Sudden Stops and the macro-prudential role of monetary policy

Paolo Cavallino [*] Jeongwon Son[†]

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Abstract

This paper examines the impact of large capital flows on emerging market economies. Large capital outflow episodes reduce economic activity and restrict private sector credit supply while large capital inflows stimulate economic activity and credit supply. Sudden Stops, large capital outflow episodes with reductions in credit supply larger than 5%, primarily drive the effect of large capital outflow episodes. We also find inflows predict outflows and Sudden Stops even after controlling for credit supply. We construct a small open economy model with occasionally binding constraints that accounts for these stylized facts. Sudden stops are driven by an increase in the asset holdings of domestic banks following capital flight of foreign investors. When banks' leverage constraint becomes binding, the capital flight causes a domestic credit crunch and a severe recession. The optimal monetary policy has a macro-prudential component and leans against the accumulation of domestic and external debt.

[*]Corresponding author. Bank for International Settlements. E-mail: paolo.cavallino@bis.org
[†]Johns Hopkins University. E-mail: json8@jhu.edu

1 Introduction

Volatile capital flows have been the center of policy discussions in emerging markets since the surge of capital flows in the early 1990s (Bacchetta and van Wincoop, 2000). Characterized by rapid economic growth and development potential, these economies often attract substantial foreign investments. However, this inflow of capital is frequently subject to swift reversals driven by changes in global financial conditions and investor sentiment. Such volatility in capital flows can lead to significant financial and macroeconomic instability, posing a major challenge for policymakers in these countries (Kim and Singal, 2000).

Several seminal papers have examined various aspects of how capital flows impact the performance of emerging market economies and what the appropriate policy measures are. For instance, Calvo et al. (1993) find that the surge in capital inflows to Latin America in the early 1990s resulted in a real appreciation and elevated economic volatility. They also highlight the concern for large outflows and economic crises that may follow large inflows by policy makers. Edwards (2000) analyzed the relationship between capital flows and economic performance in emerging markets, emphasizing the role of capital controls. More recently, Rey (2013) discussed the global financial cycle and its implications for capital flows and monetary policy in emerging economies. One of the most critical problems associated with volatile capital flows is the phenomenon known as "sudden stops." These are abrupt reversals of capital inflows, which can lead to severe economic recessions and financial instability.

Various academic papers have proposed different strategies to address the challenges posed by volatile capital flows and sudden stops. Edwards (2007) emphasizes the effectiveness of implementing a flexible exchange rate regime in reducing the probability of experiencing a capital flow contraction. Jeanne and Korinek (2010) and Bianchi (2011) show how macroprudential taxes or capital controls can limit overborrowing to help prevent sudden stops while Benigno et al. (2013) calls for the use of ex-post rather than ex-ante policies. Gourinchas and Obstfeld (2012) and more recently, Davis et al. (2023), Fernando Arce and Bianchi (2019) and Lutz and Zessner-Spitzenberg (2023) show that foreign exchange reserve accumulation can help prevent sudden stops and minimize their macroeconomic impact.

This paper highlights stylized facts on the impact of large capital flows using local projections. Large capital outflows, defined as a fall in capital flows by more than 2 standard deviations, reduce GDP growth, consumption growth and investment growth in emerging market economies. They also depreciate the exchange rate in both real and

nominal terms while creating a net trade surplus and restricting credit supply to the private sector from banks. We find that sudden stops, defined as large capital outflow episodes with a fall in credit supply that is larger than 5%, drive most of the results highlighting the link between credit supply and macroeconomic activity. The opposite holds for large capital inflows, defined as an increase in capital flows by more than 2 standard deviations. We also highlight the predictive power of inflows on forecasting large capital outflows and sudden stops. By using a linear probability model, we also find that large capital inflow episodes have predictive power in forecasting large capital outflows and sudden stops that occur within 3 years even after controlling for credit supply. We also find that these stylized facts are robust to controlling for the currency composition of external liabilities.

We replicate these stylized facts using a model with occasionally binding constraints in the banking sector following Gertler and Kiyotaki (2010). Banks issue deposits, invest in government bonds and issue loans to firms. Because banks can default on their liabilities, depositors only save using deposits if the value-at-risk constraint is satisfied. These occasionally binding constraints make capital outflows more damaging as they limit the amount of capital that banks can access and as a result, reduce credit supply to firms. In this setting, we find that it is optimal to lean against capital inflows ex-ante by raising the real rate and curbing economic activity to prevent and minimize the damage of sudden stops, highlighting the macro-prudential role of monetary policy.

This paper is closely related to two strands of literature. First, it is related to the literature that empirically evaluates the impact of capital flows on emerging market economies. Benigno et al. (2015) find that large net capital inflows increase economic activity and also shifts factors of production from the manufacturing sector to the services sector. Large net capital inflows can also predict sudden stops though the predictive power of credit supply is stronger. Eichengreen and Gupta (2018) analyze sudden stops and find they reduce GDP, investment and create a current account surplus. We contribute to this literature by showing that similar results can be shown by defining large capital outflow episodes and large inflow episodes using gross capital flows, following the definitions used in Forbes and Warnock (2012).

Second, our paper is related to the literature on the macro-prudential use of policy instruments in models with occasionally binding constraints. Our paper is closest to Devereux et al. (2019), which explains the optimal use of capital controls and monetary policy in a model with occasionally binding constraints. They find that optimal monetary policy stabilizes inflation if the constraint does not bind and helps reduce how hard the constraint binds only after it binds. In our model, we show that optimal monetary policy leans against the wind ex-ante so that inflation targeting is not the only motive before the

constraint binds.

This paper is organized as follows. We empirically analyze the impact of large capital inflows and large capital outflows in Section 2. In Section 3 we introduce a model of sudden stops that accounts for these stylized facts. Section 4 explains how we calibrate and solve the model using global solution methods. Next, we highlight the baseline results in Section 5 and show the implications of optimal policy in Section 6. Finally, Section 7 concludes.

2 Empirical analysis

In this section we empirically analyze the macroeconomic impact of large capital flow events.

2.1 Macroeconomic impact of large inflows and outflows

We define large capital inflow and large capital outflow episodes following Forbes and Warnock (2012), henceforth FW. Large capital inflow episodes and large capital inflow episodes are what FW define as "Surges" and "Stops" respectively. More specifically, let $C_{i,t}$ be the quarterly series of 4-quarter moving sum of gross capital inflows for country i and define $\Delta C_{i,t}$ as the year-over-year change in $C_{i,t}$. Then, compute the rolling mean and standard deviation of $\Delta C_{i,t}$ over the last 5 years. A large inflow episode starts when $\Delta C_{i,t}$ is more than one standard deviation above the rolling mean and ends when it is below one standard deviation above the rolling mean. Also, for the episode to qualify as a large inflow episode there has to be at least one quarter where $\Delta C_{i,t}$ is more than two standard deviations above the rolling mean. A large outflow episode is defined symmetrically. A large outflow episode starts when $\Delta C_{i,t}$ falls below one standard deviation of the rolling mean and ends when it is above one standard deviation below the rolling mean. Similarly, in order for an episode to qualify as a large outflow episode, there must be at least one quarter where $\Delta C_{i,t}$ is more than two standard deviations below the rolling mean.

We use capital flow data from the IMF's International Financial Statistics (IFS) Database. We focus on portfolio and debt flows as these are known to predict financial crises.[1] Our sample consists of emerging market economies and we focus on the time period from 1999 to 2019.[2] This sample gives us a total of 44 large inflow and 38 large outflow episodes. The

[1]We define capital inflows as the sum of net occurrence of portfolio equity and debt liabilities (indicator code "BFOLDXF_BP6_USD" and "BFPLXF_BP6_USD") in the IMF IFS Database.

[2]The country sample we look at is Brazil, Chile, Colombia, Czech Republic, Guatemala, Hungary, Indonesia, Korea, Mexico, Peru, Philippines, Poalnd, Thailand, Turkey, Uruguay, South Africa, Ghana,

complete list of inflow and outflow episodes is given in Tables 1 and 2.

Table 1: Large inflow episodes

Country	Year	Country	Year	Country	Year	Country	Year
Armenia	2006	Czech	2003	Korea	2009	Romania	2000
Armenia	2013	Czech	2007	Korea	2016	Romania	2004
Brazil	2005	Czech	2017	Mexico	2004	Romania	2007
Brazil	2009	Ghana	2019	Mexico	2007	Romania	2015
Chile	2005	Guatemala	2000	Mexico	2010	Thailand	2004
Chile	2008	Guatemala	2006	Peru	2007	Thailand	2009
Chile	2010	Hungary	2003	Peru	2019	Turkey	2000
Chile	2016	Hungary	2005	Philippines	2007	Turkey	2010
Colombia	2006	Indonesia	2006	Philippines	2009	Uruguay	2012
Colombia	2009	Indonesia	2009	Philippines	2018	Uruguay	2017
Czech	2001	Korea	2006	Poland	2007	South Africa	2006

Table 2: Large outflow episodes

Country	Year	Country	Year	Country	Year	Country	Year
Armenia	2010	Colombia	2015	Indonesia	2011	Romania	2008
Armenia	2014	Czech	2005	Indonesia	2015	Thailand	2007
Brazil	2008	Czech	2009	Korea	2008	Turkey	2001
Brazil	2015	Czech	2018	Mexico	2008	Turkey	2007
Chile	2000	Ghana	2018	Mexico	2015	Uruguay	2016
Chile	2007	Guatemala	2004	Peru	2005	South Africa	2000
Chile	2009	Guatemala	2008	Peru	2008	South Africa	2007
Chile	2015	Hungary	2002	Philippines	2008	South Africa	2015
Colombia	2008	Hungary	2009	Poland	2008		
Colombia	2011	Indonesia	2008	Poland	2017		

To analyze the macroeconomic impact of large inflows and outflows, we use local projection methods and estimate the change in macroeconomic variables after these events have occurred. The specification of the regression we run is shown in Equation (1).

$$y_{i,t+h} - y_{i,t-1} = \alpha_h + \beta_h x_{i,t} + \sum_{k=1}^{3} \gamma_{k,h} \Delta y_{i,t-k} + FE_{i,h} + \varepsilon_{i,h,t} \tag{1}$$

$y_{i,t}$ is the log of a macroeconomic variable (real GDP, consumption, gross fixed capital formation, CPI inflation, real exchange rate, nominal exchange rate, exports, imports and the trade balance) in country i at year t. Exchange rates are bilateral USD exchange rates denoted such that an increase captures a depreciation of the local currency against the US dollar. $x_{i,t}$ is a dummy variable for either large inflow episodes or outflow episodes where it takes the value of 1 if there was a corresponding episode in country i in year

Romania, Armenia and Serbia.

t and 0 otherwise. We run the regression independently for 6 different horizons where $h \in \{0, 1, 2, 3, 4, 5\}$, control for country fixed effects and use standard errors clustered by country.

We show the estimated results for β_h for each macroeconomic variable and horizon in Figure 1. The circled blue line represents the estimate for large outflow episodes with the blue area showing the 90% confidence interval. The starred red line and red area show similar results for large inflow episodes. Large outflows are followed by a fall in real

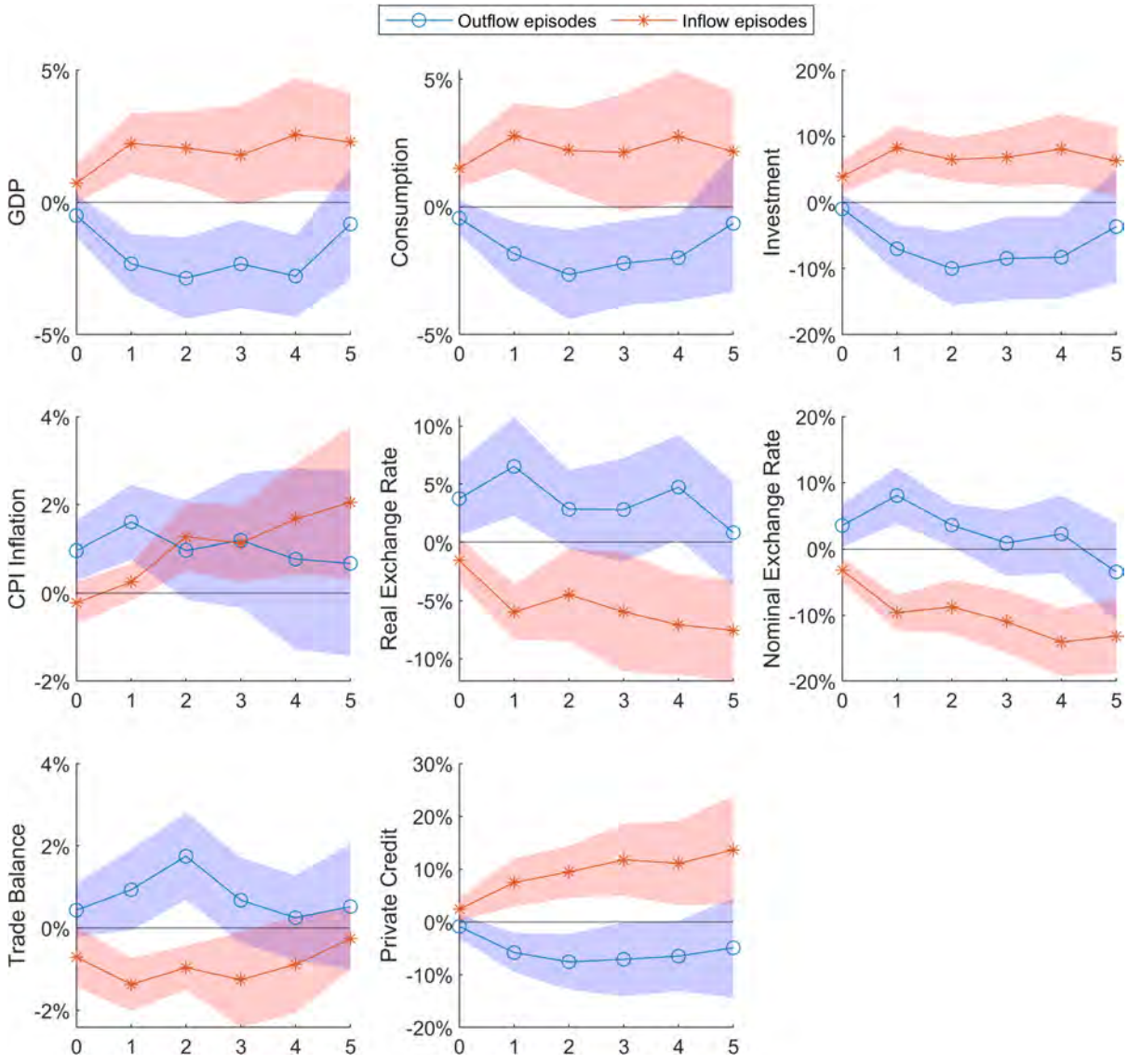


Figure 1: Local projection estimates for large outflows and inflows

GDP, consumption and investment and a real and nominal depreciation of the exchange rate. CPI inflation is slightly elevated, but it is only significant during and one year after the large outflow episode. The impact on exports and imports tends to be insignificant,

while the trade balance is improved significantly the first two years after the large outflow episode. Large inflow episodes tend to have the opposite effect. It is followed by an increase in GDP, consumption and investment. CPI inflation seems to increase in the long-run after a large inflow episode. The exchange rate appreciates both in real and nominal terms and this appreciation lasts even five years after the inflow episode. The trade balance is deteriorated during the first three years after the inflow episode, but the impact on exports and imports is muted and only a fall in exports during and one year after the inflow episode is significant at the 10%. These findings are largely consistent with those of the literature where capital inflows are associated with booms and outflows are related with busts.

The macroeconomic impact of large inflows and outflows is largely symmetric. If one elevates a macroeconomic variable, the other tends to lower it. However, they differ quantitatively. Outflow episodes tend to have a larger impact on GDP, investment and the trade balance while inflow episodes tend to have a larger impact on the exchange rate.

We calibrate the model developed in the next section so that it matches the macroeconomic impact of large outflow episodes.

