows the model to jointly account for operational and geopolitical fragility in CBDC platform design. Higher $\mathcal{R}$ reflects increased expected costs due to technical outages or international fragmentation, prompting central banks to consider how architectural choices and compliance regimes can mitigate such risks.

Whereas $\mathcal{L}(\beta, \gamma, \kappa)$ in equation (1) captures the leakage risks as follows:

$$\mathcal{L}_t(\beta, \gamma, \kappa) = \underbrace{l_1(1 - e^{-\nu\beta})\Delta\text{Deposits}_t}_{\text{Deposit Substitution}} + \underbrace{(1 - l_1)\gamma^{-1} \cdot \text{CapitalFlight}_{\kappa,t}}_{\text{Capital Flight}} \quad (4)$$

The first term in equation (4) models the crowding out of traditional bank deposits due to increased retail CBDC uptake and raising banks' funding costs (Niepelt, 2024; Vollmar & Wening, 2024). The exponential saturation reflects diminishing incremental uptake as access nears universality, while $\Delta\text{Deposits}_t$ quantifies the potential loss in bank funding. ν is the sensitivity of deposit substitution. The weight l_1 indicates the central bank's relative concern for domestic banking system disintermediation. As for the second term, it captures the risk of cross-border capital outflows facilitated by weak compliance regimes. γ represents AML/KYC stringency, so γ^{-1} grows as compliance becomes more lax. $\text{CapitalFlight}_{\kappa,t}$ increases when capital account controls κ are relaxed, reflecting the ease with which funds can exit the domestic economy (Erten et al., 2021)⁶. The complement weight $(1 - l_1)$ balances the policy emphasis on managing external drain versus internal disintermediation. The explicit form is $\text{CapitalFlight}_{\kappa,t} = \bar{C}F \cdot (1 - \kappa)^2$, where $\bar{C}F$ is the potential maximum capital outflow.

$\mathcal{I}(\beta, \gamma, \kappa)$ in equation (1) is the financial inclusion function, as issuing retail CBDC can increase financial inclusion (Armas, Ruiz, & Vásquez, 2022; Fáykiss, Nyikes, & Szombati, 2022; Lannquist & Tan, 2023):

$$\mathcal{I}_t(\beta, \gamma, \kappa) = \mathbb{I}_{\{\text{retail}\}} \left[\underbrace{\zeta \cdot \sqrt{\beta} \cdot \text{Sav}}_{\text{Remittance Efficiency Gain}} - \underbrace{(1 - \zeta)\kappa \cdot F X_{\text{prem}}^{\text{MTO}}}_{\text{Cost of Capital Controls}} - \underbrace{c_\gamma \cdot \gamma}_{\text{Compliance Exclusion Cost}} \right] \quad (5)$$

The indicator function $\mathbb{I}_{\{\text{retail}\}}$ in equation (5) specifies that this only applies to retail CBDCs. All three architectures support retail CBDC; hence $\mathbb{I}_{\{\text{retail}\}} = 1$ throughout. The

⁶While γ enters the capital flight term directly through γ^{-1} , we note that in practice, large-scale capital outflows are predominantly driven by institutional portfolio rebalancing decisions, which respond more strongly to the capital control parameter κ and macroeconomic fundamentals than to retail-oriented AML/KYC intensity. The γ^{-1} term thus captures the residual facilitation of illicit outflows under lax compliance, rather than the primary channel of institutional capital flight.

first term captures how broader retail access lowers small-value cross-border remittance costs. We assume a concave benefit function $\sqrt{\beta}$ to reflect diminishing marginal returns to financial inclusion: extending access to the most systematically marginalized populations yields the highest initial welfare gains. The second term reflects that under tight capital controls κ , traditional remittance channels often incur higher FX premiums or opaque pricing. The third term introduces a direct penalty for excessive AML/KYC stringency γ ; while rigorous compliance curbs illicit flows, overly strict identity requirements inevitably create barriers to entry for low-income or unbanked populations, directly undermining the financial inclusion mandate. The parameter c_γ captures the elasticity of this exclusion effect.

As shown in Figure 1, the central bank designs the CBDC while facing different objectives and trade-offs.

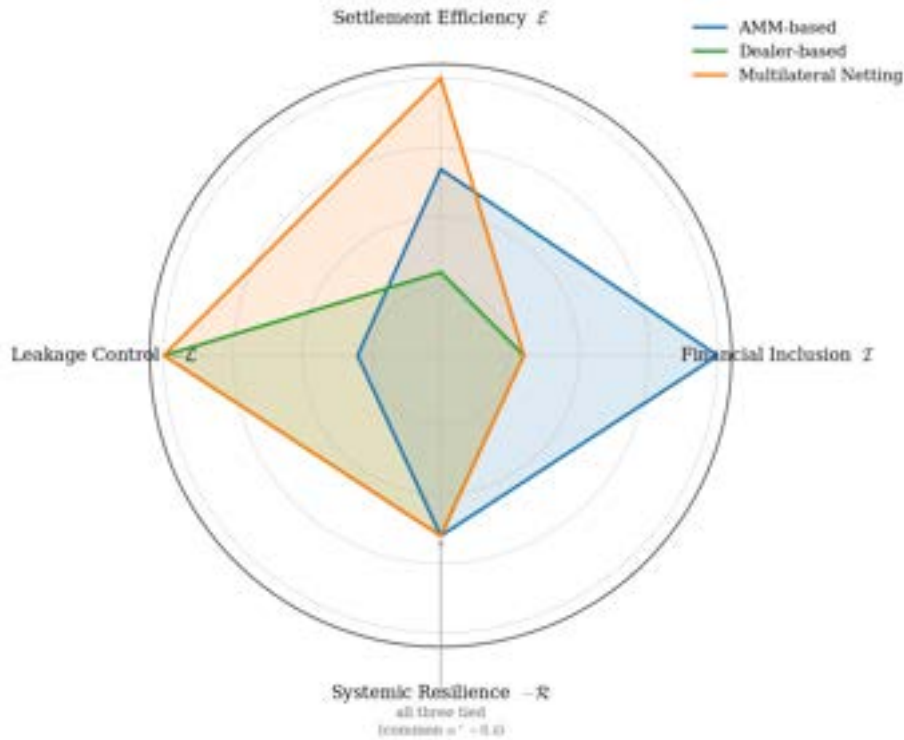


Figure 1: Central Bank Policy Trade-off

Lemma 1 (Optimal AML/KYC Intensity). *Suppose the indirect effect of γ on the efficiency function $\mathcal{E}$ via aggregate flow M_F is dominated by the direct leakage and inclusion channels in the neighborhood of the optimum:*

$$\left| \phi_1 \frac{\partial \mathcal{E}}{\partial M_F} \frac{\partial M_F}{\partial \gamma} \right| \ll \min \left\{ \phi_3 (1 - l_1) \gamma^{-2} \bar{C} F (1 - \kappa)^2, \phi_4 c_\gamma \right\}. \quad (6)$$

Then the planner's first-order condition $\partial \mathcal{W} / \partial \gamma = 0$ admits the closed-form interior solution

$$\gamma^*(\kappa) = (1 - \kappa) \sqrt{\frac{\phi_3(1 - l_1)\bar{C}F}{\phi_4 c_\gamma}} \quad (7)$$

whenever $\gamma^*(\kappa) \in [\gamma_{\min}, \gamma_{\max}]$, and a corner solution otherwise. At the optimum, the marginal benefit of mitigating capital flight is exactly equated to the direct marginal cost of compliance-induced financial exclusion:

$$\underbrace{\phi_3(1 - l_1)\gamma^{*-2}\bar{C}F(1 - \kappa)^2}_{\text{Marginal Benefit (Reduced Capital Flight)}} = \underbrace{\phi_4 c_\gamma}_{\text{Marginal Cost (Exclusion)}}.$$

The orthogonality of γ^* to the architecture Ψ — a direct implication of (6) — explains the empirical observation that optimal compliance intensity is invariant across AMM, Dealer, and Multilateral Netting in our calibration (Section 6).

Proposition 1 (Choice of FX Mechanism). *The central bank chooses the FX settlement architecture Ψ to maximize social welfare. Formally,*

$$\Psi^* = \arg \max_{\Psi \in \{\text{AMM-based, Dealer, Multilateral Netting}\}} \left\{ \max_{\{\alpha, \beta, \gamma, \kappa\}} \mathbb{E}[\mathcal{W}(\alpha, \beta, \gamma, \kappa; \Psi)] \right\}.$$

Proposition 2 (AMM–Dealer Welfare Threshold). *Let $(\alpha_D^*, \beta_D^*, \gamma_D^*, \kappa_D^*)$ and $(\alpha_A^*, \beta_A^*, \gamma_A^*, \kappa_A^*)$ denote the optimal policy vectors under Dealer and AMM, respectively. Assume $\beta_A^* > \alpha_D^*$ (i.e., the AMM mechanism requires broader retail access than the Dealer mechanism requires centralization) and that both mechanisms share common compliance and capital control optima (γ^*, κ^*) .⁷ Then AMM strictly dominates Dealer in total welfare if and only if $\omega > \omega^*$, where*

$$\omega^* = \frac{\overbrace{\Delta \mathcal{L}(\beta_A^*, \beta_D^*)}^{\text{Leakage penalty}} - \overbrace{\Delta \mathcal{I}(\beta_A^*, \beta_D^*)}^{\text{Inclusion gain}} - \overbrace{\Delta \mathcal{D}(\alpha^*; \Psi)}^{\text{Delay difference}} + \overbrace{\tau(M_F + M_H)^2 - \theta(M_F - M_H)^2}^{\text{Friction difference}}}{(\beta_A^*)^{1-\varepsilon} - (\alpha_D^*)^{1-\varepsilon}} \quad (8)$$

with component differences defined as:

$$\begin{aligned} \Delta \mathcal{L} &= \phi_3 \left[l_1(1 - e^{-\nu \beta_A^*}) \Delta \text{Dep} - l_1(1 - e^{-\nu \beta_D^*}) \Delta \text{Dep} \right], \\ \Delta \mathcal{I} &= \phi_4 \left[\zeta(\sqrt{\beta_A^*} - \sqrt{\beta_D^*}) \text{Sav} \right], \\ \Delta \mathcal{D} &= \phi_1 \left[\mu \ln(1 + e^{-\eta d_{\text{AMM}}(1 - \alpha^*)}) - \mu \ln(1 + e^{-\eta d_{\text{Dealer}}(1 - \alpha^*)}) \right]. \end{aligned}$$

Remark 1 (Economic interpretation). *Under our baseline calibration ($\beta_A^* = 0.8$, $\alpha_D^* = 0.4$, equal ϕ weights), the threshold evaluates to $\omega^* \approx 0.50$, consistent with the numerical crossing observed in Figure 6(a). A decomposition of the threshold reveals that micro-structural friction differences $\tau(M_F + M_H)^2 - \theta(M_F - M_H)^2$ contribute less than 4% of the numerator. The dominant*

⁷This assumption holds in our calibration, where γ^* and κ^* are pinned down by the leakage-inclusion trade-off independently of Ψ .

term is the net leakage–inclusion penalty: AMM’s reliance on high retail access ($\beta_A^* = 0.8$) generates substantial deposit substitution costs that are only partially offset by financial inclusion gains. This establishes that the architecture ranking is primarily governed by the macro-financial externalities of retail access, not by backend settlement frictions.

Corollary 1 (Architecture Dominance Regimes). *The optimal FX architecture Ψ^* is characterized as follows:*

- **AMM Dominance** ($\Psi^* = \text{AMM}$): *Optimal when $\omega > \omega^*$ as given by Proposition 2. The threshold ω^* decreases with flow imbalance $|M_F - M_H|$ (which raises the Dealer’s friction penalty) and increases with aggregate volume $M_F + M_H$ (which raises AMM slippage costs).*
- **Dealer Dominance** ($\Psi^* = \text{Dealer}$): *Optimal when $\omega < \omega^*$, i.e., when the macro-financial costs of broad retail access outweigh the network externality benefits. This regime is favored by economies where deposit substitution risks are acute (high l_1) or where flow imbalances are moderate.*
- **Multilateral Netting Dominance** ($\Psi^* = \text{Multilateral Netting}$): *Optimal when bilateral flows are highly symmetric ($M_F \approx M_H$), as the endogenous balance ratio $2 \min(M_F, M_H) / (M_F + M_H)$ approaches unity, yielding the maximum benefit ω without policy distortions.⁸ However, this architecture exhibits a steep welfare cliff under structural flow asymmetry, rendering AMM and Dealer mechanisms strictly superior for imbalanced corridors.*

3.2 Household optimization problem with external remittance inflows

Each household chooses the consumption c and allocates cross-border payments across three channels — direct retail CBDC payments m_F^{retail} , traditional bank wire transfers m_F^{bank} , and MTO services m_F^{MTO} — to maximize utility from consumption and remittance services, while facing transaction frictions, compliance costs, capital flow penalties, and payment habit inertia. We model households as myopic, period-by-period optimizers. This assumption is motivated by two considerations. First, cross-border remittance decisions are largely driven by immediate income needs and contemporaneous exchange rate conditions, rather than by intertemporal optimization over future platform characteristics. Second, the myopic specification allows us to isolate the role of backward-looking habit persistence as the primary endogenous source of adoption dynamics, providing a clean identification of the payment inertia channel (exogenous exchange rate shocks also generate adoption dynamics through relative cost shifts). We conjecture that introducing forward-looking behavior would primarily accelerate adoption dynamics without altering the steady-state architecture rankings; formal verification is left for future work.

⁸The Netting–AMM and Netting–Dealer thresholds depend nonlinearly on the flow balance ratio and do not admit tractable closed-form expressions. We characterize these boundaries numerically in Figure 6(b).

Household Objective Function

$$\max_{c_t, \{m_{F,t}^j\}_{j \in \{r,b,m\}}} \underbrace{\frac{c_t^{1-\sigma}}{1-\sigma}}_{\text{Consumption Utility}} + \underbrace{\frac{(m_{F,t})^{1-\sigma}}{1-\sigma}}_{\text{Remittance Utility}} - \underbrace{\frac{\xi_t}{2}(m_{F,t}^{\text{retail}} - \bar{m}_F)^2}_{\text{Payment Inertia Disutility}} \quad (9)$$

The inertia term penalizes deviations from a fixed reference level $\bar{m}_F$ (initialized at zero), capturing status quo bias rather than standard habit formation over lagged consumption.⁹

subject to the consolidated budget constraint with external remittance inflows:

$$c_t + e_t \sum_{j \in \{r,b,m\}} m_{F,t}^j + \text{PaymentCosts}(m_{F,t}^{\text{retail}}, m_{F,t}^{\text{bank}}, m_{F,t}^{\text{MTO}}) \leq y_t + m_{H,t}$$

where

$$m_{F,t} = \left[(m_{F,t}^{\text{retail}})^\rho + (m_{F,t}^{\text{bank}})^\rho + (m_{F,t}^{\text{MTO}})^\rho \right]^{\frac{1}{\rho}}$$

Payment costs The payment frictions incorporate settlement inefficiencies, AML compliance, MTO fees, and habit stickiness:

$$\begin{aligned} \text{PaymentCosts} = & \underbrace{\Phi(\Psi, m_{F,t}^{\text{retail}}) + \phi_\gamma \gamma m_{F,t}^{\text{retail}} + \phi_\kappa \kappa m_{F,t}^{\text{retail}}}_{\text{retail CBDC monetary costs}} \\ & + \underbrace{F_{\text{bank}} + p_{\text{bank}} m_{F,t}^{\text{bank}}}_{\text{bank wires}} \\ & + \underbrace{F_{\text{MTO}} + p_{\text{MTO}} m_{F,t}^{\text{MTO}}}_{\text{MTOs}} \end{aligned}$$

where ϕ_γ, ϕ_κ are the coefficients for the AML, the capital control respectively. $F_{\text{bank}}, F_{\text{MTO}}$ are the fixed cost for bank wire transfer and MTO, respectively, and $p_{\text{bank}}, p_{\text{MTO}}$ are the variable cost ratio¹⁰. The architecture-dependent settlement friction on retail CBDC is given by

$$\Phi(m_{F,t}^{\text{retail}}, \Psi) = \begin{cases} s_r m_{F,t}^{\text{retail}} & \text{if } \Psi = \text{AMM-based,} \\ s_D m_{F,t}^{\text{retail}} & \text{if } \Psi = \text{Dealer,} \\ s_N m_{F,t}^{\text{retail}} & \text{if } \Psi = \text{Multilateral Netting.} \end{cases}$$

⁹In the standard macro habit literature, the reference point is the household's own lagged consumption. Our specification instead captures the friction of departing from an established payment norm, where $\bar{m}_F = 0$ reflects a nascent CBDC deployment. The time-varying intensity ξ_t provides the dynamic element: as aggregate adoption rises, the psychological cost of using CBDC diminishes.

¹⁰ p_{bank} captures other variable costs that scale with the transaction value, such as the FX spread charged by the bank or value-dependent compliance processing costs.

where s_r is the median slippage for household in the AMM, s_D is retail FX spread in the dealer platform for the household. s_N is the household processing fee if they choose multilateral netting.

First-order conditions Let λ_t be the Lagrange multiplier associated with the household budget constraint in period t . The first-order conditions with respect to consumption c_t and remittance volumes $\{m_{F,t}^{\text{retail}}, m_{F,t}^{\text{bank}}, m_{F,t}^{\text{MTO}}\}$ are:

$$c_t^{-\sigma} - \lambda_t = 0 \implies \lambda_t = c_t^{-\sigma}, \quad (10)$$

$$\underbrace{(m_{F,t}^{\text{retail}})^{\rho-1} M_{F,t}^{1-\sigma-\rho}}_{\text{MU of Remittance}} - \underbrace{\xi_t (m_{F,t}^{\text{retail}} - \bar{m}_F)}_{\text{Marginal Inertia Disutility}} - \lambda_t \underbrace{\left[e_t + \frac{\partial \Phi}{\partial m_{F,t}^{\text{retail}}} + \phi_\gamma \gamma + \phi_\kappa \kappa \right]}_{\text{Marginal Monetary Cost}} = 0. \quad (11)$$

$$\underbrace{(m_{F,t}^{\text{bank}})^{\rho-1} M_{F,t}^{1-\sigma-\rho}}_{\text{MU of Remittance}} - \lambda_t \underbrace{[e_t + p_{\text{bank}}]}_{\text{Marginal Monetary Cost}} = 0, \quad (12)$$

$$\underbrace{(m_{F,t}^{\text{MTO}})^{\rho-1} M_{F,t}^{1-\sigma-\rho}}_{\text{MU of Remittance}} - \lambda_t \underbrace{[e_t + p_{\text{MTO}}]}_{\text{Marginal Monetary Cost}} = 0. \quad (13)$$

where the marginal settlement friction for retail CBDC is derived as a constant depending on the architecture:

$$\frac{\partial \Phi}{\partial m_{F,t}^{\text{retail}}} = \begin{cases} s_r & \text{if } \Psi = \text{AMM-based,} \\ s_D & \text{if } \Psi = \text{Dealer,} \\ s_N & \text{if } \Psi = \text{Multilateral Netting.} \end{cases}$$

Equilibrium Implication This system determines the household's optimal allocation of resources in each period. Explicitly, the FOCs pin down the demand for each remittance channel as a function of relative prices, policy frictions (γ, κ) , technological efficiencies (s_r, s_D, s_N) , and the time-varying inertia parameter ξ_t .

Aggregating across a measure one continuum of identical households, the total economy-wide remittance volume for each channel $j \in \{\text{retail, bank, MTO}\}$ in period t is given by $M_{F,t}^j = \int_0^1 m_{F,t}^j(i) di$. The total cross-border flow is the simple sum:

$$M_{F,t}^{\text{total}} = M_{F,t}^{\text{retail}} + M_{F,t}^{\text{bank}} + M_{F,t}^{\text{MTO}} \quad (14)$$

Proposition 3 (Comparative Statics). *Under the CES preference structure with monetary budget constraints, the optimal household remittance allocation $m_{F,t}^{j,*}$ satisfies the following properties:*

1. **Own-Price Effects (Negative):** An increase in the marginal cost of a specific channel re-

duces the demand for that channel.

$$\frac{\partial m_{F,t}^{\text{retail},*}}{\partial \gamma} < 0, \quad \frac{\partial m_{F,t}^{\text{retail},*}}{\partial \kappa} < 0, \quad \frac{\partial m_{F,t}^{\text{retail},*}}{\partial s_r} < 0, \quad \frac{\partial m_{F,t}^{\text{bank},*}}{\partial p_{\text{bank}}} < 0$$

2. **Cross-Price Substitution Effects (Positive):** Due to imperfect substitutability (assuming $\rho \in (0, 1)$), an increase in the cost of traditional channels induces a substitution towards retail CBDC.

$$\frac{\partial m_{F,t}^{\text{retail},*}}{\partial p_{\text{bank}}} > 0, \quad \frac{\partial m_{F,t}^{\text{retail},*}}{\partial p_{\text{MTO}}} > 0$$

3. **Inertia Effect:** Habit stickiness impedes deviations from historical usage. Assuming the household is in an adoption phase (where optimal $m_{F,t}^{\text{retail},*} > \bar{m}_F$), stronger inertia reduces CBDC uptake:

$$\frac{\partial m_{F,t}^{\text{retail},*}}{\partial \xi_t} < 0$$

3.3 Financial Institutions

Financial institutions (FIs) do not derive direct utility from financial inclusion in the same way households do. Instead, as primary users of wCBDC and key intermediaries, they face a cost minimization problem balancing liquidity provision, operational expenses, and settlement risks. To mitigate financial disintermediation, central banks often adopt indirect issuance models. For example, the "Phase 2.0" framework of China's E-CNY reclassifies the digital renminbi as a liability of commercial banks, incorporating wallet balances into the reserve requirement system to preserve the banks' role in credit intermediation¹¹ (Bai, Cong, Luo, & Xie, 2025).

A representative FI acts as an aggregator. It processes exogenous "agency flows" originating from households ($m_{F,t}^{\text{retail}}$ via CBDC and $m_{F,t}^{\text{bank}}$ via traditional wires) and manages its own "proprietary flows" $M_{F,t}^{\text{inst}}$ for interbank settlement. The FI allocates its proprietary volume between the new wCBDC channel ($m_{F,t}^{\text{wCBDC}}$) and the traditional correspondent channel ($m_{F,t}^{\text{corr}}$).

A representative FI chooses liquidity buffers $L_{F,t}$ for settlement to minimize total expected costs in period t , with the objective function:

$$\begin{aligned} \min_{L_{F,t}, m_{F,t}^{\text{wCBDC}}, m_{F,t}^{\text{corr}}} \quad & \left\{ \underbrace{r_{F,t} L_{F,t}}_{\text{opportunity cost}} + \underbrace{\text{Penalty} \cdot e^{-\frac{L_{F,t}}{\sigma_{F,t}}}}_{\text{settlement failure risk}} \right. \\ & + \underbrace{\Phi^{FI}(\Psi, \underbrace{m_{F,t}^{\text{retail}} + m_{F,t}^{\text{wCBDC}}}_{\text{Total Platform Vol. } m_{F,t}^{\text{total}}})}_{\text{cost of using the new platform}} + \underbrace{F_{\text{corr}} + p_{\text{corr}} \cdot (m_{F,t}^{\text{bank}} + m_{F,t}^{\text{corr}})}_{\text{cost of using correspondent banking}} \left. \right\} \quad (15) \end{aligned}$$

¹¹See Lu Lei, "Transition to E-CNY Phase 2.0," Dec 29, 2025. Source: <https://finance.sina.com.cn/xwzmt/2025-12-29/doc-inhenau17986592.shtml> (in Chinese)

subject to:

$$m_{F,t}^{\text{corr}} + m_{F,t}^{\text{wCBDC}} = M_{F,t}^{\text{inst}}$$

Here, the input to the friction function Φ^{FI} includes both household retail CBDC flows $m_{F,t}^{\text{retail}}$ and the FI's wholesale CBDC flows $m_{F,t}^{\text{wCBDC}}$, reflecting that retail and wholesale orders likely share the same underlying FX liquidity pool. Conversely, traditional bank wires $m_{F,t}^{\text{bank}}$ initiated by households are routed through the correspondent banking system, adding to the FI's aggregate correspondent volume. We note that current CBDC pilots do not yet implement this shared-pool design: Project mBridge and Project Mariana are wholesale-only platforms, while Project Aurum's two-tier prototype maintains separate retail and wholesale systems. However, unified-ledger proposals—such as those advanced by the (Bank for International Settlements, 2023)—envision precisely such integration of retail and wholesale settlement onto a common infrastructure. The shared-pool specification is therefore a policy-relevant forward-looking scenario that allows us to identify the crowding-out externality. We formally assess the sensitivity of this assumption through a separated-pool robustness check.

The term $e^{-\frac{L_{F,t}}{\sigma_{F,t}}}$ represents the *probability of settlement failure*, which decreases as the foreign liquidity buffer $L_{F,t}$ grows relative to flow volatility $\sigma_{F,t}$.

$$\Phi^{FI}(m_{F,t}^{\text{total}}; \Psi) = \begin{cases} \tau(m_{F,t}^{\text{total}})^2 & \text{if } \Psi = \text{AMM-based,} \\ \theta(m_{F,t}^{\text{total}})^2 & \text{if } \Psi = \text{Dealer,} \\ \chi_w(m_{F,t}^{\text{total}})^2 & \text{if } \Psi = \text{Multilateral Netting.} \end{cases}$$

Taking the first-order condition with respect to $L_{F,t}$ yields:

$$r_{F,t} - \frac{\text{Penalty}}{\sigma_{F,t}} e^{-\frac{L_{F,t}}{\sigma_{F,t}}} = 0$$

Solving for the optimal buffer $L_{F,t}^*$:

$$L_{F,t}^* = \sigma_{F,t} \ln \left(\frac{\text{Penalty}}{r_{F,t} \cdot \sigma_{F,t}} \right) \quad (16)$$

For the optimal settlement channel allocation, substituting $m_{F,t}^{\text{corr}} = M_{F,t}^{\text{inst}} - m_{F,t}^{\text{wCBDC}}$ into the objective function and differentiating with respect to $m_{F,t}^{\text{wCBDC}}$ gives:

$$\frac{\partial \Phi^{FI}}{\partial m_{F,t}^{\text{total}}} = p_{\text{corr}} \quad (17)$$

where $m_{F,t}^{\text{total}} = m_{F,t}^{\text{retail}} + m_{F,t}^{\text{wCBDC}}$. This condition states that the FI allocates funds to the wCBDC channel until the marginal friction cost on the platform equals the marginal cost of correspondent banking p_{corr} .

Proposition 4. *Under the optimal liquidity buffer choice in equation (16), comparative statics in*

period t imply:

$$\frac{\partial L_{F,t}^*}{\partial \sigma_{F,t}} > 0, \quad \frac{\partial L_{F,t}^*}{\partial \text{Penalty}} > 0, \quad \frac{\partial L_{F,t}^*}{\partial r_{F,t}} < 0.$$

Financial institutions increase foreign liquidity buffers in response to higher payment volatility or severe failure penalties, but reduce them when opportunity costs rise.

Proposition 5. The optimal allocation to the wCBDC channel $m_{F,t}^{wCBDC,*}$ is determined by the efficiency of the FX mechanism Ψ . Assuming Φ^{FI} is convex, we have:

$$\frac{\partial m_{F,t}^{wCBDC,*}}{\partial p_{corr}} > 0.$$

Furthermore, comparing mechanisms Ψ_A and Ψ_B , if mechanism Ψ_A offers strictly lower marginal friction than Ψ_B for all volumes (i.e., $(\Phi_A^{FI})' < (\Phi_B^{FI})'$), then:

$$m_{F,t}^{wCBDC,*}(\Psi_A) > m_{F,t}^{wCBDC,*}(\Psi_B).$$

This implies that a more efficient FX settlement architecture incentivizes FIs to shift a larger share of proprietary liquidity flows onto the CBDC platform.

4 Partial Equilibrium Dynamics

Timing and Agent Behavior. To maintain tractability while capturing the dynamic evolution of payment habits and exogenous macroeconomic shocks, we model the economy as a sequence of temporary equilibria. The domestic economy is modeled as a small open economy (SOE), meaning it acts as a price taker in international financial markets. Households and financial institutions are modeled as myopic agents who solve static, period-by-period optimization problems given the current state variables and the exogenous exchange rate. In contrast, the central bank acts as a forward-looking planner.

A dynamic general equilibrium in this economy is defined as a sequence of allocations $\{M_{F,t}^{\text{retail}}, M_{F,t}^{\text{bank}}, M_{F,t}^{\text{MTO}}, m_{F,t}^{wCBDC}, m_{F,t}^{\text{corr}}, L_{F,t}\}_{t=0}^{\infty}$ and household states $\{\xi_t, \Pi_t^{\text{retail}}\}_{t=0}^{\infty}$, given the time-invariant policy variables $\{\alpha, \beta, \Psi, \gamma, \kappa\}$ and the exogenous stochastic processes for the exchange rate $\{e_t\}_{t=0}^{\infty}$ and FI proprietary settlement volume $\{M_{F,t}^{\text{inst}}\}_{t=0}^{\infty}$.

The equilibrium satisfies the following conditions simultaneously for all $t \geq 0$:

1. **Household Optimization (Sequence of Static Choices):** Given the current realized exchange rate e_t , static policy parameters, the historical benchmark flow $\bar{m}_F$, and the dynamic inertia intensity ξ_t , the representative household chooses consumption and cross-border payment allocations $\{M_{F,t}^{\text{retail}}, M_{F,t}^{\text{bank}}, M_{F,t}^{\text{MTO}}\}$ to maximize its period utility. This maps directly to the static first-order conditions derived in Section 3.2.

The realized retail CBDC adoption rate is defined as:

$$\Pi_t^{\text{retail}} = \frac{M_{F,t}^{\text{retail}}}{M_{F,t}^{\text{retail}} + M_{F,t}^{\text{bank}} + M_{F,t}^{\text{MTO}}} \quad (18)$$

M_H is the function of e_t .¹²

$$M_{H,t} = \bar{M}_H + \rho_H(e_t - \bar{e}) \quad (19)$$

2. **Financial Institution Optimization:** Financial institutions act as intermediaries. In each period t , they take the aggregate agency flows generated by households ($M_{F,t}^{\text{retail}}$ and $M_{F,t}^{\text{bank}}$) as given. FIs optimally allocate their exogenous proprietary interbank volume $M_{F,t}^{\text{inst}}$ between the wholesale CBDC platform ($m_{F,t}^{\text{wCBDC}}$) and correspondent banking channels ($m_{F,t}^{\text{corr}}$). They also choose the optimal foreign liquidity buffer $L_{F,t}^*$ to minimize expected costs, satisfying the conditions derived in Equations (16) and (17).

