Sudden Stops and Bank Competition

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Abstract

This paper 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.

I 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

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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.

II 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 (Chang and Velasco (2001), Mendoza (2010), Caballero and Krishnamurthy (2001), Kaminsky and Reinhart (1999), Aghion et al. (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.

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

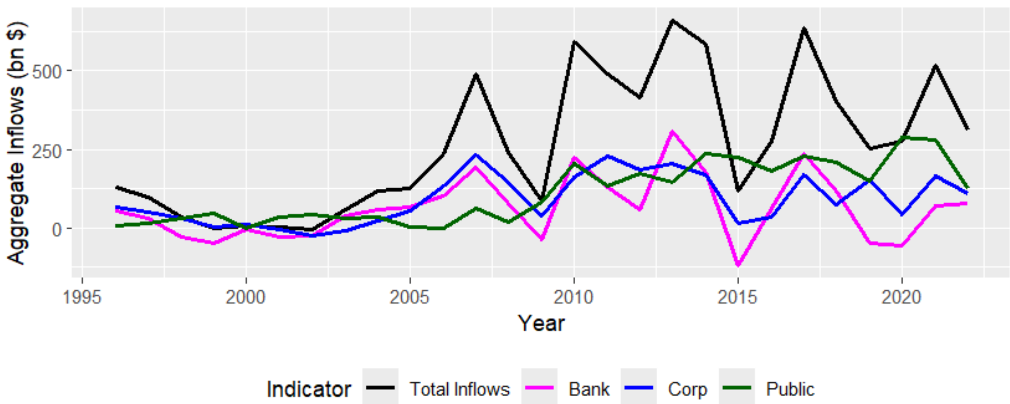


Figure 1: Total capital inflows & sector specific inflows

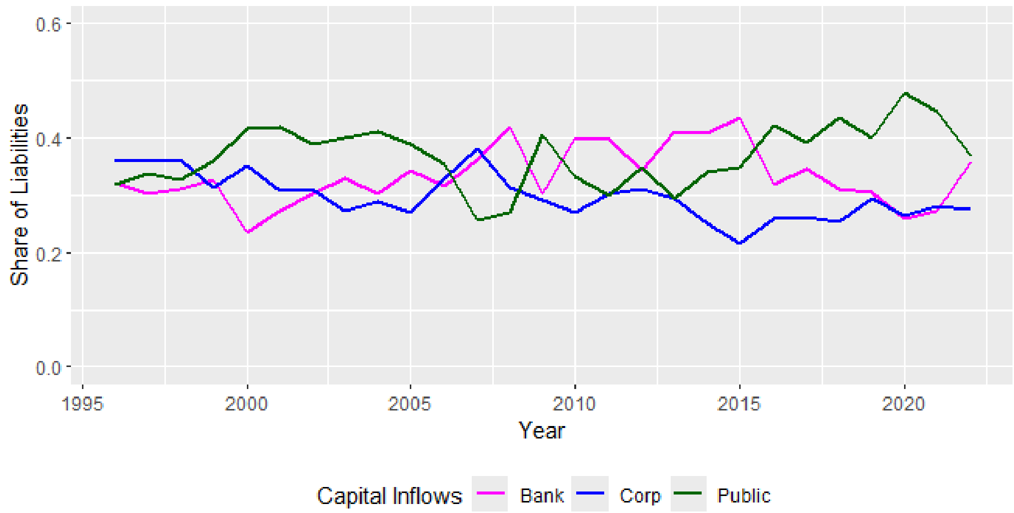


Figure 2: Share of sectors(bank, corp, public) in total external liabilities

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.

A 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) .

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.

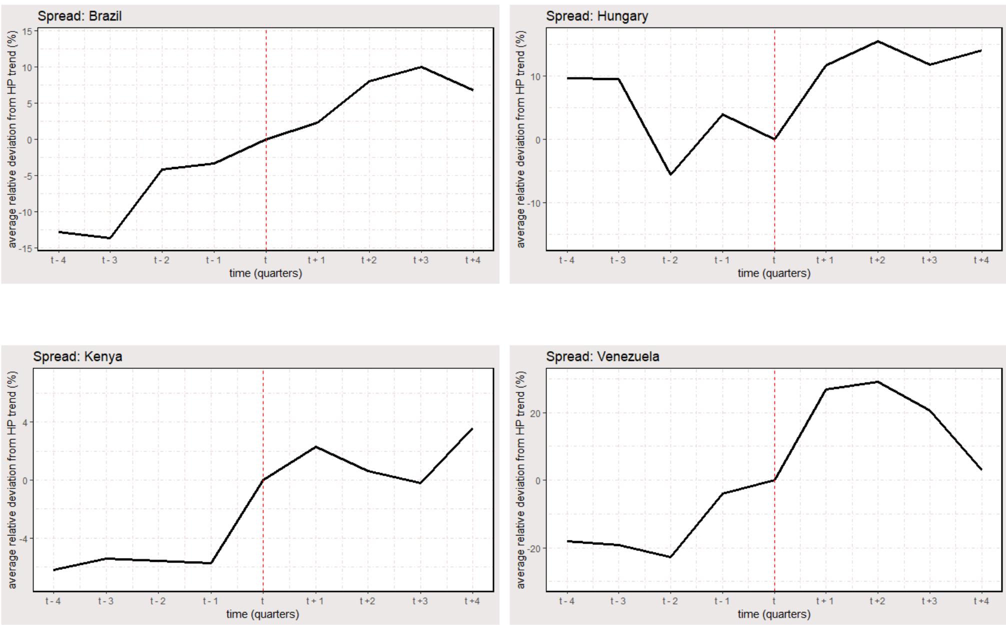


Figure 3: Relative deviations in lending-deposit spread averaged across country-specific sudden stop episodes

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

[1]Figure plots the deviations using quarterly data. The deviations are indexed at zero for the

For each country, this relative deviation of the lending-deposit spread is averaged across all sudden stop episodes, providing insights into bank behavior and market conditions surrounding these event. Figure 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) 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.

first quarter of the sudden stop episode at t=0

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: Country Regression

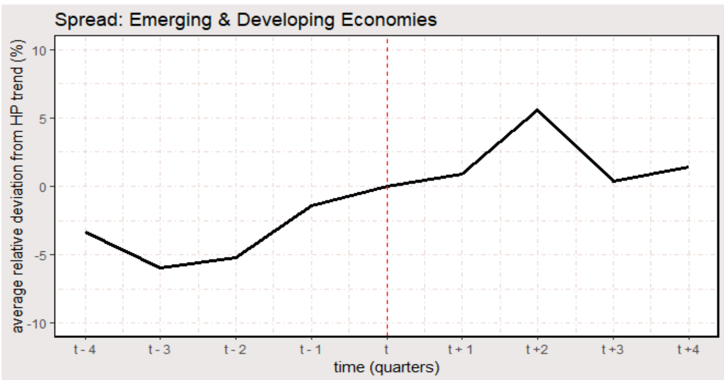


Figure 4: Relative deviations in lending-deposit spread averaged across all countries & their sudden stop episodes

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 2: Panel Regression

Figure 4 and Table 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.. 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.

