Sudden Stops and the macro-prudential role of monetary policy

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Abstract

This paper examines the challenges faced by emerging market economies due to large swings in capital inflows driven by the global financial cycle. We document three key stylized facts: (1) During capital inflow stops (surges), credit to the private non-financial sector contracts (expands), while credit to the public sector expands (contracts). (2) Countries experiencing surges are more likely to face stops within the subsequent five years. (3) Borrowing in local currency neither mitigates the impact nor reduces the frequency of stops and surges. To explain these dynamics, we develop a small open economy model where domestic banks are subject to occasionally binding leverage constraints. During capital flight, foreign investors sell off local-currency government bonds, which must be absorbed by domestic banks. When banks reach their leverage limits, the resulting credit crunch amplifies capital outflows, triggering a stop. Conversely, surges ease financial conditions but hinder the development of the domestic financial sector, increasing the likelihood of future stops. We derive the optimal monetary policy and emphasize its macroprudential component. During surges, central banks should counteract the buildup of external imbalances to reduce the severity of future stops. Failure to act exacerbates trade-offs during stops, leading to higher and more volatile inflation, even in normal times.

JEL Codes: ...
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1 Introduction

Following the high inflation and economic crises of the 1990s, many emerging market economies (EMEs) adopted inflation targeting as their monetary policy framework, aligning with a trend pioneered by advanced economies. This transition was supported by efforts to strengthen economic fundamentals, including reforms to reduce fiscal dominance, enhance banking system soundness, and develop domestic financial markets. These policy measures have coincided with a significant decline in inflation to lower and more stable levels, smoother economic growth, and greater financial stability. As a result, EMEs have better integrated into the global financial system, leveraging the opportunities of financial globalisation.

However, deeper integration into global financial markets has introduced new challenges. EMEs have become increasingly exposed to large fluctuations in capital flows, a trend that has intensified since the Great Financial Crisis (GFC) of 2007–09. Near-zero policy rates and large-scale asset purchases in major advanced economies have driven strong capital inflows and exchange rate appreciation in EMEs. More recently, as advanced economy central banks have moved toward monetary policy normalisation, EMEs have experienced alternating phases of significant capital inflows and outflows, driven by shifts in global market sentiment between risk-on and risk-off periods.

Capital flows and associated exchange rate fluctuations influence macroeconomic and financial stability in EMEs through their impact on domestic financial conditions. These flows exert a direct quantity effect on credit and asset markets. Additionally, asset prices can move significantly even without large transactions, while changes in quantities can affect asset prices and exchange rates without involving capital flows. Reflecting these tight links and global arbitrage, asset returns and bond yields denominated in EME currencies have closely tracked those in advanced economies, despite divergent macroeconomic conditions at times.

This paper examines the challenges posed by large capital flow swings driven by the global financial cycle (Rey (2013)) and explores how monetary policy can address them. We document three key stylized facts:

1. During capital inflow stops (surges), credit to the private non-financial sector contracts (expands), while credit to the public sector expands (contracts).

2. Countries experiencing surges are more likely to face stops within the subsequent five years.

3. Borrowing in local currency neither mitigates the impact nor reduces the frequency

of stops and surges.

To explain these dynamics, we develop a small open economy model in which domestic banks face occasionally binding leverage constraints. During capital flight, foreign investors sell off local-currency government bonds, which must be absorbed by domestic banks. When banks reach their leverage limits, the resulting credit crunch amplifies capital outflows, triggering a stop. Conversely, surges ease financial conditions but hinder the development of the domestic financial sector, increasing the likelihood of future stops. We derive the optimal monetary policy and emphasize its macroprudential component. During surges, central banks should counteract the buildup of external imbalances to reduce the severity of future stops. Failure to act exacerbates trade-offs during stops, leading to higher and more volatile inflation, even in normal times.

This paper builds on two strands of literature. First, it contributes to the empirical literature on the impact of capital flows on EMEs. Benigno, Converse and Fornaro (2015) find that large net capital inflows boost economic activity and shift factors of production from the manufacturing sector to the services sector. These inflows also predict sudden stops, although credit supply has stronger predictive power. Eichengreen and Gupta (2018) show that sudden stops reduce GDP and investment while creating a current account surplus. We extend this literature by analyzing large episodes of capital inflows and outflows using gross capital flows, following the methodology of Forbes and Warnock (2012).

Second, this paper relates to the literature on the macroprudential use of policy instruments in models with occasionally binding constraints. Our work is closely related to Devereux, Young and Yu (2019), which examines the optimal use of capital controls and monetary policy in such models. They find that optimal monetary policy stabilizes inflation when constraints are not binding and mitigates the severity of the constraint once it binds. In our model, we show that optimal monetary policy leans against the wind ex-ante, emphasizing that inflation targeting is not the sole objective 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 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 provide stylized facts on capital flows. We first show that capital outflow and inflow episodes have a significant impact on macroeconomic variables, such as output, consumption and investment in emerging market economies. Second, by differentiating outflow and inflow episodes that are associated with large swings in global financial conditions, proxied using the global financial cycle factor from Miranda-Agrippino and Rey (2020), we show that the macroeconomic impact of outflows (inflows) are driven by those that coincide with a significant tightening (loosening) of global financial conditions which we define as sudden stops (surges). Third, we show that capital inflow episodes and surges have predictive power in forecasting outflow episodes and even sudden stops. Lastly, we show that these stylized facts are robust to controlling for the currency denomination of external liabilities.

2.1 Macroeconomic impact of outflows and inflows

To understand the impact of capital flows on the macroeconomy, we follow the literature and analyze episodes of large swings in capital flows using local projections. We define large capital outflow and inflow episodes following Forbes and Warnock (2012). More specifically, let $C_{i,t}$ be the quarterly series of the 4-quarter moving sum of gross capital inflows for country i in quarter t and define $\Delta C_{i,t}$ as the year-over-year change in $C_{i,t}$.[1] We then compute the 3-year rolling mean and standard deviation of $\Delta C_{i,t}$. We define a large outflow episode to start when $\Delta C_{i,t}$ is more than one standard deviation below the rolling mean and ends when it is above one standard deviation below the rolling mean. In addition, for the episode to qualify as a large outflow episode there has to be at least one quarter where $\Delta C_{i,t}$ is more than two standard deviations below the rolling mean. A large inflow episode is defined symmetrically.

We use an unbalanced panel that consists of 28 emerging market economies[2] and focus on the time period from 2000 to 2019. This sample gives us a total of 55 large outflow and 64 large inflow episodes, which given the total sample size of 511, results in an unconditional

[1] 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. More specifically, we define capital inflows as the sum of net occurrence of portfolio equity and debt liabilities (indicator code "BFOLXF_BP6_USD" and "BFPLXF_BP6_USD") in the IMF IFS Database.

[2] The country sample we look at is Czech Republic, Israel, Poland, Brazil, Chile, Colombia, South Africa, Thailand, Korea, Mexico, Hungary, Peru, Philippines, Guatemala, Indonesia, Romania, Turkey, Armenia, Uruguay, Albania, Georgia, Paragauy, Uganda, Dominican Republic, Moldova, India, Kazakhstan and Russia.

frequency of 10.8% for large outflows and 12.5% for large inflows.[3] The complete list of inflow and outflow episodes along with their staring year is given in Tables 2.1 and 2.1.

Table 1: Large outflow episodes[4]

Country	Year	Country	Year	Country	Year	Country	Year
Albania	2005	Czech Republic	2009*	India	2008*	Paraguay	2014
Albania	2009*	Czech Republic	2018*	India	2015*	Romania	2008*
Armenia	2010	Georgia	2009*	Korea	2008*	Russia	2008*
Armenia	2014	Georgia	2013	Kazakhstan	2007	Russia	2014
Brazil	2008*	Guatemala	2004	Moldova	2009*	Thailand	2007
Brazil	2015	Guatemala	2009*	Moldova	2014	Thailand	2008*
Chile	2000	Hungary	2002*	Mexico	2008*	Turkey	2001*
Chile	2007	Hungary	2009*	Mexico	2015*	Turkey	2007
Chile	2009*	Indonesia	2008*	Peru	2005	Turkey	2008*
Chile	2015*	Indonesia	2015*	Peru	2008*	Uruguay	2016*
Colombia	2008*	Israel	2001*	Philippines	2008*	South Africa	2000
Colombia	2011	Israel	2008*	Poland	2008*	South Africa	2007*
Colombia	2015*	Israel	2011	Poland	2017	South Africa	2015*
Czech Republic	2005	Israel	2017	Paraguay	2006		

Table 2: Large inflow episodes[5]

Country	Year	Country	Year	Country	Year	Country	Year
Albania	2006*	Czech Republic	2017	Korea	2016	Paraguay	2012
Albania	2008	Dominican Republic	2018	Kazakhstan	2002	Paraguay	2014
Albania	2017	Georgia	2006*	Kazakhstan	2005*	Romania	2000
Armenia	2007*	Guatemala	2000	Moldova	2004*	Romania	2004*
Armenia	2013	Guatemala	2006*	Moldova	2007*	Romania	2007*
Brazil	2005*	Hungary	2003*	Moldova	2013	Romania	2015
Brazil	2009	Hungary	2005*	Mexico	2005*	Russia	2007*
Chile	2005*	Indonesia	2006*	Mexico	2007*	Thailand	2004*
Chile	2008	Indonesia	2009	Mexico	2010	Thailand	2009
Chile	2010	Israel	2004*	Peru	2007*	Turkey	2000
Chile	2017	Israel	2009	Peru	2019	Turkey	2010
Colombia	2007*	India	2003*	Philippines	2007*	Uganda	2007*
Colombia	2010	India	2004*	Philippines	2009	Uganda	2018
Czech Republic	2001	India	2007*	Philippines	2018	Uruguay	2012
Czech Republic	2003*	Korea	2006*	Poland	2007*	Uruguay	2017
Czech Republic	2008	Korea	2009	Paraguay	2008	South Africa	2006*

We use local projection methods following Jorda (2005) to estimate the impact of large capital outflows and inflows on macroeconomic variables at the annual frequency. The

[3] If two inflow or outflow events start in the same year, we consider them as one event.
[4] Sudden stops are denoted with an asterisk.
[5] Surges are denoted with an asterisk.

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 or level of a macroeconomic variable (real GDP, consumption, gross fixed capital formation, CPI inflation, real exchange rate, nominal exchange rate, gross exports, gross imports and credit to the private sector)[6] in country i at year t. We use the bilateral exchange rate against the USD for the nominal exchange rate, denoted such that an increase reflects a depreciation of the local currency against the USD. The real exchange rate is also defined as the bilateral real exchange rate vis-a-vis the US and defined such that an increase reflects a real depreciation of the local currency. $x_{i,t}$ is a dummy variable for either large inflow episodes or outflow episodes where it takes the value of 1 if a corresponding episode started in country i in year t and 0 otherwise. We run the regression independently for 6 different horizons where $h \in \{0, 1, 2, 3, 4, 5\}$ controlling for country fixed effects and using standard errors clustered by country.

We show the estimated results for β_h for each independent variable and horizon in Figure 1. The circled blue line represents the estimate for large outflow episodes with the blue area capturing 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 GDP, consumption and investment, increase in CPI inflation, a real and nominal depreciation of the exchange rate, an increase in the trade balance via an increase in exports and decrease in imports, and a fall in credit supplied to the private sector. Large inflows have the opposite effect, with the exception of CPI inflation which increases as well following large inflows. In particular, the impact on GDP, consumption and investment is slightly larger for outflow episodes highlighting the possibility of a non-linear impact of capital outflows. These findings are largely consistent with those of the literature where capital inflows and outflows are associated with booms and busts.

