Bank Competition and Capital Flow Shocks in Open Economies

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Abstract

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This dissertation examines the interactions between sudden stops in international capital flows, the structure and behavior of the banking sector, and the broader dynamics of external debt across economic sectors in emerging and advanced economies.

Chapter 1 investigates the consequences of sudden stops for the competitive landscape of the banking sector and, in turn, how changes in the latter amplify the effects of sudden stops. Using data for 46 emerging economies, I present evidence of a reduction in banking competition following sudden stop episodes. A small open economy model with imperfectly competitive banks that face an occasionally binding collateral constraint can explain this evidence and other standard effects of sudden stops on the economy. Entry and exit of banks influence market power in the banking sector. The diminished availability of external funds during sudden stops causes the sector to contract, resulting in a reduced number of banks. This amplifies market concentration and allows surviving banks to exercise stronger monopoly power. In turn, this results in higher loan rates, exacerbating borrowing costs for firms and households, and amplifying the negative consequences of sudden stops for the aggregate economy.

Chapter 2 introduces heterogeneous banks into a small open economy dynamic stochastic general equilibrium (DSGE) framework to study how endogenous market structure interacts with macroeconomic shocks. Banks differ in productivity governed by Pareto distribution.

Two structural shocks, a permanent reduction in bank entry costs and a permanent increase in government spending are analyzed to understand their effects on credit markets and aggregate outcomes. Lower entry costs increase selection pressure, raising average bank productivity and expanding credit despite a declining number of operating banks. Conversely, higher government spending boosts loan demand, lowers the profitability threshold for entry, and draws more marginal banks into operation. The degree of productivity heterogeneity, shaped by the thickness of the Pareto tail, governs the intensity of reallocation, market power dynamics, and the resulting changes in lending spreads.

Chapter 3 turns to the sectoral composition of external debt. Leveraging a three-state Markov-switching model, I analyze portfolio and other investment debt flows to banks, corporates, and sovereigns across advanced and emerging economies. I uncover pronounced differences in the timing, persistence, and severity of regime shifts across sectors and regions, highlighting the importance of sector-specific vulnerabilities.

In sum, this dissertation shows that the macroeconomic consequences of sudden stops are shaped not only by the availability of external finance but also by the structure and granularity of domestic financial intermediation. Bank competition, productivity heterogeneity, and the sectoral allocation of external debt jointly determine how external shocks transmit through the economy. The findings underscore the importance of accounting for institutional features of the financial sector when designing macroprudential and capital flow management policies.

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ACKNOWLEDGMENTS

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DEDICATION

to *Maple*, for being my most loyal supporter

Chapter 1

SUDDEN STOPS AND BANK COMPETITION

1.1 Introduction

The banking sector is central to flows of capital through emerging market economies. Rapid surges in inflows of international capital can induce liquidity abundance in domestic banks, prompting excessive credit expansion and heightened systemic risk. Conversely, sudden stops, characterized by abrupt halts or reversals of capital inflows, lead to reduced access to foreign financing for domestic banks and, as a consequence, firms and households. This paper studies the effects of sudden stops on the financial structure of the economy–specifically, the competitive landscape of the banking sector–and how changes in the latter amplify the consequences of sudden stops for the economy.

Sudden reversals of international capital flows are frequently associated with shifts in the economy's perceived creditworthiness or could be triggered by falling in global risk appetite. Using data for a panel of 46 emerging economies, I show that, in addition to the typical characteristics of sudden stop crises (fall in output and investment, falling prices and depreciating exchange rates), the domestic banking sector faces significant shifts in competitive pressure during these events. As financial institutions grapple with liquidity constraints, some banks may be forced to retrench or exit the market, and small banks often merge with larger ones. With fewer banks vying for market share, the intensity of competition diminishes. Higher concentration then allows the remaining banks to charge higher markups.

To explain this evidence and investigate its interaction with the broader effects of sudden stops, the next part of the paper develops a small open economy model with an endogenous number of imperfectly competitive banks that can obtain financing from abroad. External financing is subject to a collateral constraint that becomes tighter when the value of bank equity falls. Consistent with the evidence, a sudden stop in the model results in falling bank equity values, a smaller number of operating banks with larger market shares, and higher loan rates as a consequence of widening spreads between deposit and lending rates. This amplifies the fall in investment, consumption and output generated by the sudden stop relative to the effects of a standard business cycle recession.

Most standard models of small open economies and sudden stop dynamics overlook the role of bank competition, but competition influences the stability of the banking industry and its resilience in the event of shocks originating abroad. Analyzing how competitive pressures interact with capital flows provides valuable insights into the transmission of shocks that can guide the design of policy measures and reforms intended to ameliorate the negative consequences of sudden stops.

The rest of the paper is structured as follows. Section II reviews the related literature and explains how this paper contributes to it. Section III presents empirical evidence. Section IV introduces the model. Section V presents analytical results that guide the interpretation of numerical exercises. Section VI presents model calibration and numerical results. Section VII concludes.

1.2 Related Literature

This research contributes to several key strands of literature, with a primary focus on the dynamics of imperfect competition in the banking sector. The model framework features financial accelerator mechanism ([Bernanke et al., 1999]) augmented with bank market power to analyze the propagation and amplification of shocks.

This study deepens the understanding of financial instability under sudden stops, enhancing the insights of prior work ([Aghion et al., 2001], [Caballero and Krishnamurthy, 2001], [Kaminsky and Reinhart, 1999], [Mendoza, 2010], [Chang and Velasco, 2001]), which emphasize country-level credit constraints as a form of financial friction. Here, however, banks are modeled explicitly in an open economy framework to explore how competition among banks evolves and interacts with broader bank dynamics, echoing the firm entry framework of

[Ghironi and Melits, 2005].

While closely related to macro models that use financial intermediation to simulate banking crises with credit constraints ([Gertler and Kiyotaki, 2010], [Gertler and Karadi, 2011]), this research introduces a new perspective by incorporating occasionally binding constraints. Unlike models where constraints are persistently binding, this study simulates sudden stops as crises triggered by non-linear, occasionally binding constraints, capturing the sporadic nature of these shocks.

By incorporating imperfect competition in the banking sector, the model facilitates amplification even in flexible exchange rate environments. Relatedly, [Mandelman, 2010] presents a business cycle amplification mechanism in a monopolistic banking sector within a small open economy, where countercyclical markups emerge from strategic limit pricing. Similarly, [Olivero, 2010] uses a two-country setup to examine how countercyclical margins in the banking sector influence international business cycle transmission, ultimately promoting co-movement of consumption, investment, and output. This research builds on these insights by allowing bank market power to dynamically respond to shocks, amplifying their effects through the financial sector and beyond.

The analysis also intersects with literature examining bank entry and exit, particularly in oligopolistic contexts where bank market structure shifts with economic cycles. For example, [Totzek, 2011] demonstrates how high profits during economic expansions attract new banks into the market, reducing incumbents' market power and lowering markups, thereby intensifying the response to economic shocks. This study's model captures similar dynamics, but extends them to account for macro-level implications of bank entry and competition in an open economy, achieving persistent amplification effects in line with financial accelerator framework.

Finally, this research parallels works analyzing firm and banking dynamics within macroeconomic models ([Gerali et al., 2010] and [La Croce and Rossi, 2018]), where endogenous firm entry and monopolistic banking amplify business cycles. [Cacciatore et al., 2015] also examines how US bank market deregulation influences firm entry in a two-country DSGE model, linking reduced bank monopoly power to improved credit access and, subsequently, to business cycle moderation. The current study furthers this line of research by incorporating collateral constraints that bind only occasionally. This approach leads to infrequent yet impactful crises due to non-linear dynamics, capturing a more realistic pattern of financial instability.

The current work aligns with the existing literature in capturing the amplification of financial shocks and their transmission to real economic activity. However, unlike previous models of sudden stop crises, this model incorporates collateral constraints that bind only occasionally, leading to crises that emerge infrequently due to these non-linear dynamics.

1.3 Data Analysis

To examine the impact of international capital flows on the financial landscape, this analysis leverages capital flows data from the AHKS dataset and lending-deposit spread data from the IMF. The AHKS dataset, provided by [Avdjiev et al., 2022], includes quarterly sector-specific capital flows data from 1996 to 2022.

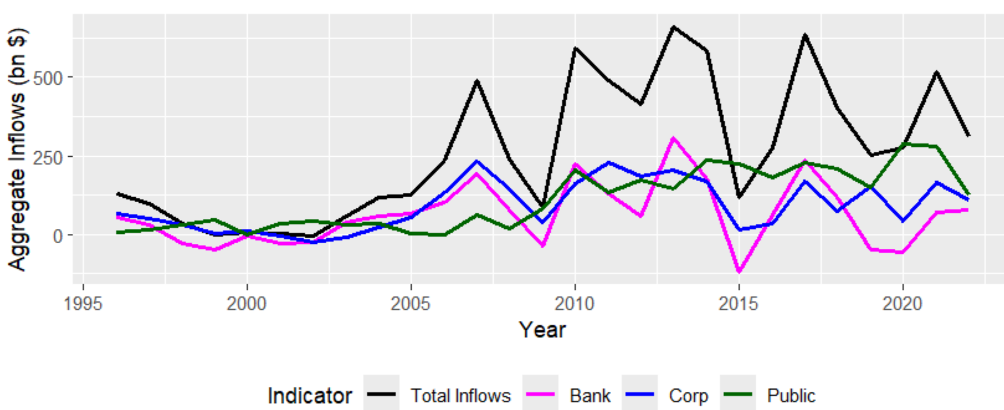


Figure 1.1: Total capital inflows & sector specific inflows

Figure 1.1 presents the aggregate inflow of capital across various economic sectors, highlighting the substantial capital movement within the banking sector in emerging economies[1].

Figure 1.2 underscores the critical role of capital in the banking sector: the banking sector's share of total liability flows (measured as the proportion of |bank inflows| relative to |total inflows|) constitutes a substantial component of overall liabilities for emerging markets.

These capital flows significantly shape how financial institutions operate, particularly in managing the surges and sudden-stop episodes characteristic of these flows. This dynamic highlights the importance of understanding bank competition during and following sudden stops, as shifts in capital flows can profoundly influence the behavior and stability of the banking sector.

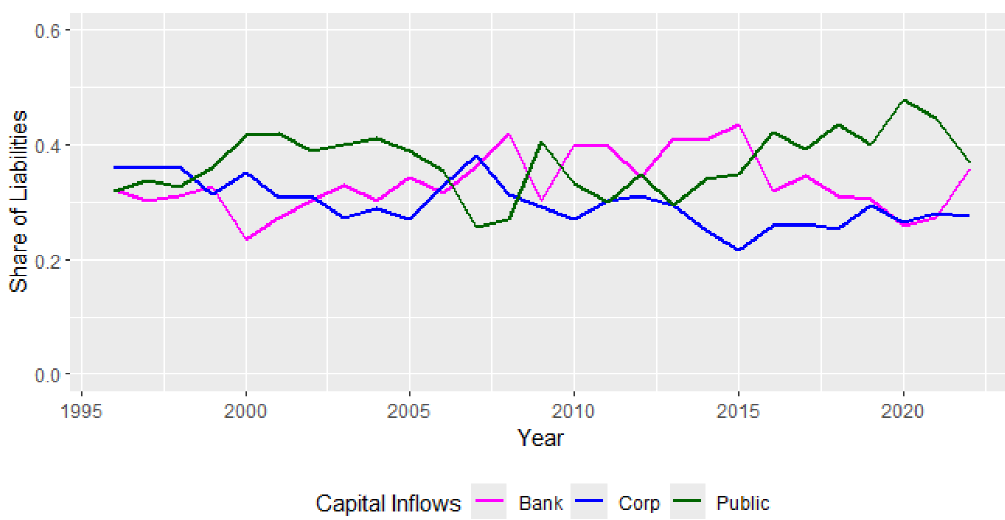


Figure 1.2: Share of sectors(bank, corp, public) in total external liabilities

1.3.1 Identifying Sudden Stop Episodes

Following [Calvo et al., 2008] and [Forbes and Warnock, 2012], quarterly data is annualized to avoid seasonality effects.

$$C_t = \Sigma_{i=1}^{3} inflow_{t-i} \qquad \forall t = 1, 2, 3, ...$$

$$\Delta C_t = C_t - C_{t-4} \qquad \forall t = 5, 6, 7, ...$$

Computing rolling means and standard deviation of ΔC_t over the last 5 years, a sudden stop is defined as the situation when ΔC_t falls more than two standard deviations below the mean. The episode starts and ends when ΔC_t falls one standard deviation below the mean, given it falls more than two standard deviations below the mean during that window and the episode lasts for at least two quarters. The standard practice in sudden stop literature is to often isolate the sudden stop events accompanied with economic duress such as falling GDP. No such filters are applied in the present research as the episodes are being identified using the gross capital flows of banking sector alone. Table 3 in appendix lists the sudden stop episodes for the countries analyzed (listed in Table 4).

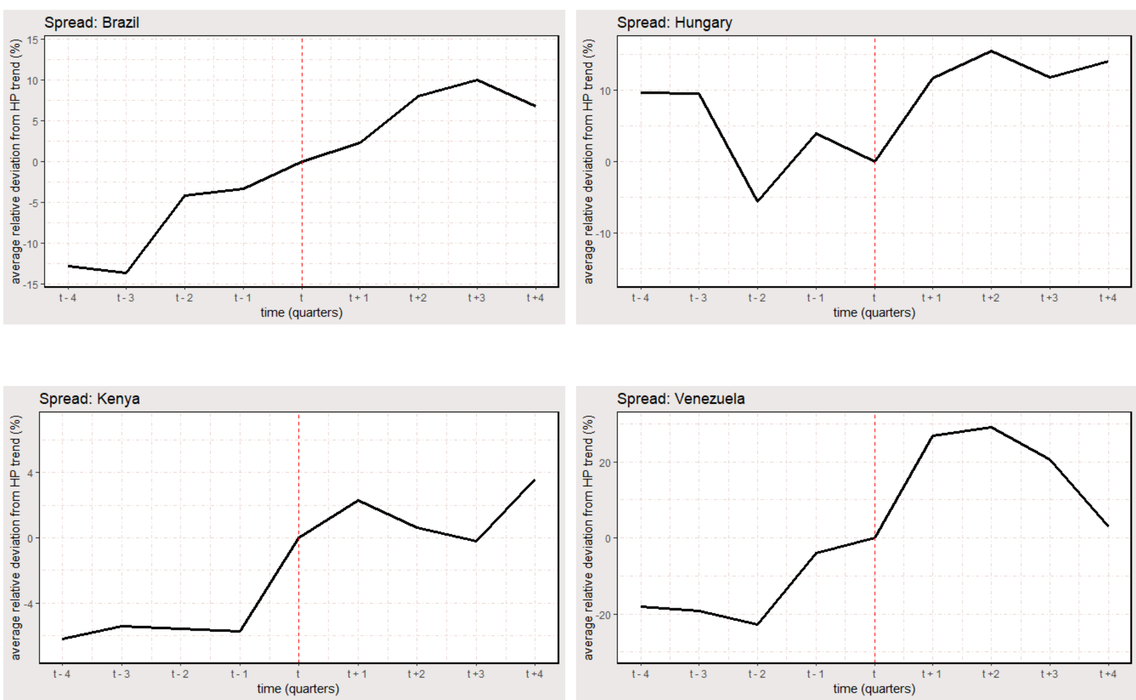


Figure 1.3: Relative deviations in lending-deposit spread averaged across country-specific sudden stop episodes

[1]The emerging & developing economies classification is the same as [Avdjiev et al., 2022].

Dependent: relative lending-deposit spread, y_i; nobs=21

	(1)	(2)	(3)	(4)
Variables	Brazil	Hungary	Kenya	Venezuela
intercept	−0.10***	−0.092**	−0.047**	−0.17***
	(0.017)	(0.032)	(0.02)	(0.025)
ss	0.15***	0.05	0.10*	0.37***
	(0.03)	(0.06)	(0.05)	(0.05)
ss^{post}	0.054	0.16**	0.21***	0.18***
	(0.026)	(0.049)	(0.037)	(0.04)
R-squared	0.56	0.38	0.64	0.78

Standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05

Table 1.1: Country Regression

Following the procedure outlined by [Cavallo et al., 2015], event windows are constructed to examine financial indicators before and after each sudden stop episode. For each episode, $t = 0$ marks the first quarter of the sudden stop, with an event window spanning 10 quarters before and after the starting quarter. This yields a total of 21 observations per episode, covering 161 sudden stop episodes across 46 emerging and developing economies.

To capture shifts in bank market dynamics, the relative deviation of the lending-deposit spread (calculated as the spread's deviation from its HP-trended value) is used as a key measure.

For each country, this relative deviation of the lending-deposit spread is averaged across

[1]Figure plots the deviations using quarterly data. The deviations are indexed at zero for the first quarter of the sudden stop episode at t=0

all sudden stop episodes, providing insights into bank behavior and market conditions surrounding these event. Figure 1.3 displays a noticeable upward trend in the deviation as the sudden stop episode begins ($t = 0$). This increase in the lending-deposit spread deviation at and following $t = 0$ reflects the growing market power of banks during periods when the economy is under constraint. Importantly, these identified episodes are not always linked to a downturn in GDP or a typical bust cycle. Thus, the widening spread can likely be attributed, at least in part, to the restricted access to foreign funds facing the banking sector.

The averaged deviations (across all sudden stop episodes for each country) give 21 observations for each country, capturing the 10 quarters before and after the sudden stop hit (t=0). These observations are used to perform regressions to analyze the significance of sudden stop episodes.

$$y_{i,t} = \beta^0_{i,t} + \beta^1_{i,t} ss_{i,t} + \beta^1_{i,t} ss^{post}_{i,t} + \epsilon_{i,t} \tag{A}$$

where, $y_{i,t}$ is the relative deviation of spread from the HP trend for country i in quarter t. $ss_{i,t}$ is the sudden stop dummy variable which takes the value 1 for all quarters of the episode. T^{end} is the last quarter of the sudden stop episode. Thus, $ss_{i,t} = 1$ when $0 \leq t \leq T^{end}_i$; $ss^{post}_{i,t}$ is the post sudden stop dummy variable, which marks the quarters following the sudden stop episode, such that $ss^{post}_{i,t} = 1$ when $T^{end}_i < t \leq 10$. As suggested by the significant coefficient (Table 1.1) for $ss_{i,t}$, the lending-deposit spread increases during the sudden stop episode and in most cases even beyond the episode.

The episodes discussed above highlight the critical need to study and analyze the banking industry and competition during and after sudden stop episodes. The observed trends are not unique to specific countries but are prevalent across many emerging economies that are vulnerable to external shocks.

Figure 1.4 and Table 1.2 report the results for 46 emerging economies and 161 sudden stop episodes. All the event windows are used to provide the relative deviation of spread around each sudden stop.

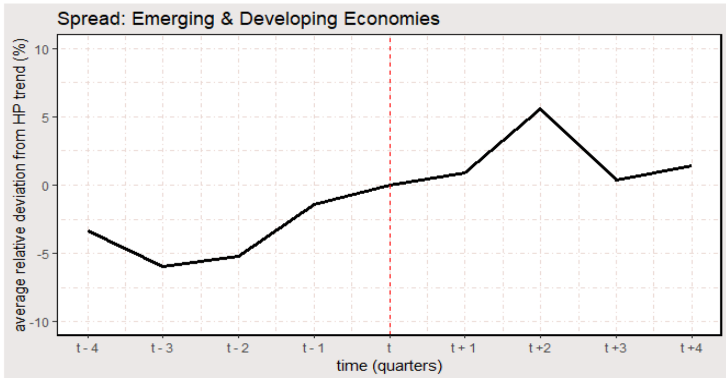


Figure 1.4: Relative deviations in lending-deposit spread averaged across all countries & their sudden stop episodes

Dependent: relative lending-deposit spread; nobs=21 × 46

	(1)	(2)
VARIABLES	Pooled	Within
intercept	-0.032**	-
	(0.011)	
ss	0.049*	0.049**
	(0.022)	(0.017)
ss^{post}	-0.014	-0.014
	(0.018)	(0.014)
R-squared	0.008	0.014

Standard errors in parentheses

*** p<0.001, ** p<0.01, * p<0.05

Table 1.2: Panel Regression

The observations for all emerging and developing economies is pooled together to perform a panel regression.

$$y_{i,t} = \beta^0_{i,t} + \beta^1_{i,t} ss_{i,t} + \beta^1_{i,t} ss^{post}_{i,t} + fe_i + \epsilon_{i,t} \tag{B}$$

where fe_i are the country fixed effects.

1.4 The Model

An open economy version of [Totzek, 2011] is considered, with added ingredients of occasionally binding constraint and endogenous bank entry along the lines of [Ghironi and Melits, 2005].

The world economy comprises of a small open economy and the foreign economy/rest of the world. The domestic open economy is made up of a continuum of households, firms of unit mass and a discrete number of banks N_t. The banks operate in an oligopolistically competitive loan market.

Domestic agents can't borrow directly from abroad, instead they need to go through the financial intermediaries who can borrow funds from the international financial market. Households ultimately own the banks and firms. All prices are flexible and the model is setup with real variables. The law of one price (LOP) holds, however the setup exhibits purchasing power parity (PPP) deviation.

Along with imperfect competition, the model features an additional financial friction such that banks' foreign borrowing is constrained by an occasionally binding collateral constraint. Banks can borrow only up to a fraction of their bank value. When the sudden stop hits, this collateral constraint binds, restricting the foreign funds that banks can obtain. This trickles down to the real economy and has adverse consequences, eventually causing an amplification. An endogenous spread between domestic and foreign interest rate appears through the model dynamics.

1.4.1 Households Preferences

Households are infinitely lived and are populated on a continuum of unit mass. They seek to maximize expected intertemporal utility from consumption net of disutility from labor services, $E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t)$. The utility function is given by

$$u(c_t, h_t) = \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\phi}}{1+\phi} \right) \qquad \phi > 0, \quad \sigma > 0 \tag{1}$$

such that $\beta \in (0,1)$ is the discount factor, $\frac{1}{\sigma}$ is the intertemporal elasticity of substitution and $\frac{1}{\phi}$ is the Frisch elasticity of labor supply. The consumption (c_t) is a composite good, comprised of home (c_t^H) and foreign(c_t^F) goods. It is an Armington aggregate of home and foreign produced goods.

$$c_t(c_t^H, c_t^F) = \left[\gamma^{\frac{1}{\eta}} (c_t^H)^{\frac{\eta-1}{\eta}} + (1-\gamma)^{\frac{1}{\eta}} (c_t^F)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{2}$$

η is the intertemporal elasticity of substitution between home and foreign goods. The preferences for both economies exhibit home bias that is, $\gamma = \gamma^* > \frac{1}{2}$, implying that the consumption baskets are not identical and thus, PPP does not hold.

Households make consumption, investment, labor and savings decisions. They can save the excess funds as risk-free one-period deposits in the domestic intermediaries. The deposits pay risk-free real return in units of the home consumption basket, r_t. Moreover, they can invest in the banks by buying the shares in the mutual fund of domestic intermediaries.

All prices are flexible and set in the consumers' currency. The home price index (cost of composite consumption basket) has been normalized to 1.

$$P_t = \left[\gamma (p_t^H)^{1-\eta} + (1-\gamma)(p_t^F)^{1-\eta} \right]^{\frac{1}{1-\eta}} = 1 \tag{3}$$

1.4.2 Firms

The real sector is operating in a perfectly competitive market and producing the home good, y_t in period t. The firms use labor in a linear production technology, $y_t = Z_t h_t$, where Z_t is the aggregate productivity of labor.

The firms have a working capital requirement where they need to pre-finance the wage bill. The firms must borrow these funds from the intermediaries. They obtain a within-period loan to pay for wages in advance incurring an additional cost of borrowing.

The firms borrow different loan products from all N_t banks operating in period t and combine them in Dixit-Stiglitz fashion.

$$L_{t+1} = \left[\sum_{t=1}^{N_t} l_{i,t+1}^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{4}$$

$$R_{t+1}^L = \left[\Sigma_{i=1}^{N_t}(r_{i,t+1}^l)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{5}$$

where, L_{t+1} is the composite loan product aggregating the loan products and R_{t+1}^L is the composite loan rate. All firms pay back their loans at all times and there is no default risk.

Real profit of the firm is given by

$$\pi_t^{firm} = \rho_t^H Z_t h_t - w_t h_t + L_{t+1} - (1 + R_{t+1}^L) L_{t+1} \tag{6}$$

where $\rho_t^H = \frac{p_t^H}{P_t}$ is the real price of home good in units of home consumption basket and the amount of loan required is

$$L_{t+1} = w_t h_t \tag{7}$$

Firms take w_t, ρ_t^H, R_t^L as given and choose $h_t, l_{i,t}$. The optimization provides the first-order conditions for the firm.

$$\rho_t^H = (1 + R_{t+1}^L)\frac{w_t}{Z_t} \tag{8}$$

Given the perfectly competitive setup, the real price of home good is equal to the marginal cost of production, which comprises of the effective labor wage and the additional interest expense to pay them in advance. The demand for each bank i's loan product is given by

$$l_{i,t+1} = \left(\frac{r_{i,t+1}^l}{R_{t+1}^L}\right)^{-\epsilon} L_{t+1} \tag{9}$$

where ϵ is the elasticity between various loan products.

1.4.3 Banks as financial intermediaries

Period t begins with a discrete number of banks, N_t operating in the economy. Each bank issues a loan product as well as a deposit product. Deposit market is perfectly competitive, all banks issue a homogenous deposit product and issue deposits at the market rate. This deposit market is further assumed to operate at the same rate as the policy rate r_t.

They compete over loans in oligopolistic fashion. Each bank i provides a differentiated loan product ($l_{i,t+1}$) to the firms and thus, has some market power in rate setting. To finance their operations, each bank obtains funds from households by issuing deposit products ($d_{i,t+1}$) and borrows funds in foreign currency from the international financial market (valued at period t home consumption basket, $Q_t d^*_{i,t+1}$). $Q_t = \frac{\epsilon_t P^*_t}{P_t}$ is the real exchange rate and gives the units of home consumption basket that can be bought by 1 unit of foreign consumption basket, such that an increase in Q_t signifies a depreciation. Imposing LOP, the real exchange rate captures the relative real price of home good in home economy and foreign economy.

$$Q_t = \frac{\frac{p^H_t}{P_t}}{\frac{p^{H*}_t}{P^*_t}} = \frac{\rho^H_t}{\rho^{H*}_t}$$

Thus, the balance sheet constraint for bank i is

$$l_{i,t+1} \leq d_{i,t+1} + Q_t d^*_{i,t+1} \tag{10}$$

The banks face a second financial friction in the form of a credit constraint. Since the domestic economy credit is perceived as potentially risky, they can't borrow an unconstrained amount of funds from abroad. The amount of foreign borrowing they can acquire is constrained by a fraction ($\theta > 0$) of their equity (v_t). This collateral constraint for the permissible foreign borrowing is given by

$$Q_t d^*_{i,t+1} \leq \theta x_{i,t} v_{i,t} \tag{11}$$

A fall in θ constraints the banks of the amount of foreign borrowing and tightens the collateral constraint. This might push the economy from an unconstrained (non-binding) region to a constrained (binding) region.

Analogous to the firm entry model of [Ghironi and Melits, 2005], each bank faces an exit shock at the end of period t with probability δ. Each bank i takes r_t, r^*_t, R^L_t, Q_t as given and chooses the loan rate, $r^l_{i,t}$, the foreign borrowing, $d^*_{i,t}$ and domestic deposits, $d_{i,t}$ to maximize the present discounted sum of future profits.

$$\max_{\{r^l_{i,s+1}, d^*_{i,s+1}, d_{i,s+1}\}^{\infty}_{s=t+1}} E_t \sum_{s=t+1}^{\infty} \left(\frac{c_s}{c_t}\right)^{-\sigma} [\beta(1-\delta)]^{s-t} \pi_{i,s}$$

subject to

$$l_{i,s+1} \leq d_{i,s+1} + Q_s d^*_{i,s+1} \qquad \text{(Balance Sheet Constraint)}$$

$$Q_s d^*_{i,s+1} \leq \theta x_{i,s} v_{i,s} \qquad \text{(Collateral Constraint)}$$

$$\pi_{i,t} = d_{i,t+1} + Q_t d^*_{i,t+1} - (1+r_t)d_{i,t} - (1+r^*_t)Q_t d^*_{i,t} + (1+r^l_{i,t})l_{i,t} - l_{i,t+1} \tag{12}$$

Each period the bank receives the loan payments, pays the interest income on deposits and foreign borrowing, valued at current period's exchange rate. Thus, a depreciation in the exchange rate might increase the interest burden on the foreign borrowing.

The optimization provides the first-order conditions.

$$\lambda_t = (1-\delta)E_t\Lambda_{t,t+1}(1+r_{t+1})(1+\mu_t x_t \theta) \tag{13}$$

When the collateral constraint is non-binding ($\mu = 0$), the marginal gain from an additional unit of deposit is equal to the discounted cost of it. However, when the collateral constraint is binding ($\mu > 0$), the cost includes the impact on the collateral as well, since the amount of foreign borrowing is dependent on bank value which is acting as the collateral.
The loan rate charged by each bank i given by

$$r^l_{i,t+1} = \frac{\epsilon(\alpha_{i,t}-1)}{\epsilon(\alpha_{i,t}-1)+1} r_{t+1} \tag{14}$$

Each bank charges a loan rate as a mark-up of the deposit rate. The mark-up charged depends on the market share ($\alpha_i \in (0,1)$) of each bank and thus signals its rate setting power in the market. The arbitrage condition is captured by

$$E_t(1-\delta)\Lambda_{t,t+1}\left(\frac{Q_{t+1}}{Q_t}\right)(1+r^*_{t+1})(1+\mu_t\theta x_t) = E_t(1-\delta)\Lambda_{t,t+1}(1+r_{t+1})(1+\mu_t\theta x_t) - \mu_t \tag{15}$$

where μ_t is the Lagrangian multiplier associated with the collateral constraint and $\Lambda_{t,t+1} = \beta\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}$ is the stochastic discount factor. The world interest rate (r^*) is exogenous to the small open economy.

When the collateral constraint is non-binding ($\mu = 0$), it gives a standard uncovered interest parity (UIP) condition which delivers the same returns on domestic and foreign assets with optimal adjustment of the real exchange rate. However, when the collateral constraint binds ($\mu > 0$), there is a deviation from UIP as there is an interest rate spread between the domestic and world interest rate. When the constraint binds, it reflects the decreasing credit worthiness of the economy and appears as the risk premium that needs to be paid to compensate for the increased risk. The real exchange rate thus evolves in accordance with the existing interest differential and the risk premium.

Bank Entry

In every period, there is a positively discrete amount of potential entrants who are willing to enter the market, incentivized by the positive profits in the banking sector. New banks can enter in period t by incurring a sunk cost valued at the labor cost $f^E(w_t/Z_t)$. The fixed entry cost captures the initial investment required to setup a bank, which includes but is not limited to the advertising cost, hiring costs, managerial costs, infrastructure costs etc. Entrants at period t only start producing in period $t+1$.

Each prospective bank can correctly anticipate their future earnings and will enter the market if the entry is profitable. Thus, bank entry continues until the bank value, which is the present discount value of the anticipated future earnings of the bank; are equalized to the cost of entry.[2]

$$v_t = f^E \frac{w_t}{Z_t} \qquad \text{such that} \tag{16}$$

$$v_t = E_t \sum_{s=t+1}^{\infty} \left(\frac{c_s}{c_t}\right)^{-\sigma} [\beta(1-\delta)]^{s-t} \pi_{i,s} \tag{17}$$

The exit shock occurs at the end of each period. Thus, δ fraction of banks in period t, $\delta(N_t + N_{E,t})$ will exit the market. The exiting banks transfer their deposits to the surviving entrants. Thus, the number of banks entering period $t+1$ is

$$N_{t+1} = (1-\delta)(N_t + N_{E,t}) \tag{18}$$

1.5 Equilibrium: Symmetric Banks

Assuming all banks are identical and households own the banks (imposing $x_{t+1} = x_t = 1$), implies that each bank i issues the same amount of loan and borrows the same amount of foreign funds.

$l_{i,t+1} = l_{t+1}$, $d_{i,t+1} = d_{t+1}$, $r^l_{i,t} = r^l_t$, $\pi_{i,t} = \pi_t, \upsilon_{i,t} = \upsilon_t$, $\mu_{i,t} = \mu_t \quad \forall i = 1, 2, ..., N_t$

$$L_{t+1} = N_t^{\frac{\epsilon}{\epsilon-1}} l_{t+1}$$

$$R^L_{t+1} = N_t^{\frac{1}{1-\epsilon}} r^l_{t+1}$$

Thus, the market share (α_t) of each bank is equal and depends on total number of banks operating in the economy at time t.

$$\alpha_t = \frac{1}{N_t}$$

$$r^l_{t+1} = \frac{\epsilon(\alpha_t - 1)}{\epsilon(\alpha_t - 1) + 1} r_{t+1}$$

As the number of banks operating in the economy grows, the market share of each bank diminishes, resulting in lower loan rates being charged.

1.5.1 Household Budget Constraint

The economy enters period t with N_t banks. $N_{E,t}$ new banks enter the market and will start their operations in period $t+1$. Households finance these new banks by investing in the mutual fund of banks in period t which is made up of a portfolio of the existing banks N_t and the new banks $N_{E,t}$.

[2]The entry condition should be an inequality as the number of banks are discrete. However, equality is considered for analytical tractability.

Households enter period t with x_t outstanding shares in the banks' mutual fund and d_t deposits in domestic intermediaries. They have at their disposal the dividend income from the mutual funds, gross interest income from last period's deposit holdings, the value of liquidating the share holdings and the labor income. They use the proceeds to allocate the resources between consumption, deposits and shares.

In period t, they buy x_{t+1} shares in the mutual fund of $N_t + N_{E,t}$ banks valued at th price v_t in home currency. Post the exit shock, only $(1-\delta)(N_t + N_{E,t})$ banks will pay the profits and dividends at time t+1. v_t is the date t price of the mutual fund and reflects the value of banks' future stream of profits.

Deposit products issued by all banks are homogenous and the household buys an equal amount from each bank operating during period t. However, the household deposits are protected despite the bank exits. The exiting banks (δN_t) transfer the deposit holdings to the surviving new banks ($(1-\delta)N_{E,t}$) who will begin operations in period $t+1$. To pin down the domestic deposits, households pay an adjustment cost on deposits which is returned to them as transfers in the equilibrium.

$$c_t + d_{t+1}N_t + v_t x_{t+1}(N_t + N_{E,t}) + \frac{\kappa}{2}(d_{t+1} - \bar{d})^2(N_t + N_{E,t}) \tag{19}$$
$$\leq (1 + r_t)d_t N_t + w_t h_t + x_t N_t(v_t + \pi_t) + t_t \quad (\textbf{HH Budget Constraint})$$

where r_t is the consumption-based real interest rate on domestic deposit holdings between $t-1$ and t, known to households at period $t-1$. $w_t = \frac{W_t}{P_t}$ is the real wage and $\frac{\kappa}{2}(d_{t+1} - \bar{d})^2$ is the adjustment cost to be paid for the domestic deposits to ensure the unique steady state of deposits as $\bar{d}$. The households receive this fee as transfers, t_t in equilibrium.