IV 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. Law of one price holds, however the setup exhibits 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 stops 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.

A 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, $E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, h_t)$.

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

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.

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

B 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.

C 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.

$$Q_t = \frac{\frac{p_t^H}{P_t}}{\frac{p_t^{H*}}{P_t^*}} = \frac{\rho_t^H}{\rho_t^{H*}}$$

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 not 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_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.

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

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 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.

C.1 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

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

V Symmetric Equilibrium

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.

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

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

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

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

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.

A 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. 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 households 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.

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

(**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

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

The Euler equations for share holdings and deposit holdings are

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

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

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

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

B 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.

C 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

$$\pi_t = -(1+r_t)d_t - (1+r^*_t)Q_t d^*_t + (1+r^l_t)l_t$$

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

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.

D 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:

$c_t, c_t^H, c_t^F, h_t, d_{i,t+1}, w_t, v_t, N_t, N_{E,t}, y_t, L_{t+1}, l_{i,t+1}, \rho_t^H, \rho_t^F, r_{t+1}, R_{t+1}^L, r_{i,t+1}^l, d_{i,t+1}^*, \alpha_{i,t}, Q_t,$ $\pi_{i,t}, \mu_t, f(\mu_t)$

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

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

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

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

$$l_{i,t+1} = \left(\frac{r_{i,t+1}^l}{R_{t+1}^L}\right)^{-\epsilon} w_t \frac{y_t}{Z_t} \tag{M5}$$

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

$$R_{t+1}^L = \left[\Sigma_{i=1}^{N_t}(r_{i,t+1}^l)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}} \tag{M7}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\mu = 0 \tag{M23a: non-binding}$$

$$Q_t d^*_{t+1} = \theta v_t \tag{M23b: binding}$$

VI 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, we 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.

A Calibration

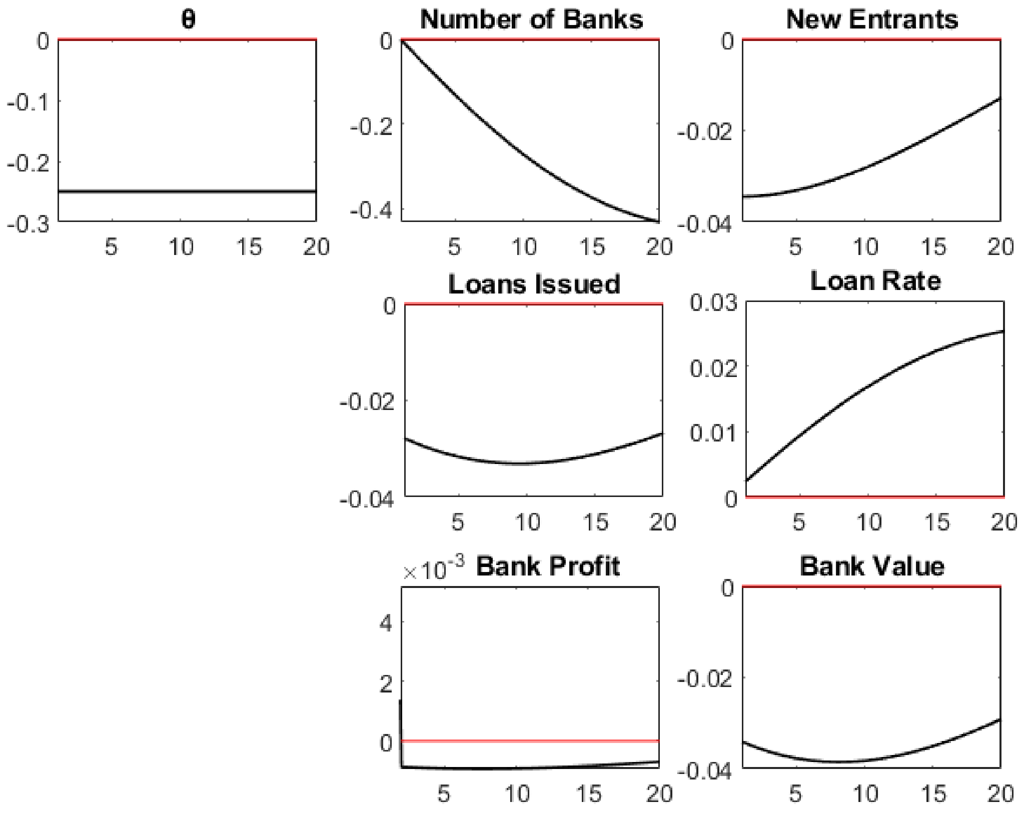
The parameters have been calibrated over quarterly frequency to reflect a small open economy which takes foreign preferences and shocks as fixed and cannot influence the foreign economy. The households have been assumed to have log preferences over consumption with unit elasticity of labor supply, $\phi = 1$ 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 $e_Q = 0.3$

B 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. 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:

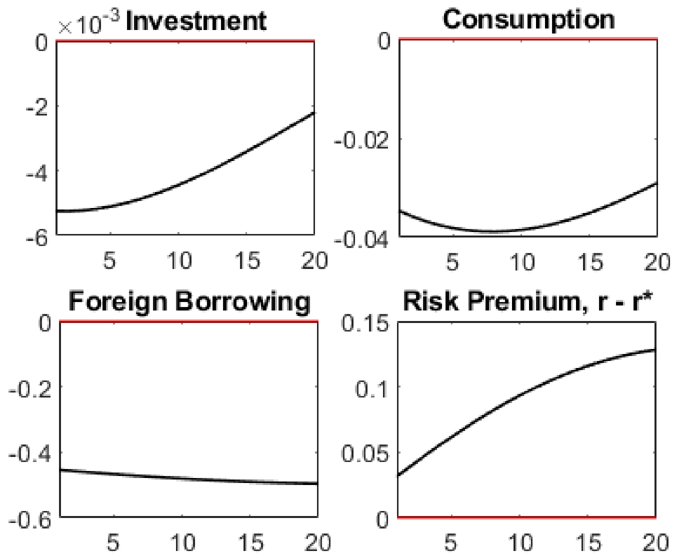
$$\theta_t = (1 - \rho_\theta)\theta + \rho_\theta \theta_{t-1} + \epsilon_{\theta,t}$$

Figure 5 (a)-(c) 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 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.