In addition, we test the robustness of these results by controlling for the cyclical position of real credit, the real effective federal funds rate, the level and change in reserves, the exchange rate regime and financial market openness. We find that the results are significant even after controlling for these variables. Please refer to Appendix **??** for further details.

[6] We use data from the World Bank World Development Indicator database for the macroeconomic variables.

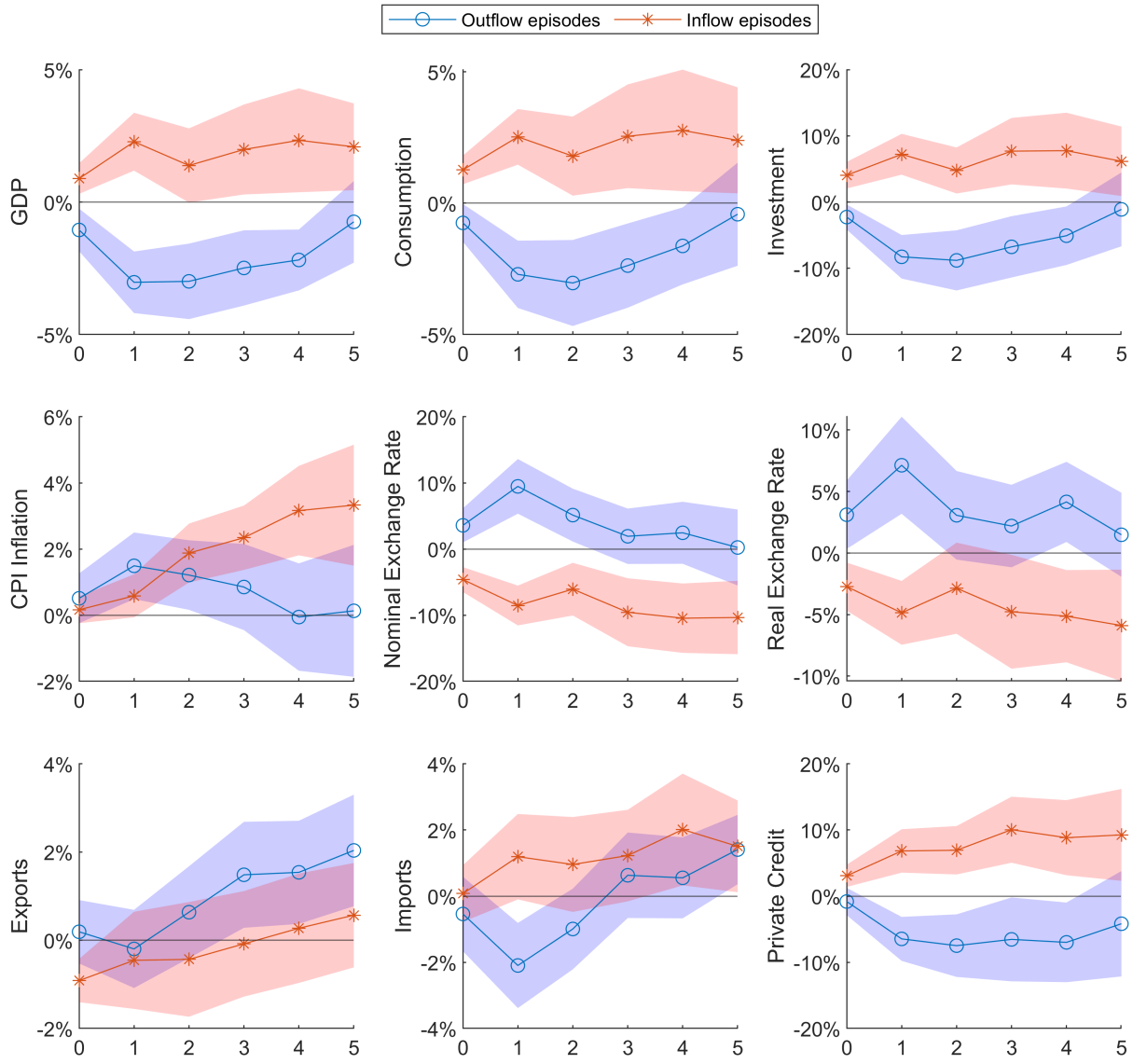


Figure 1: Local projection estimates for large outflows and inflows

2.2 Sudden stops and surges

We define sudden stops as large capital outflow episodes that coincide with a tightening of global financial conditions, proxied by the Global Financial Cycle factor developed by Miranda-Agrippino and Rey (2020). Similar to how we defined large capital outflows, we define a tightening of global financial conditions as an episode that starts when the Global Financial Cycle factor is lower than its mean by one standard deviation and ends when the factor is higher than one standard deviation below its mean.[7] In addition, there has to

[7]Similar to how we defined capital outflow and inflow episodes, we use the 3-year rolling mean and standard deviation. Since the Global Financial Cycle factor is available at the monthly frequency, we define financial tightening and loosening episodes at the monthly frequency.

be at least one month where the Global Financial Cycle factor is lower than its mean by two standard deviations. If in a given year a large capital outflow episode starts and there is a tightening of global financial conditions, we consider it as a sudden stop. Similarly, we define surges as large capital inflow episodes that coincide with a loosening of global financial conditions.

We show the standardized Global Financial Cycle factor and episodes of global financial condition tightening and loosening in Figure 2. The areas shaded in blue represent periods of global financial tightening while the areas shaded in red represent periods of global financial loosening. We can see that this method is able to capture the loosening of financial conditions prior to the Global Financial Crisis as well as the sharp tightening of financial conditions during the Global Financial Crisis.

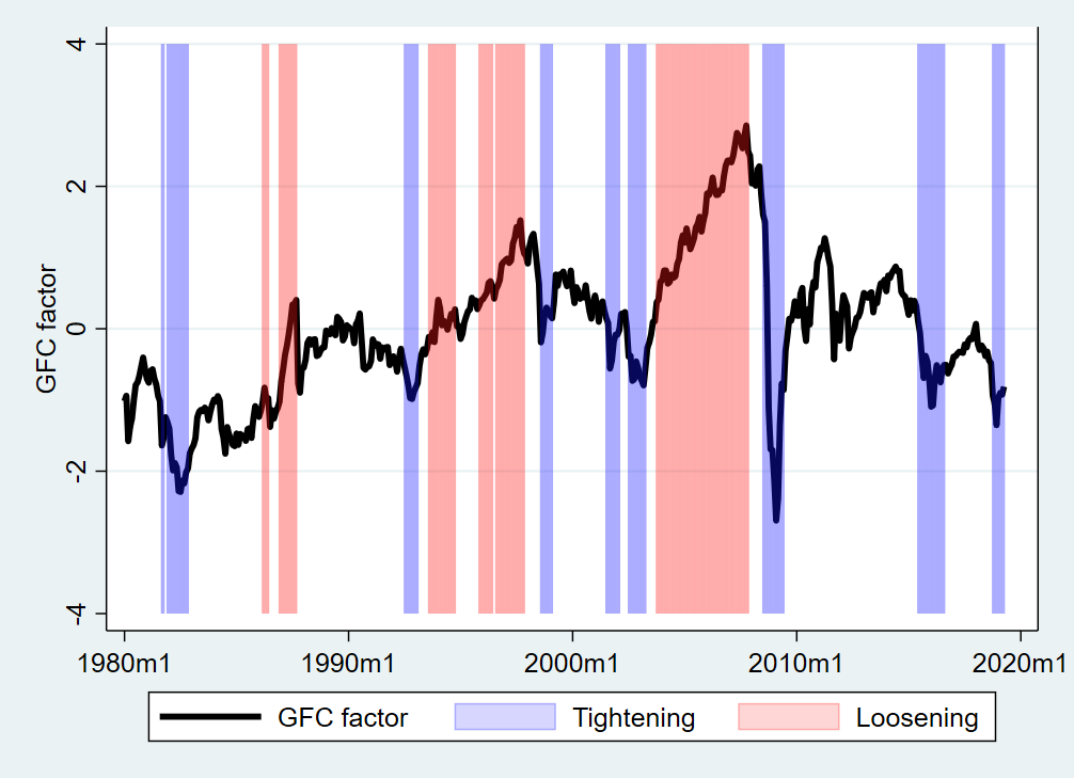


Figure 2: The Global Financial Cycle (GFC) factor and global financial conditions

Out of the 55 large outflow episodes, 33 qualify as sudden stops while 30 qualify as surges out of the 64 large inflow episodes. Given our sample size, this results in an unconditional frequency of 6.5% sudden stops and 5.9% surges per year.[8] A complete list of sudden stops and surges along with their starting years are shown in Tables 2.1 and 2.1

[8]The frequency of sudden stops is approximately three times higher than the estimate from Eichengreen and Gupta (2018). The difference arises due to differences in the definition of sudden stops.

with asterisks.

To analyze how much of the impact of outflow events is driven by sudden stops, we split the sample of outflow episodes into sudden stops and outflow episodes that are not classified as sudden stops and compare their local projections. We report the findings in Figure 3. The circled clue line represents the estimate of β_h in Equation 1 where $x_{i,t}$ is a dummy variable for sudden stops. The shaded blue area captures the 90% confidence interval. The green crossed line represents the estimate of β_h in Equation 1 where $x_{i,t}$ is a dummy variable for outflow episodes that are not sudden stops. The shaded green area is the 90% confidence interval. We find that the fall in GDP, consumption and investment, the nominal and real depreciation, the fall in imports, and reduction in private credit of outflow episodes are driven by sudden stops. Non-sudden stop outflow episodes do not have a significant impact on these variables. Interestingly, the increase in headline CPI inflation is driven by non-sudden stop outflow episodes while exports respond in opposite directions to sudden stops and non-sudden stop outflow episodes.