2.2 Sudden stops

In addition to episodes that are defined with only capital flows, we define sudden stops as large outflow episodes that are followed by a fall in credit to the private sector from banks that is larger than 5% one year later. Out of the 38 large outflow episodes, 13 qualify as sudden stops in our sample. With 420 observations in our sample, this results in an unconditional frequency of 3.1% sudden stops per year. These are shown in Table 3.

Table 3: Sudden stops

Country	**Year**	**Country**	**Year**	**Country**	**Year**	**Country**	**Year**
Armenia	2014	Colombia	2008	Peru	2008	Uruguay	2016
Brazil	2015	Guatemala	2004	Philippines	2008		
Chile	2009	Guatemala	2008	Romania	2008		
Chile	2015	Korea	2008	Turkey	2001		

We use the same local projection method used above to compare the impact of sudden stops with the impact of non-sudden stop outflow episodes. We report the findings in Figure 2. We find that the fall in GDP, consumption and investment of outflow episodes are driven by sudden stops. Non-sudden stop outflow episodes do not have a significant impact on GDP, consumption and investment. These results show that one of the main channels as to how outflows affect the macroeconomy is through a reduction in credit

supply to the private sector from banks.

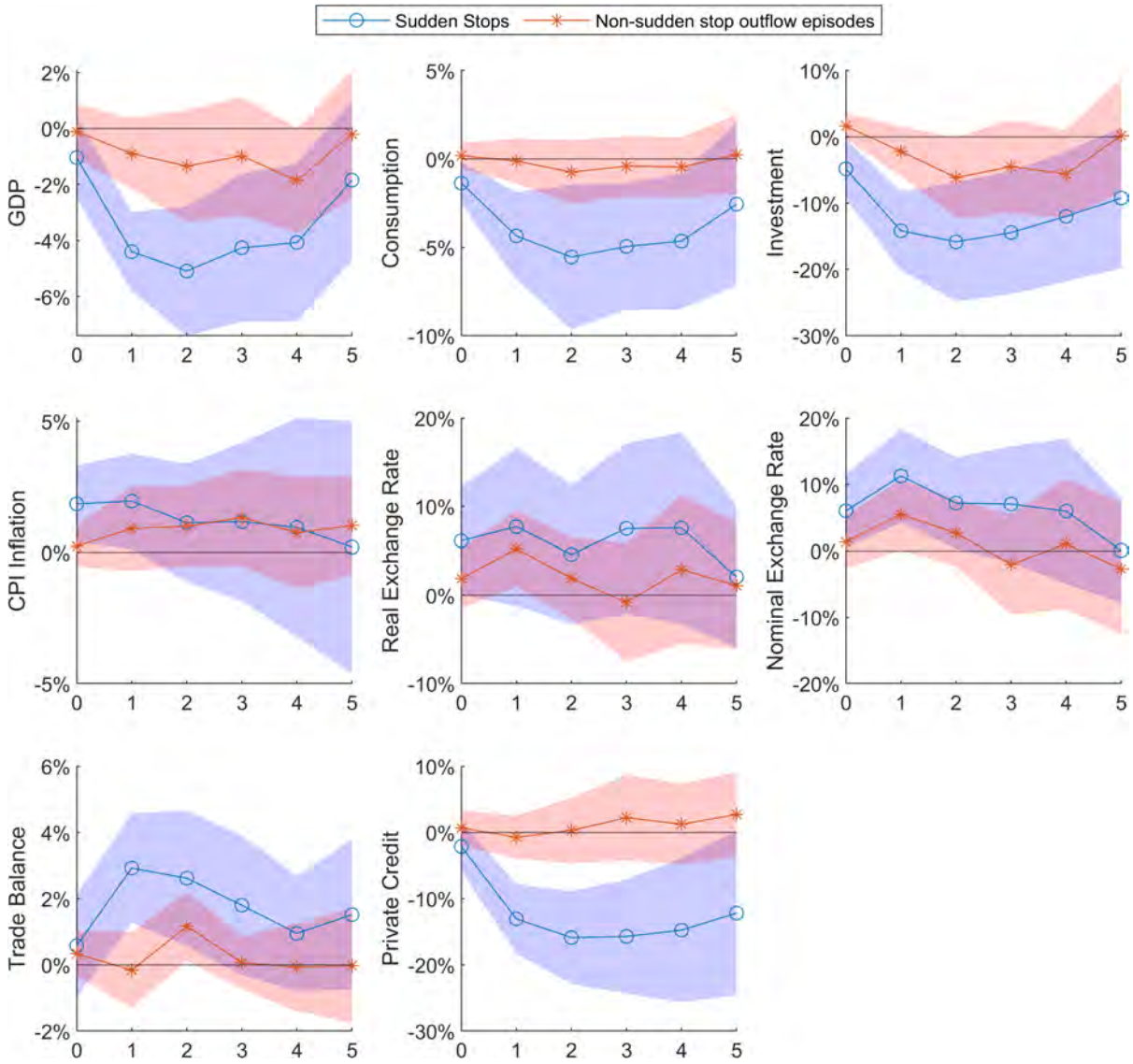


Figure 2: Local projection estimates for sudden stops and non-sudden stop outflow episodes

2.3 Predictive power of inflows

Next, we show that large inflow episodes have predictive power in forecasting large outflow episodes and sudden stops, following the literature on credit booms and financial crises. We first show how inflows predict outflows. We use the linear probability model specification given in Equation (4). $Outflow_{i,t}(h)$ is a dummy variable that takes the value of 1 if there is a large outflow episode that starts in years $t+1$, $t+2$, ..., or $t+h$ and 0

otherwise. $Inflow_{i,t}$ is another dummy variable that takes the value of 1 if there is a large inflow episode that starts in year t and 0 otherwise. We control for growth in GDP and credit supplied to the private sector by banks and nominal depreciation vis-a-vis the US dollar. We also control for country fixed effects. The exact regression that we run is given by Equation (3) and we use standard errors clustered by country.[3]

$$Pr\left(Outflow_{i,t}(h)=1|X_{i,t}\right)=\Phi\left(\begin{array}{c}\beta Inflow_{i,t}+\gamma_1\Delta\log(GDP_{i,t})\\+\gamma_2\Delta\log(Credit_{i,t})+\gamma_3\Delta\log(FX_{i,t})+FE_i\end{array}\right) \quad (2)$$

$$\begin{aligned}Outflow_{i,t}(h)=&\beta Inflow_{i,t}+\gamma_1\Delta\log(GDP_{i,t}) \\ &+\gamma_2\Delta\log(Credit_{i,t})+\gamma_3\Delta\log(FX_{i,t})+FE_i+\varepsilon_{i,t}\end{aligned} \quad (3)$$

The estimates for Equation (2) are shown in the first three columns of Table 4. We find that large inflow episodes are able to predict large outflow episodes and this is robust across several horizons. This can also be seen looking at the inflow and outflow episodes in Tables 1 and 2. Several outflow episodes are preceded by large inflow episodes. For example, Peru had a large inflow episode in 2007 that was followed by a large outflow episode in 2008. Interestingly, credit growth also has predictive power in forecasting large outflow episodes while GDP growth and exchange rate depreciation do not. This is in contrast with Benigno et al. (2015) who find that credit supply to the private sector is unable to predict capital flow reversals.

We also test whether inflow episodes are able to predict sudden stops as defined in Section 2.2. We use the following linear probability specification:

$$Pr\left(SS_{i,t}(h)=1|X_{i,t}\right)=\Phi\left(\begin{array}{c}\beta Inflow_{i,t}+\gamma_1\Delta\log(GDP_{i,t})+\gamma_2\Delta\log(Credit_{i,t})\\+\gamma_3\Delta\log(FX_{i,t})+FE_i\end{array}\right) \quad (4)$$

and run the following regression:

$$\begin{aligned}SS_{i,t}(h)=&\beta Inflow_{i,t}+\gamma_1\Delta\log(GDP_{i,t})+\gamma_2\Delta\log(Credit_{i,t}) \\ &+\gamma_3\Delta\log(FX_{i,t})+FE_i+\varepsilon_{i,t}\end{aligned} \quad (5)$$

[3]This method is similar to that used in Benigno et al. (2015) but differs in the controls. Benigno et al. (2015) controls for private credit, manufacturing employment and investment, fed funds rate, reserve accumulation, initial reserves, exchange rate regime, and financial openness. Some of these controls are included in our specification. For example, a measure of private credit is included in our controls and country fixed effects control for financial openness and the exchange rate regime. We do not control for activities in the manufacturing sector, reserve usage, nor the fed funds rate, but add GDP growth and nominal depreciation as extra controls.

where $SS_{i,t}(h)$ is a dummy variable that takes the value of 1 if there is a sudden stop that starts in years $t+1$, $t+2$, ..., or $t+h$ and 0 otherwise. We report the results in the last three columns of Table 4. Again, we find that large inflow episodes have predictive power in forecasting sudden stops, with the strongest predictive power in forecasting sudden stops that occur within two years. This finding is consistent with Muller and Verner (2023) that show large capital inflows are followed by busts or financial crises.

Interestingly, credit growth again has predictive power in forecasting sudden stops, though the significance is weaker than for outflow episodes. This is consistent with the findings in Benigno et al. (2015). Despite the difference in the definition of sudden stops (Benigno et al. (2015) use output contraction to define sudden stops) and large inflow episodes (Benigno et al. (2015) use net capital flows) both studies show private credit supply has predictive power in forecasting sudden stops.

	$Outflow_{i,t}(h)$			$SS_{i,t}(h)$		
	h=1	h=2	h=3	h=1	h=2	h=3
$Inflow_{i,t}$	0.148**	0.269***	0.181***	0.117**	0.154***	0.107**
	(0.066)	(0.075)	(0.061)	(0.053)	(0.050)	(0.052)
$\Delta \log(GDP_{i,t})$	-0.938	-0.843	-0.543	-0.070	0.078	-0.111
	(0.879)	(0.987)	(1.271)	(0.271)	(0.262)	(0.357)
$\Delta \log(Credit_{i,t})$	0.375***	0.742***	0.861***	0.164*	0.295*	0.316*
	(0.085)	(0.204)	(0.249)	(0.088)	(0.154)	(0.170)
$\Delta \log(FX_{i,t})$	-0.101	-0.036	-0.372	0.073	0.208	0.022
	(0.174)	(0.250)	(0.310)	(0.133)	(0.214)	(0.276)
R^2	0.0716	0.1408	0.1495	0.081	0.124	0.144
N	345	326	307	345	326	307

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Linear probability model estimation results

In the next section, we develop a model that is able to replicate this finding that large inflow episodes are predictive of large outflow episodes.

2.4 The role of currency denomination in external liabilities

We also test whether the macroeconomic impact of inflow and outflow episodes and the predictive power of inflow episodes are sensitive to the currency denomination of external liabilities.

Many early works on capital outflows and sudden stops in emerging market economies focused on the “Original Sin" phenomenon, coined by Eichengreen et al. (2002), which

highlights the inability of emerging market economies to borrow in their own currency from abroad. This makes emerging market economies more vulnerable to capital outflows as the currency depreciation usually associated with capital outflows amplifies the external liability position in local currency.

Over the years, however, emerging markets have become more resilient to the Original Sin and have become more able to borrow abroad in local currency, especially the governments of these emerging market economies. In recent work Onen et al. (2023) show that governments have been able to borrow from abroad more in local currency such that the fraction of long-term sovereign bonds held by foreign entities denominated in local currency has increased from around 30% to 60% over the last 20 years. Figure 3 shows the share of all external liabilities in local currency (left) and the share of external debt liabilities in local currency (right) for emerging market economies and advanced economies from 1990 to 2017.[4] We can see that over time, the currency composition of external liabilities and external debt liabilities of the median emerging market economy has become similar to that of the median advanced economy in 2017 with the local currency share of external liabilities at around 60% and that of external debt liabilities at around 20%.

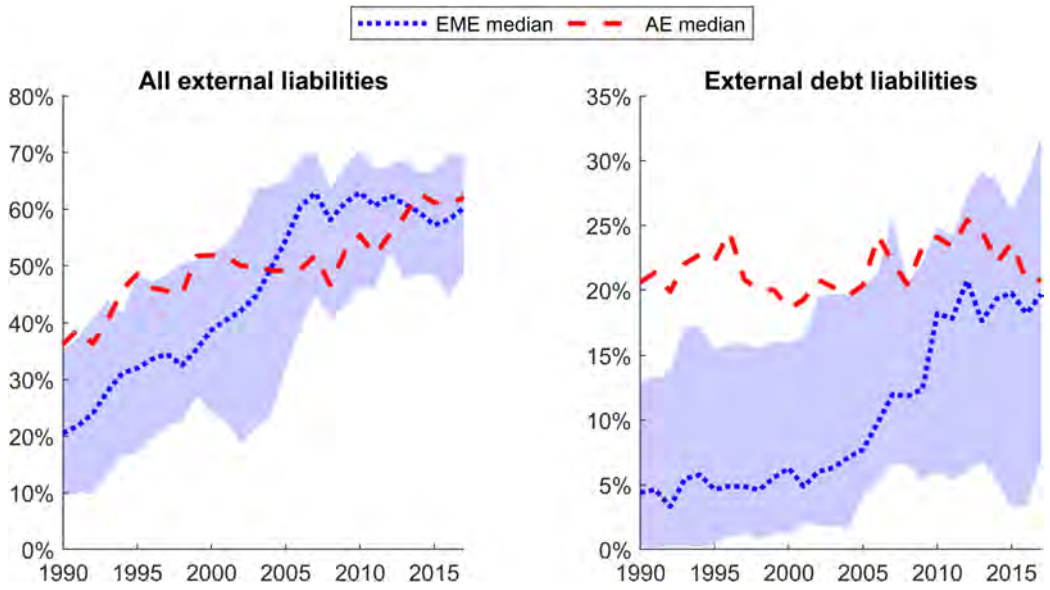


Figure 3: Local currency share of external liabilities

However, despite the dissipation of the "Original Sin" in emerging market economies,

[4]For Figure 3, our sample of emerging market economies include Armenia, Brazil, Chile, China, Colombia, Czech Republic, Egypt, Guatamala, Hungary, Indonesia, India, Korea, Sri Lanka, Morocco, Mexico, Malaysia, Peru, Philippines, Pakistan, Poland, Russia, Thailand, Tunisia, Turkey, Uruguay and South Africa. Advanced economies include the UK, Hong Kong, New Zealand, Australia, Switzerland, Norway, Japan, Sweden, Denmark, the US, Canada, Germany, Singapore and Israel.

emerging market economies are still prone to sudden stops and large capital outflow episodes. Bertaut et al. (2023) show that dollar appreciation amplifies the sell-off in emerging market local currency bonds, while dollar denominated bonds are unaffected, showing that the ability to borrow in local currency has not insulated emerging markets from fluctuations in global financial conditions. As the existence of currency risk shifts from the external balance sheet of emerging market economies to that of foreign investors, Hofmann et al. (2022) theoretically explain that monetary tightening abroad can instigate large portfolio re-balancing by foreign investors which then propagates to emerging market economies. A series of papers have called this continued exposure to fluctuations in global financial conditions by emerging market economies the "Original Sin Redux."

Following this literature, we check if the macroeconomic implications of large inflow and outflow episodes are sensitive to the currency composition of external liabilities. We run the local projections shown in Equation (1) separately for a sample of countries that have above median local currency share of external liabilities and for a sample of countries that have below median local currency share of external liabilities.[5]

The local projection estimates for outflow episodes are shown in Figure 4. Due to a smaller sample size, we show one standard error confidence intervals instead. We find that the impact of outflow episodes on GDP, consumption and investment is larger in countries with higher local currency share of external liabilities while the results are mixed for other variables. This provides supportive evidence for Hofmann et al. (2022) that emphasizes having higher local currency share of external liabilities does not fully insulate the country from volatile capital flows.

A similar figure can be shown for large inflow episodes. Figure 5 shows the local projection estimates for large inflow episodes across the two groups of countries. We again see that having a higher local currency share of external liabilities does not fully insulate a country from volatile capital flows. Contrary to outflows, the impact of large inflow episodes on GDP, consumption and investment is roughly symmetric across the two groups.