Households take wages, domestic rate, price of shares, transfers as given and choose $c_t, h_t, d_{t+1},$ and x_{t+1}

$$\max_{\{c_t, h_t, x_{t+1}, d_{i,t+1}\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\phi}}{1+\phi} \right) \qquad \sigma > 0,\, \phi > 0$$

subject to,

$$c_t + d_{t+1}N_t + v_t x_{t+1}(N_t + N_{E,t}) + \frac{\kappa}{2}(d_{t+1} - \bar{d})^2 N_t \leq (1 + r_t)d_t N_t + w_t h_t + x_t N_t(v_t + \pi_t) + t_t$$

The optimization provides the first order conditions. The consumption-labor trade-off is given by

$$\frac{c_t^{-\sigma}}{\chi h_t^{\phi}} = \frac{1}{w_t} \tag{20}$$

The Euler equations for share holdings and deposit holdings are

$$v_t = (1-\delta)\beta E_t\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}(v_{t+1}+\pi_{t+1})\right] \tag{21}$$

$$\beta E_t\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}(1+r_{t+1})\right] = 1+\kappa(d_{t+1}-\bar{d}) \tag{22}$$

The forward iteration of the share holdings equation gives the share price solution

$$v_t = E_t \sum_{s=t+1}^{\infty}\left(\frac{c_s}{c_t}\right)^{-\sigma}[\beta(1-\delta)]^{s-t}\pi_{i,s}$$

1.5.2 Central Bank

The model setup assumes that the Central Bank is able to set the policy rate to manage deviations in output and real exchange rate. It is further assumed that the policy rate is set to exactly match the rate operational in the deposit market by banks.

$$1+r_{t+1} = \left(1+r^*_{t+1}+f(\mu_t)\right)\left(1+\frac{y_t-y}{y}\right)^{e_y}\left(1+\frac{Q_t-Q}{Q}\right)^{e_q} \tag{23}$$

The policy rule includes the term $f(\mu_t)$ which captures the impact of the constraint in the financial sector. The central bank thus reacts to the credit conditions in the economy, as well as to output and the real exchange rate. $f(\mu_t)$ captures the risk premium on the domestic currency. It is an increasing function of μ. The tighter the collateral constraint binds, the larger the magnitude of μ.

1.5.3 Market Clearing Conditions

Aggregate labor supply must equal the labor employed by firms for producing the home good and the labor hired by new banks to setup the banking infrastructure.

$$h_t = \frac{y_t}{Z_t} + N_{E,t}\frac{f^E}{Z_t} \tag{24}$$

In the loan market, total loans issued by the banking sector must equal the demand for these loans by the firms for advance wage payments.

$$L_{t+1} = N_t^{\frac{\epsilon}{\epsilon-1}} l_{t+1} = w_t h_t \tag{25}$$

Profit made by each bank in equilibrium is

$$\pi_t = -(1+r_t)d_t - (1+r_t^*)Q_t d_t^* + (1+r_t^l)l_t$$
$$\implies \pi_t = l_t - d_t - Q_t d_t^* - r_t d_t - r_t^* Q_t d_t^* + r_t^l l_t$$

Imposing the balance sheet constraint,

$$\implies \pi_t = r_t^l l_t - r_t d_t - r_t^* Q_t d_t^* - (Q_t - Q_{t-1})d_t^*$$

Thus, the bank's profit comes from the loan interest payments, netting out the interest cost on deposits, foreign borrowing and the changing valuation of the foreign borrowing.

Model Summary

Assuming banks are identical implies that each bank i issues the same amount of loan and borrows the same amount of foreign funds. Thus, the market share of each bank is equal and depends on total number of banks operating in the economy at time t.
$l_{i,t+1} = l_{t+1},\ d_{i,t+1} = d_{t+1},\ r_{i,t}^l = r_t^l,\ \pi_{i,t} = \pi_t, v_{i,t} = v_t,\ \mu_{i,t} = \mu_t \quad \forall i = 1, 2, ..., N_t$

This provides a system of 23 equations and 23 endogenous variables:
$c_t, c_t^H, c_t^F, h_t, d_{i,t+1}, w_t, v_t, N_t, N_{E,t}, y_t, L_{t+1}, l_{i,t+1}, \rho_t^H, \rho_t^F, r_{t+1}, R_{t+1}^L, r_{i,t+1}^l, d_{i,t+1}^*, \alpha_{i,t}, Q_t,$
$\pi_{i,t}, \mu_t, f(\mu_t)$

$$\frac{c_t^{-\sigma}}{\chi h_t^{\phi}} = \frac{1}{w_t} \tag{M1}$$

$$v_{i,t} = (1-\delta)\beta E_t\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}(v_{i,t+1} + \pi_{i,t+1})\right] \tag{M2}$$

$$\beta E_t\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}(1+r_{t+1})\right] = 1 + \kappa(d_{i,t+1} - \bar{d}) \tag{M3}$$

$$c_t + d_{i,t+1}N_t + v_{i,t}N_{E,t} = (1+r_t)d_{i,t}N_t + w_t h_t + N_t\pi_{i,t} \tag{M4}$$

$$l_{i,t+1} = \left(\frac{r^l_{i,t+1}}{R^L_{t+1}}\right)^{-\epsilon} w_t \frac{y_t}{Z_t} \tag{M5}$$

$$L_{t+1} = \left[\sum_{i=1}^{N_t} l_{i,t+1}^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{M6}$$

$$R^L_{t+1} = \left[\Sigma_{i=1}^{N_t}(r^l_{i,t+1})^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{M7}$$

$$r^l_{i,t+1} = \frac{\epsilon(\alpha_{i,t}-1)}{\epsilon(\alpha_{i,t}-1)+1} r_{t+1} \tag{M8}$$

$$(1-\delta)E_t\Lambda_{t,t+1}\left(\frac{Q_{t+1}}{Q_t}\right)(1+r^*)(1+\theta\mu_{i,t}) = (1-\delta)E_t\Lambda_{t,t+1}(1+r_{t+1})(1+\mu_{i,t}\theta) - \mu_t \tag{M9}$$

$$\rho^H_t = (1+R^L_{t+1})\frac{w_t}{Z_t} \tag{M10}$$

$$\pi_{i,t} = d_{i,t+1} + Q_t d^*_{i,t+1} - (1+r_t)d_{i,t} - (1+r^*)Q_t d^*_{i,t} + (1+r^l_{i,t})l_{i,t} - l_{i,t+1} \tag{M11}$$

$$\alpha_{i,t} = \frac{1}{N_t} \tag{M12}$$

$$v_{i,t} = f^E \frac{w_t}{Z_t} \tag{M13}$$

$$c^H_t = \gamma\left(\rho^H_t\right)^{-\eta} c_t \tag{M14}$$

$$c^F_t = (1-\gamma)\left(\rho^F_t\right)^{-\eta} c_t \tag{M15}$$

$$Q_t = \frac{\rho^H_t}{\rho^{H*}_t} \tag{M16}$$

$$1 = \left[\gamma(\rho^H_t)^{1-\eta} + (1-\gamma)(\rho^F_t)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{M17}$$

$$N_t = (1-\delta)(N_{t-1} + N_{E,t-1}) \tag{M18}$$

$$1 + r_{t+1} = \left(1 + r^* + f(\mu_{i,t})\right)\left(1 + \frac{y_t - y}{y}\right)^{e_y}\left(1 + \frac{Q_t - Q}{Q}\right)^{e_q} \tag{M19}$$

$$h_t = \frac{y_t}{Z_t} + N_{E,t}\frac{f^E}{Z_t} \tag{M20}$$

$$y_t = c^H_t + c^{H*}_t \tag{M21}$$

$$l_{i,t+1} = d_{t+1} + Q_t d^*_{t+1} \tag{M22}$$

$$\mu = 0 \qquad \text{(M23a: non-binding)}$$

$$Q_t d^*_{t+1} = \theta v_t \qquad \text{(M23b: binding)}$$

1.6 Impulse Responses

To examine how sudden stops affect the real economy through their interaction with bank competition, two exercises are conducted. In the first exercise, I assume that the economy is consistently constrained and a sudden decrease in θ(triggered by a global shock) reduces the availability of foreign funds and has macroeconomic consequences for the real economy.

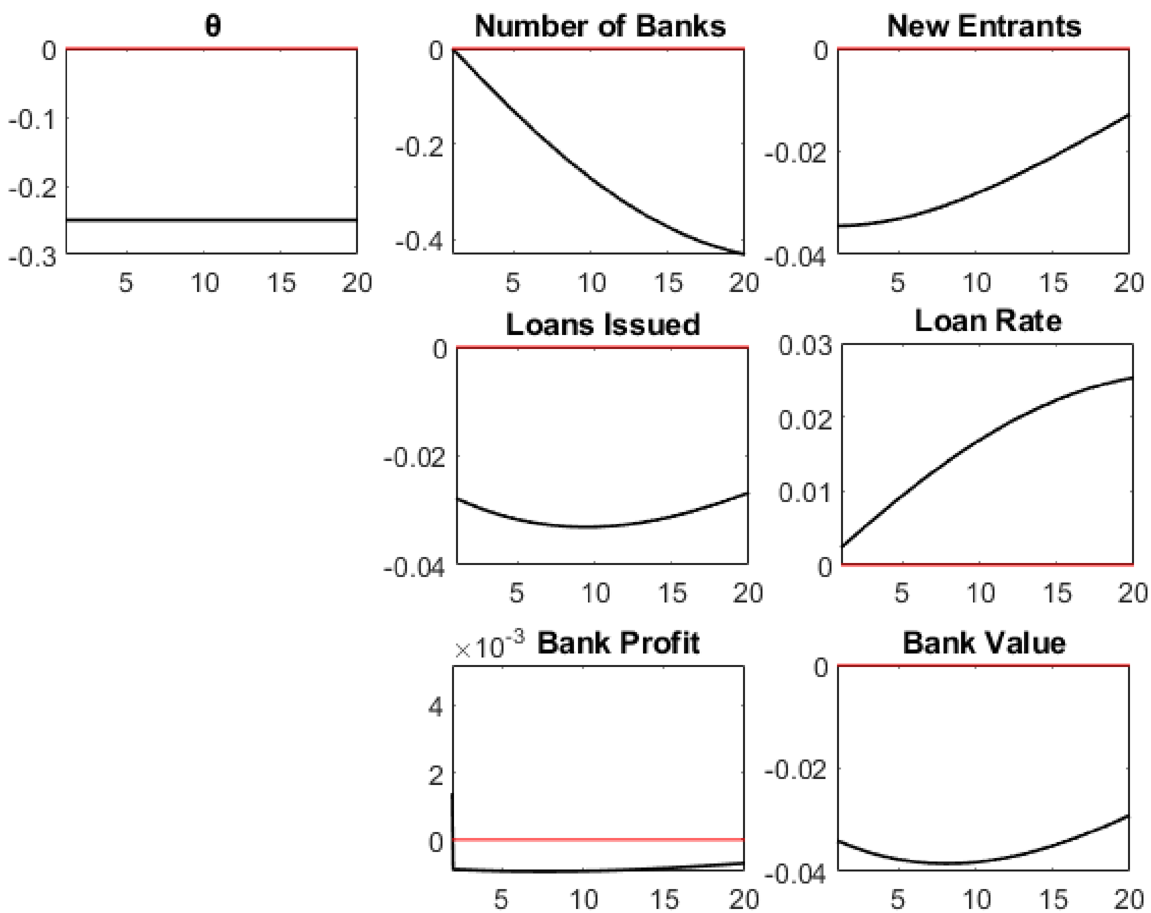
In the second exercise, the economy encounters a positive technology shock leading to expansion of the real economy. We examine the impulse responses for both non-binding and binding states. During the unconstrained state, the economy can freely expand in response to the productivity shock by increasing its foreign borrowing, thus accumulating leverage. This progressively tightens the collateral constraint until it becomes binding, placing the economy in a constrained region. During the constrained state, the economy faces restrictions on its foreign borrowing and experiences a crisis due to excessive leveraging during the expansion phase.

Calibration

The parameters have been calibrated over quarterly frequency to reflect a small open economy which takes foreign preferences and shocks as fixed and cannot influence the foreign economy. The households have been assumed to have log preferences over consumption with unit elasticity of labor supply, $\phi = 1$ and $\sigma = 1$ with scaling parameter $\chi = 5$ and the adjustment cost(κ) as 1. β is set to 0.99, such that the annual domestic rate is 4%. The real price of home good in the foreign market, valued at home consumption basket, $\rho^{H*} = \frac{p^*_H}{P}$ has been set to 1, with exogenously given exports, $c^{H*} = 0.1$. The elasticity between home and foreign goods is set to 1.2 and home bias γ=0.55. The elasticity between various loan products are set to 4 and the sunk cost f^E to 1. The death rate, δ of banks is set to 0.015. The monetary policy parameters are $e_y = 0.1$ and $e_Q = 0.3$

1.6.1 Global Shock

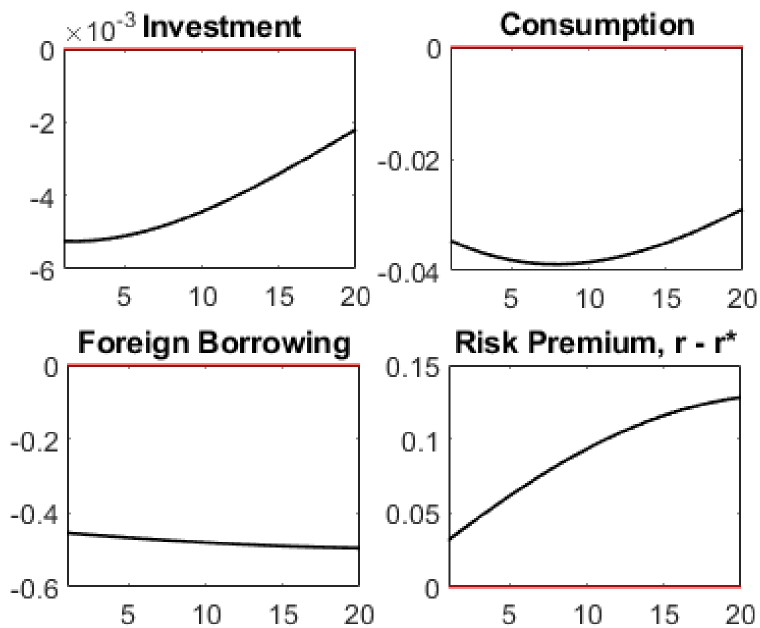
The perceived creditworthiness of the economy is captured by θ. It reflects the investors' appetite for risk when investing in the small open economy.



(a) **Responses I**

This perceived risk arises from various factors including lower levels of institutional quality, historically high economic volatility, political instability, a history of defaults, amount of government borrowing and other economic indicators. θ is susceptible to change not only due to these domestic factors but also in response to global shocks that alter global risk appetite, independent of the domestic environment. Such a sudden stop shock is assumed to follow:

$$\theta_t = (1 - \rho_\theta)\theta + \rho_\theta \theta_{t-1} + \epsilon_{\theta,t}$$



(b) **Responses II**

Figure 1.5: **Global Shock**

Figure 1.5 (a)-(b) shows responses to a permanent shock to θ [3]. The responses highlight the economy which is already in a binding state. The impulse responses display the response

[2]The impulse responses are depicting the deviations in levels.

of various variables. The zero level is depicting the steady state of the variable and the responses show the deviation from the steady state in levels.

As θ falls, the banks can now access a smaller fraction of their bank value. This captures the sudden stop in foreign capital. Fewer funds are now available for loans, leading to a fall in loans issued and falling bank profits and bank value. Lower profit discourages new entrants and leads to an overall contraction in the banking industry.

Fewer competitors in the industry results in higher market power enjoyed by the incumbent banks. As the constraint tightens further due to smaller θ, the magnitude of the Lagrange multiplier increases. The policy rate thus goes up as the risk premium $(r - r^*)$ emerges due to the increase in perceived risk in the domestic currency. Investors demand a higher return to compensate for the increased risk. Increasing policy rate along with fewer banks results in the banks charging a higher markup on loans. The real economy thus witnesses a fall in consumption and investment.

1.6.2 Technology Shock

Non-Binding State

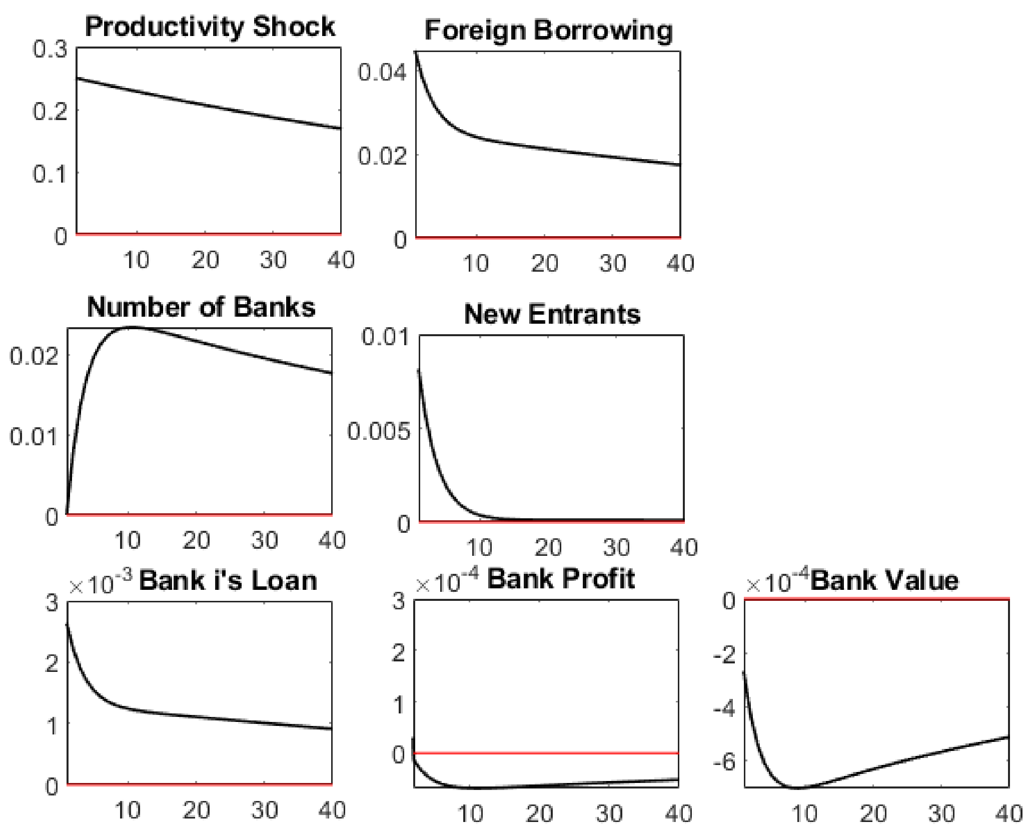
Figure 1.6 (a)-(c) presents the responses during a non-binding state, such that $Q_t d^*_{t+1} < \theta v_t$, the banks are unconstrained in their foreign borrowing. The economy experiences a temporary positive technology shock. The productivity shock is assumed to follow:

$$Z_t = (1 - \rho_z)Z + \rho_z Z_{t-1} + \epsilon_{z,t}$$

An increase in the technology makes the labor more productive. The economy reacts with an increase in output, which requires an increase in loans to pre-finance the wage bill.

Bank profit goes up on impact, triggering an increase of new banks entering the market. This results in an increase in operating banks, reducing the market share of the existing banks. A reduction in the market power and policy rate results in the declining loan rates charged by banks. Cheaper loans are accompanied with falling price of the home good and an appreciation in the real exchange rate.

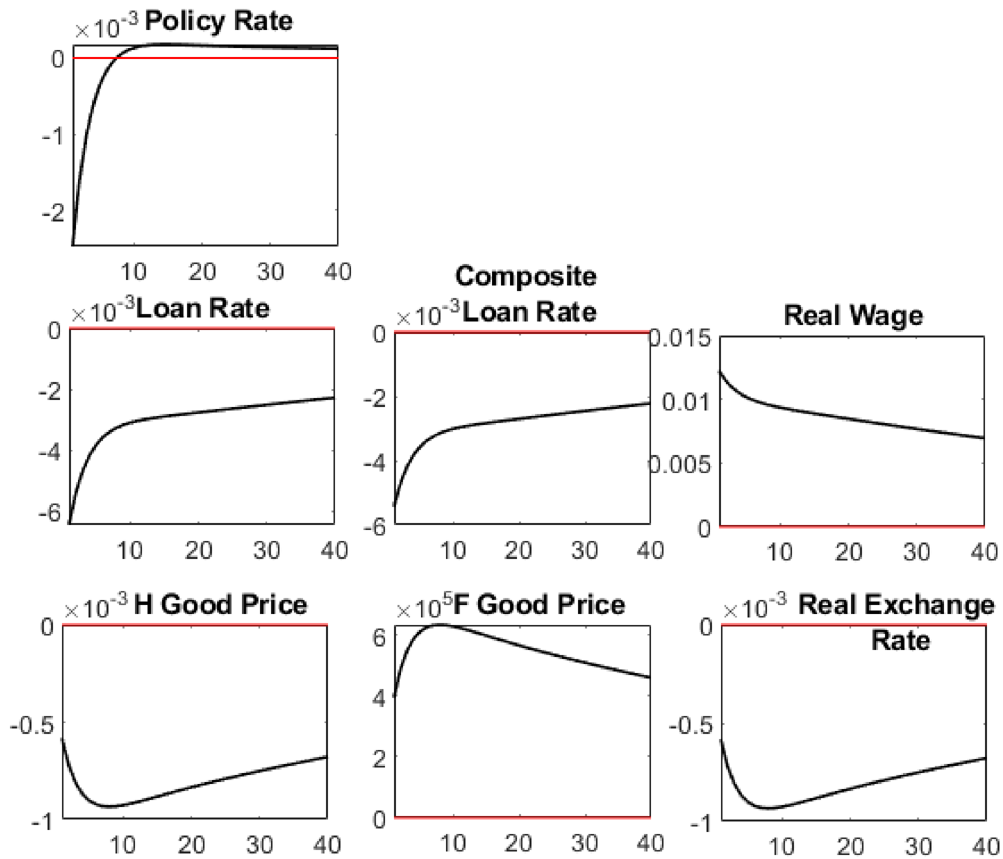
During the expansionary phase, banks increase their borrowing of foreign funds to capitalize on growth opportunities and meet the rising demand for credit from firms. The expansionary phase thus results in an increased investment in the new banks, and buildup of leverage by the banks.



(a) **Responses I**

Endogenous switch to the binding state

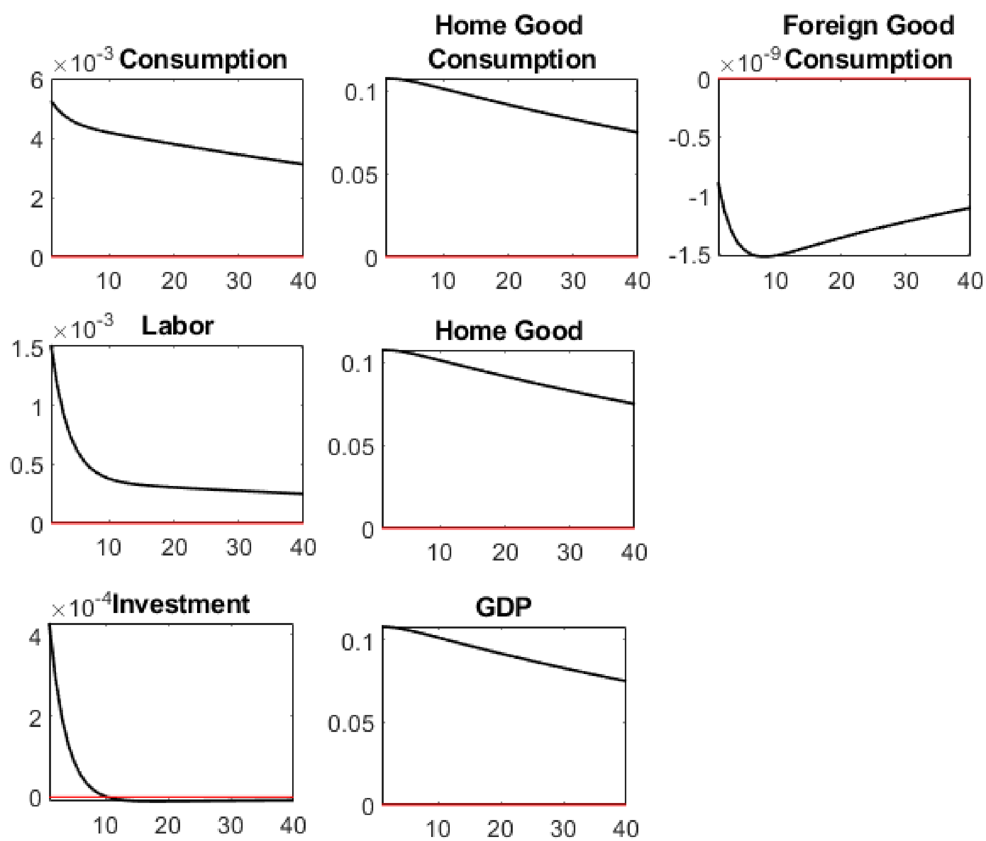
Figure 1.7 (a)-(b) presents the piecewise-linear responses associated with the binding state of the economy. The y-axis represents the actual values of the variables in levels. The technology, z undergoes a continuous increase from its steady state level of 3. As highlighted by the responses, the economy enters an expansionary phase and the banks buildup leverage by increasing their foreign borrowing.



(b) **Responses II**

The increased competition during expansion and lower markup depresses the bank value. When banks' values fall, they become more risky, leading to a tightening of the credit conditions. Buildup of foreign borrowing persists until the decline in bank value reaches a level where it triggers the tightening of the collateral constraint $\theta v - Qd^*$. It pushes the economy into the constrained region, such that ($\theta \times$ bank value) falls short of the desired foreign borrowing.

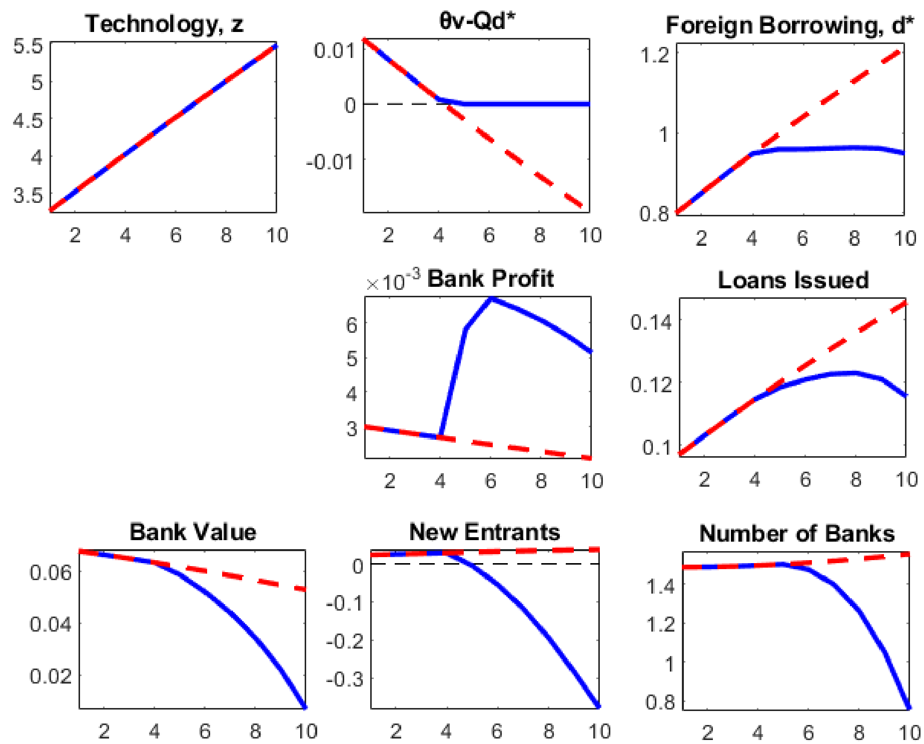
As the inequality $Q_t d^*_{t+1} \leq \theta_t v_t$ binds, the economy enters the constrained state and the foreign borrowing plummets. With lower bank values, fewer banks enter the market weakening the competitive pressure on the incumbents. The incumbents now issue fewer loans.



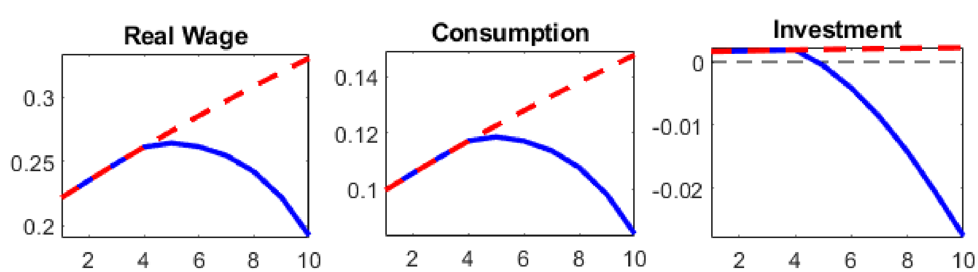
(c) **Responses III**

Figure 1.6: **Technology Shock**

The binding state thus contracts the size of the banking sector, which feeds into the production sector, thereby contracting production and consumption. The crises events are thus rare events embedded within the business cycle and endogenously switch states as a consequence of the occasionally binding collateral constraint.



(a) **Responses I**



(b) **Responses II**

Figure 1.7: **Technology Shock: Non-Linear Responses**

1.7 Conclusion

The paper sheds light on the intricate relationship between sudden stops in capital flows, bank competition, and financial disruptions in the real economy. Using a small open economy DSGE model incorporating the two layers of financial frictions – imperfect competition among the financial intermediaries and the occasionally binding collateral constraints–the study reveals that sudden stops reduce bank equity, tighten access to foreign funding, and trigger higher loan markups as competitive pressures decrease. These factors collectively amplify declines in consumption and investment, deepening the economic downturn beyond typical recessionary impacts.

The model's impulse response functions illustrate that sudden stops, by constraining bank equity and foreign financing, lead to fewer banks with larger market shares, resulting in higher loan markups. This rise in market concentration and loan costs limits credit availability and raises borrowing costs for firms and households. The amplification effect thus arises not only from the direct shock of reduced capital flows but also from the reduced competition within the banking sector, which deepens the decline in consumption and investment relative to a typical recession scenario. As banks retrench or consolidate, the reduced competitive pressure allows remaining banks to set higher markups, worsening the contraction in economic activity during these episodes.

This highlights the role of banking sector structure in amplifying external shocks, suggesting that market power in banking can either stabilize or destabilize economies depending on the flow of international capital. For policymakers, the findings emphasize that banking competition should not be overlooked in designing responses to capital flow volatility. By fostering healthy competition within the banking sector, policymakers can help reduce the economy's vulnerability to sudden stops, mitigating the adverse effects on financial intermediation and, in turn, on consumption, investment, and output. Through these insights, the study offers a basis for policy measures that promote financial stability in emerging markets frequently exposed to external capital shocks.

Chapter 2

BANK COMPETITION WITH HETEROGENEOUS BANKS

2.1 Introduction

In extending the framework from the previous chapter, this chapter considers the role of heterogeneity among banks in shaping macro-financial dynamics in a small open economy. While representative bank models provide useful insights into the average response of the financial sector to shocks, real world banking systems are composed of diverse institutions that differ in size, efficiency, market power, and exposure to financial frictions. These differences matter when a macroeconomic shock hits. Their individual characteristics determine how they absorb or transmit stress, and together, these uneven responses shape the aggregate outcome.

Traditional models often abstract from bank-level heterogeneity, assuming a representative bank structure that masks the dynamics introduced by differential productivity, balance sheet strength, or foreign market access. In contrast, recent literature emphasizes that macroeconomic outcomes can be shaped significantly by who is doing the lending. High productivity banks, with superior loan screening technologies or broader deposit networks, can better absorb funding shocks and even expand market share, whereas marginal banks may be forced to retrench or exit altogether. This selective survival process reshapes the banking landscape, altering aggregate credit supply and lending spreads.

To explore these dynamics, the chapter develops a small open economy DSGE model with heterogeneous banks that compete in loan markets, face collateral constraints that occasionally bind, and choose whether to enter or exit depending on profitability. The model draws on the firm entry literature of [Ghironi and Melits, 2005], adapting it to the banking context and incorporating financial frictions following [Khurana, 2024]. This approach allows for endogenous fluctuations in the number and composition of banks and highlights how macroeconomic shocks interact with the internal structure of the banking system.

From a policy standpoint, bank heterogeneity demands tailored interventions. Regulatory measures calibrated to average bank characteristics may inadequately address the vulnerabilities of smaller, under-capitalized institutions while failing to account for the systemic importance of large, highly leveraged banks. Entry barrier policies such as licensing requirements or minimum capital thresholds shape the productivity distribution of entrants and thus the resilience of the banking system to future shocks. Similarly, macroprudential tools like capital buffers must account for the fact that banks on the low end of the productivity spectrum will hit constraints sooner and exacerbate downturns.

By bringing heterogeneity and granularity into the analysis, this chapter offers a more detailed view of how financial systems adjust to macroeconomic shocks. This approach reveals not only changes in aggregate lending volumes but also shifts in the composition of credit providers, offering valuable insights for designing more effective regulatory policies.

2.2 Related Literature

The literature on bank heterogeneity spans several interconnected dimensions that collectively explain how differences across financial institutions amplify economic fluctuations, shape monetary policy transmission, and influence financial stability. This section examines key theoretical frameworks that have advanced our understanding of heterogeneous banking systems.

The foundational mechanism lays out how binding collateral or capital constraints generate non-linear responses. It emphasizes how balance-sheet heterogeneity amplifies shocks once borrowing constraints bind. [Gertler and Kiyotaki, 2010] introduced collateral based borrowing limits in a representative bank model, illustrating that net worth shocks produce non-linear effects on credit supply. [He and Krishnamurthy, 2012] builds on this by modeling intermediaries with heterogeneous net worth, showing that low net worth banks reduce lending disproportionately. Taken together, these papers highlight that once a constraint binds, small shocks can trigger large, persistent downturns. Thus, cross-sectional heterogeneity in balance sheets creates amplification of shocks.

A second strand of research builds on those frictions to show how bank market power adds a second layer of financial amplification and generates a broad accelerator. Banks set credit and deposit rates strategically, giving rise to endogenous, counter-cyclical markups and markdowns. [Freixas and Rochet, 2008] lay the foundations by modeling banks' endogenous markups under monopolistic competition. Heterogeneity in bank efficiency, cost structures, or risk profiles makes this amplification uneven across institutions. Larger or more efficient banks exploit tighter credit demand in downturns to raise loan spreads, further contracting credit. This strategic behavior is exactly the kind of cross-sectional variation this work seeks to embed in a general equilibrium framework.

Within this literature, the granular banking approach borrows from firm-level granularity to highlight the macroeconomic consequences of size heterogeneity in banks. Building on [Gabaix, 2011], [Bremus et al., 2018] show that the size distribution of banks is highly skewed and follows a power law. Because smaller banks cannot perfectly substitute for larger ones, idiosyncratic shocks to top-tier institutions can generate aggregate fluctuations in credit and output. Their model features incomplete markets and financial frictions, where borrowing relationships are sticky and tied to specific intermediaries, enabling micro-level shocks to propagate through macroeconomic channels. [Cuciniello and Signoretti, 2015] show that a few large banks with greater market power disproportionately influence lending conditions during downturns by charging higher markups.

[Corbae and D'Erasmo, 2015],[Mandelman, 2010] and [Mandelman, 2011] analyze foreign bank entry. Mandelman contributes to the bank heterogeneity literature by introducing a dynamic general equilibrium model with an endogenous number of heterogeneous banks operating under monopolistic competition . Banks differ in their cost efficiency, drawn from a uniform distribution, which shapes their strategic behavior and operating costs. The model features market segmentation, where each incumbent bank serves a niche and deters potential entrants through limit pricing, setting markups below profit-maximizing levels to obscure their relative efficiency. This strategic pricing, influenced by entry costs and market size, generates a distribution of markups and amplifies the cyclical effects of financial conditions. [Jamilov et al., 2025] offer a comprehensive general equilibrium model in which banks differ both ex-ante in terms of profitability, screening technologies, or management quality; and ex-post through idiosyncratic risk. Their framework generates realistic, right-skewed distributions of bank size and shows that ex-ante heterogeneity increases the marginal propensity to lend. Larger banks with higher net worth lend more aggressively, while countercyclical idiosyncratic risk tightens credit further in downturns, amplifying real and financial fluctuations.