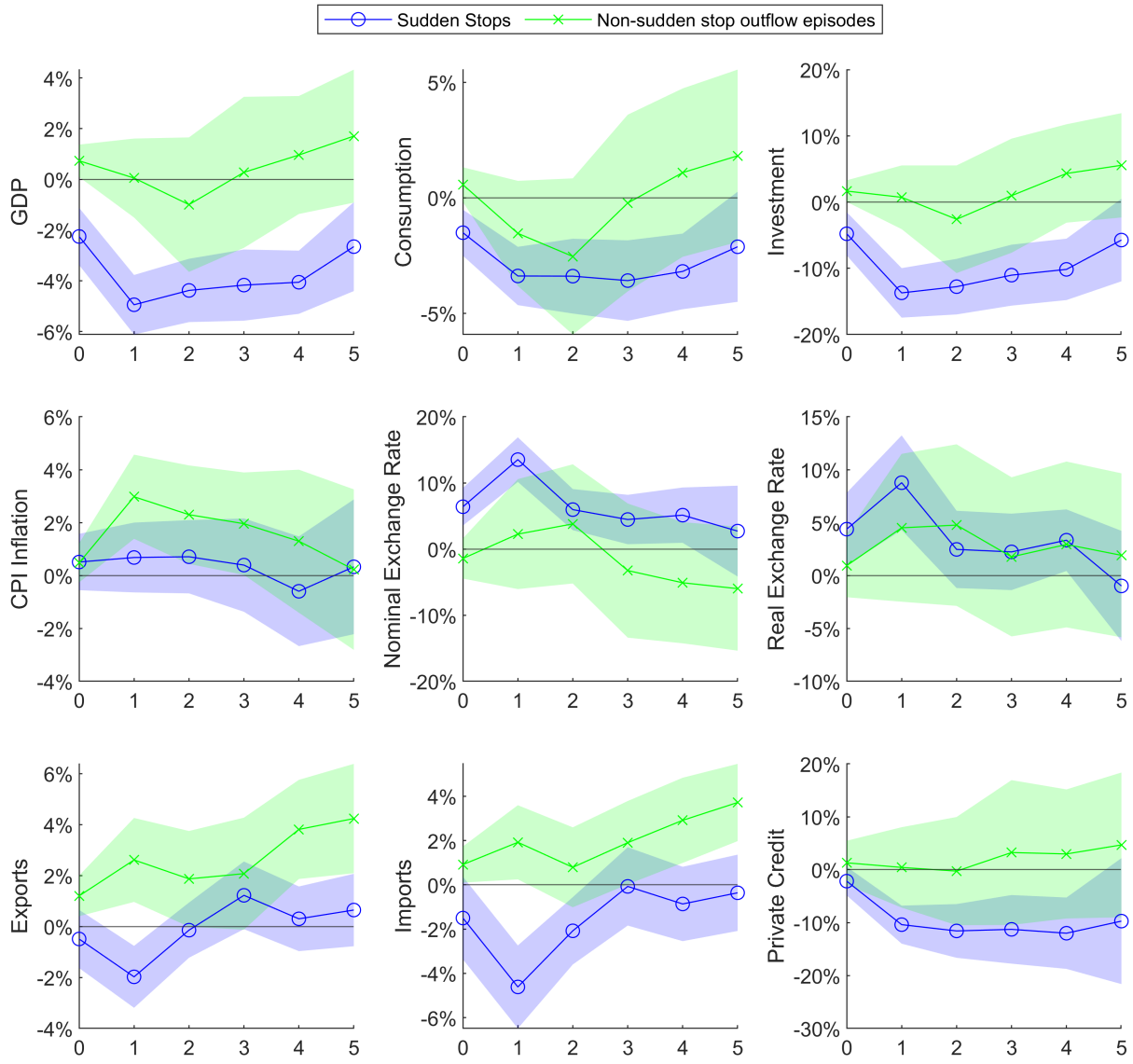


Figure 3: Local projection estimates for sudden stops and non-sudden stop outflow episodes

Similarly, we analyze how the impact of inflows are driven by surges by splitting the sample of inflow episodes into surges and non-surge inflow episodes and comparing the local projection estimates. We show the local projection estimates in Figure 4. The starred red line represents estimates of β_h in Equation 1 for surges with the shaded red area representing the 90% confidence interval. The crossed green line captures the estimates of β_h for non-surge inflow episodes with the 90% confidence interval shown as the shaded green area. The results are largely symmetric to those from the analysis above. Surges explain the increase in GDP, consumption and investment, the real and nominal appreciation, and the increase in imports and private credit following inflows.

Non-surge episodes do not have a significant impact on these variables. Interestingly, surges significantly increase inflation while non-surge inflow episodes reduce inflation. We report the findings in

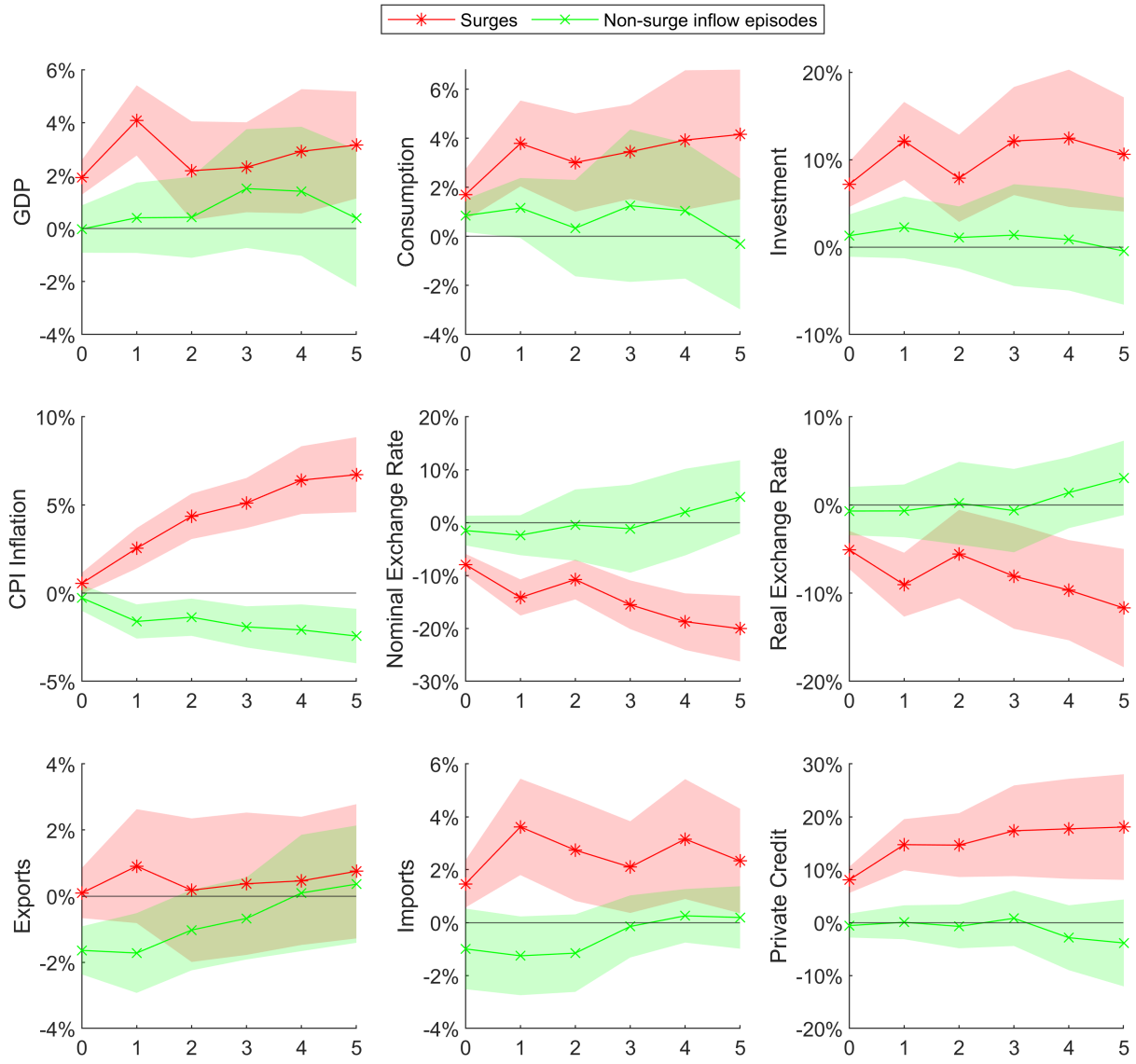


Figure 4: Local projection estimates for surges and non-surge inflow episodes

We again test the robustness of these results Appendix **??**.

2.3 Predictive power of inflows

Next, we show that inflow episodes have predictive power in forecasting 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 (2). $Outflow_{i,t}(h)$ 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. In the baseline, we control for country fixed effects and use standard errors clustered by country. For robustness tests, we also include the cyclical position of real credit, the real effective federal funds rate, the lag of the real effective federal funds rate, the level of and change in reserves as a percent of GDP, a dummy variable controlling for flexible exchange rate regimes, financial market openness and time fixed effects in $\boldsymbol{X}_{i,t}$.[9]

$$Outflow_{i,t}(h) = \beta_h Inflow_{i,t} + \gamma_h \boldsymbol{X}_{i,t} + FE_{i,h} + \varepsilon_{i,h,t} \tag{2}$$

The estimates for Equation (2) are shown Table 3. We find that large inflow episodes are able to predict large outflow episodes. This is also evident by observing how inflow episodes precede outflow episodes in Tables 2.1 and 2.1. For example, Peru had a large inflow episode in 2007 that was followed by a large outflow episode in 2008. We also note that the results are robust to controlling for time fixed effects, showing that even though there is a bulk of inflow and outflow episodes that have occurred around the global financial crisis the results are not solely driven by these episodes.

We also test whether surges are able to forecast outflow episodes and sudden stops. The results are similar to inflow episodes and are shown in columns 4-6 in Table 3. We find similarly significant results for longer horizons ($h > 1$) for both inflows and surges and report them in Appendix **??**.

We also test whether inflow episodes and surges are able to predict sudden stops using the following linear probability specification:

$$SS_{i,t}(h) = \beta_h Inflow_{i,t} + \gamma_h \boldsymbol{X}_{i,t} + FE_i + \varepsilon_{i,t} \tag{3}$$

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 Table 4. Again, we find that large inflow episodes surges have predictive power in forecasting sudden stops.

[9] We derive the cyclical position of real credit by taking the log deviation of per capital real credit to the private sector from its trend using an HP filter. We use the classification of exchange rate regimes from Ilzetzki, Reinhart and Rogoff (2019) and the financial market openness index from Chinn and Ito (2006).

	$Outflow_{i,t}(h)$					
	h=1	h=1	h=1	h=1	h=1	h=1
$Inflow_{i,t}$	0.196***	0.140***	0.120**			
	(0.056)	(0.049)	(0.052)			
$Surge_{i,t}$				0.212**	0.071	0.132**
				(0.084)	(0.077)	(0.065)
$RealCredit_{i,t}$			-0.005			-0.007
			(0.027)			(0.028)
$RealFFR_{i,t}$			0.037			0.041
			(0.054)			(0.052)
$RealFFR_{i,t-1}$			-0.013			-0.017
			(0.054)			(0.054)
$Res_{i,t}$			-0.130			-0.167
			(0.178)			(0.180)
$\Delta Res_{i,t}$			1.866***			2.082***
			(0.698)			(0.722)
$FXregime$			-0.033			-0.041
			(0.037)			(0.037)
$KAOPEN$			0.009			0.010
			(0.008)			(0.008)
Country FE	Y	Y	Y	Y	Y	Y
Time FE	N	Y	Y	N	Y	Y
R^2	0.0631	0.2123	0.2739	0.0454	0.1941	0.2657
N	483	483	380	483	483	380

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

Table 3: Linear probability model estimation results for outflow episodes

	$SS_{i,t}(h)$					
	h=1	h=1	h=1	h=1	h=1	h=1
$Inflow_{i,t}$	0.164***	0.113**	0.092**			
	(0.049)	(0.043)	(0.038)			
$Surge_{i,t}$				0.212**	0.106*	0.184***
				(0.080)	(0.056)	(0.060)
$RealCredit_{i,t}$			-0.030			-0.039
			(0.028)			(0.026)
$RealFFR_{i,t}$			0.047			0.050
			(0.052)			(0.051)
$RealFFR_{i,t-1}$			-0.025			-0.029
			(0.050)			(0.052)
$Res_{i,t}$			-0.091			-0.113
			(0.141)			(0.136)
$\Delta Res_{i,t}$			1.489**			1.596**
			(0.677)			(0.729)
$FXregime$			-0.025			-0.034
			(0.036)			(0.036)
$KAOPEN$			-0.001			-0.000
			(0.005)			(0.005)
Country FE	Y	Y	Y	Y	Y	Y
Time FE	N	Y	Y	N	Y	Y
R^2	0.0666	0.3347	0.4010	0.0605	0.3222	0.4065
N	483	483	380	483	483	380