(a) **Responses I**

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.



(a) **Responses II**

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.

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

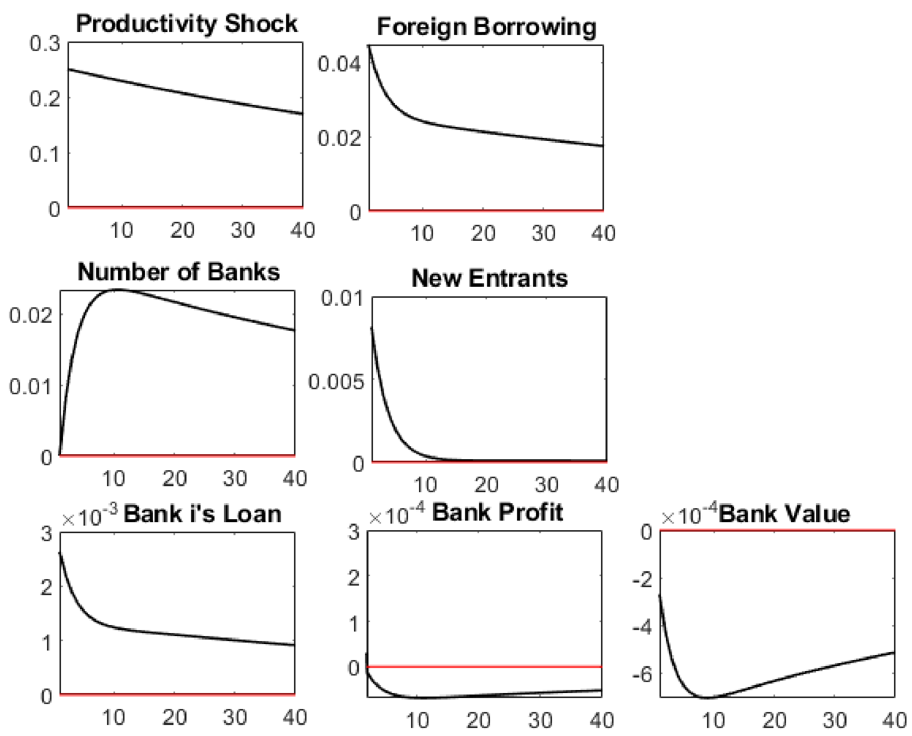
C Technology Shock

C.1 Non-Binding State

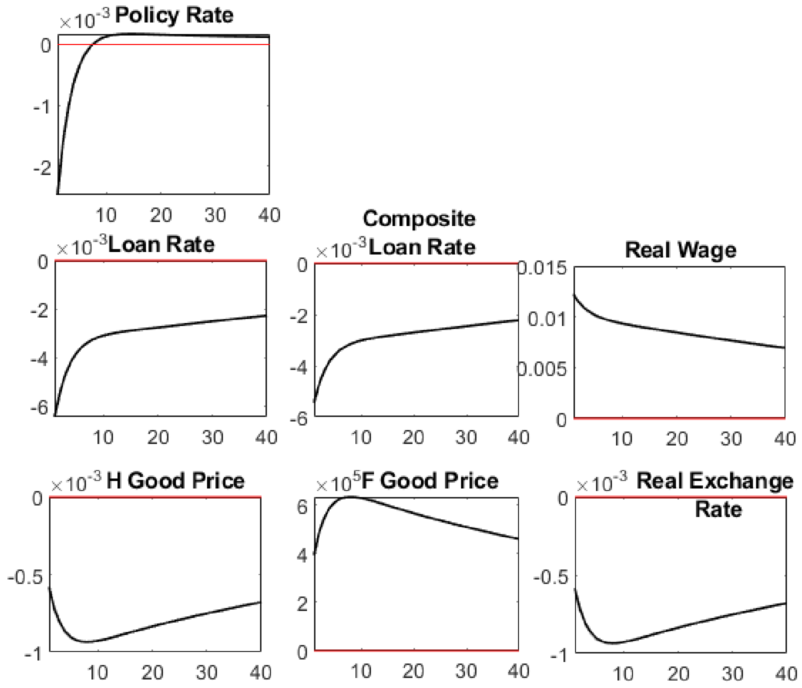
Figure 6 (a)-(c) presents the responses during a non-binding state, such that $Q_t d^*_{t+1} < \theta v_t$, the banks are unconstrained in their foreign borrowing. The economy experiences a temporary positive technology shock. The productivity shock is assumed to follow:

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

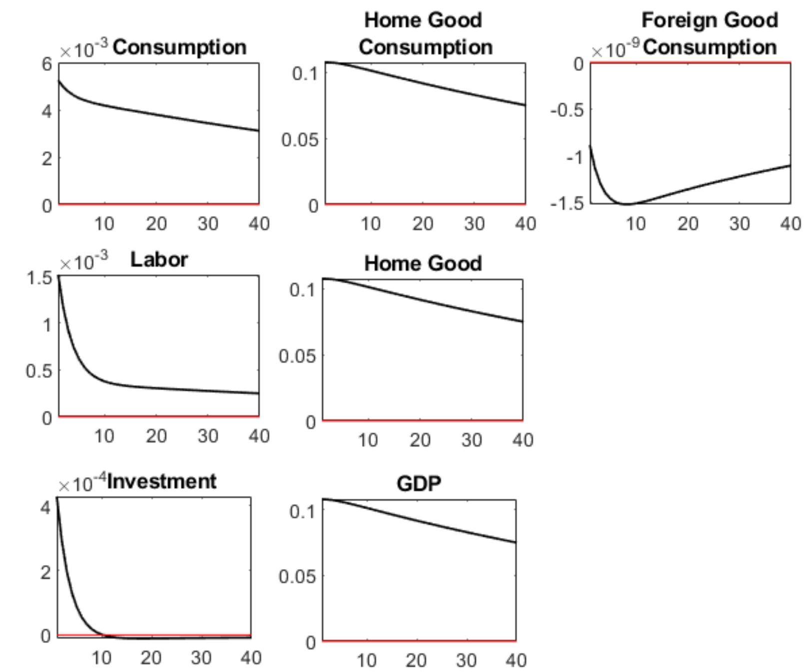
An increase in the technology makes the labor more productive. The economy reacts with an increase in output, which requires an increase in loans to pre-finance the wage bill.