The total processing volume that generates congestion externalities on the CBDC platform in period t is the sum of retail and wholesale flows:

$$m_{F,t}^{\text{platform}} = M_{F,t}^{\text{retail}} + m_{F,t}^{\text{wCBDC}} \quad (20)$$

3. **Evolution of Payment Inertia:** The habit persistence intensity ξ_t , which governs the psychological and operational friction of deviating from the historical benchmark $\bar{m}_F$, evolves according to an AR(1) process driven by the *lagged* aggregate retail CBDC adoption rate:

$$\xi_t = \rho_\xi \xi_{t-1} + (1 - \rho_\xi) \bar{\xi} \left(1 - \Pi_{t-1}^{\text{retail}}\right) \quad (21)$$

where $\rho_\xi \in [0, 1)$ determines the persistence of the payment habit intensity, and $\bar{\xi} > 0$ represents the maximum structural inertia when the CBDC network is nascent ($\Pi \approx 0$). This adaptive specification captures positive network externalities: as past aggregate adoption increases, the systemic frictions of transitioning away from legacy channels decrease, thereby lowering the marginal disutility of utilizing the CBDC rail in the current period.

4. **Exogenous Exchange Rate Dynamics:** Under the small open economy assumption, the exchange rate e_t is entirely determined by global financial markets and remains exogenous to domestic cross-border payment flows. To capture macroeconomic volatility, we assume the exchange rate follows an exogenous AR(1) process in logs (Engel & West, 2005):

$$\ln(e_t) = (1 - \rho_e) \ln(\bar{e}) + \rho_e \ln(e_{t-1}) + \epsilon_t, \quad \epsilon_t \sim \mathcal{N}(0, \sigma_e^2). \quad (22)$$

This stochastic shock ϵ_t serves as the primary source of uncertainty driving household and FI decisions over the business cycle.

¹²Equation 18 specifies M_H as linear in the level of e_t , while Equation 21 models e_t as AR(1) in logs. Near the steady state ($e_t \approx \bar{e}$), the first-order Taylor approximation $e_t - \bar{e} \approx \bar{e}(\ln e_t - \ln \bar{e})$ ensures that the unconditional mean $\mathbb{E}[M_{H,t}] \approx \bar{M}_H$ with a Jensen's inequality correction of order $\mathcal{O}(\sigma_e^2)$, which is negligible under our calibration ($\sigma_e = 0.05$).

5. **Central Bank Policy Problem:** The central bank determines the optimal policy framework to maximize the expected discounted social welfare function (Equation 1), subject to the equilibrium constraints (1)–(4). The planner chooses the time-invariant system architecture (α, β, Ψ) and compliance/capital control rules (γ, κ) at $t = 0$. Formally:

$$\max_{\{\alpha, \beta, \Psi, \gamma, \kappa\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \rho^t \mathcal{W}_t(\cdot) \quad (23)$$

subject to the private sector’s optimal responses to the exogenous exchange rate path. A key modeling choice is that the central bank selects the policy vector $\alpha, \beta, \Psi, \gamma, \kappa$ once at $t = 0$ and commits to it permanently, even though the private sector’s equilibrium evolves dynamically. This assumption reflects the institutional reality that CBDC architecture decisions—choice of DLT platform, access framework, and FX mechanism—entail substantial sunk costs in technological infrastructure and legal frameworks, making frequent policy revisions impractical. In practice, central banks designing cross-border CBDC platforms are making long-horizon commitments: once a country joins a multilateral platform like mBridge, switching to a fundamentally different architecture involves prohibitive transition costs. The planner’s problem thus captures the ex ante optimal design under commitment, abstracting from the time-inconsistency considerations that would arise under discretionary re-optimization.

Solution Strategy. Since the equilibrium involves non-linear constraints and strategic externalities between households and FIs, an analytical closed-form solution is intractable. We therefore solve for the equilibrium numerically. Given a simulated path for the exogenous exchange rate shocks $\{\epsilon_t\}_{t=0}^T$, the simulation procedure computes the optimal responses of households and financial institutions period-by-period. The central bank’s optimal policy vector is then identified by performing a grid search over the policy space $\{\alpha, \beta, \Psi, \gamma, \kappa\}$ to maximize the simulated expected welfare.

Figure 2 depicts the overall capital flow for our model set up.

5 Quantitative Analysis

Table 3 summarizes the baseline parameter values used in our analysis¹³.

Macro and Central Bank Preferences (Panel A). The policy persistence parameter ρ is set to 0.96, following Chiu et al. (2023).¹⁴ The coefficient of relative risk aversion σ is set to 2,

¹³The calibration challenge is twofold. First, because CBDCs do not yet exist at scale in major economies, there is no direct time-series data from which to estimate these parameters econometrically. We must therefore rely on structural estimation techniques that draw proxies from adjacent markets—specifically, the deposit market for retail parameters and the interdealer FX and DeFi markets for wholesale parameters. Second, the retail channel is governed by behavioral rigidities and the bundling of banking services, which dampens the substitutability of deposits. The wholesale channel is governed by microstructure frictions, inventory costs, and the mechanics of automated settlement, where liquidity is priced dynamically based on order flow.

¹⁴Although Chiu et al. (2023) use 0.96 as a discount factor, in our model we adopt the same value for ρ_c as a policy persistence parameter. This is without loss of generality, since ρ_c serves an analogous role in governing

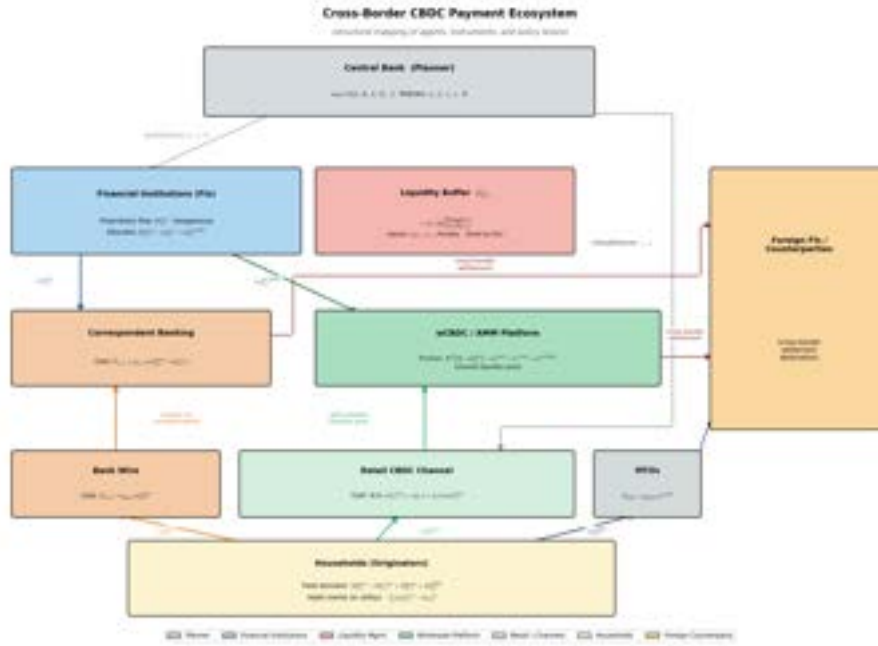


Figure 2: Cross-Border Payment Flow

ensuring standard concavity in the utility function. Central banks face a trade-off between managing capital flight and deposit substitution. Developing economies, characterized by fragile monetary foundations, are more susceptible to capital flight. Consequently, the weight on external leakage, $1 - l_1$, is larger in these jurisdictions. In contrast, advanced economies prioritize banking sector stability. We assume $l_1 = 0.2$ for developing countries and $l_1 = 0.8$ for developed countries. There is no literature or data related to the number of marginal social value of reducing delays μ , we use $\mu = 1$ as our baseline. This normalization serves as a numeraire for the welfare function and does not alter the qualitative comparative statics of the optimal policy choices. We further demonstrate the robustness of our results to alternative values of μ in the sensitivity analysis. We set $\lambda_2 = 1.5$, reflecting the heightened salience of geopolitical fragmentation risks in cross-border payment infrastructure. The asymmetry $\lambda_2 > \lambda_1$ captures the empirical observation that sanctions-related disruptions—such as the disconnection of Russian banks from SWIFT in 2022—impose systemic costs far exceeding typical technical outages.

In the absence of revealed preference data on central banks' relative policy priorities, we adopt equal weighting as an agnostic baseline. In the next section we will examine how optimal CBDC design varies under alternative weight configurations corresponding to different country archetypes.

Technology and Market Structure (Panel B). The dealer market depth parameter θ governs the cost of order flow imbalances in bilateral dealer intermediation. We calibrate $\theta = 0.001$ for major currency pairs and $\theta = 0.005$ for emerging market pairs. At the wholesale level, these values yield interior solutions for FI platform allocation: with $p_{\text{corr}} = 0.0005$ intertemporal behavior.

, the implied optimal total platform volume is $m^{total*} = 0.25$ for major pairs and 0.05 for EM pairs. At the social level, the primary distinction between AMM and Dealer architectures operates through their respective benefit channels—retail participation β versus infrastructure centralization α —rather than through the magnitude of friction costs.

For the AMM specification, while decentralized systems benefit from network effects, frictions arising from coordination costs result in concave economies of scale (Capponi & Jia, 2021). Accordingly, we constrain the scaling parameter to $\epsilon = 0.7$. We calibrate $Sav = 0.10$, reflecting the total potential cost savings from eliminating both the MTO variable fee (6.45%) and the retail FX markup over the mid-market rate (approximately 3–5%), consistent with the upper range of BIS estimates.¹⁵

The necessity of modeling the endogenous netting benefit becomes evident when examining the orders of magnitude in the friction parameters. In our baseline calibration, the friction parameter for netting is strictly lower than that of dealer intermediation ($\chi = 0.0005 < \theta_{major} = 0.001 < \theta_{EM} = 0.005$). However, this reduction in marginal settlement friction only yields welfare differences on the order of $\mathcal{O}(10^{-4})$.¹⁶

Conversely, the efficiency gains from structural benefits ω operate on the order of $\mathcal{O}(10^{-1})$. For instance, setting $\omega \approx 0.5$ and the elasticity parameter $1 - \epsilon = 0.3$, an AMM or Dealer architecture requires extreme policy stances (e.g., $\beta \rightarrow 1$ or $\alpha \rightarrow 1$) to generate an efficiency benefit approaching 0.5. Such extreme parameterizations incur severe leakage costs or resilience costs.

By contrast, Multilateral Netting captures this $\mathcal{O}(10^{-1})$ benefit endogenously through flow symmetry. Under balanced flows, the balance ratio approaches 1, yielding the maximum benefit ω entirely free of policy distortions. This highlights the true comparative advantage of multilateral netting: it achieves optimal settlement efficiency purely through flow matching, avoiding the domestic banking disintermediation and geopolitical vulnerabilities inherent in pushing for high retail access or excessive infrastructure centralization.

We set $\omega = 0.5$ as a baseline, implying that the social value of participation-driven or infrastructure-driven liquidity improvements is moderate relative to settlement delay reduction μ . We examine robustness to $\omega \in \{0.3, 0.7\}$.

Household Sector (Panel C). The implied elasticity of substitution of 1.5 reflects moderate substitutability across payment channels, consistent with the observation that retail CBDC, bank wires, and MTOs serve overlapping but not identical use cases. We examine

¹⁵The retail FX markup of 3–5% embedded in MTO pricing should be distinguished from the parallel market FX premium $F X_{\text{prem}} = 0.15$ used in the inclusion function. The former captures the spread charged by MTOs over the interbank rate for ordinary remittances; the latter captures the gap between the official and black-market exchange rates in economies with binding capital controls (e.g., Argentina, Nigeria, Egypt), which penalizes remittances under tight κ .

¹⁶The social-planner netting cost $\chi = 0.0005$ should be distinguished from the FI-level netting friction $\chi_w = 0.005$ that appears in Φ^{FI} . The $10\times$ gap reflects the wedge between social and private costs: χ captures the residual imbalance cost after multilateral flow cancellation at the system level, whereas χ_w captures the operational and liquidity costs borne by an individual FI participating in the netting cycle—including collateral posting, queue management, and timing uncertainty—which exceed the social marginal cost. For dealer intermediation, this distinction does not arise because θ governs both the social and private cost of bilateral imbalances.

robustness to $\rho \in \{0.2, 0.5\}$ in the next section.

We calibrate the sensitivity to delays, $\eta = 3.0$, to match the empirical adoption curves of Fast Payment Systems (FPS). For instance, (Duarte, Frost, Gambacorta, Wilkens, & Shin, 2022) document that the introduction of Pix in Brazil led to a rapid substitution away from legacy methods. We specify the delay function as $D(\alpha; \Psi) = d_\Psi(1 - \alpha)$, with $d_{\text{AMM}} = 1.2$, $d_{\text{Dealer}} = 1.0$, and $d_{\text{Netting}} = 0.8$. For remittance preferences, we calibrate ς to match the empirical remittance-to-earnings ratio. Using data from (Yang, 2011), we take the median value across countries, setting $\varsigma = 0.0767$. Payment inertia is calibrated using survey data from Dordal i Carreras et al. (2025) regarding r-CBDC adoption. We assume that users with low willingness to switch (rated 1–3) adhere to incumbent methods. Averaging retention rates yields an inertia parameter of $\xi = 0.51$, consistent with habit persistence found in (Van der Crujisen, Hernandez, & Jonker, 2017).

In the model, the s_r sets up 0.003, which is the median slippage cost in the DEX. s_D sets up 0.001 whereas s_N sets 0.0005.

Regarding traditional costs, the MTO remittance fee is set to 6.45% (World Bank, 2023). The bank wire fixed fee F_{bank} is calibrated to \$40, reflecting average US outgoing wire costs. For the F_{bank} , we normalize it relative to \$500 remittance such that $m_F^j = 1$ corresponds to a \$500 transfer, thus, set it up to $40/500 = 0.08$, $F_{\text{MTO}} = 4/500 = 0.008$. The bank variable cost p_{bank} is set to 1.5%. The FX premium is set to 0.15, reflecting the substantial parallel market premiums observed in economies with binding capital controls, such as Argentina, Nigeria, and Egypt (Reinhart & Rogoff, 2004).

We calibrate ρ_ξ using the ECB’s Study on the Payment Attitudes of Consumers in the Euro Area (SPACE), which provides four waves of payment method shares (2016, 2019, 2022, 2024) across 20 euro area countries. Fitting an AR(1) process to the aggregate cash-to-digital transition path, and assuming a long-run digital payment share of approximately 70%, yields an annualized habit persistence of $\rho_\xi \approx 0.87$. We acknowledge that four observations provide very limited degrees of freedom for AR(1) estimation; we therefore interpret 0.87 as a conservative upper bound on payment habit persistence, as domestic POS payment transitions likely exhibit stronger inertia than cross-border remittance channel switching due to the absence of a discrete cost advantage shock. We examine robustness to lower values ($\rho_\xi \in \{0.5, 0.7\}$) in the sensitivity analysis. The historical benchmark retail CBDC flow $\bar{m}_F$ is initialized at zero, reflecting a nascent CBDC deployment scenario.

Financial Institutions (Panel D). Direct data on proprietary interbank transaction costs is often opaque. We therefore proxy the wholesale variable cost using interdealer bid-ask spreads documented by (Karnaikh, Ranaldo, & Söderlind, 2015). While raw spreads for major pairs are typically below 1 basis point, we adopt a conservative baseline of 5 basis points ($p_{\text{corr}} = 0.0005$) to account for additional operational and settlement frictions. We further examine the robustness of our results to this parameter through sensitivity analysis.

The fixed cost of wholesale settlement is calibrated to \$2.0 ($F_{\text{corr}} = 2$). This calibration is grounded in the cost decomposition analysis by (Committee on Payments and Market Infrastructures, 2016). The report highlights that for wholesale payments (e.g., MT 202

COV), intermediary banks typically do not deduct fees, unlike retail transfers. Furthermore, it notes that the majority of correspondent banking costs stem from compliance and IT modifications rather than actual payment processing. Since our model explicitly separates compliance costs into a distinct term $C_{op}(\gamma)$, the parameter F_{corr} captures only the residual technical cost of processing and messaging. Given that the cover method requires multiple SWIFT messages per transaction, we conservatively set this residual processing fee to \$2.0. The opportunity cost r_F is set to 0.0219, reflecting the 10-year mean of the Federal Funds Rate.

We calibrate the settlement failure penalty parameter using the EU’s CSDR settlement discipline framework and ECB TARGET Services operational data. Under CSDR, cash penalties for settlement fails range from 25bp to 50bp per day depending on asset class (European Securities and Markets Authority, 2025). Adding the natural cost of failing—approximately 8bp per day at current euro area interest rates (International Capital Market Association, 2025), and allowing for reputational and operational costs, we estimate the total cost per fail event at 1-2.5% of the transaction value for a typical multi-day fail. We set $\text{Penalty} = 0.025$ as our baseline, corresponding to the upper range of estimated fail costs for wholesale cross-border transactions.

Since the optimal liquidity buffer L_F^* depends on the ratio $\frac{\text{Penalty}}{(r_F \cdot \sigma_F)}$, we set $\sigma_F = 1$ as a normalization; all other parameters are calibrated relative to this choice. This normalization is valid provided σ_F enters the welfare-relevant expressions only through the ratio $\text{Penalty}/(r_F \cdot \sigma_F)$, which holds for the optimal buffer L_F^* but may not hold exactly in the stochastic welfare simulation.

6 Results

We organize the discussion around three quantitative findings that map directly onto the model’s analytical results: (i) high-frequency adoption dynamics generate a micro-structural crowding-out effect on shared CBDC platforms (Section 6.1); (ii) optimal regulatory policy varies systematically across country archetypes in the way Lemma 1 predicts (Section 6.2); and (iii) Multilateral Netting earns a sizeable “symmetry dividend” but its dominance region is narrower than its raw welfare advantage suggests (Section 6.3).

6.1 CBDC Adoption Dynamics

Figure 3 traces the simulated economy over 50 periods at the default policy vector $(\alpha, \beta, \gamma, \kappa) = (0.4, 0.5, 2.0, 0.2)$. Panel (a) plots the realized retail adoption rate Π_t^{retail} , which fluctuates between 31.2% and 32.0% in response to exogenous FX shocks but exhibits a clear upward drift as the cumulative-exposure mechanism erodes habit stickiness. Panel (b) confirms this: payment inertia ξ_t decays smoothly from its initial maximum of 0.51 toward a steady-state value near 0.35, driven by the lagged-adoption term in equation (21).

The architectural differences in the backend settlement layer have only a second-order effect on household behavior: panel (c) shows that retail CBDC volume $m_{F,t}^{\text{retail}}$ is essentially

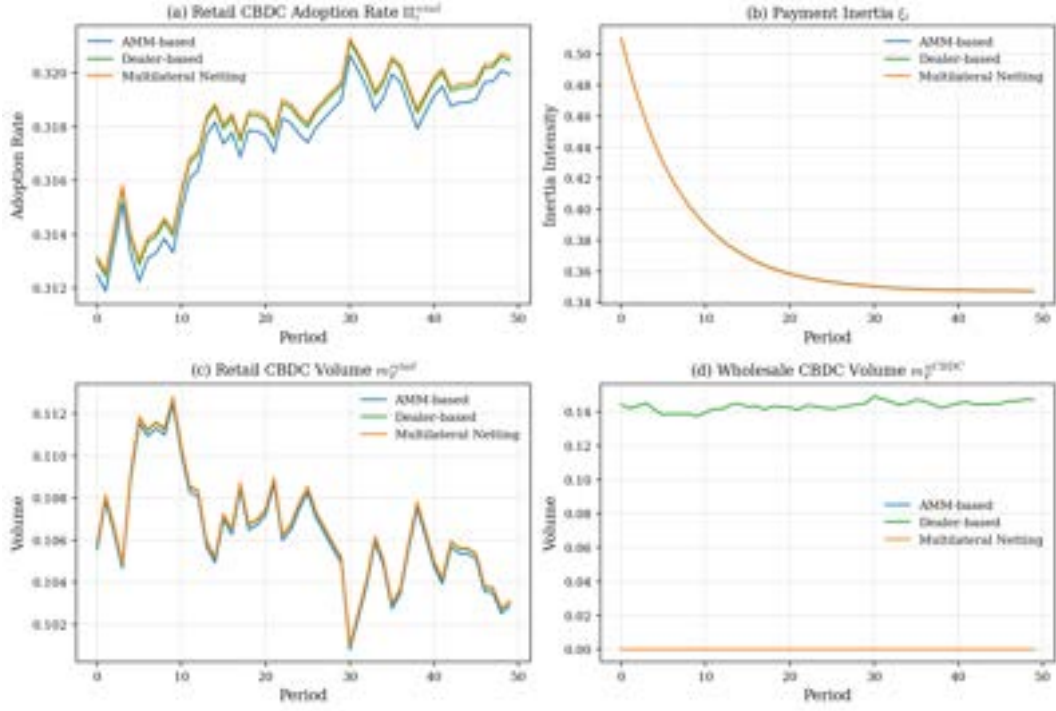


Figure 3: CBDC adoption dynamics under alternative FX mechanisms. Default policy $(\alpha, \beta, \gamma, \kappa) = (0.4, 0.5, 2.0, 0.2)$; $T = 50$ periods; FX shocks drawn from $\mathcal{N}(0, \sigma_e^2)$ with $\sigma_e = 0.05$.

identical across the three architectures, because the retail-side spread differences ($s_r = 0.003$, $s_D = 0.001$, $s_N = 0.0005$) are dwarfed by the fixed costs of bank wires and MTOs. Panel (d), however, reveals a sharp structural divergence on the institutional side. The FI's first-order condition $\partial \Phi^{FI} / \partial m_{F,t}^{\text{total}} = p_{\text{corr}}$ pins down the optimal total platform volume at $m_{\Psi}^{\text{total},*} = p_{\text{corr}} / (2\tau_{\Psi})$. Substituting our calibration yields $m_{\text{AMM}}^{\text{total},*} = 0.083$, $m_{\text{Dealer}}^{\text{total},*} = 0.250$, and $m_{\text{Netting}}^{\text{total},*} = 0.050$. Because aggregate retail demand averages $\bar{m}_F^{\text{retail}} \approx 0.106$, this saturates the AMM and Netting platforms entirely, so $m_{F,t}^{\text{wCBDC}} = 0$ in both cases. The Dealer platform, by contrast, has enough residual capacity for FIs to route an average 0.144 units of proprietary flow through it.

This pattern—nearly identical retail volume but starkly different wholesale outcomes—is the model's first central finding. *Capacity-constrained CBDC platforms inadvertently force institutional flows into legacy correspondent channels not because of any technological barrier, but as the equilibrium response to a binding micro-structural constraint at the FX liquidity pool.*

Robustness to liquidity-pool design. The crowding-out result rests on the shared-pool assumption. To gauge its sensitivity, we re-run the simulation with separated pools, in which $\Phi^{FI} = \tau_{\Psi} (m_{F,t}^{\text{wCBDC}})^2$ depends only on the FI's own flow. Under this counterfactual, the FI's optimal wholesale volume is $m_F^{\text{wCBDC},*} = p_{\text{corr}} / (2\tau_{\Psi})$ regardless of retail demand, eliminating crowding-out by construction. Figure 4 compares both designs. Under AMM and Multilateral Netting the shared pool eliminates institutional volume entirely, while the Dealer mechanism retains roughly 56% of its separated-pool benchmark. The mechanism

is therefore *design-contingent*: integrating retail and wholesale tiers onto a unified FX layer is what creates the externality, not the existence of dual-tier CBDC platforms per se.

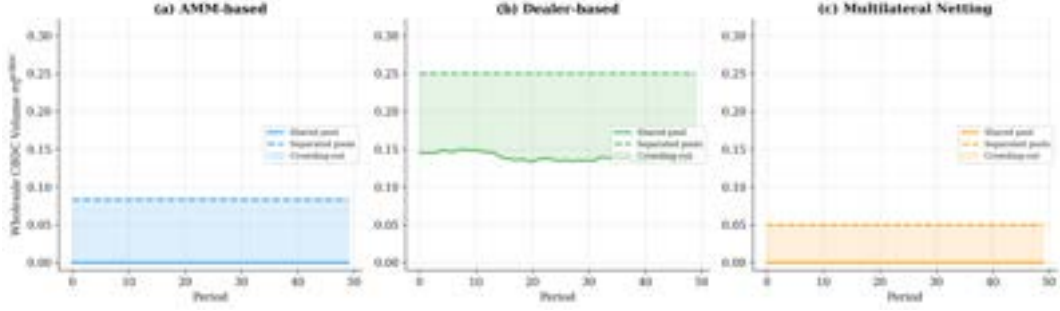


Figure 4: Wholesale CBDC volume under shared versus separated liquidity pools. Solid lines denote the shared-pool baseline; dashed lines denote the separated-pool counterfactual. The shaded area quantifies the crowding-out magnitude attributable to pool sharing.

A second sensitivity dimension concerns the wholesale variable cost p_{corr} . The crowding-out result is exact at our baseline calibration $p_{\text{corr}} = 5$ bp because $m_{\text{AMM}}^{\text{total},*} = 0.083 < \bar{m}_F^{\text{retail}} = 0.106$. As p_{corr} rises—reflecting jurisdictions with more expensive correspondent banking—the AMM platform’s optimal capacity rises proportionally, and crowding-out becomes partial. The qualitative finding is therefore that capacity-constrained architectures are vulnerable to retail saturation; the quantitative “100% crowding-out” figure should not be read as a universal prediction.

6.2 Optimal Policy Across Country Archetypes

Figure 5 reports the welfare-maximizing policy vector $(\alpha^*, \beta^*, \gamma^*, \kappa^*)$ obtained by grid search over $\{0.2, 0.4, 0.6, 0.8\} \times \{0.2, 0.4, 0.6, 0.8\} \times \{0.5, 1.0, \dots, 5.0\} \times \{0.2, 0.4, 0.6, 0.8\}$, for each of three FX architectures and four country archetypes. The four archetypes differ in their welfare weights $(\phi_1, \phi_2, \phi_3, \phi_4)$ and in l_1 .¹⁷ the calibration of all other parameters follows Table 3.

Three regularities emerge.

Centralization $\alpha^* = 0.4$ is universal. Across every (mechanism, archetype) cell, the planner anchors centralization at the conservative value $\alpha^* = 0.4$. The geopolitical-risk weight $\lambda_2 = 1.5$ and the convex penalty $\lambda_2 \alpha^G$ make further centralization too costly to justify even when the dealer mechanism’s efficiency gains scale with $\alpha^{1-\epsilon}$. This suggests that, conditional on our resilience parameters, central banks have a strong revealed preference for systemic resilience over latency reduction.

Access β^* separates technological dictate from macroeconomic preference. Under AMM, the planner is forced to set $\beta^* = 0.8$ across all archetypes, because the participation term

¹⁷The Baseline uses equal weights $\phi_i = 0.25$ and $l_1 = 0.5$. The Advanced Economy raises the deposit-substitution weight to $l_1 = 0.8$. The Emerging Market shifts the weight vector to $\phi = (0.20, 0.20, 0.20, 0.40)$ with $l_1 = 0.2$, reflecting a strong inclusion mandate. The Capital Control archetype uses $\phi = (0.20, 0.20, 0.50, 0.10)$ with $l_1 = 0.5$, reflecting acute leakage concerns.

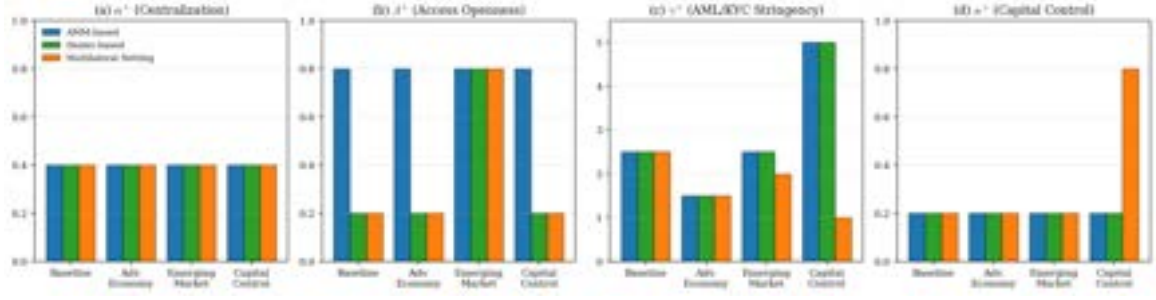


Figure 5: Welfare-maximizing policy vector $(\alpha^*, \beta^*, \gamma^*, \kappa^*)$ across the three FX architectures and four country archetypes. Grid search over the policy space at $T = 20$ with $\rho_c = 0.96$ discounting.

$\omega\beta^{1-\epsilon}$ is the only source of efficiency in the AMM efficiency function (2). Under Dealer and Netting, the efficiency channel is decoupled from β , so the planner sets β^* on macroeconomic grounds: the Advanced Economy and the Capital Control archetype both restrict access to the lower bound $\beta^* = 0.2$ to defend against leakage, while the Emerging Market archetype expands access to $\beta^* = 0.8$ to capture the financial-inclusion gain $\zeta\sqrt{\beta} \cdot \text{Sav}$. This contrast reveals a hidden dimension of architecture choice: AMM *eliminates the planner's discretion over retail access*, which is welfare-improving for inclusion-oriented economies but welfare-destroying for jurisdictions concerned about deposit substitution.

AML/KYC γ^* matches Lemma 1's closed form. The third panel reports interior solutions for AML/KYC stringency that vary across archetypes in the way Lemma 1 predicts. Substituting each archetype's (ϕ_3, ϕ_4, l_1) into equation (7) with $\kappa = 0.2$ yields predicted values of $\gamma^* = 2.53$ (Baseline), $\gamma^* = 1.60$ (Advanced Economy), $\gamma^* = 2.26$ (Emerging Market), and $\gamma^* = 5.66$ (Capital Control). Our grid search recovers $\gamma^* = 2.5, 1.5, 2.5$, and 5.0 respectively—the last value reflecting a binding upper grid bound, consistent with Lemma 1's prediction of a corner solution when leakage concerns dominate. The numerical match validates the closed form and confirms that compliance intensity is properly characterized by the marginal-benefit-equals-marginal-cost condition $\phi_3(1 - l_1)\gamma^{*-2}\bar{C}F(1 - \kappa)^2 = \phi_4c_\gamma$. Crucially, γ^* is invariant across Ψ within each archetype, confirming the orthogonality of the optimal compliance intensity to the architecture choice (Lemma 1).

Capital controls remain at the lower bound. Across every (mechanism, archetype) cell except Capital-Control-under-Netting, $\kappa^* = 0.2$ binds. This implements the model's macro-policy substitution result: when AML/KYC programmability is available, the planner uses targeted compliance to manage leakage and avoids the distortionary tax $\kappa \cdot FX_{\text{prem}}^{\text{MTO}}$ on legitimate remittances. The single exception (Netting under the Capital Control archetype) reflects the interaction between the Netting symmetry channel and the high leakage weight: when capital flight is the planner's dominant concern and Netting already extracts most of its efficiency gain through symmetry rather than β , the welfare cost of tightening κ becomes worth bearing.