Cross-border banking introduces another layer of heterogeneity. [Niepmann, 2015] adapt the Melitz trade model to banking, where only the most productive banks incur fixed costs to establish foreign affiliates. The decision to operate abroad depends on a bank's own productivity, as well as frictions such as entry costs and regulatory barriers. This endogenous sorting into cross-border activity means that aggregate outcomes depend critically on the productivity distribution of banks. [De Blas and Russ, 2013] addresses how FDI and cross-border lending by foreign institutions affect aggregate macroeconomic outcomes. In their framework, banks differ in managerial efficiency modeled using a Weibull distribution to determine each bank's ability to transform deposits into loans and to manage nonperforming loans. The most efficient bank, the one with the lowest cost can charge a markup above its marginal cost by exploiting its cost advantage over the next-best competitor. Because firms apply to multiple banks, only the most cost-efficient bank among the applicants wins the business, leading to endogenous market segmentation based on cost. More efficient banks have larger market shares, and the distribution of bank size is fat-tailed.

A complementary direction incorporates heterogeneity in risk-taking and regulatory constraints. [Coimbra and Rey, 2024] develop a general equilibrium model with endogenous entry and financial intermediaries that differ in their Value-at-Risk (VaR) constraints. More capitalized and less constrained banks take on greater leverage during booms, amplifying credit expansion, while contracting more sharply during downturns. The model shows that heterogeneity in risk-taking is central to explaining credit booms, systemic risk buildups, and fluctuations in risk premia. As riskier intermediaries gain market share, aggregate risk becomes concentrated in larger, more fragile balance sheets. This state-dependent amplification makes the distribution of leverage and net worth the key determinants of systemic risk.

Intersecting with these themes, another literature builds on the joint role of banks' heterogeneity and competition in producing cycles of boom and collapse, making the structure of the banking sector a critical determinant of financial stability. [Boissay et al., 2013] presents a dynamic model of endogenous financial fragility in which bank-level heterogeneity and risk-taking behavior during credit booms play a central role in banking crises. In their framework, banks are assumed to be heterogeneous with respect to their intermediation skills, which gives rise to an interbank market. Financial crises emerge from the procyclical behavior of bank balance sheets. During economic expansions, banks increase their use of funding and expand credit supply, which drives down the returns on both corporate and interbank loans. These declining returns intensify agency problems within the interbank market, ultimately undermining the willingness of banks to lend to each other and triggering a sharp contraction in market funding. [Bellifemine et al., 2022] deepens the literature on heterogeneous bank competition by incorporating both permanent and stochastic heterogeneity in bank returns into a general equilibrium model of banking. In their model, banks differ in their return profiles, which include permanent differences in profitability as well as stochastic fluctuations over time. The model shows that larger banks, which typically have greater market power and higher net worth, exhibit pro-cyclical credit markups and counter-cyclical deposit markups.

This literature moves beyond representative agent banking models, reinforcing the view that distributions of bank-level features such as size, efficiency, and profitability are critical for explaining both cross-sectional variation in bank behavior and aggregate policy outcomes. It motivates the approach in this chapter, which introduces heterogeneous banks into an open economy dynamic stochastic general equilibrium (DSGE) framework. The next section introduces the model framework and key features.

2.3 The Model

This chapter extends the framework of [Khurana, 2024] to incorporate heterogenous banks. The world economy comprises of a small open economy and the foreign economy/rest of the world. The domestic open economy is made up of a continuum of households, firms of unit mass and a discrete number of banks, N_t. Banks in this economy are heterogeneous in productivity, which reflects their ability to convert funding into loans and, by extension, determines their effective size. These banks operate in an oligopolistically competitive loan market, where they set rates for differentiated loan products.

Domestic agents can't borrow directly from abroad, instead they need to go through the financial intermediaries who can borrow funds from the international financial market. Households ultimately own the banks and firms. The model focuses on real variables, assuming all prices are fully flexible. While the law of one price holds, the setup allows for deviations from purchasing power parity (PPP).

2.3.1 Households Preferences

Households are infinitely lived and are populated on a continuum of unit mass. They seek to maximize expected intertemporal utility from consumption net of disutility from labor services, $E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t)$. The utility function is given by

$$u(c_t, h_t) = \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\phi}}{1+\phi} \right) \qquad \phi > 0, \quad \sigma > 0 \tag{1}$$

such that $\beta \in (0, 1)$ is the discount factor, $\frac{1}{\sigma}$ is the intertemporal elasticity of substitution and $\frac{1}{\phi}$ is the Frisch elasticity of labor supply. The consumption (c_t) is a composite good, comprised of home (c_t^H) and foreign(c_t^F) goods. It is an Armington aggregate of home and foreign produced goods.

$$c_t(c_t^H, c_t^F) = \left[\gamma^{\frac{1}{\eta}} (c_t^H)^{\frac{\eta-1}{\eta}} + (1-\gamma)^{\frac{1}{\eta}} (c_t^F)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{2}$$

η is the intertemporal elasticity of substitution between home and foreign goods. The preferences for both economies exhibit home bias that is, $\gamma = \gamma^* > \frac{1}{2}$, implying that the consumption baskets are not identical and thus, PPP does not hold.

Households make consumption, investment, labor and savings decisions. They can save the excess funds as risk-free one-period deposits in the domestic intermediaries. The deposits pay risk-free real return in units of the home consumption basket, r_t. Moreover, they can invest in the banks by buying the shares in the mutual fund of domestic intermediaries.

All prices are flexible and set in the consumers' currency. The home price index (cost of composite consumption basket) has been normalized to 1.

$$P_t = \left[\gamma(p_t^H)^{1-\eta} + (1-\gamma)(p_t^F)^{1-\eta}\right]^{\frac{1}{1-\eta}} = 1 \tag{3}$$

2.3.2 Firms

The real sector is operating in a perfectly competitive market and producing the home good, y_t in period t. The firms use labor in a linear production technology, $y_t = Z_t h_t$, where Z_t is the aggregate productivity of labor.

The firms have a working capital requirement where they need to pre-finance the wage bill. The firms must borrow these funds from the intermediaries. They obtain a within-period loan to pay for wages in advance incurring an additional cost of borrowing.

The firms borrow different loan products from all $N_{O,t}$ banks operating in period t and combine them in Dixit-Stiglitz fashion.

$$L_{t+1} = \left[\sum_{t=1}^{N_{O,t}} l_{i,t+1}^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{4}$$

$$R_{t+1}^L = \left[\Sigma_{i=1}^{N_{O,t}} (r_{i,t+1}^l)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{5}$$

where, L_{t+1} is the composite loan product aggregating the loan products and R_{t+1}^L is the composite loan rate. All firms pay back their loans at all times and there is no default risk.

Real profit of the firm is given by

$$\pi_t^{firm} = \rho_t^H Z_t h_t - w_t h_t + L_{t+1} - (1 + R_{t+1}^L) L_{t+1} \tag{6}$$

where $\rho_t^H = \frac{p_t^H}{P_t}$ is the real price of home good in units of home consumption basket and the amount of loan required is

$$L_{t+1} = w_t h_t \tag{7}$$

Firms take w_t, ρ_t^H, R_t^L as given and choose $h_t, l_{i,t}$. The optimization provides the first-order conditions for the firm.

$$\rho_t^H = (1 + R_{t+1}^L) \frac{w_t}{Z_t} \tag{8}$$

Given the perfectly competitive setup, the real price of home good is equal to the marginal cost of production, which comprises of the effective labor wage and the additional interest expense to pay them in advance. The demand for each bank i's loan product is given by

$$l_{i,t+1} = \left(\frac{r_{i,t+1}^l}{R_{t+1}^L} \right)^{-\epsilon} L_{t+1} \tag{9}$$

where ϵ is the elasticity between various loan products.

2.3.3 Banks as financial intermediaries

At the beginning of each period t, the economy contains a total of N_t banks. These banks differ in their ability to transform funding into loans, captured by a bank-specific productivity parameter ψ_i. This productivity level, ψ_i is drawn at entry from a common distribution $G(\psi)$, with support on $[\psi_{min}, \infty)$, and remains fixed for the lifetime of the bank.

Only a subset of these banks is actively operating in any period. The distinction between total banks, N_t and operating banks, $N_{O,t}$ arises endogeneously based on productivity and profitability conditions discussed later.

Each operating bank issues a loan product as well as a deposit product. Deposit market is perfectly competitive, all banks issue a homogenous deposit product and issue deposits at the market rate. This deposit market is further assumed to operate at the same rate as the policy rate r_t.

They compete over loans in oligopolistic fashion. In period t, each bank i provides a differentiated loan product ($l_{i,t+1}$) to the firms and thus, has some market power in rate setting. To finance their operations, each bank obtains funds from households by issuing deposit products ($d_{i,t+1}$) and borrows funds in foreign currency from the international financial market (valued at period t home consumption basket, $Q_t d^*_{i,t+1}$). $Q_t = \frac{\epsilon_t P^*_t}{P_t}$ is the real exchange rate and gives the units of home consumption basket that can be bought by 1 unit of foreign consumption basket, such that an increase in Q_t signifies a depreciation.

Thus, the balance sheet constraint for bank i is

$$l_{i,t+1} \leq \psi_i(d_{i,t+1} + Q_t d^*_{i,t+1}) \qquad \psi_i > 1 \tag{10}$$

Each bank converts total funding into loans according to its productivity level ψ_i which governs the loan production technology. A higher ψ implies greater efficiency in generating loans from available resources. In addition to the balance sheet constraint, the banks face a second financial friction in the form of a credit constraint. Since the domestic economy credit is perceived as potentially risky, they can't borrow an unconstrained amount of funds from abroad. The amount of foreign borrowing they can acquire is constrained by a fraction ($\theta > 0$) of their equity (v_t). This collateral constraint for the permissible foreign borrowing is given by

$$Q_t d^*_{i,t+1} \leq \theta x_{i,t} v_{i,t} \tag{11}$$

A fall in θ constraints the banks of the amount of foreign borrowing and tightens the collateral constraint.

Endogenous productivity distribution of the banking sector

Analogous to the firm entry model of [Ghironi and Melits, 2005], each bank faces an exit shock at the end of period t with probability δ. Additionally, each bank needs to pay a per period fixed operating cost of f^O effective labor units. Thus, a bank with productivity ψ_i

will operate if and only if $\pi(\psi_i) \geq 0$. This implies that all banks with productivity levels ψ less than the cut-off productivity level $\psi_t^c = inf\{\psi : \pi_t(\psi) > 0\}$ will shut down operations temporarily. This cut-off varies endogenously every period and thus the distribution of productivities operating in period t varies endogenously. The number of operating banks at time t is given by $N_{O,t} = [1 - G(\psi_t^c)]N_t$.

Each bank i takes r_t, r_t^*, R_t^L, Q_t as given and chooses the loan rate, $r_{i,t}^l$; the foreign borrowing, $d_{i,t}^*$ and domestic deposits, $d_{i,t}$ to maximize the present discounted sum of future profits.

$$\max_{\{r^l_{i,t+1}, d^*_{i,t+1}, d_{i,t+1}\}} E_t \sum_{s=t+1}^{\infty} \left(\frac{c_s}{c_t}\right)^{-\sigma} [\beta(1-\delta)]^{s-t}(1 - G(\psi_t^c))\pi_{i,s}$$

subject to,

$$l_{i,s+1} \leq \psi_i(d_{i,s+1} + Q_s d^*_{i,s+1}) \qquad \text{(Balance Sheet Constraint)}$$

$$Q_s d^*_{i,s+1} \leq \theta x_{i,s} v_{i,s} \qquad \text{(Collateral Constraint)}$$

$$\pi_{i,t}(\psi_i) = d_{i,t+1} + Q_t d^*_{i,t+1} - (1 + r_t)d_{i,t} - (1 + r_t^*)Q_t d^*_{i,t} + (1 + r^l_{i,t})l_{i,t} - l_{i,t+1} - \frac{f^O w_t}{Z} \tag{12}$$

Each period the bank receives the loan payments, pays the interest income on deposits and foreign borrowing, valued at current period's exchange rate and pays the per period operating costs.

The optimization provides the first-order conditions:

$$\lambda_t \psi_i = (1 - \delta)E_t \Lambda_{t,t+1}[1 - G(\psi_t^c)](1 + r_{t+1})(1 + \mu_t x_t \theta) \tag{13}$$

The marginal gain from issuing an additional deposit product equals the discounted cost of the deposit in the form of future interest payment and its impact on the bank value which influences the potential for future foreign borrowing. The marginal cost is higher, the tighter the collateral constraint is. Additionally, this marginal cost reduces with the bank's productivity (higher the ψ_i, lower the marginal cost) for a given μ.

The loan rate charged by each bank i is given by

$$r^l_{i,t+1} = \frac{\epsilon(\alpha_{i,t} - 1)}{\epsilon(\alpha_{i,t} - 1) + 1}\left(\frac{1 + r_{t+1}}{\psi_i} - 1\right) \tag{14}$$

Each bank charges a loan rate as a mark-up of the deposit rate. Holding all else constant, a bank with higher productivity, ψ_i faces a lower marginal cost of creating loans and can therefore afford to charge a lower loan rate. The markup component also depends on the bank's market share. Banks with higher ($\alpha_i \in (0,1)$) have more pricing power and set higher markups.

The arbitrage condition is captured by

$$\begin{aligned} E_t(1-\delta)[1-G(\psi_t^c)]\Lambda_{t,t+1}\left(\frac{Q_{t+1}}{Q_t}\right)(1+r^*_{t+1})(1+\mu_t\theta x_t) \\ = E_t(1-\delta)[1-G(\psi_t^c)]\Lambda_{t,t+1}(1+r_{t+1})(1+\mu_t\theta x_t) - \mu_t \end{aligned} \tag{15}$$

where μ_t is the Lagrangian multiplier associated with the collateral constraint and $\Lambda_{t,t+1} = \beta\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}$ is the stochastic discount factor. The world interest rate (r^*) is exogenous to the small open economy.

When the collateral constraint is non-binding ($\mu = 0$), it gives a standard UIP condition which delivers the same returns on domestic and foreign assets with optimal adjustment of the real exchange rate. However, when the collateral constraint binds ($\mu > 0$), there is a deviation from UIP as there is an interest rate spread between the domestic and world interest rate. When the constraint binds, it reflects the decreasing credit worthiness of the economy and appears as the risk premium that needs to be paid to compensate for the increased risk. The real exchange rate thus evolves in accordance with the existing interest differential and the risk premium.

2.4 Equilibrium: Bank Averages

To incorporate heterogeneous banks while maintaining tractability, the model aggregates over individual banks by considering industry averages, following the methodology of [Melitz, 2003]. The model is isomorphic to one where $N_{O,t}$ banks with the average productivity level $\tilde{\psi}_t$ operate in period t, charge an average loan rate of $\tilde{r}^l_{t+1}$ and earn an average profit of $\tilde{\pi}_t$. Following [Melitz, 2003], the average productivity level for the banking industry is defined by $\tilde{\psi}_t$ such that

$$\tilde{\psi}_t \equiv \left[\frac{1}{1 - G(\psi_t^c)} \int_{\psi_t^c}^{\infty} \psi^{\epsilon - 1} \right]^{\frac{1}{\epsilon - 1}} \tag{16}$$

$\tilde{\pi}_t = \pi_t(\tilde{\psi}_t)$, $\tilde{v}_t = v_t(\tilde{\psi}_t)$ $\tilde{r}^l_{t+1} = r^l_{t+1}(\tilde{\psi}_t)$ and $\tilde{Q}t = Q_t(\tilde{\psi}_t)$ are respectively the profit, bank value, loan rate and real exchange rate when the average productivity level of the banking industry is $\tilde{\psi}_t$.

Bank Entry

In every period, there is a positively discrete amount of potential entrants who are willing to enter the market, incentivized by the positive profits in the banking sector. New banks can enter in period t by incurring a sunk cost valued at the labor cost $f^E(w_t/Z_t)$. The fixed entry cost captures the initial investment required to setup a bank, which includes but is not limited to the advertising cost, hiring costs, managerial costs, infrastructure costs etc. Entrants at period t only start producing in period $t+1$.

Each prospective bank can correctly anticipate their future earnings and will enter the market if the entry is profitable. Thus, bank entry continues until the bank value, which is the present discount value of the anticipated future earnings of the bank; are equalized to the cost of entry.[1]

$$\tilde{v}_t = f^E \frac{w_t}{Z_t} \qquad \text{such that}$$

$$\tilde{v}_t = E_t \sum_{s=t+1}^{\infty} \left(\frac{c_s}{c_t} \right)^{-\sigma} [\beta(1-\delta)]^{s-t} [1 - G(\psi_t^c)] \tilde{\pi}_{i,s} \tag{17}$$

The exit shock occurs at the end of each period. Thus, δ fraction of banks in period t, $\delta(N_t + N_{E,t})$ will exit the market. The exiting banks transfer their deposits to the surviving entrants. Thus, the number of banks moving to period $t+1$ is

$$N_{t+1} = (1-\delta)(N_t + N_{E,t}) \tag{18}$$

[1]The entry condition should be an inequality as the number of banks are discrete. However, equality is considered for analytical tractability

Parametrization of productivity draws

The banks draw their productivity levels from a time-invariant Pareto distribution $G(\psi)$ with support on $[\psi_{min}, \infty)$ and shape parameter $k > \epsilon - 1$. The distribution takes the form:

$$G(\psi) = 1 - \left(\frac{\psi_{min}}{\psi}\right)^k \tag{19}$$

The parameter k captures the concentration of the banking sector. A higher k implies that the distribution is more heavily weighted toward smaller, less productive banks, consistent with a more skewed size distribution. Due to the properties of the Pareto distribution, the average productivity among operating banks can be expressed as a constant multiple of the cut-off productivity ψ^c, the minimum productivity required to operate profitably:

$$\tilde{\psi}_t = \nu \psi_t^c, \qquad \text{where } \nu = \left(\frac{k}{k - \epsilon + 1}\right)^{\frac{1}{\epsilon - 1}} \tag{20}$$

. This aggregation allows the heterogenous banking sector to be summarized by the dynamics of $\tilde{\psi}_t$ which evolves endogenously with the cut-off. The number of operating banks at time t are the banks with productivity level higher than the cut-off productivity,

$$N_{O,t} = [1 - G(\psi_t^c)]N_t = \left(\frac{\psi_{min}}{\psi}\right)^k N_t \tag{21}$$

2.4.1 Household Budget Constraint

The economy enters period t with N_t banks. $N_{E,t}$ new banks enter the market and will start their operations in period $t + 1$. Households finance these new banks by investing in the mutual fund of banks in period t which is made up of a portfolio of the existing banks N_t and the new banks $N_{E,t}$.

Households enter period t with x_t outstanding shares in the banks' mutual fund and d_t deposits in domestic intermediaries operating in period t, $N_{O,t}$. They have at their disposal the dividend income from the mutual funds, gross interest income from last period's deposit holdings, the value of liquidating the share holdings and the labor income. They use the proceeds to allocate the resources between consumption, deposits and shares.

In period t, they buy x_{t+1} shares in the mutual fund of $N_t + N_{E,t}$ banks valued at the price v_t in home currency. Post the exit shock, only $(1-\delta)(N_t + N_{E,t})$ banks will pay the profits and dividends at time t+1. v_t is the date t price of the mutual fund and reflects the value of banks' future stream of profits.

Deposit products issued by all banks are homogenous and the household buys an equal amount from each bank operating during period t. However, the households deposits are protected despite the bank shutdowns and exits. To pin down the domestic deposits, households pay an adjustment cost on deposits which is returned to them as transfers in the equilibrium.

$$c_t + d_{t+1}N_{O,t} + \tilde{v}_t x_{t+1}(N_t + N_{E,t}) + \frac{\kappa}{2}(d_{t+1} - \bar{d})^2(N_t + N_{E,t})$$
$$\leq (1+r_t)d_t N_{O,t} + w_t h_t + x_t N_t \tilde{v}_t + x_t N_{O,t}\tilde{\pi}_t + t_t \quad (\textbf{HH Budget Constraint})$$

where r_t is the consumption-based real interest rate on domestic deposit holdings between $t-1$ and t, known to households at period $t-1$. $w_t = \frac{W_t}{P_t}$ is the real wage and $\frac{\kappa}{2}(d_{t+1} - \bar{d})^2$ is the adjustment cost to be paid for the domestic deposits to ensure the unique steady state of deposits as $\bar{d}$. The households receive this fee as transfers, t_t in equilibrium.

Households take wages, domestic rate, price of shares, transfers as given and choose $c_t, h_t, d_{t+1},$ and x_{t+1}

$$\max_{\{c_t, h_t, x_{t+1}, d_{i,t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\phi}}{1+\phi} \right) \qquad \sigma > 0,\ \phi > 0$$

subject to,

$$c_t + d_{t+1}N_{O,t} + \tilde{v}_t x_{t+1}(N_t + N_{E,t}) + \frac{\kappa}{2}(d_{t+1} - \bar{d})^2 N_t \leq (1+r_t)d_t N_{O,t} + w_t h_t + x_t N_t \tilde{v}_t + N_{O,t}\tilde{\pi}_t + t_t$$

The optimization provides the first-order conditions. The consumption-labor trade-off is given by

$$\frac{c_t^{-\sigma}}{\chi h_t^{\phi}} = \frac{1}{w_t} \tag{22}$$

The Euler equations for share holdings and deposit holdings are

$$\tilde{v}_t = (1-\delta)\beta E_t \left[\left(\frac{c_{t+1}}{c_t} \right)^{-\sigma} \left(\tilde{v}_{t+1} + [1 - G(\psi_{t+1}^c)]\tilde{\pi}_{t+1} \right) \right] \tag{23}$$

$$\beta E_t\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}(1+r_{t+1})\right] = 1+\kappa(d_{t+1}-\bar{d}) \tag{24}$$

The forward iteration of the share holdings equation gives the share price solution

$$\tilde{v}_t = E_t\sum_{s=t+1}^{\infty}\left(\frac{c_s}{c_t}\right)^{-\sigma}[\beta(1-\delta)]^{s-t}[1-G(\psi_t^c)]\tilde{\pi}_{i,s}$$

2.4.2 Central Bank

The model setup assumes that the Central Bank is able to set the policy rate to manage deviations in output and real exchange rate. It is further assumed that the policy rate is set to exactly match the rate operational in the deposit market by banks.

$$1+r_{t+1} = \left(1+r^*_{t+1}+f(\mu_t)\right)\left(1+\frac{y_t-y}{y}\right)^{e_y}\left(1+\frac{Q_t-Q}{Q}\right)^{e_q} \tag{25}$$

The policy rule includes the term $f(\mu_t)$ which captures the impact of the constraint in the financial sector. The central bank thus reacts to the credit conditions in the economy, as well as to output and the real exchange rate. $f(\mu_t)$ captures the risk premium on the domestic currency. It is an increasing function of μ. The tighter the collateral constraint binds, the larger the magnitude of μ.

2.4.3 Market Clearing Conditions

Aggregate labor supply must equal the labor employed by firms for producing the home good, labor hired for the day-to-day operations of the banks and the labor hired by new banks to setup the banking infrastructure.

$$h_t = \frac{y_t}{Z_t} + N_{E,t}\frac{f^E}{Z_t} + N_{O,t}\frac{f^O}{Z_t} \tag{26}$$

In the loan market, total loans issued by the banking sector must equal the demand for these loans by the firms for advance wage payments.

$$\tilde{L}_{t+1} = N_{O,t}^{\frac{\epsilon}{\epsilon-1}}\tilde{l}_{t+1} = w_t h_t \tag{27}$$

Home good is being used for domestic consumption, government spending and exported to the foreign economy.

$$y = c_t^H + c_t^{H*} + G \tag{28}$$

Model Summary

The model is being solved for the bank averages and thus, the market share of each bank is equal and depends on total number of banks operating in the economy at time t, $N_{O,t}$.

The equilibrium conditions provide a system of 26 equations and 26 endogenous variables: $c_t, c_t^H, c_t^F, h_t, d_{i,t+1}, w_t, \tilde{v}_t, \psi_t^c, \tilde{\psi}_t, N_t, N_{O,t}, N_{E,t}, y_t, \tilde{L}_{t+1}, \tilde{l}_{i,t+1}, \rho_t^H, \rho_t^F, r_{t+1}, \tilde{R}_{t+1}^L, \tilde{r}_{i,t+1}^l,$ $d_{i,t+1}^*, \alpha_{i,t}, Q_t, \tilde{\pi}_{i,t}, \mu_t, f(\mu_t)$

$$\frac{c_t^{-\sigma}}{\chi h_t^{\phi}} = \frac{1}{w_t} \tag{M1}$$

$$\tilde{v}_{i,t} = (1-\delta)\beta E_t\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}(\tilde{v}_{i,t+1} + \left(\frac{\psi_{min}}{\psi_{t+1}^c}\right)^k \tilde{\pi}_{i,t+1})\right] \tag{M2}$$

$$\beta E_t\left[\left(\frac{c_{t+1}}{c_t}\right)^{-\sigma}(1+r_{t+1})\right] = 1 + \kappa(d_{i,t+1} - \bar{d}) \tag{M3}$$

$$c_t + d_{i,t+1}N_{O,t} + \tilde{v}_{i,t}N_{E,t} = (1+r_t)d_{i,t}N_{O,t} + w_t h_t + N_{O,t}\tilde{\pi}_{i,t} \tag{M4}$$

$$\tilde{l}_{i,t+1} = \left(\frac{\tilde{r}_{i,t+1}^l}{\tilde{R}_{t+1}^L}\right)^{-\epsilon} w_t \frac{y_t}{Z_t} \tag{M5}$$

$$\tilde{L}_{t+1} = \left[\sum_{i=1}^{N_{O,t}} \tilde{l}_{i,t+1}^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{M6}$$

$$\tilde{R}_{t+1}^L = \left[\Sigma_{i=1}^{N_{O,t}}(\tilde{r}_{i,t+1}^l)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{M7}$$

$$\tilde{r}_{i,t+1}^l = \frac{\epsilon(\alpha_{i,t}-1)}{\epsilon(\alpha_{i,t}-1)+1}\left(\frac{1+r_{t+1}}{\tilde{\psi}} - 1\right) \tag{M8}$$

$$(1-\delta)\left(\frac{\psi_{min}}{\psi_t^c}\right)^k E_t\Lambda_{t,t+1}(r_{t+1} - r^*)(1+\mu_{i,t}\theta) = \mu_t \tag{M9}$$

$$\tilde{\rho}_t^H = (1+\tilde{R}_{t+1}^L)\frac{w_t}{Z_t} \tag{M10}$$

$$\tilde{\pi}_{i,t} = d_{i,t+1} + Q_t d^*_{i,t+1} - (1+r_t)d_{i,t} - (1+r^*)Q_t d^*_{i,t} + (1+r^l_{i,t})l_{i,t} - l_{i,t+1} - \frac{f^O w_t}{Z_t} \tag{M11}$$

$$\alpha_{i,t} = \frac{1}{N_{O,t}} \tag{M12}$$

$$\tilde{v}_{i,t} = f^E \frac{w_t}{Z_t} \tag{M13}$$

$$c^H_t = \gamma\left(\tilde{\rho}^H_t\right)^{-\eta} c_t \tag{M14}$$

$$c^F_t = (1-\gamma)\left(\rho^F_t\right)^{-\eta} c_t \tag{M15}$$

$$\tilde{Q}_t = \frac{\tilde{\rho}^H_t}{\rho^{H*}_t} \tag{M16}$$

$$1 = \left[\gamma(\tilde{\rho}^H_t)^{1-\eta} + (1-\gamma)(\rho^F_t)^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{M17}$$

$$N_t = (1-\delta)(N_{t-1} + N_{E,t-1}) \tag{M18}$$

$$N_{O,t} = \left(\frac{\psi_{min}}{\psi^c_t}\right)^k N_t \tag{M19}$$

$$1 + r_{t+1} = \left(1 + r^* + f(\mu_{i,t})\right)\left(1 + \frac{y_t - y}{y}\right)^{e_y}\left(1 + \frac{Q_t - Q}{Q}\right)^{e_q} \tag{M20}$$

$$h_t = \frac{y_t}{Z_t} + N_{E,t}\frac{f^E}{Z_t} + N_{O,t}\frac{f^O}{Z_t} \tag{M21}$$

$$y_t = c^H_t + c^{H*}_t + G \tag{M22}$$

$$l_{i,t+1} = \tilde{\psi}_t(d_{t+1} + Q_t d^*_{t+1}) \tag{M23}$$

$$\tilde{\psi}_t = \nu\psi^c_t \tag{M24}$$

$$\pi(\psi^c_t) = 0 \tag{M25}$$

$$\pi^c{}_t = d_{t+1} + Q_t d^*_{t+1} + \left[1 + \frac{\epsilon(N_{O,t-1} - 1)}{\epsilon(N_{O,t-1} - 1) - N_{O,t-1}}\left(\frac{1 + r_{t-1,t}}{\psi^c_{t-1}} - 1\right)\right] l_t - \psi^c_t(d_{t+1} + Q_t d^*_{t+1})$$
$$- (1+r_t)d_t - (1+r^*)Q_t d^*_t - \frac{f^O w_t}{Z_t}$$

$$\mu = 0 \qquad \text{(M26a: non-binding)}$$

$$Q_t d^*_{t+1} = \theta v_t \qquad \text{(M26b: binding)}$$

2.4.4 Steady State

In steady state, the average loan rate is given by

$$\tilde{r}^l = \frac{\epsilon(N_O - 1)}{\epsilon(N_O - 1) - N_O}\left(\frac{1 + r - \nu\psi^c}{\nu\psi^c}\right) \tag{29}$$

where N_O is the number of operating banks, ϵ is the elasticity of substitution across loan products, and $\nu\psi^c$ represents average productivity in the banking sector. For $\tilde{r}^l$ to be positive, it must be that , $\epsilon(N_O - 1) - N_O < 0 \iff N_O < \frac{\epsilon}{\epsilon - 1}$ since $\epsilon(N_O - 1) > 0$ and $\nu\psi^c > 1 + r$ This inequality defines a threshold for the number of operating banks below which market power remains strong enough to sustain positive loan markups.

The relationship between loan rate and productivity level can be obtained as:

$$\frac{dr^l}{d\psi} = \frac{\epsilon(N_O - 1)}{\epsilon(N_O - 1) - N_O}\left[\frac{-(1 + r)}{\psi^2}\right] > 0 \tag{30}$$

Because the first factor is negative ($N_O < \frac{\epsilon}{\epsilon - 1}$) and the second is also negative, the overall derivative is positive. In other words, more efficient (and hence typically larger) banks set higher loan rates. This result reflects that when the number of operating banks remains below the competitive threshold $\frac{\epsilon}{\epsilon - 1}$, each surviving bank enjoys sufficient market power to extract a markup. Higher efficiency lowers a bank's marginal cost but, by also augmenting its scale and pricing power, enables it to charge an even larger spread over cost.

The cost advantage from higher productivity tends to push loan rates down. However, market power from a more concentrated industry structure (and from being a larger bank) tends to push rates up. In this model, when market concentration is high (few operating banks), the markup effect outweighs the marginal cost effect, leading to a positive relationship between productivity and loan rates in equilibrium.

2.5 Impulse Responses

To analyze the dynamic interaction between banking sector structure and macroeconomic shocks, I simulate impulse responses to two distinct permanent structural changes: a cut in bank entry costs and an increase in government spending. The first shock triggers intense selection among entrants, leading to higher average bank productivity, a leaner yet more efficient banking sector. The second shock raises loan demand and profitability, easing the threshold for bank operation and spurring entry by marginal banks. In both cases, the nature and magnitude of adjustment depend critically on the shape of the bank productivity distribution.

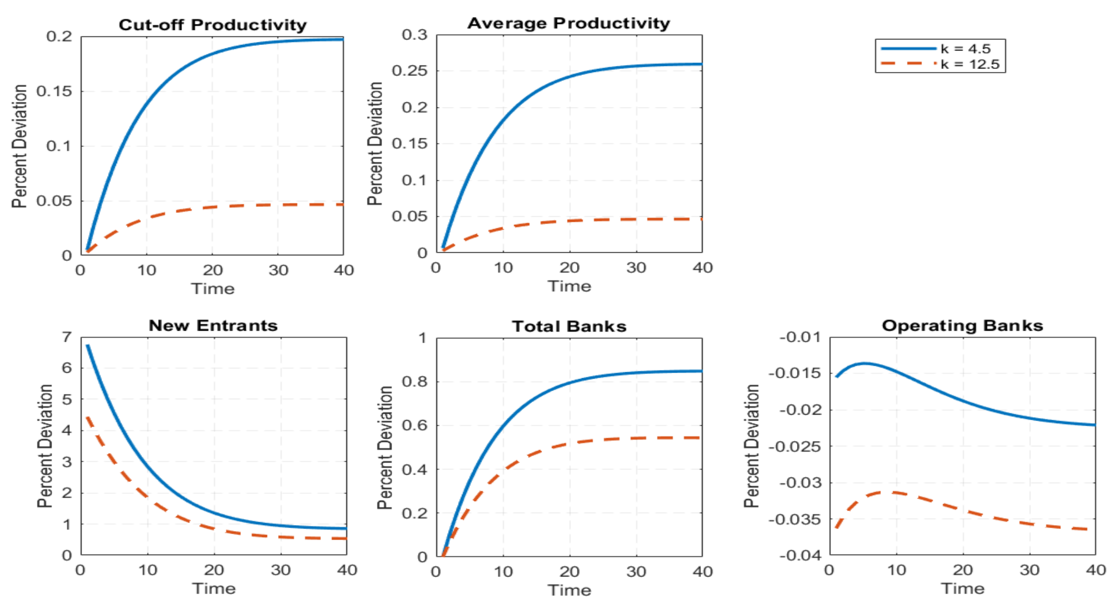
Calibration

The parameters have been calibrated to reflect a small open economy which takes foreign preferences and shocks as fixed and cannot influence the foreign economy. The households have been assumed to have log preferences over consumption with unit elasticity of labor supply, $\phi = 1$ and $\sigma = 1$ with scaling parameter $\chi = 5$ and the adjustment cost(κ) as 1. β is set such that the domestic rate is 4%. The real price of home good in the foreign market, valued at home consumption basket, $\rho^{H*} = \frac{p^*_H}{P}$ has been set to 1, with exogenously given exports, $c^{H*} = 0.1$. The elasticity between home and foreign goods is set to 1.2 and home bias γ=0.55. The elasticity between various loan products are set to 4, the sunk cost f^E to 1, operating cost to 0.1. The monetary policy parameters are $e_y = 0.1$ and $e_Q = 0.3$

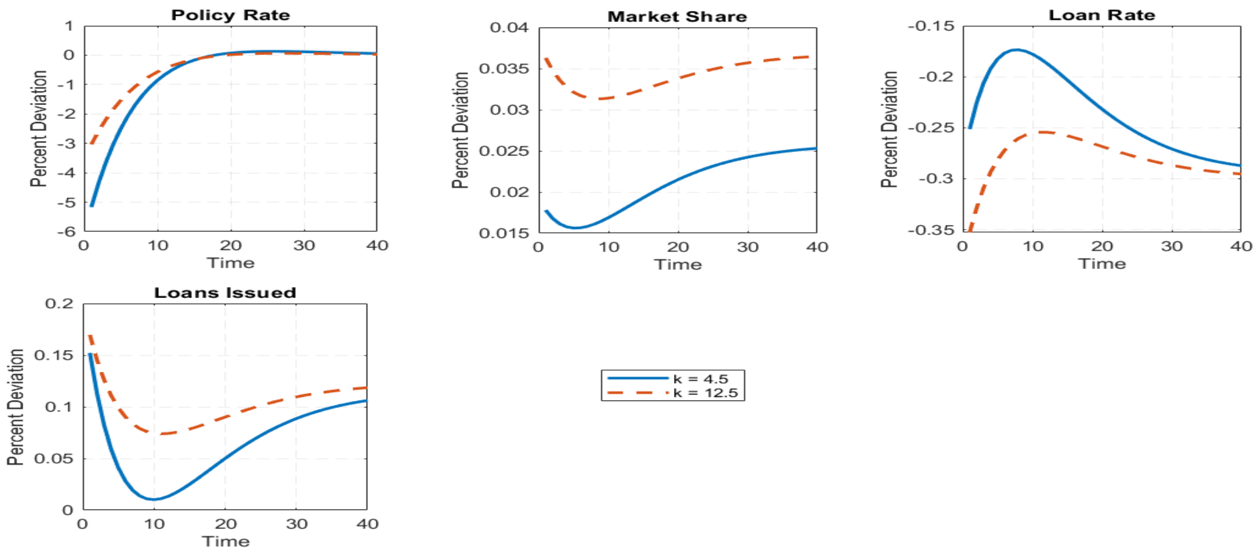
2.5.1 Entry Cost Shock

Figure 2.1 shows the responses to a 1% permanent decrease in entry cost. As barriers to entry fall, new banks enter the market, expanding the total number of banks. Households reallocate resources from home good consumption toward investment to fund these entrants, which temporarily reduces domestic demand and output. In response, the monetary authority lowers the policy rate to stabilize the economy. The influx of new entrants intensifies competition, driving up the productivity threshold (ψ^c) required for banks to break even. Only the more efficient banks remain viable, which raises the average productivity of operating banks. The operating banks doesn't change substantially and in-fact falls a little with improved productivity of the operating banks as new entrants crowd out the marginal incumbents. However, loan issuance rises, driven by improved bank productivity and greater credit supply. A fall in policy rate drives down the loan rates. Loan rates decline, even though surviving banks have stronger pricing power because of improved intermediation efficiency and reduced cost of borrowing. Entry remains dynamic, with churn among banks reshaping the operating pool without significantly altering its size but markedly improving its productivity.