(a) **Responses I**



(b) **Responses II**



(c) **Responses III**

Figure 7: **Technology Shock**

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.

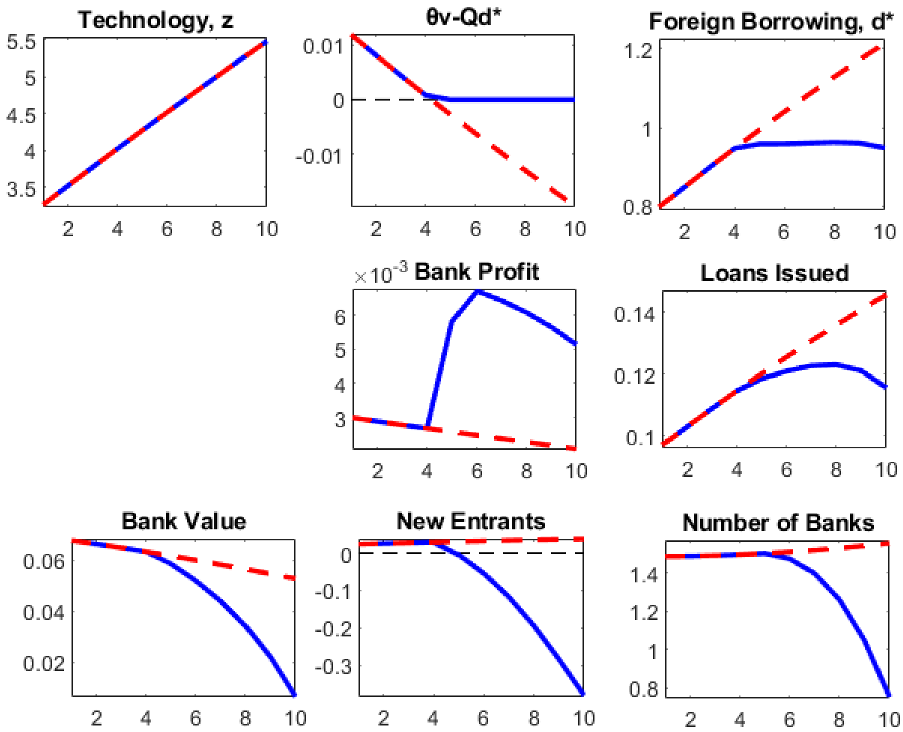
C.2 Endogenous switch to the binding state

Figure 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.

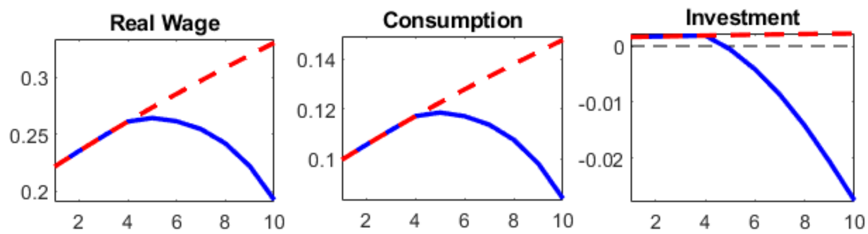
The increased competition during expansion and lower markup depresses the bank value. When banks' values fall, they become more risky, leading to a tightening of the credit conditions. Buildup of foreign borrowing persists until the decline in bank value reaches a level where it triggers the tightening 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.

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 8: **Technology Shock: Non-Linear Responses**

VII 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.

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Appendix A: Detailed solutions for FOCs

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,

$$c_t+d_{t+1}N_t+v_tx_{t+1}(N_t+N_{E,t})+\frac{\kappa}{2}(d_{t+1}-\bar{d})^2N_t$$
$$\leq(1+r_t)d_tN_t+w_th_t+x_tN_t(v_t+\pi_t)+t_t$$

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 $d_{i,t+1}$

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

FOCs:

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

$$\frac{\partial\mathcal{L}}{\partial h_t}=-\chi h_t^{\phi}+\lambda_tw_t=0 \tag{2}$$

Using (23) and (24),

Consumption-Labor tradeoff:

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

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

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

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

Using (23) in (26),

Euler Equation for share holdings:

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

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

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

Using (23) in (28),

Euler Equation for deposits:

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

Budget constraint:

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

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,

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

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

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

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

$$\boxed{\rho_t^H = (1 + R^L_{t+1})\frac{w_t}{Z_t}} \tag{9}$$

$$\text{where, composite loan rate: } R^L_{t+1} = \left[\Sigma_{i=1}^{N_t}(r^l_{i,t+1})^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$$

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

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

$$\text{Loan demand from bank } i\text{: } \boxed{l_{i,t+1} = \left(\frac{r^l_{i,t+1}}{R^L_{t+1}}\right)^{-\epsilon} L_{t+1}} \tag{12}$$

Bank's problem

The bank takes r_t, r_t^*, R_t^L, 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 discounted sum of profits.