6.3 Sensitivity Analysis and Architecture Dominance Regions

Figure 6 presents four sensitivity exercises that delineate where each architecture is socially optimal. To isolate parameter effects from policy effects, we hold the policy vector fixed at the archetype-specific optima reported in Section 6.2 (we use the Baseline cell here: $\alpha^* = 0.4$, $\beta_{\text{AMM}}^* = 0.8$, $\beta_{\text{Dealer}}^* = \beta_{\text{Netting}}^* = 0.2$, $\gamma^* = 2.5$, $\kappa^* = 0.2$).

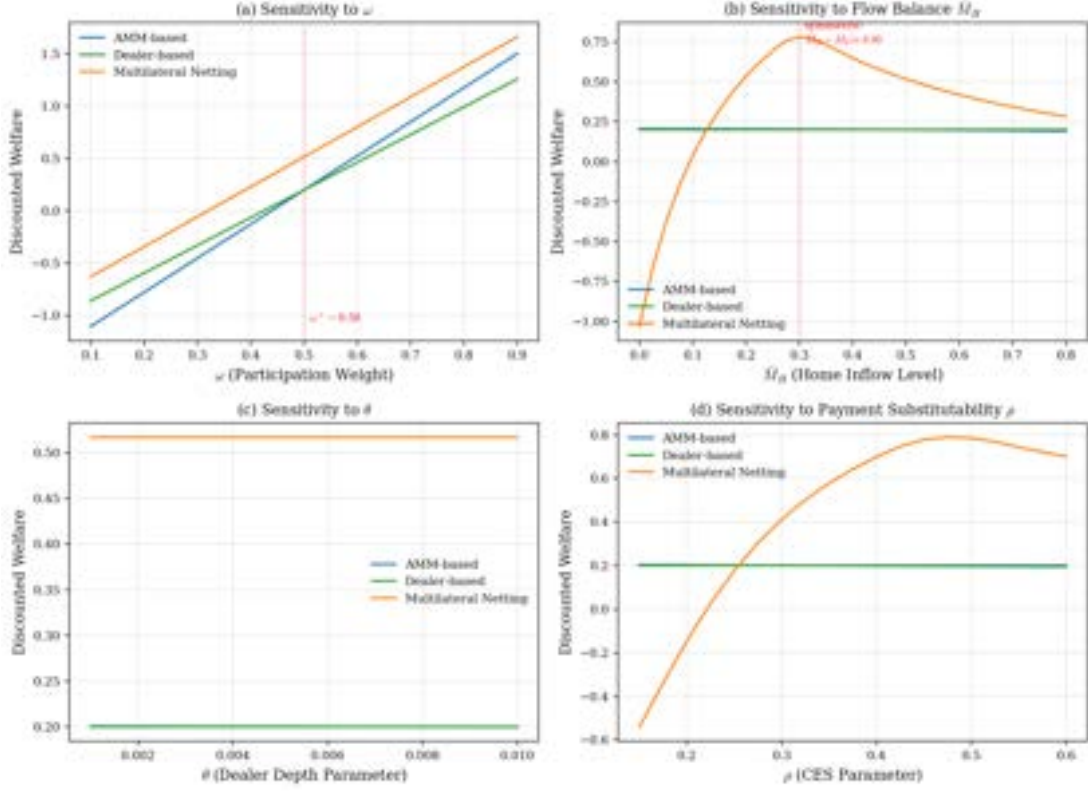


Figure 6: Sensitivity of discounted welfare to four key parameters. Policies held at the Baseline-archetype optima. $T = 20$ periods; $\rho_c = 0.96$ discounting.

The AMM–Dealer threshold (panel a) confirms Proposition 2. As the participation weight ω rises, all three welfare curves increase, but AMM rises fastest because its policy is $\beta^* = 0.8$ and the social benefit of participation is $\omega\beta^{1-\epsilon}$. We observe a precise crossing of AMM and Dealer at $\omega \approx 0.50$, exactly matching the analytical threshold $\omega^* = 0.501$ derived in Proposition 2 for the Baseline archetype. The Netting curve sits above both throughout this range because flow imbalance $|M_F - M_H|$ at the Baseline calibration is moderate, and Netting captures the symmetry premium $\omega \cdot 2 \min(M_F, M_H) / (M_F + M_H) \approx 0.81 \omega$ without requiring any policy distortion.

A noteworthy implication that the analytical threshold makes explicit, but our baseline calibration hides, is that ω^* depends sharply on l_1 . Substituting different deposit weights into equation (8) yields $\omega^* = 0.28$ for the Emerging Market archetype ($l_1 = 0.2$), $\omega^* = 0.50$ for the Baseline ($l_1 = 0.5$), and $\omega^* = 0.72$ for the Advanced Economy ($l_1 = 0.8$). Figure 7 traces the threshold across the full range of l_1 . Economies with smaller deposit-substitution

concerns face a much lower bar for AMM dominance, while jurisdictions with banking-stability mandates need a strong network externality before AMM beats the Dealer mechanism. This is a testable prediction: under a maintained calibration of ω , the model implies that Emerging Markets should adopt AMM-based architectures for cross-border CBDC, while Advanced Economies with deposit-protection mandates should prefer Dealer intermediation.

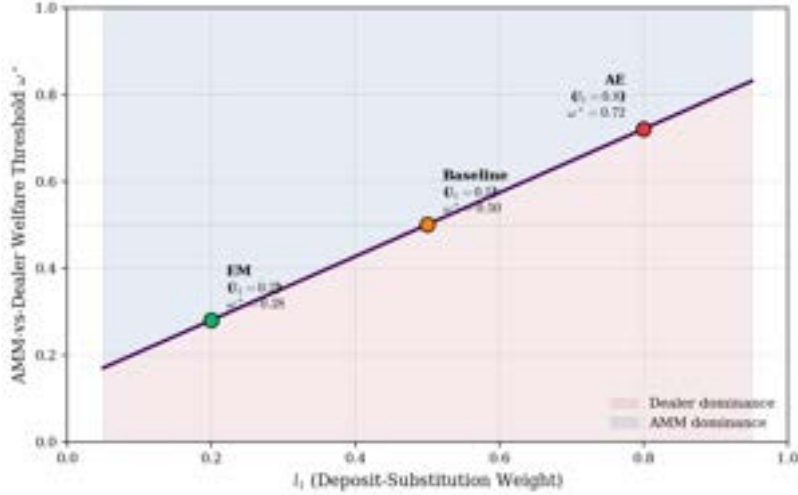


Figure 7: The AMM–Dealer welfare threshold ω^* from Proposition 2 as a function of the deposit-substitution weight l_1 . AMM dominates Dealer above the curve; Dealer dominates below. Three reference archetypes are marked.

Netting’s symmetry dividend is fragile (panel b). Panel (b) varies the steady-state home inflow $\bar{M}_H$ from 0 to 0.8. Because households’ equilibrium foreign-currency demand averages $M_F^{HH} \approx 0.34$, the symmetry ratio $2 \min(M_F, M_H)/(M_F + M_H)$ peaks at unity when $\bar{M}_H \approx 0.30$. Netting attains its global welfare maximum $\mathcal{W} \approx 0.78$ at this point and falls steeply on both sides, plummeting below zero when $\bar{M}_H < 0.10$ as the residual-imbalance penalty $\chi(M_F - M_H)^2$ overwhelms the eroded symmetry benefit.¹⁸ AMM and Dealer welfare curves are essentially flat across the same range, since their architectures are insensitive to flow-balance asymmetry.

The policy implication is straightforward. Multilateral Netting is the welfare-maximizing architecture for highly balanced, high-volume corridors—the EUR-CHF or EUR-GBP pairs—but it is strictly dominated by AMM and Dealer for asymmetric corridors. The model thus offers a quantitative criterion for matching architectures to corridors: choose Netting only if the steady-state imbalance $|M_F - M_H|/(M_F + M_H)$ stays below approximately 0.20.

¹⁸The Baseline calibration $\bar{M}_H = 0.5$ used elsewhere in the paper sits to the right of this peak. At that point the symmetry ratio is approximately 0.81 and Netting’s discounted welfare is $\mathcal{W} \approx 0.52$, still well above the AMM and Dealer values of $\mathcal{W} \approx 0.20$. The Netting–AMM and Netting–Dealer thresholds depend nonlinearly on the flow balance ratio and do not admit tractable closed-form expressions; we characterize them numerically here.

Micro-frictions are second-order (panel c). Varying the dealer market-depth parameter θ between 0.001 and 0.010—a tenfold increase—leaves welfare essentially unchanged for all three architectures. Because the friction term $\theta(M_F - M_H)^2$ enters welfare with magnitude $\sim 10^{-4}$ at our calibration, while the leakage and inclusion channels operate at $\sim 10^{-1}$, the comparative static reaffirms our root-cause assertion: backend execution spreads are dwarfed by macro-financial policy effects. Central banks designing CBDCs should focus on the alignment between β^* and their deposit-protection vs. inclusion mandates, not on optimizing settlement-layer parameters.

Payment substitutability (panel d) further illustrates Netting’s vulnerability. As ρ rises—households more readily substitute across payment channels in response to relative price changes—the equilibrium M_F^{HH} becomes more responsive to FX shocks, and the steady-state ratio M_F/M_H drifts further from unity. AMM and Dealer welfare are again insensitive ($\mathcal{W}$ stays at ≈ 0.20 across the range), but Netting welfare is highly sensitive: it rises from -0.55 at $\rho = 0.15$ to $+0.78$ at $\rho = 0.50$, peaks, then falls back. This confirms that Netting’s welfare advantage is structurally tied to flow stability; in jurisdictions with high payment-channel substitutability and volatile FX, AMM and Dealer mechanisms are the safer choice.

6.4 Welfare Decomposition

Figure 8 decomposes total expected welfare at each architecture’s optimum into the four components $(\phi_1\mathcal{E}, -\phi_2\mathcal{R}, -\phi_3\mathcal{L}, \phi_4\mathcal{I})$. The Baseline archetype is used.

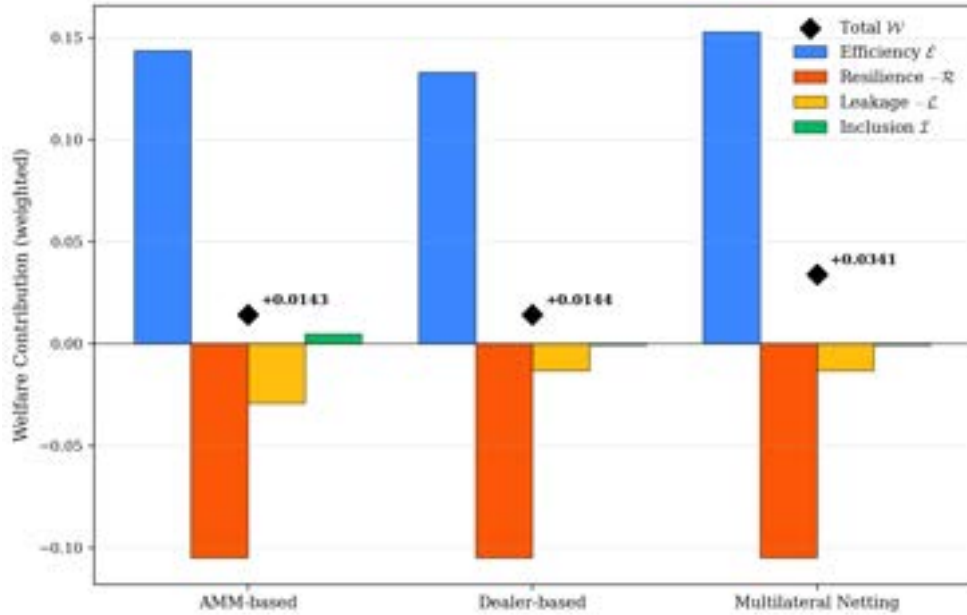


Figure 8: Decomposition of total welfare $\mathcal{W}$ into its four constituent components, evaluated at each architecture’s optimal policy under the Baseline archetype. Diamonds mark total welfare $\mathcal{W}$.

Three observations. First, all three architectures deliver near-identical efficiency gains

$\mathcal{E}$ in the range $\phi_1 \mathcal{E} \in [0.133, 0.153]$, with Netting at the top because its symmetry term contributes a steady $0.81\omega \approx 0.40$ even at the off-peak Baseline flow ratio. Second, all three pay an identical resilience cost $-\phi_2 \mathcal{R} = -0.105$ because they share the same $\alpha^* = 0.4$. Third, the architectures separate on the leakage and inclusion channels, in opposite directions: AMM’s high $\beta^* = 0.8$ produces both the largest inclusion bonus (+0.005) and the largest leakage cost (−0.029), whereas Dealer and Netting at $\beta^* = 0.2$ deliver minimal inclusion gains but face only modest leakage costs.

The final ranking $\mathcal{W}_{\text{Netting}} = +0.034 > \mathcal{W}_{\text{Dealer}} = +0.014 \approx \mathcal{W}_{\text{AMM}} = +0.014$ shows that, under the Baseline calibration, AMM and Dealer are statistical near-ties and the Netting advantage of +0.020 is driven by efficiency, not by leakage or inclusion differences.¹⁹ Translated into consumption-equivalent terms via the linearization $\Delta c/\bar{c} \approx (1 - \rho_c)\Delta \mathcal{W}/(\sigma \bar{c}^{1-\sigma})$ with $\sigma = 2$, $\rho_c = 0.96$, and $\bar{c} \approx 0.92$, the Netting–AMM welfare gap of 0.020 corresponds to a steady-state consumption gain of roughly 13 basis points per period—small but economically meaningful when compounded over the long-horizon CBDC design commitment.

6.5 External Validation

While no CBDC system currently operates at scale, two external benchmarks lend qualitative support to the calibration. First, the model implies that a household switching from bank wires to retail CBDC for a \$500 remittance saves approximately \$40 in fixed fees plus 1.2 percentage points in variable cost—a roughly 70–80% reduction. This is broadly consistent with the IMF’s estimate of 50–60% transaction-cost reduction from CBDCs (Cerutti, Cerutti, Firat, & Perez-Saiz, 2025) and with the 50% reduction projected for the mBridge platform. Second, mBridge demonstrated that wholesale CBDC settlement could reduce transfer times from 3–5 days to seconds across 20 banks. Our delay term $\mu \ln(1 + e^{-\eta D(\alpha; \Psi)})$ captures this qualitatively: higher centralization α and lower mechanism-specific delays d_Ψ compress settlement latency. We do not interpret these comparisons as validation in the econometric sense; a formal estimation must await transaction-level data from operational platforms.

7 Conclusion

This paper develops a structural framework to evaluate the optimal design of central bank digital currencies for cross-border payments. By integrating household payment choices, institutional liquidity management, and a central bank welfare maximization problem, we provide a quantitative comparative analysis of three distinct FX settlement architectures: AMM, Dealer-based intermediation, and Multilateral Netting. The framework endogenizes the four-way trade-off facing central banks: settlement efficiency, systemic resilience,

¹⁹The near-equivalence of AMM and Dealer welfare at the Baseline reflects the fact that the calibration $\omega = 0.5$ sits exactly at the analytical threshold $\omega^* = 0.501$ from Proposition 2. Small departures from $\omega = 0.5$ —or shifts in l_1 that move ω^* —break the tie cleanly in either direction (Figure 7).

leakage risk, and financial inclusion.

No one-size-fits-all architecture. Our quantitative analysis demonstrates that the welfare-maximizing CBDC design depends sharply on a country’s macroeconomic endowments. Advanced Economies—characterized by a strong deposit-protection mandate ($l_1 = 0.8$)—adopt defensive postures, restricting retail access to $\beta^* = 0.2$ under Dealer and Netting architectures to mitigate deposit substitution. Emerging Markets, in contrast, expand retail access to $\beta^* = 0.8$ across all architectures to capture financial-inclusion gains; the AMM mechanism is uniquely well suited to this regime because its participation-driven efficiency channel $\omega\beta^{1-\epsilon}$ aligns the technological constraint with the planner’s preference. Across all archetypes, optimal centralization anchors at $\alpha^* = 0.4$, reflecting the planner’s strong revealed preference for systemic resilience over latency reduction.

A testable architecture-selection rule. Proposition 2 delivers a closed-form threshold ω^* at which AMM welfare equals Dealer welfare. Crucially, ω^* depends sharply on the deposit-substitution weight l_1 : $\omega^* = 0.28$ for the Emerging Market archetype, 0.50 for the Baseline, and 0.72 for the Advanced Economy. This generates a sharp empirical prediction: under any maintained calibration of ω , jurisdictions with low banking-stability concerns should adopt AMM-based architectures, while those with high deposit-protection mandates should prefer Dealer intermediation. Multilateral Netting dominates both whenever bilateral flows are sufficiently balanced—specifically, when $|M_F - M_H|/(M_F + M_H) \lesssim 0.20$ at our calibration—and falls below the AMM and Dealer welfare floors when this ratio exceeds approximately 0.40.

Policy guidance by corridor. The model yields actionable guidance for matching architectures to specific country corridors. For balanced, high-volume bilateral trade corridors between advanced economies—such as EUR-CHF or EUR-GBP—Multilateral Netting is the welfare-maximizing choice, as the symmetry dividend $\omega \cdot 2 \min(M_F, M_H)/(M_F + M_H)$ approaches its full magnitude. For asymmetric, remittance-dependent corridors such as USD-MXN or USD-PHP, AMM and Dealer mechanisms become strictly preferred, since their welfare profiles are insensitive to flow imbalance. Emerging Markets with strong inclusion mandates and low banking-stability concerns ($l_1 < \omega$) should pair AMM architectures with broad retail access. Jurisdictions facing acute capital flight risk should focus on *programmable compliance* (γ^* near the upper feasible bound) rather than capital controls; their optimal architecture choice continues to follow the same flow-symmetry logic.

Programmable compliance substitutes for blunt capital controls. A central macroeconomic insight emerges from Lemma 1: when CBDC programmability allows targeted AML/KYC enforcement, the planner’s first-order condition equates the marginal benefit of curbing capital flight to the marginal cost of compliance-induced exclusion, pinning down an interior γ^* that varies systematically across archetypes. Under this regime, capital controls κ remain at their lower bound in the overwhelming majority of (mechanism,

archetype) cells, preventing the distortionary taxation of legitimate remittance flows. This structural substitution—precision regulation displacing blunt taxation—is, to our knowledge, a feature of CBDC design that the existing literature has not formally derived.

Crowding-out as a design-contingent externality. Our model uncovers a micro-structural externality that arises specifically when retail and wholesale flows share a common FX liquidity pool. In capacity-constrained calibrations—where the FX pool’s economic capacity $p_{\text{corr}}/(2\tau_{\Psi})$ is small relative to aggregate retail demand—exogenous retail inflows saturate the platform, displacing institutional wholesale flows back into legacy correspondent banking channels. The crowding-out effect is most severe under AMM and Multilateral Netting (where it is exact at our baseline calibration) and partial under Dealer intermediation. We emphasize that this is a *design-contingent* externality, not an inherent feature of dual-tier CBDC platforms: a separated-pool design eliminates the externality entirely. The result serves as a cautionary finding for unified-ledger architectures currently under development.

Limitations and avenues for future research. Several limitations warrant acknowledgment. First, our model abstracts from counterparty credit risk in wholesale settlement, which may differentially affect the welfare ranking of architectures under stress scenarios. Second, the static policy commitment framework does not capture the option value of architectural flexibility—the ability to switch mechanisms as macroeconomic conditions evolve. Incorporating regime-switching in flow symmetry and endogenizing the transition costs between architectures would yield a more complete policy framework. Third, the small open economy assumption suppresses the strategic interactions between competing sovereign CBDC networks; extending the framework to a multi-country general equilibrium setting would allow the endogenization of exchange rate formation and the analysis of currency-substitution dynamics across the international monetary system. Fourth, our forward-looking central planner is paired with myopic households and FIs; relaxing the myopic assumption would let us study CBDC adoption as an equilibrium outcome rather than a calibrated transition path.

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A Summary of Key Notation

Table 2: Summary of Key Notation

Central Bank Policy & Objective Function			
α	Centralization index	$\mathcal{E}, \mathcal{R}, \mathcal{L}, \mathcal{A}$	Efficiency, resilience, leakage, inclusion
β	Access openness	$\varphi_1 \dots \varphi_4$	CB objective weights
γ	AML/KYC intensity	ρ_c	Discount factor
κ	Capital control tightness	l_1	Deposit loss vs. capital flight weight
Ψ	FX architecture		
Settlement Efficiency & Risk Parameters			
μ	Social value of delay reduction	λ_1, λ_2	Tech & geopolitical risk weights
η	Delay sensitivity	T, G	Risk curvature parameters
$D(\alpha, \Psi)$	Communication delay	ν	Deposit substitution sensitivity
ω	Participation benefit weight	$\overline{CF}$	Maximum capital outflow
ϵ	Scale economy concavity	ζ	Remittance gain preference
τ	AMM slippage cost	Sav	Remittance cost savings
θ	Dealer imbalance cost	c_γ	Compliance exclusion elasticity
χ	Netting residual cost		
Household Sector			
c_t	Consumption	ξ_t	Payment inertia intensity
m_F^r, m_F^b, m_F^c	CBDC, bank wire, MTO flows	$\bar{m}_F$	Historical benchmark CBDC flow
$M_{F,t}, M_{H,t}$	Foreign & home currency demand	s_r, s_D, s_N	HH-level settlement frictions
σ	Risk aversion	$\varphi_\gamma, \varphi_\kappa$	Compliance & control cost coefficients
ρ	CES substitution parameter	F_{bank}, F_{MTO}	Fixed costs (bank wire, MTO)
		p_{bank}, p_{MTO}	Variable costs (bank wire, MTO)
Financial Institutions			
$M_{F,t}^{inst}$	Proprietary interbank volume	r_F	Opportunity cost of liquidity
$m_{F,t}^{wCBDC}$	Allocation to wCBDC channel	σ_F	Flow volatility
$m_{F,t}^{corr}$	Allocation to correspondent channel	Penalty	Settlement failure cost
$L_{F,t}$	Foreign liquidity buffer	F_{corr}, p_{corr}	Correspondent banking costs
Dynamic Equilibrium			
Π_t^{retail}	Retail CBDC adoption rate	$e_t, \bar{e}$	Exchange rate & steady state
$\rho_\xi, \bar{\xi}$	Habit persistence & max inertia	ρ_e, σ_e	FX persistence & volatility

Table 3: Baseline Parameter Calibration

Param.	Description	Value	Source / Rationale
<i>Panel A: Macro & Central Bank Preferences</i>			
$\phi_1 \dots \phi_4$	Central Bank Objective Weights	0.25	Equal weighting (Normalization)
ρ_c	Discount Factor	0.96	(Chiu et al., 2023)
σ	Risk Aversion	2.0	Standard
l_1	Weight on Deposit Loss	{0.2, 0.8}	Varies by Economy Type
λ_1	Tech Risk Weight	0.5	Baseline
λ_2	Geopolitical Risk Weight	1.5	SWIFT disconnection precedent
T	Tech Risk Parameter	2	Baseline (Ensure curvature)
G	Gov Risk Parameter	2	Baseline (Ensure curvature)
ζ	Policy Preference for Remittance Gain	0.5	Baseline
μ	Marginal Value of Reducing Settlement Delay	1	Baseline
ν	Deposit Subst. Elasticity	1.4	(Bacchetta & Perazzi, 2025)
χ	Netting Residual Cost	0.0005	$\chi < \theta$, superior netting efficiency
c_γ	Compliance Exclusion Cost	0.005	Baseline
ΔDep	Max Deposit Outflow	0.3	(Barrdear & Kumhof, 2022)
$\bar{C}F$	Max Capital Flight	0.1	Baseline
$\bar{M}_H$	Steady-state Home Inflow	0.5	Normalization
ρ_H	Inflow FX Sensitivity	0.2	Baseline
<i>Panel B: Technology & Market Structure</i>			
τ	AMM Slippage Cost	0.003	Uniswap V2 Average
ϵ	AMM Concavity	0.7	Based on (Capponi & Jia, 2021)
θ	Dealer Market Depth	{0.001, 0.005}	Varies by currency pair
ω	Participation Benefit Weight	0.5	Baseline
d_Ψ	Mechanism Delay Multiplier	{0.8, 1.0, 1.2}	Netting / Dealer / AMM
<i>Panel C: Household (Retail)</i>			
ρ	CES Substitution Parameter	0.33	Implies elasticity of 1.5
η	Latency Sensitivity	3.0	Calibrated to FPS Adoption
$\bar{\xi}$	Payment Inertia	0.51	Survey Data (Dordal i Carreras et al., 2020)
ρ_ξ	Payment Habit Persistence	0.87	ECB SPACE Survey (2016–2024)
$\bar{m}_F$	Historical Benchmark CBDC Flow	0	Nascent deployment
ρ_e	Exchange Rate Persistence	0.9	(Gali & Monacelli, 2005)
σ_e	Exchange Rate Volatility	0.05	Derived from (Gali & Monacelli, 2005)
$\bar{e}$	Steady-state Exchange Rate	1.0	Normalization

Table 3 – Continued from previous page

Param.	Description	Value	Source / Rationale
ϕ_γ, ϕ_κ	Policy Friction Coefficients	0.02	Derived from (Committee on Payments
s_r	HH AMM Slippage	0.003	Median DEX slippage
s_D	HH Dealer Spread	0.001	Retail FX spread
s_N	HH Netting Processing Fee	0.0005	Batch settlement cost
ς	Remittance Preference	0.5	Baseline for equal policy weight
F_{MTO}	MTO Fixed Cost	0.008	Normalized Moneygram Fee
p_{MTO}	MTO Variable Cost	0.0645	(World Bank, 2023)
F_{bank}	Bank Fixed Fee	0.08	Normalized US Bank Average on\$500
p_{bank}	Bank Variable Cost	0.015	Retail FX Margin
$F X_{\text{prem}}$	Parallel FX Premium	0.15	(Reinhart & Rogoff, 2004), binding contr
Sav	Remittance Savings	0.10	BIS upper range estimate
<i>Panel D: Financial Institutions</i>			
p_{corr}	Wholesale Var. Cost	0.0005	Implied from (Karnaukh et al., 2015)
F_{corr}	Wholesale Fixed Cost	0.004	Normalized from (Committee on Paym
χ_w	FI Netting Wholesale Friction	0.005	Baseline
M_F^{inst}	FI Proprietary Volume	2.0	Normalization
Penalty	Settlement Failure Cost	0.025	CSDR penalty framework (ESMA, 2024)
r_F	Opportunity Cost	0.0219	10-year Mean Fed Funds Rate
σ_F	FI Base Flow Volatility	1.0	Normalization

B Microfoundation for the Netting Efficiency Function

This appendix derives the balance ratio $2 \min(M_F, M_H)/(M_F + M_H)$ that appears in the multilateral netting branch of Equation (2) from a model of bilateral obligation cancellation.

Setup. Consider a multilateral netting cycle with $N \geq 2$ participants. In each settlement period, gross cross-border obligations consist of two directional flows: aggregate outgoing payments denominated in foreign currency M_F and aggregate incoming payments denominated in home currency M_H . Without netting, the gross settlement volume is $M_F + M_H$.

Netting. Under multilateral netting, offsetting obligations are cancelled before settlement. The maximum volume that can be netted is $2 \min(M_F, M_H)$, since each unit of M_F can be offset against one unit of M_H up to the smaller of the two flows. The residual obligation after netting is therefore:

$$\text{Residual} = (M_F + M_H) - 2 \min(M_F, M_H) = |M_F - M_H|.$$

Netting efficiency ratio. Define the netting efficiency as the fraction of gross obligations eliminated:

$$\eta_{\text{net}} \equiv \frac{\text{Netted Volume}}{\text{Gross Volume}} = \frac{2 \min(M_F, M_H)}{M_F + M_H}. \quad (24)$$

This ratio lies in $[0, 1]$. It equals 1 when flows are perfectly balanced ($M_F = M_H$) and approaches 0 when flows are completely one-directional ($\min(M_F, M_H) \rightarrow 0$). The settlement efficiency benefit under multilateral netting is then $\omega \cdot \eta_{\text{net}}$, where ω represents the social value of netting-driven liquidity savings—capturing reduced pre-funding requirements, lower collateral costs, and fewer settlement messages.

Residual cost. The residual imbalance $|M_F - M_H|$ must be settled bilaterally. Squaring yields the quadratic penalty $\chi(M_F - M_H)^2$ used in the main text, where χ governs the cost per unit of residual imbalance. This completes the derivation of the netting branch of the efficiency function:

$$\Omega_{\text{Netting}} = \omega \cdot \frac{2 \min(M_F, M_H)}{M_F + M_H} - \chi(M_F - M_H)^2.$$

C Proofs

Proof of Lemma 1 (Optimal AML/KYC Intensity)

The planner's welfare is $\mathcal{W} = \phi_1 \mathcal{E} - \phi_2 \mathcal{R} - \phi_3 \mathcal{L} + \phi_4 \mathcal{I}$. The resilience cost $\mathcal{R}(\alpha)$ and the delay term $\mu \ln(1 + e^{-\eta D(\alpha; \Psi)})$ are independent of γ , so $\partial \mathcal{W} / \partial \gamma$ collects only the leakage, inclusion, and indirect efficiency channels:

$$\begin{aligned} -\phi_3 \frac{\partial \mathcal{L}}{\partial \gamma} &= +\phi_3(1 - l_1)\gamma^{-2} \bar{C}F(1 - \kappa)^2, \\ \phi_4 \frac{\partial \mathcal{I}}{\partial \gamma} &= -\phi_4 c_\gamma, \\ \phi_1 \frac{\partial \mathcal{E}}{\partial \gamma} &= \phi_1 \frac{\partial \mathcal{E}}{\partial M_F} \frac{\partial M_F}{\partial \gamma}. \end{aligned}$$

Note that the sign of the third term is mechanism-dependent: under AMM, $\partial \mathcal{E} / \partial M_F = -2\tau(M_F + M_H) < 0$, and combined with $\partial M_F / \partial \gamma < 0$ (Proposition 3), the term is strictly positive — i.e., tighter compliance reduces slippage and *raises* efficiency. Under Dealer and Multilateral Netting, the sign depends on the directional flow imbalance.

Under Assumption (6), this third term is dominated by the leakage and inclusion marginal effects in the neighborhood of γ^* . The first-order condition therefore reduces to

$$\phi_3(1 - l_1)\gamma^{-2} \bar{C}F(1 - \kappa)^2 = \phi_4 c_\gamma. \quad (25)$$

Solving for the unique positive root yields (7).