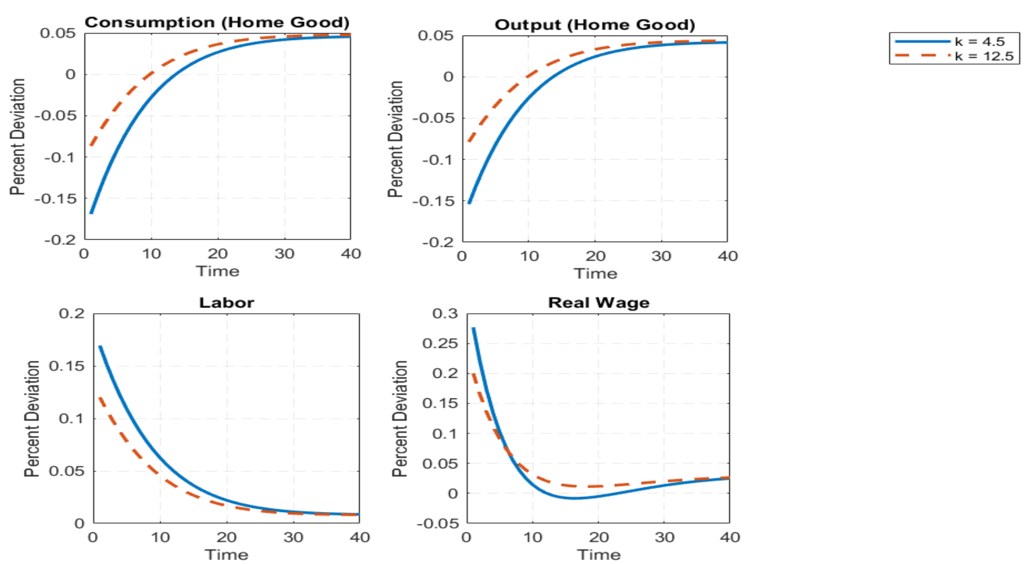
Comparing Pareto tail parameters $k = 4.5$ (fat tail) Vs $k = 12.5$ (thin tail) reveals similar qualitative patterns but quantitatively different magnitudes. With $k = 4.5$, entrants are disproportionately drawn from the high-productivity tail, so average productivity rises more sharply. However, since these large survivors wield greater market power, the drop in loan rates is smaller than under $k = 12.5$. Under the thinner tail, productivity gains are more muted but competition is relatively stronger, yielding a larger reduction in loan rates.



(a) **Responses I**



(b) **Responses II**



(c) **Responses III**

Figure 2.1: Cut in Bank Entry Cost

As the cut-off productivity goes up, the less productive banks tend to exit the market. Because entry is free, the number of operating banks simply falls until entry and exit again balance at the new cut-off. The fraction of banks exiting is $(1 - G(\psi^c))N = 1 - \left(\frac{\psi_{min}}{\psi^c}\right)^k$. How many banks exit for a given cut-off shift depends on the density of banks near the cut-off, ψ^c. Larger k (thin tail) means the CDF, $G(\psi)$ rises more quickly near ψ^c. Even though the rise in the cut-off is smaller under a high k distribution (because fewer high productivity banks means profits decline rapidly), the number of banks near the old cut-off is much larger. Most banks cluster just above ψ^c. Hence a small shift in cut-off sweeps away a big share of banks. By contrast, with low k (fat tail) the distribution is flatter, fewer banks sit just above the cut-off, so even a larger cut-off shift eliminates a smaller share. Thus, a thin tail economy sees a larger drop in the count of operating banks after a cost shock.

Thus, cutting entry costs tightens selection, boosts average efficiency, expands credit, and lowers loan rates. However, the quantitative trade-off between productivity gains and market power effects depends on the tail thickness of the bank size distribution.

2.5.2 Government spending shock

Figure 2.2 illustrates the effects of a 1% permanent increase in government spending. The fiscal expansion raises aggregate demand, leading firms to increase borrowing for working capital. This surge in loan demand expands bank operations and boosts profitability. As profits rise, the productivity threshold required to break even declines, enabling a wider range of banks to operate. Incumbent banks above the previous threshold remain profitable, while many previously marginal banks, just below the cut-off enter operation. Anticipation of sustained future profits encourages new bank entry, making it worthwhile to incur the sunk entry cost.

The extent of this response depends on the distribution of bank productivity. In a fat-tailed economy ($k = 4.5$), entrants are drawn from the high productivity tail, raising average productivity more significantly. However, operating bank numbers increase only modestly, as fewer banks sit near the old cut-off. In contrast, in a thin-tailed economy ($k = 12.5$), many banks cluster just above ψ^c, so even a modest drop in the threshold activates a large mass of banks. Operating banks rise sharply, and entry is more front-loaded, as many marginal types quickly find it worthwhile to enter.

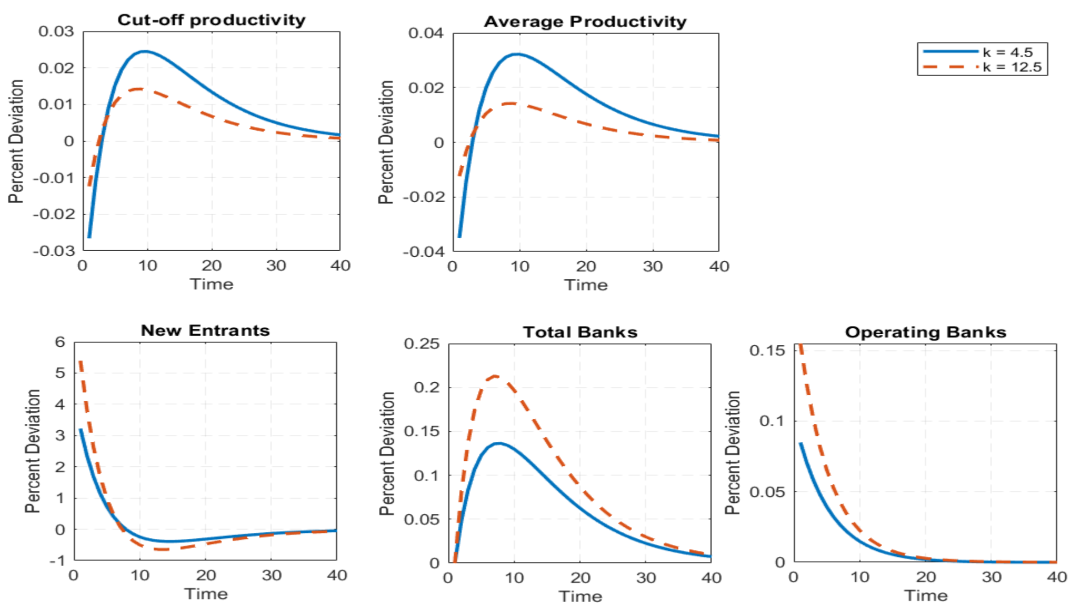


Figure 2.2: **Expansionary Government Spending**

Over time, as competition intensifies and fiscal response wane, profits normalize, and threshold productivity drifts back up toward its steady-state level. As profits are competed away, entry value falls faster in the thin-tailed world, so the $k = 4.5$ entry response eventually overtakes $k = 12.5$. The fat-tailed economy has more deep pocket banks that see value even after the initial boom fades.

In response to a permanent increase in government spending, stronger loan demand raises bank profits, lowering the cut-off productivity threshold and encouraging greater bank entry. However, over time, market entry intensifies competition, policy tightens and demand normalizes, driving both the number of banks and the cut-off productivity back to their steady-state levels.

2.6 Conclusion

This chapter has developed a small open-economy DSGE model in which heterogeneous banks differing in productivity, market power, and balance sheet strength. By embedding endogenous entry and exit alongside financial frictions, the results show how the interaction of entry costs and productivity heterogeneity endogenously shapes the number, size, and pricing behavior of surviving banks.

The model highlights that reductions in entry costs lead not only to a greater number of bank entrants, but also to intensified selection pressures as only the most productive banks survive. This competitive sorting mechanism raises the average productivity of the operating banking sector, reduces loan markups, and amplifies credit supply even as the number of operating banks may remain stable or decline. Conversely, positive demand shocks such as government spending expansions initially ease the break even conditions for banks, lowering the cut-off productivity threshold and inducing a surge in both operating banks and entrants. However, this expansion is tempered over time as increased competition erodes profits, leading to an endogenous normalization in entry behavior and market structure.

Finally, the model reveals that the degree of productivity heterogeneity governed by the tail thickness of the Pareto distribution plays a central role in shaping both the intensive and extensive margin responses of the banking sector. Thin tailed economies experience sharper changes in the number of operating banks for a given shift in cut-off productivity, while fat tailed economies exhibit larger average productivity gains and more persistent market power effects.

Overall, the chapter contributes to the literature by demonstrating how financial intermediation, macroeconomic policy, and aggregate dynamics evolve in an environment with endogenous banking structure. The framework can be extended in future work to explore regulatory design, capital flow volatility, and welfare implications of banking market concentration in open economies.

Chapter 3

REGIME SHIFTS IN SECTORAL CAPITAL FLOWS

3.1 Introduction

Financial globalization enabled a rapid increase in cross-border lending and borrowing, giving rise to complex external balance sheets across both advanced and emerging economies. However, this openness has also introduced vulnerabilities, as financial crises often follow sharp reversals in capital flows. While gross capital flows surged with financial globalization, their procyclical and often volatile nature has made them central to several episodes of financial distress, most notably in emerging and developing economies. Within this landscape, the sectoral distribution of external liabilities across sectors can influence the macroeconomic impact and persistence of external shocks. Yet, most existing research has focused on aggregate capital flows, leaving the sectoral and regime-dependent nature of external debt dynamics underexplored. Recent episodes (e.g. taper tantrum, COVID-19 shock) have shown that debt inflows into banks, corporates, and sovereigns can switch abruptly between calm and turbulent regimes.

A growing body of evidence shows that capital inflows into emerging markets oscillate between tranquil and turbulent phases, with sudden stop episodes often precipitating sharp contractions in credit and output. Notably, the 2013 taper tantrum and the COVID-19 shock demonstrated how quickly debt inflows to banks, corporates, and sovereigns can enter a high volatility regime, amplifying local financial stress. Yet most early warning frameworks blend all debt flows into a single aggregate series, obscuring sector-specific dynamics that may signal an impending regime shift. By modeling sectoral debt flows at the country level through a Markov-switching lens, this chapter aims to uncover which (country, sector) pairs exhibit the most pronounced volatility jumps, which sectors lead or lag in transitioning to crisis regimes, and how persistence in each state varies across geographies.

Different sectors face distinct financial constraints and respond asymmetrically to global shocks. For instance, banks are typically exposed to rollover risks and foreign exchange mismatches due to their reliance on short-term funding, while corporates rely more on bond and syndicated loan markets that are sensitive to global risk appetite and interest rate differentials. The public sector, although often viewed as more stable, can become a source of fragility when fiscal space is limited or when sovereign spreads widen during crises. The sectoral structure of external debt, therefore, is a key determinant of how capital flow reversals affect economic performance. Financial crises rarely originate from a uniform shock across all sectors. History shows us that imbalances often start in one sector and spill over to others through financial and macroeconomic linkages. The Asian Financial Crisis (1997) began with overleveraged corporates and bank mismanagement, leading to currency depreciation and sovereign debt problems. The Global Financial Crisis (2008) originated in the banking sector through mortgage-backed securities but quickly transmitted to corporate investment and public balance sheets.

Sectoral dynamics matter because different sectors face unique constraints, borrowing instruments, and market access. Banks are typically reliant on short-term wholesale funding, often categorized as other investment flows in balance of payments statistics. These are prone to quick reversals during global risk-off episodes. Corporates, especially multinationals and large firms, access international bond markets and loans, primarily under portfolio debt flows. Their vulnerability depends on currency mismatches, hedging behavior, and rollover risk. Public sectors may rely on both portfolio debt (sovereign bonds) and official lending, but their vulnerabilities increase with fiscal deficits, weak institutions, or loss of market confidence. Therefore, capital flow reversals are not symmetric across sectors, nor are their macroeconomic implications. Ignoring sectoral composition risks overlooking key vulnerabilities and policy levers. Despite its importance, empirical work focusing on sector-level international liabilities remains limited. This paper argues that a sectoral analysis of external debt flows is essential to understand the transmission, amplification, and recovery dynamics during capital flow shocks.

Financial markets are inherently nonlinear, often transitioning between tranquil, vulnerable, and crisis regimes. Linear models fall short in capturing these dynamics, especially in the context of capital flows, where abrupt transitions such as sudden stops, surges, or retrenchments are common ([Forbes and Warnock, 2012]). Markov Switching Models (MSMs), first introduced by [Hamilton, 1989], provide a flexible framework to model these unobserved state transitions, allowing for differences in the behavior and persistence of capital flows across regimes.

Recent applications of MSMs in macro-finance have demonstrated their usefulness in identifying crisis periods, measuring regime persistence, and forecasting transitions. However, few studies apply these models to capital flow data disaggregated by sector, and even fewer examine differences in transition probabilities across advanced and emerging markets.

This paper fills these gaps by applying a three-state Markov Switching framework to analyze the dynamics of portfolio and other investment debt flows across banking, corporate, and public sectors, distinguishing between advanced and emerging economies. By estimating regime transition probabilities and persistence for each sector and flow type, the study highlights systematic differences in how sectors enter and exit crisis or recovery phases. The findings contribute to the literature in three key ways. First, sector-level insights into the dynamics of external debt regimes are provided, assessing which sectors are more prone to prolonged distress or faster recovery. Second, substantial heterogeneity between advanced and emerging economies is documented, reflecting different structural and policy environments. Third, by focusing on regime persistence and transitions, the research offers a forward-looking lens for macroprudential and capital flow management policies.

3.2 Related Literature

Early research on capital flows has largely been shaped by the push-pull framework, emphasizing how both external global conditions (push) and domestic fundamentals (pull) jointly drive international financial movements. Foundational studies ([Kaminsky and Reinhart, 1999] and [Reinhart and Reinhart, 2009]) emphasized the cyclical nature of capital flow bonanzas and their link to financial crises, showing that banking and currency crises often co-occur, preceded by episodes of credit booms, large-scale capital inflows, and financial liberalization. In seminal work, [Calvo et al., 1996], [Calvo et al., 1993] showed that periods of low U.S. interest rates and abundant global liquidity fueled large inflows into Latin American economies, while episodes of rising global risk aversion often triggered sudden stops and financial crises. Building on this, [Rey, 2015] introduced the notion of a global financial cycle emphasizing that cross-border capital flows, credit growth, and asset prices around the world are heavily synchronized through global liquidity conditions and U.S. monetary policy. Much of this early work employed panel regression methods to assess the relative roles of push and pull factors in shaping capital flows, as seen in contributions by [Fratzscher, 2012], [Bruno and Shin, 2015], survey by [Koepke, 2019].

Initially, research primarily focused on net capital flows, analyzing the difference between inflows and outflows. As episodes of sudden surges and stops became more prevalent, researchers recognized the importance of distinguishing between gross inflows (non-resident purchases of domestic assets) and gross outflows (resident purchases of foreign assets). Gross flows capture distinct motivations, foreign investors' appetite for domestic risk versus domestic investors' search for higher returns abroad. [Forbes and Warnock, 2012] were among the first to show that even when net flows remain stable, gross capital flows have become increasingly volatile, leading to surges, stops, retrenchments, and flight episodes often tied to shifts in global risk appetite. These findings opened the door to a richer analysis of gross flows as indicators of macro-financial risk. Subsequent studies, such as [Broner et al., 2013], [Calderón and Kubota, 2013], [Davis and Van Wincoop, 2018], deepened this understanding by showing that sensitivities to global factors can vary significantly between gross inflows and outflows.

Building on the gross flows framework, researchers increasingly recognized that it was not only important to distinguish between residents and non-residents but also to disaggregate capital flows by instrument type. Capital inflows could take the form of portfolio equity, portfolio debt, foreign direct investment (FDI), or bank loans, each of which behaves differently in response to changes in global and domestic financial conditions. [Cerutti et al., 2019] advanced this line of research by decomposing gross capital inflows into global and country-specific components, showing that bank-related, portfolio bond, and equity inflows exhibit strong synchronization with global factors, whereas FDI and non-bank flows are relatively insulated.

A complementary line of research emphasizes the heterogeneity of capital flows not only by asset class but also by borrowing sector. Sectoral differentiation matters because financial crises rarely hit all sectors simultaneously. Often, distress originates in one sector and spills over to others. Banks, for instance, are highly vulnerable to rollover risk and sudden stops in funding markets; corporates are sensitive to global risk appetite and access to international bond markets; and sovereigns, while relatively stable, can trigger broader financial instability when faced with fiscal deterioration. Thus, understanding the sectoral composition of external liabilities has become critical for assessing systemic vulnerabilities. [Avdjiev et al., 2022] demonstrate that empirical regularities observed at the aggregate level do not necessarily hold across sectors. Similarly, [Cerutti and Hong, 2021] provide important evidence on how different sectors adjust their financing structures across financial cycles. They find substitution between loans and bonds for advanced economy corporates and sovereigns after 2008, while emerging-market corporates continued to display complementary inflow patterns, likely constrained by borrowing limits. Further advancing the sectoral focus, [Lepers and Mercado, 2021] analyze sectoral flows, finding that banking flows display stronger synchronization across countries than corporate or sovereign flows. Literature thus acknowledges the sensitivity of capital flows to global conditions varies by asset class, sector, maturity, and by currency. ([Avdjiev et al., 2016])

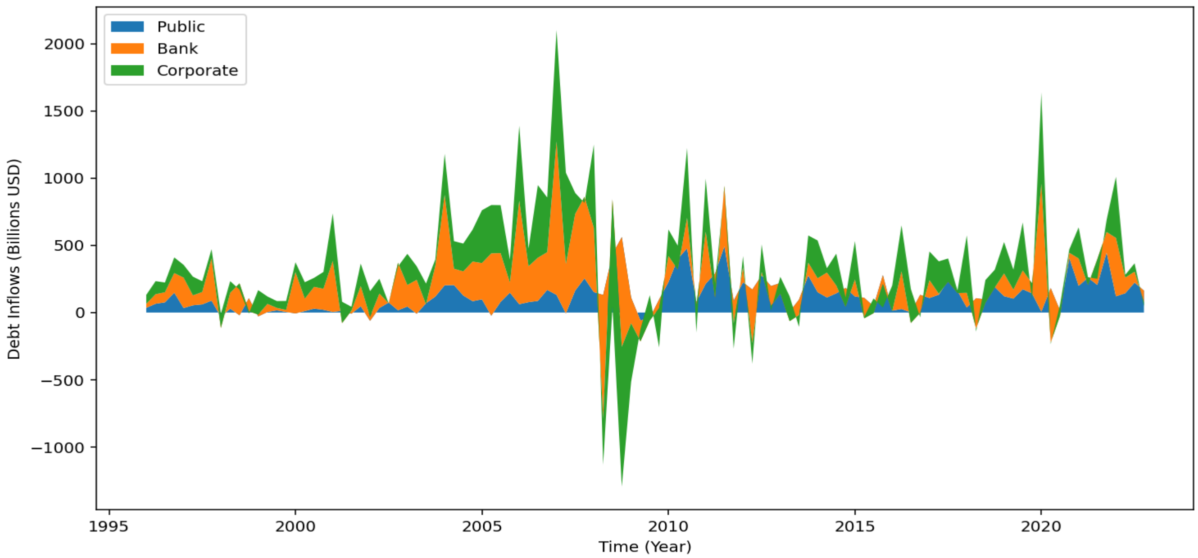
While these studies offer rich insights into sectoral and compositional aspects of capital flows, most treat flows as evolving smoothly over time, relying on linear models. Yet, real-world capital flows often experience abrupt regime changes, including sudden stops, surges, and retrenchments. To effectively capture the nonlinear dynamics of capital flows, especially the sudden regime shifts associated with crises, economists have increasingly turned to regime-switching models. [Hamilton, 1989] seminal work introduced the Markov-Switching framework, which has since been applied to a variety of macro-financial phenomena. These models allow for different states (low-volatility, moderate volatility, high-volatility) and can estimate transition probabilities across states, capturing not just the occurrence of crises but also the dynamics of persistence and recovery. Recent work by [Friedrich and Guérin, 2020] and [Dhar, 2021] applies regime-switching models to capital flows, showing that global risk factors significantly influence the probability of moving into or out of high-volatility regimes. However, these studies generally focus on aggregate capital flows or financial assets and do not systematically analyze flows disaggregated by borrowing sector.

This paper builds on the sectoral and regime-switching literatures by applying a three-state Markov-Switching framework to sector-specific external debt flows using the AHKS dataset ([Avdjiev et al., 2022]). By distinguishing between banks, corporates, and sovereigns, the analysis identifies which sectors are most prone to entering crisis regimes, explores differences in regime persistence across country groups, and investigates potential lead-lag structures between sectoral regime transitions. The next section describes the empirical methodology employed to detect and analyze sectoral regime shifts in external debt flows.

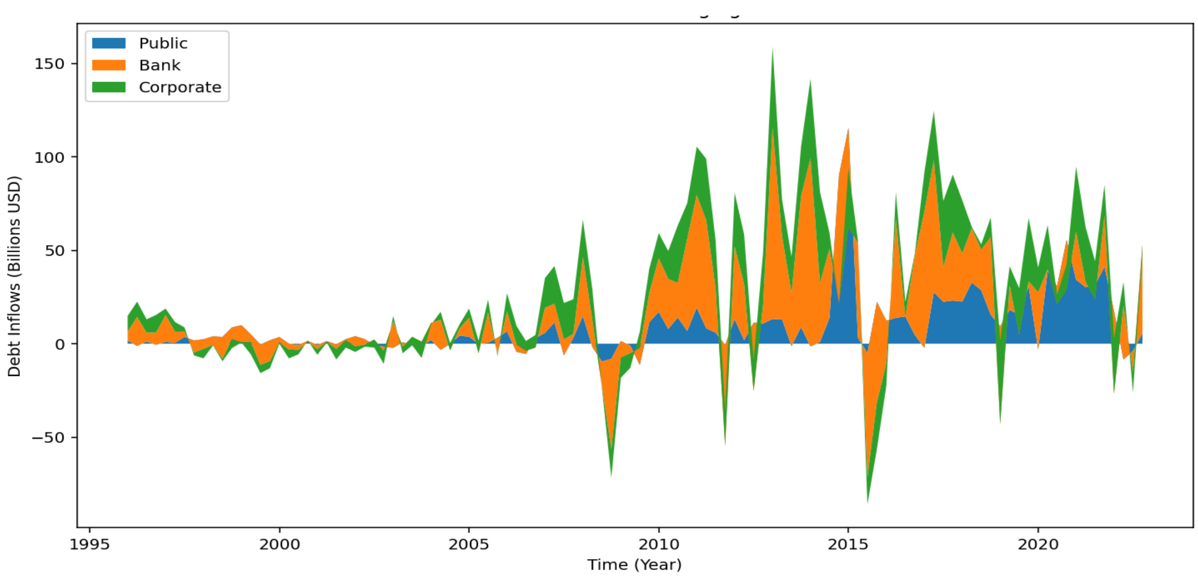
3.3 Data

This section presents key stylized facts about external debt inflows using the AHKS dataset ([Avdjiev et al., 2022]) spanning 1996–2022, disaggregated by banking sector, corporate sector and public (government & central bank) sector; and debt instrument type (portfolio vs. other investment debt), across various regions. The figures provide a regional breakdown of aggregate flows, the composition of capital inflows across sectors, and the long-run evolution of debt structures. These patterns form the empirical foundation for the Markov-switching model developed later.

Figure 3.1 (a)– Figure 3.1 (f) plots aggregate inflows by sector (banks, corporates, public) for six regions: Advanced Economies, Emerging Asia, Latin America, Emerging Europe, Africa, and Middle Asia.

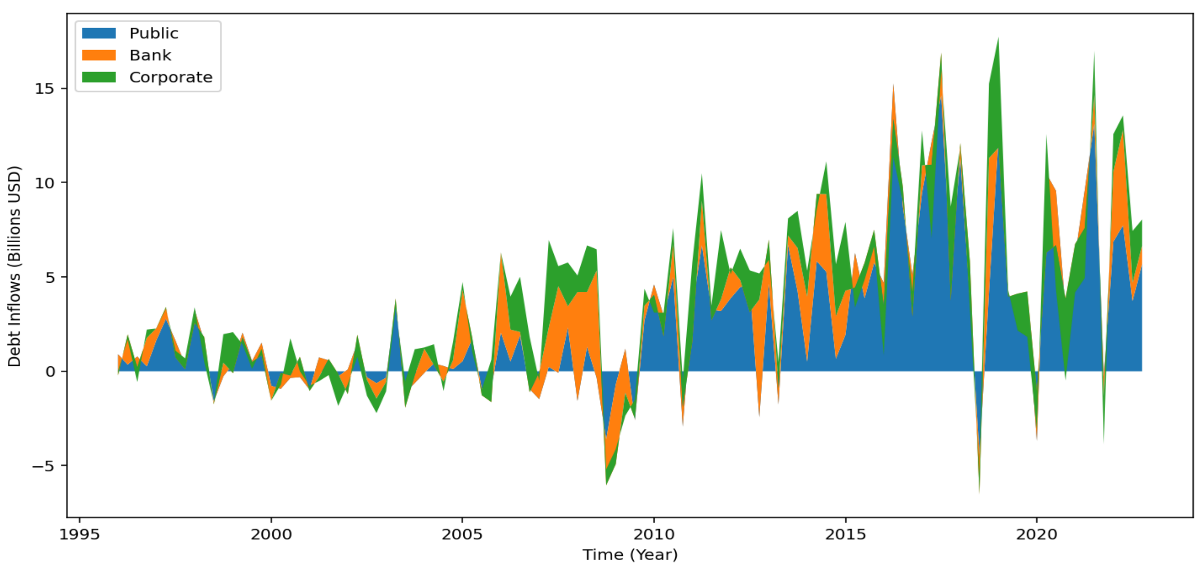


(a) Advanced Economies

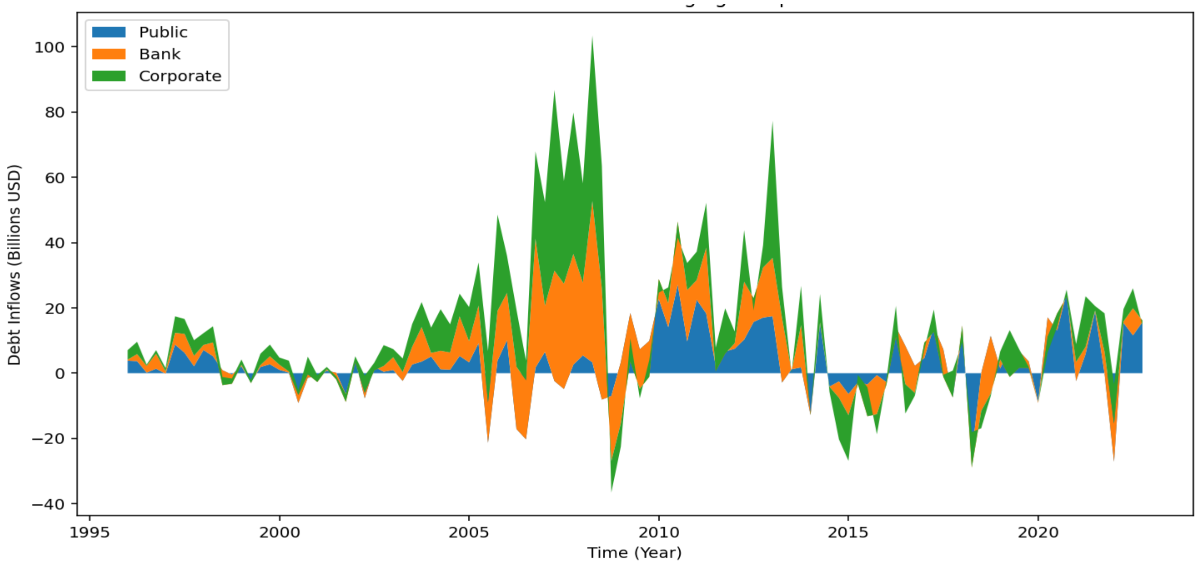


(b) Emerging Asia

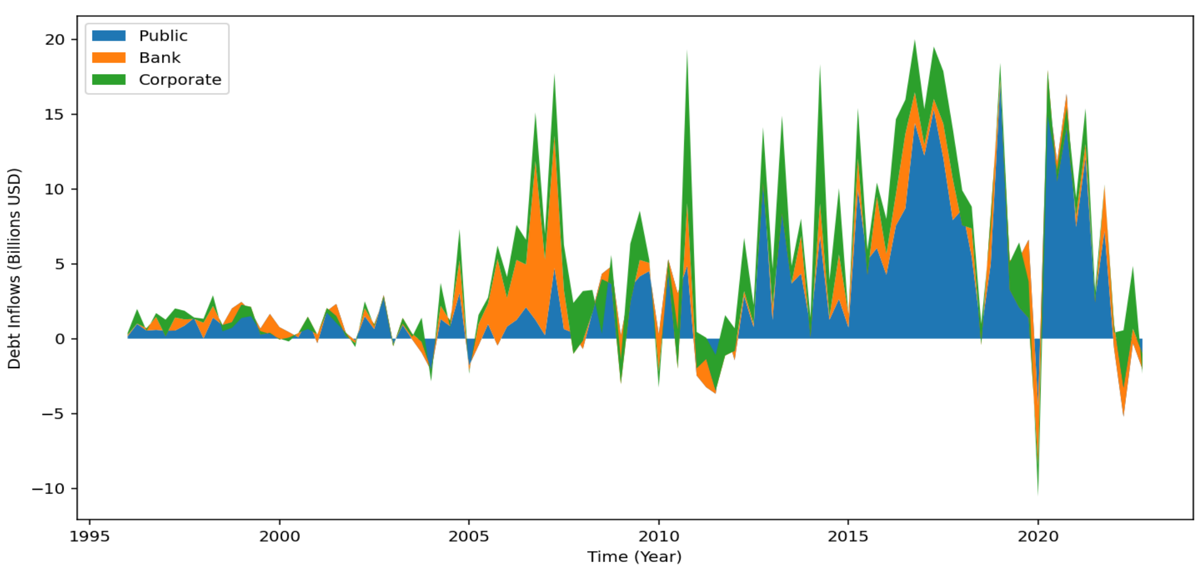
(c) Latin America



(d) Africa



(e) Emerging Europe

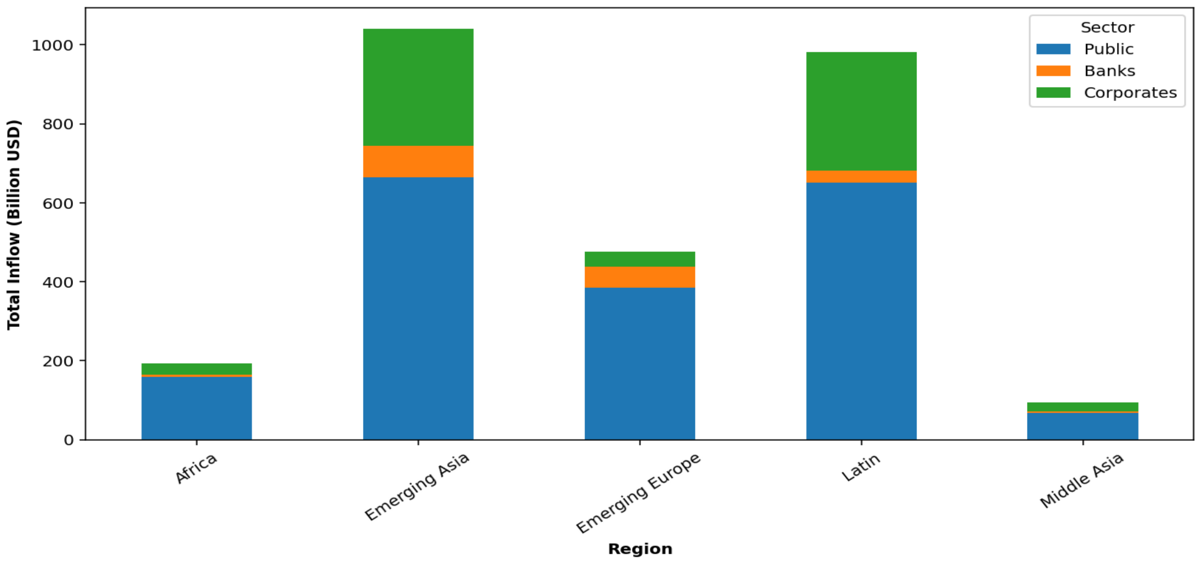


(f) Middle East and Central Asia

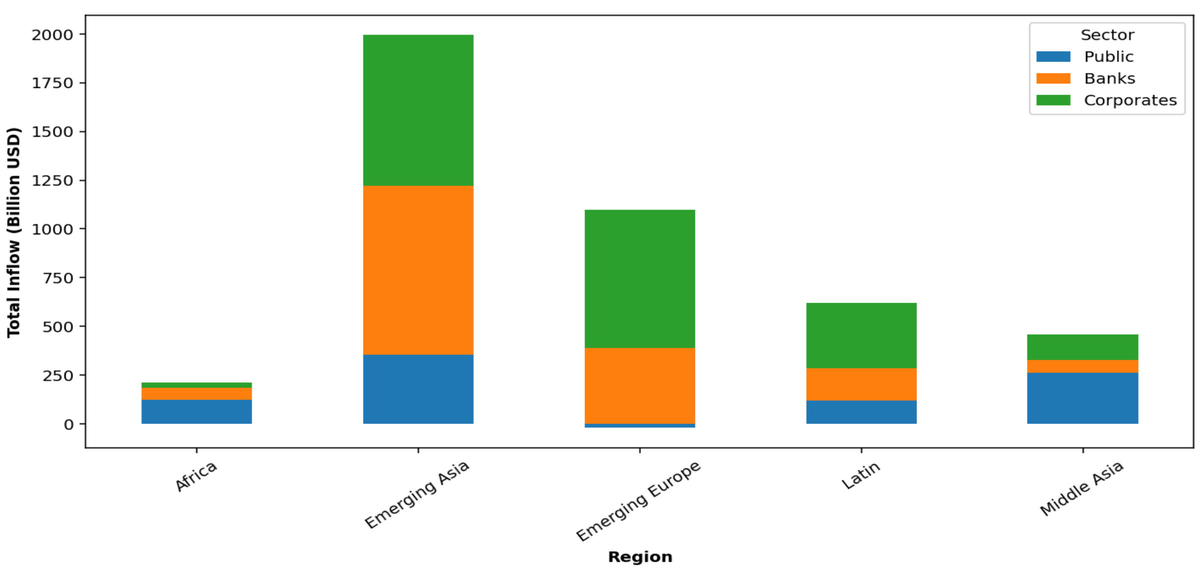
Figure 3.1: Debt Inflows

The Global Financial Crisis in 2008 marks a clear turning point across all regions, with a sharp contraction in total debt inflows. This was driven primarily by a collapse in banking sector inflows in Advanced Economies, reflecting the sudden stop in inter-bank lending and retrenchment by global banks. In advanced economies and emerging Europe, banking flows only partially recovered post crisis. Emerging Asia (Figure 3.1 (b)) saw a sustained rise in banking flows from 2000 to 2019, reflecting the increased regional integration and reliance on global banking networks. For Latin America, Africa and Middle Asia public-sector borrowing dominates the region's external debt profile, with portfolio debt inflows forming the bulk of capital entering the region. Sovereign access to international bond markets remains central to external financing in the region, with elevated vulnerability during periods of fiscal stress or rising global rates. These regions illustrate distinct sectoral profiles with increased role of banks in emerging Asia, the dominance of sovereign flows in Latin America and Africa, and the post-GFC shift in Advanced Economies away from banks and toward corporate and sovereign portfolio issuance.