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

subject to,

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

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

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

where cash flows each period are:

$$\begin{aligned}\pi_{i,t} =& d_{i,t+1} + Q_t d^*_{i,t+1} - (1+r_t)d_{i,t} - (1+r_t^*)Q_t d^*_{i,t} \\ &+ (1+r^l_{i,t})l_{i,t} - l_{i,t+1}\end{aligned} \tag{13}$$

and bank value is given by:

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

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

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

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

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

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

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

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

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

Using (39) in (38)

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

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

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

Using (37) in (40):

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

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

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

Using (37) in (42):

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

$$\begin{aligned}
&\frac{\partial\mathcal{L}}{\partial\mu_{i,t}} \geq 0: \qquad Q_s d^*_{i,s+1} \leq \theta x_{i,t} v_{i,t} \\
&\mu_{i,t} \geq 0 \\
&\mu_{i,t}\frac{\partial\mathcal{L}}{\partial\mu_{i,t}} = 0: \quad \mu_{i,t}\left(\theta x_{i,t} v_{i,t} - Q_t d^*_{i,t+1}\right) = 0
\end{aligned}$$

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

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

$$\begin{aligned}
&\frac{\partial\mathcal{L}}{\partial\lambda_{i,t}} \geq 0: \qquad l_{i,s+1} \leq d_{i,t+1} + Q_s d^*_{i,t+1} \\
&\lambda_{i,t} \geq 0 \\
&\lambda_{i,t}\frac{\partial\mathcal{L}}{\partial\lambda_{i,t}} = 0: \quad \lambda_{i,t}\left(d_{i,t+1} + Q_t d^*_{i,t+1} - l_{i,t+1}\right) = 0
\end{aligned}$$

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 $Q_t d^*_{i,t+1} = \theta x_{i,s} v_{i,t}$

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

Central Bank

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

Appendix B: Detailed solutions for steady state

Non-Binding Case

$$\mu = 0$$

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

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

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

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.

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

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

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

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

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

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

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

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

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

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

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

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

$$\text{Using (5): } v = (1-\delta)\beta(v+\pi)$$
$$\implies v = \frac{(1-\delta)\beta}{1-(1-\delta)\beta}\pi$$
$$\text{Using (16): } v = \frac{f^E w}{Z}$$
$$\implies \pi = \frac{f^E w}{Z}\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) \tag{1a}$$

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

$$c + dN + vx(N+N_E) = (1+r)dN + wh + xN(v+\pi)$$
$$\implies c + \bar{d}N + vN_E = rN\bar{d} + wh + N\pi$$

$$\text{Put } \bar{d} = 0 \implies c + vN_E = wh + N\pi$$
$$\implies c = wh + \frac{Nwf^E}{Z}\left(r + \frac{\delta}{1-\delta}r\right)$$
$$\implies c = wh + \frac{wf^E}{Z}\left(\frac{1-\beta}{\beta} - \frac{\delta}{1-\delta}\frac{1-\beta}{\beta}\right)$$
$$\implies c = wh + N\frac{wf^E}{Z}\left(\frac{1-\beta-\delta+\delta\beta+\delta-\delta\beta}{(1-\delta)\beta}\right)$$
$$\implies c = wh + N\frac{wf^E}{Z}\left(\frac{1-\beta}{(1-\delta)\beta}\right)$$
$$\text{Using (3): } \implies \frac{w}{\chi h} = wh + N\frac{wf^E}{Z}\left(\frac{1-\beta}{(1-\delta)\beta}\right)$$
$$\implies \frac{1}{\chi h} = h + \frac{Nf^E}{Z}\left(\frac{1-\beta}{(1-\delta)\beta}\right)$$
$$\implies \chi h^2 + \frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)}h - 1 = 0$$
$$\implies h = \frac{-\frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)} + \sqrt{\left(\frac{(1-\beta)Nf^E\chi}{Z\beta(1-\delta)}\right)^2 + 4\chi}}{2\chi} \text{ (ignore the negative root)} \tag{\textbf{I}}$$

Step 2: loan supply = loan demand

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

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

$$\text{Using (13): } \pi = d + Qd^* - (1+r)d + \frac{\kappa}{2}(d - \bar{d})^2 - (1+r^*)Qd^* + (1+r^l)l - l$$

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

$$\text{Since, } r = r^* \implies \pi = (r^l - r)(\bar{d} + Q\bar{d}^*)$$

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

$$\pi = \left(\frac{N}{\epsilon(N-1) - N}\right) r(\bar{d} + Q\bar{d}^*) \tag{1c}$$

$$\text{Using (1a), (1b) and (1c): } \frac{f^E w}{Z}\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) = \left(\frac{Nr}{\epsilon(N-1) - N}\right)\left(N^{\frac{\epsilon}{1-\epsilon}} \frac{wy}{Z}\right)$$

$$\implies f^E\left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right) = \left(\frac{N^{\frac{1}{1-\epsilon}}}{\epsilon(N-1) - N}\right) y$$

$$\implies y = \left(\frac{1-(1-\delta)\beta}{(1-\delta)\beta}\right)(\epsilon(N-1) - N) N^{\frac{1}{\epsilon-1}} f^E \tag{1d}$$

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

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

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

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

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

Using the SS values to find other variables:

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

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

Binding Case

Step 1: Bank Entry

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

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

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

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

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

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

Using (2c):