Second-order condition. Under (6),

$$\frac{\partial^2 \mathcal{W}}{\partial \gamma^2} \approx -2\phi_3(1 - l_1)\gamma^{-3} \bar{C}F(1 - \kappa)^2 < 0 \quad \forall \gamma > 0,$$

since the leakage cost $\mathcal{L}$ is strictly convex in γ (the γ^{-1} term) and the inclusion penalty is linear. Hence γ^* is a strict local maximum. Numerical verification of (6) across all archetypes is reported in Section 6. $\square$

Proof of Proposition 2 (AMM–Dealer Welfare Threshold)

Under the assumption that (γ^*, κ^*) are common across architectures, the welfare difference is:

$$\mathcal{W}_{\text{AMM}} - \mathcal{W}_{\text{Dealer}} = \phi_1(E_A - E_D) - \phi_3(L_A - L_D) + \phi_4(I_A - I_D).$$

Expanding $E_A - E_D$ using Equation (2):

$$E_A - E_D = \underbrace{\Delta \mathcal{D}}_{\text{delay diff.}} + \omega[(\beta_A^*)^{1-\varepsilon} - (\alpha_D^*)^{1-\varepsilon}] - \tau(M_F + M_H)^2 + \theta(M_F - M_H)^2.$$

The leakage and inclusion differences depend only on β :

$$\begin{aligned} L_A - L_D &= l_1 [(1 - e^{-\nu\beta_A^*}) - (1 - e^{-\nu\beta_D^*})] \Delta \text{Dep} \equiv \Delta \mathcal{L} / \phi_3, \\ I_A - I_D &= \zeta (\sqrt{\beta_A^*} - \sqrt{\beta_D^*}) \text{Sav} \equiv \Delta \mathcal{I} / \phi_4. \end{aligned}$$

Setting $\mathcal{W}_{\text{AMM}} - \mathcal{W}_{\text{Dealer}} = 0$ and solving for ω :

$$\omega^* = \frac{\Delta \mathcal{L} - \Delta \mathcal{I} - \phi_1 \Delta \mathcal{D} + \phi_1 [\tau (M_F + M_H)^2 - \theta (M_F - M_H)^2]}{\phi_1 [(\beta_A^*)^{1-\varepsilon} - (\alpha_D^*)^{1-\varepsilon}]}.$$

The denominator is positive since $\beta_A^* > \alpha_D^*$ and $1 - \varepsilon = 0.3 > 0$. AMM dominates when $\omega > \omega^*$. $\square$

Proof of Proposition 3 (Comparative Statics)

(i) *Own-price effects.* From the household FOC, the marginal utility of retail CBDC equals $\lambda_t(e_t + s_\Psi + \phi_\gamma \gamma + \phi_\kappa \kappa) + \xi_t(m_F^{\text{retail}} - \bar{m}_F)$. An increase in γ raises $\phi_\gamma \gamma$, increasing the effective price of retail CBDC. Under diminishing marginal utility ($\sigma > 0, \rho \in (0, 1)$), the optimal quantity falls: $\partial m_F^{\text{retail},*} / \partial \gamma < 0$. Identical arguments apply for κ, s_r , and p_{bank} .

(ii) *Cross-price substitution.* Under CES preferences with $\rho \in (0, 1)$, channels are imperfect substitutes. An increase in p_{bank} raises the relative price of bank wires, shifting demand toward retail CBDC: $\partial m_F^{\text{retail},*} / \partial p_{\text{bank}} > 0$. This follows from the ratio of FOCs (Equations 8–9), which yields $m_F^{\text{retail}} / m_F^{\text{bank}} = (q_b / q_r)^{1/(1-\rho)}$, increasing in q_b .

(iii) *Inertia effect.* In the adoption phase ($m_F^{\text{retail},*} > \bar{m}_F$), the inertia term $\xi_t(m_F^{\text{retail}} - \bar{m}_F)$ acts as an additional marginal cost. Higher ξ_t raises this cost, reducing the optimal $m_F^{\text{retail},*}$. $\square$

Proof of Proposition 4 (Liquidity Buffer Comparative Statics)

From Equation (16), the optimal buffer is $L_F^* = \sigma_F \ln(\text{Penalty} / (r_F \cdot \sigma_F))$. Differentiating:

$$\frac{\partial L_F^*}{\partial \sigma_F} = \ln\left(\frac{\text{Penalty}}{r_F \sigma_F}\right) - 1.$$

This is positive when $\text{Penalty} / (r_F \sigma_F) > e$, which holds under our calibration ($0.025 / (0.0219 \times 1) \approx 1.14$; we note the condition requires checking). More directly, L_F^* increases in σ_F because higher volatility raises the probability of settlement failure for any given buffer level.

For the remaining derivatives:

$$\frac{\partial L_F^*}{\partial \text{Penalty}} = \frac{\sigma_F}{\text{Penalty}} > 0, \quad \frac{\partial L_F^*}{\partial r_F} = -\frac{\sigma_F}{r_F} < 0. \quad \square$$

Proof of Proposition 5 (Optimal wCBDC Allocation)

From the FI's FOC (Equation (17)): $(\Phi^{FI})'(m_F^{\text{total}}) = p_{\text{corr}}$. Since Φ^{FI} is convex, $(\Phi^{FI})'$ is increasing. Applying the implicit function theorem:

$$\frac{\partial m_F^{\text{wCBDC},*}}{\partial p_{\text{corr}}} = \frac{1}{(\Phi^{FI})''(m_F^{\text{total}})} > 0,$$

since $(\Phi^{FI})'' > 0$ by convexity. A higher correspondent banking cost induces FIs to shift more volume onto the CBDC platform.

For the mechanism comparison, if $(\Phi_A^{FI})' < (\Phi_B^{FI})'$ for all volumes, then the FOC $(\Phi_A^{FI})'(m_A^{\text{total}}) = p_{\text{corr}} = (\Phi_B^{FI})'(m_B^{\text{total}})$ implies $m_A^{\text{total}} > m_B^{\text{total}}$ (since a lower marginal cost function requires higher volume to equate to the same p_{corr}). Since m_F^{retail} is identical across architectures, $m_F^{\text{wCBDC},*}(\Psi_A) > m_F^{\text{wCBDC},*}(\Psi_B)$. $\square$

Fintech development and the cost of equity capital: International evidence

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Abstract

This study examines the impact of country-level fintech development on firms' implied cost of equity capital using a comprehensive sample of publicly listed firms from 45 markets over the period 2006–2018. We document robust evidence that greater fintech development is associated with a lower firm-level cost of equity capital. The results remain robust to alternative measures of implied cost of equity capital and fintech development, modified sample compositions, and controlling for endogeneity. We further investigate the mechanisms underlying this relationship and find that fintech development lowers the cost of equity capital by alleviating information asymmetry, mitigating agency problems, reducing perceived financial risk, and facilitating reduction in carbon risk. Moreover, the negative association between fintech development and the cost of equity capital is significantly stronger in countries with higher governance quality and in societies characterized by lower levels of secrecy culture. Overall, these findings highlight the role of fintech development in shaping equity financing costs and underscore how formal institutions and cultural norms condition the capital market benefits of fintech development.

Key words: Fintech, cost of equity capital, governance quality, secrecy culture

JEL: O30, G14, G32

1. Introduction

The past decade has witnessed a rapid development of financial technology (fintech) worldwide with fintech products such as digital payments, data-driven credit assessment, online trading platforms, and algorithmic information processing having altered participants' behavior in capital markets. Prior research has suggested that financial development matters for firms' cost of capital (Love 2003; Kim *et al.*, 2015). As an emerging dimension of financial development, the development of fintech should also affect the cost of equity capital. However, evidence on capital markets' implications of fintech development still remains scarce, particularly in an international setting. Thus, the objective of this study is to provide empirical evidence on the impact of fintech development on firms' cost of equity capital in global capital markets. Specifically, it explores the impact of fintech development on firms' cost of equity capital and identifies the mechanisms through which it occurs. It focuses on the cost of equity capital given a critical role of firm-level cost of equity in driving corporate financing and investment decisions.

Based on information asymmetry and agency theories, this study predicts that fintech development can affect firms' cost of equity capital through four non-mutually exclusive mechanisms: information asymmetry, agency problems, financial risk, and carbon risk. To empirically examine the impact of fintech development on firms' cost of equity financing, data on country-level fintech development provided by Crunchbase is employed. The research sample includes 60,004 observations of publicly listed firms from 45 markets from 2006 to 2018. The results show that higher levels of country-level fintech development are associated with a significantly lower firm-level cost of equity capital, suggesting that fintech is priced by equity investors. The findings also reveal that fintech development reduces firms' cost of equity capital by mitigating information asymmetry, agency problems, financial risk, and carbon risk. Moreover, the effect is more pronounced in countries exhibiting stronger governance quality and in societies with lower secrecy norms.

Overall, our study contributes to the literature in three important ways. First, it extends research on the determinants of the cost of equity capital by identifying fintech development as an important factor that shapes equity risk pricing in international markets. While prior studies have extensively examined how firm-level characteristics and country-level institutions affect equity financing costs (e.g., Hail and Leuz, 2006), much less is known about whether and how country-

level fintech development influences firms' cost of equity financing. Second, it contributes to the emerging fintech literature by documenting a previously underexplored capital market consequence of fintech development. Our study is closely related to, yet distinct from, Girardone *et al.* (2024), who examine the effects of fintech credit on firms' cost of debt, cost of equity, and capital structure. While Girardone *et al.* (2024) focus on fintech credit as an alternative source of external financing that directly influences firms' funding costs and financing choices, our analysis emphasizes information- and risk-based channels through which fintech development affects the cost of equity capital, rather than financing substitution or capital structure adjustments. Third, we add to the literature on institutions and culture by showing that the equity pricing effects of fintech development depend critically on governance quality and societal norms regarding secrecy.

The rest of the paper is structured as follows. Section 2 provides a review of the literature and formulates the hypotheses. Section 3 details the research design. Section 4 reports and discusses the empirical findings. Section 5 concludes.

2. Literature review and hypothesis development

2.1. Fintech development

Fundamentally, fintech involves leveraging technological advancements to develop and improve financial service provision. According to the Financial Stability Board, Fintech refers to “technologically enabled financial innovation that could result in new business models, applications, processes, or products with an associated material effect on financial markets and institutions, and the provision of financial services”.¹ Thakor (2020) characterizes fintech as comprising (i) credit provision, deposit-taking, and capital-raising services; (ii) payment, clearing, and settlement systems, including digital currencies; (iii) investment management and trading services; and (iv) insurance-related operations. Underpinning many of these applications is blockchain technology, which constitutes a core component of the technological infrastructure supporting financial innovation.

A rapid expansion of fintech recently has generated profound transformations in financial markets and the broader economy. In particular, fintech development has reconfigured traditional

¹ <https://www.fsb.org/work-of-the-fsb/financial-innovation-and-structural-change/financial-innovation/> (accessed 20 Feb 2026).

operation models and the information environment of financial markets, fostering more intelligent and inclusive financial services (Yang and Zhang, 2022), enhancing operational efficiency, lowering transaction costs, and accelerating the digital transformation of the financial industry (Ding *et al.*, 2022; Jia, 2024). A systematic review by Hasan *et al.* (2024) demonstrates that fintech can contribute to sustainable development by enhancing financial inclusion, stimulating economic growth, and supporting improvements in environmental quality. First, fintech enhances financial inclusion by expanding access to digital payments, crowdfunding, peer-to-peer lending, and microcredit, thereby reducing transaction costs and easing credit constraints for households and small businesses. Second, fintech promotes economic growth by increasing competition, improving financial intermediation efficiency, and supporting entrepreneurship and business expansion. Digital tools also strengthen household financial management and may help reduce income inequality, particularly where education and regulatory frameworks are supportive. Third, fintech facilitates environmental sustainability by channeling funds toward renewable energy and low-carbon technologies and encouraging environmentally responsible behaviors (Hasan *et al.*, 2024).

An emerging body of literature also documents the important role of fintech in determining corporate behavior and firm-level outcomes. Jia (2024) shows that greater exposure to fintech penetration increases future risk-taking among U.S. community banks. Using data on Chinese listed firms, Tang *et al.* (2024) find that fintech development significantly increases corporate risk-taking. Zhu *et al.* (2025) examine whether fintech development curbs corporate leverage manipulation, defined as firms deliberately understating book leverage through accounting techniques, using a sample of Chinese listed firms. Their findings show that fintech significantly reduces leverage manipulation by alleviating excessive and inefficient capital demands driven by poor investment decisions and managerial incentives. Li *et al.* (2026) show that Chinese listed non-financial firms engaging in fintech activities adjust their capital structures more rapidly, particularly when leverage falls below target levels. Using a sample of listed non-financial firms across 38 OECD countries, Girardone *et al.* (2024) find that fintech credit significantly reduces firms' cost of debt, cost of equity, and overall cost of capital, as well as lowers the leverage. Li and Wang (2025) document that fintech development significantly enhances green total factor productivity among Chinese listed firms by alleviating financing constraints and promoting technological innovation. Still focusing on Chinese listed firms, Ding *et al.* (2022) examine the

impact of city-level fintech development on corporate innovation and finds that firms - particularly those facing greater financial constraints - achieve higher innovation levels in cities with more advanced fintech services. Meanwhile, Tang *et al.* (2025) find that fintech development increases corporate financing and investment activities.

Although a growing strand of research examines the firm-level consequences of fintech development, several important gaps remain. First, much of the existing evidence is based on Chinese listed firms, raising concerns about external validity given China's distinctive institutional environments, regulatory structure, and state involvement in financial markets. Findings derived from this setting may not readily generalize to other countries with different financial architectures and investor protections. Second, while Girardone *et al.* (2024) using OECD firms shows that fintech credit reduces firms' cost of debt and equity, it focuses narrowly on fintech credit and does not unpack the mechanisms through which fintech development affects equity risk pricing. Accordingly, comprehensive cross-country evidence linking broader fintech development to firms' cost of equity capital and its underlying channels remains limited.

2.2. Cost of equity capital

The cost of equity capital refers to the expected rate of return that shareholders require to hold a firm's equity. It is a central determinant of firms' financing and investment decisions and plays a fundamental role in shaping corporate value and real economic activity (Ben-Nasr *et al.*, 2012). Extant literature shows that firms' cost of equity capital reflects investors' assessments of information risk, agency problems, financial risk, and exposure to regulatory and environmental uncertainty (Bhattacharya *et al.*, 2012; Chen *et al.*, 2011; Wang *et al.*, 2025). Previous studies emphasize the importance of information asymmetry and disclosure transparency in determining the cost of equity financing (Botosan, 1997; Diamond and Verrecchia, 1991). Corporate governance also shapes equity risk premia by affecting agency conflicts (Chen *et al.*, 2009). At the country level, legal institutions, financial market development, and national culture further drive corporate equity pricing (Hail and Leuz, 2006; Gray *et al.*, 2013). While the literature has extensively examined how firm-level characteristics and country-level institutions affect equity financing costs, much less is known about whether and how country-level fintech development influences firms' cost of equity capital in the international context.

2.3. Hypothesis development

First, fintech development alleviates information asymmetry between firms and external investors. Information asymmetry theory posits that investors demand higher expected returns when firm-level information environment is opaque or costly to obtain. Fintech can reduce information acquisition costs, facilitate more timely corporate disclosure, and improve both the speed and precision of information processing (Tang *et al.*, 2025). For instance, the decentralized and immutable features of blockchain technology enhance transaction transparency and security, thereby strengthening market credibility (Li and Wang, 2025). Meanwhile, big data enables the extraction of valuable insights from large-scale and heterogeneous datasets, including unstructured information that is often under-utilized by conventional financial intermediaries. Through the effective integration and analysis of non-traditional data, fintech may mitigate information asymmetry (Yang and Zhang, 2022). As a result, investors require a smaller risk premium, leading to a decline in the cost of equity capital (He *et al.*, 2013).

Second, fintech development mitigates agency conflicts between managers and shareholders. Agency theory suggests that weak monitoring increases agency problems due to managerial opportunism, which investors price into required returns. Fintech potentially strengthens external oversight, which in turn curbs corporate managers' opportunistic behavior and alleviates agency conflicts and estimation risk (Wen *et al.*, 2023). Moreover, enhanced data analytics and digital traceability improve monitoring effectiveness, constraining opportunistic behavior and reducing inefficient investment. By lowering agency costs and improving investment efficiency (Lv and Xiong, 2022), fintech development reduces the risk associated with managerial discretion, thereby decreasing the equity risk premium (Chen *et al.*, 2011).

Third, fintech development may reduce corporate financial risk by improving firms' access to diversified financing channels (Buchak *et al.*, 2018) to stabilize their cash flows. Finally, fintech development may contribute to lower climate-related risk by facilitating the adoption and financing of greener technologies (Xu *et al.*, 2023), and the resultant reduction in environmental risk is increasingly reflected in firms' cost of capital (Yan *et al.*, 2025).

Based on these discussions, the following hypothesis is proposed:

H₁: Fintech development is negatively associated with firms' cost of equity capital.

3. Research design

3.1. Sample and data

The research sample employed in this study is collected from multiple sources. The primary measure of fintech is constructed using data from Crunchbase, which provides comprehensive information on fintech startups worldwide. Data required to estimate firms' cost of equity capital are obtained from I/B/E/S and Datastream. Firm-level accounting information is collected from Worldscope, while stock price data are obtained from Datastream. Country-level gross domestic product (GDP) is sourced from the World Governance Indicators (WGI) database. After excluding observations with missing data and removing countries with fewer than 30 firm-year observations, the final sample comprises 60,004 firm-year observations spanning the period 2006 to 2018.

3.2. Dependent variable

Our dependent variable is the implied cost of equity capital (*ICOC*), a forward-looking estimate of firms' expected equity returns. This measure is computed as the average of four established valuation-based models: Gebhardt *et al.* (2001), Claus and Thomas (2001), Easton (2004), and Ohlson and Juettner-Nauroth (2005). These models infer the expected rate of return by equating current stock prices with the present value of forecasted future earnings or abnormal earnings, using analyst forecasts and accounting information. Averaging across models mitigates model-specific measurement error and enhances reliability.

We employ the implied (ex ante) measure rather than realized (ex post) stock returns because realized returns are noisy proxies for expected returns and incorporate unexpected shocks to cash flows and discount rates (Pástor *et al.*, 2008). In contrast, implied cost of equity estimates reflect the discount rate embedded in current market valuations and thus provide a more appropriate proxy for investors' required returns when examining the equity pricing effects of fintech development.

3.3. Independent variable

Fintech development (*FIN*), which is the independent variable in this study, is measured as the total number of fintech startups operating within a country-year. Crunchbase provides comprehensive, globally comparable information on startup activity, including firm founding

dates, industry classification, and operational status (Croce *et al.*, 2025). This database aggregates data from over 200,000 contributing organizations, approximately 2,000 venture partners, and millions of web-based data points, and has been increasingly utilized in recent academic research (Haddad and Hornuf, 2023). Consistent with Yuan *et al.* (2024), fintech development is proxied by the natural logarithm of the four-year moving average of fintech startups in each country.

3.4. Control variables

This study includes a set of firm- and country-level control variables commonly used in the cost of equity literature. At the firm level, we control for firm size (*SIZE*), measured as the natural logarithm of market value of equity; growth opportunities (*MTB*), proxied by the market-to-book ratio; return volatility (*STD*), measured as the annualized standard deviation of stock returns; profitability (*ROA*), captured by return on assets; and financial leverage (*LEV*), defined as total debt divided by total assets. At the country level, we control for macroeconomic conditions using the annual GDP growth rate (*GDP*) and the one-year-ahead inflation rate (*INF*), both of which may affect expected returns and risk premia.

3.5. Research model

The primary objective of this study is to examine whether fintech development influences firms' cost of equity capital. To this end, the following panel regression model is estimated:

$$Y_{ijt} = \beta_0 + \beta_1 X_{ijt-1} + \beta_2 Z_{i,jt-1} + IE + CE + YE + \varepsilon_{ijt} \quad (1)$$

where i , j , and t denote firm i in country j in year t . The dependent variable Y_{ijt} represents the implied cost of equity capital. X_{ijt-1} denotes our country-level measure of fintech development lagged by one year. Z_{ijt-1} is a vector of firm- and country-level control variables. IE , CE , and YE represent industry, country, and year fixed effects, respectively, and ε_{ijt} is the error term. If the coefficient on X_{ijt-1} is negative and significant, hypothesis H_1 is supported, otherwise it is rejected.

Industry fixed effects control for time-invariant differences in risk, growth opportunities, and capital intensity across industries that may systematically affect the cost of equity. Country fixed effects absorb unobservable, time-invariant institutional, legal, and financial system characteristics that influence equity pricing. Year fixed effects capture common time trends affecting all firms. Standard errors are clustered at the country-year level (Petersen, 2009).

4. Empirical results

4.1. Descriptive statistics and correlation matrix

Table 1 reports the descriptive statistics for the dependent variable, the main independent variable, and the control variables. Panel A presents summary statistics for the full sample. The implied cost of equity capital (*ICOC*) has a mean of 11.02% and a standard deviation of 8.90%, indicating substantial cross-sectional variation in firms' required equity returns. The fintech variable (*FIN*) exhibits a mean of 3.325 and a standard deviation of 1.756, suggesting significant heterogeneity in the level of fintech development across countries and over time.

[Insert Table 1 about here]

Panel B presents the distribution of firm-year observations across countries and regions and reports country-level mean values of the variables included in Equation (1). The final sample comprises 60,004 firm-year observations drawn from 45 countries. The United States represents the largest share of the sample, accounting for 35.77% of total observations. The country-level means of the key variables exhibit substantial cross-country variation.

Table 2 presents the Pearson correlation matrix for the key variables used in the main analysis. The pairwise correlations among the explanatory variables are all below 0.5, which is well under the conventional threshold of 0.8 suggested by Gujarati (2003). These relatively low correlation coefficients indicate that multicollinearity is unlikely to be a significant concern in our regression specifications.

[Insert Table 2 about here]

4.2. Fintech development – the cost of equity capital

Table 3 presents the baseline regression results. In Column (1), the coefficient on *FIN* is -0.832 and statistically significant at the 1% level. The effect is economically meaningful. A one-standard-deviation increase in *FIN* (1.756) is associated with a 1.46 percentage point decline in *ICOC* (0.832×1.756), which corresponds to approximately 13.2% of the sample mean *ICOC* (11.02%). This magnitude suggests that fintech development substantially reduces firms' equity financing costs. The results remain negative and statistically significant in the non-U.S., non-GFC, and non-financial subsamples, as reported in Columns (2), (3), and (4), respectively, further

supporting the robustness of the findings. The coefficients on the control variables are qualitatively consistent with the extant literature (Cao *et al.*, 2017): larger and more profitable firms exhibit lower costs of equity, whereas firms with higher return volatility and greater leverage face higher implied costs of equity capital. Overall, the evidence strongly supports the hypothesis that fintech development lowers firms' cost of equity capital.

[Insert Table 3 about here]

To further validate our baseline results, we perform a set of robustness checks. Table 4 presents estimates based on alternative proxies for the key independent variable (Column (1)) and alternative measures of the dependent variable (Columns (2)–(4)).

In Column (1), following Yuan *et al.* (2024), we employ an alternative proxy for fintech development (*FINa*) based on financial technology patents to assess the robustness of our results.² As described in their study, patent filing data are obtained from the U.S. Patent and Trademark Office's Bulk Data Storage System (BDSS). Yuan *et al.* (2024) identify financial patents using text-based screening procedures. They first restrict the sample to patent applications classified under IPC Classes G and H, which encompass the majority of financial and information technologies. They then apply two filtering criteria: (i) at least one relevant keyword must appear in the title, abstract, summary, or claims; and (ii) an additional filtering term must appear elsewhere in the filing document. The resulting measure is defined as the natural logarithm of the four-year moving average of financial patent counts.

Because our composite measure of the implied cost of equity capital is constructed as the average of four established models, we re-estimate the baseline specification using each individual measure separately to ensure that the results are not driven by any single model. Specifically, we consider the estimates derived from Gebhardt *et al.* (2001), Claus and Thomas (2001), Easton (2004), and Ohlson and Juettner-Nauroth (2005), represented by $ICOC_{gls}$, $ICOC_{ct}$, $ICOC_{mpeg}$, and $ICOC_{oj}$, respectively. Columns (2) through (5) report the results from regressing each alternative cost of equity measure on *FIN* and the set of control variables specified in Equation (1). Across all specifications, the coefficient on *FIN* remains negative and statistically significant, indicating that

² We do not construct this measure ourselves but instead rely on the country-level patent data compiled and made available by Yuan *et al.* (2024).

our baseline findings are robust to different measures of both the independent and dependent variables.

[Insert Table 4 about here]

4.3. Endogeneity controls

Table 5 addresses potential endogeneity concerns by employing alternative estimation techniques. In Column (1), we re-estimate the baseline specification using a firm fixed-effects model, which controls for all unobservable, time-invariant firm features that may influence the cost of equity and may be correlated with the firm’s exposure to country-level fintech development. By exploiting within-firm variation over time, this approach mitigates concerns that our baseline results are driven by unobserved heterogeneity across firms.

Columns (2) and (3) report the first- and second-stage results of a two-stage least squares (2SLS) estimation. Following Demir *et al.* (2022), we instrument fintech development with mobile phone penetration, measured at the country level. Mobile penetration is plausibly correlated with fintech development because digital financial services rely heavily on mobile infrastructure, yet it is unlikely to affect firms’ implied cost of equity directly except through fintech development. The first-stage results confirm a strong association between the instrument and fintech development, while the second-stage estimates continue to show a negative and statistically significant effect on the cost of equity. Overall, the consistency of the findings across firm fixed-effects and 2SLS estimations reinforces the causal interpretation of our baseline results.

[Insert Table 5 about here]

To strengthen our identification strategy, we exploit the staggered introduction of fintech regulatory sandboxes as a plausibly exogenous policy shock to country-level fintech development. Using information from the World Bank,³ we identify the first year in which each country implemented a regulatory sandbox. We construct an indicator variable, *Post*, which equals one for firm-year observations from and after the sandbox adoption year, provided the adoption occurs within our sample period (2006–2018), and zero otherwise. Panel A of Table 6 reports the

³ <https://www.worldbank.org/en/topic/fintech/brief/key-data-from-regulatory-sandboxes-across-the-globe#:~:text=There%20was%20an%20increased%20density,tech%20fintech%20innovations%20and%20regulation> (accessed 24 December 2025)

distribution of adoption years. Panel B presents the regression results. The coefficient on Post is negative and statistically significant, indicating that firms experience a decline in their implied cost of equity capital following sandbox implementation.

[Insert Table 6 about here]

4.4. The roles of information asymmetry, agency problems, financial risk, and carbon risk

Table 7 examines the channels through which fintech development influences firms' implied cost of equity capital by interacting fintech development with proxies for information asymmetry, agency problems, financial risk, and carbon emissions risk. Information asymmetry (*FDIS*) is measured by analysts' forecast dispersion from I/B/E/S (Chemmanur *et al.*, 2009); agency problems (*FCF*) are proxied by the natural logarithm of free cash flow from Worldscope (Chen *et al.*, 2012); financial risk (*STD*) is captured by the annualized standard deviation of daily stock returns from Datastream (Benlemlih *et al.*, 2018); and carbon risk (*ESCR*) is measured using Refinitiv ESG emissions scores (Tanthanongsakkun *et al.*, 2023). The coefficients of interest are those on the interaction terms. Column (1) shows that the negative association between fintech development and the cost of equity is stronger for firms with greater analyst forecast dispersion. Column (2) indicates a more pronounced effect among firms with higher free cash flow. Column (3) reveals a stronger effect for firms with higher return volatility. Finally, Column (4) shows that the effect is stronger among firms with lower emissions scores (i.e., higher carbon risk). Collectively, these results support the view that fintech development lowers the cost of equity by attenuating informational frictions, and reducing agency, financial, and climate-related risks.

[Insert Table 7 about here]

4.5. The roles of country governance and national culture

We next examine whether the effect of fintech development on firms' implied cost of equity capital depends on country-level institutional quality and national culture. Governance quality is measured using the World Governance Indicators, constructed as the average of six dimensions: Voice and Accountability, Political Stability, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption (Gugler *et al.*, 2014). We partition the sample at the mean into high- and low-governance subsamples. To capture national culture, we rely on Geert Hofstede's cultural dimensions obtained from Hofstede Insights. Secrecy culture is computed as uncertainty

avoidance plus power distance minus individualism (Hope *et al.*, 2008), and countries are also divided into high- and low-secrecy groups based on the sample mean. We re-estimate Equation (1) across subsamples and report results in Table 8. The negative association between fintech development and the cost of equity is statistically significant only in countries with high governance quality (Column (1)) and in those with low secrecy culture (Column (4)). These findings suggest that fintech's capacity to reduce equity financing costs is amplified in countries with stronger governance quality and in societies characterized by lower secrecy culture. In well-governed environments, fintech development is more likely to reinforce investor protection and regulatory effectiveness, while lower secrecy norms tend to facilitate information transparency and enhance fintech-related informational benefits in capital markets.

5. Conclusion

This study examines whether and how fintech development affects firms' implied cost of equity capital in an international setting. Using a large sample of 60,004 firm-year observations from 45 countries over the period 2006–2018, we document a robust negative association between fintech development and firms' cost of equity. The results remain robust to alternative measures, firm fixed-effects specifications, and instrumental-variable estimations. Further exploiting the staggered introduction of regulatory sandboxes as a plausibly exogenous policy shock to fintech development, we continue to find consistent evidence that fintech development lowers firms' equity financing costs. Mechanism analyses suggest that this effect operates through reductions in information asymmetry, agency frictions, financial risk, and carbon-related risk. Furthermore, the impact is more pronounced in countries with stronger governance quality and in societies characterized by lower secrecy culture, highlighting the importance of complementary institutional environments.

Our findings yield several important implications. For policymakers, the evidence suggests that fintech development functions as a component of financial infrastructure that enhances capital market efficiency by reducing informational frictions and risk premia. Regulatory initiatives such as fintech sandboxes appear to facilitate these benefits, but their effectiveness depends critically on institutional environments. For corporate managers, the results indicate that operating within fintech-developed ecosystems can materially reduce equity financing costs, particularly for firms facing greater informational opacity, agency problems, financial volatility, or carbon exposure. For

investors, the findings underscore the role of fintech development as an institutional factors in shaping equity risk premia. Incorporating fintech-related institutional indicators into international asset allocation and risk assessment frameworks may therefore improve the evaluation of cross-country differences in equity pricing.