Figure 3.2 offer a long-run perspective on the instrumental composition of debt inflows across regions. Over the 1996-2022 period, portfolio debt is used primarily by the public sector and corporates, with a heavier concentration in the public sector across emerging markets. Sovereign bond issuance accounts for a large share of external finance in these economies. Corporates in advanced economies (Figure 3.3 (a)), also tap global bond markets regularly, but their footprint in emerging markets remains smaller and more recent (Figure 3.3 (b)). Other investment debt mostly includes cross-border bank loans and trade credit. It is predominantly used by banks and corporates. Banks rely on these inflows to fund domestic lending operations, particularly in Emerging Asia where domestic financial systems are often bank reliant. Corporates also utilize loans and trade related credit lines, especially when bond market access is limited or costly. The banking sector stands out in its almost exclusive reliance on other investment debt unlike public and corporate sectors, which have broader access to portfolio financing. This composition reveals that portfolio debt is favored by issuers seeking long-term financing (sovereigns and corporates), while other investment debt is often short-term, and tied to banking relationships and trade dynamics.

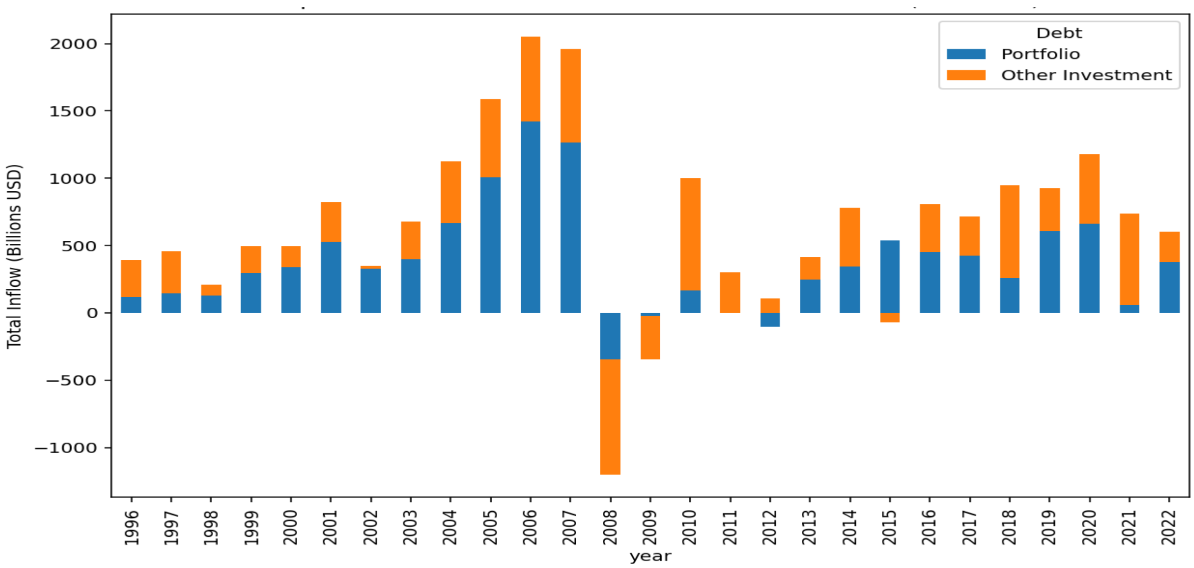


(a) Portfolio debt

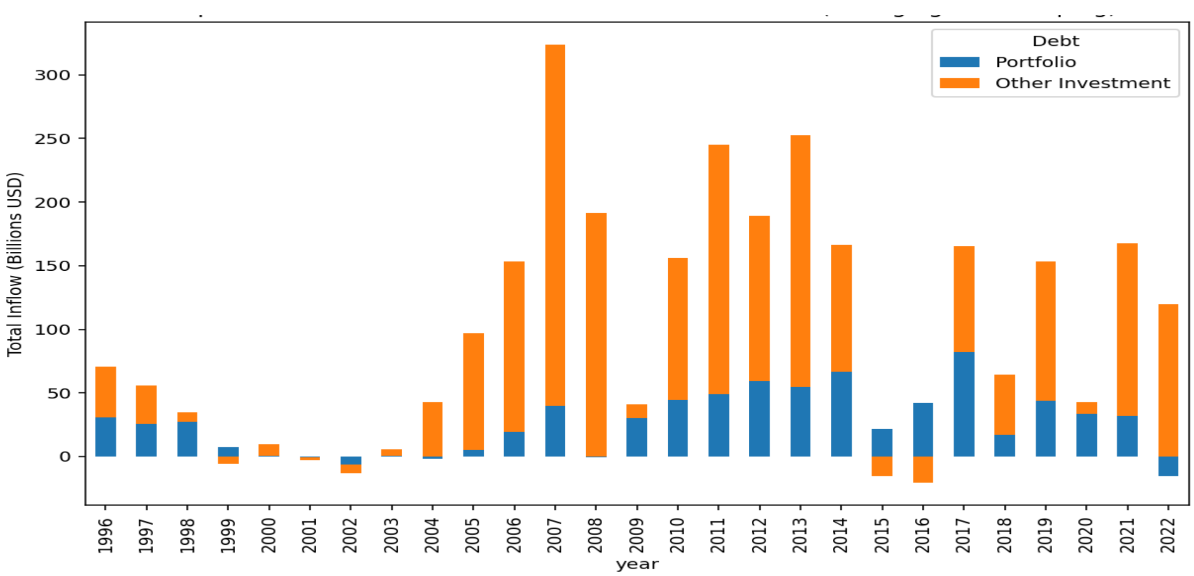


(b) Other investment debt

Figure 3.2: **Sectoral share**

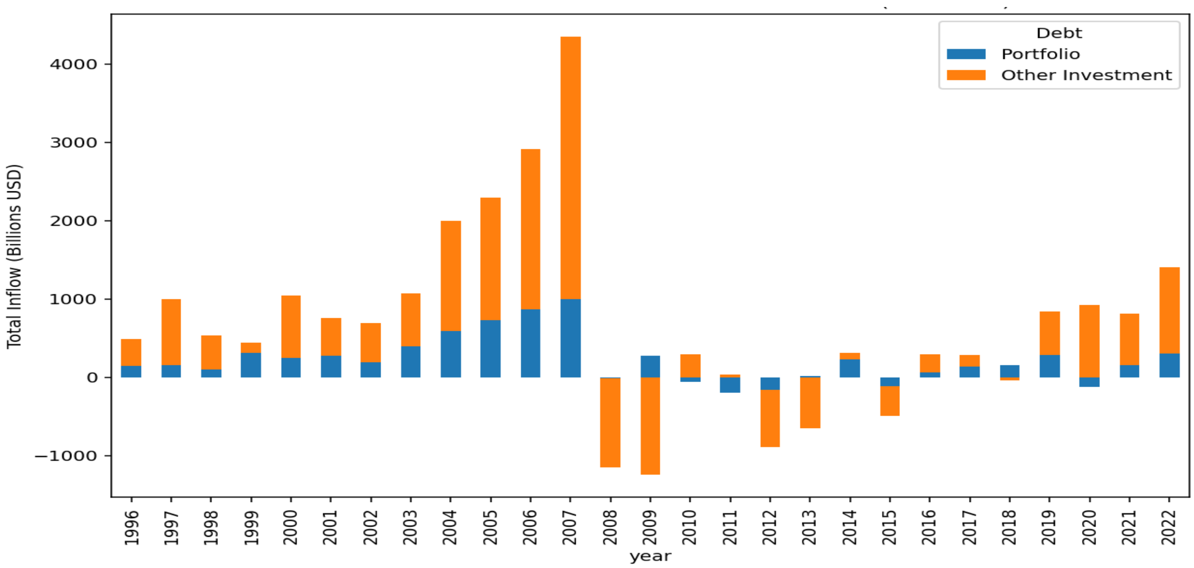


(a) Advanced Economies

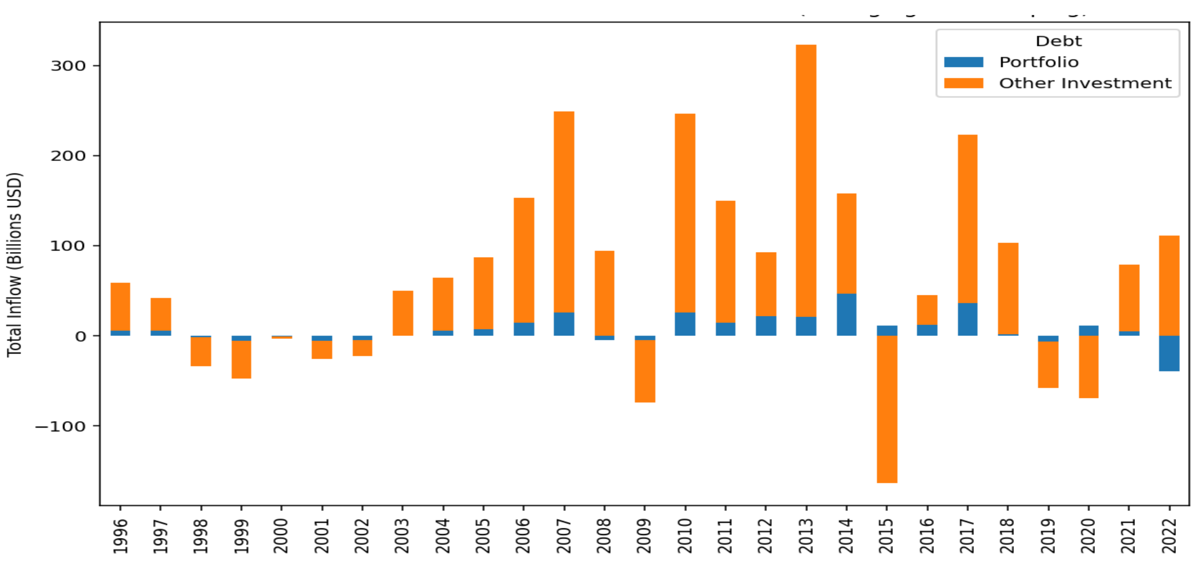


(b) Emerging & Developing Economies

Figure 3.3: **Corporate Inflows**

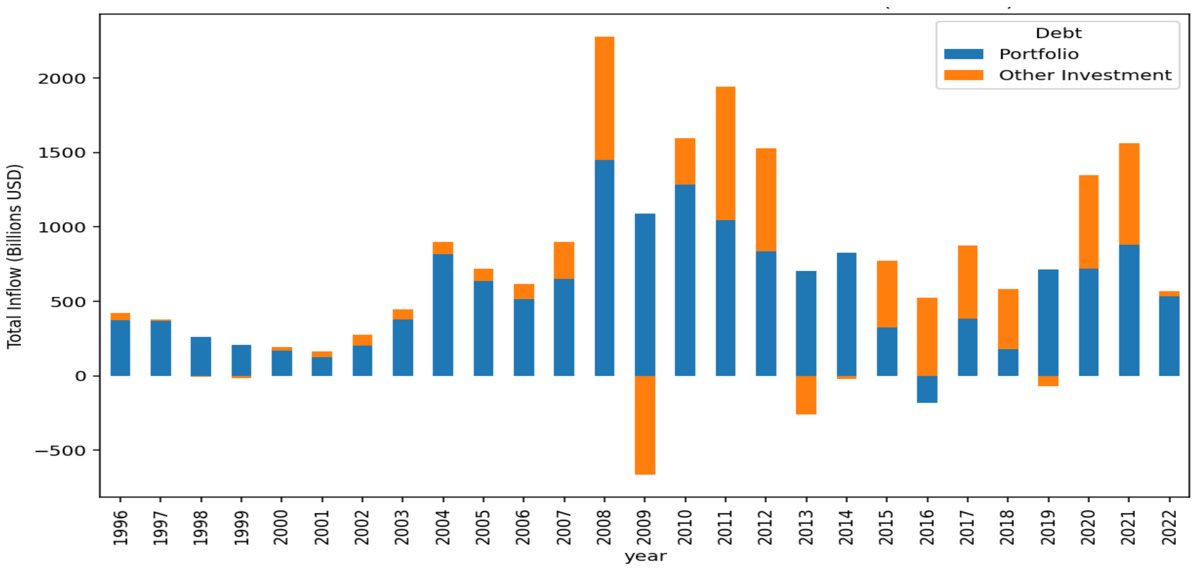


(a) Advanced Economies

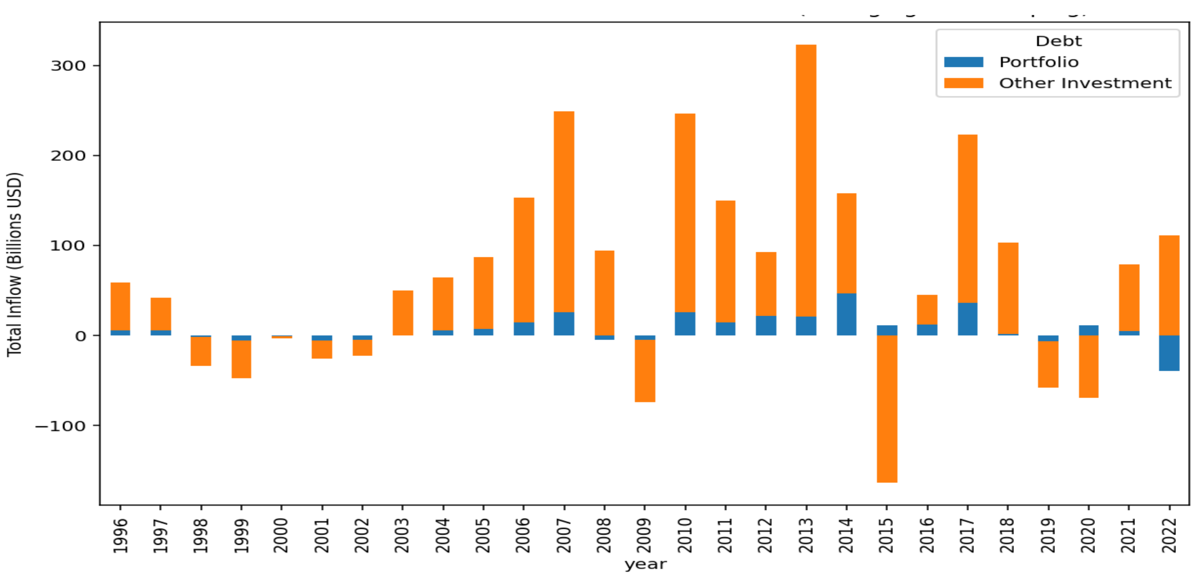


(b) Emerging & Developing Economies

Figure 3.4: **Bank Inflows**



(a) Advanced Economies



(b) Emerging & Developing Economies

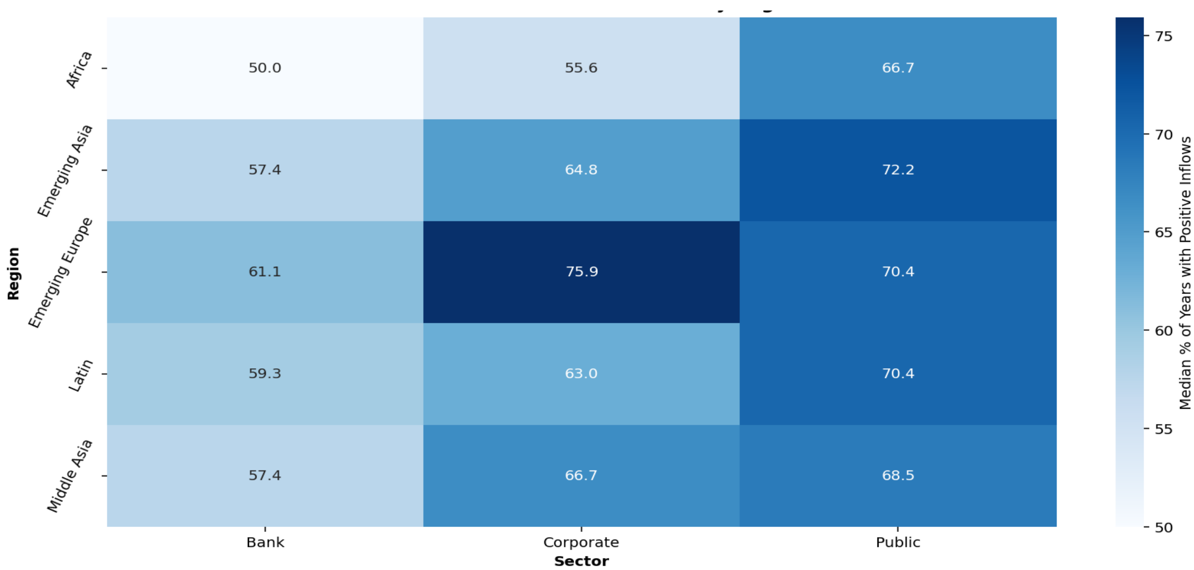
Figure 3.5: **Public Inflows**

In Advanced Economies' bank inflows, mostly in the form of short-term loans and interbank deposits grew steadily until 2007, then collapsed with the onset of the crisis (Figure 3.4). By contrast, emerging economies' bank inflows surged more aggressively post 2000, reflecting capital account liberalization and foreign bank entry. These flows were primarily other investment debt, signaling a reliance on short-term, relationship driven finance. The sharp retrenchment during COVID-19 suggests that these flows remain sensitive to global shocks and risk sentiment.

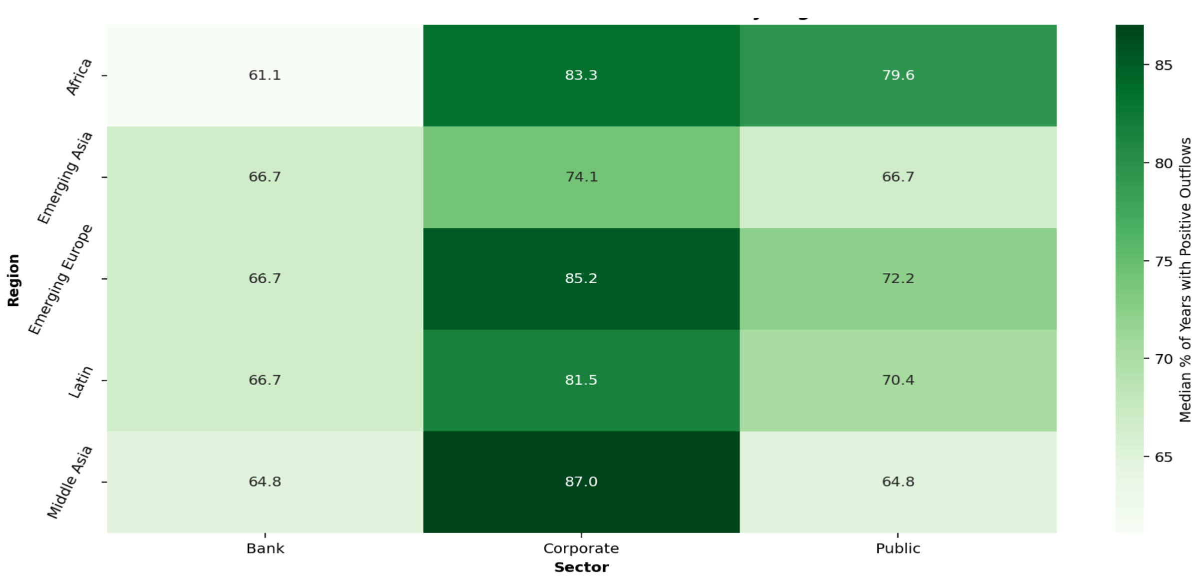
Portfolio debt inflows rose modestly across both groups for corporate flows, though with a sharper increase in advanced countries (Figure 3.3). Emerging market corporates remain more dependent on bank loans and trade credit, pointing to a still developing global investor base. The corporate sector, recovered relatively faster post-GFC, particularly in terms of portfolio debt issuance. For advanced economies, portfolio debt inflows increase each time global investors hunt yield.

Advanced sovereigns increased bond issuance steadily since early 2000s, while emerging market sovereigns expanded portfolio borrowing more cautiously (Figure 3.5). The emerging & developing sovereigns still remains more reliant on concessional loans and inter-bank finance due to limited bond market depth and creditworthiness constraints. The trends suggest that Advanced Economies diversified toward market based debt, while emerging & developing economies deepened their reliance on banks and official finance, particularly up until GFC. Post 2008, some convergence began to emerge, but clear structural differences persist in sectoral debt profiles.

Figure 3.6 present heatmaps summarizing the fraction of years from 1996 to 2022 in which each region-sector combination recorded positive inflows from non-residents into the domestic economy and positive outflows from residents into rest of the world. This measure captures the frequency and persistence of international capital engagement across different sectors, banks, corporates, and sovereigns; across regions. A higher fraction indicates a sector that regularly taps into international capital markets. The heatmap reveals that all sectors across all regions recorded positive inflows from non-residents in more than 55% of years between 1966 and 2022, indicating that external finance has been a consistent feature of economic activity.



(a) Inflows



(b) Outflows

Figure 3.6: **Fraction of years with positive inflows/outflows**

The public sector in emerging & developing economies stands out, with inflows in nearly 70% of years, highlighting its central role in sovereign borrowing, especially concessional finance in low-income regions due to limited domestic finance options. A rising trend for corporate inflows in Asia and Latin America further signals deepening financial markets and growing global investment linkages.

The outflows by residents seeking higher return abroad highlight a similar picture, a high fraction implies that the sector was consistently engaged in cross-border investment or capital deployment, indicating structural international financial integration. All sector-region combinations exhibit a high frequency (60–80%), pointing to a widespread and persistent pattern of outbound capital flows. Even sovereigns in emerging & developing markets, traditionally thought of as recipients have been increasingly involved in outward flows, especially in the form of sovereign wealth fund activity or reserve diversification. Firms across all regions show growing engagement in trade finance, and portfolio investment, reflecting global supply chain participation and financial market development. Thus, all three sectors are consistently engaged with global markets, albeit to varying degrees and through different channels.

3.4 The Model

To capture non-linear dynamics and endogenous regime shifts in capital flow behavior, I apply a three-state Markov switching model to identify time-varying regimes for each country-sector pair. This approach allows for the identification of structural breaks and abrupt transitions in flow behavior without imposing arbitrary thresholds or predefined dates, aligning with recent empirical strategies in international finance literature.

The underlying model assumes that the behavior of sector-specific flows can be characterized by discrete shifts among unobserved states, governed by a first-order Markov process. Formally, for each sector, s and country, i:

$$y_{i,S_t} = \mu_{i,S_t} + \epsilon_{i,S_t}$$

where, y_{i,S_t} is relative deviation of inflow in country i's sector s , from their trend, μ_{i,S_t} is the regime-specific mean deviation, $\epsilon_{i,S_t} \sim \mathcal{N}(0, \sigma^2_{S_t})$ is regime-specific error term. $S_t \in \{1, 2, 3\}$ is the regime at time t.

To ensure stationarity, stabilize variance, and allow cross-country comparability, I use HP-filter for each sectoral flow series and express the cyclical component as a share of the trend. This relative deviation series not only aligns the regimes with economically meaningful 'above-trend' and 'below-trend' episodes, but also materially improves model convergence. Regime 1 is the tranquil state with little to no deviation from its trend, regime 2 is moderate stress, and regime 3 is crisis/outlier state with large deviations from trend.

Regime switches follow the Markov process, such that the probability of switching from state i to state j, depends only on previous period's state:

$$P_{ij} = P(S_t = j | S_{t-1} = i)$$

This regime structure captures abnormal movements relative to the expected structural behavior of sectoral flows rather than absolute changes alone.

The model parameters, regime-specific means (μ_1, μ_2, μ_3), variances $(\sigma^2_1, \sigma^2_2, \sigma^2_3)$, and transition probabilities $(P_{11}, P_{12}, P_{13}, P_{21}, P_{22}, P_{23}, P_{31}, P_{32}, P_{33})$ are estimated using the Expectation-Maximization (EM) algorithm. State probabilities are filtered and smoothed using standard recursive algorithms.

3.5 Results

The estimation results offer rich insights into how sector-specific capital flows behave across different economic regimes and country groups. Across most regions, regime 1 (tranquil) is associated with small to no deviations from trend with lowest variance, regime 2 is associated with moderate deviations from the trend with moderate volatility, while regime 3 represents extreme inflow or outflow events with high volatility (Table 3.1). In emerging and developing economies, banking flows also exhibit large financial cycle amplitudes (4.15), though somewhat lower than in advanced economies, possibly due to less global financial integration or capital account regulations(Table 3.2). Corporate and public sector flows show smaller amplitudes in advanced economies, consistent with their relatively more stable investor base and institutional quality.

Region	**Sector**	**Regime 1**	**Regime 2**	**Regime 3**
Advanced	Bank	-0.013	0.155	9.966
	Corporate	-0.054	0.136	0.009
	Public	-0.030	0.393	-0.044
Africa	Bank	-0.562	0.279	3.470
	Corporate	-0.185	0.224	-0.541
	Public	-0.636	-0.251	1.327
Emerging Asia	Bank	0.040	0.133	0.087
	Corporate	-0.068	0.162	-0.783
	Public	-0.101	-0.008	1.660
Emerging Europe	Bank	-0.163	0.053	-5.090
	Corporate	-0.012	-0.634	-0.348
	Public	-0.032	-0.132	-0.275
Latin	Bank	-0.124	0.657	12.779
	Corporate	0.035	0.145	0.984
	Public	-0.201	0.280	2.738
Middle Asia	Bank	-0.104	-0.562	31.390
	Corporate	-0.097	0.830	-2.401
	Public	-0.017	0.094	1.280

Table 3.1: Estimated intercepts (Median) for each region

Country Type	Sector	$(\mu_3 - \mu_1)_{median}$
Advanced	Bank	10.77
	Corporate	0.09
	Public	0.27
Emerging & Developing	Bank	4.15
	Corporate	-1.19
	Public	2.18

Table 3.2: Amplitude of financial cycle

sector	Country Type	$\text{corr}(\mu_3 - \mu_1, var_3)$
Bank	Advanced	0.841*
	Emerging & Developing	0.890*
Corporate	Advanced	0.995*
	Emerging & Developing	-0.135
Public	Advanced	-0.999*
	Emerging & Developing	-0.548*

Table 3.3: Correlation: Financial cycle amplitude Vs Variance of the extreme regime

A key finding of Table 3.3 is the strong positive correlation between the amplitude of the financial cycle and the variance of the crisis regime (regime 3), particularly for banking and corporate sectors (correlation > 0.84). This implies that countries experiencing larger swings in financial flows also face more volatile conditions during crises, which is a well-established result in literature on procyclicality and capital flow volatility.

Country Group	Sector	Regime 1	Regime 2	Regime 3
Advanced	Bank	0.60	0.30	0.10
	Corporate	0.55	0.32	0.14
	Public	0.53	0.36	0.12
Africa	Bank	0.46	0.45	0.09
	Corporate	0.55	0.38	0.07
Africa	Public	0.51	0.38	0.11
Emerging Asia	Bank	0.50	0.33	0.16
	Corporate	0.56	0.31	0.13
	Public	0.56	0.34	0.10
Emerging Europe	Bank	0.52	0.38	0.09
	Corporate	0.63	0.29	0.08
	Public	0.56	0.33	0.11
Latin	Bank	0.53	0.38	0.10
	Corporate	0.60	0.30	0.10
	Public	0.55	0.36	0.09
Middle Asia	Bank	0.62	0.32	0.06
	Corporate	0.58	0.27	0.15
	Public	0.63	0.29	0.08

Table 3.4: Unconditional Probabilities of each regime (Averages)

Unconditional probabilities of each regime (Table 3.4) show that regime 1 is the most likely state across both advanced and emerging markets, reflecting a dominance of relatively calm periods. Regime 2 is the next most frequent, while regime 3 characterized by extreme deviations and high volatility remains rare, as expected. However, Emerging Asia stands out with elevated probabilities of being in Regime 3.

Country Type	Sector	Regime 1	Regime 2	Regime 3
Advanced	Bank	0.91	0.73	0.54
	Corporate	0.85	0.64	0.68
	Public	0.84	0.75	0.60
Emerging & Developing	Bank	0.91	0.78	0.55
	Corporate	0.90	0.72	0.59
	Public	0.81	0.68	0.51

Table 3.5: Average Persistence by Sector and Country Type

Country Type	sector	Regime 1	Regime 2	Regime 3
Advanced	Bank	[13.74,60.12]	[3.61,9.66]	[1.63,4.18]
	Corporate	[7.44,22.94]	[2.11,7.70]	[2.25,6.21]
	Public	[7.85, 24.35]	[3.56,8.81]	[1.69,3.34]
Emerging & Developing	Bank	[10.74,19.22]	[3.93,9.61]	[1.79,4.11]
	Corporate	[10.40,25.59]	[3.32 ,6.46]	[1.88,6.59]
	Public	[4.48,24.60]	[2.44,6.99]	[1.48,3.74]

Table 3.6: Expected Duration (in quarters) by Sector and Country Type, [lower quartile,upper quartile]

Persistence metrics and expected durations, presented in Table 3.5 and Table 3.6 reinforce these dynamics. Regime 1, being the most stable state is highly persistent in both advanced and emerging economies (~ 0.90), reflecting the long-lasting nature of tranquil states. However, regime 3 episodes are more short-lived, with durations typically ranging from 1.5 to 6 quarters. Notably, emerging markets exhibit greater dispersion in regime durations, reflecting their vulnerability to external shocks and limited policy buffers. In particular, public sector flows in emerging & developing economies are more erratic, with frequent switches and shorter-lived regimes, indicative of fiscal vulnerabilities and political risk.

For Banking flows, persistence is comparable (if not more) for emerging & developing economies to advanced economies. The expected duration (Table 3.6) of each regime however, suggests a higher dispersion for emerging & developing economies. For corporate flows, the emerging economies' regime 3 is shorter-lived than its advanced counterpart, due to the unstable nature of flows to emerging & developing economies.

Among the emerging & developing economies, Latin American countries tend to spend the most time in the extreme/outlier regime, followed by Asia and Europe (Figure 3.7). Morever, Latin countries also tend to show more dispersion in the expected duration of regime 3, owing to the idiosyncratic fiscal and political risks in these countries.

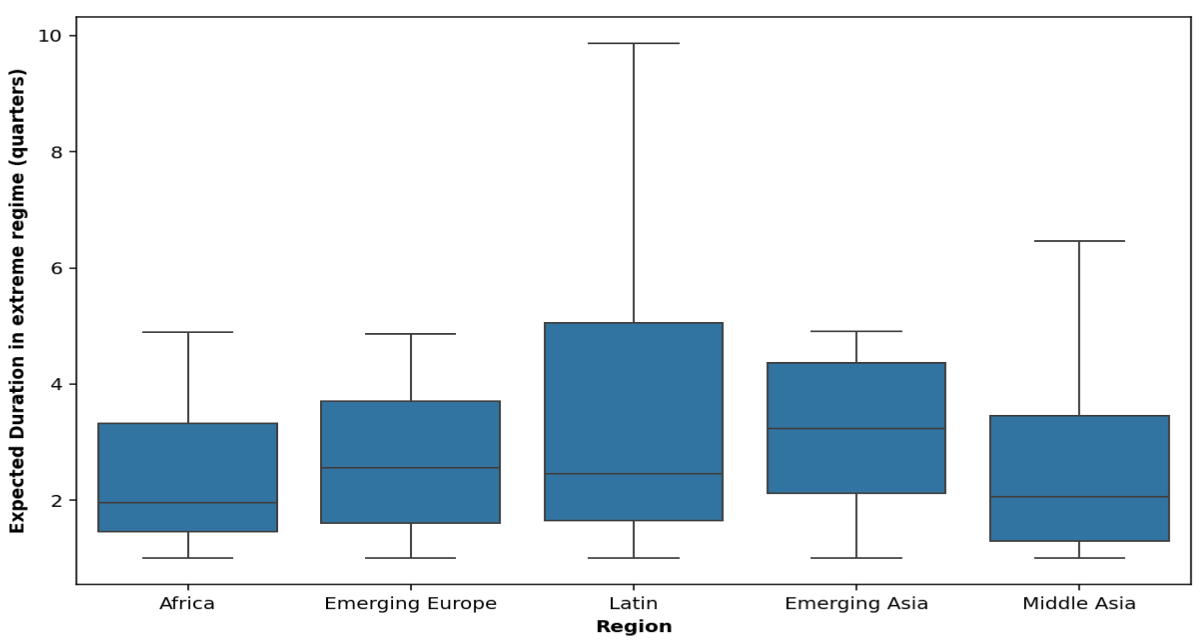


Figure 3.7: Expected Duration in Regime 3

Country Type	Sector	P_{12}	P_{13}	P_{21}	P_{23}	P_{31}	P_{32}
Advanced	Bank	0.087	0.003	0.154	0.112	0.007	0.455
	Corporate	0.132	0.017	0.224	0.132	0.052	0.265
	Public	0.154	0.004	0.129	0.121	0.125	0.273
Emerging & Developing	Bank	0.076	0.011	0.134	0.081	0.063	0.388
	Corporate	0.095	0.006	0.198	0.085	0.045	0.362
	Public	0.176	0.015	0.206	0.119	0.075	0.414

Table 3.7: Transition Probabilities (Average)

As for the probabilities of transiting between the states, Table 3.7 suggests that the countries have a tendency to move towards the lower volatility states, with very rare instances of economies jumping directly between regime 1 and regime 3 ($P_{13}\&P_{31}$), confirming the gradual transitions out of the crises, a characteristic observed in sudden-stop literature.