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

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

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

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

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

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

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

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

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

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

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

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

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

Step 4: Home Good Supply = Home Good Demand

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

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

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

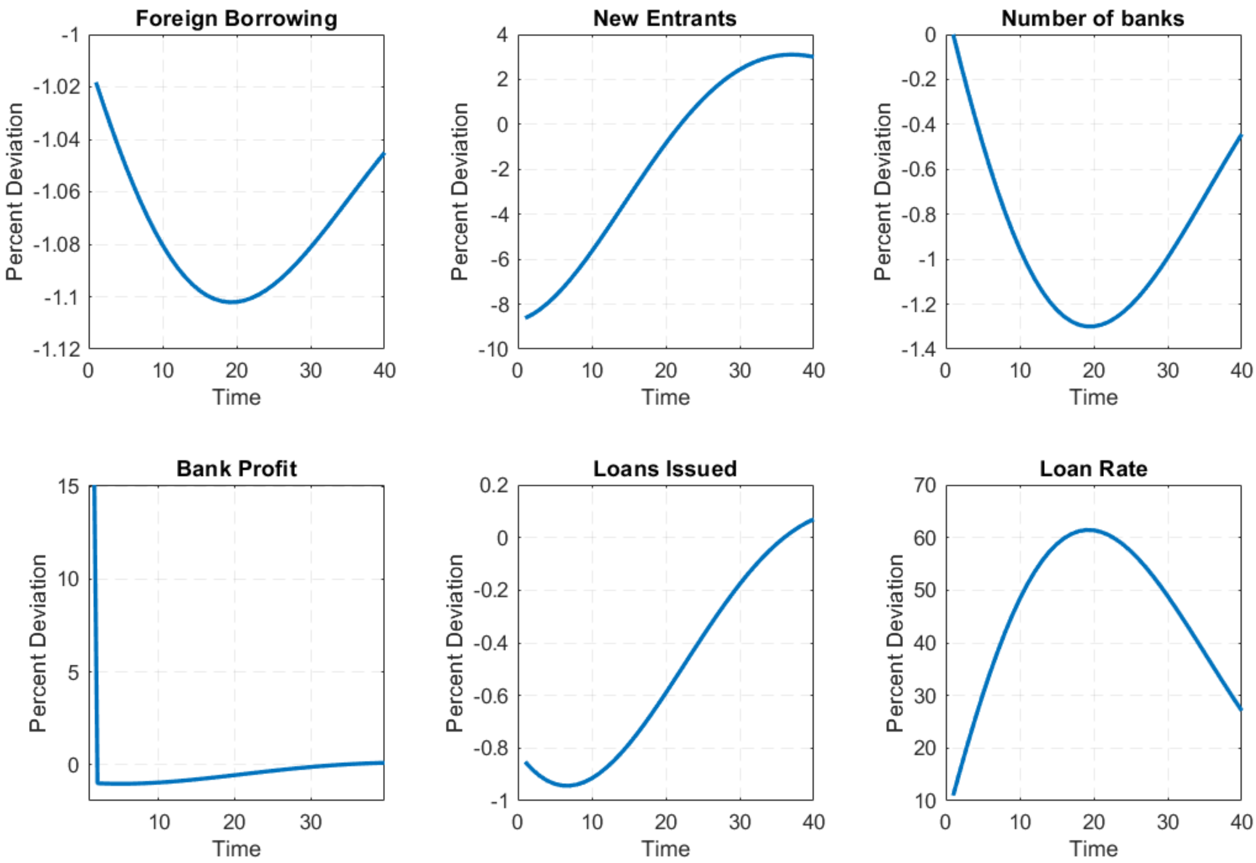
Using (21): $(1-\delta)\beta(1+r^*)(1+\mu\theta) = (1-\delta)\beta(1+r) - \mu$

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

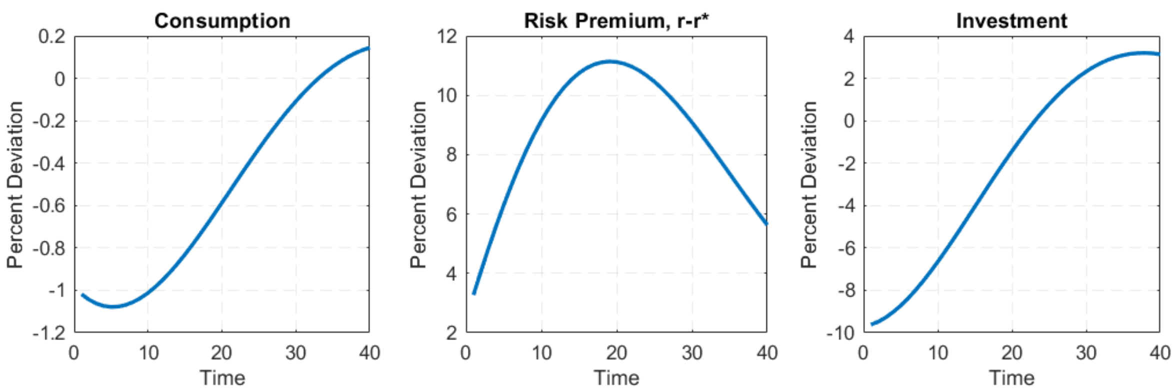
Using (22): $r = r^* + f(\mu)$ in (21)