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

Table 4: Linear probability model estimation results for sudden stops

	$SS_{i,t}(h)$					
	h=1	h=1	h=1	h=1	h=1	h=1
$Inflow_{i,t}$	0.102***	0.071***	0.109***			
	(0.031)	(0.024)	(0.035)			
$Surge_{i,t}$				0.164***	0.089***	0.140***
				(0.047)	(0.032)	(0.049)
$RealCredit_{i,t}$			0.001			0.001
			(0.001)			(0.001)
$RealFFR_{i,t}$			-0.130			-0.129
			(0.187)			(0.188)
$RealFFR_{i,t-1}$			0.064			(0.060)
			(0.125)			(0.125)
$Res_{i,t}$			0.011			-0.009
			(0.124)			(0.129)
$\Delta Res_{i,t}$			0.320			0.370
			(0.327)			(0.339)
$FXregime$			-0.077**			-0.088**
			(0.034)			(0.036)
$KAOPEN$			0.002			0.005
			(0.011)			(0.011)
Country FE	Y	Y	Y	Y	Y	Y
Time FE	N	Y	Y	N	Y	Y
R^2	0.0482	0.2653	0.3202	0.0559	0.2625	0.3156
N	1231	1231	746	1231	1231	746

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

Table 5: Linear probability model estimation results for sudden stops

2.4 The role of currency denomination in external liabilities

We also test whether the macroeconomic impact of inflow and outflow episodes is 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, Hausmann and Panizza (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 govern-

ments of these emerging market economies. In recent work Onen, Shin and Peter (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 5 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.[10] 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%.

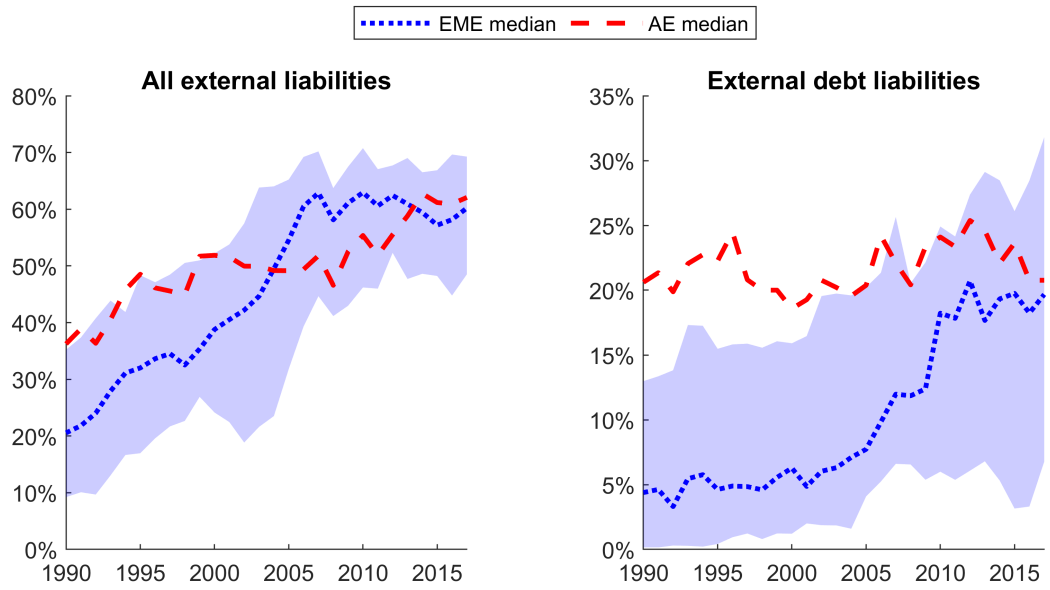


Figure 5: Local currency share of external liabilities

However, despite the dissipation of the "Original Sin" in emerging market economies, emerging market economies are still prone to sudden stops and large capital outflow episodes. Bertaut, Bruno and Shin (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

[10]For Figure 5, 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.

from the external balance sheet of emerging market economies to that of foreign investors, Hofmann, Patel and Wu (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 outflow and inflow 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.[11]

The local projection estimates for outflow and inflow episodes are shown in Figures 6 and 7. We find that the impact of outflows and inflows is largely similar across the two different sample of countries, highlighting that having a higher share of external liabilities denominated in local currency does not fully insulate a country from volatile capital flows.

We formally test whether the currency denomination of external liabilities matters for the macroeconomic impact of capital flow episodes by using the following local projection:

$$y_{i,t+h} - y_{i,t-1} = \alpha_h + \beta_h x_{i,t} + \delta_h x_{i,t} \times LC_{i,t} + \sum_{k=1}^{3} \gamma_{k,h} \Delta y_{i,t-k} + FE_{i,h} + \varepsilon_{i,h,t} \tag{4}$$

which is Equation 1 but with an interaction term $x_{i,t} \times LC_{i,t}$. $LC_{i,t}$ is a measure of external liabilities denominated in local currency of country i. We use three different measures. We first use a dummy variable that takes the value of 1 if country i's average local currency external liabilities as a share of total external liabilties is above the cross-country median and 0 otherwise. Second, we use country i's average local currency external liabilities as a share of total external liabilities. And lastly, we use country i's time varying local currency external liabilities as a share of total external liabilities.

We find that δ_h is insignificant for most horizons, capital flow events and macro variables. We describe the exercise in more detail in the appendix. Overall, we do not find any evidence that supports that the currency composition of external liabilities matters for the impact of capital flow episodes. **ADD APPENDIX**

[11] 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 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.

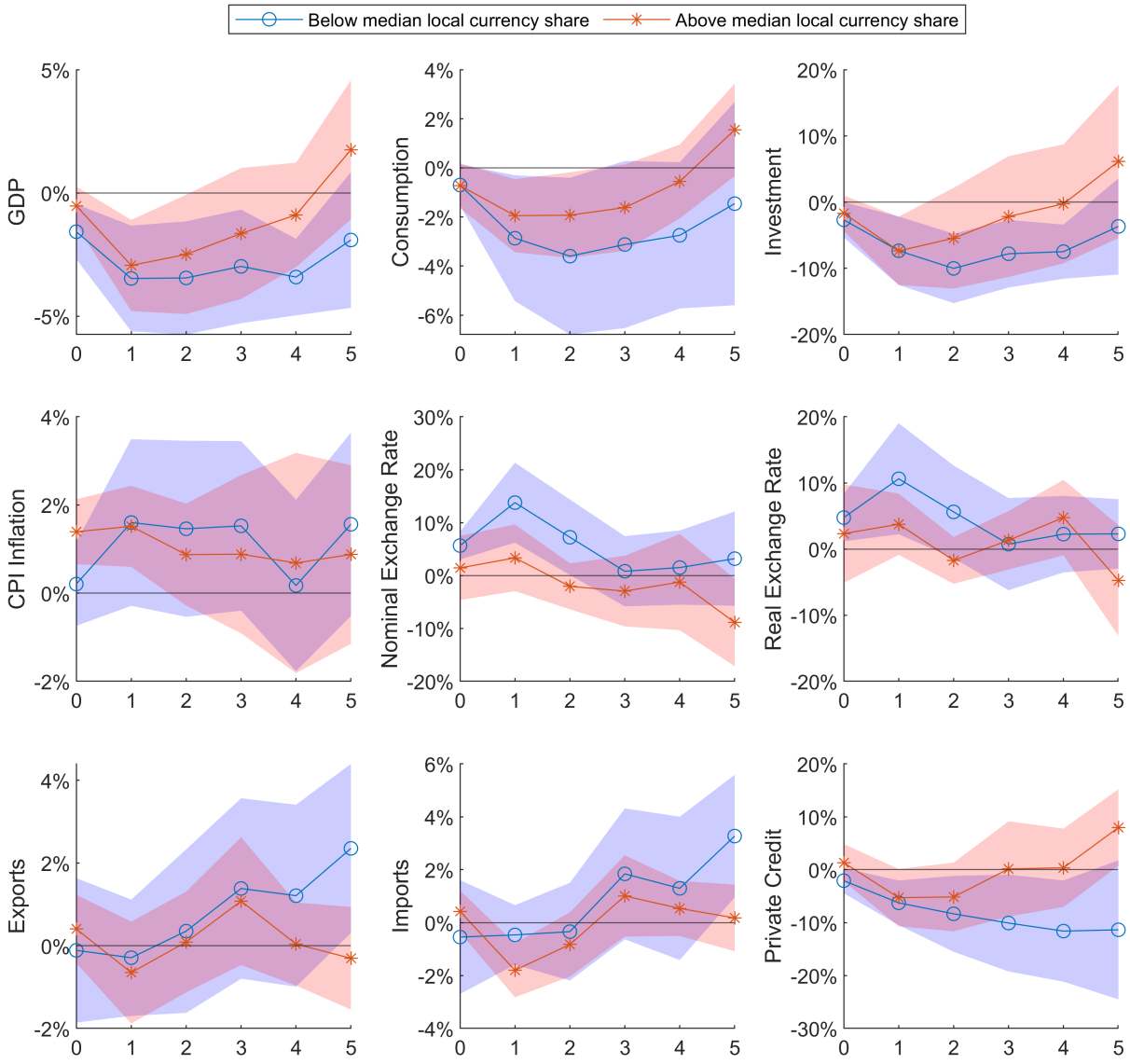


Figure 6: Impact of outflows

3 Model

In this section, we develop a model of a small open economy with shallow domestic financial markets. This economy, referred to as "Home," is composed of households that consume both domestic and imported goods and supply labor. Labor, combined with physical capital, is used to produce differentiated domestic tradable goods, which are consumed domestically and exported internationally. The production of physical capital requires investment, which is financed by domestic banks. These banks collect short-term deposits from households and invest the proceeds in short- and long-term loans to firms and long-term government bonds. However, their ability to channel households' savings