Volatility scores, defined as the sum of off-diagonal transition probabilities, offer a quantitative proxy for instability in capital flow regimes. (Table 3.8). A lower score is associated with stable country-sector pair, while a higher score is evidence of frequent regime reversion. Public sector flows in emerging economies score the highest (1.004), particularly in regions like Emerging Europe and Latin America, where fiscal shocks and sovereign risk episodes often disrupt investor sentiment. Asia and Europe experience somewhat more volatile banking sector relative to corporate sector. Banking flows, while also volatile, show slightly more stable patterns in Latin America, where macroprudential tools and currency management might mitigate abrupt transitions. Corporate flows, by contrast, show elevated volatility in Africa and Emerging Asia, consistent with a reliance on external credit and susceptibility to global risk appetite.

The estimates for the smoothed probabilities are used to find the most likely regime of each country-sector pair in each quarter. Figure 3.8 shows the fraction of countries that were in regime 3 (extreme deviation from trend) from 1966-2022. Figure 3.9 further shows these countries' sector-wise crises episodes. The plots of regime 3 incidence show clear clustering around 2008 Global Financial Crisis and COVID-19. The sectoral decomposition further indicates that banking flows dominated the extreme regime during global crises, followed by corporates as firms experienced tightened credit conditions and emerging economies' sovereigns faced fiscal stress, along with advanced safe-haven sovereigns experiencing flight to safety inflows.

(a) By Country Type and Sector

Country Type	Sector	Median
Advanced	Bank	0.713
	Corporate	0.619
	Public	0.771
Emerging & Developing	Bank	0.706
	Corporate	0.767
	Public	1.004

(b) By Sector and Region

Region	Sector	Score
Africa	Bank	0.71
	Corporate	0.88
	Public	0.85
Emerging Asia	Bank	0.89
	Corporate	0.86
	Public	0.71
Emerging Europe	Bank	0.70
	Corporate	0.63
	Public	1.26
Latin	Bank	0.63
	Corporate	0.79
	Public	1.11
Middle Asia	Bank	0.88
	Corporate	0.80
	Public	1.11

Table 3.8: Volatility Scores

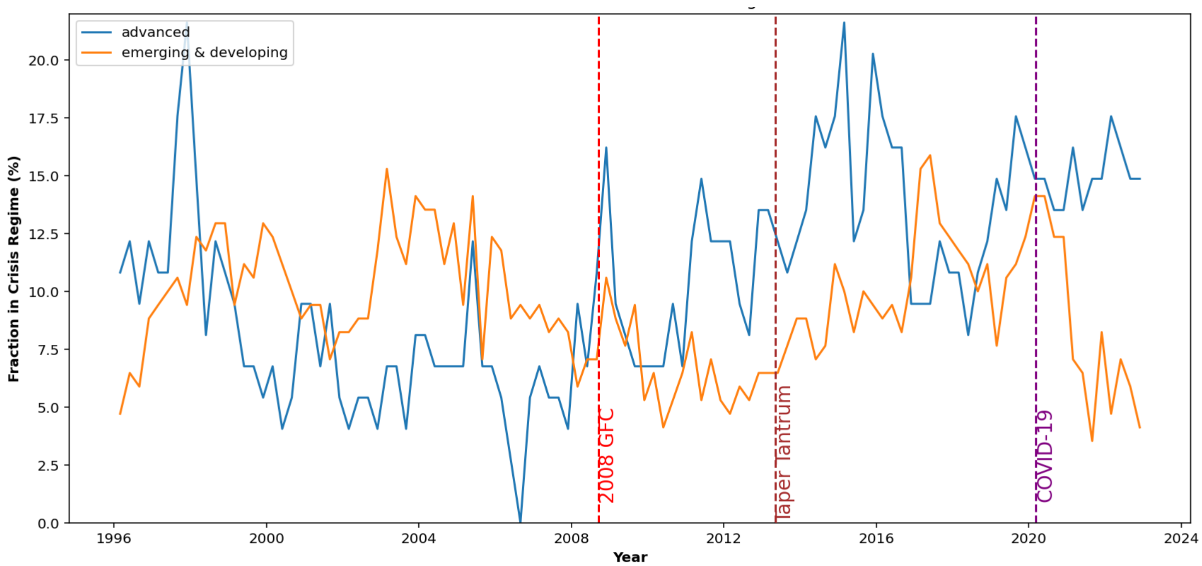


Figure 3.8: Fraction of countries in Regime 3 (high volatility)

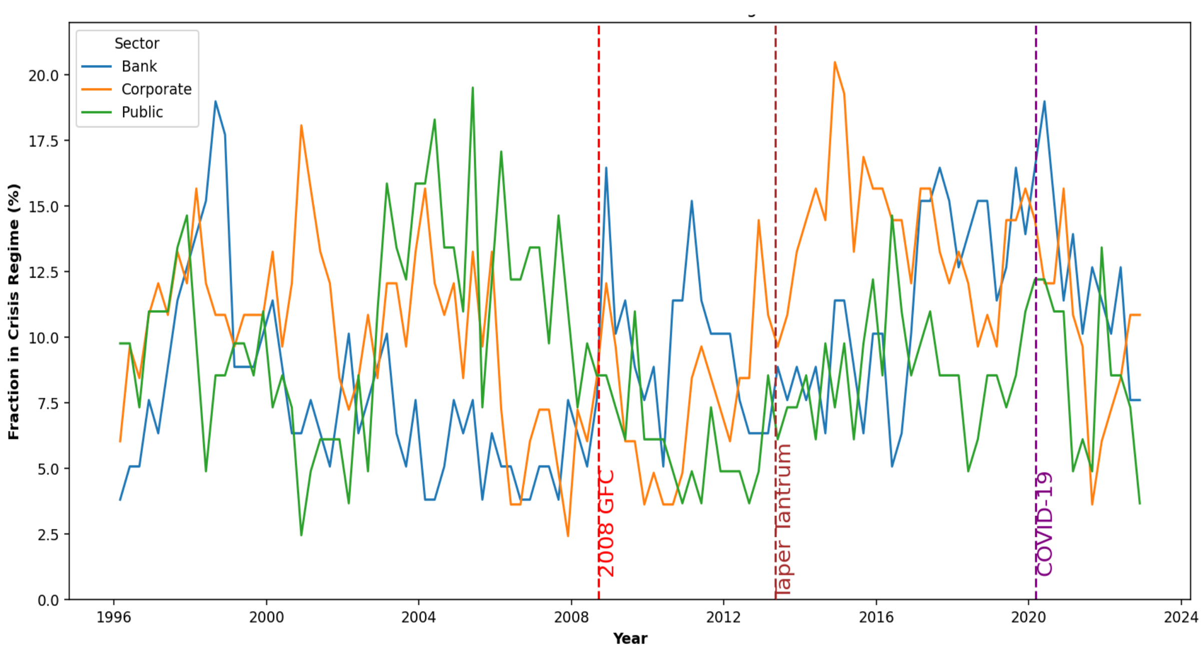


Figure 3.9: Fraction of countries in each sector's regime 3 (high volatility)

3.6 Conclusion

This paper has demonstrated that the behavior of cross-border debt flows is both deeply sectoral and inherently nonlinear, with banking, corporate, and public-sector exposures each exhibiting distinct patterns of volatility, persistence, and transition. By applying a three-state Markov switching model to disaggregated sectoral debt flows across advanced and emerging economies from 1996 to 2022, the research has shown that tranquil periods (Regime 1) are remarkably persistent, while crisis episodes (Regime 3) are short-lived but intense, typically spanning only a few quarters. Banking flows register the largest swings above and below trend, reflecting their susceptibility to sudden stops, liquidity squeezes, and rollover risk; corporate flows, although generally more muted in advanced economies, can experience sharp reversals in emerging markets when global risk aversion intensifies; and public-sector flows, while relatively stable in safe-haven jurisdictions, become highly volatile in emerging and developing economies, where sovereign spreads and fiscal vulnerabilities compound external shocks.

The strong positive correlation between financial-cycle amplitudes and crisis-regime variances for banking and corporate flows confirms that larger cycle swings tend to accompany more turbulent crisis regimes, reinforcing the procyclical nature of capital flows documented in the literature. Moreover, the very low probabilities of jumping directly between tranquil and crisis regimes highlight the path-dependent character of financial stress as recovery typically unfolds through intermediate, moderate-stress conditions rather than instant normalization.

These insights carry important implications for policy design. First, macroprudential frameworks benefit from sector-specific calibration. Countercyclical capital buffers and liquidity surcharges are most critical for the banking sector, while corporate debt markets may require targeted backstop facilities and hedging support during periods of tightening global financial conditions. Second, early-warning systems should incorporate regime-switch probabilities at the sectoral level, as aggregate flow measures can obscure emerging stress in particular segments, especially within emerging markets, where public-sector distress often precedes broader contagion. Third, capital flow management measures such as temporary controls on volatile short-term borrowing can help smooth excessive surges and prevent abrupt reversals, thereby reducing the severity of crisis regimes that follow. Finally, extending the analysis to equity flows, foreign direct investment, or granular bond-level data may reveal additional layers of heterogeneity in how global financial integration shapes vulnerability.

By illuminating the sectoral contours of capital flow regimes, this study offers a richer foundation for policy interventions aimed at enhancing the resilience of both advanced and emerging economies to the inevitable ebbs and flows of international finance.

BIBLIOGRAPHY

[Aghion et al., 2001] Aghion, P., Bacchetta, P., and Banerjee, A. (2001). Currency crises and monetary policy in an economy with credit constraints. *European economic review*, 45(7):1121–1150.

[Avdjiev et al., 2022] Avdjiev, S., Hardy, B., Kalemli-Özcan, Ş., and Servén, L. (2022). Gross capital flows by banks, corporates, and sovereigns. *Journal of the European Economic Association*, 20(5):2098–2135.

[Avdjiev et al., 2016] Avdjiev, S., McCauley, R. N., and Shin, H. S. (2016). Breaking free of the triple coincidence in international finance. *Economic Policy*, 31(87):409–451.

[Bellifemine et al., 2022] Bellifemine, M., Jamilov, R., and Monacelli, T. (2022). *Hbank: Monetary policy with heterogeneous banks*. Centre for Economic Policy Research.

[Bernanke et al., 1999] Bernanke, B. S., Gertler, M., and Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of macroeconomics*, 1:1341–1393.

[Boissay et al., 2013] Boissay, F., Collard, F., and Smets, F. (2013). Booms and systemic banking crises. Technical report, ECB working paper.

[Bremus et al., 2018] Bremus, F., Buch, C. M., Russ, K. N., and Schnitzer, M. (2018). Big banks and macroeconomic outcomes: Theory and cross-country evidence of granularity. *Journal of Money, Credit and Banking*, 50(8):1785–1825.

[Broner et al., 2013] Broner, F., Didier, T., Erce, A., and Schmukler, S. L. (2013). Gross capital flows: Dynamics and crises. *Journal of monetary economics*, 60(1):113–133.

[Bruno and Shin, 2015] Bruno, V. and Shin, H. S. (2015). Cross-border banking and global liquidity. *The Review of Economic Studies*, 82(2):535–564.

[Caballero and Krishnamurthy, 2001] Caballero, R. J. and Krishnamurthy, A. (2001). International and domestic collateral constraints in a model of emerging market crises. *Journal of monetary Economics*, 48(3):513–548.

[Cacciatore et al., 2015] Cacciatore, M., Ghironi, F., and Stebunovs, V. (2015). The domestic and international effects of interstate us banking. *Journal of International Economics*, 95(2):171–187.

[Calderón and Kubota, 2013] Calderón, C. and Kubota, M. (2013). Sudden stops: Are global and local investors alike? *Journal of International Economics*, 89(1):122–142.

[Calvo et al., 2008] Calvo, G. A., Izquierdo, A., and Mejía, L.-F. (2008). Systemic sudden stops: the relevance of balance-sheet effects and financial integration. Technical report, National Bureau of Economic Research.

[Calvo et al., 1993] Calvo, G. A., Leiderman, L., and Reinhart, C. M. (1993). Capital inflows and real exchange rate appreciation in latin america: the role of external factors. *Staff Papers*, 40(1):108–151.

[Calvo et al., 1996] Calvo, G. A., Leiderman, L., and Reinhart, C. M. (1996). Inflows of capital to developing countries in the 1990s. *Journal of economic perspectives*, 10(2):123–139.

[Cavallo et al., 2015] Cavallo, E., Powell, A., Pedemonte, M., and Tavella, P. (2015). A new taxonomy of sudden stops: Which sudden stops should countries be most concerned about? *Journal of International Money and Finance*, 51:47–70.

[Cerutti et al., 2019] Cerutti, E., Claessens, S., and Puy, D. (2019). Push factors and capital flows to emerging markets: why knowing your lender matters more than fundamentals. *Journal of international economics*, 119:133–149.

[Cerutti and Hong, 2021] Cerutti, E. and Hong, G. H. (2021). Substitution patterns in capital inflows: Evidence from disaggregated capital flow data. *Journal of International Money and Finance*, 112:102314.

[Chang and Velasco, 2001] Chang, R. and Velasco, A. (2001). A model of financial crises in emerging markets. *The Quarterly Journal of Economics*, 116(2):489–517.

[Coimbra and Rey, 2024] Coimbra, N. and Rey, H. (2024). Financial cycles with heterogeneous intermediaries. *Review of Economic Studies*, 91(2):817–857.

[Corbae and D'Erasmo, 2015] Corbae, D. and D'Erasmo, P. (2015). Foreign competition and banking industry dynamics: An application to mexico. *IMF Economic Review*, 63(4):830–867.

[Cuciniello and Signoretti, 2015] Cuciniello, V. and Signoretti, F. (2015). Large banks, loan rate markup, and monetary policy. *International Journal of Central Banking*, 11(3):141–177.

[Davis and Van Wincoop, 2018] Davis, J. S. and Van Wincoop, E. (2018). Globalization and the increasing correlation between capital inflows and outflows. *Journal of Monetary Economics*, 100:83–100.

[De Blas and Russ, 2013] De Blas, B. and Russ, K. N. (2013). All banks great, small, and global: Loan pricing and foreign competition. *International Review of Economics & Finance*, 26:4–24.

[Dhar, 2021] Dhar, A. (2021). Identification of extreme capital flows in emerging markets. *International Review of Economics & Finance*, 71:359–384.

[Forbes and Warnock, 2012] Forbes, K. J. and Warnock, F. E. (2012). Capital flow waves: Surges, stops, flight, and retrenchment. *Journal of international economics*, 88(2):235–251.

[Fratzscher, 2012] Fratzscher, M. (2012). Capital flows, push versus pull factors and the global financial crisis. *Journal of international Economics*, 88(2):341–356.

[Freixas and Rochet, 2008] Freixas, X. and Rochet, J.-C. (2008). *Microeconomics of banking*. MIT press.

[Friedrich and Guérin, 2020] Friedrich, C. and Guérin, P. (2020). The dynamics of capital flow episodes. *Journal of Money, Credit and Banking*, 52(5):969–1003.

[Gabaix, 2011] Gabaix, X. (2011). The granular origins of aggregate fluctuations. *Econometrica*, 79(3):733–772.

[Gerali et al., 2010] Gerali, A., Neri, S., Sessa, L., and Signoretti, F. M. (2010). Credit and banking in a dsge model of the euro area. *Journal of money, Credit and Banking*, 42:107–141.

[Gertler and Karadi, 2011] Gertler, M. and Karadi, P. (2011). A model of unconventional monetary policy. *Journal of monetary Economics*, 58(1):17–34.

[Gertler and Kiyotaki, 2010] Gertler, M. and Kiyotaki, N. (2010). Financial intermediation and credit policy in business cycle analysis. In *Handbook of monetary economics*, volume 3, pages 547–599. Elsevier.

[Ghironi and Melits, 2005] Ghironi, F. and Melits, M. J. (2005). International trade and macroeconomic dynamics with heterogeneous firms. *The Quarterly Journal of Economics*, 120(3):865–915.

[Hamilton, 1989] Hamilton, J. D. (1989). A new approach to the economic analysis of nonstationary time series and the business cycle. *Econometrica: Journal of the econometric society*, pages 357–384.

[He and Krishnamurthy, 2012] He, Z. and Krishnamurthy, A. (2012). A model of capital and crises. *The Review of Economic Studies*, 79(2):735–777.

[Jamilov et al., 2025] Jamilov, R., Monacelli, T., et al. (2025). Bewley banks. *THE REVIEW OF ECONOMIC STUDIES*.

[Kaminsky and Reinhart, 1999] Kaminsky, G. L. and Reinhart, C. M. (1999). The twin crises: the causes of banking and balance-of-payments problems. *American economic review*, 89(3):473–500.

[Khurana, 2024] Khurana, M. (2024). Sudden stops and bank competition.

[Koepke, 2019] Koepke, R. (2019). What drives capital flows to emerging markets? a survey of the empirical literature. *Journal of Economic Surveys*, 33(2):516–540.

[La Croce and Rossi, 2018] La Croce, C. and Rossi, L. (2018). Firms'endogenous entry and monopolistic banking in a dsge model. *Macroeconomic Dynamics*, 22(1):153–171.

[Lepers and Mercado, 2021] Lepers, E. and Mercado, R. (2021). Analysing sectoral capital flows: Covariates, comovements, and controls. *OECD Working Papers on International Investment*, (4):1–51.

[Mandelman, 2010] Mandelman, F. S. (2010). Business cycles and monetary regimes in emerging economies: A role for a monopolistic banking sector. *Journal of International Economics*, 81(1):122–138.

[Mandelman, 2011] Mandelman, F. S. (2011). Business cycles and the role of imperfect competition in the banking system. *International Finance*, 14(1):103–133.

[Melitz, 2003] Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *econometrica*, 71(6):1695–1725.

[Mendoza, 2010] Mendoza, E. G. (2010). Sudden stops, financial crises, and leverage. *American Economic Review*, 100(5):1941–1966.

[Niepmann, 2015] Niepmann, F. (2015). Banking across borders. *Journal of International Economics*, 96(2):244–265.

[Olivero, 2010] Olivero, M. P. (2010). Market power in banking, countercyclical margins and the international transmission of business cycles. *Journal of International Economics*, 80(2):292–301.

[Reinhart and Reinhart, 2009] Reinhart, C. M. and Reinhart, V. R. (2009). Capital flow bonanzas: An encompassing view of the past and present. In *NBER international seminar on macroeconomics*, volume 5, pages 9–62. The University of Chicago Press Chicago, IL.

[Rey, 2015] Rey, H. (2015). Dilemma not trilemma: the global financial cycle and monetary policy independence. Technical report, National Bureau of Economic Research.

[Totzek, 2011] Totzek, A. (2011). Banks, oligopolistic competition, and the business cycle: A new financial accelerator approach. Technical report, Economics Working Paper.

Appendix A

HOMOGENOUS BANKS

A.1 Detailed solutions for FOCs

A.1.1 Households' problem

HHs maximize the lifetime utility:

$$\max_{\{c_t, h_t, x_{t+1}, d_{i,t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\phi}}{1+\phi} \right) \qquad \sigma > 0,\ \phi > 0$$

subject to,

$$\begin{aligned} c_t + d_{t+1}N_t + v_t x_{t+1}(N_t + N_{E,t}) + \frac{\kappa}{2}(d_{t+1} - \bar{d})^2 N_t \\ \leq (1 + r_t) d_t N_t + w_t h_t + x_t N_t (v_t + \pi_t) + t_t \end{aligned}$$

Each HH takes $r_t, w_t, p_t^H, p_t^F, p_t$ as given and chooses $c_t, c_t^H, c_t^F, h_t, x_{t+1}$ and $d_{i,t+1}$

$$\begin{aligned} \mathcal{L} = & E_0 \sum_{t=0}^{\infty} \beta^t \Bigg[\left(\frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\phi}}{1+\phi} \right) + \lambda_t \bigg((1 + r_t) d_t N_t + w_t h_t + x_t N_t (v_t + \pi_t) + t_t \\ & - c_t - d_{t+1} N_t - v_t x_{t+1} (N_t + N_{E,t}) - \frac{\kappa}{2} (d_{t+1} - \bar{d})^2 N_t \bigg) \Bigg] \end{aligned}$$

FOCs:

$$\frac{\partial \mathcal{L}}{\partial c_t} = c_t^{-\sigma} - \lambda_t = 0 \tag{A.1}$$

$$\frac{\partial \mathcal{L}}{\partial h_t} = -\chi h_t^{\phi} + \lambda_t w_t = 0 \tag{A.2}$$

Using (23) and (24),

Consumption-Labor tradeoff:

$$\boxed{\frac{c_t^{-\sigma}}{\chi h_t^{\phi}} = \frac{1}{w_t}} \tag{A.3}$$

$$\frac{\partial \mathcal{L}}{\partial x_{t+1}} = -\lambda_t v_t (N_t + N_{E,t}) + \beta \lambda_{t+1} N_{t+1} (v_{t+1} + \pi_{t+1}) = 0$$

$$\implies -\lambda_t v_t (N_t + N_{E,t}) + \beta \lambda_{t+1} (1-\delta)(N_t + N_{E,t})(v_{t+1} + \pi_{t+1}) = 0$$

$$\implies v_t = \frac{\lambda_{t+1}}{\lambda_t} \beta (1-\delta)(v_{t+1} + \pi_{t+1}) \tag{A.4}$$

Using (23) in (26),

Euler Equation for share holdings:

$$\boxed{v_t = (1-\delta)\beta E_t \left[\left(\frac{c_{t+1}}{c_t} \right)^{-\sigma} (v_{t+1} + \pi_{t+1}) \right]} \tag{A.5}$$

$$\frac{\partial \mathcal{L}}{\partial d_{t+1}} = -\, \lambda_t (N_t + N_{E,t}) - \lambda_t \kappa (d_{t+1} - \bar{d})(N_t + N_{E,t}) + \beta \lambda_{t+1} (1 + r_{t+1}) N_{t+1} = 0$$

$$\implies (1-\delta)\beta E_t \Big[\lambda_{t+1} (1 + r_{t+1}) \Big] = \lambda_t \Big[1 + \kappa (d_{t+1} - \bar{d}) \Big] \tag{A.6}$$

Using (23) in (28),

Euler Equation for deposits:

$$\boxed{\beta E_t \left[\left(\frac{c_{t+1}}{c_t} \right)^{-\sigma} (1 + r_{t+1}) \right] = 1 + \kappa (d_{t+1} - \bar{d})} \tag{A.7}$$

Budget constraint:

$$\boxed{\begin{aligned} c_t + d_{t+1}N_t + v_t x_{t+1}(N_t + N_{E,t}) + \frac{\kappa}{2}(d_{t+1} - \bar{d})^2 N_t =& (1 + r_t)d_t N_t + w_t h_t \\ &+ x_t N_t(v_t + \pi_t) + t_t \end{aligned}} \tag{A.8}$$

A.1.2 Firms' problem

Firms maximize the real profit:

$$\rho_t^H Z_t y_t - w_t h_t + L_{t+1} - (1 + R_{t+1}^L)L_{t+1}$$

subject to,

$$y_t = Z_t h_t \qquad \text{(production function)}$$

$$L_{t+1} = w_t h_t \qquad \text{(composite loan demand)}$$

$$\mathcal{L} = \rho_t^H Z_t h_t - w_t h_t + w_t h_t - (1 + R_{t+1}^L)L_{t+1}$$

$$\frac{\partial \mathcal{L}}{\partial h_t} = \rho_t^H Z_t - (1 + R_{t+1}^L)w_t = 0$$

$$\boxed{\rho_t^H = (1 + R_{t+1}^L)\frac{w_t}{Z_t}} \tag{A.9}$$

$$\text{where, composite loan rate: } R_{t+1}^L = \left[\Sigma_{i=1}^{N_t}(r_{i,t+1}^l)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$$

$$\boxed{y_t = Z_t h_t} \tag{A.10}$$

$$\boxed{L_{t+1} = w_t h_t} \tag{A.11}$$

$$\text{Loan demand from bank } i\text{: } \boxed{l_{i,t+1} = \left(\frac{r_{i,t+1}^l}{R_{t+1}^L}\right)^{-\epsilon} L_{t+1}} \tag{A.12}$$

A.1.3 Bank's problem

The bank takes r_t, r_t^*, R_t^L, Q_t as given and chooses the loan rate, $r_{i,t}^l$; the foreign borrowing, $d_{i,t}^*$ and domestic deposits, $d_{i,t}$ to maximize the discounted sum of profits.

$$\max_{\{r_{i,t+1}^l, d_{i,t+1}^*, d_{i,t+1}\}} E_t \sum_{s=t+1}^{\infty} \left(\frac{c_s}{c_t}\right)^{-\sigma} [\beta(1-\delta)]^{s-t} \pi_{i,s}$$

subject to,

$$l_{i,s+1} \leq d_{i,s+1} + Q_s d_{i,s+1}^* \qquad \text{(Balance Sheet Constraint)}$$

$$Q_s d_{i,s+1}^* \leq \theta x_{i,s} v_{i,s} \qquad \text{(Collateral Constraint)}$$

$$l_{i,s+1} = \left(\frac{r_{i,s+1}^l}{R_{s+1}^L}\right)^{-\epsilon} L_{s+1} \qquad \text{(Loan demand)}$$

where cash flows each period are:

$$\begin{aligned} \pi_{i,t} =& d_{i,t+1} + Q_t d_{i,t+1}^* - (1+r_t) d_{i,t} - (1+r_t^*) Q_t d_{i,t}^* \\ &+ (1+r_{i,t}^l) l_{i,t} - l_{i,t+1} \end{aligned} \tag{A.13}$$

and bank value is given by:

$$v_{i,t} = E_t \sum_{s=t+1}^{\infty} \left(\frac{c_s}{c_t}\right)^{-\sigma} [\beta(1-\delta)]^{s-t} \pi_{i,s} \tag{A.14}$$

$$\begin{aligned} \mathcal{L} = E_t(1-\delta)\Lambda_{t,t+1}\Big[&(1+r_{i,t+1}^l) l_{i,t+1} - (1+r_{t+1}) d_{i,t+1} - (1+r_{t+1}^*) Q_{t+1} d_{i,t+1}^* + d_{i,t+2} + Q_s d_{i,t+2}^* \\ &- l_{i,t+2}\Big] + \lambda_t\Big(d_{i,s+1} + Q_s d_{i,s+1}^* - l_{i,s+1}\Big) + \mu_t\Big(\theta x_{i,t} v_{i,t} - Q_s d_{i,s+1}^*\Big) \end{aligned}$$

$$\frac{\partial \mathcal{L}}{\partial d_{i,t+1}} = -(1-\delta) E_t \Lambda_{t,t+1}(1+r_{t+1}) + \mu_t \theta x_t \frac{\partial v_{i,t}}{\partial d_{i,t+1}} + \lambda_t = 0$$

$$\text{Using (14), } \frac{\partial v_{i,t}}{\partial d_{i,t+1}} = -(1-\delta) E_t \Lambda_{t,t+1}(1+r_{t+1})$$

$$\implies \boxed{\lambda_t = (1-\delta) E_t \Lambda_{t,t+1}(1+r_{t+1})(1+\mu_t x_t \theta)} \tag{A.15}$$

$$\frac{\partial \mathcal{L}}{\partial r^l_{i,t+1}} = (1-\delta)E_t\Lambda_{t,t+1}\left(l_{i,t+1} + r^l_{i,t+1}\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}} + \frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}\right) - \lambda_t\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}} + \mu_t x_t \theta \frac{\partial v_{i,t}}{\partial r^l_{i,t+1}} = 0$$

$$\text{Using (36), } \frac{\partial v_{i,t}}{\partial r^l_{i,t+1}} = (1-\delta)E_t\Lambda_{t,t+1}\left(l_{i,t+1} + r^l_{i,t+1}\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}} + \frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}\right)$$

$$\implies -\lambda_t\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}} + (1+\mu_t x_t\theta)(1-\delta)E_t\Lambda_{t,t+1}\left(l_{i,t+1} + r^l_{i,t+1}\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}} + \frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}\right) = 0 \quad \text{(A.16)}$$

$$\begin{aligned}
\text{Using (A.12), } \frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}} &= -\epsilon\frac{(r^l_{i,s+1})^{-\epsilon-1}}{(R^L_{i,s+1})^{-\epsilon}}L_{s+1} + \epsilon\frac{(r^l_{i,s+1})^{-\epsilon}}{(R^L_{i,s+1})^{-\epsilon+1}}L_{s+1}\frac{\partial R^L_{i,s+1}}{\partial r^l_{i,s+1}} \\
&= -\epsilon\left(\frac{r^l_{i,s+1}}{R^L_{i,s+1}}\right)^{-\epsilon}\frac{L_{s+1}}{r^l_{i,s+1}} + \epsilon\left(\frac{r^l_{i,s+1}}{R^L_{i,s+1}}\right)^{-\epsilon}\frac{L_{s+1}}{R^L_{i,s+1}}\left(\frac{r^l_{i,s+1}}{R^L_{i,s+1}}\right)^{-\epsilon} \\
&= -\epsilon\left(\frac{l_{i,s+1}}{L_{i,s+1}}\right)\frac{L_{s+1}}{r^l_{i,s+1}} + \epsilon\left(\frac{l_{i,s+1}}{L_{i,s+1}}\right)\frac{L_{s+1}}{R^L_{i,s+1}}\left(\frac{l_{i,s+1}}{L_{i,s+1}}\right)\frac{r^l_{i,t+1}}{r^l_{i,t+1}} \\
\implies \frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}} &= \frac{\epsilon l_{i,t+1}}{r^l_{i,t+1}}\left(\frac{l_{i,t+1}r^l_{i,t+1}}{R^L_{t+1}L_{t+1}} - 1\right) = \frac{\epsilon l_{i,t+1}}{r^l_{i,t+1}}(\alpha_{i,t}-1) \qquad \text{(A.17)}
\end{aligned}$$

Using (39) in (38)

$$\implies \frac{\epsilon l_{i,t+1}}{r^l_{i,t+1}}(\alpha_{i,t}-1)\left(-\lambda_t + (1+\mu_t x_t\theta)(1-\delta)E_t\Lambda_{t,t+1}(1+r^l_{i,t+1})\right) = -(1+\mu_t x_t\theta)(1-\delta)E_t\Lambda_{t,t+1}l_{i,t+1}$$

$$\implies r^l_{i,t+1}\left([\epsilon(\alpha_{i,t}-1)+1][(1-\delta)E_t\Lambda_{t,t+1}(1+\mu_t x_t\theta)]\right) = \epsilon(\alpha_{i,t}-1)\left(\lambda_t - (1-\delta)E_t\Lambda_{t,+1}(1+\mu_t x_t\theta)\right)$$

$$\implies r^l_{i,t+1} = \frac{\epsilon(\alpha_{i,t}-1)}{\epsilon(\alpha_{i,t}-1)+1}\left[\frac{\lambda_t - (1-\delta)E_t\Lambda_{t,t+1}(1+\mu_t x_t\theta)}{(1-\delta)E_t\Lambda_{t,t+1}(1+\mu_t x_t\theta)}\right] \qquad \text{(A.18)}$$

Using (37) in (40):

$$\implies \boxed{r^l_{i,t+1} = \frac{\epsilon(\alpha_{i,t}-1)}{\epsilon(\alpha_{i,t}-1)+1}r_{t+1}} \qquad \text{(A.19)}$$

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial d^*_{i,t+1}} &= -(1-\delta)E_t\Lambda_{t,t+1}(1+r^*_{t+1})Q_{t+1} + \lambda_t Q_t + \mu_t\theta x_t\frac{\partial v_{i,t}}{\partial d^*_{i,t+1}} - \mu_t Q_t = 0 \\
&\implies (1-\delta)E_t\Lambda_{t,t+1}\left(\frac{Q_{t+1}}{Q_t}\right)(1+r^*_{t+1})(1+\mu_t\theta x_t) = \lambda_t - \mu_t \qquad \text{(A.20)}
\end{aligned}$$

Using (37) in (42):

$$\boxed{(1-\delta)E_t\Lambda_{t,t+1}\left(\frac{Q_{t+1}}{Q_t}\right)(1+r^*_{t+1})(1+\mu_t\theta x_t) = (1-\delta)E_t\Lambda_{t,t+1}(1+r_{t+1})(1+\mu_t\theta x_t) - \mu_t} \tag{A.21}$$

$$\frac{\partial\mathcal{L}}{\partial\mu_{i,t}} \geq 0: \qquad Q_s d^*_{i,s+1} \leq \theta x_{i,t} v_{i,t}$$

$$\mu_{i,t} \geq 0$$

$$\mu_{i,t}\frac{\partial\mathcal{L}}{\partial\mu_{i,t}} = 0: \quad \mu_{i,t}\left(\theta x_{i,t} v_{i,t} - Q_t d^*_{i,t+1}\right) = 0$$

If collateral constraint **does not bind**, $\implies \mu_{i,t} = 0$

If collateral constraint **binds**, such that $Q_t d^*_{i,t+1} = \theta x_{i,t} v_{i,t} \implies \mu_{i,t} > 0$

$$\frac{\partial\mathcal{L}}{\partial\lambda_{i,t}} \geq 0: \qquad l_{i,s+1} \leq d_{i,t+1} + Q_s d^*_{i,t+1}$$

$$\lambda_{i,t} \geq 0$$

$$\lambda_{i,t}\frac{\partial\mathcal{L}}{\partial\lambda_{i,t}} = 0: \quad \lambda_{i,t}\left(d_{i,t+1} + Q_t d^*_{i,t+1} - l_{i,t+1}\right) = 0$$

If collateral constraint **does not bind**, then using $\mu_{i,t} = 0$, $r_{i,t} = r^*_{i,t}$ from policy rule

If collateral constraint **binds**, such that $Q_t d^*_{i,t+1} = \theta x_{i,s} v_{i,t}$

$\implies l_{i,s+1} = d_{i,t+1} + \theta x_{i,t} v_{i,t}$

A.1.4 Central Bank

$$1 + r_{t+1} = \left(1 + r^*_{t+1} + f(\mu_{i,t})\right)\left(1 + \frac{y_t - y}{y}\right)^{e_y}\left(1 + \frac{Q_t - Q}{Q}\right)^{e_q} \tag{A.22}$$

A.2 Detailed solutions for steady state

A.2.1 Non-Binding Case

$$\mu = 0$$

$$\text{Using (A.22): } r = r^*$$

$$\text{Home Euler: } \beta(1+r) = 1 + \kappa(d - \bar{d})$$

$$\text{Foreign Euler: } \beta(1+r) = 1 + \kappa(d^F - \bar{d^F})$$

d^F are foreigners' deposits in domestic banks.

Assuming foreign deposits in domestic banks to be negative ($\simeq 0$ for small open economy)

Thus, global supply of deposits by home banks = 0.