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

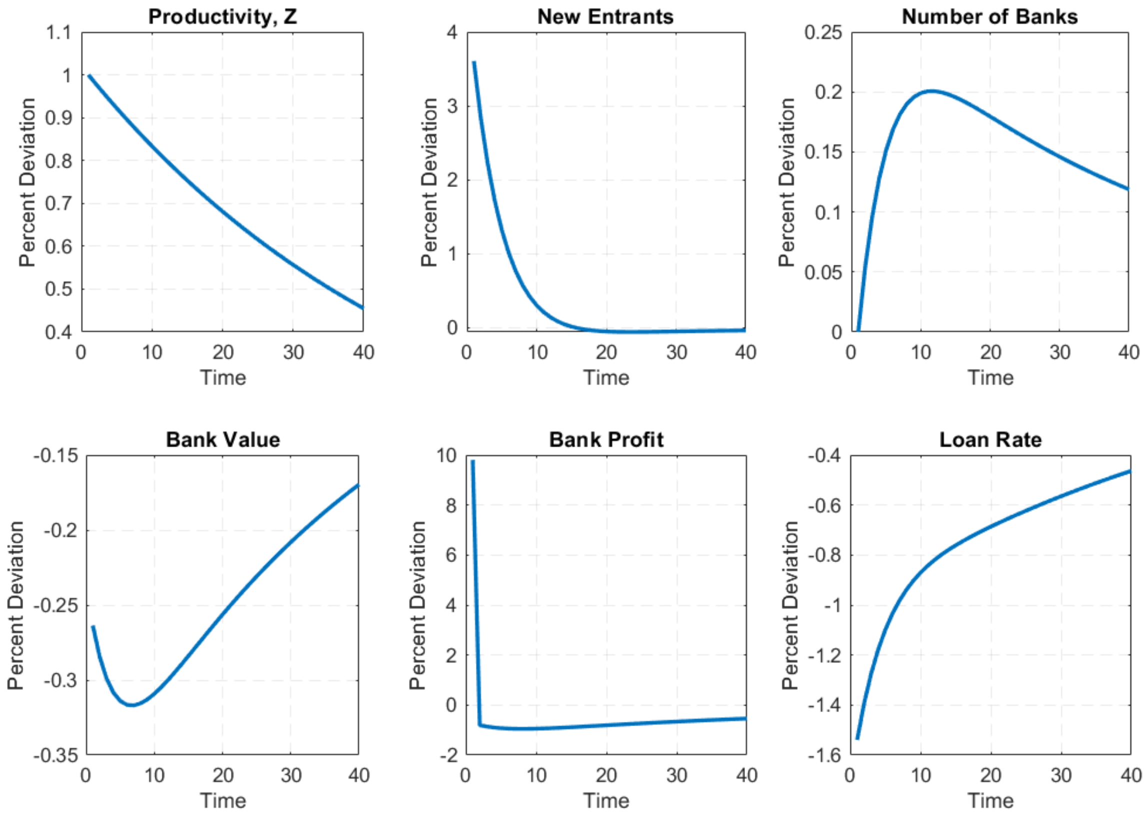
Impulse Responses in percent deviations



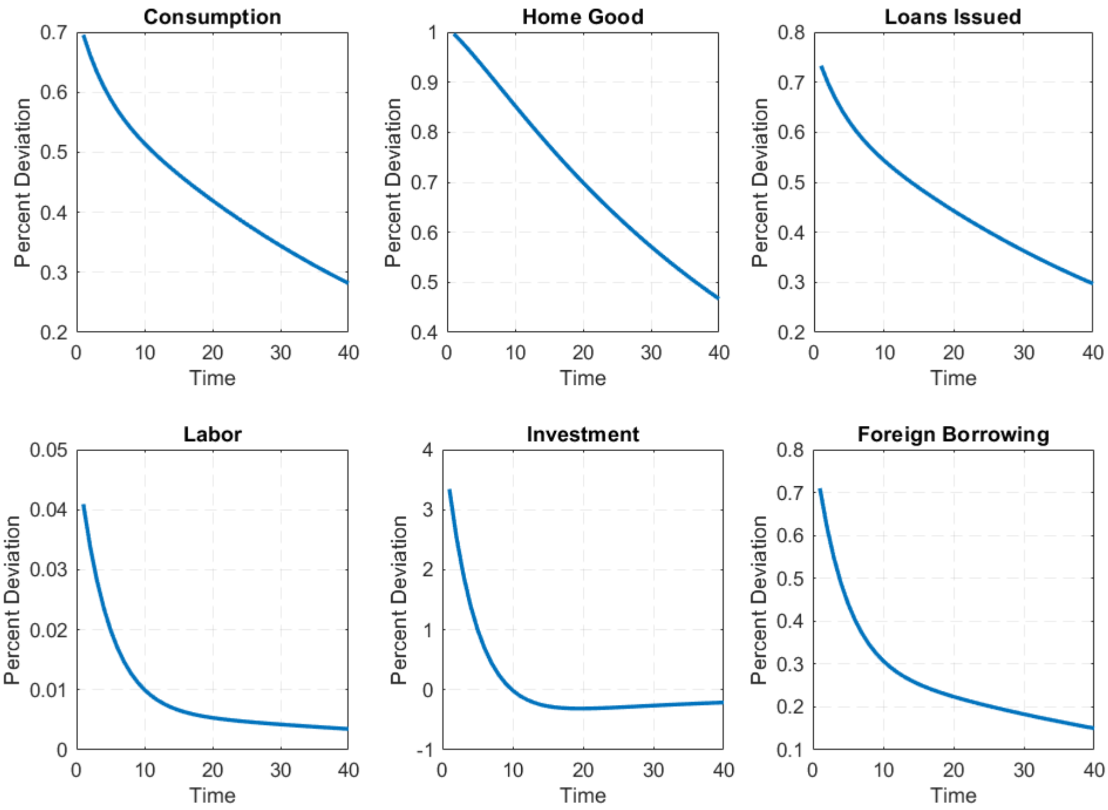
(a) **Responses I**



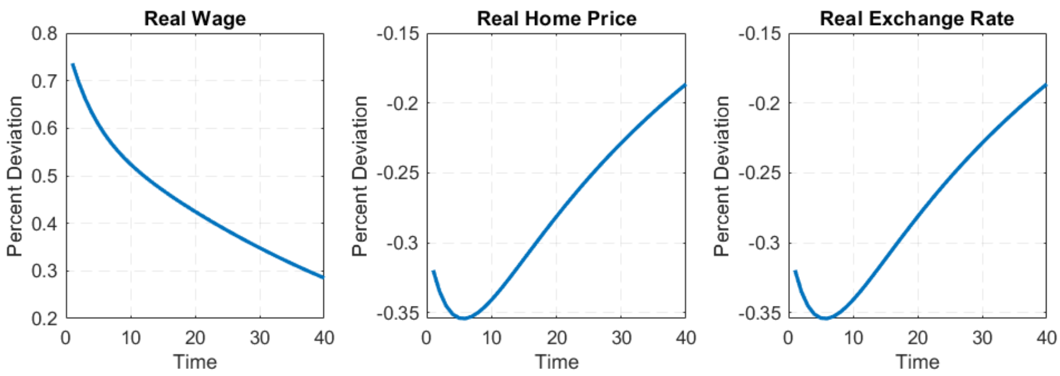
(b) **Responses II**



(a) **Responses I**

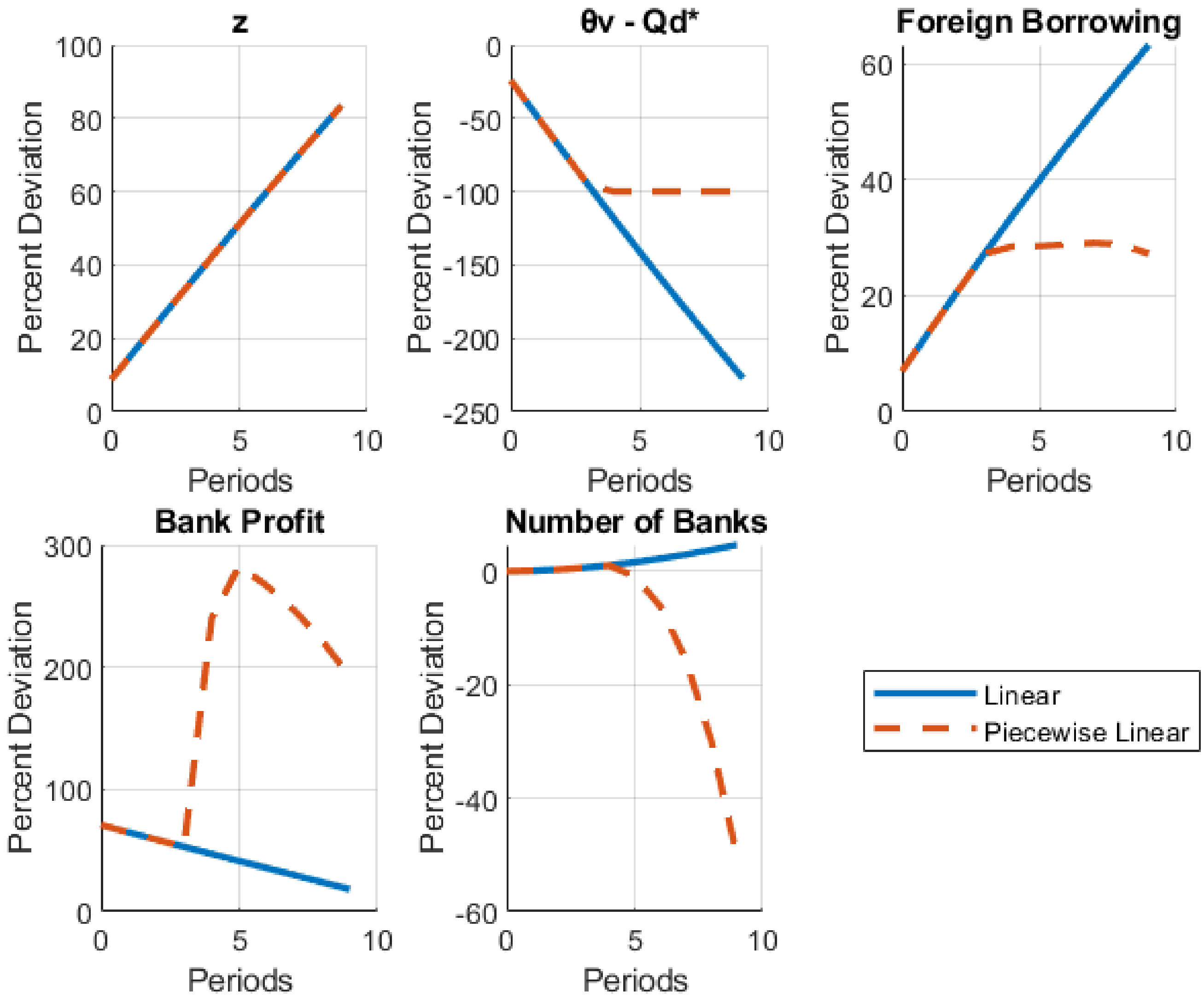