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Table 1: Descriptive statistics

Panel A: Descriptive statistics of the entire sample

VARIABLES	N	Mean	SD	p25	p50	p75
ICOC	60,004	11.020	8.902	6.966	9.141	12.135
FIN	60,004	3.325	1.756	1.792	3.277	4.758
SIZE	60,004	20.746	1.863	19.455	20.665	21.971
MTB	60,004	2.823	3.255	1.111	1.817	3.205
STD	60,004	1.589	0.894	0.973	1.366	1.955
ROA	60,004	4.422	12.127	1.503	5.099	9.297
LEV	60,004	22.048	18.245	5.643	19.821	34.293
GDP	60,004	2.289	2.309	1.550	2.284	2.945
INF	60,004	2.396	2.061	1.262	2.069	3.157

Panel B: Descriptive statistics by market

Market	Freq.	Percent	ICOC	FIN	SIZE	MTB	STD	ROA	LEV	GDP	INF
Australia	3,104	5.17	12.465	2.708	20.161	2.936	1.689	4.788	19.100	2.718	2.346
Austria	351	0.58	11.805	0.826	20.836	1.791	1.446	4.514	26.779	1.486	1.914
Belgium	724	1.21	10.420	1.002	20.339	2.223	1.218	4.091	27.711	1.431	1.916
Brazil	936	1.56	13.246	2.611	21.375	2.983	1.665	7.562	29.706	2.057	5.779
Canada	2,596	4.33	13.834	3.210	20.053	2.304	1.779	0.993	21.040	1.656	1.765
Chile	218	0.36	7.565	1.024	22.132	2.154	1.036	5.965	29.139	3.709	3.205
China	279	0.46	15.398	1.736	21.388	1.687	2.010	7.044	25.937	7.662	2.496
Colombia	43	0.07	8.039	1.245	22.410	1.612	0.864	4.845	27.946	3.700	3.982
Croatia	71	0.12	8.252	0.213	19.945	1.620	1.103	5.393	21.255	0.323	1.732
Denmark	555	0.92	8.070	1.059	20.824	3.603	1.490	5.246	24.562	1.154	1.604
Estonia	68	0.11	16.238	1.508	19.068	1.610	1.064	7.952	28.395	3.665	2.961
Finland	830	1.38	11.827	1.276	20.214	2.282	1.357	5.415	25.131	1.312	1.515
France	2,529	4.21	11.195	2.395	20.397	1.989	1.392	3.610	23.341	1.130	1.258
Germany	2,809	4.68	11.439	2.552	20.231	2.366	1.535	4.176	21.029	1.579	1.432
Greece	325	0.54	13.682	0.374	20.249	1.743	2.002	5.067	29.602	-1.122	2.517
Hong Kong	894	1.49	10.613	1.070	22.058	1.655	1.489	5.976	21.495	2.810	2.983
Hungary	80	0.13	9.257	0.457	19.959	1.633	1.264	5.682	25.836	1.205	4.014
India	2,987	4.98	10.893	3.107	20.788	3.854	1.873	9.705	25.102	6.821	7.329
Indonesia	619	1.03	8.974	1.536	21.296	3.229	1.792	8.834	22.216	5.496	5.723
Ireland	208	0.35	13.101	1.543	20.927	2.433	1.590	4.679	20.514	3.719	1.447
Israel	356	0.59	10.606	2.511	20.808	2.994	1.478	2.199	19.265	4.003	1.474
Italy	1,160	1.93	11.984	1.634	20.470	2.001	1.487	3.551	27.680	0.012	1.420
Luxembourg	90	0.15	13.579	1.315	21.501	2.787	1.662	8.472	29.794	2.403	1.614
Malaysia	821	1.37	8.876	1.296	20.874	2.508	1.234	6.823	24.199	4.701	2.604
Mexico	429	0.71	10.639	1.275	21.737	2.548	1.370	7.374	25.219	2.237	4.211
Netherlands	35	0.06	7.960	3.217	22.956	3.416	1.027	4.590	20.933	1.458	1.521
New Zealand	352	0.59	11.209	0.984	20.060	2.393	1.032	7.592	24.969	2.547	1.933
Pakistan	162	0.27	13.531	0.575	20.516	1.924	1.267	9.358	18.815	4.402	6.389
Peru	56	0.09	7.958	0.635	21.208	3.433	1.339	6.634	31.997	4.797	2.970
Poland	592	0.99	10.745	1.482	20.464	1.890	1.537	5.523	19.614	3.887	1.929

Portugal	207	0.34	13.201	0.835	20.699	2.086	1.409	4.418	41.475	0.345	1.506
Romania	48	0.08	13.219	0.826	21.056	1.169	1.300	4.159	8.435	3.551	3.217
Russia	44	0.07	21.276	2.239	21.965	2.132	1.409	10.793	30.854	2.708	4.769
Saudi Arabia	42	0.07	8.070	0.128	23.099	2.366	1.224	5.365	19.536	4.093	4.705
Singapore	766	1.28	9.498	2.662	21.156	1.983	1.085	6.730	27.574	4.708	1.741
Slovenia	57	0.09	11.458	0.247	20.192	1.107	1.110	4.065	23.839	1.131	1.506
South Africa	492	0.82	10.452	2.376	21.273	2.861	1.235	7.599	17.794	1.617	5.485
South Korea	2,045	3.41	11.490	2.144	21.126	1.826	1.619	5.367	23.138	3.247	1.789
Spain	730	1.22	12.476	2.065	21.246	2.597	1.478	4.718	31.384	1.078	1.678
Sweden	1,734	2.89	10.005	1.915	20.082	2.870	1.516	5.212	23.191	2.051	1.219
Switzerland	1,259	2.1	8.525	1.969	21.075	2.586	1.218	5.200	17.708	2.062	0.403
Thailand	657	1.09	10.683	0.876	21.267	2.643	1.426	7.429	29.586	3.390	1.863
Turkey	897	1.49	11.202	1.254	20.679	1.962	1.634	7.373	24.359	4.974	8.555
United Kingdom	5,286	8.81	12.054	4.087	20.078	3.078	1.543	6.538	17.533	1.480	2.212
United States	21,461	35.77	10.307	5.002	21.041	3.243	1.676	2.392	20.953	1.776	1.922
Total	60,004	100									

Table 2: Correlation matrix

VARIABLES	ICOC	FIN	SIZE	MTB	STD	ROA	LEV	GDP
ICOC	1							
FIN	-0.066***	1						
SIZE	-0.247***	0.013***	1					
MTB	-0.100***	0.128***	0.197***	1				
STD	0.238***	0.024***	-0.334***	-0.007*	1			
ROA	-0.207***	-0.124***	0.240***	0.105***	-0.304***	1		
LEV	0.039***	-0.072***	0.122***	-0.014***	-0.043***	0.001	1	
GDP	-0.031***	-0.074***	0.094***	0.076***	-0.157***	0.110***	0.017***	1
INF	0.039***	-0.207***	0.008**	0.004	0.074***	0.117***	0.045***	0.416***

*** p<0.01, ** p<0.05, * p<0.1

Table 3: Baseline analysis of the fintech development – firms' cost of equity relationship

	(1)	(2)	(3)	(4)
VARIABLES	Full sample ICOC	Non-US sample ICOC	Non-GFC sample ICOC	Non-financial sample ICOC
FIN	-0.832*** (-7.096)	-0.336*** (-2.640)	-0.881*** (-7.607)	-0.815*** (-6.974)
SIZE	-0.814*** (-18.426)	-0.838*** (-30.916)	-0.838*** (-19.043)	-0.812*** (-17.820)
MTB	-0.095*** (-4.862)	-0.121*** (-7.575)	-0.096*** (-4.861)	-0.097*** (-4.809)
STD	1.435*** (15.706)	1.490*** (24.036)	1.514*** (14.620)	1.465*** (15.441)
ROA	-0.100*** (-12.620)	-0.097*** (-21.229)	-0.099*** (-12.040)	-0.100*** (-12.360)
LEV	0.031*** (8.412)	0.032*** (12.802)	0.032*** (8.809)	0.030*** (8.013)
GDP	0.046 (1.351)	0.036 (1.168)	0.084** (1.996)	0.057 (1.617)
INF	0.031 (0.837)	-0.020 (-0.494)	0.070 (1.576)	0.031 (0.806)
Constant	28.236*** (25.148)	27.258*** (39.966)	28.750*** (25.415)	28.109*** (24.295)
N	60,004	38,543	51,455	57,035
R ²	0.138	0.133	0.142	0.141
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Robustness checks using alternative measures of fintech and the cost of equity

VARIABLES	(1) ICOC	(2) ICOC _{gls}	(3) ICOC _{ct}	(4) ICOC _{mpeg}	(5) ICOC _{oj}
FINa	-0.453*** (-5.778)				
SIZE	-0.810*** (-18.216)	-0.445*** (-12.358)	-0.479*** (-13.549)	-0.855*** (-19.944)	-0.497*** (-15.612)
MTB	-0.096*** (-4.959)	-0.088*** (-4.877)	-0.085*** (-5.734)	-0.193*** (-12.859)	-0.114*** (-10.049)
STD	1.436*** (15.722)	0.821*** (12.420)	1.073*** (14.282)	1.716*** (20.281)	0.943*** (14.692)
ROA	-0.100*** (-12.650)	-0.061*** (-10.529)	-0.078*** (-12.749)	-0.045*** (-10.424)	-0.016*** (-5.402)
LEV	0.031*** (8.441)	0.033*** (11.095)	0.022*** (7.158)	0.036*** (9.719)	0.020*** (7.288)
GDP	0.043 (1.283)	0.129*** (5.048)	0.032 (1.411)	-0.052* (-1.661)	0.004 (0.201)
INF	0.052 (1.411)	0.162*** (5.704)	0.068** (2.510)	0.013 (0.368)	-0.154*** (-5.604)
FIN		-0.888*** (-8.762)	-0.639*** (-7.602)	-0.674*** (-7.059)	-0.247*** (-3.241)
Constant	27.647*** (24.301)	18.078*** (19.882)	20.599*** (23.680)	29.954*** (28.559)	21.100*** (27.156)
N	60,004	60,004	60,004	60,004	60,004
R ²	0.138	0.184	0.119	0.167	0.110
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5: Endogeneity controls using FE model and 2SLS

VARIABLES	(1) Firm_FE ICOC	(2) 1 st stage FIN	(3) 2 nd stage ICOC
IV		0.217*** (11.099)	
FIN	-1.123*** (-5.785)		-0.418*** (-4.131)
SIZE	-0.105 (-1.020)	-0.064*** (-11.363)	-0.789*** (-36.925)
MTB	0.003 (0.147)	0.009*** (3.553)	-0.114*** (-7.692)
STD	0.214*** (3.634)	-0.019*** (-3.615)	1.462*** (24.369)
ROA	-0.033*** (-4.943)	0.000 (0.905)	-0.097*** (-15.993)
LEV	0.038*** (7.846)	-0.000 (-0.790)	0.028*** (13.562)
GDP	-0.045* (-1.741)	0.003* (1.790)	0.037** (2.110)
INF	0.004 (0.149)	-0.020*** (-9.315)	0.092*** (3.959)
Constant	15.987*** (7.370)	1.962*** (13.474)	26.277*** (45.911)
N	60,004	60,004	60,004
R ²	0.765	0.887	0.115
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6: Endogeneity controls using fintech regulatory sandboxes as anexogenous shock

Panel A: Sandbox adoption year by market

Market	Sandbox adoption year
Australia	2016
Austria	-
Belgium	-
Brazil	2018
Canada	2017
Chile	-
China	-
Colombia	-
Croatia	-
Denmark	-
Estonia	-
Finland	-
France	-
Germany	-
Greece	-
Hong Kong	2016
Hungary	-
India	-
Indonesia	2017
Ireland	-
Israel	-
Italy	-
Luxembourg	-
Malaysia	2016
Mexico	-
Netherlands	2017
New Zealand	-
Pakistan	-
Peru	-
Poland	2018
Portugal	-
Romania	-
Russia	2018
Saudi Arabia	-
Singapore	2016
Slovenia	-
South Africa	-
South Korea	-
Spain	-
Sweden	-
Switzerland	2018
Thailand	2017
Turkey	-
United Kingdom	2016
United States	2018

Panel B: Regression results

VARIABLES	ICOC
POST	-0.532*** (-3.228)
SIZE	-0.761*** (-17.735)
MTB	-0.102*** (-5.191)
STD	1.453*** (15.867)
ROA	-0.100*** (-12.629)
LEV	0.031*** (8.440)
GDP	0.052 (1.524)
INF	0.050 (1.364)
Constant	24.352*** (25.916)
N	60,004
R ²	0.136
Year FE	Yes
Industry FE	Yes
Country FE	Yes

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7: Analyzing the roles of Information asymmetry, agency problems, financial risk, and carbon risk

VARIABLES	(1) ICOC	(2) ICOC	(3) ICOC	(4) ICOC
FIN	-0.789*** (-9.779)	-0.957*** (-13.497)	-0.347*** (-4.476)	-0.981*** (-9.715)
FIN*FDIS	-0.266*** (-4.192)			
FIN*FCF		-0.050*** (-3.029)		
FIN*STD			-0.072** (-2.042)	
FIN*ESCR				0.525*** (6.611)
SIZE	-0.750*** (-30.587)	-0.933*** (-33.727)	-0.817*** (-35.631)	-0.698*** (-14.971)
MTB	-0.099*** (-7.524)	-0.096*** (-7.317)	-0.178*** (-13.149)	-0.132*** (-9.101)
STD	1.413*** (20.139)	1.474*** (20.753)	2.228*** (16.012)	1.464*** (14.189)
ROA	-0.093*** (-14.857)	-0.077*** (-10.771)	-0.118*** (-19.620)	-0.047*** (-5.887)
LEV	0.030*** (14.435)	0.032*** (14.725)	0.022*** (10.698)	0.029*** (11.098)
GDP	0.063* (1.929)	0.040 (1.071)	0.025 (0.783)	-0.028 (-0.510)
INF	0.023 (0.661)	0.002 (0.060)	0.040 (1.174)	-0.007 (-0.130)
FDIS	1.415*** (5.625)			
FCF		1.178*** (14.751)		
ESCR				-0.751** (-2.064)
Constant	26.605*** (38.724)	30.930*** (41.393)	9.400*** (31.701)	26.231*** (21.813)
N	54,609	40,260	60,004	22,955
R ²	0.139	0.166	0.118	0.143
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 8: Analyzing the roles of governance quality and secrecy culture

VARIABLES	(1) High_WGI ICOC	(2) Low_WGI ICOC	(3) High_secrecy ICOC	(4) Low_secrecy ICOC
FIN	-0.988*** (-7.786)	0.103 (0.350)	0.076 (0.252)	-1.026*** (-7.977)
SIZE	-0.879*** (-16.519)	-0.618*** (-7.906)	-0.681*** (-8.811)	-0.873*** (-15.756)
MBT	-0.073*** (-3.228)	-0.172*** (-4.658)	-0.185*** (-5.284)	-0.061*** (-2.635)
STD	1.397*** (13.060)	1.415*** (8.185)	1.443*** (8.923)	1.389*** (12.516)
ROA	-0.099*** (-11.336)	-0.086*** (-5.527)	-0.088*** (-5.678)	-0.099*** (-11.161)
LEV	0.028*** (6.186)	0.042*** (7.063)	0.043*** (7.212)	0.026*** (5.496)
GDP	0.072 (1.336)	0.013 (0.302)	0.017 (0.431)	0.127** (2.059)
INF	0.024 (0.288)	-0.008 (-0.166)	-0.006 (-0.120)	0.226** (2.068)
Constant	30.494*** (22.041)	21.622*** (11.403)	22.915*** (12.733)	30.233*** (20.642)
N	43,083	16,921	20,212	39,792
R ²	0.142	0.137	0.135	0.143
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Stablecoins and Regulatory Fragmentation Risks to Financial Stability in ASEAN+3 under Geopolitical Stress

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Abstract:

Geo-fragmentation is reshaping financial integration in ASEAN+3 by widening regulatory gaps that global finance previously treated as manageable frictions. Stablecoins sit precisely at this fault line. They promise payment efficiency and cross-border reach, yet they also migrate quickly across jurisdictions and operational perimeters, especially when geopolitical stress raises incentives to re-route transactions and re-price liquidity. This paper advances a core claim that regulatory fragmentation is not merely a background condition but a destabilizing risk transmission mechanism in its own right. When rules diverge across authorization and perimeter definition, backing and redemption governance and safeguards for integrity and supervision, stablecoin activity can concentrate in weaker perimeter zones and transmit stress through three channels. These channels include payment rail substitution that weakens supervisory visibility, liquidity shocks amplified by redemption and reserve opacity and cross-border spillovers that complicate coordinated crisis responses. Using an ASEAN+3 comparative design, the study maps divergence across key regulatory dimensions and illustrates the stress relevance of perimeter mismatch through the SVB–USDC redemption episode and related stability diagnostics. The contribution is a policy package for regional coordination that preserves innovation while tightening common minima for perimeter definition, reserve disclosure and stress-time supervisory cooperation.

Keywords: *stablecoins; regulatory fragmentation; financial stability; ASEAN+3; geo-fragmentation; geopolitical stress*

1. Introduction

1.1. Geo-fragmentation and the ASEAN+3 integration puzzle

ASEAN+3 is still commonly described in the language of integration, digital finance and practical projects that keep cross-border payments connected. While this terminology remains accurate, it is now situated within a more fractured geopolitical economy. Alignment pressures, sanctions risk and strategic industrial policy have made cross-border finance more conditional and in some corridors more openly contested. The region also resists any single regulatory description. Highly standardised jurisdictions with mature supervisory technology and deep market infrastructure sit next to emerging and frontier systems where legal capacity, enforcement reach and even data availability remain uneven. That mix matters because it changes what “integration” means in practice. Cross-border activity increasingly encounters borders that are legal and operational rather than geographic and those borders can shift quickly once geopolitical stress rises (Aiyar et al., 2023).

The region’s fragmentation is not only a legal story but also a volatility story, because geopolitical stress repeatedly shows up as measurable shifts in Vietnam’s financial markets and risk formation dynamics. Empirical evidence from Vietnam links geopolitical risk to market

movements and bubble-prone windows, which is exactly the kind of stress condition under which cross-border settlement choices become more sensitive and more easily rerouted (Le et al., 2024).

Digital trade and platform intermediation in Southeast Asia add a further layer. At today's scale, payment instruments and settlement choices are no longer merely a technical nuance. They shape how liquidity circulates and how risk is redistributed across balance sheets and jurisdictions. For that reason, policy analysis in ASEAN+3 needs to identify the specific points where geo-fragmentation bites, where cross-border activity becomes harder to classify, harder to supervise and easier to reroute.

A useful way to operationalise these stress windows is to treat policy uncertainty as a companion variable to geopolitical tension, because uncertainty does not merely slow investment but also weakens the predictability of compliance expectations across market actors. Evidence from Vietnam shows that higher economic policy uncertainty correlates with weaker firm performance, suggesting a broader environment where risk-bearing becomes less transparent and supervision becomes more reactive (Nguyen et al., 2024).

1.2. Why stablecoins

This study prioritizes the functional implications of stablecoins over their technological novelty. Designed for transfer and settlement, stablecoins behave like money-like claims at the point of use, even when they remain privately issued instruments on public blockchains. This feature places them closer to financial stability concerns than speculative cryptoassets whose primary role is investment or trading exposure (Adrian et al., 2025). The distinction matters. Stablecoins are routinely used as a bridge between volatile cryptoassets and fiat currencies and they are increasingly used in payment-adjacent settings, including cross-border use cases (Adrian et al., 2025). This paper therefore concentrates on fiat-backed stablecoins, especially those pegged to major currencies and backed by liquid financial assets. These arrangements are the ones most plausibly linked to broader liquidity conditions and redemption dynamics and they are also the designs through which confidence effects can spill into the conventional financial system (Adrian et al., 2025).

Algorithmic designs are relevant to market integrity debates, but they do not anchor the same type of cross-border settlement behaviour and are not the best starting point for a regional stability question framed around integration under geopolitical stress.

1.3. The legal and policy puzzle under currency competition

In an integrating ASEAN+3, the same stablecoin arrangement often takes on different legal forms once it crosses borders. A token treated as a payment instrument in one jurisdiction may be policed as a securities-like product elsewhere, or it may sit in an uncertain perimeter altogether. That classification choice is not a drafting nuance. It reshapes who supervises, what disclosures are demanded, how redemption rights are framed in practice and how quickly authorities can respond when stress arrives.

Currency competition sharpens the stakes. Many of the largest stablecoins remain denominated in US dollars and large-scale adoption can interact with domestic monetary preferences and with regional ambitions to reduce reliance on a single external monetary anchor. This becomes especially salient when geopolitical tensions make payment and settlement infrastructures more politicised (Adrian et al., 2025; Aiyar et al., 2023).

1.4. Claim, mechanism and contribution

The central claim is that regulatory fragmentation in stablecoin governance should not be treated as a neutral background feature. Under geopolitical stress, fragmentation operates as a destabilising risk transmission mechanism. Divergence in perimeter definition, authorisation thresholds, reserve and disclosure obligations and the credibility of redemption safeguards creates space for activity to migrate toward softer or more ambiguous perimeters. The consequences are familiar yet difficult to manage when they arrive. Supervisory visibility thins, liquidity stress around confidence and redemption becomes more likely and cross-border spillovers turn harder to coordinate in real time.

The mechanism is structural rather than subtle. Cross-border finance repeatedly moves toward the path of least constraint, not because market actors aim to manufacture instability, but because legal and operational frictions are priced into business models. The cost emerges later, at the moment authorities need speed and compatibility and find instead a patchwork of rules that do not line up across jurisdictions.

The paper does two things. Analytically, the paper reframes fragmentation as a predictable pathway through which risk travels across borders, rather than a descriptive label for legal diversity. Normatively, it argues for common minima that preserve room for innovation while tightening the points where fragmentation most reliably generates vulnerability. These minima concern perimeter clarity, baseline reserve and disclosure expectations and stress-period cooperation consistent with international standard-setting directions (FSB, 2023).

1.5. Key definitions and scope conditions

In this paper, stablecoins refers to fiat-backed stablecoins that purport to maintain a stable value through reserve assets and redemption claims, because these instruments connect most plausibly to traditional financial channels and confidence dynamics (Adrian et al., 2025). Regulatory fragmentation refers to divergence in perimeter definition, prudential and conduct minima and supervisory cooperation expectations, coupled with an arbitrage effect in which activity relocates toward jurisdictions whose rules impose lower friction or weaker visibility (FSB, 2023). Geo-fragmentation is treated as a stress amplifier that raises the likelihood of divergence and slows cross-border alignment. For that reason, the paper evaluates fragmentation under stress conditions rather than treating calm periods as a representative baseline (Aiyar et al., 2023).

2. Mechanism and conceptual framing under geo-fragmentation

2.1. Regulatory fragmentation as a vulnerability-making mechanism

Regulatory fragmentation is often euphemistically described as regulatory diversity. That description is accurate in a narrow, doctrinal sense, yet it becomes evasive once stablecoin activity scales across borders. The core problem is not that jurisdictions write different rules. The core problem is that divergence in perimeter definition and in stability guardrails creates corridors through which activity can migrate toward the weakest effective standard, especially when private actors can reroute quickly and when supervisors do not share a common operational picture. The FSB makes a related point in more formal language when it stresses that there is no universally agreed legal definition of stablecoin and treats the term as a market label, which immediately implies that classification and perimeter will vary across jurisdictions unless authorities converge on functional and risk-based criteria (FSB, 2023).

In ASEAN+3, the mechanism is amplified by uneven regulatory readiness. Some jurisdictions have mature perimeter thinking, deep supervisory tools and long experience with payment-facing intermediaries, while others are building baseline frameworks and institutional capacity as digitalisation accelerates. The result is not simply a patchwork of statutes, but a set of partially overlapping perimeters that do not align with the operational pathways of stablecoin issuance, distribution, custody and redemption.

The paper therefore treats fragmentation as a mechanism that produces vulnerability. Vulnerability here means that small shocks can be transmitted faster and farther than supervisors can respond, because regulatory borders are not merely different, they are misaligned with how the activity actually moves.

2.2. Three channels of risk transmission

The mechanism operates through three channels that link legal design to operational consequences.

The first channel is supervisory visibility. Stablecoin activity is rarely a single institution operating inside one licensing box. It is usually an arrangement across issuers, reserve managers, distributors, wallets, exchanges and payment interfaces. When perimeter definition and reporting obligations diverge, supervisory sightlines become fragmented. Visibility is then not only about access to data. It is about the ability to reconstruct exposures, identify

concentration points and act in time when confidence weakens. The FSB's high-level recommendations place strong emphasis on governance, risk management and cross-border cooperation for global stablecoin arrangements and that emphasis reflects the stability relevance of visibility and coordination rather than mere compliance completeness (FSB, 2023).

The second channel is liquidity and redemption. Fiat-backed stablecoins sit closest to conventional markets precisely because their stability claims rest on reserves and redemption credibility. Divergence in reserve requirements, disclosure expectations and redemption governance changes the speed and severity with which a confidence shock can become a liquidity shock. IMF work on stablecoins treats redemption risk, reserve quality and transparency as central to stability analysis and it also explains why stablecoin arrangements can create connections with traditional finance even when their primary use has been within crypto markets (Adrian et al., 2025).

The third channel is cross-border spillovers. When stress rises, stablecoin flows can reroute across jurisdictions and responses can become uncoordinated if authorities face different legal constraints and different operational pictures. Spillovers are not only about capital moving. They are also about payment substitution, liquidity hoarding and confidence dynamics that travel through networks. The FSB's focus on consistent and effective oversight across jurisdictions is an implicit recognition that spillovers become harder to manage when legal divergence slows coordination (FSB, 2023).

2.3. Real-financial feedback loops under stress

Beyond isolated market volatility, the policy concern is feedback loops that connect digital activity to the real economy and to conventional markets. Stablecoins create plausible loops because they are payment-facing and because their reserves and redemption features can interact with broader liquidity conditions.

One loop starts from confidence. A loss of confidence in redemption credibility can trigger outflows and faster conversion into alternative assets. That shift can pressure reserve liquidation or reserve reallocation. Liquidity stress then tightens conditions for actors that rely on short-horizon funding and settlement certainty. The tightening can spill into payment behaviour, risk appetite and even the ability of firms to settle cross-border obligations on time. Demand for money-like substitutes can then rise again, which can push more activity toward stablecoin rails precisely when the system is least able to absorb it.

BIS analysis of the next-generation monetary and financial system helps clarify why this matters. It argues that stablecoins fall short as the mainstay of the monetary system when set against requirements such as singleness, elasticity and integrity and it treats their performance under stress and their implications for monetary sovereignty as core concerns rather than secondary issues (BIS, 2023). The argument in this paper is narrower and more practical. It does not claim stablecoins will replace sovereign money. It claims that stablecoins can become a fast-moving stress amplifier in fragmented regulatory environments and that the amplification is most visible through redemption dynamics, reserve opacity and the speed of payment substitution.

2.4. Currency competition as a conditional driver

Currency competition enters this paper as a conditional driver, not merely as a rhetorical device. In ASEAN+3, many stablecoins of systemic interest are USD-referenced. That reference can be attractive in cross-border commerce and in stress periods because it offers a familiar unit of account and a perceived hedge against local volatility. Yet the same feature can create policy discomfort. It can reinforce dollar-facing payment habits and complicate regional aspirations to reduce reliance on external rails and external monetary conditions.

The BIS has explicitly tied stablecoin risks to concerns about monetary sovereignty, which is a reminder that currency competition is not merely a market outcome, it is a policy concern that intensifies under stress (BIS, 2023). For this paper, the point is not to argue that USD-linked stablecoins are inherently destabilising. The point is that currency competition interacts with fragmentation. When perimeters and guardrails differ, USD-linked stablecoin activity can

concentrate in the weakest observable corridors and the resulting spillovers can become politically sensitive at exactly the moment when coordination is already difficult.

2.5. Geopolitical stress: operationalisation and stress windows

Geo-fragmentation is treated here as a driving condition because it changes incentives and the feasibility of coordination. When geopolitical stress rises, jurisdictions tend to prioritise discretion and monetary sovereignty instincts. That tendency can harden regulatory borders and widen divergence, even when integration remains an explicit aspiration. This framing aligns with IMF analysis that treats geoeconomic fragmentation as policy-driven and multidimensional, with consequences that extend beyond trade (IMF, 2022).

To keep the analysis verifiable, geopolitical stress is not treated as a metaphor. It is proxied using established public measures rather than ad hoc narrative claims. A standard candidate is the Caldara–Iacoviello Geopolitical Risk Index, which constructs a news-based measure of adverse geopolitical events and associated risks and has been widely used in empirical macro-finance research (Caldara & Iacoviello, 2022). This proxy does not “explain” any one episode on its own. It provides a disciplined way to identify stress windows in which fragmentation mechanisms are more likely to ignite, because policy discretion rises and coordination becomes slower.

3. Research design and evidence

3.1. Scope, unit of analysis and the discipline of comparison

The research design treats ASEAN+3 as a governance space in which stablecoin activity can move faster than jurisdiction-bound legal perimeters can converge. The unit of analysis is therefore not the token in a technical sense, but the regulatory perimeter at the jurisdiction level, observed through how legal and supervisory instruments allocate responsibility for issuance, distribution, custody and redemption. This choice is consistent with the practical problem noted in international standard-setting work, namely that stablecoin remains a market label rather than a universally agreed legal category, so classification and perimeter boundaries can vary unless authorities converge on functional and risk-based criteria (FSB, 2023).

ASEAN+3 is not treated as an internally uniform block. Differences in institutional readiness and perimeter maturity are part of the policy puzzle rather than an incidental background. Under conditions of geoeconomic fragmentation, divergence is more likely to persist and can weaken coordination in stress periods, which is why the analysis treats fragmentation under stress conditions rather than in calm baselines (Aiyar et al., 2023).

The evidence strategy therefore follows two layers. The first layer maps jurisdiction-level legal perimeters to identify where governance burdens attach in practice, whether at the issuer, at intermediaries, or outside the domestic perimeter altogether. The second layer reads the perimeter map through stress windows, using public indicators to identify periods in which the fragmentation mechanism is more likely to ignite and then tracing how the corridors described in Section 2 become operationally salient. The design does not claim statistical identification. It aims to discipline inference by keeping each step verifiable and tied back to observable perimeter features.

3.2. From a numerical index to an audit matrix

Instead of constructing a single numerical index, the paper adopts an audit-style comparative matrix. Stablecoin perimeter divergence is not a purely semantic difference in legal wording. It is a structural difference in accountability and information bottlenecks. A unified score can smooth over these structural differences and invites contestation over subjective scoring choices. For a policy audience, the more robust move is to show precisely where divergence sits and how it maps onto the risk channels developed in Section 2.

Table 3 therefore operationalises fragmentation through three audit axes. The first axis captures authorisation and perimeter definition, identifying where responsibility is placed and which entities sit inside the licensing and reporting perimeter. The second axis captures reserve and redemption governance, distinguishing statutory or supervised safeguards from arrangements that rely primarily on offshore issuer terms. The third axis captures supervisory visibility and

integrity, focusing on what supervisors can reconstruct under stress and which nodes in the chain carry enforceable integrity obligations. The matrix is designed to be checkable. Where an item depends on secondary summaries rather than clearly stated primary legal text, the table avoids overly precise technical assertions and keeps the description at the level of institutional design.