$\implies ad + (1-a)d^F = 0.$

$$\implies \beta(1+r) = 1 + \kappa[ad + (1-a)d^F - a\bar{d} - (1-a)\bar{d^F}]$$

$$\implies \beta(1+r) = 1$$

$$\implies d = \bar{d}$$

$$\text{Using (A.7), } r = \frac{1-\beta}{\beta}$$

$$\text{Market share, } \alpha = \frac{1}{N}$$

$$\text{Using (18): } N_E = \frac{\delta N}{(1-\delta)}$$

$$\text{Using (A.19), } r^l = \left(\frac{\epsilon(N-1)}{\epsilon(N-1)-N}\right)r$$

$$\text{Using (A.1.2), } R^L = N^{\frac{1}{1-\epsilon}} r^l$$

$$\text{Using (A.12), } l = N^{\frac{\epsilon}{1-\epsilon}} L$$

$$\text{Using (A.11), } L = wy$$

$$Q = \rho^H = (1+R^L)\frac{w}{Z}$$

$$\text{Using (A.5): } v = (1-\delta)\beta(v+\pi)$$

$$\implies v = \frac{(1-\delta)\beta}{1-(1-\delta)\beta}\pi$$

$$\text{Using (2.4): } v = \frac{f^E w}{Z}$$

$$\implies \pi = \frac{f^E w}{Z}\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) \tag{1a}$$

Step 1: Using (A.8), HH budget constraint:

$$c + dN + vx(N + N_E) = (1+r)dN + wh + xN(v+\pi)$$

$$\implies c + \bar{d}N + vN_E = rN\bar{d} + wh + N\pi$$

$$\text{Put } \bar{d} = 0 \implies c + vN_E = wh + N\pi$$

$$\implies c = wh + \frac{Nwf^E}{Z}\left(r + \frac{\delta}{1-\delta}r\right)$$

$$\implies c = wh + \frac{wf^E}{Z}\left(\frac{1-\beta}{\beta} - \frac{\delta}{1-\delta}\frac{1-\beta}{\beta}\right)$$

$$\implies c = wh + N\frac{wf^E}{Z}\left(\frac{1-\beta-\delta+\delta\beta+\delta-\delta\beta}{(1-\delta)\beta}\right)$$

$$\implies c = wh + N\frac{wf^E}{Z}\left(\frac{1-\beta}{(1-\delta)\beta}\right)$$

$$\text{Using (A.3): } \implies \frac{w}{\chi h} = wh + N\frac{wf^E}{Z}\left(\frac{1-\beta}{(1-\delta)\beta}\right)$$

$$\implies \frac{1}{\chi h} = h + \frac{Nf^E}{Z}\left(\frac{1-\beta}{(1-\delta)\beta}\right)$$

$$\implies \chi h^2 + \frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)}h - 1 = 0$$

$$\implies h = \frac{-\frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)} + \sqrt{\left(\frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)}\right)^2 + 4\chi}}{2\chi} \text{ (ignore the negative root)} \tag{\textbf{I}}$$

Step 2: loan supply = loan demand

$$\bar{d} + Q\bar{d}^* = l = \left(\frac{r^l}{N^{\frac{1}{1-\epsilon}} r^l}\right)^{-\epsilon} \frac{wy}{Z}$$

$$\implies \bar{d} + Q\bar{d}^* = N^{\frac{\epsilon}{1-\epsilon}} \frac{wy}{Z} \tag{1b}$$

$$\begin{aligned}
\text{Using (A.13): } \pi &= d + Qd^* - (1+r)d + \frac{\kappa}{2}(d-\bar{d})^2 - (1+r^*)Qd^* + (1+r^l)l - l \\
\implies \pi &= r^l l - r\bar{d} - r^* Q\bar{d}^* \\
\text{Since, } r = r^* \implies \pi &= (r^l - r)(\bar{d} + Q\bar{d}^*) \\
&= \left(\frac{\epsilon(N-1)r}{\epsilon(N-1)-N} - r\right)(\bar{d} + Q\bar{d}^*) \\
\pi &= \left(\frac{N}{\epsilon(N-1)-N}\right) r(\bar{d} + Q\bar{d}^*)
\end{aligned} \tag{1c}$$

$$\begin{aligned}
\text{Using (1a), (1b) and (1c): } \frac{f^E w}{Z}\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) &= \left(\frac{Nr}{\epsilon(N-1)-N}\right)\left(N^{\frac{\epsilon}{1-\epsilon}} \frac{wy}{Z}\right) \\
\implies f^E\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) &= \left(\frac{N^{\frac{1}{1-\epsilon}}}{\epsilon(N-1)-N}\right) y \\
\implies y &= \left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right)(\epsilon(N-1)-N) N^{\frac{1}{\epsilon-1}} f^E
\end{aligned} \tag{1d}$$

Step 3: Labor Supply = Labor Demand

$$h = \frac{y}{Z} + \frac{\delta N}{1-\delta}\frac{f^E}{Z}$$

Using (1d) and(**I**):

$$\frac{-\frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)} + \sqrt{\left(\frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)}\right)^2 + 4\chi}}{2\chi} = \left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right)(\epsilon(N-1)-N) N^{\frac{1}{\epsilon-1}} \frac{f^E}{Z} + \frac{\delta N}{1-\delta}\frac{f^E}{Z} \tag{II}$$

Solving (**II**) for $\bar{N}$

Step 4: Home Good Supply = Home Good Demand

$$y = c^H + c^{H*}$$

$$\text{Using (M14): } y = \gamma\left[(1+R^L)\frac{w}{Z}\right]^{-\eta} c + c^{H*}$$

$$y = \gamma\left[(1+R^L)\frac{w}{Z}\right]^{-\eta} \frac{w}{\chi h} + c^{H*}$$

$$w = \left[\frac{(y - c^{H*})(1+R^L)^{\eta}\chi Z^{-\eta} h}{\gamma}\right]^{\frac{1}{1-\eta}} \quad \textbf{(III)}$$

Using the SS values to find other variables:

$$\bar{Q} = \frac{(1+\bar{R}^L)\bar{w}}{\rho^{H*}}$$

$$\bar{d} + \bar{Q}\bar{d}^* = \bar{l} \implies \bar{d}^* = \frac{\bar{l} - \bar{d}}{\bar{Q}}$$

A.2.2 Binding Case

Step 1: Bank Entry

$$\text{Using (A.13): } \pi = d + Qd^* - (1+r)d - (1+r^*)Qd^* + (1+r^l)l - l$$

$$\implies \pi = r^l l - r\bar{d} - r^* Q\bar{d}^*$$

$$\implies \pi = r^l(\bar{d} + \theta v) - r\bar{d} - r^*\theta v$$

$$\implies \pi = (r^l - r)\bar{d} + (r^l - r^*)\theta v$$

$$\implies \pi = \left(\frac{\epsilon(N-1)r}{\epsilon(N-1)-N} - r\right)\bar{d} + \left(\frac{\epsilon(N-1)r}{\epsilon(N-1)-N} - r^*\right)\theta v$$

$$\pi = \left(\frac{N}{\epsilon(N-1)-N}\right)r\bar{d} + \left(\frac{\epsilon(N-1)r}{\epsilon(N-1)-N} - r^*\right)\theta v \quad (2c)$$

Using (2c):

$$f^E w\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) = \left(\frac{N}{\epsilon(N-1)-N}\right)r\bar{d} + \left(\frac{\epsilon(N-1)r}{\epsilon(N-1)-N} - r^*\right)\theta w f^E$$

$$\text{Put } \bar{d} = 0 \implies f^E w\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) = \left(\frac{\epsilon(N-1)r}{\epsilon(N-1)-N} - r^*\right)\theta w f^E$$

$$\implies N\left((\epsilon-1)(1-\delta)\beta[r+\theta r^*] + (\epsilon-1)\delta - (1-\delta)\beta\theta\epsilon r\right) =$$

$$(1-\delta)\beta\epsilon[r-\theta(r-r^*)] + \epsilon\delta$$

$$\implies N = \frac{(1-\delta)\beta\epsilon[r-\theta(r-r^*)] + \epsilon\delta}{(\epsilon-1)(1-\delta)\beta[r+\theta r^*] + (\epsilon-1)\delta - (1-\delta)\beta\theta\epsilon r} \tag{2d}$$

Step 2: loan supply = loan demand

$$\bar{d} + Q\bar{d}^* = l = \left(\frac{r^l}{N^{\frac{1}{1-\epsilon}} r^l}\right)^{-\epsilon} \frac{wy}{Z}$$

$$\implies \bar{d} + \theta v = N^{\frac{\epsilon}{1-\epsilon}} \frac{wy}{Z}$$

$$\text{Put } \bar{d} = 0 \implies y = \theta N^{\frac{\epsilon}{\epsilon-1}} f^E \tag{2b}$$

Labor Supply = Labor Demand

$$h = \frac{y}{Z} + \frac{\delta N}{1-\delta}\frac{f^E}{Z}$$

$$\text{Using (2b) } h = \theta N^{\frac{\epsilon}{\epsilon-1}} \frac{f^E}{Z} + \frac{\delta N}{1-\delta}\frac{f^E}{Z} \tag{\textbf{IB}}$$

Step 3: Using (A.8), HH budget constraint:

$$c + dN + vx(N + N_E) = (1+r)dN + wh + xN(v+\pi)$$

$$\implies c + \bar{d}N_E + vN_E = rN\bar{d} + wh + N\pi$$

$$\implies h = \frac{-\frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)} + \sqrt{\left(\frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)}\right)^2 + 4\chi}}{2\chi} \text{ (ignore the negative root)} \tag{\textbf{IIB}}$$

Set r^* using (**IB**) = (**IIB**)

Step 4: Home Good Supply = Home Good Demand

$$y = c^H + c^{H*}$$
$$w = \left[\frac{(y - c^{H*})(1 + R^L)^\eta \chi h Z^{-\eta}}{\gamma}\right]^{\frac{1}{1-\eta}} \qquad \textbf{(IIIB)}$$

$$1 = \left[\gamma(\rho_t^H)^{1-\eta} + (1-\gamma)(\rho_t^F)^{1-\eta}\right]^{\frac{1}{1-\eta}} \implies \rho^F = \frac{1 - \gamma(\rho^H)^{1-\eta}}{1-\gamma}$$

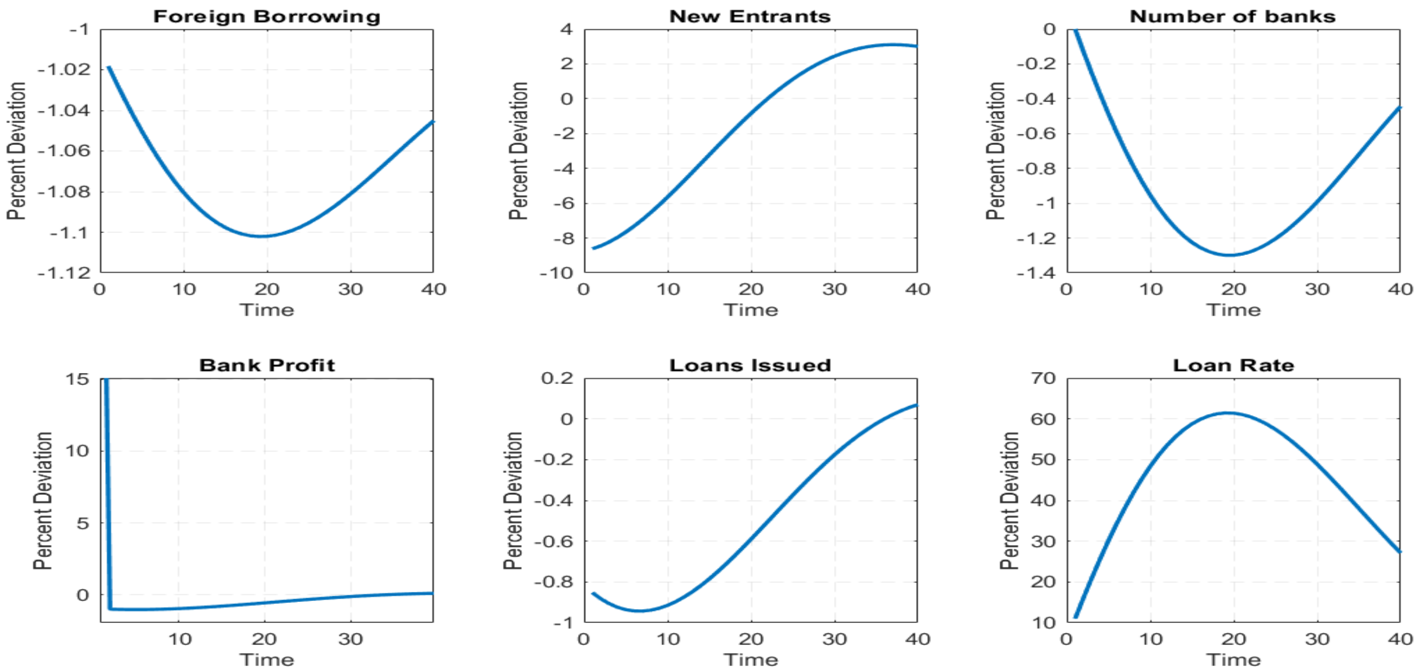
Using (A.21): $(1-\delta)\beta(1+r^*)(1+\mu\theta) = (1-\delta)\beta(1+r) - \mu$

$$\implies \mu = \frac{(1-\delta)(1-\beta-\beta r^*)}{1-\theta(1-\delta)(1-\beta-\beta r^*)}$$

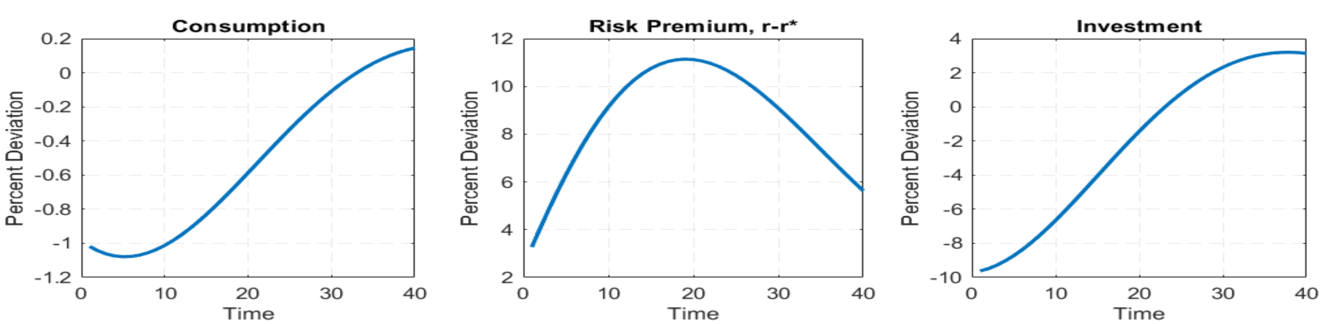
Using (A.22): $r = r^* + f(\mu)$ in (A.21)

$$\implies f(\mu) = \frac{\mu}{(1-\delta)\beta(1+\theta\mu)}$$

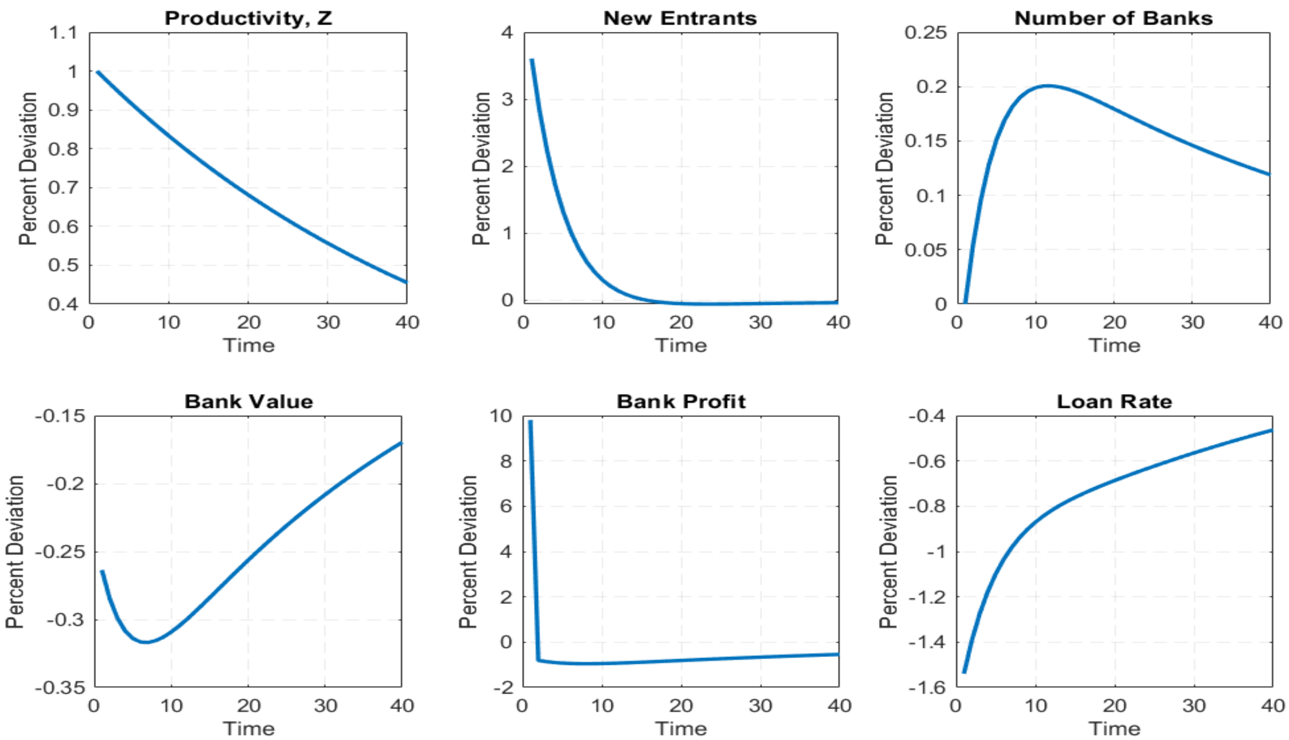
Impulse Responses in percent deviations



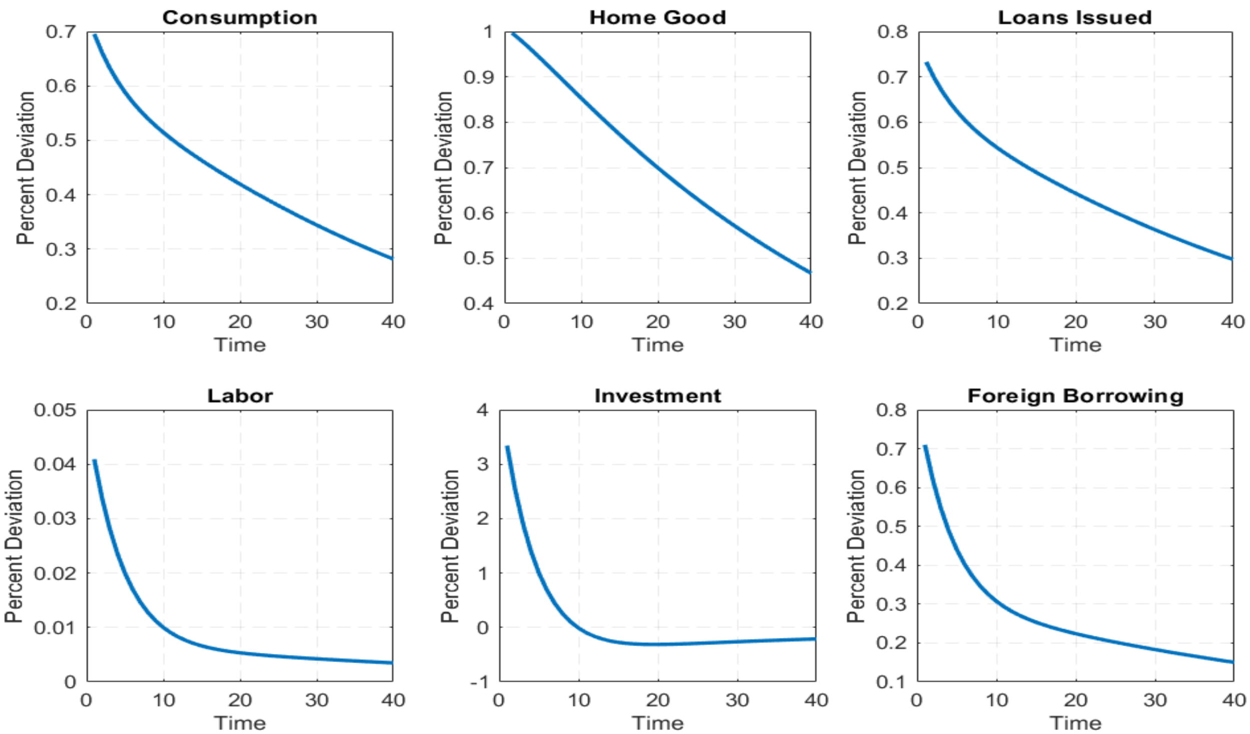
(a) **Responses I**



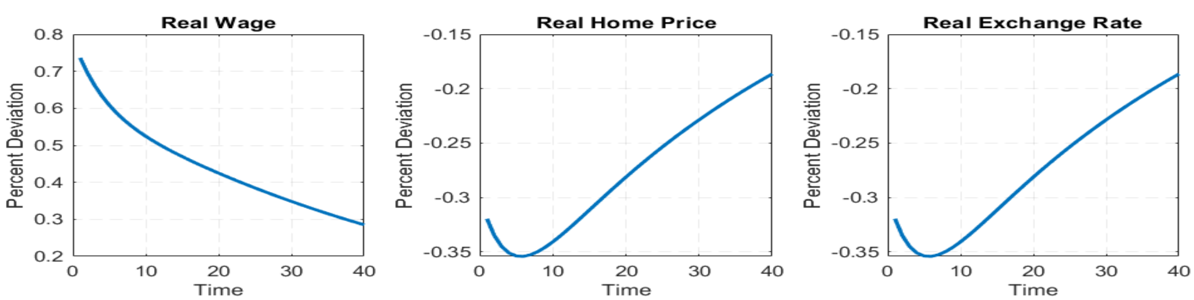
(b) **Responses II**



(a) **Responses I**

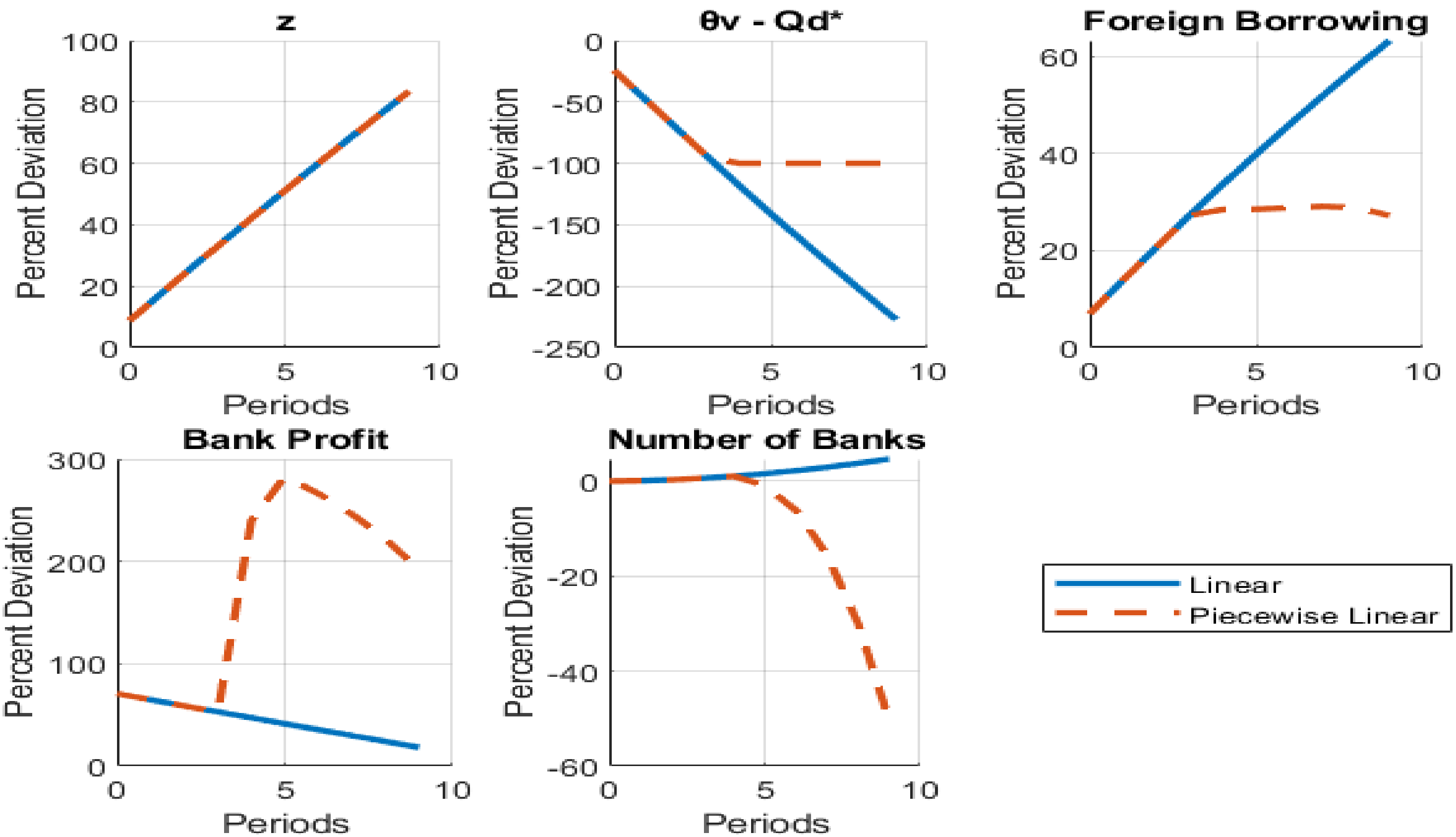


(b) **Responses II**

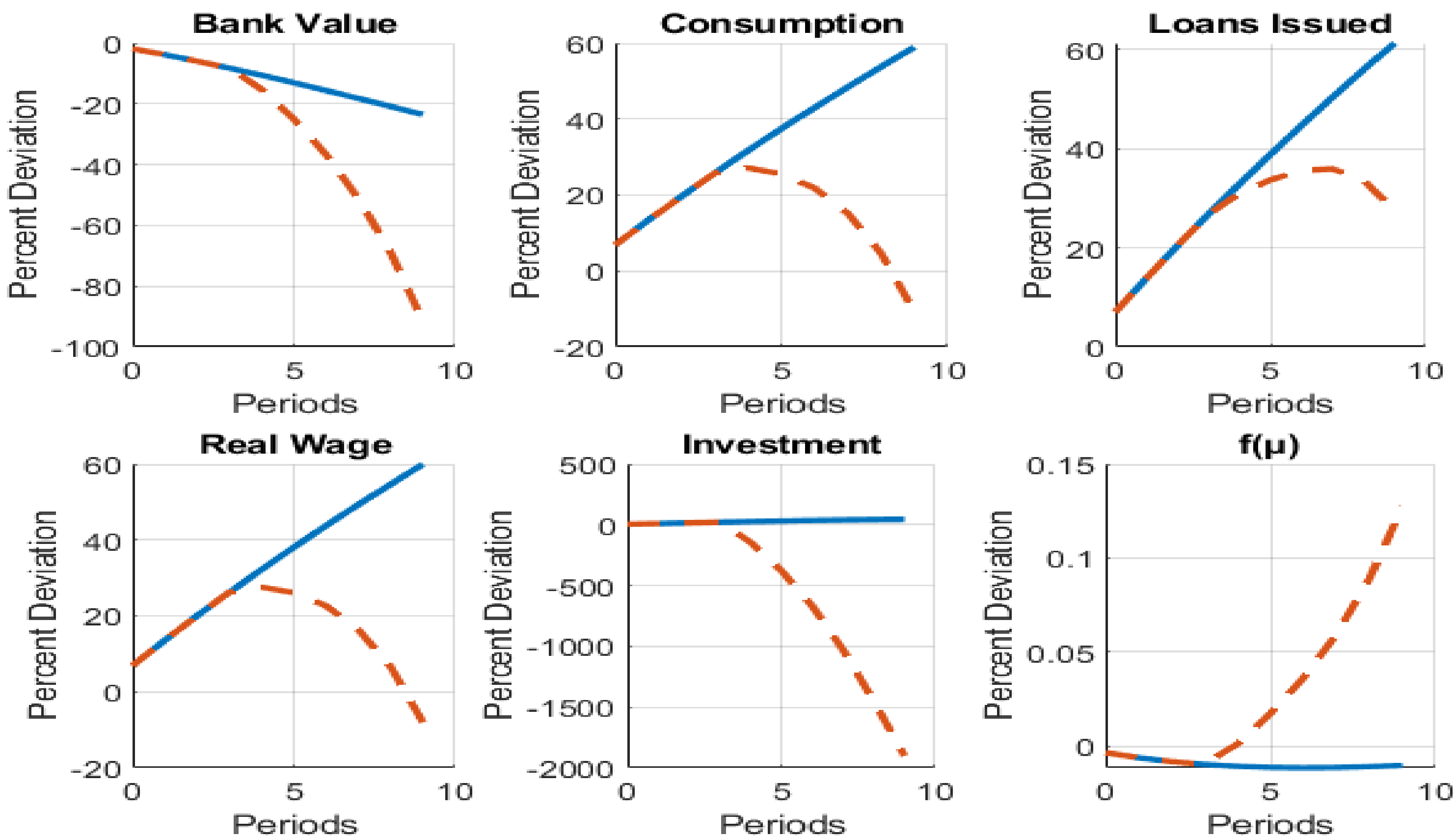


(c) **Responses III**

Figure A.2: **Technology Shock**



(a) **Responses I**



(a) **Responses II**

Figure A.4: **Technology Shock: Non-Linear Responses**

COUNTRIES	START	END
Brazil	2008 Q1	2008 Q4
	2011 Q3	2012 Q2
	2015 Q3	2016 Q1
Hungary	2009 Q2	2009 Q4
	2015 Q3	2016 Q2
	2018 Q1	2018 Q4
	2020 Q3	2021 Q1
Kenya	2008 Q4	2009 Q2
	2014 Q2	2014 Q4
	2020 Q3	2021 Q2
Venezuela	2007 Q3	2008 Q1
	2014 Q3	2015 Q1
	2018 Q1	2018 Q4

Table A.1: Sudden Stop Episodes

TYPE	COUNTRIES
Emerging	BRA, ARG,BGR, CHL, CHN COL, CZE, HRV, HUN, IDN, JOR, LBN, LTU, MEX, MYS, PER, PHL, ROU, THA, UKR URY, VEN, ZAF
Developing	AGO, ALB, BGD, BLR, BOL CIV, CRI, DOM, ECU, GAB, GTM, KEN, LKA, MAR, NAM, NGA, PAK, PNG, PRY, TTO VNM, JAM

Table A.2: 46 Emerging & Developing Economies

Appendix B

HETEROGENOUS BANKS

B.1 Detailed solutions for FOCs

B.1.1 Households' problem

HHs maximize the lifetime utility:

$$\max_{\{c_t, h_t, x_{t+1}, d_{i,t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\phi}}{1+\phi} \right) \qquad \sigma > 0,\ \phi > 0$$

subject to,

$$\begin{aligned} c_t + d_{t+1} N_{O,t} + \tilde{v}_t x_{t+1}(N_t + N_{E,t}) + \frac{\kappa}{2}(d_{t+1} - \bar{d})^2 (N_t + N_{E,t}) \\ \leq (1 + r_t) d_t N_{O,t} + w_t h_t + x_t N_t \tilde{v}_t + N_{O,t} \tilde{\pi}_t + t_t \quad (\textbf{HH Budget Constraint}) \end{aligned}$$

Each HH takes $r_t, w_t, p_t^H, p_t^F, p_t$ as given and chooses $c_t, c_t^H, c_t^F, h_t, x_{t+1}$ and $d_{i,t+1}$

$$\begin{aligned} \mathcal{L} =& E_0 \sum_{t=0}^{\infty} \beta^t \Bigg[\left(\frac{c_t^{1-\sigma}}{1-\sigma} - \chi \frac{h_t^{1+\phi}}{1+\phi} \right) + \lambda_t \Bigg((1 + r_t) d_t N_{O,t} + w_t h_t + x_t N_t \tilde{v}_t + x_t \pi_t N_{O,t} + t_t \\ & - c_t - d_{t+1} N_{O,t} - \tilde{v}_t x_{t+1}(N_t + N_{E,t}) - \frac{\kappa}{2}(d_{t+1} - \bar{d})^2 N_{O,t} \Bigg) \Bigg] \end{aligned}$$

FOCs:

$$\frac{\partial \mathcal{L}}{\partial c_t} = c_t^{-\sigma} - \lambda_t = 0 \tag{B.1}$$

$$\frac{\partial \mathcal{L}}{\partial h_t} = -\chi h_t^{\phi} + \lambda_t w_t = 0 \tag{B.2}$$

Consumption-Labor tradeoff:

$$\boxed{\frac{c_t^{-\sigma}}{\chi h_t^{\phi}} = \frac{1}{w_t}} \tag{B.3}$$

$$\frac{\partial \mathcal{L}}{\partial x_{t+1}} = -\lambda_t \tilde{v}_t (N_t + N_{E,t}) + \beta \lambda_{t+1} (N_{t+1} \tilde{v}_{t+1} + N_{O,t+1} \pi_{t+1}) = 0$$

$$\implies -\lambda_t \tilde{v}_t (N_t + N_{E,t}) + \beta \lambda_{t+1} (1-\delta)(N_t + N_{E,t})(\tilde{v}_{t+1} + (1 - G(\psi_{t+1}^c))\pi_{t+1}) = 0$$

$$\implies \tilde{v}_t = \frac{\lambda_{t+1}}{\lambda_t} \beta (1-\delta)(\tilde{v}_{t+1} + (1 - G(\psi_{t+1}^c))\pi_{t+1}) \tag{B.4}$$

Euler Equation for share holdings:

$$\boxed{\tilde{v}_t = (1-\delta)\beta E_t \left[\left(\frac{c_{t+1}}{c_t} \right)^{-\sigma} (\tilde{v}_{t+1} + [1 - G(\psi_{t+1}^c)]\pi_{t+1}) \right]} \tag{B.5}$$

$$\frac{\partial \mathcal{L}}{\partial d_{t+1}} = -\lambda_t N_{O,t} - \lambda_t \kappa (d_{t+1} - \bar{d}) N_{O,t} + \beta \lambda_{t+1} (1 + r_{t+1}) N_{O,t+1} = 0$$

$$\implies (1-\delta)\beta E_t \left[\lambda_{t+1} (1 + r_{t+1}) \right] = \lambda_t \left[1 + \kappa (d_{t+1} - \bar{d}) \right] \tag{B.6}$$

Euler Equation for deposits:

$$\boxed{\beta E_t \left[\left(\frac{c_{t+1}}{c_t} \right)^{-\sigma} (1 + r_{t+1}) \right] = 1 + \kappa (d_{t+1} - \bar{d})} \tag{B.7}$$

$$c_t + d_{t+1} N_{O,t} + \tilde{v}_t x_{t+1} (N_t + N_{E,t}) + \frac{\kappa}{2} (d_{t+1} - \bar{d})^2 (N_t + N_{E,t})$$
$$\leq (1 + r_t) d_t N_{O,t} + w_t h_t + x_t N_t \tilde{v}_t + N_{O,t} \tilde{\pi}_t + t_t \quad \textbf{(HH Budget Constraint)}$$

Budget constraint:

$$\boxed{\begin{aligned} c_t + d_{t+1}N_{O,t} + \tilde{v}_t x_{t+1}(N_t + N_{E,t}) + \frac{\kappa}{2}(d_{t+1} - \bar{d})^2(N_t + N_{E,t}) =& (1 + r_t)d_t N_{O,t} + w_t h_t \\ &+ x_t N_t \tilde{v}_t + N_{O,t}\tilde{\pi}_t + t_t \end{aligned}} \tag{B.8}$$

B.1.2 Firms' problem

Firms maximize the real profit:

$$\rho_t^H Z_t y_t - w_t h_t + \tilde{l}_{t+1} - (1 + \tilde{r}_{t+1}^l)\tilde{l}_{t+1}$$

subject to,

$$y_t = Z_t h_t \qquad \text{(production function)}$$

$$L_{t+1} = w_t h_t \qquad \text{(composite loan demand)}$$

$$\mathcal{L} = \rho_t^H Z_t h_t - w_t h_t + w_t h_t - (1 + \tilde{r}_{t+1}^l)\tilde{l}_{t+1}$$

$$\frac{\partial \mathcal{L}}{\partial h_t} = \rho_t^H Z_t - (1 + R_{t+1}^L)w_t = 0$$

$$\boxed{\rho_t^H = (1 + R_{t+1}^L)\frac{w_t}{Z_t}} \tag{B.9}$$

where, composite loan rate: $R_{t+1}^L = \left[\Sigma_{i=1}^{N_t}(r_{i,t+1}^l)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$

$$\boxed{y_t = Z_t h_t} \tag{B.10}$$

$$\boxed{\tilde{l}_{t+1} = w_t h_t} \tag{B.11}$$

Loan demand from bank i: $\boxed{l_{i,t+1} = \left(\frac{r_{i,t+1}^l}{\tilde{r}_{t+1}^l}\right)^{-\epsilon}\tilde{l}_{t+1}}$ (B.12)