Next, we also test whether the predictive ability of large inflow episodes is sensitive to the currency composition of external liabilities. We augment Equations (3) and (5) by including an interaction term $Inflow_{i,t} \times LC_{i,t}$ where $LC_{i,t}$ is a dummy variable that takes

[5]More specifically, we derive the average local currency share of external liabilities for each country and derive the median value of these country averages. Then, we split our sample of 20 countries into two groups, one group with countries that have an average local currency share of external liabilities higher than the cross-country median and another group with countries that have a below median local currency share. The data for local currency share of external liabilities comes from Benetrix et al. (2019). We use the variable "w_L_DC" for the share of local currency in external liabilities.

the value of 1 if country i is a country with higher than median local currency share of external liabilities. The exact specifications are shown in Equations (6) and (7).

$$\begin{aligned} Outflow_{i,t} =& \alpha + \beta Inflow_{i,t} + \delta Inflow_{i,t} \times LC_{i,t} \\ &+ \gamma_1 \Delta \log(GDP_{i,t}) + \gamma_2 \Delta \log(Credit_{i,t}) + \gamma_3 \Delta \log(FX_{i,t}) + FE_i + \varepsilon_{i,t} \end{aligned} \tag{6}$$

$$\begin{aligned} SS_{i,t} =& \alpha + \beta Inflow_{i,t} + \delta Inflow_{i,t} \times LC_{i,t} \\ &+ \gamma_1 \Delta \log(GDP_{i,t}) + \gamma_2 \Delta \log(Credit_{i,t}) + \gamma_3 \Delta \log(FX_{i,t}) + FE_i + \varepsilon_{i,t} \end{aligned} \tag{7}$$

We report the estimates in Table 5. We find that δ is significant for two and three year horizons when predicting outflow episodes and sudden stops, showing that the currency composition of external liabilities does matter. However, we do note that even for countries with an above median local currency share of external liabilities, inflow episodes do predict large outflow episodes since $\beta + \delta > 0$ for two and three year horizons. The predictive ability of inflows for the above median group also holds for sudden stops, but is quantitatively much weaker. At the two year horizon, the coefficient on inflows is only 0.041 (=0.272-0.231) while at the three year horizon, the coefficient on inflows is negative (=0.245-0.254).

	$Outflow_{i,t}(h)$			$SS_{i,t}(h)$		
	h=1	h=2	h=3	h=1	h=2	h=3
$Inflow_{i,t}$	0.167	0.434***	0.324***	0.163	0.272***	0.245***
	(0.125)	(0.118)	(0.082)	(0.108)	(0.101)	(0.090)
$Inflow_{i,t} \times LC_{i,t}$	-0.093	-0.280*	-0.230*	-0.141	-0.231**	-0.254**
	(0.141)	(0.164)	(0.126)	(0.114)	(0.112)	(0.099)
$\Delta \log(GDP_{i,t})$	0.249	0.565	1.380	0.159	0.224	0.236
	(0.540)	(0.956)	(1.224)	(0.419)	(0.468)	(0.595)
$\Delta \log(Credit_{i,t})$	0.332***	0.641**	0.615**	0.143	0.221	0.165
	(0.124)	(0.280)	(0.285)	(0.105)	(0.155)	(0.149)
$\Delta \log(FX_{i,t})$	-0.055	0.012	-0.270	0.121	0.246	0.091
	(0.211)	(0.292)	(0.347)	(0.135)	(0.204)	(0.255)
R^2	0.055	0.137	0.143	0.083	0.144	0.168
N	303	287	271	303	287	271

*** p<0.01, ** p<0.05, * p<0.1

Table 5: Linear probability model estimation results with local currency share of external liabilities

Overall, we find that the currency composition of external liabilities reduces the predictive power of large inflows in forecasting outflow episodes and sudden stops, but it does

not disappear (except for sudden stops at long horizons). Also, the impact of large capital flows does not differ much between groups of countries with high and low local currency share of external liabilities. Therefore, being able to borrow in local currency does not fully insulate the economy from volatile capital flows.

To account for the fact that even for countries with high local currency share of external liabilities, the macroeconomic impact of large capital flow episodes and the predictive power of large inflow episodes persists, we develop a model where external liabilities are fully comprised of local currency bonds in the next section.

3 Model

In this section we introduce a model of a small open economy, which we refer to as "Home." The economy is inhabited by a measure one of households and produces tradable goods which are consumed domestically and exported to the rest of the world. Households consume domestic and imported goods and supply labor which is combined with physical capital to produce domestic tradable goods. The production of physical capital requires risky investment and is financed by domestic banks. Banks collect short-term deposits from households and invest in long-term assets. They issue loans to capital producers and purchase long-term government bonds. However, an agency problem affects their ability to raise deposits and limits their leverage, constraining the domestic supply of credit. Fortunately, banks are not the only source of credit for the Home economy. Foreign investors lend to the domestic government by purchasing Home-currency government bonds. Capital inflows, by affecting the size and composition of the balance sheet of the banking sector, are a critical determinant of the domestic cost of credit. When capital inflows are abundant, the leverage of the banking sector falls allowing banks to channel funds to the private sector. However, when inflows retrench domestic leverage rises and banks are forced to curtail their supply of credit giving rise to a sudden stop.

Households

The Home economy is inhabited by a measure one of identical households, each composed of a unit mass of family members. Within each household there are two types of members. A fraction $1-\varpi$ of them are workers and a fraction ϖ are bankers. Workers supply labor while bankers manage domestic financial intermediaries. Both agents return their earnings to the household within which there is perfect consumption insurance. Individuals switch across occupations stochastically. In particular, in each period a fraction $1-\sigma$ of randomly

selected bankers become workers in the following period.[6] An exiting banker pays out all retained earnings as dividends to her household and is replaced by a former worker, which becomes a new banker.

Each household maximizes

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \frac{\left(C_t - \chi \frac{H_t^{1+\varphi}}{1+\varphi} \right)^{1-\eta} - 1}{1-\eta} \right]$$

where C_t is consumption, H_t is the aggregate amount of labor supplied by its workers and φ the inverse of the Frisch elasticity of labor supply. The consumption index is a composite of Home and imported goods, given by

$$C_t = \frac{C_{H,t}^{1-\alpha} C_{F,t}^{\alpha}}{(1-\alpha)^{1-\alpha} \alpha^{\alpha}},$$

where $\alpha \in [0,1]$ measures the degree of Home bias in consumption. The optimal allocation of expenditure between domestic and foreign goods yields the demand function

$$C_{H,t} = (1-\alpha) \frac{C_t}{P_{H,t}}$$

where $P_{H,t}$ is the real price of the Home good, that is its price in units of domestic consumption. To avoid confusion, we express all prices in real terms, that is in units of domestic consumption, except for inflation rates which represent the growth rate of nominal prices and nominal interest rates. This implies

$$P_{H,t} = (P_{F,t})^{-\frac{\alpha}{1-\alpha}}$$

where $P_{F,t}$ denotes the domestic price of the imported good. We assume that the foreign good is priced in foreign currency and there is full exchange rate pass-through to import prices. This implies that $P_{F,t} = E_t P_{F,t}^*$, where E_t denotes the real exchange rate, defined as the relative price of foreign consumption in terms of domestic consumption such that an increase in E_t represents a real depreciation for the domestic economy. We let Π_t and $\Pi_{H,t}$ denote CPI and PPI inflation respectively such that $\Pi_t = \Pi_{H,t} \frac{P_{H,t-1}}{P_{H,t}}$.

Domestic households can save by holding bank deposits which pay the nominal gross

[6] This assumption implies that bankers have a finite horizon. This, in turn, insures that they do not accumulate enough earnings to fund their balance sheets entirely through their own capital.

risk-free rate R_t^d. Then the budget constraint of the representative household is

$$C_t = -D_t + D_{t-1}\frac{R_{t-1}^d}{\Pi_t} + W_t H_t + \Omega_t$$

where D_t denotes the aggregate real amount of deposits, W_t is the real wage rate and Ω_t denotes her net non-labor income which is the sum of dividends from firms, entrepreneurs, and financial intermediaries, minus lump-sum taxes: $\Omega_t = \Omega_t^y + \Omega_t^k + \Omega_t^f - T_t$. The households' labor supply decision is $W_t = \chi H_t^{\varphi}$, while their Euler equation is

$$1 = \mathbb{E}_t\left[\beta \Lambda_{t|t+1}\frac{R_t^d}{\Pi_{t+1}}\right]$$

where $\Lambda_{t|t+1} = \beta\left(\frac{C_{t+1}-\chi\frac{H_{t+1}^{1+\varphi}}{1+\varphi}}{C_t-\chi\frac{H_t^{1+\varphi}}{1+\varphi}}\right)^{-\eta}$ is the households stochastic discount factor.

Banks

Banks channel funds from savers to borrowers. In doing so, they engage in maturity transformation since they issue short-term liabilities and invest in long-term assets. These banks finance three types of activities. First, they make loans to non-financial firms to finance the production of physical capital. Loans are claims to a stream of earnings associated with the underlying capital. Let P_t^l denote the market value of a loan that is financing one unit of capital and Q_t its cash flow. Then the real rate of return to the bank is

$$\frac{R_{t+1}^l}{\Pi_{t+1}} = \frac{Q_{t+1} + (1-\delta)\, P_{t+1}^l}{P_t^l}$$

where $\delta \in (0,1)$ is the depreciation rate of capital.

In addition, banks lend to the domestic government by purchasing long-term bonds. Government bonds are real perpetuities with coupons that decay exponentially. Specifically, a bond issued in period t pays $(1-\rho)^j$ units of the domestic consumption basket $j+1$ periods later, for $\rho \in (1-\beta^{-1}, 1]$. Their gross real rate of return is

$$\frac{R_{t+1}^b}{\Pi_{t+1}} = \frac{1 + (1-\rho)\, P_{t+1}^b}{P_t^b}$$

where P_t^b denotes the price of a new bond issued in period t.

Finally, banks finance working capital loans to producers, Z_t. These are intraperiod loans that pay the nominal interest rate R_t^w. Since these loans are intraperiod, the money

used to finance them can also be used to finance the acquisition of intertemporal assets at the end of the period. For simplicity, we assume that net profits are immediately rebated to households.

The aggregate balance sheet of the banking sector is

$$P_t^l L_t + P_t^b B_t + S_t = N_t + D_t$$

where N_t is banks' end-of-period net worth, L_t their holding of loans, B_t their holding of government bonds, and S_t are reserves held by banks on accounts at the central bank which pay the gross nominal interest rate R_t. The bankers' objective is to maximize the present discounted value of their dividends to their households. Since dividends are paid only upon exiting, this is tantamount to maximizing their terminal wealth. Therefore, the problem of the representative banker is

$$\mathcal{V}_t\left(N_t\right) = \max_{L_t, B_t, D_t} \left\{ \left(R_t^w - 1\right) Z_t + \mathbb{E}_t \Lambda_{t|t+1} \left[\left(1-\sigma\right) \dot{N}_{t+1} + \sigma V_{t+1}\left(\dot{N}_{t+1}\right) \right] \right\}$$

where $\dot{N}_{t+1}$ is the beginning-of-period net worth in period $t+1$, that is before the exit and entry of bankers take place, which is given by

$$\begin{aligned} \dot{N}_{t+1} = & \left(\frac{R_{t+1}^l}{\Pi_{t+1}} - \frac{R_t}{\Pi_{t+1}} \right) P_t^l L_t + \left(\frac{R_{t+1}^b}{\Pi_{t+1}} - \frac{R_t}{\Pi_{t+1}} \right) P_t^b B_t \\ & + \frac{R_t}{\Pi_{t+1}} N_t - \left(\frac{R_t^d}{\Pi_{t+1}} - \frac{R_t}{\Pi_{t+1}} \right) D_t. \end{aligned}$$

We write the banks' problem directly in terms of the representative bank since, as will be clear in a moment, their value function is linear in net worth and therefore can be aggregated across bankers.

Following Gertler and Kiyotaki (2010) we assume that banks are subject to a moral hazard problem which might limit their ability to raise deposits. At the beginning of each period, a banker can divert a fraction of the assets held by the bank she manages and transfer the proceeds to her household. In particular, we assume that the banker can divert a fraction ζ_l of its claims on physical capital, a fraction ζ_b of its government bond holdings and a fraction ζ_w of its claims on working capital loans. Reserves held at the central bank cannot be diverted. When diversion occurs, depositors force the bank into bankruptcy and recover the remaining fraction of assets. Anticipating the incentives of the banker, depositors are willing to lend her if and only if the value of the bank exceeds the value of

divertable assets. Hence, the following incentive compatibility constraint must be satisfied

$$\mathcal{V}_t\left(N_t\right) \geq \zeta_l P_t^l L_t + \zeta_b P_t^b B_t + \zeta_w Z_t$$

where $\mathcal{V}_t$ denotes the value of the bank for the households. Let μ_t be the Lagrange multiplier associated with the incentive compatibility constraint. The first order conditions of the banks problem give rise to the following pricing equations:

$$\begin{aligned}
\zeta_l \mu_t &= \mathbb{E}_t\left[\left(1-\sigma+\sigma V_{t+1}\right)\Lambda_{t|t+1}\left(\frac{R_{t+1}^l}{\Pi_{t+1}}-\frac{R_t}{\Pi_{t+1}}\right)\right] \\
\zeta_b \mu_t &= \mathbb{E}_t\left[\left(1-\sigma+\sigma V_{t+1}\right)\Lambda_{t|t+1}\left(\frac{R_{t+1}^b}{\Pi_{t+1}}-\frac{R_t}{\Pi_{t+1}}\right)\right] \\
\zeta_w \mu_t &= R_t^w - 1
\end{aligned}$$

and $R_t^d = R_t$, where V_t is the marginal value of net worth for the banks and satisfies

$$\left(1-\mu_t\right)V_t = \mathbb{E}_t\left[\left(1-\sigma+\sigma V_{t+1}\right)\Lambda_{t|t+1}\frac{R_t}{\Pi_{t+1}}\right]$$

and their value function is linear in net worth, $\mathcal{V}_t\left(N_t\right) = V_t N_t$.