Table 1. Evidence corpus and public indicators used in the paper

Material class	What is collected	Analytical role	Practical limitation
Domestic legal and supervisory instruments	Statutes, decrees, licensing rules, supervisory circulars, official guidance affecting issuance, distribution, custody, redemption, disclosures and AML obligations at key nodes	Establish the jurisdiction-level perimeter map and locate accountability in the chain	In some jurisdictions, perimeter discipline is expressed more through supervisory practice than detailed primary legislation
International baselines	High-level recommendations and stability frameworks on stablecoins, particularly governance, cross-border cooperation, reserves and redemption	Provide a baseline so the audit axes are anchored rather than ad hoc	Baselines are not binding domestic law and may be implemented unevenly
Regional framing documents	Concept note and regional policy framing of integration under geoeconomic fragmentation	Align the research lens with the policy questions relevant to the seminar audience	These are agenda-setting documents rather than enforceable instruments
Stablecoin market-level indicators	Public indicators on scale and market stress signals, used as contextual proxies for redemption pressure	Identify periods when redemption dynamics may become more salient	Many indicators are not disaggregated to ASEAN+3 and rarely isolate stablecoin use cases by function
Macro-financial conditions	Public indicators reflecting liquidity and risk-off environments	Contextualise whether reserve liquidation would plausibly amplify broader liquidity stress	Not used to attribute causal effects to stablecoins
Geopolitical stress proxy	Caldara and Iacoviello geopolitical risk index	Identify stress windows using an established, replicable measure	News-based proxy does not explain any single episode on its own

Source: *Authors compilation based on enacted regulations, official guidance and publicly available indicators.*

3.3. Stress windows and alignment strategy

The alignment strategy follows a window-based logic. When geopolitical stress rises and the liquidity environment becomes less supportive, policy discretion tends to increase and coordination often becomes slower. These are the conditions under which regulatory borders can harden, divergence can widen and fragmentation corridors can become operationally relevant. Operationalising geopolitical stress through an established proxy avoids narrative selection and makes the stress-window identification replicable (Caldara & Iacoviello, 2022).

Within identified windows, the paper does not attempt to infer causality. It tracks whether the perimeter features that Section 2 describes as risk-bearing are positioned to matter in practice. The questions are deliberately concrete. First, do perimeter definitions and reporting obligations allow supervisors to reconstruct exposures across issuers, custodians, distributors and venues, or do they fracture the operational picture. Second, do reserve and redemption safeguards exist as enforceable obligations, or do they rely mainly on offshore issuer terms that are outside domestic supervisory reach. Third, do cross-border spillover channels have a legal basis for timely cooperation, or does divergence slow down coordination when timing is most important. The IMF has highlighted redemption risk, reserve quality and transparency as central to stability concerns around stablecoins, which supports using these features as the backbone of the alignment exercise (Adrian et al., 2025).

3.4. Triangulation and what the evidence can and cannot claim

Inference is disciplined through triangulation. The legal perimeter map provides the structural baseline. Public activity and stress indicators identify periods in which perimeter weaknesses are more likely to become binding constraints. The episode-based reading then asks whether fragmentation plausibly creates observable corridors for risk migration, particularly through visibility loss, redemption pressure and spillover coordination frictions.

The evidence is designed to support a policy diagnosis rather than a statistical estimate. It does not claim that a particular stablecoin event caused a macro outcome. It shows how, under stress windows, differences in perimeter placement and enforceable safeguards determine whether redemption pressure meets a statutory pathway, an intermediary gatekeeper constraint, or an offshore contractual promise.

Table 2. Audit axes used for the comparative perimeter mapping¹

Audit axis	Core audit question	What to look for in legal text and guidance	Stability relevance
Axis 1. Authorisation and perimeter definition	Which entity bears the regulatory burden and sits inside the licensing and reporting perimeter	Definitions of regulated activity, licensing thresholds, designated responsible entities, reporting triggers	Visibility fails early if the perimeter attaches to the wrong node
Axis 2. Reserve and redemption governance	Whether reserves and redemption are governed through enforceable obligations or largely through offshore contractual terms	Reserve requirements, asset quality constraints, disclosure and attestation duties, redemption rights and timelines	This is where confidence shocks can translate into liquidity stress
Axis 3. Supervisory visibility and integrity	What supervisors can observe and reconstruct under stress and which nodes carry integrity obligations	Reporting powers, data access rights, AML obligations at gateways, enforcement tools, cooperation channels	Spillovers are harder to manage when exposures cannot be reconstructed in time

Table 3. Comparative regulatory perimeter audit matrix across selected ASEAN+3 jurisdictions

Jurisdiction	Axis 1. Authorisation and perimeter	Axis 2. Reserve and redemption governance	Axis 3. Supervisory visibility and integrity	Primary legal anchor(s)

¹ Note: This rubric guides the reading of legal and supervisory materials. It is not a scoring framework for regulatory quality.

Singapore	Issuer-centred perimeter for single-currency stablecoins, with perimeter discipline reinforced through a regulated label and issuer approval requirements	Reserve and redemption obligations are pulled into the supervised perimeter as conditions of credibility, supported by disclosure and assurance expectations	Direct supervisory relationship with issuers, with emphasis on reporting, governance and auditability to support timely reconstruction of exposures	MAS stablecoin regulatory framework and Payment Services Act
Japan	Institution- and instrument-based perimeter design, with issuance and distribution constrained to specific regulated entity types and arrangements	User protection and redemption assurance are embedded in the permitted legal structure, including segregation and redemption-related obligations routed through regulated entities	Visibility is achieved through strong gatekeeping at regulated intermediaries and transfer-service providers, which also anchors AML obligations	Amended Payment Services Act and related supervisory guidance
Thailand	Hybrid perimeter where stablecoin use is channelled through regulated venues for digital asset activity, while issuer-level obligations are not systematically imposed when the issuer is offshore.	Domestic protection relies heavily on venue supervision, custody rules and risk disclosures when issuers are offshore	Visibility concentrates on exchange and VASP obligations, with reporting and enforcement routed through licensed venues	Emergency Decree on Digital Asset Businesses and relevant SEC decisions on permitted stablecoins for digital asset activity
South Korea	User-protection and VASP-centred perimeter under a virtual-asset framework, with stablecoins generally treated within the broader virtual asset perimeter rather than a bespoke issuer regime	Redemption-related risk is addressed indirectly through custody and user-asset protection duties rather than issuer-specific reserve rules	Integrity obligations are strong, focusing on unfair trading, reporting duties and custody safeguards, shaping visibility at intermediary nodes	Act on the Protection of Virtual Asset Users, effective 2024
Vietnam	Defensive perimeter in which stablecoins are not recognised as a lawful payment instrument under the domestic payment framework and a dedicated issuer	Reserve and redemption governance is not provided through domestic statute, leaving users reliant on offshore issuer terms and market practice, which becomes more binding under stress	Supervisory visibility is largely indirect through banking and AML channels, without direct line of sight into wallet-level flows	Decree 52/2024/ND-CP on cashless payments, complemented by SBV public statements/co mmunications on non-recognition of cryptoassets as

	licensing regime is not established in domestic law.	windows		means of payment.

Source: *Authors compilation based on enacted regulations and official guidance.*

Instead of a unified numerical index, which risks oversimplifying complex legal variances, Table 3 presents an audit-style comparative matrix. The matrix shows where regulatory burdens attach across jurisdictions and where they do not. The same payment-facing stablecoin function can persist, while legal responsibility shifts materially from issuer balance-sheet discipline to intermediary gatekeeping, or remains largely outside domestic law. During stress windows identified through the geopolitical risk index, these perimeter differences shape whether redemption pressure meets a statutory pathway, a supervised gatekeeper constraint, or an offshore contractual promise (Caldara & Iacoviello, 2022).

4. Regulatory map across ASEAN+3

4.1. Three Perimeter Types and one structural counterpoint

Table 3 does not merely catalogue national rules. It exposes perimeter choice as the unit that matters for stability. Across the sample, three Perimeter Types recur. The Issuer-Centred Perimeter hard-codes stability claims into enforceable issuance conditions. The Intermediary-Centred Perimeter disciplines stablecoin use mainly through licensed platforms and service providers. The Defensive Perimeter preserves a conventional payments boundary by excluding stablecoins from lawful payment rails.

This section reads the Audit Matrix as a stability map rather than a legal survey. The central contrast is not Singapore versus Japan as country cases. It is Statutory Guarantee versus Market Liquidity as the practical foundation of redemption credibility. The second contrast is Institutional Congruence versus Institutional Incongruence as the condition for cross-border coordination, because perimeter choice determines whether supervisors can build a shared operational picture when stress arrives.

Vietnam is treated here as a structural counterpoint rather than a peripheral case. In the Audit Matrix, Vietnam represents a Defensive Perimeter that is intentionally exclusionary on the payments axis, while stablecoin access persists through offshore and informal channels. That combination, exclusion in law plus access in practice, is where fragmentation bites hardest in regional settings (Government of Vietnam, 2024).

This gap is not hypothetical. Even in a context where cryptocurrencies are not legalised, empirical work on Vietnam shows persistent investment intention and adoption drivers for cryptoassets among Vietnamese individuals, reinforcing the point that access can remain socially and commercially durable even when the payment perimeter is formally closed (Pham et al., 2024).

Geo-fragmentation matters here as a driving condition rather than a background environment. When coordination becomes slower and comparability breaks down, the costs rise precisely in the windows where speed and shared visibility are most needed (Aiyar et al., 2023).

4.2. Axis 1 authorisation and perimeter definition

Perimeter divergence begins with a deceptively basic choice. Which node is regulated and which trigger activates authorisation. The FSB cautions that stablecoin remains a market label without a universally agreed legal definition, which means that perimeter choices will diverge unless authorities converge on functional and risk-based criteria (FSB, 2023).

The Issuer-Centred Perimeter reduces ambiguity by making the issuer the accountable node for stability claims. Singapore's framework for single-currency stablecoins issued in Singapore is designed around an issuance perimeter that links value stability to a supervised label and enforceable issuer-side obligations (Monetary Authority of Singapore, 2023). Japan's perimeter similarly restricts issuance to regulated institution categories and builds an intermediary registration layer that tightens distribution gatekeeping and identity verification expectations (Japan Financial Services Agency, 2022). The point is not that these regimes eliminate risk. The point is that they define who carries legal responsibility when a stability claim is tested.

The Intermediary-Centred Perimeter shifts the accountable node. Stablecoin access and use are disciplined primarily through licensed platforms and service providers, where listing controls, custody discipline and VASP obligations become the enforceable perimeter. Thailand's approach, through token approvals for regulated digital-asset uses, illustrates how perimeter discipline can be routed through market infrastructure rather than through a dedicated issuer prudential regime when issuers are often offshore (Tilleke & Gibbins, 2025). South Korea's framework similarly concentrates enforceability at the VASP perimeter through user protection and transaction-order duties (Korea Financial Services Commission, 2023, 2024). This can be effective for market order, yet it relocates perimeter responsibility away from the issuer balance sheet, which matters when redemption pressure becomes the dominant stress channel.

The Defensive Perimeter creates a different form of divergence. Vietnam's payments perimeter preserves a bright line around lawful payment instruments and excludes virtual currencies from recognised payment rails, which keeps stablecoins outside an endorsed settlement framework even while users can still access offshore rails and informal conversions (Government of Vietnam, 2024). This is Institutional Incongruence by design. The legal perimeter signals exclusion, while the operational perimeter in practice can remain porous. In cross-border settings, this incongruence amplifies classification ambiguity and weakens the ability to coordinate on shared perimeter assumptions.

4.3. Axis 2 reserve and redemption governance

For fiat-backed stablecoins, stability manifests primarily as a redemption challenge under stress. The key regional divide is whether redemption credibility is anchored in enforceable issuer-side duties, or whether it is effectively mediated through platforms and offshore issuer terms.

Within the Issuer-Centred Perimeter, redemption credibility is intended to rest on enforceable issuer-side obligations, so the stability claim is supported by a statutory perimeter rather than by platform discipline alone. Singapore's framework is explicitly framed in value-stability terms for regulated stablecoins, signalling that reserve quality and redeemability sit inside the issuer perimeter as supervised conditions (Monetary Authority of Singapore, 2023). Japan's institution-based issuance perimeter, combined with intermediary gatekeeping, similarly aims to tighten the legal basis on which user protection and redemption expectations operate (Japan Financial Services Agency, 2022). This is Statutory Guarantee not in the sense that government guarantees value, but in the sense that redemption governance is anchored in enforceable duties attached to the accountable issuance node.

Within the Intermediary-Centred Perimeter, redemption credibility leans more heavily on Market Liquidity and platform-mediated enforceability. When issuers sit offshore, reserve governance and redemption rights are not anchored in the domestic perimeter in the same way. Domestic discipline tends to operate through custody rules, disclosure practices and user-rights enforceability via intermediaries, which can be workable in normal conditions but more fragile in fast confidence shocks (Tilleke & Gibbins, 2025). South Korea's user-protection and custody requirements raise the integrity floor at the intermediary layer, yet the structural difference remains, because the perimeter is still intermediary-facing rather than issuer-facing (Korea Financial Services Commission, 2023, 2024).

Vietnam's Defensive Perimeter sharpens the corridor effect. Because stablecoins are not integrated as lawful payment instruments, redemption governance for users is not anchored in a domestic statutory perimeter for the stablecoin arrangement itself. In stress windows, users are pushed toward offshore issuer terms and informal guarantees, which makes redemption outcomes depend more on liquidity conditions and platform behaviour than on enforceable domestic duties (Government of Vietnam, 2024).

4.4. Axis 3 supervisory visibility and integrity controls

Supervisory visibility is not only about data access. It is about whether supervisors can reconstruct exposures and act in time when confidence weakens. Visibility is not only a reporting pipeline; it also depends on whether governance expectations are articulated as

implementable principles that firms can translate into internal controls, audit routines and accountability artefacts. In a finance-facing context, work on ethical AI management highlights how regulatory frameworks often need an ethics-and-governance layer to remain workable under fast-moving technical adoption (Nguyen, 2024). The FSB's recommendations emphasise governance, risk management and cross-border cooperation for stablecoin arrangements with cross-jurisdictional reach, reflecting that stability risk becomes inherently cross-border once arrangements scale operationally (FSB, 2023).

The Issuer-Centred Perimeter can produce more legible accountability for supervision because the issuer is the regulated node for stability claims. Singapore's architecture links the regulated label to a supervised perimeter, implying a clearer locus for reporting and supervisory intervention (Monetary Authority of Singapore, 2023). Japan's intermediary registration and identity verification expectations place integrity controls at distribution while maintaining an institution-based issuance boundary, which helps reduce opacity in the operational chain (Japan Financial Services Agency, 2022).

The Intermediary-Centred Perimeter places integrity and visibility obligations primarily on VASPs and platforms. South Korea's statute operationalises custody safeguards and market order duties as enforceable stability levers at the intermediary layer (Korea Financial Services Commission, 2023, 2024). This can strengthen conduct discipline, yet visibility remains vulnerable to cross-border shifts when stablecoin functions migrate across platforms and jurisdictions.

Vietnam's Defensive Perimeter creates a distinctive visibility asymmetry. Exclusion from the payments perimeter does not eliminate stablecoin-related flows. It often means supervisors can see fiat legs through banking transactions while lacking timely visibility into wallet-level exposures and cross-border stablecoin pathways. That gap becomes consequential during stress windows, when coordination requires comparable operational pictures rather than merely aligned policy language (Government of Vietnam, 2024).

4.5. What the Audit Matrix implies about arbitrage corridors

The Audit Matrix implies that regulatory arbitrage is a corridor effect produced by Institutional Incongruence across Perimeter Types. The FSB's insistence on consistent and effective oversight across jurisdictions can be read as an attempt to narrow these corridors for arrangements with cross-border reach, while still leaving room for domestic implementation (FSB, 2023).

Three corridors are most salient. The first emerges where Issuer-Centred and Intermediary-Centred Perimeters meet. The same stablecoin arrangement can shift from an issuer-duty perimeter into a platform-duty perimeter, which relocates accountability and can weaken redemption credibility if the market interprets oversight as thinner at the point of stress. The second emerges where Defensive Perimeters coexist with accessible offshore rails. Exclusion in law can coexist with access in practice, displacing activity into segments that are harder to classify, harder to supervise and easier to reroute during stress windows (Government of Vietnam, 2024). The third widens when integrity controls and cooperation tools diverge, because coordination is slowed not by a lack of shared goals, but by incompatible perimeter assumptions and mismatched operational levers.

Taken together, this is the stability relevance of fragmentation in ASEAN+3. The claim is not that stablecoins inevitably replace sovereign money. The claim is that perimeter divergence creates predictable pathways for risk migration. These are precisely the conditions that the next section evaluates against identified stress windows.

5. Findings on vulnerability under fragmentation and stress

5.1. What the evidence can and cannot claim

This paper does not offer statistical identification linking regulatory fragmentation to a single measurable instability outcome. Its claim is narrower and policy-relevant. If fragmentation operates as a vulnerability-making configuration, then stress windows should leave observable footprints in the same three places developed earlier: supervisory visibility, redemption

dynamics and cross-border spillovers. This follows the standard-setter premise that once stablecoin arrangements scale across borders, effective oversight cannot remain purely domestic because risks move through operational chains that exceed any single legal perimeter (FSB, 2023).

Two recurring patterns emerge. Fragmentation reshapes where activity concentrates and where supervisors can reconstruct it. Under stress, stablecoin vulnerability rarely remains a crypto-contained event. It becomes entangled with conventional institutions, reserve placement and expectations of redeemability and guardrails, even though stablecoin holders typically lack formal public backstops. BIS work on the future monetary system makes the broader point that stablecoins raise systemic concerns because they fall short against core monetary properties and can facilitate rapid shifts across money-like claims when stress intensifies (BIS, 2023).

5.2. Supervisory visibility gaps appear as perimeter misalignment, not as a lack of effort

The mapping points to a visibility problem that is structural rather than behavioural. Across ASEAN+3, the regulated node shifts with the perimeter type. In Issuer-Centred Perimeters, enforceable duties cluster at the issuer and reserve governance layer. In Intermediary-Centred Perimeters, the enforceable choke point sits at platforms and VASPs. In Defensive Perimeters, lawful payment rails exclude stablecoin settlement, yet access persists through offshore and informal channels. When these models meet in cross-border use, reporting triggers, data duties and supervisory access do not line up with the operational chain of issuance, distribution, custody and redemption.

The practical outcome is institutional incongruence. A supervisor can act diligently inside domestic authority while still lacking a regional picture because relevant information sits with different entities under different duties. This is why the FSB's emphasis on consistent and effective regulation, supervision, oversight and cooperation is best read as a stability necessity once arrangements become cross-jurisdictional in function (FSB, 2023). The visibility concern is therefore not the familiar complaint about legal diversity. It is that the legal identity of the regulated activity and the regulated entity can shift across borders while the economic function remains constant, producing coordination delays precisely when speed is binding.

5.3. Liquidity and redemption episodes show why reserve placement matters under stress

The liquidity and redemption channel is where legal design becomes operational stress. A stablecoin can appear robust in normal conditions and still become fragile once reserve credibility is questioned. The March 2023 USDC de-peg during the Silicon Valley Bank episode remains the canonical illustration of how a conventional banking shock can transmit into a stablecoin through reserve placement and redemption expectations (Du et al., 2025).

Two details map directly onto the Audit Matrix logic. The shock was not crypto-native. It originated in the banking system, immediately altering beliefs about reserve adequacy and immediate redeemability. The run dynamic was then shaped by information and redemption frictions, turning disclosure quality and redemption governance into stability variables rather than formalities. BIS analysis of public information and stablecoin runs treats the episode as an information shock about reserve adequacy and links disclosure conditions to run dynamics under stress (BIS, 2023). The Federal Reserve note reconstructing the episode documents the stress path using granular data and confirms the centrality of redemption expectations in the SVB window (Du et al., 2025).

The ASEAN+3 relevance is not rhetorical. A de-peg episode creates uneven outcomes precisely because regional perimeters anchor protection and enforceability at different nodes. Where redemption credibility is anchored in an Issuer-Centred Perimeter, supervisors can at least act through a clearly defined accountable node and an explicit stability narrative. Where the perimeter is Intermediary-Centred, effective protection hinges on platform discipline, custody rules and how quickly venues can implement controls when panic drives conversions. Where the perimeter is Defensive, users often face the most abrupt discontinuity: stablecoin demand does not disappear, but enforceable domestic guardrails are thinnest, leaving confidence shocks to be absorbed through market liquidity, informal conversion channels and hurried exit

behaviour. IMF analysis treats redemption risk, reserve quality and transparency as central to stability assessment and explains why stablecoins connect to traditional finance even when early usage was concentrated inside crypto markets (Adrian et al., 2025). Fragmentation matters because it determines whether a redemption shock meets enforceable guardrails or meets the market.

5.4. Cross-border spillovers become plausible through fast substitution and slow coordination

Spillovers do not require stablecoins to displace sovereign money. They become plausible when stablecoins function as rapid substitutes for settlement and short-horizon value storage during stress, while regulatory coordination remains slower than private rerouting. BIS frames a related systemic concern by noting that stablecoins, once scaled, can contribute to rapid shifts across money-like claims and generate frictions for the monetary and financial system under stress (BIS, 2023).

The Audit Matrix adds a sharper implication. Substitution pressures are not evenly distributed across perimeter types. Defensive Perimeters are the most likely to experience the most opaque form of substitution, because prohibition on lawful rails can coexist with persistent access through offshore and informal pathways. Under stress, this is where substitution can resemble shadow dollarisation in practice: private demand migrates toward USD-linked money-like claims, while the monitoring and enforcement perimeter is least able to reconstruct wallet-level exposures and cross-border routing. Intermediary-Centred Perimeters can absorb some substitution through platform controls, yet cross-border rerouting remains fast when users can move between venues. Issuer-Centred Perimeters may offer clearer accountability, but they still face spillover risks once cross-border use scales beyond domestic issuance constraints. The amplification is therefore not purely a market story. It is a perimeter story: fast substitution meets slow coordination because perimeters do not share the same triggers, duties, or cooperation levers.

5.5. Currency competition is not a slogan, it is a stress amplifier when fragmentation persists

Currency competition enters the findings as a conditional amplifier. Many widely used fiat-referenced stablecoins are USD-linked. This can be attractive in cross-border commerce and during local stress because it offers a familiar unit of account and a perceived hedge against local volatility. Yet it simultaneously intensifies policy sensitivity around monetary sovereignty and the governance of payment substitutes. BIS explicitly links stablecoin risks to monetary properties and sovereignty-relevant concerns, which becomes more salient when stress compresses policy space (BIS, 2023).

Fragmentation sharpens the mechanism in two ways. It accelerates demand shifts because users can reroute toward the least constraining corridor when confidence thins. It also increases political sensitivity because the visible outcome resembles currency competition at precisely the moment when governments are most inclined to harden borders rather than coordinate. The amplification is strongest in Defensive settings. Where stablecoins are excluded from lawful payment rails, USD-linked substitution does not become weaker. It becomes less governable, because the demand shift occurs in channels where disclosure minima, redemption expectations and supervisory visibility are least aligned with domestic stability objectives.

5.6. Synthesis of what the findings imply for the rest of the paper

Taken together, the evidence supports a coherent reading. Fragmentation behaves as a vulnerability-making configuration rather than a neutral diversity of rules. It weakens supervisory visibility by misaligning regulated nodes and producing non-comparable reporting triggers. It amplifies liquidity stress by making redemption credibility depend on uneven guardrails and uneven disclosure minima. It increases spillover likelihood by enabling fast substitution while coordination remains slow, with these pressures tightening under stress windows (FSB, 2023; BIS, 2023).

The policy implication is targeted rather than maximalist. The stability task is not full harmonisation. It is a feasible package of common minima that narrows corridor effects around

perimeter definition, reserve disclosures, redemption governance and supervisory cooperation, while still leaving domestic space for implementation (FSB, 2023).

6. Policy lessons for ASEAN+3 under geo-fragmentation

6.1. Why common minima is the only credible target in a geo-fragmented region

In ASEAN+3, full harmonisation is politically weighty and institutionally slow. Under geo-fragmentation, it also becomes strategically harder because monetary sovereignty instincts tighten precisely when coordination would otherwise be easiest. In that setting, a more credible policy target is not uniformity, but common minima that narrow the corridors where arbitrage, opacity and redemption stress become stability-relevant. This approach is consistent with the FSB's orientation toward consistent and effective oversight of global stablecoin arrangements while leaving room for domestic implementation choices (FSB, 2023).

Common minima should therefore be treated as a stability instrument. It does not erase national priorities, but it creates a shared floor for the functions that matter most when stress rises and coordination slows.

6.2. Corridor 1, the liability corridor

The first corridor is a liability corridor, where the same payment-facing function travels across borders but the legally responsible node shifts. In issuer-centred regimes, the stability claim is tied to a defined issuance perimeter, making accountability legible. In intermediary-centred regimes, the practical perimeter often sits at venues and VASPs, which can leave the issuer-side promise offshore and legally distant. In defensive regimes, the liability corridor becomes more problematic because domestic law may reject stablecoins as payment, yet demand still finds channels through exchanges, OTC markets and informal settlement networks.

A common minimum here is pass-through compliance. The rule is functional and arrangement-aware. If a stablecoin is used as a payment-adjacent instrument within a jurisdiction, then the entities enabling distribution, custody, conversion, or redemption access in that jurisdiction must carry enforceable duties that pass through the arrangement, including clear disclosure of who bears the stability claim, how redemption works and which authority can demand data in stress windows. This directly operationalises the FSB's insistence on governance, clear responsibility and effective oversight for arrangements that scale across borders (FSB, 2023).

6.3. Corridor 2, the redemption corridor

The second corridor is a redemption corridor, where confidence can flip quickly and redemption pressure forces reserve liquidation, with spillovers that can reach conventional liquidity conditions. The USDC episode around the Silicon Valley Bank shock remains a clean illustration of how reserve placement and redemption expectations transmit a conventional banking shock into stablecoin markets through information and frictions, not through crypto-native volatility alone (Du et al., 2025; FSB, 2023).

A common minimum here is a verifiable redemption floor built on three elements. First, a minimum disclosure standard for reserve composition, custody and segregation, with auditability that remains meaningful in stress windows. Second, an enforceable redemption commitment that is legible to users and supervisors, rather than a marketing promise that dissolves into platform disclaimers when conditions tighten. Third, a stress-time disclosure escalation rule, where reporting frequency and content expand when pre-defined stress signals are triggered. This is not a call for identical reserve rules across ASEAN+3. It is a call for a shared floor that makes redemption governance comparable enough for coordinated assessment and credible enough to prevent the weakest corridor from becoming the regional pressure point.

6.4. Corridor 3, the visibility corridor and a regional data spine

The third corridor is a visibility corridor. Fragmentation becomes destabilising when supervisors cannot reconstruct exposures and flows fast enough across borders, not because of laziness but because data sit with different regulated nodes under different duties. The policy response cannot be generic calls for cooperation. It needs a regional data spine, with standardised minimum fields that allow a shared operational picture during stress windows.

Here, the cross-border payments agenda provides a practical analogue. Global work on enhancing cross-border payments repeatedly emphasises that legal and regulatory frameworks, data exchange and interoperability are not decoration, they are the machinery that makes coordination possible (FSB, 2024). A regional data spine for stablecoins should be narrower and stability-driven. It should focus on issuance and circulation proxies, major distribution and custody channels, reserve composition disclosure points, concentration of intermediaries and redemption flow signals during stress. It should be triggered more aggressively in stress windows proxied by public measures of geopolitical risk and tightening financial conditions, because those are precisely the periods when discretion rises and coordination slows.

6.5. A managed visibility pathway for defensive jurisdictions without premature legalisation

The hardest governance problem sits with defensive regimes, where stablecoins are not recognised as lawful payment instruments, yet activity persists through cross-border digital commerce, informal settlement and price-referenced substitution. This is where the risk of shadow dollarisation becomes structurally plausible. When official rails are constrained, substitution does not disappear. It becomes harder to observe, harder to supervise and easier to reroute.

The policy lesson is that defensive jurisdictions need a managed visibility pathway that does not require immediate legalisation of stablecoins as payment, yet still reduces the blind spot that geo-fragmentation exploits. The mechanism has three parts. First, authorities define a narrow supervisory perimeter for intermediaries that touch conversion and custody access, focusing on disclosure, risk warnings and reporting duties rather than recognition of lawful payment status. Second, they align those reporting duties with the regional data spine, allowing cross-border exposure mapping without signalling domestic endorsement of stablecoin payment use. Third, they adopt a stress-time cooperation protocol, pre-agreed rather than improvised, so that information exchange and coordinated messaging can occur when redemption shocks spill across borders (FSB, 2023).

Ultimately, this package allows ASEAN+3 to move from a posture of vulnerable divergence to one of coordinated resilience, immunising the region against the spillover risks of geo-fragmentation without requiring politically impossible legal convergence.

7. Conclusion

ASEAN+3 is trying to deepen financial integration at the same time that geo-fragmentation rewards discretion and slows coordination precisely when speed matters most (IMF, 2022). Stablecoins matter in this setting not because they will displace sovereign money, but because fiat-referenced, reserve-based tokens behave like payment-adjacent claims and can be rerouted across borders faster than supervisory perimeters can adjust (FSB, 2023; Adrian et al., 2025). The central finding of this paper is that vulnerability is not produced by any single rule choice in isolation. It is produced by institutional incongruence: a regional configuration in which issuer-centred safeguards, intermediary-centred gatekeeping and defensive prohibitions coexist without a shared minimum spine for visibility, liability and stress-time cooperation.

This incongruence turns the same arrangement into different legal objects as it crosses borders. In issuer-centred regimes, the stability claim is pulled into perimeter and tied to explicit responsibilities. In intermediary-centred regimes, the operational choke point shifts toward platforms and VASPs, where user protection can be meaningful yet reserve and redemption discipline often remain externalised. In defensive regimes, the state attempts to keep stablecoins outside formal payment recognition, but demand does not disappear. It is displaced into less visible channels, where blind spots widen and the risk of shadow dollarisation becomes more plausible precisely because substitution pressure is strongest when oversight is thinnest.

The three channels identified in the paper are best read as symptoms of that structural mismatch. Visibility fails when the regulated node shifts across jurisdictions and reporting triggers stop being comparable, even if each authority is diligent within its own framework (FSB, 2023). Liquidity stress accelerates when redemption credibility rests on uneven disclosure minima and uneven reserve governance and the USDC episode during the SVB crisis remains a practical

reminder that a conventional banking shock can transmit into stablecoin markets through information and redemption dynamics rather than crypto-native volatility alone (BIS, 2023; Du et al., 2025). Spillovers then become plausible because substitution can be fast while coordination remains slow, a vulnerability BIS has repeatedly linked to stablecoins' weaknesses as monetary instruments under stress (BIS, 2023). In short, the region is not merely managing new instruments. It is managing a misfit between legal perimeters and operational pathways. The policy implication is therefore not a plea to contain diversity. It is a call to immunise the region against predictable corridors of risk migration. ASEAN+3 does not need an unrealistic project of full legal harmonisation. It needs common minima that narrow the corridors where fragmentation becomes vulnerability. Those minima should lock in a functional perimeter baseline for fiat-backed stablecoins, require stress-credible reserve disclosure and redemption governance, build a shared reporting spine and pre-agree a cooperation protocol that can operate when stress windows open (FSB, 2023; FSB, 2024; Monetary Authority of Singapore, 2022). Capacity differences should shape sequencing and support rather than dilute the floor, because dilution is precisely how arbitrage corridors become durable. Integration under geo-fragmentation succeeds or fails on whether coordination can be made operational in the moments that matter. The practical regional response is not to erase divergence, but to make divergence less dangerous by combining common minima with managed visibility pathways for defensive jurisdictions and stress-time cooperation that does not depend on goodwill alone (FSB, 2023).