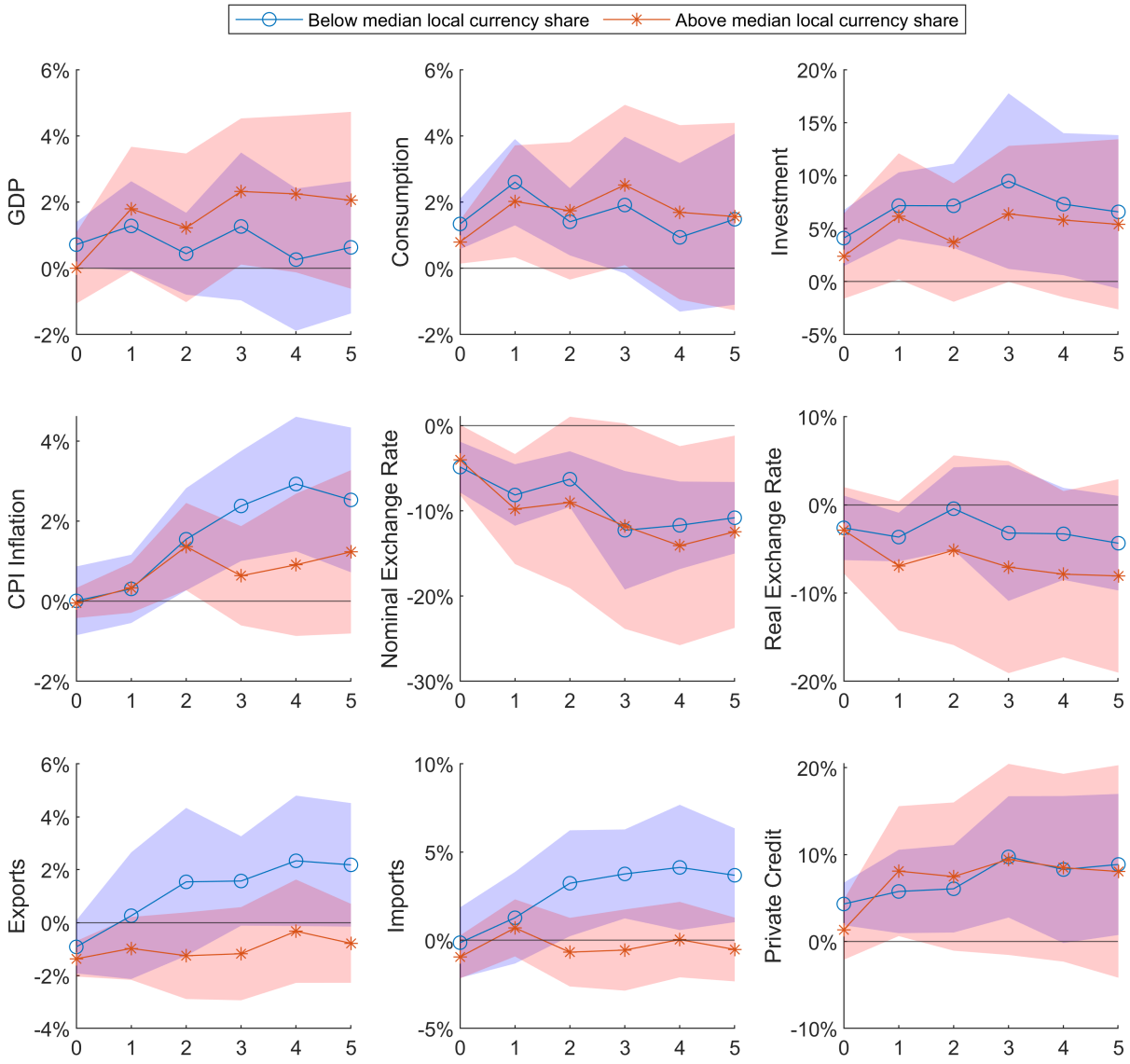


Figure 7: Impact of inflows

into loans is hindered by an agency friction that limits their leverage and constrains the domestic supply of credit.

Fortunately, banks are not the sole source of credit for the Home economy. Foreign investors lend to the domestic government by purchasing government bonds. Capital inflows play a crucial role in determining the size and composition of the banking sector's balance sheet and the domestic cost of credit. When capital inflows are plentiful, the leverage of the banking sector decreases, enabling banks to channel more funds to the private sector. Conversely, when inflows diminish, domestic leverage increases, forcing banks to reduce their supply of credit, leading to a sudden stop.

Households The Home economy is inhabited by a measure one of homogeneous households with Greenwood, Hercowitz and Huffman (1988) preferences. The representative 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 and H_t is the aggregate amount of labor supplied by its workers. The parameter $\beta\in(0,1)$ denotes the households' subjective discount factor, $\eta\geq 0$ measures their degree of risk aversion (and is an inverse measures of their elasticity of intertemporal substitution) and $\varphi\geq 0$ is the inverse Frisch elasticity of labor supply. The consumption index is a composite of Home ($C_{H,t}$) and imported goods ($C_{F,t}$), given by

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

where $\alpha\in[0,1]$ measures the degree of Home bias in consumption. The optimal allocation of expenditure between domestic and foreign goods is $P_{H,t}C_{H,t}=\left(1-\alpha\right)C_t$ and $P_{F,t}C_{F,t}=\alpha C_t$, where $P_{H,t}$ and $P_{F,t}$ are the prices of the Home and imported good, respectively, expressed in units of domestic consumption, with $P_{H,t}=\left(P_{F,t}\right)^{-\frac{\alpha}{1-\alpha}}$. To avoid confusion, we express all prices in real terms, except for inflation rates which represent the growth rate of nominal prices. Let Π_t and $\Pi_{H,t}$ denote CPI and PPI inflation, respectively, such that $\Pi_t=\Pi_{H,t}\frac{P_{H,t-1}}{P_{H,t}}$.

We assume that there is full exchange rate pass-through to import prices. That is, $P_{F,t}=E_tP_{F,t}^*$, where E_t denotes the real exchange rate, defined as the relative price of foreign consumption in terms of domestic consumption, and $P_{F,t}^*$ denotes the foreign price of the foreign good, which is assumed to follow an AR(1) process in logs: $\log\left(P_{F,t}^*\right)=\rho_P\log\left(P_{F,t-1}^*\right)+\sigma_P\varepsilon_{P,t}$, where $\varepsilon_{P,t}\sim N\left(0,1\right)$.

Households save by holding bank deposits which pay the nominal gross risk-free rate R_t. The budget constraint of the representative household is

$$C_t=-D_t+D_{t-1}\frac{R_{t-1}}{\Pi_t}+W_tH_t-T_t+\Omega_t,$$

where D_t denotes real deposits, W_t denotes the real wage rate, T_t denotes limp-sum taxes, and Ω_t is a lump-sum component of income, which includes dividends received from the firms operating in the economy. The households' labor supply decision is $W_t=\chi\left(H_t\right)^{\varphi}$ while their Euler equation is $1=\mathbb{E}_t\left[\Lambda_{t|t+1}\frac{R_t}{\Pi_{t+1}}\right]$, where $\Lambda_{t|t+1}\equiv\beta\left[C_{t+1}-\chi\frac{(H_{t+1})^{1+\varphi}}{1+\varphi}\right]^{-\eta}/\left[C_t-\chi\frac{(H_t)^{1+\varphi}}{1+\varphi}\right]^{-}$ denotes the households' stochastic discount factor.

Financial sector The financial sector of the Home economy is composed of a mass of homogeneous banks. Banks collect deposits from households and use the proceeds to finance three types of activities.

First, they make loans to capital-producing firms to finance the production of physical capital. Loans are claims to the stream of earnings associated with the underlying capital. Their real rate of return is

$$\frac{R^l_{t+1}}{\Pi_{t+1}} = \frac{Q_{t+1} + (1-\delta) P^l_{t+1}}{P^l_t}$$

where P^l_t denotes the market value of a loan that is financing one unit of capital, Q_t its cash flow, and $\delta \in (0,1)$ is the depreciation rate of capital.

Second, banks lend to the domestic government by purchasing long-term bonds denominated in units of the Home consumption bundle. We follow Woodford (2001) in modeling long-term bonds as perpetuities with exponentially decaying coupons. Specifically, we assume that a bond issued in period t pays $(1-\rho)^j$ units of the domestic consumption aggregator $j+1$ periods later, where $\rho \in (1-\beta^{-1}, 1]$ is the decaying factor.[12]. Let P^b_t denotes the price of a new bond issued in period t. Then, its real rate of return of is

$$\frac{R^b_{t+1}}{\Pi_{t+1}} = \frac{1 + (1-\rho) P^b_{t+1}}{P^b_t}$$

Finally, banks finance good-producing firms by issuing working capital loans at interest rate R^z_t. We assume that working capital loans are intraperiod, and the funds used to finance them can also be used to finance the acquisition of intertemporal assets at the end of the period. However, for simplicity, we assume that any net profits generated by working capital loans are immediately rebated to households.

Let L_t denotes the amount of loans issued by banks, B_t denote their holding of government bonds, and D_t denote deposits collected from households. The aggregate balance sheet constraint of the banking sector is

$$P^l_t L_t + P^b_t B_t = N_t + D_t,$$

where N_t is banks' end-of-period net worth.

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

[12]When the real interest rate is constant and equal to $1/\beta$, the duration of such a bond is $(1-\beta(1-\rho))^{-1}$

transfer the proceeds to her household. In particular, we assume that the banker can divert a fraction ζ of its assets. 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

$$\mathcal{V}_t\left(N_t\right) \geq \zeta\left(P_t^l L_t + P_t^b B_t + Z_t\right), \tag{5}$$

where $\mathcal{V}_t$ denotes the value of the bank for the households and Z_t denotes the amount of working capital loans issued by banks. Note that we write the incentive compatibility constraint directly in terms of the representative bank since, as will be clear in a moment, $\mathcal{V}_t$ is linear in N_t and therefore net worth can be aggregated across banks.

The banks' objective is to maximize the present discounted value of dividends paid to households. However, due to the agency friction banks would choose to postpone dividend payments and retain their earnings until their balance sheet is entirely funded by their own capital such that the incentive compatibility constraint is never binding. To prevent this outcome, we assume that banks are subject to a stochastic dividend payment policy. In each period, a fraction $1-\sigma$ of randomly selected banks transfer all their net worth to households and are replaced by new banks.[13] This implies that the objective of each bank is to maximize its expected terminal wealth. Hence, the problem of the representative banker is

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

subject to (5), where $\dot{N}_{t+1}$ denotes the beginning-of-period net worth in period $t+1$, that is before the exit and entry of banks take place, which is given by

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

Let μ_t denote the Lagrange multiplier associated with the incentive compatibility constraint. The first order conditions of the banks' problem give rise to the following

[13] Formally, we assume that each household is composed of a unit mass of family 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 each period a fraction $1-\sigma$ of randomly selected bankers become workers in the following period. 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.

pricing equations:

$$\zeta\mu_t = \mathbb{E}_t\left[\left(1-\sigma+\sigma V_{t+1}\right)\Lambda_{t|t+1}\left(\frac{R^l_{t+1}}{\Pi_{t+1}}-\frac{R_t}{\Pi_{t+1}}\right)\right],$$
$$\zeta\mu_t = \mathbb{E}_t\left[\left(1-\sigma+\sigma V_{t+1}\right)\Lambda_{t|t+1}\left(\frac{R^b_{t+1}}{\Pi_{t+1}}-\frac{R_t}{\Pi_{t+1}}\right)\right],$$
$$\zeta\mu_t = R^z_t - 1,$$

where $\mathcal{V}_t\left(N_t\right) = V_t N_t$, and V_t is the marginal value of net worth for the banks which satisfies $\left(1-\mu_t\right)V_t = \mathbb{E}_t\left[\left(1-\sigma+\sigma V_{t+1}\right)\Lambda_{t|t+1}\frac{R_t}{\Pi_{t+1}}\right]$.