Aggregate end-of-period net worth evolves as the sum of the net worth of the surviving bankers plus the start-up capital endowed to the new bankers by their households, denoted by $\hat{N}_t$, as follows:

$$N_t = \sigma \dot{N}_t + \hat{N}_t$$

We assume

$$\hat{N}_t = \frac{\sigma}{\beta}\left(\overline{N} - \overline{P^l L} - \overline{P^b B}\right) + \upsilon \overline{P^l L} + \varrho\left(V_t - 1\right)^3 - \sigma\frac{R_{t-1}}{\Pi_t}\left(N_{t-1} - P_{t-1}^l L_{t-1} - P_{t-1}^b B_{t-1}\right)$$

such that

$$N_t = \frac{\sigma}{\beta}\left(\overline{N} - \overline{P^l L} - \overline{P^b B}\right) + \sigma\left(\frac{R_t^l}{\Pi_t}P_{t-1}^l L_{t-1} + \frac{R_t^b}{\Pi_t}P_{t-1}^b B_{t-1}\right) + \upsilon\overline{P^l L} + \varrho(V_t - 1)^3$$

where we denote the steady state value of the variables with a bar. The cubic term is added to assist with solving the model globally. Therefore

$$\Omega_t^f = \left(R_t^w - 1\right) Z_t + \left(1-\sigma\right)\dot{N}_t - \hat{N}_t.$$

Tradable good firms

In the Home economy there is a measure one of monopolistically competitive firms that produce tradable goods. Each firm, indexed by $j \in [0,1]$, produces a different variety of the tradable good using the technology

$$Y_t(j) = A_t H_t(j)^{\gamma} K_t(j)^{\omega} M_t(j)^{1-\gamma-\omega}$$

with $\gamma \in (0,1)$ and $\omega \in (0,1)$, where A_t is total factor productivity which follows an exogenous stochastic process. Firms rent labor from households at the wage rate $(1-\tau_t^w) W_t$ where τ_t^w is a wage subsidy levied lump-sum on firms, rent physical capital from entrepreneurs at the rental rate Q_t, and purchase imported inputs M_t. Firms are forced to borrow a fraction ξ of their cost of labor and imported inputs (á la Mendoza 2010) for a total net cost of $Z_t(j)(R_t^w - 1)$, where $Z_t(j) = \xi[W_t H_t(j) + P_{F,t} M_t(j)]$. Their cost minimization problem yields the following (aggregate) input demands

$$\begin{aligned} H_t &= \frac{\gamma MC_t Y_t}{W_t[1+\xi(R_t^w-1)]} \\ K_{t-1} &= \frac{\omega MC_t Y_t}{Q_t} \\ M_t &= \frac{(1-\gamma-\omega) MC_t Y_t}{P_{F,t}[1+\xi(R_t^w-1)]} \end{aligned}$$

where the real marginal cost of production is

$$MC_t = \frac{[1+\xi(R_t^w-1)]^{1-\omega}}{A_t} \left(\frac{W_t}{\gamma}\right)^{\gamma} \left(\frac{Q_t}{\omega}\right)^{\omega} \left(\frac{P_{F,t}}{1-\gamma-\omega}\right)^{1-\gamma-\omega}$$

Producers sell their varieties to domestic retailers which aggregate them according to a constant elasticity of substitution technology $Y_{H,t} \equiv \left[\int_0^1 Y_{H,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}$. Retailers sell final output to consumers, capital producers and exporters in perfectly competitive markets. Their cost minimization problems give rise to the demand schedule $Y_t(j) = (P_{H,t}(j)/P_{H,t})^{-\epsilon} Y_t$, where $P_{H,t} \equiv \left[\int_0^1 P_{H,t}(j)^{1-\epsilon} dj\right]^{\frac{1}{1-\epsilon}}$ is the domestic price index. Exporters transform the domestic good into different varieties and sell them to foreign retailers that aggregate them according to $Y_{H,t}^* \equiv \left[\int_0^1 Y_{H,t}^*(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}$. Producers and exporters set their prices in domestic currency, respectively, subject to adjustment costs á la

Rotemberg. The optimal pricing decision of firms results in the following Phillips Curve:

$$(\Pi_{H,t}-1)\,\Pi_{H,t}=\frac{\epsilon-1}{\theta}\left(\frac{\epsilon}{\epsilon-1}\,(1+\tau_H)\,\frac{MC_t}{P_{H,t}}-1\right)+\mathbb{E}_t\left[\Lambda_{t,t+1}\,(\Pi_{H,t+1}-1)\,\frac{(\Pi_{H,t+1})^2\,Y_{t+1}}{\Pi_{t+1}\,Y_t}\right].$$

We assume there is imperfect exchange rate pass through onto export prices such that export prices in foreign currency are given as follows.

$$P^*_{H,t}=\frac{\nu}{\nu-1}\left(\frac{P_{H,t}}{E_t}\right)^{\vartheta}\left(\frac{\overline{P_H}}{\overline{E}}\right)^{1-\vartheta}$$

A higher value of $\vartheta\leq 1$ represents higher exchange rate pass through to export prices. The term $\frac{\nu}{\nu-1}$ is introduced since the Home economy is a monopolistic supplier of Home goods to the international goods market. Aggregate profits are

$$\begin{aligned}\Omega^y_t\equiv&\left[1-\frac{\theta}{2}\,(\Pi_{H,t}-1)^2\right]\left(P_{H,t}Y_t-P_{H,t}Y^*_{H,t}+E_tP^*_{H,t}Y^*_{H,t}\right)\\&-Q_tK_{t-1}-(W_tH_t+M_tP_{F,t})-(R^w_t-1)\,Z_t\end{aligned}$$

The planner sets taxes and subsidies as follows to offset the constant markup from monopolistic competition.

$$1=\frac{\epsilon}{\epsilon-1}\,(1+\tau_H)$$

Capital good firms

In the Home economy there is also a unit mass of homogeneous firms that produce physical capital. Capital good firms combine domestic and imported goods to produce new capital and rent it to tradable good producers at rate Q_t. Capital production is subject to adjustment costs. Producing I_t new units of capital costs $I_t+\frac{\iota}{2}\left(\frac{I_t}{K_{t-1}}-\delta\right)^2K_{t-1}$ units of the domestic consumption basket. To finance production, capital producers must borrow from banks. For each new unit of capital produced they issue a state-contingent claim to the future stream of earnings from the unit, of which a fraction ε is then sold to banks at price P^l_t. The other fraction $1-\varepsilon$ is held by households whose demand is inelastic. Capital producers maximize the present discount value of their profits for the households. Their

problem is

$$\max_{\{I_{t+j}\}_{j=0}^{\infty}} \mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t|t+j} \left\{ \left(P_{t+j}^l - 1\right) I_{t+j} - \frac{\iota}{2} \left(\frac{I_{t+j}}{K_{t+j-1}} - \delta \right)^2 K_{t+j-1} \right\}$$

The first order condition of the problem yields

$$P_t^l = 1 + \iota \left(\frac{I_t}{K_{t-1}} - \delta \right)$$

and the law of motion of capital is

$$K_t = I_t + (1 - \delta) K_{t-1}.$$

Aggregate profits from entrepreneurs are

$$\Omega_t^k = (P_t^l - 1) I_t - \frac{\iota}{2} \left(\frac{I_t}{K_{t-1}} - \delta \right)^2 K_{t-1}.$$

Foreign investors

The country can attract foreign capital by selling government bonds internationally. Foreign investors demand for Home government bonds gives rise to the following uncovered interest parity (UIP) condition

$$\mathbb{E}_t \left[\frac{E_t}{E_{t+1}} \frac{\Pi_{t+1}^*}{R_t^*} \frac{R_{t+1}^b}{\Pi_{t+1}} \right] = 1$$

where R_t^* represents the expected return that foreign investors require to invest in Home government bonds and is given by

$$\frac{R_t^*}{\overline{\Pi}} = \frac{1}{\beta} + \left[\exp\left(\kappa_t\right) - 1 \right] + \varpi \left[\exp\left(\frac{P_t^b B_t^* - \overline{P^b B^*}}{\overline{P_H Y}} \right) - 1 \right].$$

R_t^* is composed of three components. The first component contains κ_t which is an i.i.d. mean-zero shock and captures fluctuations in the risk premium which are exogenous to the Home country. This shock is a proxy for changes in global financial conditions induced by shifts in foreign investors risk sentiment. And the last component reflects how foreign investors require higher returns if they absorb more Home government bonds.

Government sector

The public sector is composed of a central bank and a fiscal authority. The central bank controls the risk-free rate of the economy by setting the nominal interest rate on reserves, R_t. In the baseline version of the model we assume the simple Taylor rule

$$\frac{R_t}{\overline{\Pi}} = \frac{1}{\beta}\left(\frac{\Pi_{H,t}}{\overline{\Pi}}\right)^{1+\phi}$$

where $\overline{\Pi}$ is the target nominal PPI inflation rate.

The fiscal authority maintains a constant supply of government debt, $\overline{B}^g$, which is financed by taxing households a lump-sum amount given by

$$T_t = \left[1 + (1-\rho)\, P_t^b\right] \overline{B}^g - P_t^b \overline{B}^g.$$

Market clearing

For the goods market to clear, we require

$$Y_t = \frac{(1-\alpha)\left(P_{H,t}\right)^{-1}\left[C_t + I_t + \frac{\iota}{2}\left(\frac{I_t}{K_{t-1}} - \delta\right)^2 K_{t-1} + G_t\right] + Y_{H,t}^*}{1 - \frac{\theta}{2}\left(\Pi_{H,t} - 1\right)^2}$$

where $Y_{H,t}^* = \alpha^* \left(P_{H,t}^*\right)^{-\nu} Y^*$. Market clearing in the labor and capital markets require $\int_0^1 H_t(j)\, dj = H_t$ and $\int_0^1 K_{t-1}(j)\, dj = K_{t-1}$, while market clearing in the asset markets require

$$\begin{aligned} L_t &= \varepsilon K_t \\ B_t^g &= B_t + B_t^c + B_t^*. \end{aligned}$$

Finally, the Home country aggregate budget constraint is

$$\begin{aligned} P_t^B B_t^* = \left[1 + (1-\rho)\, P_t^B\right] B_{t-1}^* + \frac{\alpha}{1-\alpha}\left[1 - \frac{\theta}{2}\left(\Pi_{H,t} - 1\right)^2\right] P_{H,t} Y_t \\ + M_t P_{F,t} - \frac{\alpha^* Y^*}{1-\alpha}\left(1 - \alpha + \alpha \frac{P_{H,t}}{E_t P_{H,t}^*}\right) E_t \left(P_{H,t}^*\right)^{1-\nu}. \end{aligned}$$

4 Calibration and solution method

In this section we explain the baseline calibration of the model and the method we use to derive global solutions.

4.1 Calibration

We calibrate the quantitative model by assigning values to structural parameters using annual data on benchmark emerging market economies[7] and taking values that are standard in the literature. Table 6 reports the parameter values in our baseline quantitative model.

For structural parameters concerning household preferences, the relative risk aversion is set to $\eta = 2$ and the elasticity of substitution between varieties is set to $\epsilon = 6$ which are standard values in the literature. The time discount factor is set to $\beta = 0.975$ to match the sample average external interest rate of around 2.5%, and the share of imported final consumption goods is set to $\alpha = 0.234$ to match the sample average imports to GDP ratio. The labor disutility parameter is $\chi = 0.4953$ so that labor supply is 1 in the steady state. The inverse of Frisch elasticity is $\varphi = 2$, a standard value used in the literature.

For structural parameters regarding the technology of and frictions faced by firms, the capital depreciation rate is set to $\delta = 0.025$, the Rotemberg quadratic price adjustment cost parameter is set to $\theta = 19.5122$ implying the same first-order inflation dynamics as a Calvo pricing model with an average price duration of around 1.6 years, and the rest of the world trade elasticity of substitution is set to $\nu = 3$. The exchange rate pass-through of exports is set to $\vartheta = 0.25$. The labor share is $\gamma = 0.5850$ and capital share is $\omega = 0.2930$ and are set such that the labor share of income is $2/3$ and the imported intermediate goods share matches what is observed in our sample. The rest of the world demand is normalized to $Y^* = 1$. The quadratic capital adjustment cost parameter is $\iota = 2.5$ and is set such that the ratio of the standard deviation of log investment to the standard deviation of log output matches the data.

The divertable fraction of various assets held by banks are set to $\zeta_b = \zeta_l = 0.3$ and $\zeta_w = 0.1$ and the survival rate of banks each quarter is set to $\sigma = 0.95$ following standard values used in the literature. The steady state distance of the constraint from binding is set to $\tilde{\Delta} = 0.0015$ to control the frequency of sudden stops to approximately 3 percent. The parameter for new bank startup capital is set to $\upsilon = 0.0380$ to match the steady state distance of the constraint from binding.

[7] Our sample of countries consists of Brazil, Chile, Colombia, Czech Republic, Hungary, Indonesia, India, Israel, Malaysia, Mexico, Poland, South Africa, South Korea, Turkey, Thailand and Russia and we use an unbalanced sample depending on the availability of data.

The Taylor rule coefficient is set to $\phi = 1.5$ which is standard in the literature. The steady state external debt to GDP ratio is set to $\tilde{PB}^* = 0.47$ to match the sample average and the steady state government debt to GDP ratio is set to $\frac{P^b B^g}{GDP} = 2$. The depreciation rate of perpetual bond payments is set to $\rho = 0.1209$ to match the average debt maturity of 7 years we observe in our sample. The sensitivity of taxes to government debt is set to $\psi = 0.1774$ to match the steady state credit to the private sector to GDP ratio which is around 43% in the sample. The debt elasticity of the foreign interest rate is set to $\varpi = 0.025$ which is standard in the literature.

The last set of parameters that we calibrate are related to shocks in the model. The persistence and standard deviation of risk premium shocks are set to match the median of those observed in the data. Following Son (2024), we derive an annual series of expected excess returns on local currency sovereign bonds over the US treasury by forecasting excess returns using the real exchange rate and local currency sovereign bond interest rate. Using this, we estimate an AR(1) process of κ_t. We detrend import price data from Pace et al. (2020) to estimate an AR(1) process of $P^*_{F,t}$. Lastly, we follow Devereux et al. (2019) and use detrended TFP data from the Penn World Tables to estimate an AR(1) process for A_t.

Parameter		Value
Housesholds and firms		
η	Relative risk aversion	2
ϵ	Elasticity of substitution between varieties	6
β	Discount factor	0.975
α	Share of imported final consumption goods	0.234
χ	Labor disutility parameter	0.4953
φ	Inverse of Frisch elasticity	2
ν	Trade elasticity of substitution	3
δ	Capital depreciation	0.1
θ	Price adjustment cost parameter	19.5122
γ	Labor share	0.5850
ω	Capital share	0.2930
Y^*	ROW demand	1
ι	Capital adjustment cost parameter	2.5
ϑ	Exchange rate pass-through to exports price	0.25
ξ	Fraction of working capital	1
$\overline{\Pi}$	Target inflation rate	1.04
Banks and Financial markets		
ζ_w	Divertable fraction of working capital	0.1
ζ_l	Divertable fraction of loans	0.3
ζ_b	Divertable fraction of bonds	0.3
σ	Survival rate	0.95
ϱ	Transfer based on financial market status	0.0005
$\tilde{\Delta}$	Steady state distance of constraint	0.0015
υ	New bank startup capital parameter	0.0380
ϕ	Taylor rule coefficient	1.5
$\frac{P^b B^*}{GDP}$	External debt-to-GDP ratio	0.47
$\frac{P^b B^g}{GDP}$	Government debt-to-GDP ratio	2
ρ	Bond depreciation	0.1209
ϖ	Debt elasticity of interest rate	0.025
Shocks		
ρ_κ	Persistence of capital flow shocks	0.56
ρ_A	Persistence of TFP shocks	0.59
ρ_T	Persistence of terms of trade shocks	0.44
σ_κ	SD of capital flow shocks	0.0276
σ_A	SD of TFP shocks	0.024
σ_T	SD of terms of trade shocks	0.039

Table 6: Calibrated model parameters

4.2 Solution method

Since the model encompasses occasionally binding constraints, we use global solution methods with time iteration to solve the model. More specifically, we define policy functions on a discretized state space. There are five state variables (B^*_{t-1}, K_{t-1}, A_{t-1}, κ_{t-1}, $P^*_{F,t}$) out of which two (B^*_{t-1}, K_{t-1}) are endogenous. Following Tauchen (1986), we discretize each exogenous state variable into 2 points so that we have 8 different combinations of exogenous state variables. We use equidistant grids for B^*_{t-1} and K_{t-1},

with 40 and 40 points spaced over [0, 0.12] and [1.5, 2.4] respectively. Using these policy functions, we solve the system of equations to derive the equilibrium at each grid point and update the policy functions. We iterate until the change between successive iterations is smaller than 10^{-4}.

For the baseline model, we solve for the equilibrium assuming the central bank follows a Taylor rule. We analyze the results of this baseline case in Section 5. We also solve for the optimal monetary policy under discretion in Section 6.

5 Baseline results

In this section we analyze the results of the baseline model where the central bank conducts monetary policy following a Taylor rule. We first compare the unconditional moments of the model with those observed in the data. Next, we show impulse response functions for various shocks to show the dynamics of the model. Then, we derive local projections of sudden stops using simulated data from the model to analyze the impact of large outflow episodes. We also analyze how the occasionally binding constraint affects the model by looking at sudden stops.

5.1 Moment comparison

We first compare the unconditional moments of the model with those observed in the data. Table 7 shows the unconditional standard deviation of GDP growth, consumption growth, investment growth, CPI inflation, real and nominal depreciation, net exports (% of GDP), gross exports (% of GDP) and gross imports (% of GDP) from the model simulations in the second column and the interquartile range of the standard deviations of these variables observed across countries in our sample in the third column. We also report the correlation of these variables with GDP growth and report those from the model simulations in the fourth column and the interquartile range observed across countries in the fifth column.

The model is able to match the volatility of real variables and inflation well. The unconditional standard deviations for GDP growth, investment growth, CPI inflation and net exports are within the interquartile range while consumption growth volatility is slightly below the first quartile observed in the sample. On the other hand, the model is not able to capture the same level of volatility in the data observed for exchange rate depreciation (real and nominal) and gross trade flows.