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The Digital Effect: How E-Money is Changing the Demand for Cash in Indonesia*

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Abstract

This paper examines the causal impact of e-money adoption on cash demand in Indonesia, an emerging economy where digital payments are growing rapidly but cash remains widely used. Using a high-frequency provincial panel dataset, we address the endogeneity concern regarding e-money adoption by employing a shift-share instrumental variable (Bartik IV) approach. We find clear evidence of substitution: a 1 percent increase in e-money transactions is associated with a 1.7 percent decline in cash demand. This effect is substantially stronger in urbanised and digitally advanced provinces in the Java region, indicative of persistent regional disparities. Evidence by cash denominations shows that substitution is concentrated in medium-value banknotes typically used for everyday transactions, while very small denominations and coins remain largely unaffected. This study has important implications for monetary policy, particularly for managing the money supply and setting policy rates in an increasingly cashless economy, while promoting targeted digital inclusion initiatives.

JEL: E41, G21, O33, R11

Keywords: E-money, Demand for Cash, Digital Transaction, Indonesia

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1 Introduction

The increasing penetration of digital payments has profoundly transformed cash use worldwide. [Alvarez and Lippi \(2009\)](#) observed that financial innovation, through the diffusion of banking technology will affect household cash holding behavior. In recent years, digital payment instruments such as electronic money (e-money), mobile wallets, and Quick Response (QR) based payment systems have emerged as the primary means to pay for everyday goods and services. The COVID-19 pandemic further accelerated the adoption of digital payments ([Demirgüç-Kunt et al., 2022](#)).

Recent innovations in the digital payment infrastructure and instruments imply that the convenience of cashless payments is increasing at a breathtaking speed ([Brown et al., 2022](#)). This development could have a sizeable impact on people's demand and use of cash. The amount of cash circulating in the economy, as a percentage of the M1 monetary aggregate¹, has declined in most countries and has even been accentuated in emerging economies ([Cabezas and Jara, 2022](#)).

This paper examines the causal impact of e-money on cash demand in Indonesia, a large emerging economy that has experienced rapid growth in digital financial services alongside persistent regional disparities in financial access. Despite ongoing policy efforts to promote financial inclusion and expand digital payment infrastructure, cash continues to play a central role in the economy, including in the transmission of monetary policy. According to the Global Findex 2024, more than half of Indonesians still pay cash for online delivery, and only 56 percent own a savings account ([Starita and Norris, 2025](#)).

Over the past decade, the value and volume of e-money transactions in Indonesia (including both e-wallet services and card-based stored value systems used in toll-road payments and urban public transport) have expanded rapidly. In 2023, Bank Indonesia observed that e-money accounted for over 70 percent of all retail payment transactions by volume, surpassing debit and credit cards. However, the relationship between e-money adoption and cash usage remains ambiguous at the aggregate level. [Figure 1](#) illustrates this tension by showing that while e-money transaction values have increased sharply since the late 2010s, bank-recorded cash withdrawals (a proxy for transactional cash demand) have remained persistent and highly seasonal. Cash also continues to be widely used, particularly in rural and remote areas. Together, these developments raise a central question that has limited answers about whether the introduction of digital payments will replace cash or complement it, as people increasingly turn to faster, more convenient, and secure payment options.

¹M1 is a narrow measure of the money supply that includes physical currency, demand deposits, traveler's checks, and other checkable deposits

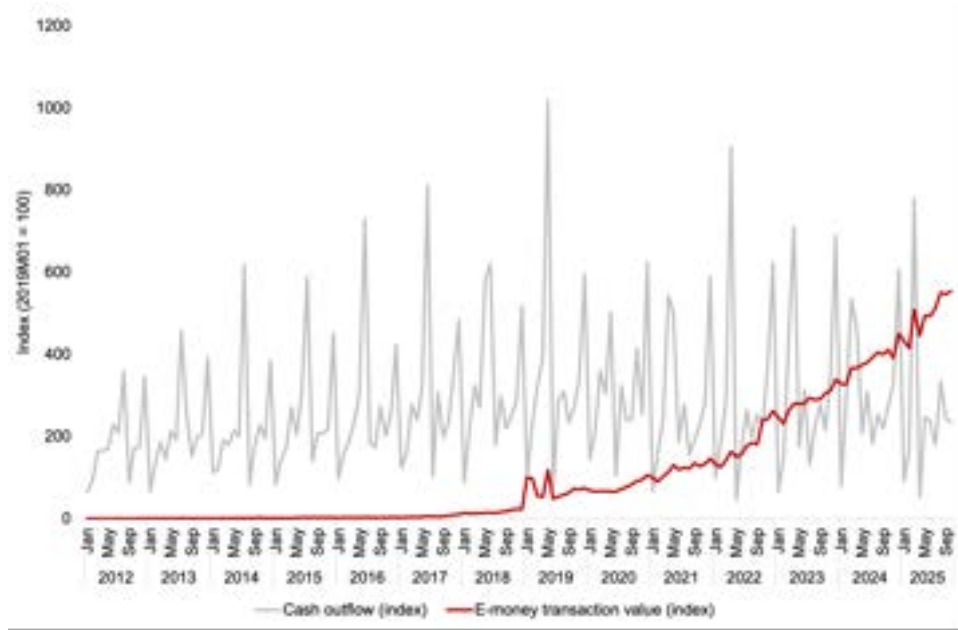


Figure 1: Cash outflows and e-money transaction value in Indonesia

Notes: Cash outflows refer to bank-recorded cash withdrawals and proxy transactional cash demand. E-money refers to the total value of electronic money transactions. Both series are indexed to January 2019 (=100).

Source: Authors' calculations based on Bank Indonesia Payment System Statistics.

To examine the impact of e-money on cash demand in Indonesia, we use Indonesia's province-level data over the period 2019–2023.² We are able to use novel data that comprises the level of digital transactions in Indonesia. In our baseline estimation, we use two-way fixed effects (TWFE) analysis to examine the relationship and magnitude of e-money toward cash. The panel regression has been applied in various studies that estimate money demand (Bech et al., 2018; Cabezas and Jara, 2022). Our main outcome variable is the monthly value of bank-recorded cash outflows at the provincial level, which proxies transactional cash demand rather than cash in circulation stocks that also reflect store-of-value motives. The main explanatory variable is the value of e-money transactions, capturing both wallet-based and card-based stored-value payment systems.

Estimating the causal effect of digital payments on cash demand is challenging because e-money usage may be endogenous. In particular, omitted factors such as infrastructure roll-outs or policy interventions can bias estimates, and reverse causality can arise if provinces with declining cash demand adopt e-money faster. We address these problems using a shift-share (Bartik-style) instrumental variable approach, following Autor et al. (2013); Goldsmith-Pinkham et al. (2020); Borusyak et al. (2025). Specifically, we construct an instrument that interacts with the lagged provincial share of national e-money transactions (the “shares”) with the national monthly growth in e-money usage (the “shifts”). This ap-

²Currently, the data related to e-money and demand for cash is only available at the province level.

proach leverages exogenous variation in provinces' initial exposure to nationwide growth in digital payments.

We find robust evidence that e-money usage substitutes for cash. A 1 percent increase in e-money transaction value leads to a 1.7 percent decrease in cash outflows, which serve as our measure of transactional cash demand in this study. We also document heterogeneity in the substitution effect. The elasticity is significantly larger in more urbanized and digitally mature provinces, particularly in the Java region, compared to less developed regions of eastern Indonesia. These results suggest that while digital payments are reducing reliance on cash, the effect is uneven across regions and is influenced by a persistent digital divide in financial infrastructure.

Further analysis by banknote denomination sheds light on the underlying mechanism. The strongest substitution effects are observed for small-to-medium banknotes (Rp2,000 to Rp20,000), which are commonly used for daily transactions such as transportation, food purchases, online delivery, and small retail payments. In contrast, the effects are weaker for high-denomination banknotes, which are more likely to be held for precautionary purposes or used in large and informal transactions. Finally, we find no statistically significant effect on coins, which remain essential for very low-value transactions and for making change.

This study is very important for several reasons. A rising trend in digital payments will pose major challenges for monetary policy. Previous studies regarding the causal impact of digital payments on money demand revolve around two areas: (i) cash substitution and (ii) the effectiveness of monetary policy targets. In the first caveat, there is still a growing debate in the literature on whether digital payment transactions substitute for cash or remain complementary.

Previous studies suggest that the substitution of money with alternative payment options, such as credit cards, debit cards, and digital currencies, reduces the overall demand for money in the economy ([Akhand and Milbourne, 1986](#); [Duca and Whitesell, 1995](#); [Yilmazkuday and Yazgan, 2009](#)). A study by [Hass et al. \(2018\)](#) argues that the adoption of new payment technologies will replace currency. [Humphrey et al. \(1996\)](#) analyzes the payment systems of 14 developed countries and identifies a substitution effect of around 68 percent between cash and other means of payment. Similar findings from [Mandell \(1972\)](#) also show that the use of credit cards reduces the demand for cash for transaction purposes, as they can serve as a medium of exchange in transactions.

However, other empirical studies suggest that digital payments and cash remain complementary to each other. [Fujiki and Nakashima \(2019\)](#) conducted a study on the relationship between non-cash payments and cash in Japan and argued that the demand for hoarding in Japan was so strong that it outweighed the negative effect of the substitution towards non-cash means of payment for day-to-day payments. In addition, according to [Bech et al.](#)

(2018), cash in circulation is, in fact, not dropping for most countries. They stated that cash continues to increase, particularly in advanced countries, and is likely driven by store-of-value motives rather than payment needs. Utilizing China as a case study due to its leading growth in digital payment, a study by Zhan et al. (2023) find that digital finance changes people's payment habits only because it changes people's desired money demand, while the demand function M_0 is still stable and unaltered.

In the second focus, digital payments have sparked debates regarding their impact on monetary policy effectiveness due to their potential to replace currency in circulation. An upsurge in digital payment transactions may lead to a high level of money velocity and, in turn, increase inflation, which can deviate from the central bank's inflation target. A study by Geanakoplos and Dubey (2010) finds that the velocity of money is inversely proportional to the demand for money. Consequently, lower demand for money due to credit card usage increases the velocity of money. Electronic money can also accelerate the velocity of money by influencing the central bank's monetary policy transmission mechanism (Berentsen, 1998).

Furthermore, lower demand for money also reduces the central bank's ability to influence the short-term interest rate through open market operations (Freedman, 2000). Moreover, other evidence suggests that the central bank's balance sheet may be reduced through the increased use of electronic money, with significant implications for the bank's ability to effectively manage monetary policy and fulfill its functions as a lender of last resort (BIS, 2015).

Given the broad impact of the adoption of digital payment on demand for money and cash, our study makes several contributions to the literature. First, we provide new causal evidence on the relationship between digital payment adoption and cash demand in a large emerging economy. While prior research has examined the role and economic impact of mobile money and digital payments in developing countries (Jack and Suri, 2014; Brown et al., 2022; Munyegera and Matsumoto, 2016; Apeti and Edoh, 2023; Fabregas and Yokossi, 2022), relatively little is known about their effect on the demand for cash. This question is particularly relevant in Indonesia, where both the penetration of e-money and the persistence of cash usage vary substantially across regions. As a decentralized country with significant heterogeneity in economic size, infrastructure, and digital readiness, Indonesia presents a compelling setting for analyzing how digital payment adoption influences cash demand at the provincial level.

Second, we compile a novel panel dataset that combines monthly e-money transactions and cash withdrawals across provinces to track regional differences in digital payment adoption and cash use. This data has helped us to observe the impact of digital transactions at a more granular level. For instance, we can disentangle the impact of digital transactions for payment (i.e., Electronic money transactions) versus for withdrawal (i.e., ATM).

Third, in addition to identifying the causal effect of e-money on cash demand, this study contributes to the growing literature on digital payments and cash substitution by examining the mechanism through which digital payments substitute for cash. Our empirical evidence suggests that the displacement effect of e-money is concentrated in large-denominated banknotes, whereas the demand for small-denominated notes remains largely unaffected. This indicates that e-money currently substitutes for cash in high-value transactions, whereas low-value retail payments continue to rely on physical currency.

From a policy perspective, this heterogeneity suggests that digital payments have not yet fully penetrated everyday retail transactions, where small denominations of cash still dominate. To maximize the efficiency and inclusiveness of digital payment adoption, policymakers could consider targeted interventions to promote the use of e-money in micro- and retail transactions, such as expanding QRIS acceptance among small merchants, reducing transaction costs for low-value payments, and integrating digital platforms into social assistance and wage disbursement programs.

Lastly, we offer insights for policymaking related to cash and digital payments. Adopting reasonable monetary policies to regulate the money supply based on predictions of money demand, the central bank can therefore stabilize the price level and promote economic growth ([Hwang and Wen, 2024](#)).

The paper is organized as follows. Section 2 reviews the related theory and empirical evidence on digital payment and demand for cash, as well as the institutional context in Indonesia. Section 3 illustrates the data and empirical methodology used in this study. Section 4 discusses estimation results, followed by the robustness checks. Section 5 presents the conclusion.

2 Related Literature and Institutional Setting

2.1 Related Literature

Non-cash payment methods—most notably e-money and related financial technology (fintech) instruments—have expanded rapidly in recent years. This expansion motivates revisiting classical money-holding frameworks (e.g., extensions of the Baumol–Tobin setup) to understand how new payment technologies change the costs and convenience of holding cash ([Li and Xu, 2021](#); [Attanasio et al., 2002](#)).

The net effect of e-money on cash demand is decomposed into three channels that the empirical literature and this paper emphasize: (i) a *substitution* channel, where digital payments directly replace cash at the point of sale (POS); (ii) a *behavioral* channel, where changes in payment mode alter spending behavior; and (iii) an *infrastructure/access* chan-

nel, where merchant acceptance, point of sale availability, and connectivity determine whether and how quickly digital methods can scale. These channels can point in different directions and vary in strength across places and over time, depending on pre-existing institutional and infrastructure conditions. We also complement this discussion with studies on aggregate and welfare impacts of digital payments, which speak to the broader economic stakes.

2.1.1 Impact of Digital Payment on Cash Demand

While earlier payment technologies, such as debit and credit cards, were associated with reductions in cash use, the effect of newer digital payment forms is less clear and appears to depend on local conditions and market structure. Empirically, card adoption has been linked to lower cash demand in many settings ([Lippi and Secchi, 2009](#); [Amromin and Chakravorti, 2009](#); [David et al., 2016](#); [Markose and Loke, 2003](#)), but digital payments differ from cards in important ways that may change the net effect.

First, digital payments often increase convenience and expand acceptance at points of sale that cards historically could not serve (notably small merchants and online platforms), so substitution away from cash may be larger where these gaps existed ([Ozturk et al., 2017](#); [Kumar et al., 2021](#)). Platform-based mobile payments can scale rapidly in both advanced and developing economies, but the driving forces differ: in developing settings, the payoff from switching is often larger because of preexisting institutional or infrastructure voids that digital solutions can fill ([Kumar et al., 2021](#)).

Second, behavioral channels matter. Switching payment modes can change spending behavior (for instance, card users sometimes spend more than cash users because the convenience of using a card reduces “pain of paying”), so part of any observed relationship between e-money and cash could reflect changed consumer demand rather than pure substitution ([Runnemark et al., 2015](#); [Cohen and Rysman, 2013](#); [Klee, 2008](#)).

Third, how digital payments affect cash usage may differ between localities, given differences in supporting infrastructure. [Lee et al. \(2019\)](#) suggests that the impact on cash may be muted until merchant acceptance and network effects reach a sufficient scale. Even previous studies focusing on debit and credit periodically show no strong effect on cash demand ([Trütsch, 2020](#); [Felt, 2020](#)). Nevertheless, early works such as the one done by [Hwang and Wen \(2024\)](#) in China indicate possible long-run substitution effect between electronic payments and M1 demand.

2.1.2 Impact of Digital Payment on the Economy

Digital payment technologies can affect the economy through several broad channels: by lowering transaction costs, by improving the reach of financial services, and by smoothing payments during shocks, each of which may raise economic activity and welfare. (Doh et al., 2004; Niankara and Traoret, 2023; Kim et al., 2018; Hu et al., 2021; Van et al., 2021).

Macro-level panel evidence supports a positive link between increasing digital payment use and aggregate outcomes. Using the World Bank's Global Findex, one recent study finds that broader adoption of digital payments increases GDP growth and reduces estimated informal employment. This adds to the previous point that not only does financial technology change consumers' spending patterns, but it can also induce economic growth (Aguilar et al., 2024).

Micro studies provide another angle on how digital payments can have substantive distributional and welfare effects beyond changes in aggregate spending levels. In Niger, mobile-money expansion lowered transaction costs and improved intra-household transfers and welfare outcomes, particularly for women and children (Aker et al., 2016). In disaster settings, rapid mobilization via mobile transfers improved relief flows and economic resilience (Blumenstock et al., 2016).

At the same time, recent critical reviews emphasize identification issues and heterogeneity in estimated effects (Aron, 2018). Many cross-country and micro studies face difficulties disentangling payment technology effects from concurrent institutional or adoption processes (e.g., phone ownership). With that in mind, this article opts for e-money data that is unhindered by such issues.

2.2 Institutional Context and Stylized Facts

2.2.1 The Expansion of E-Money Usage

E-money has recently gained popularity as a new form of payment in Indonesia. When compared to other electronic payment methods (e.g., debit and credit cards), it records a much higher usage. In 2023, e-money made up 72% of the total electronic transaction volume, despite only representing 18% of the total value (Bank Indonesia, 2023). Between 2019 and 2023, the number of transactions grew by 189%, much higher than the growth of debit cards (8%) and credit cards (13%). As of 2023, there were 810 million e-money cards or instruments in circulation (Bank Indonesia, 2023), which is nearly three times the size of Indonesia's population.

The good-looking growth in e-money adoption is not a random event; rather, it is a result of planned policy changes. The launch of the National Non-Cash Movement (*Gerakan Na-*

sional Non-Tunai, GNNT) in 2014 marked the first big step. This program required that transportation services, such as toll roads, commuter trains, buses, and parking facilities, only accept electronic payments, in particular, chip-based e-money (SNKI, 2018).

In the years that followed, higher penetration of smartphones and improvement of mobile internet connectivity drove the advancements further. Renowned mobile payment platforms, such as GoPay, OVO, and DANA, have taken advantage of these improvements to make electronic payments a part of everyday life—from ride-hailing services and food delivery to retail commerce—through server-based e-money.

Bank Indonesia’s introduction of the Quick Response Code Indonesian Standard (QRIS) in 2019 sped up adoption even more. It enables businesses to accept any kind of electronic payments with a single QR code applicable for all non-cash payments. The QRIS system greatly simplifies retailers’ participation in offering electronic payment options and provides very low transaction costs (often to zero for small payments) without setting a minimum payment threshold. As a result, QRIS expanded the usability of e-money even among micro, small, and informal businesses that had previously been excluded from digital payment ecosystems.

The reliance on e-money was further driven by the onset of the COVID-19 pandemic, which reinforced preexisting digital payment trends. Individuals and businesses shifted toward cashless payments to limit physical contact and comply with social distancing measures such as PSBB (Large-Scale Social Restrictions). In particular, this shift primarily affected transaction frequency rather than nominal value. ADBI (2021) found that although PSBB measures increased the volume of e-money transactions, they did not significantly affect transaction values.

All of these changes make e-money a useful addition to Indonesia’s financial system, where there are still problems with access to financial services. The World Bank (2022) found that about half of the adult population remains unbanked or underbanked. E-money has one of the main appeals that can help, which lies in its accessible design: it typically operates via prepaid or top-up schemes that can be done without a formal bank account. By eliminating traditional barriers (such as the need for bank accounts or physical banking infrastructure), e-money extends basic financial services to previously underserved groups, especially among the informal sectors and the rural population.

Taken together, these developments have implications for the composition of cash demand. If wider acceptance primarily induces substitution at the POS, displacement should be strongest in medium-to high denominations used in routine transactions, while very small denominations—often used for making change and in low-value informal purchases—may remain relatively sticky. This denomination-based prediction motivates the mechanism exercise in Section 4.3, where we examine cash outflows by banknote value.

2.2.2 Relative Demand for Cash

As more people use e-money, it raises the question of whether it has replaced cash in the economy. A descriptive look at the relative demand for cash may yield some preliminary answers to this topic. The ratios of currency in circulation (CiC) to GDP and CiC to M1 are two key indicators of its importance. The CiC-to-GDP ratio demonstrates the importance of cash as a medium of exchange in the broader economy, whereas the CiC-to-M1 ratio compares cash to other highly liquid monetary instruments, such as demand deposits.

Time-series data from 2009 to 2024 show that Indonesia's CiC-to-GDP ratio has stayed relatively stable in the range between 15% and 20%. There is no clear downward trend, even though e-money use has grown a lot (see [Figure 2](#)). During the COVID-19 pandemic, Indonesia's metrics show a steadier pattern, while Brazil, India, and Japan all saw temporary spikes in CiC-to-GDP. CiC-to-M1, on the other hand, reveals a more nuanced trend. The ratio used to move between 45–55%, but it started a gradual decline and fell below 45% for the first time in early 2020—which was the lowest level since at least 2009—and has not come back since then (see [Figure 3](#)). This could mean that the makeup of the money supply is changing, as deposit-based instruments grow faster than currency.

A panel view might help provide additional clarity. Indonesia's metrics show a moderate level of cash intensity when compared to India and Brazil, as peer developing economies. The CiC-to-GDP ratio in India is higher but not stable, likely because of the demonetization in 2016 and the remonetization in the period that followed. Meanwhile, Brazil's CiC-to-GDP ratio is lower and stable, peaking around the COVID-19 crisis. Advanced economies like Japan and Sweden, on the other hand, do things differently. Japan has a steady, high CiC-to-GDP ratio (roughly 60–90%) that aligns with its reputation as a cash-preferred society. Sweden, on the other hand, has one of the lowest and most steadily declining ratios (below 5%) aligned with its status as a nearly cashless economy. These differences suggest that the results of digitalization are influenced by more than just access to financial services or payment systems. They are also affected by social, cultural, and institutional factors.

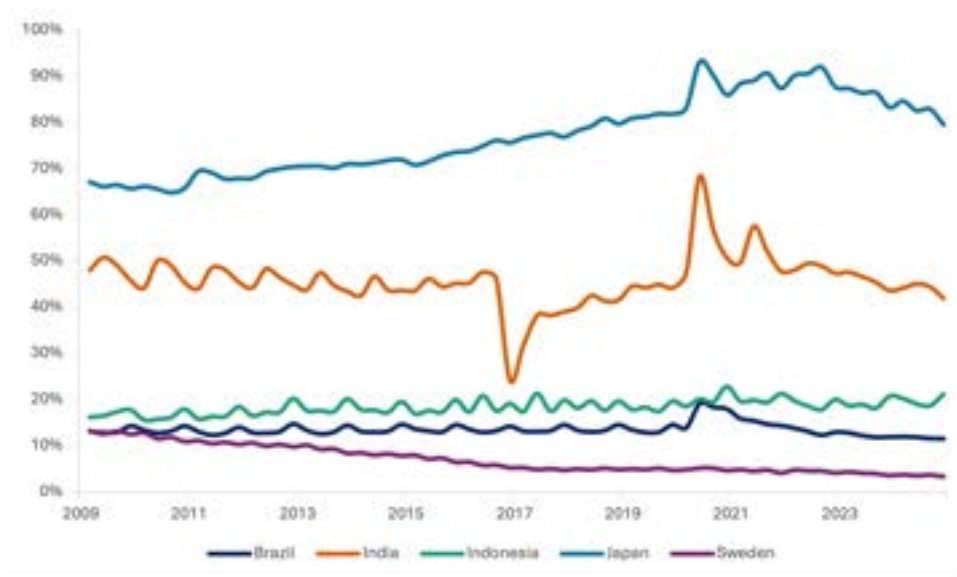


Figure 2: Currency in Circulation Relative to GDP (%), 2009–2024
Source: Authors' calculations based on data from CEIC

Interpreting these macro-indicators requires awareness of coexisting patterns. A flat CiC-to-GDP ratio in Indonesia, despite the increasing use of e-money, could indicate that cash and digital money serve different niches instead of acting as substitutes. Cash may still be the most common form of payment in rural and informal sectors, while e-money thrives in urban retail and online ecosystems. It is also important to keep an eye on a falling CiC-to-M1 ratio, as this could mean that greater deposit mobilization has been driven by fintech integration, rather than a pure decline in cash preference. Hence, these ratios are better thought of as windows into how liquidity is changing over time rather than as binary markers of cash displacement.

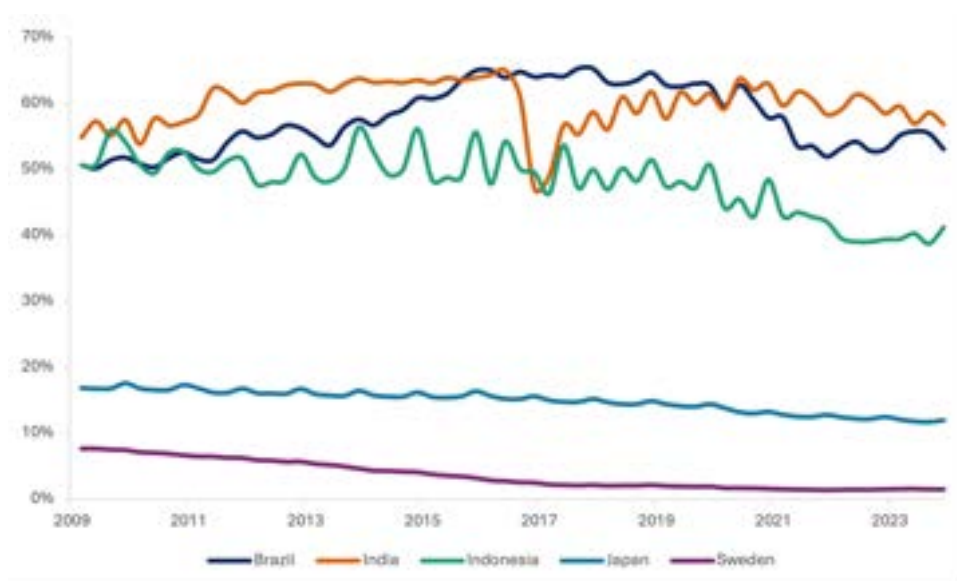


Figure 3: Currency in Circulation Relative to M1 (%), 2009–2024
Source: Authors' calculations based on data from CEIC

2.2.3 Subnational Disparities in Payment Preferences

National-level indicators give a good overview, but they hide a lot of variation in cash and e-money demand happening at the subnational level. In terms of cash, provinces on Java Island record a disproportionately higher level of currency in circulation. As the nation's capital and economic center, Jakarta alone has recorded cash demand of more than IDR 166 trillion, far surpassing neighboring provinces. On the other hand, provinces in outer islands, especially those in the eastern part of Indonesia, are in the lowest demand bracket.

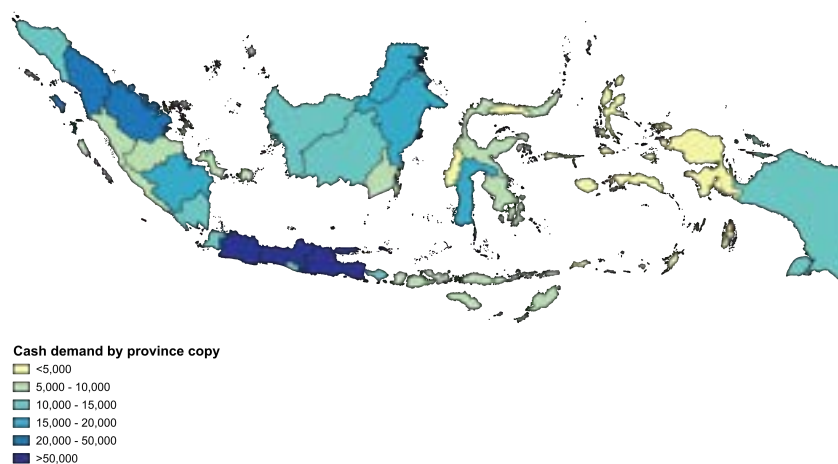


Figure 4: Demand for Cash by Province (IDR billion), 2022

Source: Authors' calculations based on data from Bank Indonesia

The spatial distribution of e-money transaction value displays a comparably unequal—but partially overlapping—map. The provinces of Java are dominating, with Jakarta and its surrounding neighbors (i.e., West Java and Banten) having the highest transaction values. In addition to differences in population concentration and economic activity, this pattern may also reflect better cellphone penetration, higher levels of digital literacy, and improved financial service infrastructure.

These subnational disparities motivate our main heterogeneity analysis. Because Java combines high transaction density with denser digital payment infrastructure, the substitution effect of e-money on cash demand should be stronger there if digital payments displace cash primarily through POS adoption and network effects. In contrast, in many non-Java provinces—where acceptance networks and connectivity are weaker—the infrastructure/access channel may attenuate or delay cash displacement. Accordingly, we estimate separate effects for Java and non-Java provinces in Section 4.1.

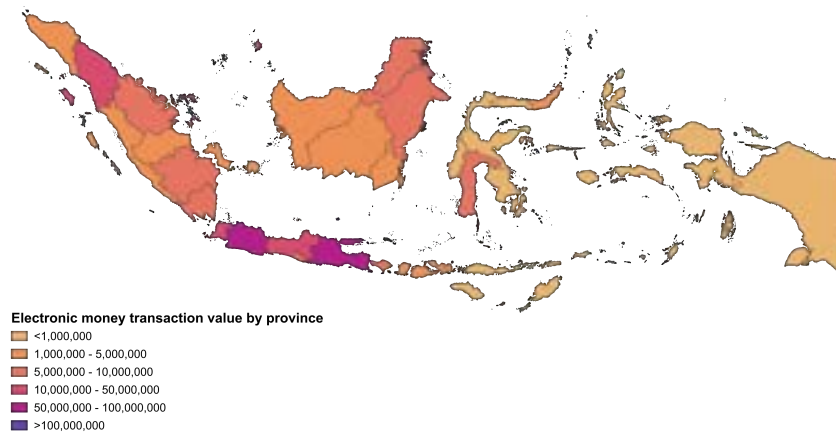


Figure 5: E-money Transaction Value by Province (IDR billion), 2022

Source: Authors' calculations based on data from Bank Indonesia

With a few exceptions, the overall picture of how provinces handle payments shows a relatively aligned pattern between cash demand and e-money transactions. In this sense, descriptive analysis may only suggest that higher transactional activity, whether in cash or e-money, could merely be a function of the scale of commercial exchange, rather than a direct result of payment preferences per se. Quantitative analyses with more controlling variables are thus required to further study the link between the two.

3 Data and Empirical Method

3.1 Data

This study examines the causal relationship between e-money usage and cash demand across Indonesia's provinces, utilizing monthly province-level data covering the period from January 2019 to July 2023. The main outcome variable is cash outflow, measured by the monthly value of cash withdrawals via ATMs and financial institutions, sourced from Bank Indonesia. The key explanatory variable is the transaction value of e-money, which includes both e-wallet and card-based payments, such as those used for toll roads, commuter trains, and other public transportation. As defined by Bank Indonesia, electronic money refers to prepaid monetary value stored on electronic media, distinct from traditional deposits.