B.1.3 Bank's problem

The bank takes r_t, r_t^*, R_t^L, Q_t as given and chooses the loan rate, $r_{i,t}^l$; the foreign borrowing, $d_{i,t}^*$ and domestic deposits, $d_{i,t}$ to maximize the discounted sum of profits.

$$\max_{\{r_{i,t+1}^l, d_{i,t+1}^*, d_{i,t+1}\}} E_t \sum_{s=t+1}^{\infty} \left(\frac{c_s}{c_t}\right)^{-\sigma} [\beta(1-\delta)]^{s-t}(1-G(\psi_s^c))\pi_{i,s}$$

subject to,

$$l_{i,s+1} \leq \psi_i(d_{i,s+1} + Q_s d_{i,s+1}^*) \qquad \text{(Balance Sheet Constraint)}$$

$$Q_s d_{i,s+1}^* \leq \theta x_{i,s} v_{i,s} \qquad \text{(Collateral Constraint)}$$

$$l_{i,s+1} = \left(\frac{r_{i,s+1}^l}{\tilde{r}_{s+1}^l}\right)^{-\epsilon} \tilde{l}_{s+1} \qquad \text{(Loan demand)}$$

where cash flows each period are:

$$\begin{aligned}\pi_{i,t}(\psi_i) =& d_{i,t+1} + Q_t d_{i,t+1}^* - (1+r_t)d_{i,t} - (1+r_t^*)Q_t d_{i,t}^* \\ &+ (1+r_{i,t}^l)l_{i,t} - l_{i,t+1} - \frac{f^O w_t}{Z}\end{aligned} \qquad \text{(B.13)}$$

and bank value is given by:

$$\tilde{v}_t = E_t \sum_{s=t+1}^{\infty} \left(\frac{c_s}{c_t}\right)^{-\sigma} [\beta(1-\delta)]^{s-t}[1-G(\psi_t^c)]\tilde{\pi}_{i,s} \qquad \text{(B.14)}$$

$$\begin{aligned}\mathcal{L} = E_t(1-\delta)\Lambda_{t,t+1}(1-G(\psi_s^c))\Bigg[&(1+r_{i,t+1}^l)l_{i,t+1} - (1+r_{t+1})d_{i,t+1} - (1+r_{t+1}^*)Q_{t+1}d_{i,t+1}^* + d_{i,t+2} + Q_s d_{i,t+2}^* \\ &- l_{i,t+2}\Bigg] + \lambda_t\Big(\psi_i d_{i,s+1} + \psi_i Q_s d_{i,s+1}^* - l_{i,s+1}\Big) + \mu_t\Big(\theta x_{i,t} v_{i,t} - Q_s d_{i,s+1}^*\Big)\end{aligned}$$

$$\frac{\partial \mathcal{L}}{\partial d_{i,t+1}} = -(1-\delta)E_t\Lambda_{t,t+1}(1-G(\psi_t^c))(1+r_{t+1}) + \mu_t\theta x_t \frac{\partial v_{i,t}}{\partial d_{i,t+1}} + \psi_i\lambda_t = 0$$

$$\text{Using } \frac{\partial v_{i,t}}{\partial d_{i,t+1}} = -(1-\delta)E_t\Lambda_{t,t+1}(1-G(\psi_t^c))(1+r_{t+1})$$

$$\implies \boxed{\lambda_t\psi_i = (1-\delta)E_t\Lambda_{t,t+1}[1-G(\psi_t^c)](1+r_{t+1})(1+\mu_t x_t\theta)} \qquad \text{(B.15)}$$

$$\frac{\partial \mathcal{L}}{\partial r^l_{i,t+1}} =(1-\delta)E_t\Lambda_{t,t+1}(1-G(\psi^c_t))\left(l_{i,t+1}+r^l_{i,t+1}\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}+\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}\right)-\lambda_t\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}+\mu_t x_t\theta\frac{\partial v_{i,t}}{\partial r^l_{i,t+1}}=0$$

$$\text{Using } \frac{\partial v_{i,t}}{\partial r^l_{i,t+1}}=(1-\delta)E_t\Lambda_{t,t+1}(1-G(\psi^c_t))\left(l_{i,t+1}+r^l_{i,t+1}\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}+\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}\right)$$

$$\implies -\lambda_t\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}+(1+\mu_t x_t\theta)(1-\delta)E_t\Lambda_{t,t+1}(1-G(\psi^c_t))\left(l_{i,t+1}+r^l_{i,t+1}\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}+\frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}}\right)=0 \tag{B.16}$$

$$\begin{aligned}\text{Using } \frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}} &=-\epsilon\frac{(r^l_{i,s+1})^{-\epsilon-1}}{(\tilde{r}^l_{i,s+1})^{-\epsilon}}\tilde{l}_{s+1}+\epsilon\frac{(r^l_{i,s+1})^{-\epsilon}}{(\tilde{r}^l_{i,s+1})^{-\epsilon+1}}\tilde{l}_{s+1}\frac{\partial\tilde{r}^l_{i,s+1}}{\partial r^l_{i,s+1}}\\
&=-\epsilon\left(\frac{r^l_{i,s+1}}{\tilde{r}^l_{i,s+1}}\right)^{-\epsilon}\frac{\tilde{l}_{s+1}}{r^l_{i,s+1}}+\epsilon\left(\frac{r^l_{i,s+1}}{\tilde{r}^l_{i,s+1}}\right)^{-\epsilon}\frac{\tilde{l}_{s+1}}{\tilde{r}^l_{i,s+1}}\left(\frac{r^l_{i,s+1}}{\tilde{r}^l_{i,s+1}}\right)^{-\epsilon}\\
&=-\epsilon\left(\frac{l_{i,s+1}}{\tilde{l}_{i,s+1}}\right)\frac{\tilde{l}_{s+1}}{r^l_{i,s+1}}+\epsilon\left(\frac{l_{i,s+1}}{\tilde{l}_{i,s+1}}\right)\frac{\tilde{l}_{s+1}}{\tilde{r}^l_{i,s+1}}\left(\frac{l_{i,s+1}}{\tilde{l}_{i,s+1}}\right)\frac{r^l_{i,t+1}}{r^l_{i,t+1}}\end{aligned}$$

$$\implies \frac{\partial l_{i,t+1}}{\partial r^l_{i,t+1}} =\frac{\epsilon l_{i,t+1}}{r^l_{i,t+1}}\left(\frac{l_{i,t+1}r^l_{i,t+1}}{\tilde{r}^l_{t+1}\tilde{l}_{t+1}}-1\right)=\frac{\epsilon l_{i,t+1}}{r^l_{i,t+1}}(\alpha_{i,t}-1) \tag{B.17}$$

$$\implies r^l_{i,t+1}=\frac{\epsilon(\alpha_{i,t}-1)}{\epsilon(\alpha_{i,t}-1)+1}\left[\frac{\lambda_t-(1-\delta)E_t\Lambda_{t,t+1}(1-G(\psi^c_t))(1+\mu_t x_t\theta)}{(1-\delta)E_t\Lambda_{t,t+1}(1-G(\psi^c_t))(1+\mu_t x_t\theta)}\right] \tag{B.18}$$

$$\implies \boxed{r^l_{i,t+1}=\frac{\epsilon(\alpha_{i,t}-1)}{\epsilon(\alpha_{i,t}-1)+1}\left(\frac{1+r_{t+1}}{\psi_i}-1\right)} \tag{B.19}$$

$$\frac{\partial \mathcal{L}}{\partial d^*_{i,t+1}} =-(1-\delta)[1-G(\psi^c_t)]E_t\Lambda_{t,t+1}(1+r^*_{t+1})Q_{t+1}+\lambda_t\psi_i Q_t+\mu_t\theta x_t\frac{\partial v_{i,t}}{\partial d^*_{i,t+1}}-\mu_t Q_t=0$$

$$\implies (1-\delta)E_t[1-G(\psi^c_t)]\Lambda_{t,t+1}\left(\frac{Q_{t+1}}{Q_t}\right)(1+r^*_{t+1})(1+\mu_t\theta x_t)=\lambda_t-\mu_t \tag{B.20}$$

$$\boxed{\begin{aligned}(1-\delta)[1-G(\psi^c_t)]E_t\Lambda_{t,t+1}\left(\frac{Q_{t+1}}{Q_t}\right)(1+r^*_{t+1})(1+\mu_t\theta x_t) =&(1-\delta)[1-G(\psi^c_t)]E_t\Lambda_{t,t+1}(1+r_{t+1})(1+\mu_t\theta x_t)\\ &-\mu_t\end{aligned}} \tag{B.21}$$

$$\frac{\partial \mathcal{L}}{\partial \mu_{i,t}}\geq 0: \qquad Q_s d^*_{i,s+1}\leq\theta x_{i,t}v_{i,t}$$

$$\mu_{i,t} \geq 0$$

$$\mu_{i,t}\frac{\partial \mathcal{L}}{\partial \mu_{i,t}} = 0: \quad \mu_{i,t}\Big(\theta x_{i,t}v_{i,t} - Q_t d^*_{i,t+1}\Big) = 0$$

If collateral constraint **does not bind**, $\implies \mu_{i,t} = 0$

If collateral constraint **binds**, such that $Q_t d^*_{i,t+1} = \theta x_{i,t}v_{i,t} \implies \mu_{i,t} > 0$

If collateral constraint **does not bind**, then using $\mu_{i,t} = 0$, $r_{i,t} = r^*_{i,t}$ from policy rule

If collateral constraint **binds**, such that $Q_t d^*_{i,t+1} = \theta x_{i,s}v_{i,t}$

$\implies l_{i,s+1} = \psi_i d_{i,t+1} + \psi\theta x_{i,t}v_{i,t}$

B.1.4 Central Bank

$$1 + r_{t+1} = \Big(1 + r^*_{t+1} + f(\mu_{i,t})\Big)\Big(1 + \frac{y_t - y}{y}\Big)^{e_y}\Big(1 + \frac{Q_t - Q}{Q}\Big)^{e_q} \tag{B.22}$$

B.2 Detailed solutions for steady state

B.2.1 Non-Binding Case

$$\mu = 0$$

$$r = r^*$$

$$\text{Home Euler: } \beta(1 + r) = 1 + \kappa(d - \bar{d})$$

$$\text{Foreign Euler: } \beta(1 + r) = 1 + \kappa(d^F - \bar{d^F})$$

d^F are foreigners' deposits in domestic banks.

Assuming foreign deposits in domestic banks to be negative ($\simeq 0$ for small open economy)

Thus, global supply of deposits by home banks = 0.

$\implies ad + (1 - a)d^F = 0.$

$$\implies \beta(1 + r) = 1 + \kappa[ad + (1 - a)d^F - a\bar{d} - (1 - a)\bar{d^F}]$$

$$\implies \beta(1 + r) = 1$$

$$\implies d = \bar{d}$$

$$
\begin{aligned}
r &= \frac{1-\beta}{\beta} \\
\alpha &= \frac{1}{N_O} \\
N_E &= \frac{\delta N}{(1-\delta)} \\
N_O &= \left(\frac{\psi_{min}}{\psi^c}\right)^k N \\
\tilde{r}^l &= \frac{\epsilon(N_O-1)}{\epsilon(N_O-1)-N_O}\left(\frac{1+r-\nu\psi^c}{\nu\psi^c}\right) \\
\tilde{R}^L &= N_O^{\frac{1}{1-\epsilon}}\tilde{r}^l \\
\tilde{L} &= N_O^{\frac{\epsilon}{1-\epsilon}}\tilde{l} \\
\tilde{L} &= wy \\
Q &= \rho^H = (1+\tilde{R}^L)\frac{w}{Z}
\end{aligned}
$$

$$
\begin{aligned}
&\tilde{v} = (1-\delta)\beta(\tilde{v} + (1-G(\psi^c))\tilde{\pi}) \\
\implies &\tilde{v} = \frac{(1-\delta)\beta}{1-(1-\delta)\beta}\left(\frac{\psi_{min}}{\psi^c}\right)^k \tilde{\pi} \\
&\tilde{v} = \frac{f^E w}{Z} \\
\implies &\tilde{\pi} = \frac{f^E w}{Z}\left(\frac{\psi_{min}}{\psi^c}\right)^{-k}\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right)
\end{aligned}
$$

Step 1: Using HH budget constraint: $c + dN_O + \tilde{v}x(N+N_E) = (1+r)dN_O + wh + xN\tilde{v} + N_O\tilde{\pi}$

$$\implies c + \tilde{v}N_E = rN_O\bar{d} + wh + N_O\tilde{\pi}$$

Put $\bar{d} = 0 \implies c + \tilde{v}N_E = wh + N_O\tilde{\pi}$

$$\implies c = wh + N_O\frac{f^E w}{Z}\left(\frac{\psi_{min}}{\psi^c}\right)^{-k}\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) - \frac{f^E w}{Z}N_E$$

$$\implies c = wh + [1 - G(\psi^c)]N\frac{f^E w}{Z}\left(\frac{\psi_{min}}{\psi^c}\right)^{-k}\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) - \frac{f^E w}{Z}\frac{\delta}{1-\delta}N$$

$$\implies c = wh + \left(\frac{\psi_{min}}{\psi^c}\right)^{k}N\frac{f^E w}{Z}\left(\frac{\psi_{min}}{\psi^c}\right)^{-k}\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) - \frac{f^E w}{Z}\frac{\delta}{1-\delta}N$$

$$\implies \frac{w}{\chi h} = wh + N\frac{wf^E}{Z}\left(\frac{1-\beta}{(1-\delta)\beta}\right)$$

$$\implies \frac{1}{\chi h} = h + \frac{Nf^E}{Z}\left(\frac{1-\beta}{(1-\delta)\beta}\right)$$

$$\implies \chi h^2 + \frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)}h - 1 = 0$$

$$\implies h = \frac{-\frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)} + \sqrt{\left(\frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)}\right)^2 + 4\chi}}{2\chi} \text{ (ignore the negative root)}$$

$$\text{Labor Supply} = \text{Labor Demand}$$

$$h = \frac{y}{Z} + \frac{\delta}{1-\delta}\left(\frac{\psi^c}{\psi_{min}}\right)^k N_O\frac{f^E}{Z} + \frac{N_O f^O}{Z}$$

$$\frac{-\frac{(1-\beta)N_O(\psi^c)^k f^E\chi}{Z\beta(1-\delta)} + \sqrt{\left(\frac{(1-\beta)N_O(\psi^c)^k f^E\chi}{Z\beta(1-\delta)}\right)^2 + 4\chi}}{2\chi} = \frac{y}{Z} + \frac{\delta}{1-\delta}\left(\frac{\psi^c}{\psi_{min}}\right)^k N_O\frac{f^E}{Z} + \frac{N_O f^O}{Z} \quad \textbf{(I)}$$

Step 2: for the cut-off bank in non-binding state, $\pi(\psi^c) = 0$

$$\pi(\psi^c) = d + Qd^* - (1+r)d - (1+r^*)Qd^* + (1+r^l)l - l - \frac{f^O w}{Z}$$

$$\implies \pi(\psi^c) = Qd^* - (1+r^*)Qd^* + (1+r^l)(\psi Qd^*) - \psi Qd^* - \frac{f^O w}{Z}$$

$$\implies \pi(\psi^c) = (r^l - r^*)\psi Qd^* - \frac{f^O w}{Z}$$

$$\implies 0 = \left[\frac{\epsilon(N_O - 1)}{\epsilon(N_O-1) - N_O}\left(\frac{1 + r - \psi^c}{\psi^c}\right) - r^*\right]\psi^c Qd^* - \frac{f^O w}{Z}$$

$$\implies \psi^c = 1 + r - \left(\frac{f^O w/Z + r^*\tilde{Q}d^*}{\tilde{Q}d^*}\right)\left(\frac{\epsilon(N_O-1) - N_O}{\epsilon(N_O - 1)}\right)$$

Using $\psi^c(d + Qd^*) = l = \implies Qd^* = N_O^{\frac{\epsilon}{1-\epsilon}}\frac{wy}{Z\psi^c}$

$$\implies \psi^c = 1 + r - \left(\frac{f^O w/Z + r^* N_O^{\frac{\epsilon}{1-\epsilon}} \frac{wy}{Z\psi^c}}{N_O^{\frac{\epsilon}{1-\epsilon}} \frac{wy}{Z\psi^c}}\right)\left(\frac{\epsilon(N_O - 1) - N_O}{\epsilon(N_O - 1)}\right) \tag{II}$$

Step 3:

$$\tilde{\pi} = (r^l - r^*)\psi Q d^* - \frac{f^O w}{Z}$$

$$\frac{f^E w}{Z}\left(\frac{\psi_{min}}{\psi^c}\right)^{-k}\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) = \left[\frac{\epsilon(N_O - 1)}{\epsilon(N_O - 1) - N_O}\left(\frac{1 + r - \nu\psi^c}{\nu\psi^c}\right) - r^*\right]\psi Q d^* - \frac{f^O w}{Z}$$

$$f^E\left(\frac{\psi_{min}}{\psi^c}\right)^{-k}\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) = \left[\frac{\epsilon(1-\nu\psi^c)(N_O - 1) + rN_O}{(\epsilon(N_O - 1) - N_O)\nu\psi^c}\right] N_O^{\frac{\epsilon}{1-\epsilon}} y - f^O \tag{III}$$

Solve (**I**), (**II**) and (**III**) for ψ^c, y and N_O

$$\text{Home Good Supply} = \text{Home Good Demand}$$

$$y = c^H + c^{H*}$$

$$y = \gamma\left[(1 + \tilde{R}^L)\frac{w}{Z}\right]^{-\eta} c + c^{H*}$$

$$w = \left[\frac{(y - c^{H*})(1 + \tilde{R}^L)^\eta \chi Z^{-\eta} h}{\gamma}\right]^{\frac{1}{1-\eta}}$$

$$(1-\delta)(\psi^c)^{-k}\beta(r - r^*)(1 + \mu\theta) = \mu$$

$$\mu = \frac{(1-\delta)(\psi^c)^{-k}(r - r^*)\beta}{1 - \theta(1-\delta)(\psi^c)^{-k}\beta(r - r^*)}$$

$$\mu = \frac{(1-\delta)(\psi^c)^{-k}(1 - \beta - \beta r^*)}{1 - \theta(1-\delta)(\psi^c)^{-k}(1 - \beta - \beta r^*)}$$

$$(1-\delta)(\psi^c)^{-k}\beta f(\mu)(1 + \mu\theta) = \mu$$

$$\mu = \frac{\mu}{(1-\delta)(\psi^c)^{-k}\beta(1 + \mu\theta)}$$

Using the SS values to find other variables:

$$\bar{Q} = \frac{(1 + \bar{\tilde{r}}^l)\bar{w}}{\rho^{H*}}$$

$$\bar{d} + \bar{Q}\bar{d}^* = \bar{l} \implies \bar{d}^* = \frac{\bar{l} - \bar{d}}{\bar{Q}}$$

Appendix C

SECTORAL FLOWS

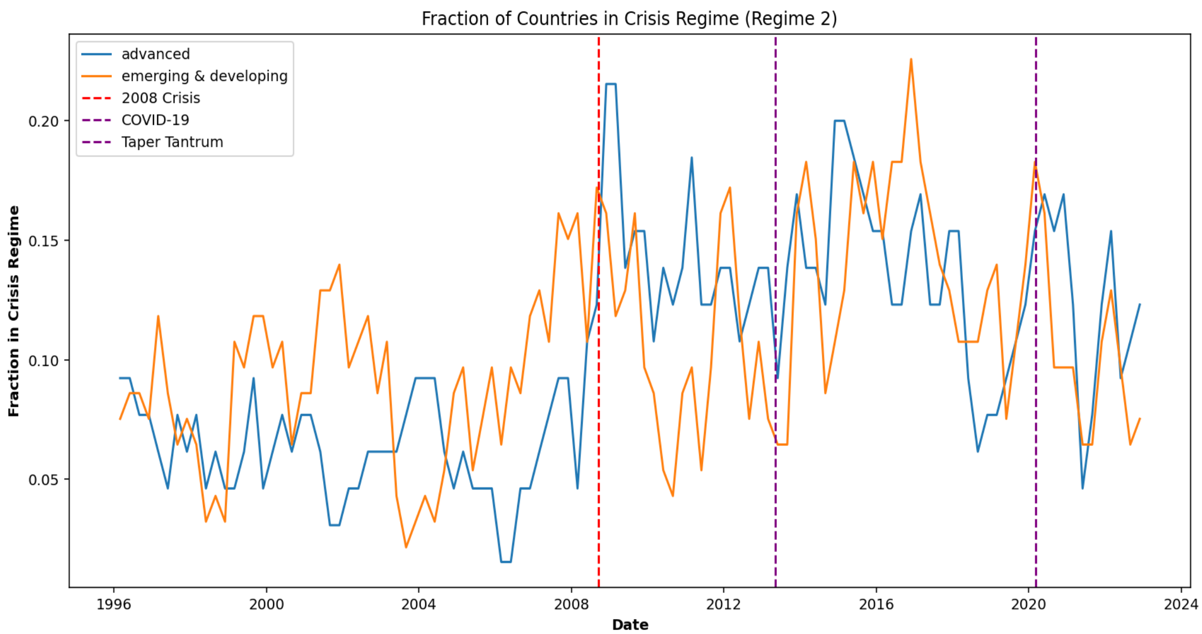
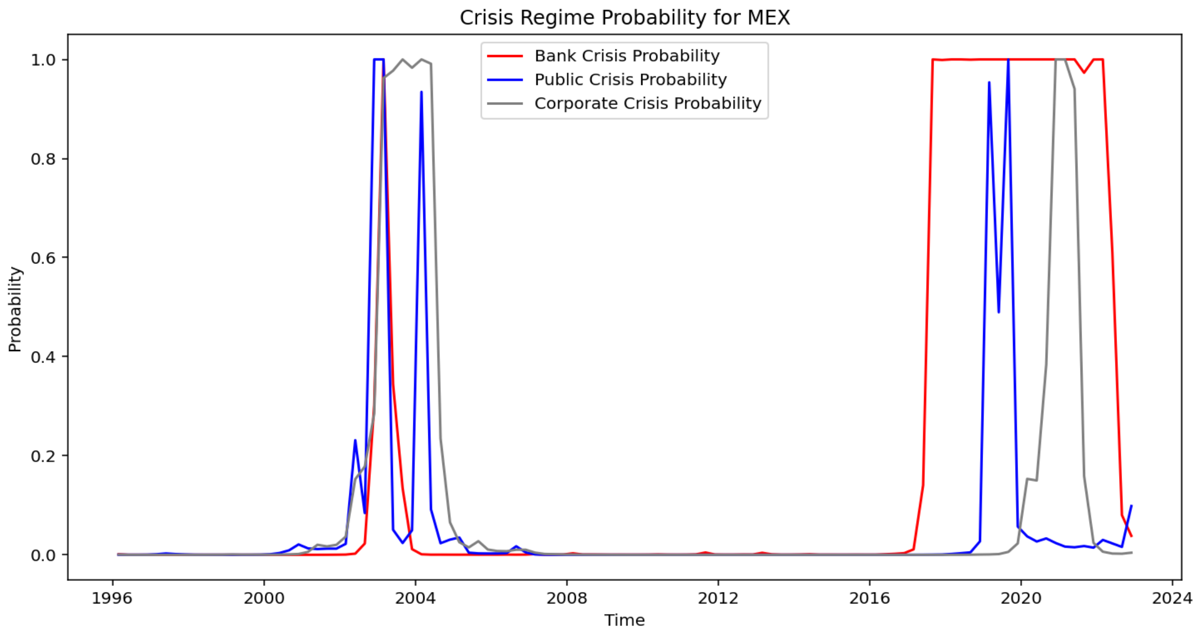
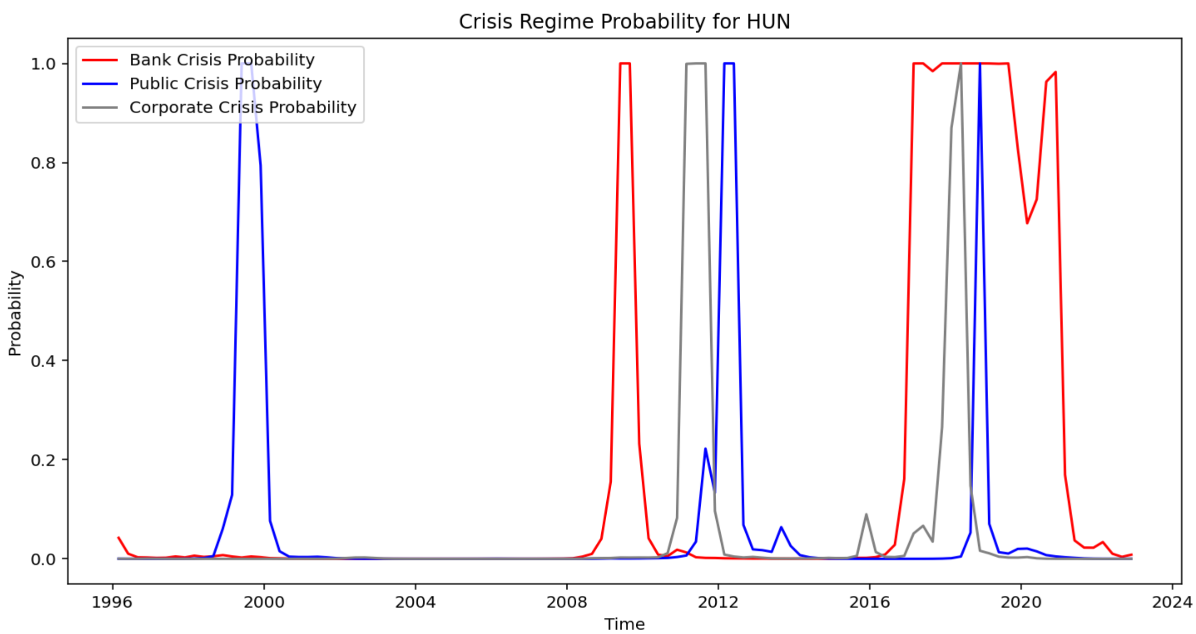
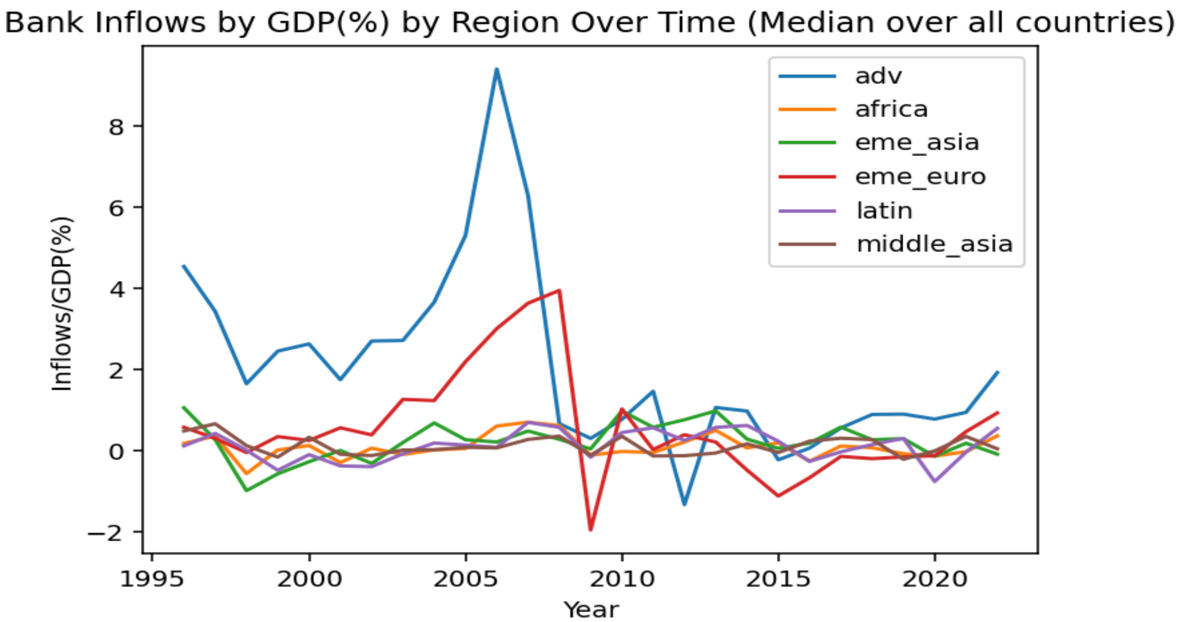
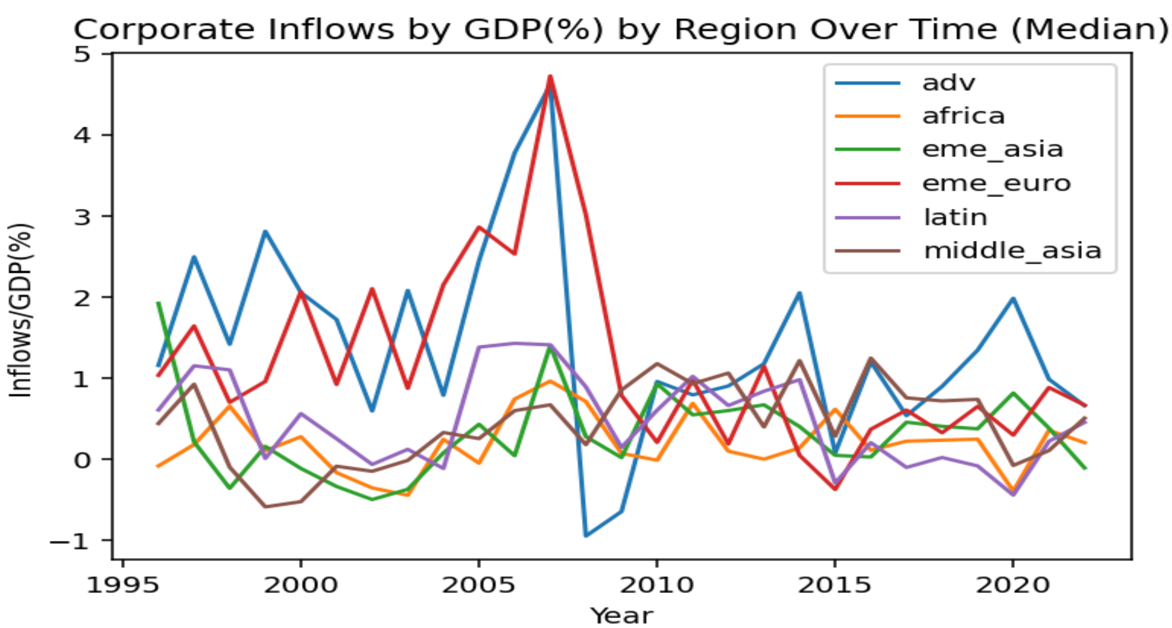


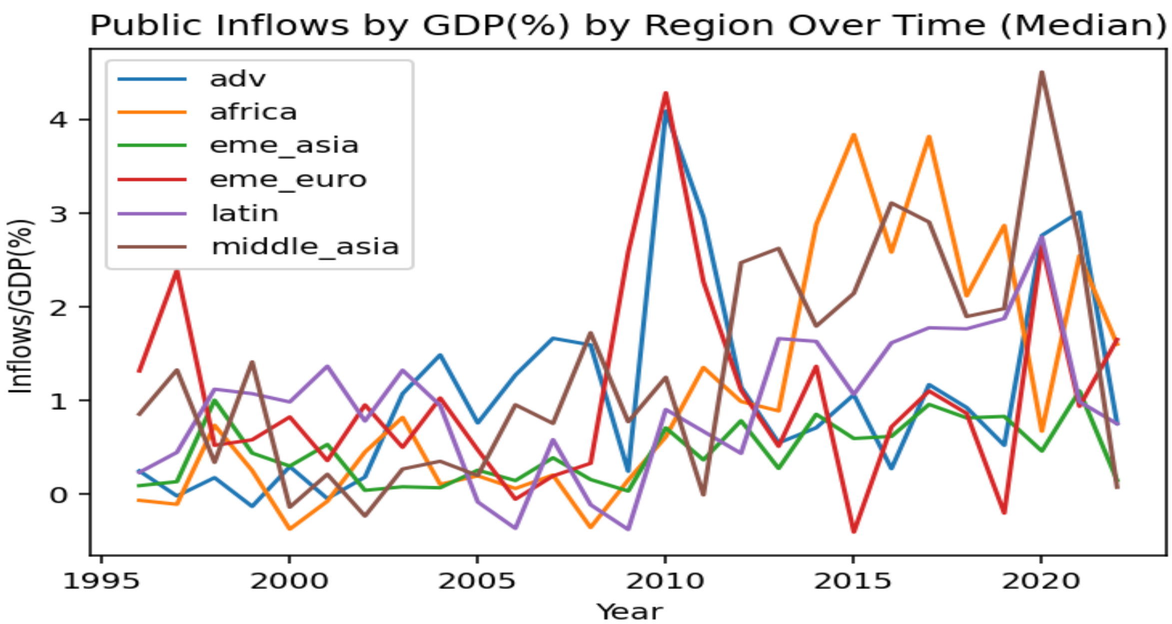
Figure C.1: Fraction of countries in Regime 3 (high volatility outflows)


Crisis Regime Probability for MEX
Bank Crisis Probability
Public Crisis Probability
Corporate Crisis Probability
Probability
1.0
0.8
0.6
0.4
0.2
0.0
1996
2000
2004
2008
2012
2016
2020
2024
Time


Crisis Regime Probability for HUN
Bank Crisis Probability
Public Crisis Probability
Corporate Crisis Probability
Probability
1.0
0.8
0.6
0.4
0.2
0.0
1996
2000
2004
2008
2012
2016
2020
2024
Time


Bank Inflows by GDP(%) by Region Over Time (Median over all countries)
Inflows/GDP(%)
Year
adv
africa
eme_asia
eme_euro
latin
middle_asia


Corporate Inflows by GDP(%) by Region Over Time (Median)
Inflows/GDP(%)
Year
adv
africa
eme_asia
eme_euro
latin
middle_asia



List of Countries

- **Advanced**: AUS, AUT, BEL, CAN, CHE, CYP, DEU, DNK, ESP, FIN, FRA, GBR, GRC, IRL, ISL, ISR, ITA, JPN, KOR, NLD, NOR, NZL, PRT, SVK, SWE,USA

- **Emerging & Developing**: AGO, ALB, ARG, BGD, BGR, BLR, BOL, BRA, CHL, CHN, CIV, COL, CRI, CZE, DOM, ECU, EGY, EST, GAB, GHA, GTM, HRV, HUN, IDN, IND, JAM, JOR, KAZ, KEN, LBN, LBR, LKA, LTU, LVA, MAR, MEX, MKD, MYS, NAM, NGA, PAK, PER, PHL, PNG, POL, PRY, ROU, RUS, SDN, SVN, THA, TTO, TUN, TUR, UKR, URY, VEN, VNM, ZAF

- **Latin**: ARG, BOL, BRA, CHL, COL, CRI, DOM, ECU, GTM,JAM, MEX, PER, PRY, TTO, URY, VEN

- **Midde Asia**: EGY, JOR, KAZ, LBN, MAR, PAK, SDN, TUN

- **Emerging Asia**: BGD, CHN, IDN, IND, LKA, MYS, PHL, PNG, THA,VNM

- **Africa**: AGO, CIV, GAB, GHA, KEN, LBR, NAM, NGA, ZAF
- **Emerging Europe**: ALB, BGR, BLR, HUN, MKD, POL, ROU, RUS, TUR,UKR