	Standard Deviation (%)		Correlation with GDP growth	
Variable	Model	Data (25% - 75%)	Model	Data (25% - 75%)
GDP growth	2.5	(1.8, 2.8)	1	(1,1)
Consumption growth	1.4	(1.7, 3.6)	0.86	(0.77, 0.92)
Investment growth	8.3	(6.5, 12.4)	0.93	(0.74, 0.88)
CPI Inflation	2.0	(1.7, 3.0)	-0.63	(-0.39, 0.02)
Real depreciation	3.5	(5.3, 9.4)	0.04	(-0.49, -0.2)
Nominal depreciation	4.4	(7.1, 14.0)	-0.26	(-0.64, -0.27)
Net exports (% of GDP)	2.5	(2.0, 4.1)		
Exports (% of GDP)	2.3	(3.6, 7.5)		
Imports (% of GDP)	0.9	(3.2, 6.8)		

Table 7: Unconditional moment comparison across data and model

5.2 Impulse response function analysis

Next, we analyze the dynamics of the model with impulse response functions. The impulse response functions are derived by simulating the model independently $N = 10000$ times for 121 periods, exogenously imposing that in period 101 an exogenous state variable takes a certain value, and comparing the simulations to the baseline case where such changes to exogenous state variables are not made. For example, κ_t can take two values in our state space (one positive and one negative). For a capital inflow shock, we change the value of κ_t to a negative value if κ_t is positive in period 101. We report the mean and the 68.7% confidence interval ($\pm$ one standard deviation).

We first start with capital flow shocks (κ_t). Figures 6 and 7 shows the impulse response functions of $\log(Y_t)$, $\log(C_t)$, $\log(I_t)$, $\log(E_t)$, $\log(P_t^l)$, $\log(P_t^b)$, bank leverage ($\frac{D_t}{P_t^b B_t + P_t^l L_t}$), μ_t, and the change in frequency of sudden stops in response to an increase and a decrease in κ_t respectively. Bank leverage is defined as the liabilities to asset ratio of banks.

A higher κ_t (capital outflow shock) implies less demand for local currency bonds by foreign investors, resulting in capital outflows. This increases the returns on bonds, driving the price of bonds down and causing the exchange rate to depreciate. Banks rebalance their portfolios by buying more bonds (while foreign investors sell them) so that there is a fall in inflows while lending less to capital good firms. This causes investment and the price of equity to fall and as a result, a decline in output. Since banks hold more bonds, this reduces their leverage ratio (liabilities over assets) and tends to make the constraint bind more which can be seen from the elevated μ_t. As a result, sudden stops occur more often.

With a lower κ_t (capital inflow shock), the opposite happens. Expected returns are lower for both bonds and equity, so that banks hold less bonds and there are capital inflows.

Lower rates incentivize investment and consumption. Output is increased less than it falls when there are capital outflow shocks because the constraint binds less with inflow shocks. Sudden stops also occur less frequently

Interestingly, capital inflow (outflow) shocks reduce (increase) the frequency of sudden stops at the immediate period of the shock, but increases (reduces) the frequency of them as time goes on. This is because once bonds flow out (in), they tend to flow back in which causes the value of banks to increase (fall) and the constraint to bind (loosen) as time goes on. In short, inflows relax the constraint today but make the constraint bind more in the future. This highlights a macro-prudential motive to intervene with monetary policy which we will discuss in more detail in the next section. Using monetary policy to limit inflows can help reduce the frequency at which the constraint binds in the future.

We also show impulse response functions for TFP shocks and shocks to the terms of trade in Figures 8, 9, 10 and 11. A positive (negative) TFP shock and a positive (negative) terms of trade shock increases (reduces) output, consumption and investment. Since output is larger (smaller), the exchange rate depreciates (appreciates) to increase (reduce) net exports and clear the market. TFP shocks also affect the frequency of sudden stops. A positive (negative) TFP shock and positive (negative) terms of trade shock increase (reduces) the frequency of sudden stops.

5.3 Large capital flow episodes

Following the local projection method used in Section 2, we estimate the impact of large outflow episodes, large inflow episodes and sudden stops by using simulated data for 8 variables: GDP growth, consumption growth, investment growth, CPI inflation, real depreciation, nominal depreciation, the trade balance (as % of GDP), and credit to the private sector.[8] The estimated results are shown in Figures 12, 13 and 14.[9] We report estimates from the model in starred red and the 90% error confidence interval for the data in blue.

Most of our model estimates fall in the 90% confidence interval derived from the data counterpart. Similar to the data, GDP, consumption and investment all fall following a large outflow and increase following a large inflow. The fall in these variables is larger with a sudden stop. Interestingly, despite having only local currency liabilities, the model is able to match the impact of capital flows on exchange rates. The real exchange rate depreciates

[8]Since we are using model simulated data, we do not control for lags.

[9]Note that we shifted the timing of the sudden stop in the model simulations by one year so that they match the data better. The model produces sharp drops the moment a sudden stop occurs, while in the data the impact is largest 1 or 2 years after the sudden stop begins.

by around 5% following large outflows and appreciates by around 7% following large inflows. For sudden stops, the exchange rate depreciation is similar to that in large outflows.

The patterns for credit supply to the private sector is also consistent with the data except for large inflows. There is around a 5% fall in credit supply following large outflows, and an 8% fall following sudden stops. For inflows, the model is not able to generate a boom in private credit. This is interesting since inflows predict future periods to have a higher frequency of sudden stops. This points to the fact that in our model, credit supply to the private sector is not the main driver of sudden stops. This is consistent with our findings in Section 2 where we show that large capital inflows have predictive power in forecasting sudden stops even after controlling for credit supply.

The model has a difficult time matching the response of CPI inflation and the net trade balance capital flow episodes, especially for large capital inflow episodes. The response of CPI inflation in the data is muted for all three episodes while inflation is elevated in outflows and sudden stops and drops following inflows. The overly volatile movement of net exports is due to gross exports responding heavily to capital flow episodes, mostly driven by the impact of exchange rates on the export price. Although our model assumes imperfect pass-through of exchange rates to export prices, it is still not enough to mute the impact of exchange rates on exports.

5.4 Occasionally binding constraint

One of the central features of the model is the value-at-risk constraint of depositors, which limits the flow of deposits to banks. To better understand the role of this occasionally binding constraint, we simulate the baseline model for 110001 periods, drop the first 10000, collect the periods with sudden stops and show how variables move 4 years before and 4 years after sudden stops in Figure 15. We report the median in solid blue and show the 25% - 75% interquartile range with the shaded area. The variables are shown in terms of log deviation from the ergodic mean except for the leverage of banks which is shown as simple deviations from the ergodic mean and μ and the distance from the constraint which are shown as levels.

We first note that for all sudden stops in our simulation, the constraint binds. As a result, the lagrangian multiplier for the constraint, μ, is positive when the sudden stop occurs with a median value of μ during a sudden stop of around 0.1. Since the constraint binds during sudden stops, the marginal value of net worth of banks, V, is elevated above the ergodic mean before the sudden stop occurs. We also see that prior to a sudden stop,

there is a slight elevation in output and investment. The build-up of output however is lower than the ergodic mean while that for investment is higher. Once a sudden stop occurs, there is a sharp fall in output, investment and loans.

Running up to a sudden stop, there is an increase in credit supplied to firms in the form of state-contingent loans for physical capital (both in the amount, L, and the value, $P^l L$) while there is a continuing decline in loans for working capital (Z). The large fall in credit supply (which defines sudden stops) is driven by both a fall in working capital loans to firms, Z, and equity loans, $P^l L$.

To understand what shocks give rise to sudden stops, we look at the exogenous state variables, κ_t, a_t and $p^*_{F,t}$ in Figure 16. For Figure 16, we report the frequency of when the state variables take positive values for a 21 year window around sudden stops. We see a clear pattern for κ_t. The economy approaches a sudden stop as κ_t falls. Then, sudden stops occur as κ_t recovers and becomes positive. A sudden stop occurs by having favorable external financial conditions for several periods, followed by a negative external financial shock. Positive TFP shocks and negative terms of trade shocks (positive shocks to P^*_F) contribute to sudden stops as well.

6 Optimal policy

In this section, we consider the case where monetary policy is used optimally under discretion. The policy maker has three uses for monetary policy. First, the policy maker uses monetary policy to stabilize PPI inflation and keep it at the target level. If PPI inflation is not at the target the economy incurs Rotemberg price adjustment costs. Second, the policy maker uses monetary policy to stabilize consumption by using monetary policy to prevent the constraint from binding and to boost the economy once it binds. Third, the policy maker uses monetary policy to manage the exchange rate and gain an advantage in the terms of trade. The second motive comes from the existence of the occasionally binding constraint and the third motive comes from the imperfect exchange rate pass-through.

We can see how the optimal use of monetary policy shifts the distribution of variables. Figures 17 and 18 show histograms for μ_t and B_t after simulating the model under the Taylor rule and under optimal monetary policy separately for 100001 periods. Figure 17 shows that there is a leftward shift in the distribution of μ_t with the optimal use of monetary policy.[10] There is less tail risk under the optimal monetary policy, implying the policy maker uses monetary policy to reduce how strongly the constraint binds. Figure

[10]The frequency for $\mu_t = 0$ is around 0.75 under optimal monetary policy and 0.83 under the Taylor rule. We cut figure 17 at 0.008 to better show the other bins.

18 shows that there is a rightward shift in the distribution of B_t with the optimal use of monetary policy. With banks holding more bonds, the constraint binds less strictly.

Also, to get a better understanding of how optimal monetary policy can be used in response to sudden stops, we set $\vartheta = 1$ so that there is perfect exchange rate pass-through and compare the optimal monetary policy case to the case where monetary policy is used to keep inflation constant. With perfect exchange rate pass-through, it is optimal to keep PPI inflation at the target level if the constraint does not exist. Therefore, the difference between the two cases reflects the use of monetary policy due to the constraint. We compare the two cases by first collecting the sudden stops that occur under the constant inflation case. Then, we take the state variables 10 years before, 10 years after and the year of sudden stops and use the optimal monetary policy solution to derive the equilibrium under optimal monetary policy. Then, we take the difference between variables and plot them in Figure 19.

The first graph in Figure 19 shows the difference in the real interest rate. We see that because of the constraint, monetary policy is used to increase the real rate before the sudden stop occurs, and lower the real rate after. The higher real rate restricts economic activity and lowers PPI inflation before the sudden stop and once it is lower after the sudden stop, PPI inflation jumps up. The higher real rate also limits credit supply to firms which is achieved both by a fall in state-contingent loans as well as working capital loans. The fall in credit however, is mostly driven by a fall in working capital loans. Once the sudden stop occurs, credit supply jumps up with working capital loans again driving the result. The value of bonds held by banks slightly increases up to a sudden stop and drops once the sudden stop occurs. These movements result in the net value and leverage of banks to fall before a sudden stop and jump up once a sudden stop occurs. The constraint also is less binding with optimal monetary policy, resulting in lower values of μ_t during sudden stops.

Overall, we see that there is a macro-prudential use of monetary policy. The policy maker restricts credit supply to prevent sudden stops from occurring and to weaken how hard the constraint binds. Once the sudden stop occurs, the policy maker uses monetary policy to quickly increase the supply of credit and minimize how hard the constraint binds.

7 Conclusion

The macro-prudential use of monetary policy in response to volatile capital flows has been widely discussed in policy circles, especially in emerging market economies. This paper highlights several stylized facts about the impact of capital flows on emerging market

economies and develops a model that is able to account for these stylized facts. First, we show that following large outflows there is a fall in GDP, consumption and investment while the exchange rate depreciates both in real and nominal terms. There is also a net trade surplus and a fall in the supply of credit from banks to the private sector. Sudden stops, which we define as large outflow episodes with a fall in private credit supply of more than 5% drive these results. Large inflows have the opposite effect. Second, we show that large inflows have predictive power in forecasting large outflows and sudden stops. This holds even after controlling for the supply of credit to the private sector.

Using a model with occasionally binding constraints in the banking sector that is able to replicate these facts, we show that there is a macro-prudential use of monetary policy. It is optimal to lean against capital inflows ex-ante by raising the real rate and limiting credit supply to the private sector to prevent and minimize the damage of sudden stops. Once a sudden stop occurs, it becomes optimal to lower rates and stimulate the economy ex-post.

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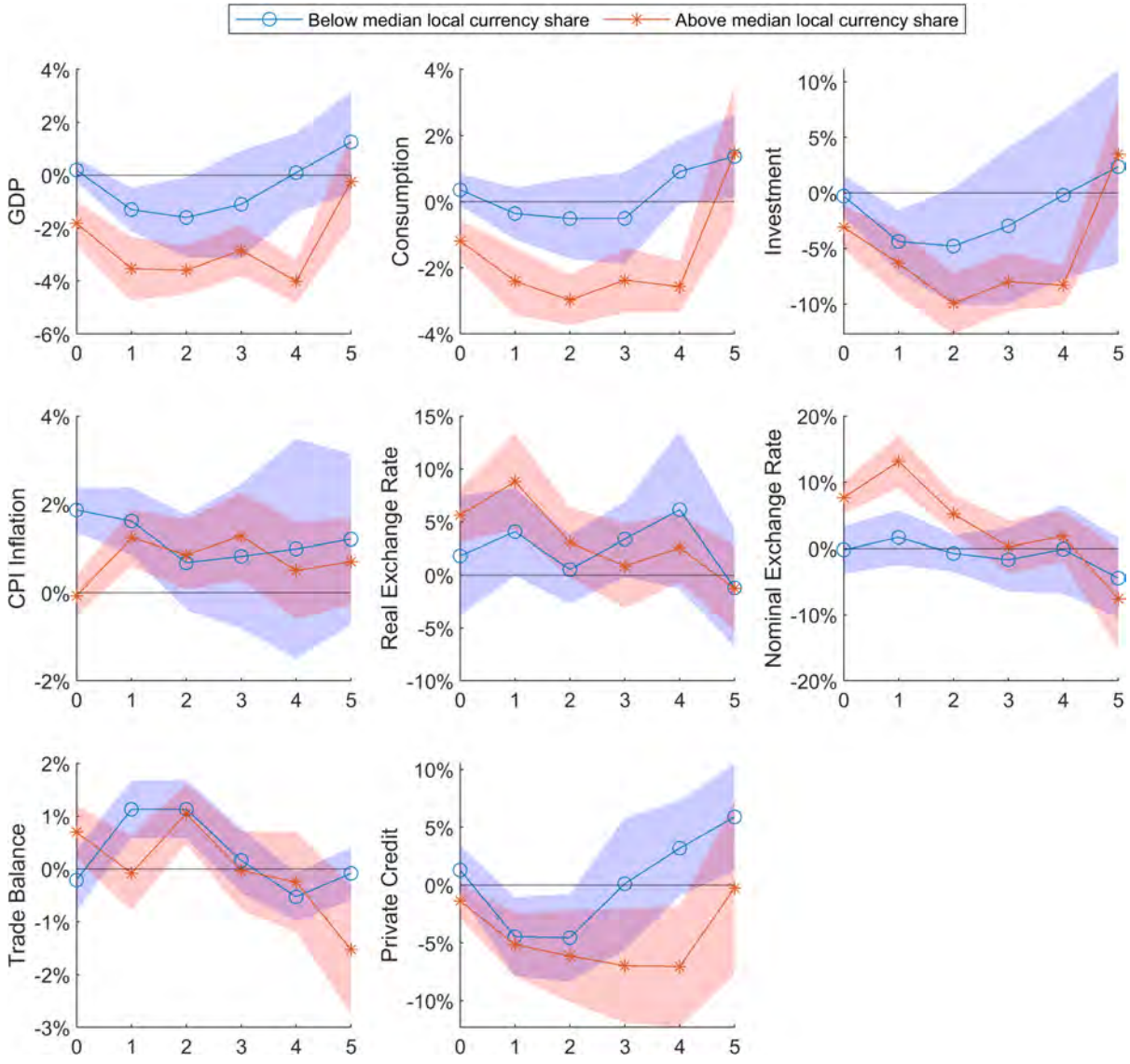


Figure 4: Local projection estimates for large outflows by local currency share of external liabilities