(b) **Responses II**

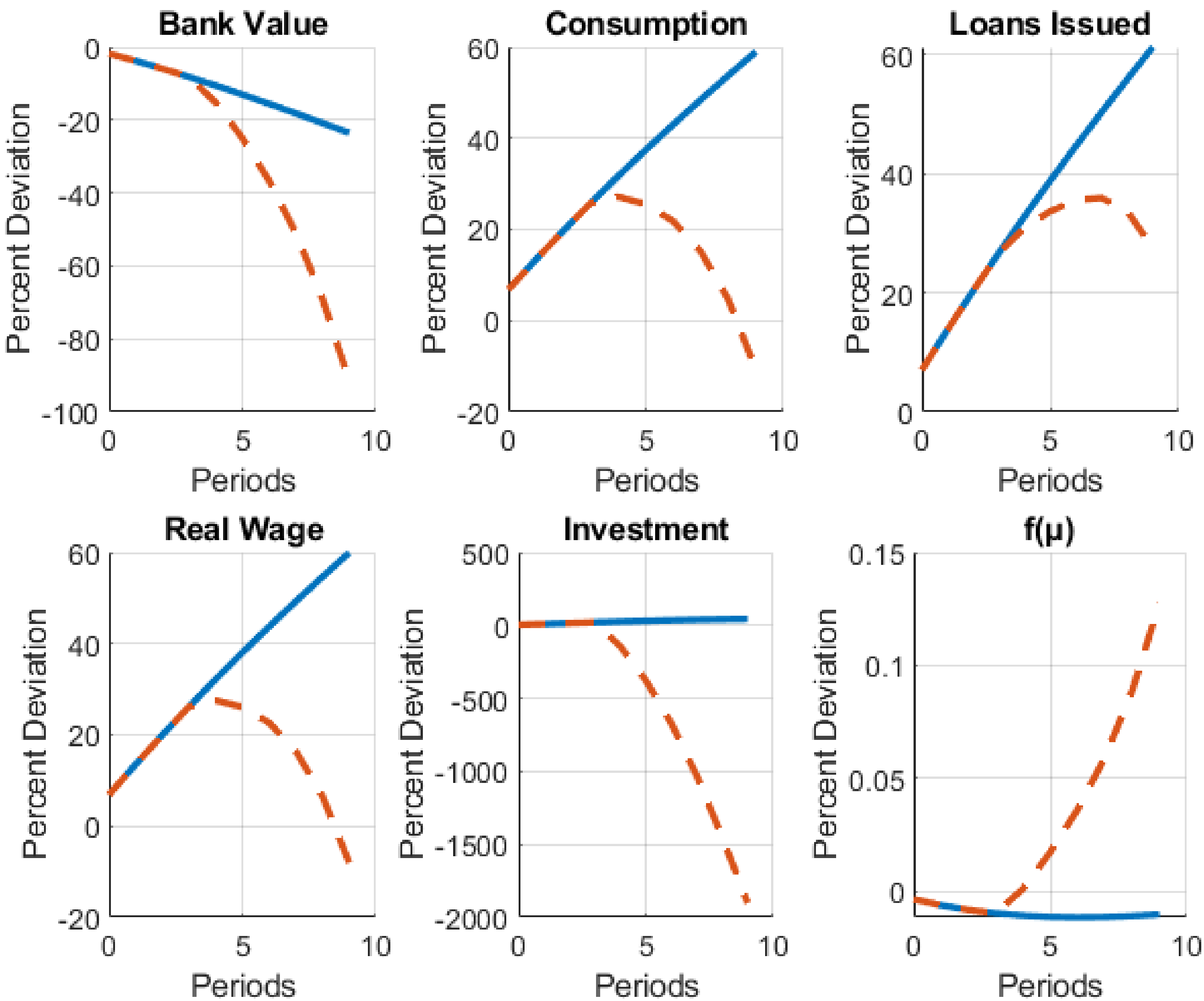


(c) **Responses III**

Figure 10: **Technology Shock**



(a) **Responses I**



(a) **Responses II**

Figure 12: **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 3: 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 4: 46 Emerging & Developing Economies