The aggregate end-of-period net worth evolves as the sum of the net worth of the surviving banks plus the start-up capital endowed to the new banks by households, denoted by $\hat{N}_t$. Hence, $N_t = \sigma\dot{N}_t + \hat{N}_t$.

$$\dot{N}_{t+1} = \frac{R^l_{t+1}}{\Pi_{t+1}}P^l_t L_t + \frac{R^b_{t+1}}{\Pi_{t+1}}P^b_t B_t - \frac{R_t}{\Pi_{t+1}}D_t$$

Banks are not the sole source of credit for the Home economy, as the Home government can borrow abroad by placing its long-term bonds internationally. We assume that foreign investors are risk neutral and price Home government bonds according to the following uncovered interest parity (UIP) condition

$$\mathbb{E}_t\left[\frac{E_t}{E_{t+1}R^*_{H,t}}\frac{R^b_{t+1}}{\Pi_{t+1}}\right] = 1$$

where $R^*_{H,t}$ represents the expected return required by foreign investors to hold the Home government bond. We follow Schmitt-Grohé and Uribe (2003) and assume that foreign investors require a debt-elastic interest rate premium

$$R^*_{H,t} = R^*_t + \varsigma\left(e^{\frac{P^b_t B^*_t - P^b B^*}{GDP}} - 1\right) \tag{6}$$

where B^*_t denotes the amount of bonds held by foreign investors, GDP the steady-state Gross Domestic Product (GDP), and R^*_t captures fluctuations in the premium which are exogenous to the Home economy and follows an AR(1) process in logs: $\log\left(\frac{R^*_t}{R^*}\right) = \rho_R\log\left(\frac{R^*_{t-1}}{R^*}\right) + \sigma_R\varepsilon_{R,t}$, where $\varepsilon_{R,t}\sim N\left(0,1\right)$. Shocks to R^*_t are proxies for changes in global financial conditions induced by shifts in foreign investors' risk sentiment.

Tradable sector The tradable sector is composed of tradable good firms, retailers and exporters. Each firm, indexed by $j \in [0,1]$, produces a different variety of the Home tradable good by combining labor (H_t), capital (K_t), and imported inputs (M_t) according to the production function

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

where $\gamma, \omega \in [0,1]$, such that $\omega + \omega \in [0,1]$ and A_t denotes total factor productivity, which follows an AR(1) process in logs: $\log(A_t) = \rho_A \log(A_{t-1}) + \sigma_A \varepsilon_{A,t}$, where $\varepsilon_{A,t} \sim N(0,1)$. Firms rent labor from households at the wage rate W_t, rent physical capital from capital producers at the rental rate Q_t, and purchase imported inputs at price $P_{F,t}$. Following Mendoza (2010), we assume that each firm must borrow from banks a fraction ξ of the cost of labor and imported inputs. The total net cost of working capital loans for firm j is $Z_t(j)(R_t^z - 1)$, where $Z_t(j) = \xi[W_t H_t(j) + P_{F,t} M_t(j)]$. The firms' cost minimization problem yields the following aggregate input demands

$$\begin{aligned} H_t W_t &= \gamma X_t \\ K_t Q_t &= [1 + \xi(R_t^z - 1)]\,\omega X_t \\ M_t P_{F,t} &= (1 - \gamma - \omega) X_t \end{aligned}$$

where $X_t \equiv \frac{MC_t Y_t}{1+\xi(R_t^z-1)}$ and MC_t denotes the real marginal cost of production, which is given by $MC_t = \frac{[1+\xi(R_t^z-1)]^{1-\omega}}{A_t} \left(\frac{W_t}{\gamma}\right)^{\gamma} \left(\frac{Q_t}{\omega}\right)^{\omega} \left(\frac{P_{F,t}}{1-\gamma-\omega}\right)^{1-\gamma-\omega}$.

Tradable good firms sell their output to domestic retailers which aggregate them to produce the Home tradable good. Retailers combine the different varieties according to the technology $Y_t \equiv \left[\int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj\right]^{\frac{\epsilon}{\epsilon-1}}$, where $\epsilon > 1$ is the elasticity of substitution between varieties, and sell their final output in a perfectly competitive market. 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 producers price index. We assume that producers set their prices in domestic currency, subject to a quadratic adjustment cost a la Rotemberg (1982). Their pricing decision gives rise to the following Phillips curve

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

where $\bar{\Pi}$ is the inflation target of the central bank, τ_H is a production subsidy, and θ measures the degree of price stickiness.

Exporters buy the Home tradable good, transform it into different export varieties and sell them to foreign retailers. Foreign retailers combine the different varieties, according to $Y_t \equiv \left[\int_0^1 Y_t(i)^{\frac{\epsilon-1}{\epsilon}} di\right]^{\frac{\epsilon}{\epsilon-1}}$, and sell their final output to foreign households. Foreign households' demand for the Home good is $Y^*_{H,t} = \alpha^* \left(P^*_{H,t}\right)^{-\nu} Y^*$, where $\nu > 0$ measures the price elasticity of demand. Exporters must borrow from banks a fraction ξ^* of the cost of their inputs. The total net cost of trade loans for exporter j is $Z^*_t(j)(R^z_t - 1)$, where $Z^*_t(j) = \xi^* P_H Y^*_{H,t}(j)$. We assume that exporters set their prices in foreign currency according to the rule

$$P^*_{H,t} = \left[1 + \xi^*\left(R^z_t - 1\right)\right] \frac{\epsilon}{\epsilon - 1}\left(1 - \tau^*_H\right)\left(\frac{P_{H,t}}{E_t}\right)^{\vartheta}\left(\frac{P_H}{E}\right)^{1-\vartheta}$$

where τ^*_H is an export subsidy and $\vartheta \in [0,1]$ measures the degree of exchange rate pass-through to export prices.

Production and export subsidies are set by the planner to maximize welfare in steady state.[14] As shown in appendix ???, this yields $\tau_H = \frac{1}{\epsilon}$ and $\tau^*_H = \frac{1}{\epsilon}\frac{\nu-\epsilon}{\nu-1}$.

Capital good sector Capital good firms combine domestic and imported goods to produce physical capital, subject to an adjustment cost. Producing I_t new units of capital costs $I_t + \frac{\iota}{2}\left(\frac{I_t}{K_{t-1}} - \delta\right)^2 K_{t-1}$ units of the domestic consumption basket. Existing capital depreciates at rate $\delta \in (0,1)$. Hence, its aggregate law of motion is

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

To finance production, capital producers borrow by taking out loans as described above. For each new unit of capital produced, capital good firms issue a state-contingent claim to the future stream of earnings generated by the unit and sell it at price P^l_t. Capital producers maximize the present discount value of dividends to households. Hence, the problem of the representative capital good firm is

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

which yields the optimality condition $P^l_t = 1 + \iota\left(\frac{I_t}{K_{t-1}} - \delta\right)$.

[14] To ease the notation, we assume that these subsidies are financed by levying lump-sum taxes directly on producers and exporters.

Public sector The public sector is composed of a monetary authority, called central bank, and a fiscal authority, called government. The central bank controls the nominal risk-free rate of the economy by setting the interest rate on banks' deposits, R_t.[15] The government levies lump-sum taxes on households to finance interest payments on its outstanding debt, $P_t^b B_t^g$. Its budget constraint is,

$$P_t^b B_t^g = \frac{R_t^b}{\Pi_t} P_{t-1}^b B_{t-1}^g - T_t + E_t X_t^{\$} - R^* E_t X_{t-1}^{\$}.$$

Market clearing and equilibrium The resource constraint of Home is

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

while its balance of payment equation is

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

An equilibrium is defined as stochastic sequences for quantities $Y_t, C_t, K_t, X_t, B_t^*, N_t$ and prices $\Pi_{H,t}, P_{H,t}, P_{H,t}^*, E_t, P_t^l, P_t^b, V_t, \mu_t$ such that households, banks, and firms solve their optimization problems and the markets for tradable goods, physical capital, labour, loans, intraperiod loans, and government bonds clear, givens exogenous stochastic sequences for $P_{F,t}^*, R_t^*, A_t$ and policies $R_t, T_t, X_t^{\$}$. The full set of equilibrium conditions are reported in Appendix A.

4 Calibration and solution method

In this section we discuss the calibration strategy and solution method.

4.1 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),

[15] We abstract from the exact mechanism through which the central bank controls the interest rate on deposits. Explains how this could be achieved...

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}.

4.2 Calibration

We assign values to the structural parameters of the model by matching moments from a sample of inflation-targeting EMEs whenever possible, covering the period from 1999 to 2019.[16] Otherwise, we use values commonly found in the literature. Parameter values are summarized in Table **??**.

We calibrate the model at annual frequency. For household preferences, we set the subjective time discount factor, β, to 0.975 which implies an annual real interest rate of 2.5%. The coefficient of relative risk aversion, η, and the Frisch elasticity of labor supply, $1/\varphi$, are set to 2 and 0.5, respectively, which are standard value used in the real business cycle literature. The labour disutility parameter, χ, is chosen to normalize the steady-state labor supply to 1. The share of imported consumption and investment goods, α, is calibrated to match the sample average imports-to-GDP ratio, which is 37%.[17] This implies $\alpha = 0.24$.

For structural parameters related to firms, we set the labor and capital shares to match the average imported inputs share of GDP in the sample, which is 11%, and a labor share of GDP of 2/3. This implies $\gamma = 0.6$ and $\omega = 0.3$.[18] The elasticity of substitution across varieties, ϵ, is set to 3, implying an average markup of 50%, which aligns with the data (see De Loecker and Eeckhout (2018)). The quadratic price adjustment cost parameter, θ, is set to 20, implying that the slope of the Phillips curve is 0.1, consistent with the evidence reported for EMEs (see, for example Forbes (2019) and Kamber, Mohanty and Morley (2020)). We set the exchange rate pass-through to export prices, ϑ, to 0.33 to match the evidence reported by Bussière, Delle Chiaie and Peltonen (2014), and the trade elasticity of substitution, ν, to 3 to obtain an exchange rate elasticity of exports, given by $\vartheta\,(\nu - 1)$, of 0.66, which is in line with the estimates of Ahmed, Appendino and Ruta (2017) for EMEs. The capital depreciation rate, δ, is set to 10%, as is common in the business cycle literature, while we calibrate the investment cost parameter, ι, to target the ratio of the standard

[16] Our unbalanced sample of countries includes...

[17] The steady-state import-to-GDP ratio is $\nu\frac{1-(1-\alpha)(\gamma+\omega)}{(\gamma+\omega)(\nu-\alpha)} + \alpha\frac{\nu-1}{\nu-\alpha}\frac{1-\beta}{\beta}\frac{EX^{\$}-P^bB^*}{GDP}$

[18] The steady-state labor share of GDP is $\frac{\gamma}{\gamma+\omega}$ while the steady-state intermediate import share of GDP is $\frac{1}{\gamma+\omega} - 1$

deviation of investment growth to the standard deviation of GDP growth estimated in the sample. This implies ι = 2.5 (need to check). Finally, we set the parameter governing the working capital constraint, ξ, to 0.4, as estimated by Uribe and Schmitt-Grohé (2017).

We calibrate the steady-state external debt-to-GDP ratio, $\frac{P^b B^*}{GDP}$, to match the average stock of portfolio and other external debt liabilities in the sample, which is 43% of GDP, and calibrate the amount of foreign reserves, $\frac{EX^\$}{GDP}$, to 14% of GDP to match the median net foreign asset position in the sample, which is -32% of GDP.

We set the parameters of the banks' incentive compatibility constraint to the midpoint of values commonly find in the literature. The divertable fraction of assets, ζ, is set to 0.3 which is the midpoint of values commonly found in the literature. The survival rate of banks, σ, is set to 0.9 which implies an expected horizon of ten years for bankers, as in Gertler and Karadi (2018). The parameter for the startup capital of new banks is calibrated to match the frequency of sudden stops observed in the sample which is 5%. This implies $\upsilon = 0.0380$.

Finally, we calibrate the steady-state level of bond supply and

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 $P\tilde{B}^* = 0.47$ 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, Juvenal and Petrella (2020) to estimate an AR(1) process of $P^*_{F,t}$. Lastly, we follow Devereux, Young and Yu (2019) and use detrended TFP data from the Penn World Tables to estimate an AR(1) process for A_t.