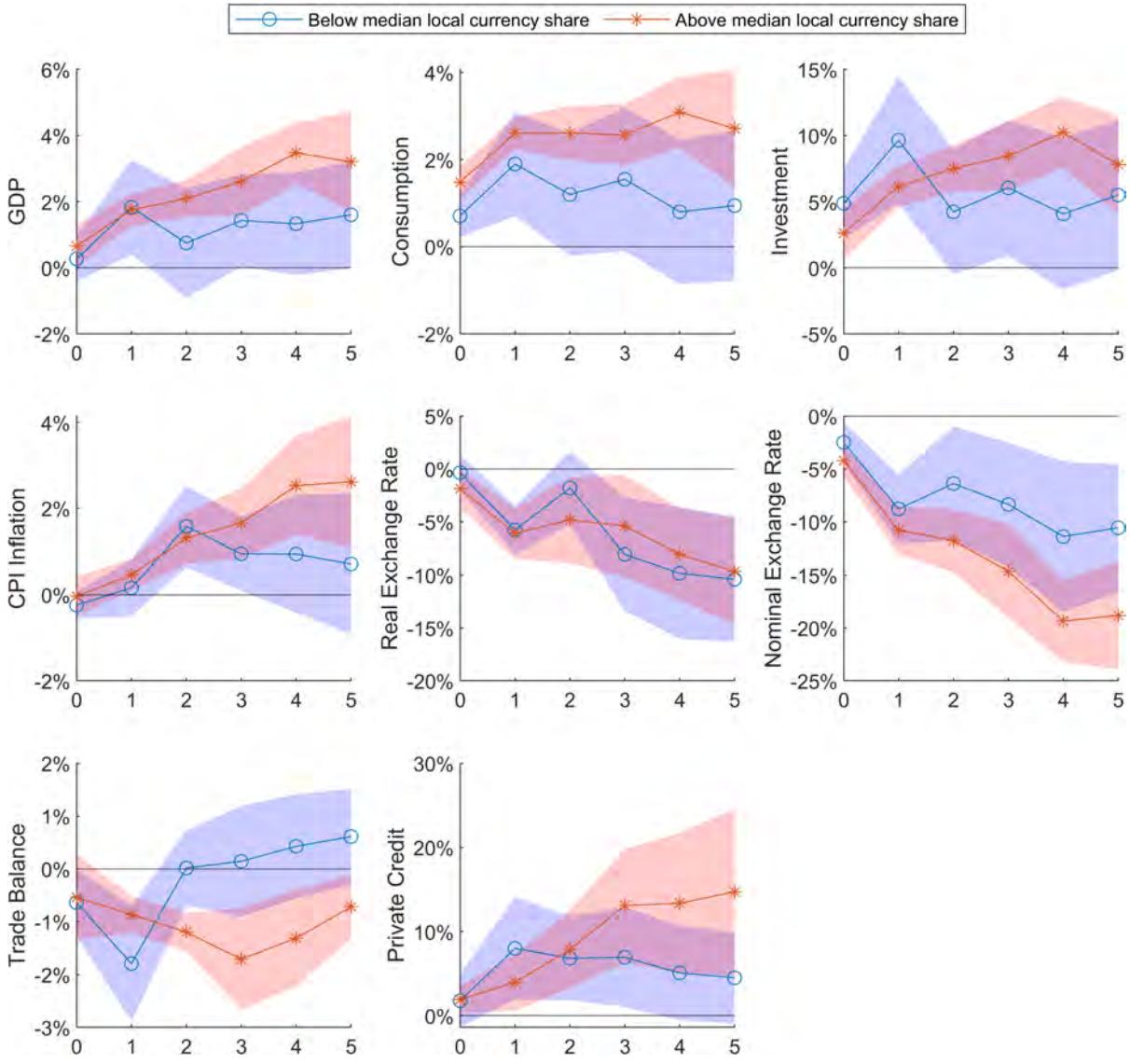


Figure 5: Local projection estimates for large inflows by local currency share of external liabilities

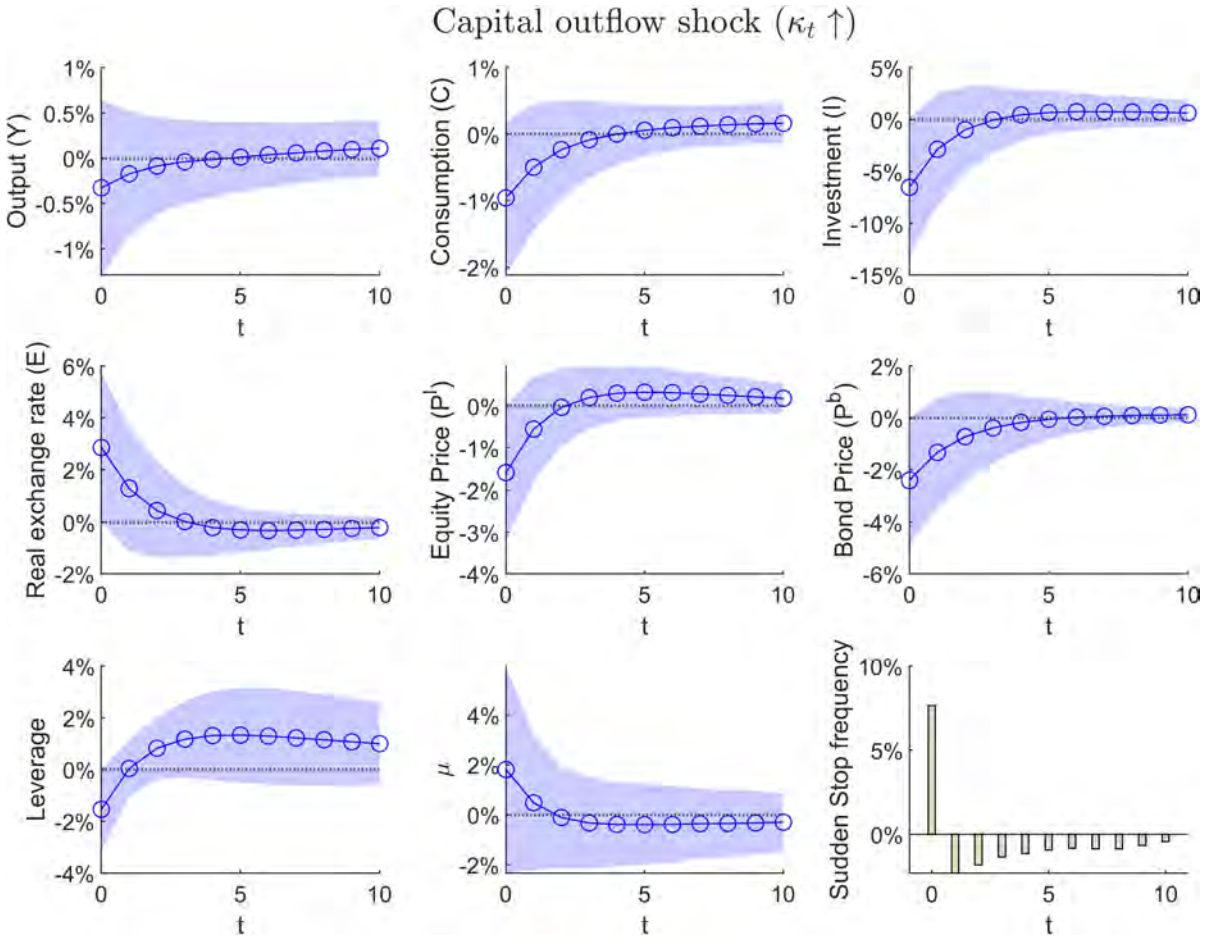


Figure 6: Impulse response functions with respect to a capital outflow shock ($\kappa_t \uparrow$)

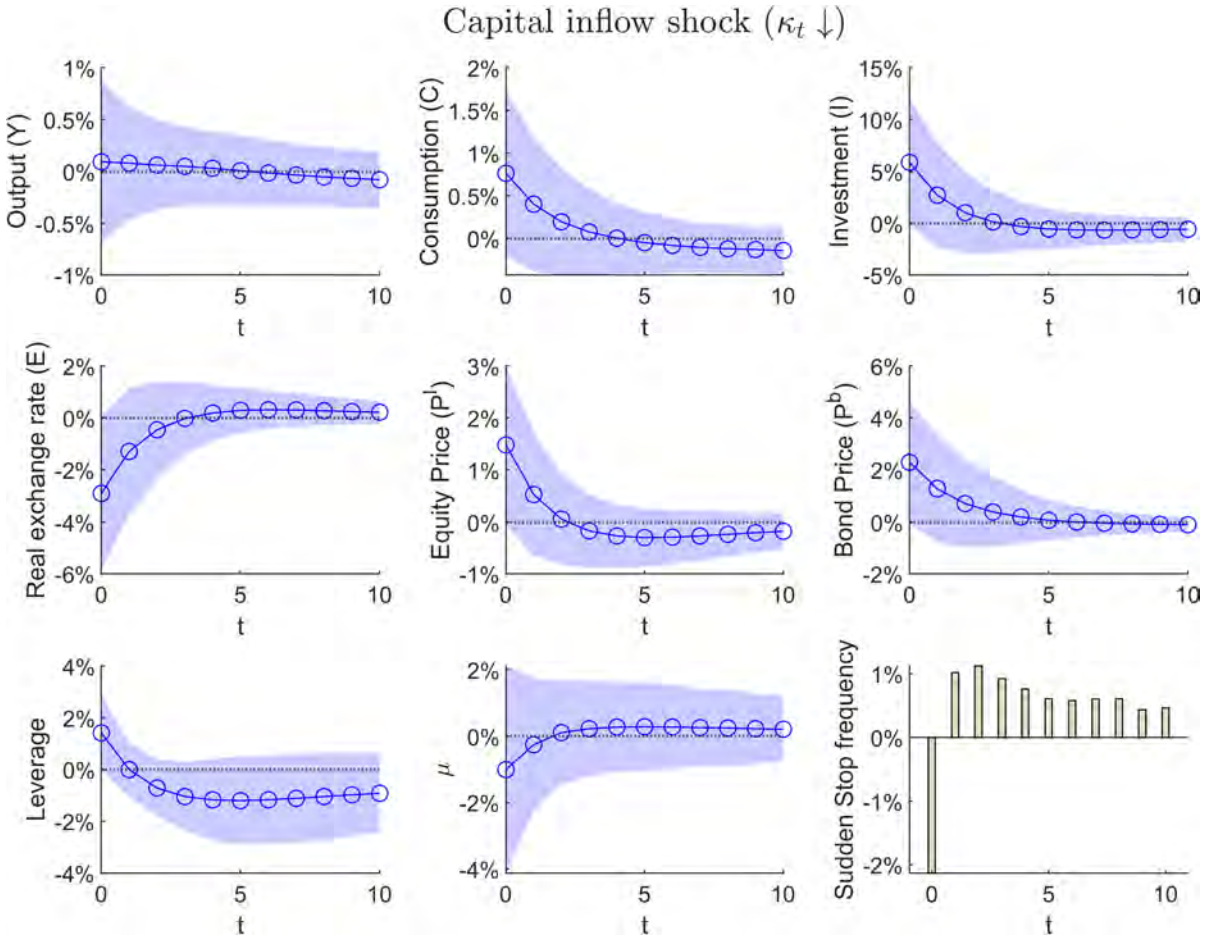


Figure 7: Impulse response functions with respect to a capital inflow shock ($\kappa_t \downarrow$)

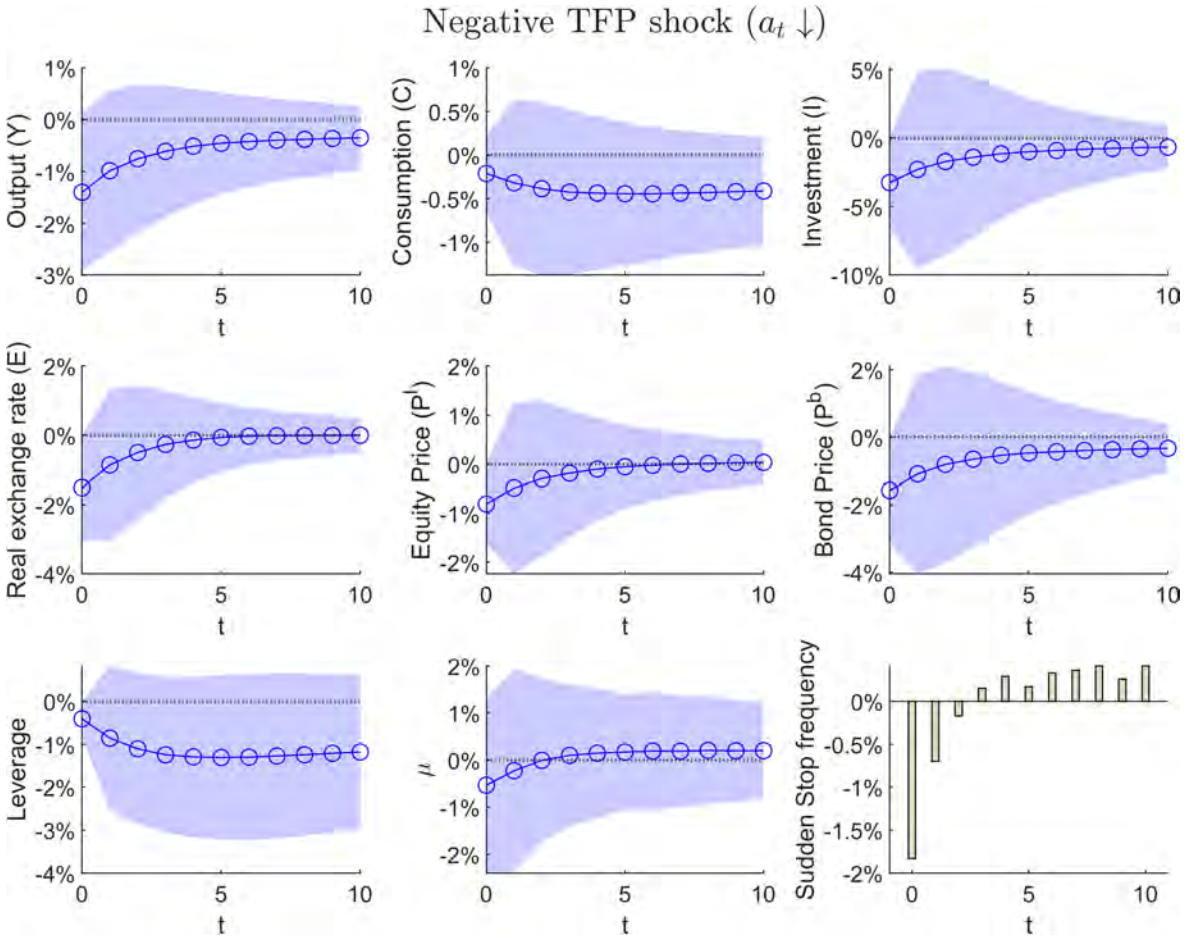


Figure 8: Impulse response functions with respect to a negative TFP shock ($a_t \downarrow$)