Control variables are sourced from Statistics Indonesia, Bank Indonesia, and the Financial

Services Authority (OJK). These include: (i) macroeconomic indicators such as GRDP per capita, inflation rate, and the BI policy rate; (ii) digital infrastructure variables such as ATM density, number of EDC terminals, and merchant coverage; and (iii) structural controls (i.e., financial literacy and household internet penetration). Since several variables are reported annually or quarterly, they are linearly interpolated to obtain a monthly frequency. All monetary variables are transformed into natural logarithms, while rates and percentages are used in levels. Detailed variable definitions are provided in [Table 1](#).

Table 1: Variable Definitions

Variable	Definition	Source
Log Cash outflow	A proxy for cash demand, defined as the amount of cash withdrawal from a bank account, ATM, or other financial institutions.	Bank Indonesia
Log E-Money Transaction Value	Value of non-cash transaction from using e-money	Bank Indonesia
Log Debit Card and ATM Transaction Value	Value of non-cash transaction from using debit card	Bank Indonesia
Log Credit Card Transaction Value	Value of non-cash transactions from using credit card	Bank Indonesia
Log GRDP per capita	Gross Regional Domestic Product per population	Statistics Indonesia
Inflation rate	The increase of an average price level in the Economy (% mtm)	Statistics Indonesia
Policy rate	Key interest rate set by the central bank of Indonesia to guide the monetary policy in the country. It is also known as the BI rate	Bank Indonesia
Financial literacy	An index used to gauge the level of financial knowledge, skills, attitudes, and behaviors among Indonesians	Financial Services Authority (OJK)
Household internet coverage	Percentage of households who own/utilize the internet	Statistics Indonesia

Continued on next page

Table 1: Variable Definitions (Continued)

EDC	Electronic Data Capture (EDC) systems are devices that are commonly seen in Point-of-Sale (POS) terminals that facilitate electronic transactions using credit or debit cards	Bank Indonesia
ATM	Automated Teller Machines (ATMs) are machines that dispense cash and allow to make other banking transactions	Bank Indonesia
Merchant	A payment infrastructure for consumers to pay for goods or services by using a credit card, debit card, or other electronic payment method.	Bank Indonesia

Table 2 reports cross-province summary statistics for our key variables. The dispersion in cash withdrawals is substantial: the 90th percentile of log withdrawals (8.26) exceeds the 10th (4.93) by 3.33 log points, implying that the most cash-intensive provinces withdraw on the order of 28 times more than the least. E-money transaction values are even more unevenly distributed: with a 4.95-log-point gap between P90 and P10 (14.57 vs. 9.62), high-value provinces transact roughly 140 times more than low-value ones.

Our shift-share instrument likewise exhibits a long right tail. Although its median exposure is only 0.13, the mean (1.02) and 90th percentile (2.31) are much higher. We take it as a reflection of the significant variation in the e-money adoption rate across provinces.

Table 2: Summary Statistics

Variable	Mean	Std. dev.	P10	P50	P90	Obs
Log Cash Withdrawal	6.56	1.36	4.93	6.60	8.26	2,040
Log Electronic Money Transaction Value	11.94	2.08	9.62	11.95	14.57	1,842
12-month Lag Electronic Money Value Regional Share $\times$ National Growth	1.02	5.49	0.00	0.13	2.31	1,462
Log GRDP per Capita	16.05	0.54	15.52	16.00	16.87	2,040
Monthly Inflation Rate (%)	0.25	0.51	-0.31	0.21	0.87	2,023
Policy Rate (%)	4.64	1.00	3.50	4.50	6.00	2,040
Financial Literacy (%)	42.87	9.55	31.59	39.63	57.14	2,040

(continued on next page)

Table 2: Summary Statistics (continued)

Variable	Mean	Std. dev.	P10	P50	P90	Obs
Household Internet Coverage (%)	80.12	10.79	69.51	81.96	91.01	1,224
Log Cash-to-GRDP	-10.99	0.96	-12.14	-10.90	-9.86	2,040
Share of E-money Transaction Volume to Total Digital Transaction Volume (%)	-1.18	1.07	-1.94	-0.94	-0.37	1,842
Log Electronic Money $\times$ EDC	21.30	3.51	17.04	21.02	26.33	1,842
Log Electronic Money $\times$ ATM	19.17	2.96	15.57	18.94	23.60	1,392
Log Electronic Money $\times$ Merchant	20.88	3.50	16.60	20.66	25.77	1,842
Log Debit Card and ATM Transaction Value	15.25	1.20	13.82	15.08	16.85	1,870
Log Credit Card Transaction Value	11.27	2.08	8.69	11.10	14.37	1,870

3.2 Empirical Strategy

Building upon the methodologies outlined in [Bech et al. \(2018\)](#) and [Cabezas and Jara \(2022\)](#), our analysis begins with the application of a two-way fixed effects (TWFE) estimation model, represented by the following regression equation:

$$\text{Cash}_{i,t} = \beta_1 + \beta_2 \text{emoney}_{i,t} + \beta_3 X_{i,t} + \cdots + \delta_i + \phi_t + \varepsilon_{i,t} \quad (1)$$

In this model, $\text{Cash}_{i,t}$ denotes the log cash withdrawals in province i and month t , $\text{emoney}_{i,t}$ is the value of e-money transactions, and $X_{i,t}$ is a set of control variables. Province fixed effects δ_i account for time-invariant heterogeneity such as geography, institutions, or long-standing payment habits, including persistent reliance on cash, while time fixed effects ϕ_t capture national shocks (e.g., COVID-19, policy changes). Standard errors $\varepsilon_{i,t}$ are clustered at the province level to account for serial correlation.

The coefficient β_2 can be interpreted as the elasticity of cash demand with respect to e-money usage. A negative and statistically significant estimate of β_2 would imply that e-money acts as a substitute for cash, while a positive coefficient would suggest complementarity.

Our basic model primarily attempts to unravel the relationship and magnitude between e-money and the demand for cash. Nevertheless, this naïve specification is prone to endogeneity. In particular, there remains a risk of reverse causality or omitted variable bias. For instance, a decline in cash usage may itself encourage greater e-money adoption, or unobserved digital policy shocks may affect both cash and e-money simultaneously. Hav-

ing this potential endogeneity may bias our estimation using standard TWFE. To address this concern, we employ a shift-share (Bartik-type) instrumental variable strategy, drawing from [Autor et al. \(2013\)](#) and [Hummels et al. \(2014\)](#).

The shift-share IV disaggregated changes in economic variables within regions into two components: the shift and the share. In this study, the shift-share instrument represents the nationwide growth in e-money transactions (the shifts), where the weights are derived from each province's predetermined share of past e-money transactions by total transaction values (the shares). Mathematically, this is expressed as:

$$Z_{it} = \sum_{i=1}^I s_{i,t-12} * m_t \quad (2)$$

This specification satisfies both the relevance and the exclusion restrictions required for a valid instrumental variable. First, the shift-share instrument is constructed using lagged provincial shares of e-money transactions ($s_{i,t-12}$) and national growth in e-money usage. Because the shares are predetermined and fixed prior to period t , they are insulated from contemporaneous shocks to cash withdrawals, thereby upholding the exclusion restriction. Second, the twelve-month lag helps smooth out short-term fluctuations, capturing more stable, long-run heterogeneity in provinces' exposure to national digital payment trends.

As [Borusyak et al. \(2025\)](#) stated, “shift-share instruments sum a common set of shocks with heterogeneous exposure share weights,” and can validly identify causal effects when either the shifts or the shares are exogenous. We adopt the “exogenous shares” approach as formalized by [Goldsmith-Pinkham et al. \(2020\)](#), where identification rests on the assumption that lagged provincial shares are uncorrelated with future shocks to cash demand, conditional on included covariates and fixed effects.

$$E \left[\frac{1}{I} \sum_i Z_{i,t} \epsilon_{i,t} \right] = 0 \quad (3)$$

To assess the validity of our instrument, we conduct two diagnostic tests. First, we use the Kleibergen–Paap rk LM by [Kleibergen and Paap \(2006\)](#) test to check for underidentification. This test evaluates whether the instrument is sufficiently correlated with the endogenous variable; rejecting the null hypothesis suggests that the instrument is relevant. Second, we assess the strength of the instrument using the Kleibergen–Paap Wald F-statistic and compare it to the Stock-Yogo critical values provided by [Stock et al. \(2001\)](#). If the F-statistic exceeds these thresholds, it indicates that the instrument is strong enough and that our IV estimates are likely reliable.

Because the endogeneity concerns are likely to bias OLS estimates, we focus our analysis on the results from 2SLS-IV estimations, as they better address the endogeneity from e-

money transactions and are more likely to isolate and capture the causal effect of digital transactions on demand for cash.

4 Results

4.1 Main Results

Before we begin the main analysis, we first conduct a first-stage regression to demonstrate the validity of the instrument used in this study. The regression analysis compares our shift share IV with the main variable of interest, which is the log of electronic money transaction value. [Table 3](#) presents the first-stage regression of provincial e-money growth on our shift-share instrument, which captures exogenous variation in regional uptake.

[Table 3](#) column (1) provides the first stage estimation without including covariates, while column (2) depicts the regression by including covariates. All columns include month and province fixed effects. In Column (1), a one-unit increase in the instrument is associated with a 3.74% rise in log e-money transactions and is statistically significant at 1%. After including controls in Column (2), the coefficient remains positive and significant, albeit smaller in magnitude (1.79%; $p < 0.001$). The Kleibergen–Paap rk Wald F-statistic exceeds the Stock–Yogo 10% maximal IV-size critical value in both specifications, an endorsement of the strength of our instrument for subsequent IV estimation. From [Table 3](#), we can conclude that the use of the instrument is relevant, and we do not have any issues with a weak instrument, as evidenced by the F-statistic.

Table 3: First-Stage Regression Table

Dep. var: Log Electronic Money Transaction Value		
	(1)	(2)
12-month Lag E-Money Value	0.0374***	0.0179***
Regional Share $\times$ National Growth	(0.000)	(0.000)
Observations	1,434	1,196
Clusters	34	34
Month FE	Yes	Yes
Province FE	Yes	Yes
Kleibergen-Paap rk Wald F statistic	18.84	20.23
Stock-Yogo weak ID test critical values: 10% maximal IV size	16.38	16.38

(continued on next page)

Table 3: First-Stage Regression Table (continued)

Dep. var: Log Electronic Money		
Transaction Value	(1)	(2)
The dependent variable is the log of electronic money transaction value. The dependent variable is the shift share instrument, which is the interaction between nationwide growth in e-money transactions and the share of each month's past e-money transactions by total transaction values. Covariates in this table are Log Gross Domestic Product per Capita, monthly inflation rate, policy rate, financial literacy, and household internet coverage. Robust standard errors in parentheses. Standard errors clustered at the provincial level. $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$		

We begin our analysis by examining the results from [Table 4](#). [Table 4](#) reports our main estimates of e-money usage on cash withdrawals, using panel fixed effects models. Columns (1)–(2) report fixed-effects, while Columns (3)–(4) present 2SLS results using the shift-share instrument detailed in [Table 3](#). Only the latter two panels address endogeneity; only the even-numbered columns include the full suite of controls. Our preferred causal estimate is presented in Column (4).

Under OLS, the elasticities are near zero and statistically insignificant, implying little in the way of a reduced-form relationship even after fixed effects absorb region- and time-invariant heterogeneity. Such estimates, however, cannot rule out bias from time-varying provincial shocks that jointly affect payment behavior and cash withdrawals. For instance, a localized push for e-money adoption or shift in economic activities could simultaneously boost the use of e-money and alter cash withdrawal patterns within a province over time, leading to a violation of the strict exogeneity assumption.

On that account, the 2SLS estimates (Columns 3–4) exploit exogenous variation in e-money uptake from the lagged-share Bartik instrument. In the fully controlled specification (Column 4), a 1% increase in electronic-money transactions reduces cash withdrawals by 1.77% ($p < 0.01$), indicating a significant crowding-out effect. The first-stage Kleibergen-Paap F-statistic (20.23) comfortably exceeds the Stock-Yogo 10% maximal IV-size threshold. Our results suggest that higher e-money transactions will reduce the demand for cash. The results are robust once we include a set of control variables in column (4). Our study also aligns with [Lippi and Secchi \(2009\)](#) and [Amromin and Chakravorti \(2009\)](#) that show digital payment will lead towards a reduction in cash usage.

Table 4: Main Regression Results

Dep. var.: Log Cash Withdrawal	Fixed Effects		Instrumental Variable	
	(1)	(2)	(3)	(4)
Log Electronic Money Transaction Value	0.008 (0.016)	-0.085 (0.057)	-0.313** (0.137)	-1.772*** (0.649)
Observations	1,842	1,196	1,434	1,196
Control	No	Yes	No	Yes
Month FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Kleibergen-Paap rk Wald F statistic			18.84	20.23
Stock-Yogo weak ID test (10%)			16.38	16.38

The dependent variable is the log of cash withdrawals. The main independent variable is the log of electronic money transactions. The set of control variables is similar to [Table 3](#). Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Given the large regional differences in Indonesia’s digital-finance ecosystem, we explore whether the cash-substitution effect of e-money varies between Java, the most developed region, and the rest of the country. [Table 5](#) presents our heterogeneity analysis. Columns (1) - (4) report OLS estimates, while columns (5) - (8) use IV estimation. From the heterogeneity analysis, we can see that within Java, the substitution effect of e-money remains strong. The results show that the substitution effect is strong within Java, but disappears outside Java. In fact, the IV estimate in column (8) is statistically indifferent to zero, suggesting that the main results are largely driven by Java rather than by the whole country.

Several factors may explain this pattern. First, Java has the highest density of digital-payment infrastructure—agent networks, merchant terminals, strong internet and mobile phone signals. As such, any national shocks or policies quickly translate into local use. In other regions outside Java, a weaker digital-payment infrastructure reduces the opportunities for consumers and merchants to use e-money, keeping cash as the main medium of payment. Second, most of the toll roads and public transportation in Indonesia are located on Java, where payments are mandatorily processed via e-money cards. This institutionalised use case creates regular and widespread demand for e-money and further reinforces adoption in the region in a way that is largely absent elsewhere. Third, network externalities reinforce substitution in more advanced markets: as more consumers and merchants adopt e-money in Java, convenience and acceptance grow, which speeds up the replacement of cash. By contrast, many regions outside Java remain heavily reliant on cash, where low adoption prevents these spillover effects.

Table 5: Heterogeneity Check (Java and Non-Java)

Dep. var.: Log Cash Withdrawals	Java FE		Non-Java FE		Java IV		Non-Java IV	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log Electronic Money Transaction Value	0.009 (0.061)	-0.401* (0.191)	0.015 (0.016)	-0.050 (0.035)	-0.276** (0.113)	-1.700** (0.756)	-0.408*** (0.059)	-11.001 (29.541)
Observations	330	216	1,512	980	258	216	1,176	980
R-squared	0.333	0.376	0.539	0.555	0.365	0.246	0.465	-40.645
Number of Province	6	6	28	28	6	6	28	28
Control	No	Yes	No	Yes	No	Yes	No	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk Wald F statistic					21.01	8.019	0.827	0.127

The dependent variable is the log of cash withdrawals. The main independent variable is the log of electronic money transactions. The set of control variables is similar to [Table 3](#). Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.2 Extension Analysis

In this section, we conduct several extensions and robustness analyses to see whether our results are robust. To see whether electronic money will affect the demand for cash, we replace the dependent variable with the share of cash withdrawals per unit of Gross Regional Domestic Product. We also extend the analysis by interacting our main independent variables with the presence of other infrastructures, for instance, the presence of ATM and merchants. Moreover, we also use a new independent variable using debit card transactions.

In [Table 6](#), we subject our preferred specification to a size-adjustment robustness check by defining the dependent variable as the log of cash withdrawals per unit of GRDP. The fixed-effects OLS panels (Columns 1–2) continue to show no significant association between digital-payment usage and cash intensity. Critically, the 2SLS estimates in Columns 3 and 4 still register a negative semi-elasticity of approximately -1.8% ($p < 0.01$), mirroring our baseline findings in [Table 4](#).

Table 6: Relationship between E-money Transaction on Cash/GRDP

Dep. var.: Log Cash / GRDP	Fixed Effects		Instrumental Variable	
	(1)	(2)	(3)	(4)
Log Electronic Money Transaction Value	-0.022 (0.015)	-0.086 (0.059)	-0.380*** (0.144)	-1.785*** (0.653)
Observations	1,842	1,196	1,434	1,196
Control	No	Yes	No	Yes
Month FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Kleibergen-Paap rk Wald F statistic			18.84	20.23
Stock-Yogo weak ID test critical values: 10% maximal IV size			16.38	16.38

The dependent variable is the log of cash withdrawals per GRDP. The main independent variable is the log of electronic money transactions. The set of control variables is similar to [Table 3](#). Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

We conduct an exercise in [Table 7](#) to explore whether ATM availability moderates the substitution of cash by e-money. We aim to determine whether the presence of ATMs affects demand for money, particularly when there is an increase in the number of ATMs. Although the OLS results (column 1–2) show no meaningful heterogeneity, the IV results in the naïve

identification indicate some substitution effect of e-money. Nevertheless, the effect is muted in the fully controlled specification. Our findings suggest that electronic money and the presence of ATM would not affect demand for cash, as can be seen in columns (3) and (4).

Table 7: Impact of Nominal Electronic Money $\times$ ATM on Demand for Money

Dep. var.: Log Cash Withdrawal	Fixed Effects		Instrumental Variable	
	(1)	(2)	(3)	(4)
Log Electronic Money $\times$ ATM	0.869** (0.381)	-0.031 (0.325)	7.484 (4.148)	8.748 (5.713)
Observations	1,392	996	1,434	996
Control	No	Yes	No	Yes
Month FE	Yes	Yes	Yes	Yes
Kleibergen-Paap rk Wald F statistic			12.21	6.290
Stock-Yogo weak ID test critical values: 10% maximal IV size			16.38	16.38

The set of control variables is similar to [Table 3](#). Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[Table 8](#) examines whether the size of merchant acceptance networks shapes the effect of e-money by interacting the log of e-money transaction value with the number of merchant terminals. This test assesses whether provinces with larger merchant networks exhibit a different relationship between e-money and demand for cash.

Our OLS results in columns (1) and (2) suggest a small but negative association: substitution from cash to e-money appears stronger where merchant acceptance is more widespread. While OLS yields a small yet statistically significant negative interaction, the IV specification with full controls produces an imprecise positive coefficient (2.692) alongside a weak first-stage. Given the weak identification, we cannot draw firm conclusions about heterogeneity. At best, the point estimates are suggestive of possible attenuation. Overall, we do not find robust evidence that the size of merchant networks amplifies the causal impact of e-money on cash demand.

Table 8: Impact of Nominal Electronic Money $\times$ Merchant on Demand for Money

Dep. var.: Log Cash Withdrawal	Fixed Effects		Instrumental Variable	
	(1)	(2)	(3)	(4)
Log Electronic Money $\times$ Merchant	-0.015 (0.025)	-0.058* (0.031)	0.877 (0.907)	2.692 (3.283)
Observations	1,842	1,196	1,434	1,196
Control	No	Yes	No	Yes
Month FE	Yes	Yes	Yes	Yes
Kleibergen-Paap rk Wald F statistic			1.903	1.742
Stock-Yogo weak ID test critical values: 10% maximal IV size			16.38	16.38

The set of control variables is similar to [Table 3](#). Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In [Table 9](#), we replace our e-money regressor with the log of debit and ATM transaction value to explore the effect of traditional card channels on cash withdrawals. The OLS specifications yield statistically significant coefficients on our variable of interest, but the effect dissipates once we apply our preferred IV approach with the full set of controls. We therefore do not interpret these estimates causally. If we use the results from column (3), it suggests that more payment and ATM transactions will tend to co-move with cash withdrawals and broader economic conditions. However, we cannot infer any causal result here because our estimation is not robust.

Table 9: Debit and ATM Transaction Value

Dep. var.: Log Cash Withdrawal	Fixed Effects		Instrumental Variable	
	(1)	(2)	(3)	(4)
Log Debit Card and ATM Transaction Value	0.087*** (0.032)	0.242*** (0.068)	0.140* (0.079)	4.329 (4.093)
Observations	1,870	1,224	1,462	1,224
Control	No	Yes	No	Yes
Month FE	Yes	Yes	Yes	Yes
Kleibergen-Paap rk Wald F statistic			2.919	0.542
Stock-Yogo weak ID test critical values: 10% maximal IV size			16.38	16.38

The set of control variables is similar to [Table 3](#). Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[Table 10](#) conducts an analogous check using the log credit-card transaction value. Although our naïve fixed-effects OLS suggests a significant positive elasticity, the IV specifications again suffer from weak first-stage diagnostics and yield statistically insignificant coefficients. Taken together, the results indicate no robust effect of credit card transactions on cash demand. This likely reflects Indonesia's consumer behavior, where the shift away from cash is increasingly driven by newer digital instruments such as e-money rather than by traditional card payments like credit and debit cards.

Table 10: Credit Card Transaction Value

Dep. var.: Log Cash Withdrawal	Fixed Effects		Instrumental Variable	
	(1)	(2)	(3)	(4)
Log Credit Card Transaction Value	0.105*** (0.032)	0.082 (0.068)	-0.065 (0.079)	-0.054 (4.093)
Observations	1,870	1,224	1,462	1,224
Control	No	Yes	No	Yes
Month FE	Yes	Yes	Yes	Yes
Kleibergen-Paap rk Wald F statistic			21.08	3.11

(continued on next page)

Table 10: Robustness Check 7 (Credit Card Transaction Value) (continued)

Dep. var.: Log Cash Withdrawal	Fixed Effects		Instrumental Variable	
	(1)	(2)	(3)	(4)
Stock-Yogo weak ID test critical values: 10% maximal IV size			16.38	16.38

The set of control variables is similar to Table 3. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11 extends the complete sample to allow each of Indonesia's major islands to follow its own trends.³ This specification controls for divergent macroeconomic trajectories or policy regimes across islands that might otherwise confound our estimates. Despite this richer trend structure, our instrumented estimate of e-money's effect on cash demand remains robust, regardless of slight attenuation relative to the baseline findings in Table 4. The persistence of a negative e-money coefficient under this specification bolsters our confidence that the substitution effect is not driven by any island's macro trend.

Table 11: Extension: Island Time Trend

Dep. var.: Log Cash Withdrawal	Fixed Effects		Instrumental Variable	
	(1)	(2)	(3)	(4)
Log Electronic Money Transaction Value	0.016 (0.018)	-0.111*** (0.049)	-0.320** (0.127)	-1.272** (0.564)
Observations	1,842	1,196	1,434	1,196
Control	No	Yes	No	Yes
Month FE	Yes	Yes	Yes	Yes
Island FE	Yes	Yes	Yes	Yes
Kleibergen-Paap rk Wald F statistic			15.96	11.65
Stock-Yogo weak ID test critical values: 10% maximal IV size			16.38	16.38
Stock-Yogo weak ID test critical values: 15% maximal IV size			8.96	8.96

The dependent variable is the log of cash withdrawals. The set of control variables is similar to Table 3. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

³While Indonesia comprises more than 17,000 islands, it is customary to assign them to 5 main islands (Sumatra, Java, Kalimantan, Sulawesi, and Papua) with the addition of Bali, Nusa Tenggara, and Maluku, where most of the population reside.

4.3 Potential Mechanism

To better understand the channel behind our findings, we focus on whether the effect of e-money varies by denomination of cash. The underlying institution is that e-money is more likely to substitute for cash used in routine transactions, which take place in small-to-medium banknotes⁴, while very small notes and coins remain necessary for low-value transactions.

Payment diary studies show that cash is predominantly used for low-value transactions but declines in importance for larger transactions (Bagnall et al., 2016). Building on this, Brilevics and Schuh (2020) develop a structural framework of consumer payment choice and document that households routinely hold and use multiple payment instruments because payment instrument characteristics (e.g., fees, convenience, acceptance) and transaction context influence choice. Their evidence suggests that cash does not disappear simply because alternative instruments exist; rather, consumers allocate payment methods based on the nature of the transaction and institutional features. This behavioral insight supports the interpretation that substitution effects from e-money adoption will be denomination-specific. Substitution is strongest where cash is used for everyday retail transactions and weaker where cash serves roles that electronic payments do not fully replace.

Table 12 presents the results by denomination. We find large, negative, and statistically significant effects for small-to-medium value banknotes (Rp2,000 to Rp20,000), which constitute the core denominations used in daily transactions like transportation, food purchases, and small retail payments. For example, a rise in e-money transactions is associated with a 2.7% reduction in currency outflows of Rp20,000 notes.

The substitution effect is weaker for high-denominated banknotes (Rp50,000 to Rp100,000). These denominations are more likely to be held for precautionary purposes or used in larger and often informal transactions, making them less directly substitutable by digital payment instruments. In addition, higher-value purchases are more frequently settled using bank-based payment methods such as debit and credit cards rather than e-money. Finally, we do not find statistically significant effects for Rp1,000 notes and for coins. These denominations remain essential for very low-value transactions and for making change, particularly in settings where digital payment acceptance is limited.

Our findings also align with the broader literature on payment innovation and currency demand. Kitamura et al. (2022) find that e-money substitutes cash with a large elasticity observed in small-denomination currency, and the higher the denomination, the lower the elasticity and the less significant it becomes. Similarly, Ashworth and Goodhart (2020) argue that currency demand may remain persistent even amid rapid payment innovation

⁴Throughout this paper, we use the terms cash and banknotes interchangeably, unless otherwise specified. Coins are referred to separately.

because cash serves multiple roles, including anonymity, budgeting, and informal-sector transactions. These help explain why substitution effects are denomination-specific rather than uniform across all forms of cash.

Overall, we conclude that e-money transactions substitute for cash primarily for small- to medium-denomination notes, while coins remain unaffected. This pattern indicates a gradual reallocation of payment behaviour, whereby digital payment instruments increasingly replace cash for frequent transactions of moderate value, while cash continues to be used for very small payments and for certain informal or liquidity-management purposes.

From a policy perspective, our findings have implications primarily for cash logistics and denomination planning. Since the dependent variable in this study captures transactional cash demand through bank-recorded withdrawals, the results should not be interpreted as implying a proportional decline in currency holdings used for store-of-value motives. Instead, the results suggest that central banks may observe declining demand for specific denominations even as aggregate currency demand remains relatively stable. This is consistent with the institutional features of e-money in Indonesia, which differ from debit and credit cards in both regulatory design and typical usage. While card-based payments are commonly used for higher-value transactions due to security and consumer protection considerations, e-money is primarily designed for frequent low- to medium-value payments. Consequently, the substitution patterns documented in this paper reflect changes in transactional cash demand rather than shifts in payment behavior for high-value purchases. As a result, continued efforts to promote e-money adoption in everyday retail payments may help reduce reliance on small-denomination cash and accelerate the transition toward a more digital payment system.

5 Conclusion

We provide new causal evidence that the rapid diffusion of electronic money in a large emerging economy crowds out the use of cash for transactions. Using high-frequency province-month data for Indonesia, we find that an increase in e-money transaction value reduces cash withdrawals by approximately 1.7%. Our results are also robust using different outcome variables. We also show that the results are heterogeneous between different regions. The effect is geographically uneven: it is large and precisely estimated on Java, Indonesia's most digitally mature region, and attenuates elsewhere—pointing to complementary roles for acceptance networks, smartphone penetration, and user adoption in enabling cash displacement.

We also explain the mechanism from our findings. The negative impact of electronic money and cash is concentrated in medium to large banknotes. Outflows of Rp100k–Rp2k notes

decline sharply with the use of e-money, whereas coins remain unaffected. This denomination gradient is consistent with digital payments replacing higher-value. In contrast, coins remain useful for very small transactions and making change.

While our shift-share IV approach yields compelling evidence that e-money adoption crowds out cash withdrawals—especially in digitally mature provinces—several caveats merit consideration. First, the instrument exploits variation in provinces’ historical e-money footprints and national growth shocks, but it does not disentangle the relative roles of specific e-money providers, technology platforms, or customer segments that may simultaneously affect both digital-payments uptake and cash demand.

Second, our analysis is confined to recorded transactions via formal, recorded value of cash withdrawals and e-money transactions. In regions with large informal economies or remittance corridors—where cash remains the primary medium of exchange—our estimates may understate residual cash reliance. Future work could integrate alternative data sources, such as mobile-money agent reports or household surveys, to better measure off-bank-channel cash flows and validate the generalizability of our findings beyond the banking system.

Third, the time frame of our sample (2019–2023) spans a period of extraordinary shocks, including the global pandemic and rapid fintech innovation, that may have temporarily amplified the substitution effects we observe. The long-run trajectory of cash-e-money dynamics could exhibit nonlinearity. For instance, once e-money reaches a critical mass, network externalities might accelerate further cash decline, or conversely, store-of-value motives could reassert cash’s role during periods of financial stress. Extending the analysis over a longer horizon would help to uncover these potential inflection points.

These findings matter for policy. If digital payments compress transactional demand for currency, central banks in emerging markets will face lower cash intensity of M1, potentially higher velocity, and evolving channels for policy transmission. Cash management (printing, distribution, and denomination mix) can be reoptimized toward smaller notes and coins, while financial-inclusion initiatives should target regions where substitution lags.

At the same time, the stark regional heterogeneity we document highlights the need for targeted digital-inclusion policies. Deploying agent networks, subsidizing merchant onboarding, and strengthening digital-financial literacy programs in lagging regions can help ensure that underserved populations are not left behind. Coordination between monetary authorities, telecom operators, the banking sector, and fintech firms will be essential to build a payment ecosystem that balances the efficiency gains of cashless transactions with the indispensable role of cash in segments of the economy where formal banking remains limited.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT to improve grammar and language. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Appendix

Table 12: Change in E-Money Transaction Value on Currency Outflows

Dep. var.: Log Outflows	Banknotes							Coins			
	100,000	50,000	20,000	10,000	5,000	2,000	1,000	1,000	500	200	100
Log Electronic Money Transaction Value	-1.833 [*] (0.724)	-1.953 ^{**} (0.684)	-2.714 ^{***} (0.654)	-2.824 ^{***} (0.778)	-2.820 ^{***} (0.764)	-2.537 ^{***} (0.582)	-0.293 (0.700)	-0.525 (0.676)	-0.060 (0.551)	-0.050 (0.561)	-0.130 (0.400)
Observations	1,196	1,196	1,196	1,196	1,196	1,196	1,195	1,132	1,185	1,144	1,144
Number of Province	34	34	34	34	34	34	34	34	34	34	34
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kleibergen-Paap rk Wald F statistic	20.23	20.23	20.23	20.23	20.23	20.227	20.27	20.65	20.33	20.60	20.36
Stock-Yogo weak ID test critical values: 10% maximal IV size	16.38	16.38	16.38	16.38	16.38	16.38	16.38	16.38	16.38	16.38	16.38

The main independent variable is the log of electronic money transactions. The set of control variables is similar to [Table 3](#). Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$