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 6 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.

	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 6: Unconditional moment comparison across data and model

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.

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 8 and 9 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

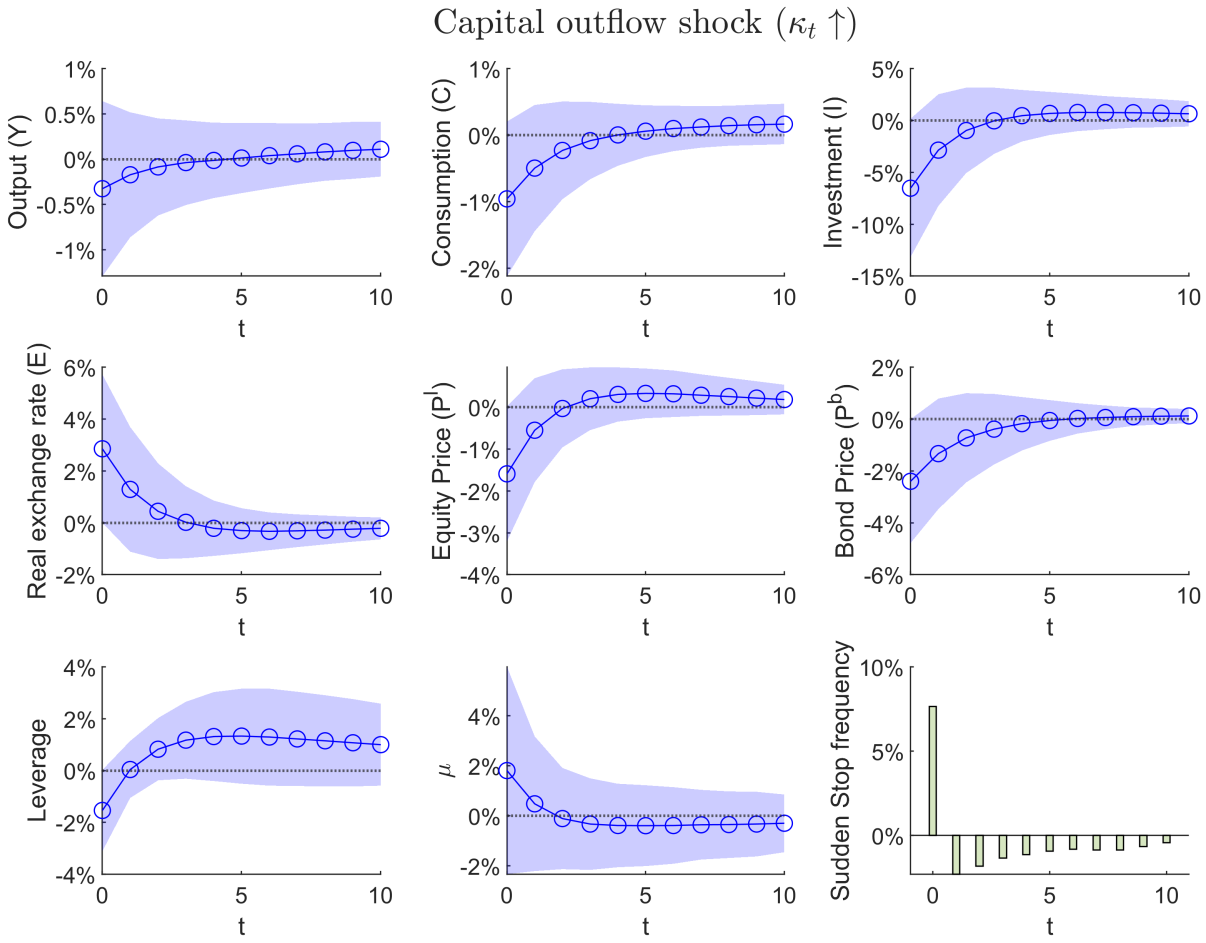


Figure 8: Impulse response functions with respect to a capital outflow shock ($\kappa_t \uparrow$)

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 10, 11, 12 and 13. 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

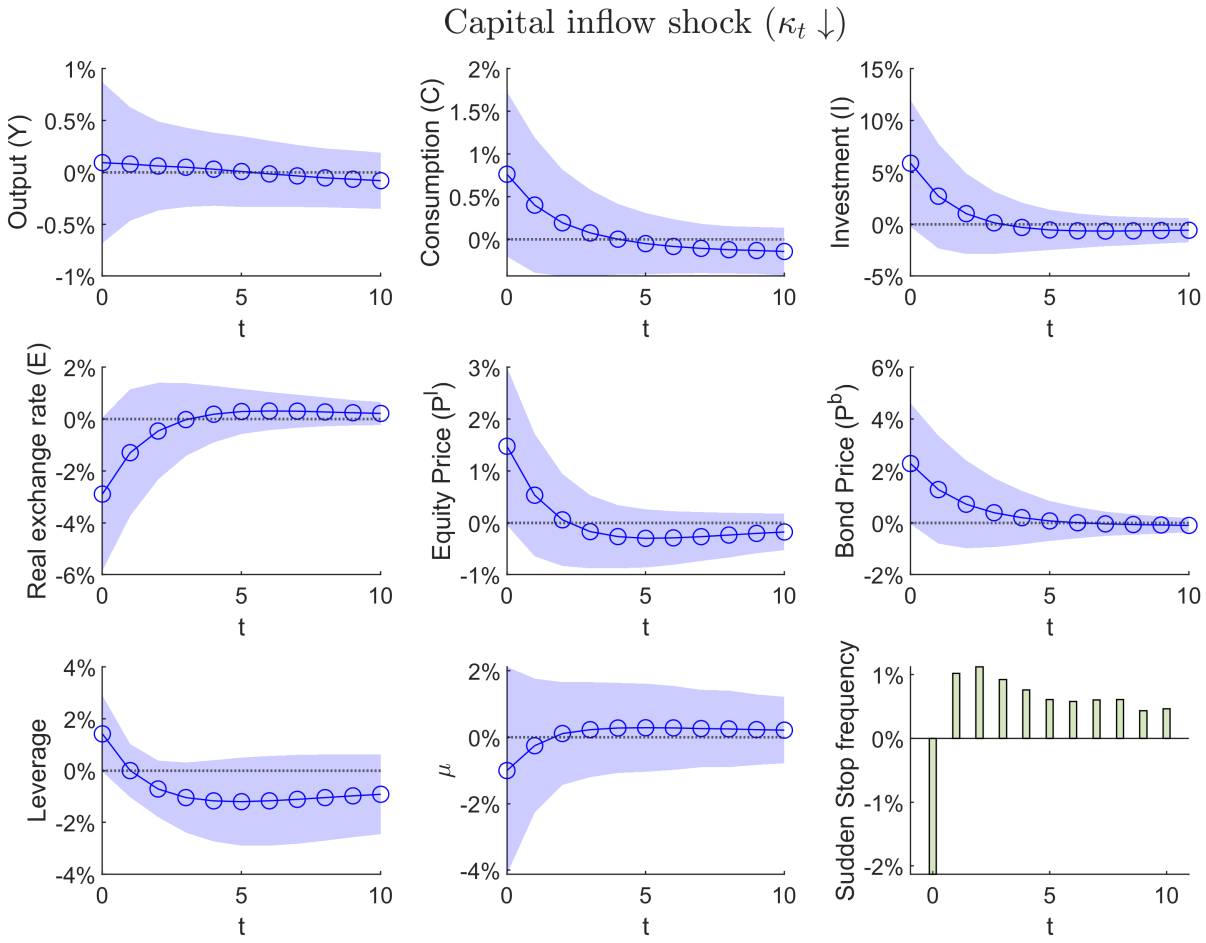


Figure 9: Impulse response functions with respect to a capital inflow shock ($\kappa_t \downarrow$)

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.[19] The estimated results are shown in Figures 14, 15 and 16.[20] 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 by around 5% following large outflows and appreciates by around 7% following large

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

[20]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.

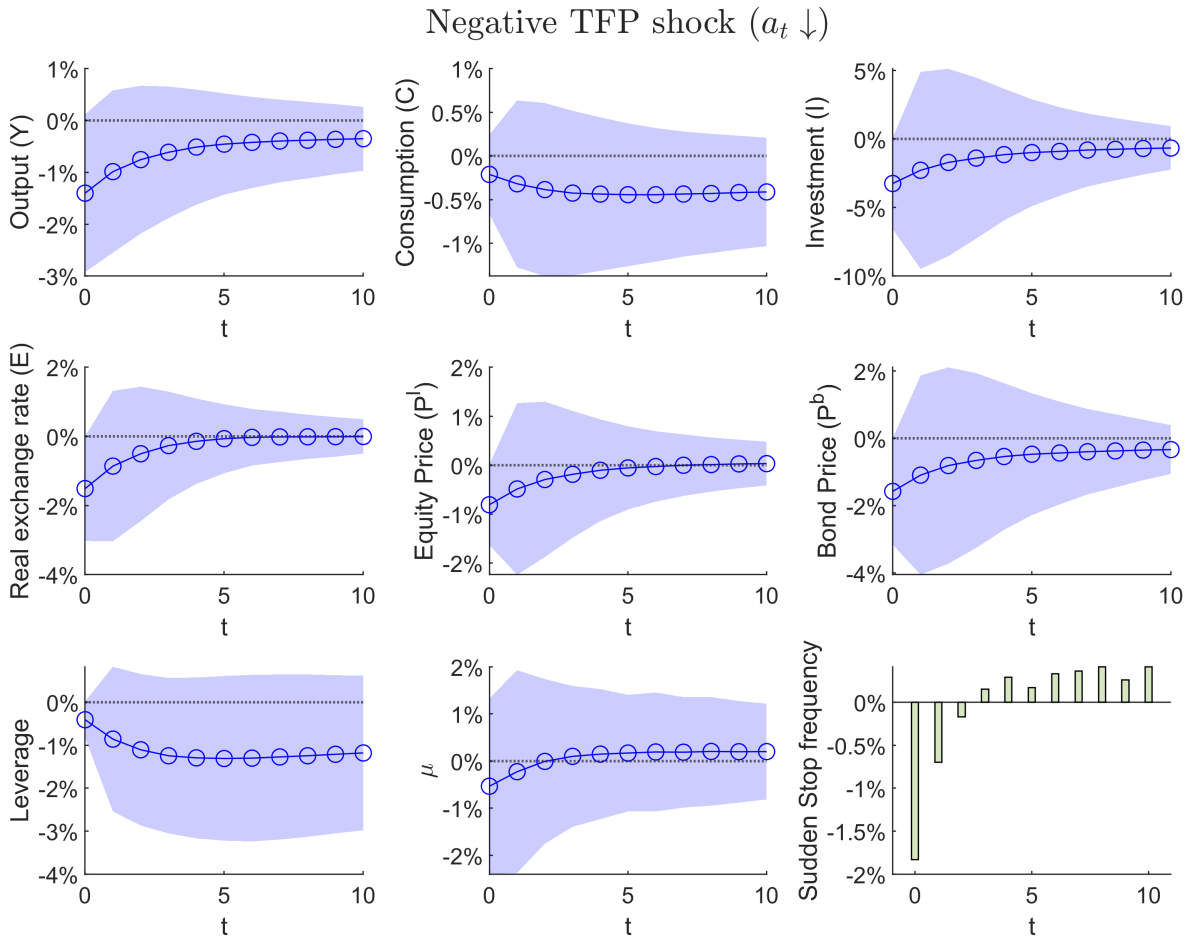


Figure 10: Impulse response functions with respect to a negative TFP shock ($a_t \downarrow$)