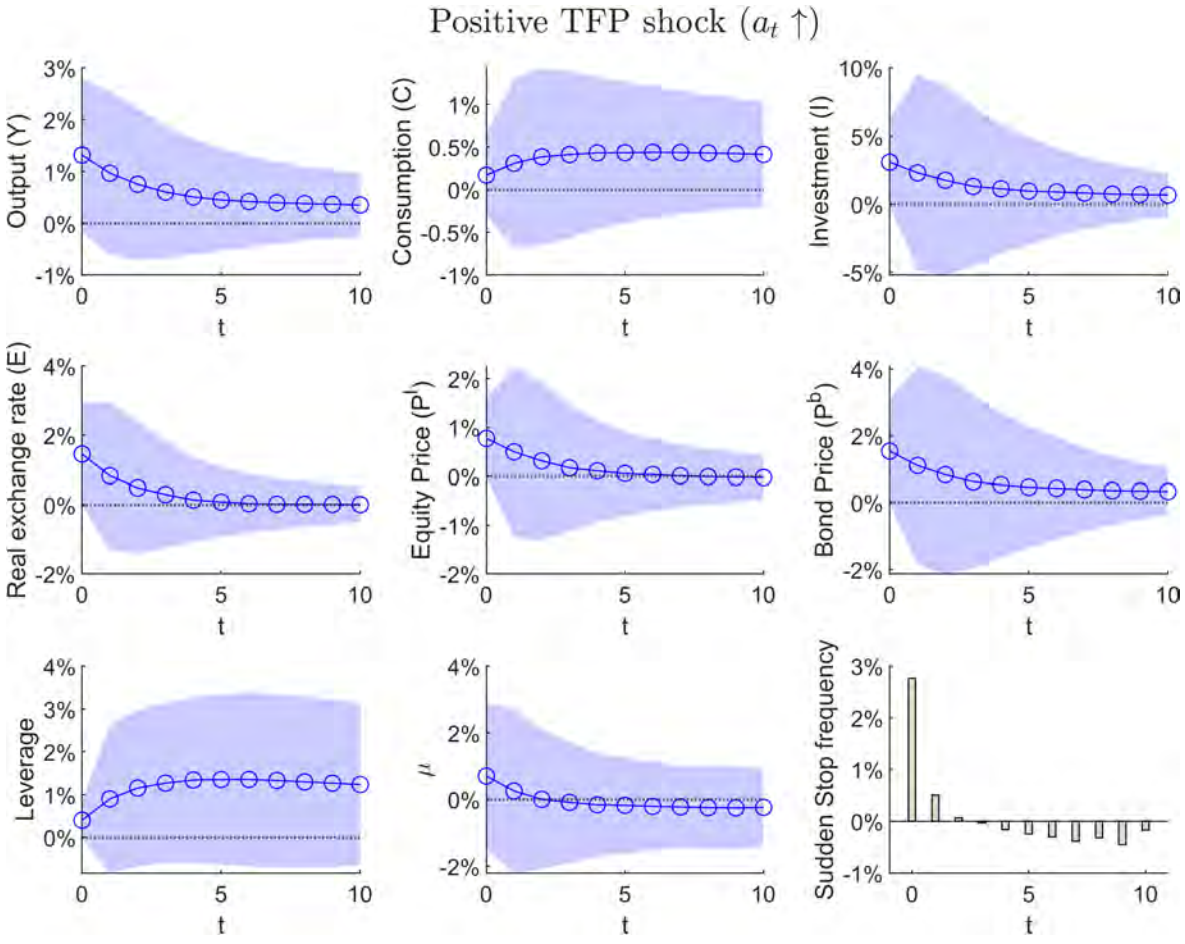


Figure 9: Impulse response functions with respect to a positive TFP shock ($a_t \uparrow$)

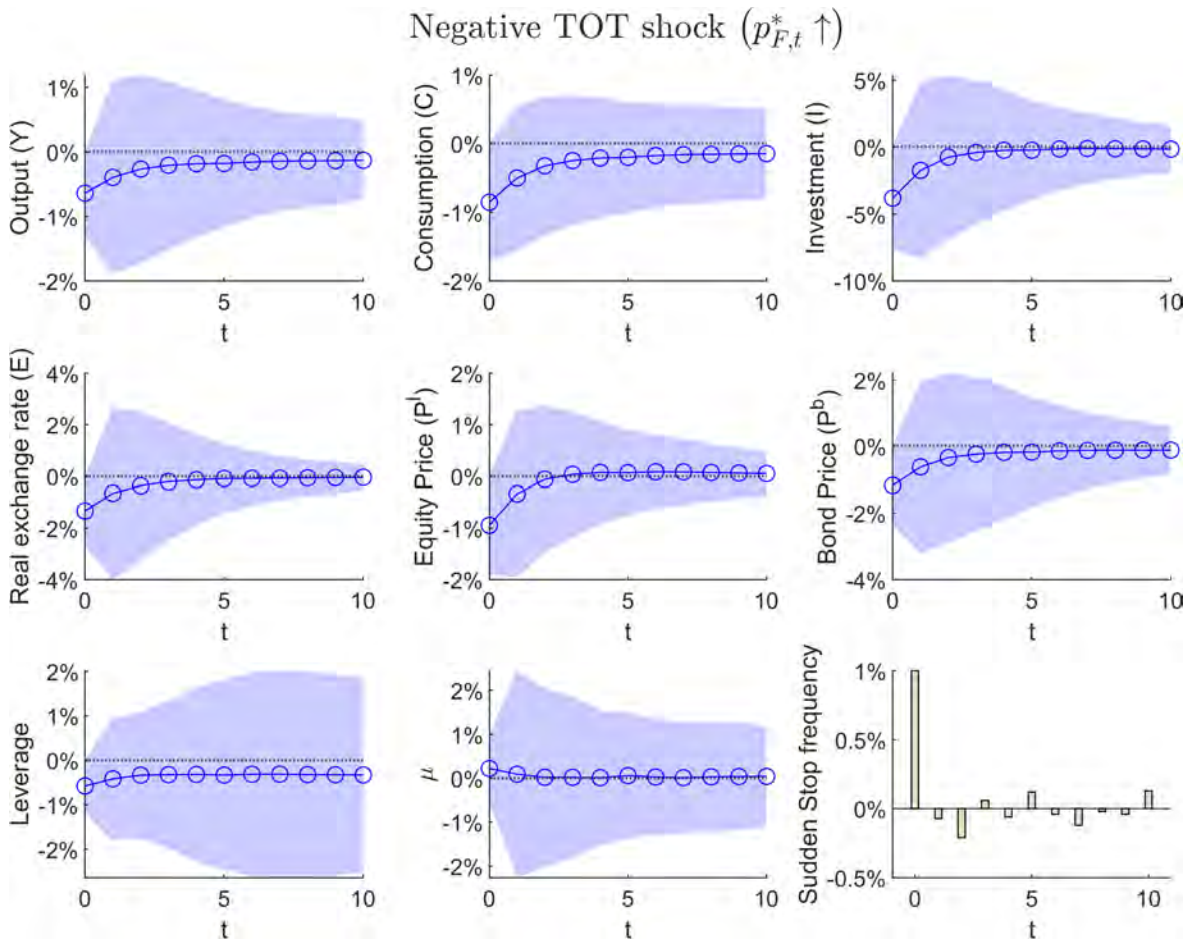


Figure 10: Impulse response functions with respect to a positive terms of trade shock $(p^*_{F,t} \downarrow)$

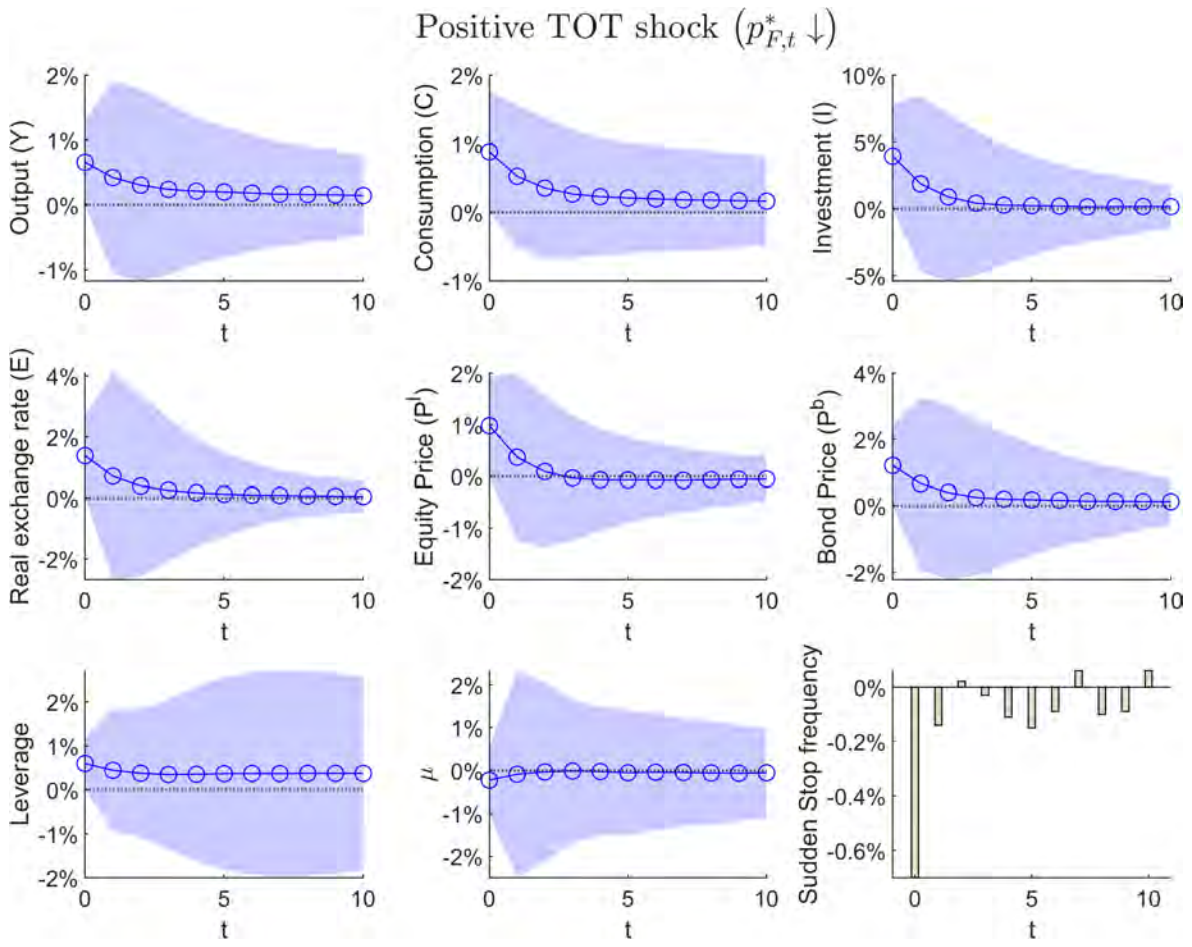


Figure 11: Impulse response functions with respect to a negative terms of trade shock $(p^*_{F,t} \uparrow)$

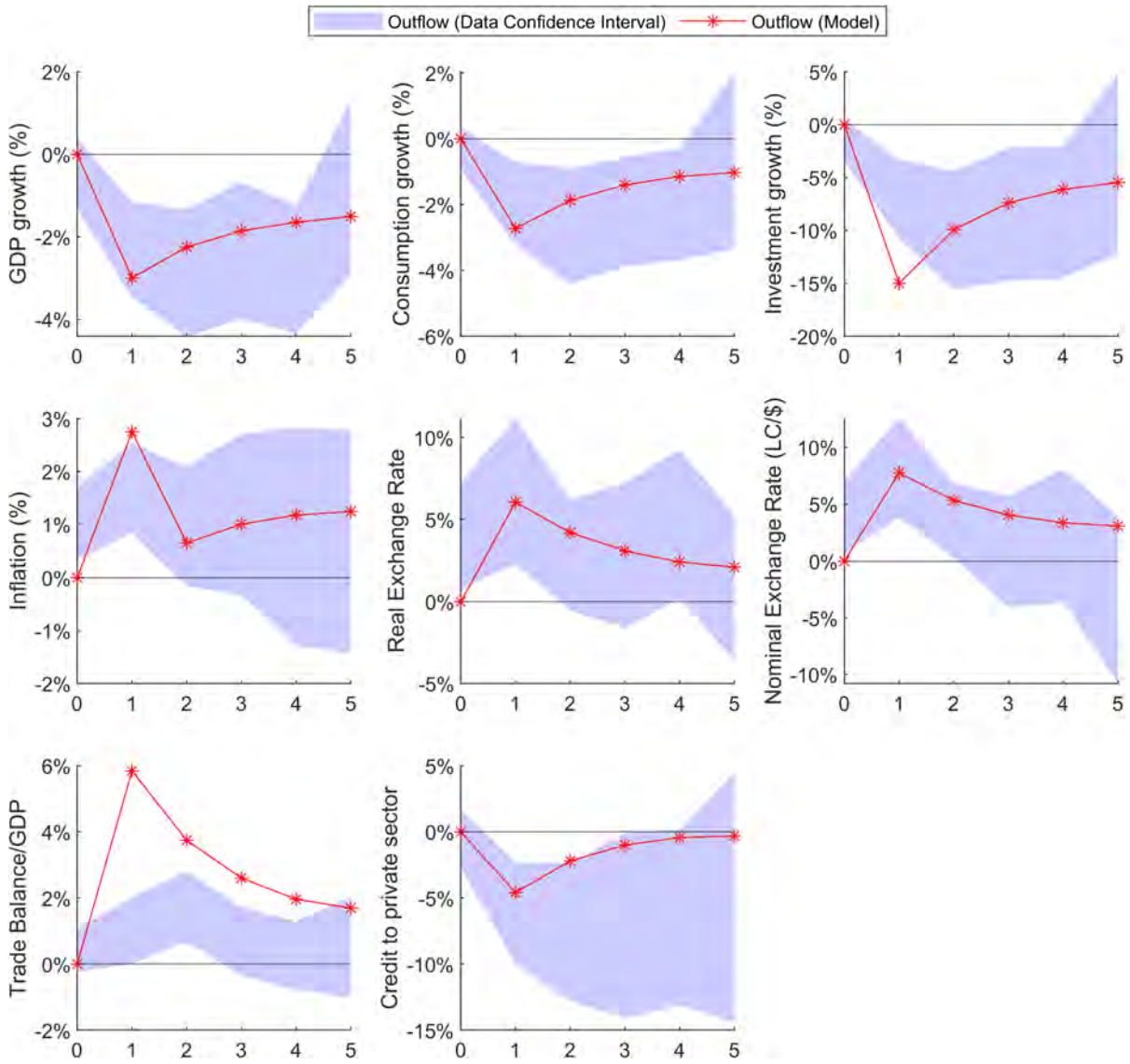


Figure 12: Model implied local projections for large outflow episodes

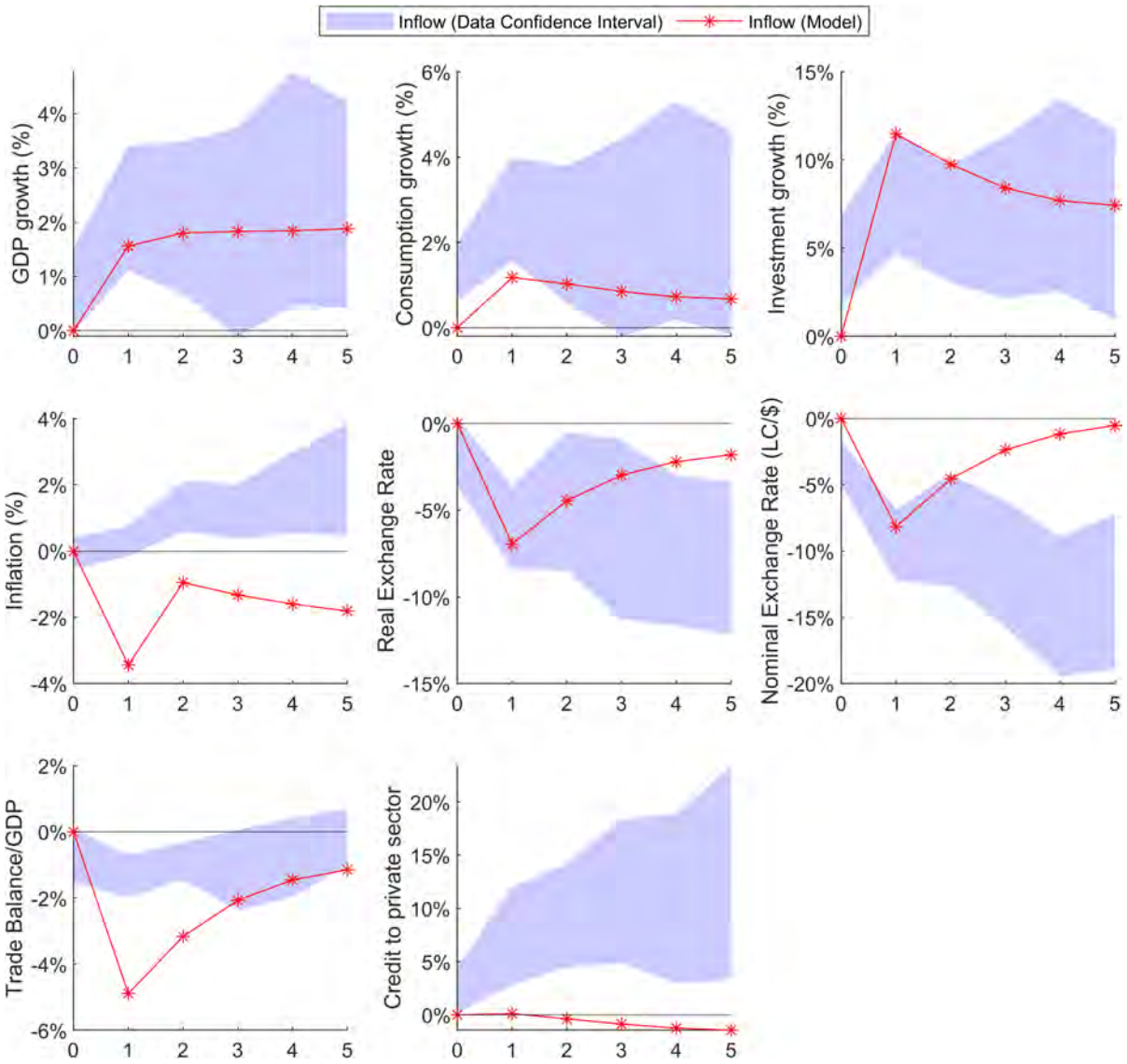


Figure 13: Model implied local projections for large inflow episodes

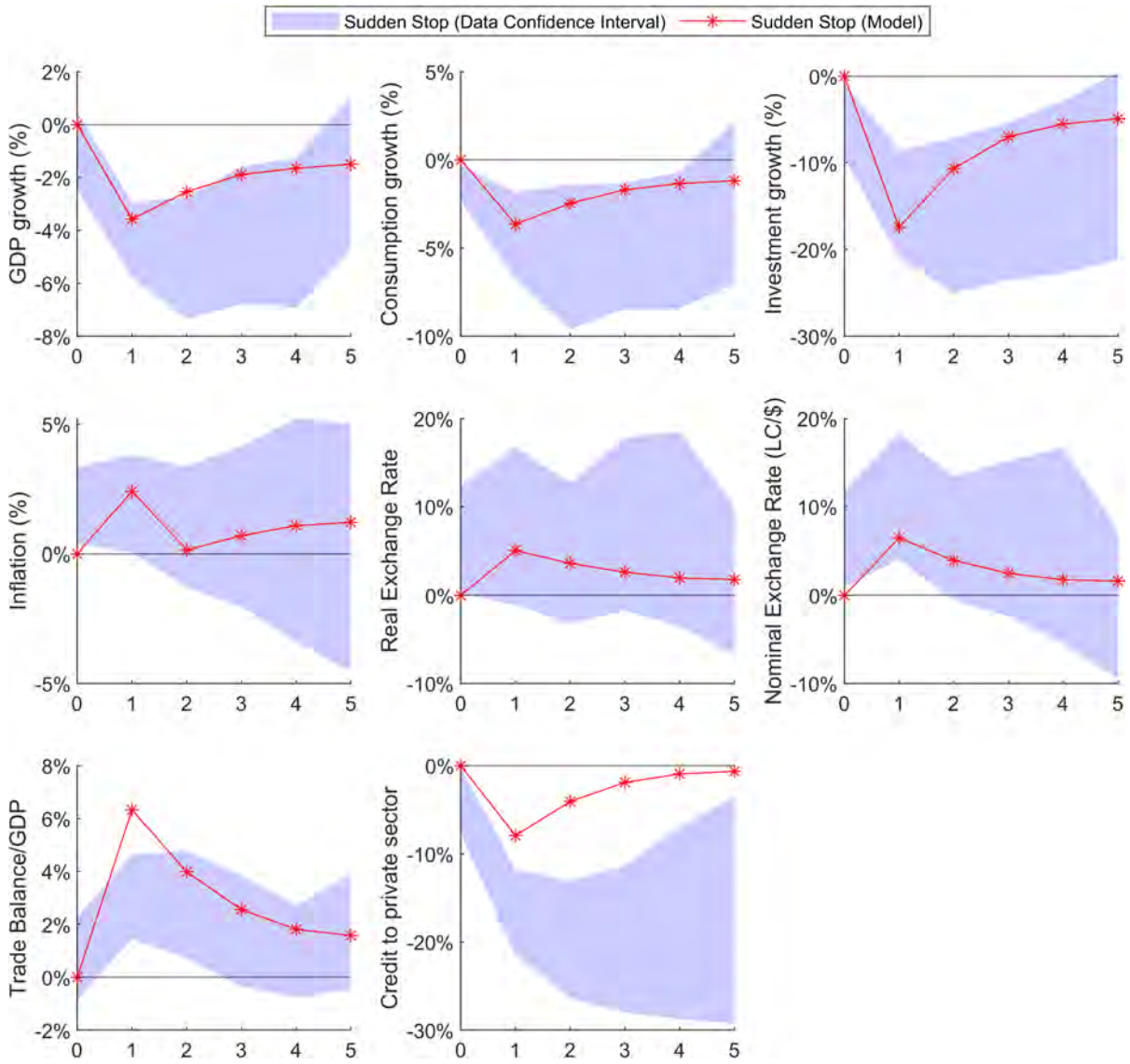


Figure 14: Model implied local projections for sudden stops

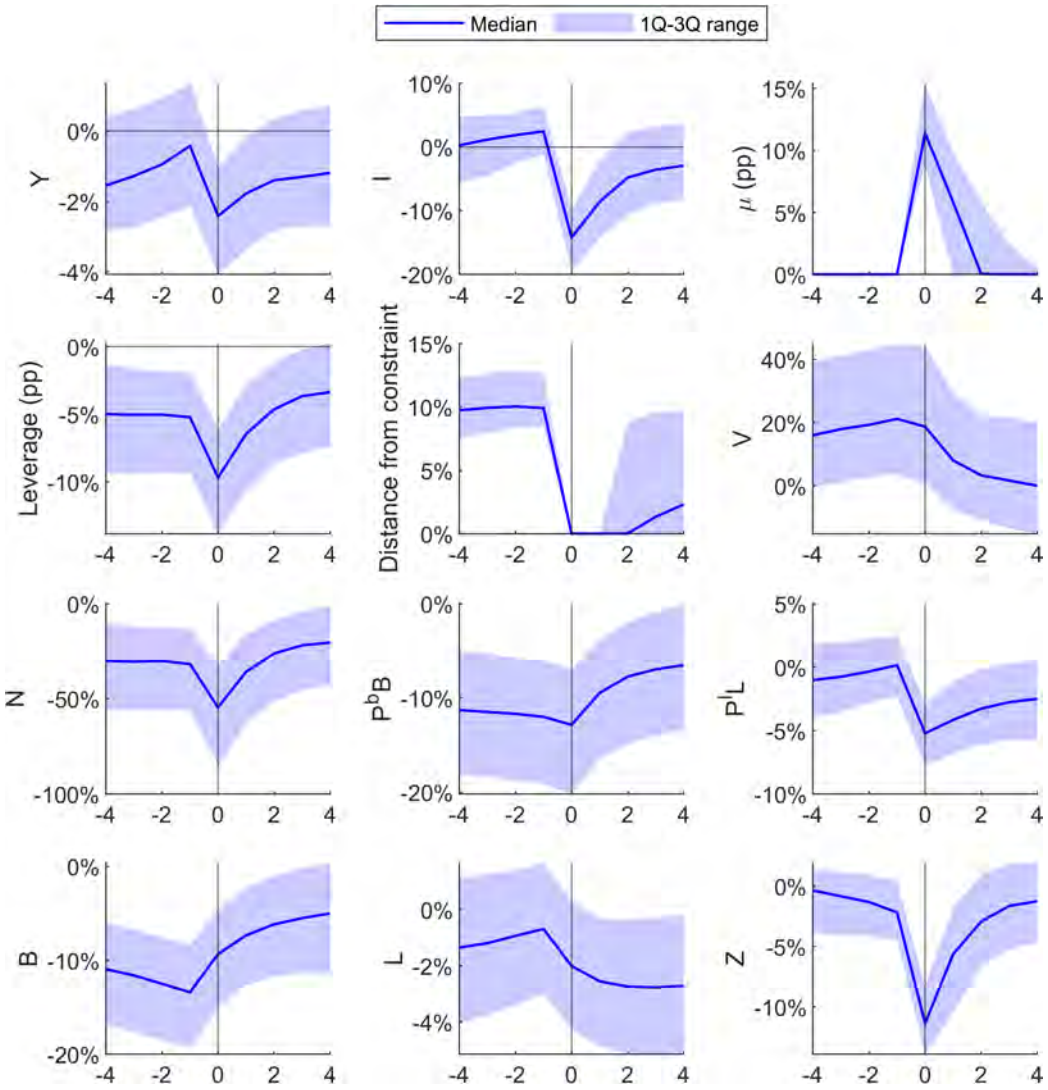


Figure 15: Baseline dynamics around sudden stops

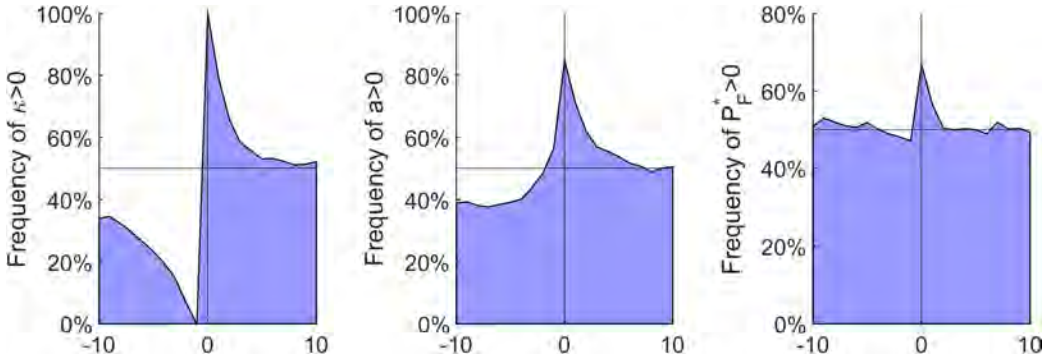


Figure 16: Distribution of shocks around sudden stops

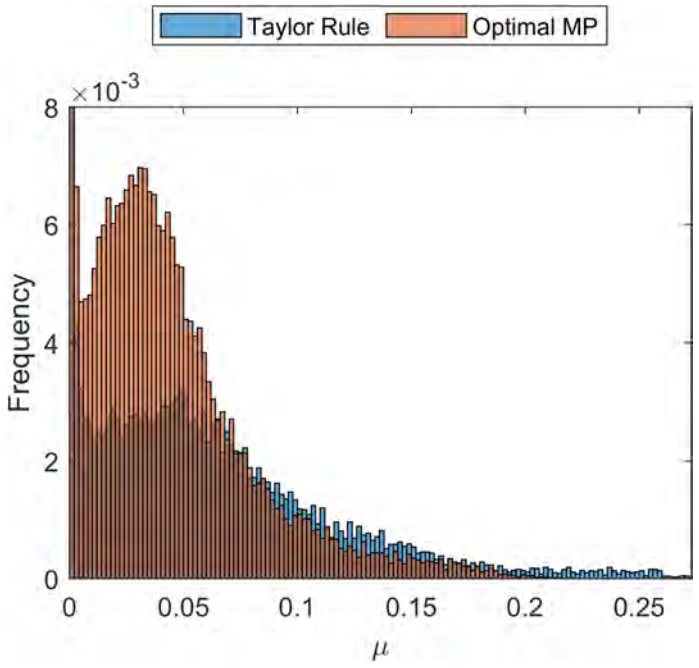


Figure 17: Density of μ under the Taylor Rule and Optimal MP

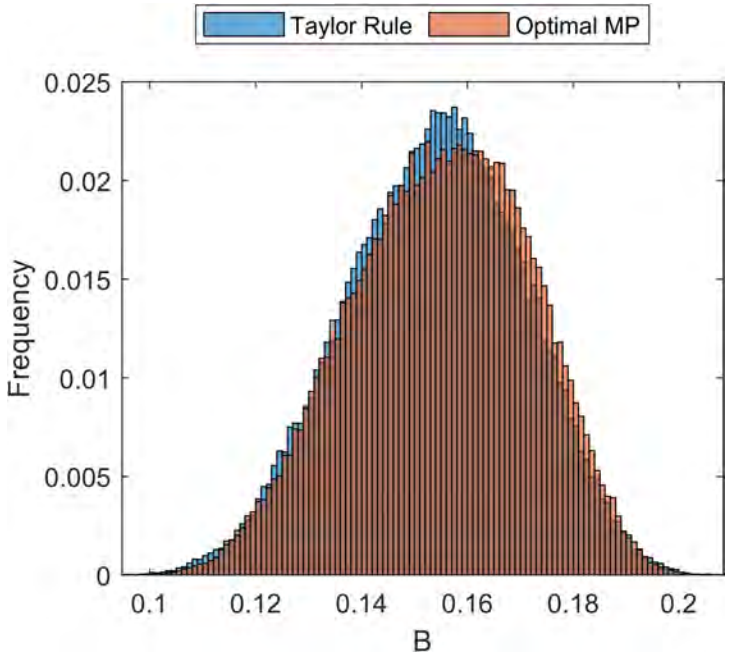


Figure 18: Density of B under the Taylor Rule and Optimal MP

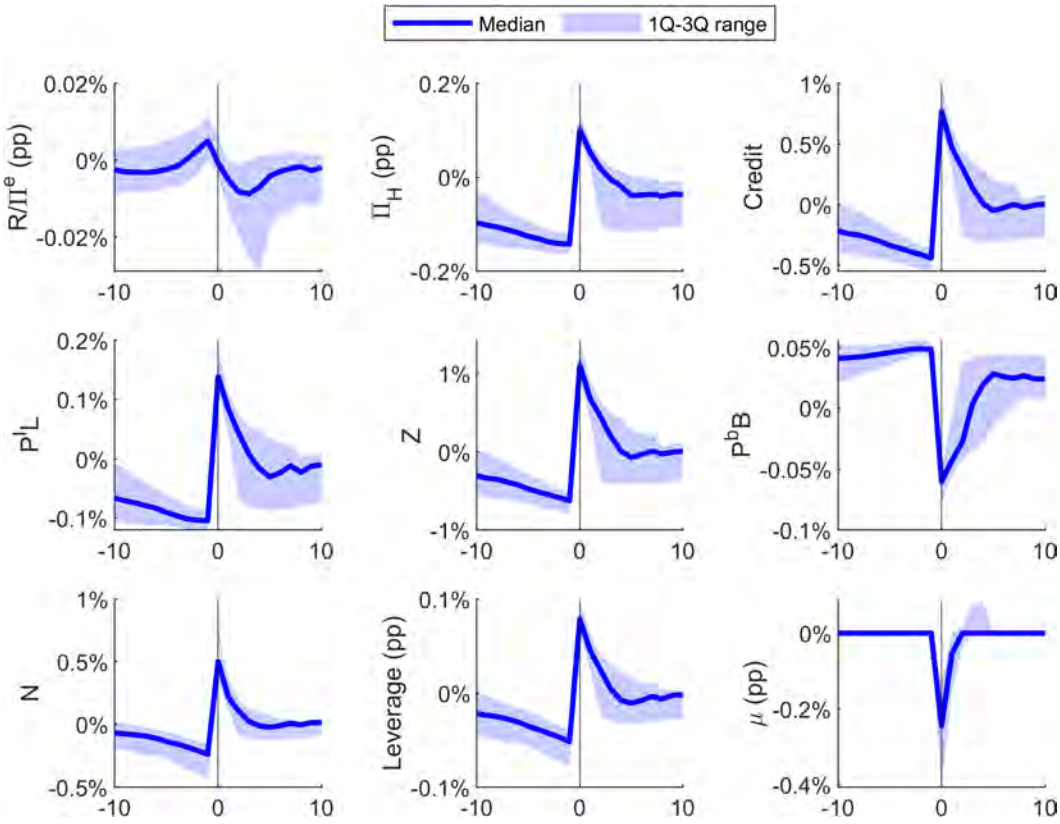


Figure 19: Difference between the Optimal MP case and Constant Inflation case around sudden stops