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

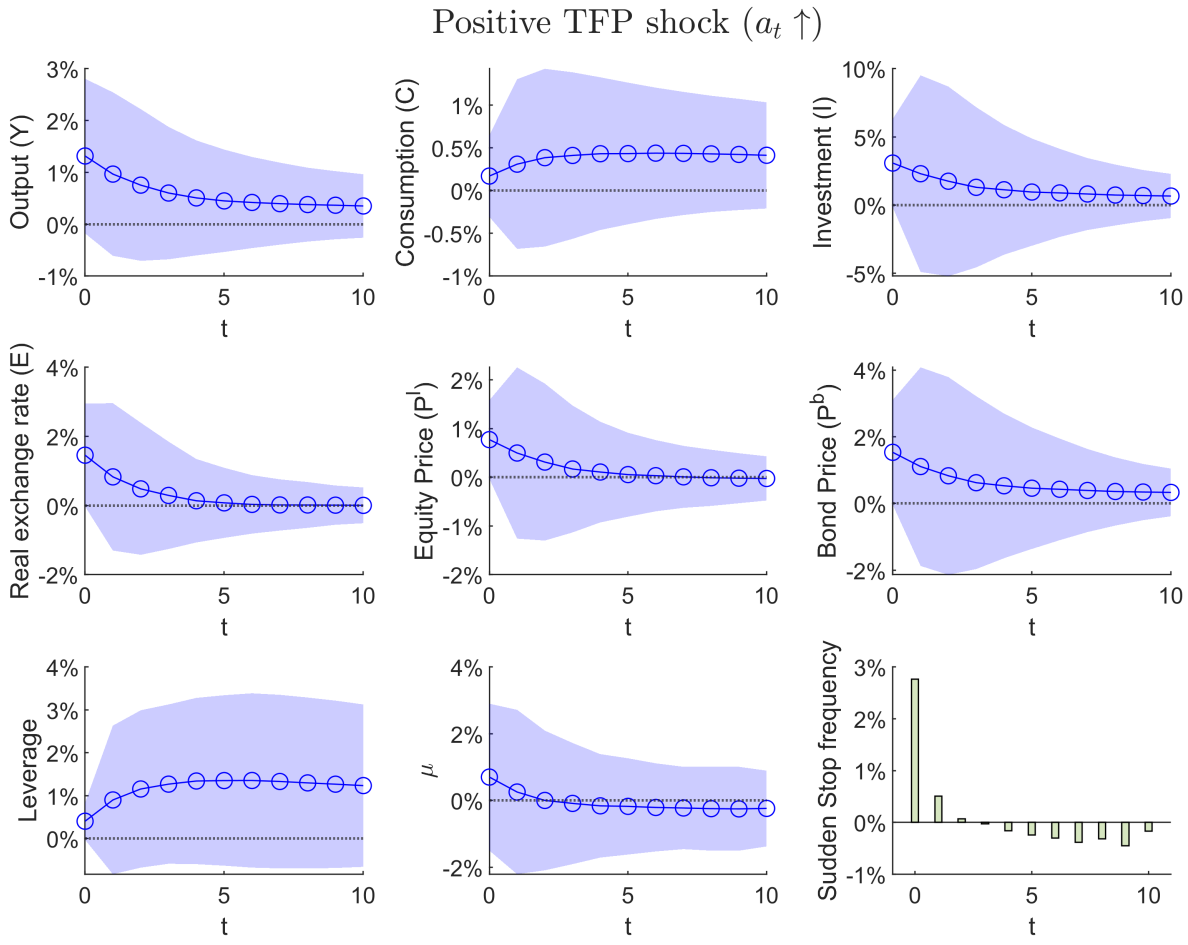


Figure 11: Impulse response functions with respect to a positive TFP shock ($a_t \uparrow$)

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 17. 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

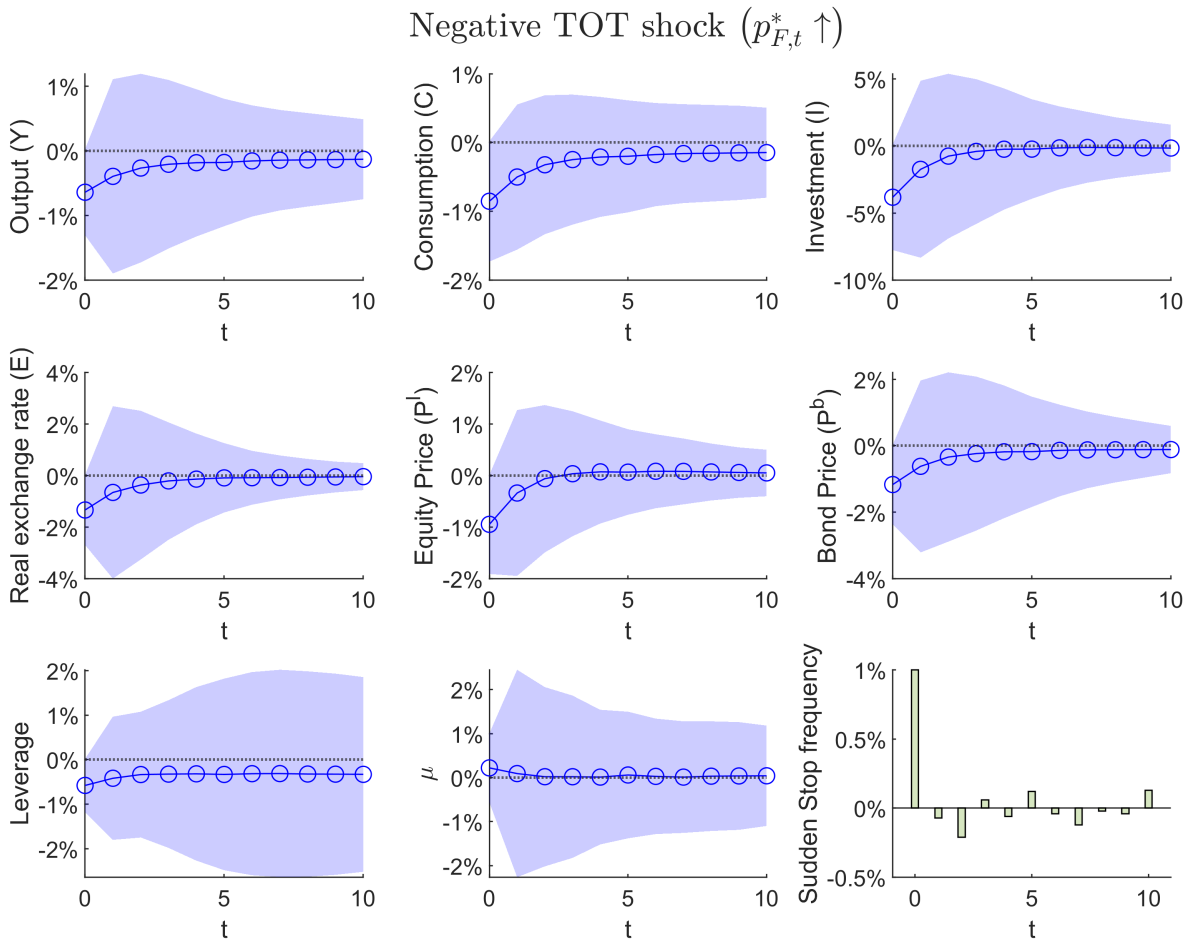


Figure 12: Impulse response functions with respect to a positive terms of trade shock $(p^*_{F,t} \downarrow)$

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

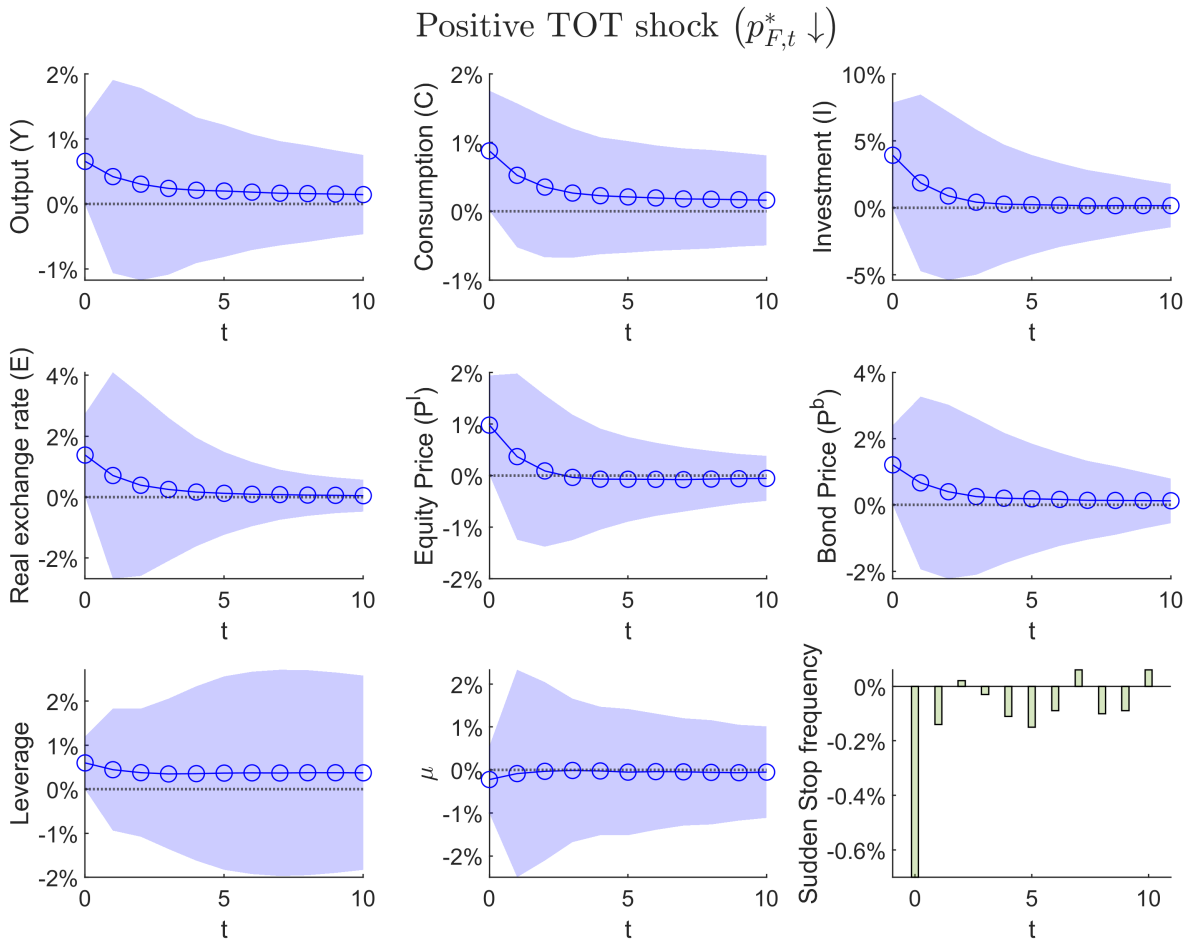


Figure 13: Impulse response functions with respect to a negative terms of trade shock $(p^*_{F,t} \uparrow)$

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 18. For Figure 18, 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.

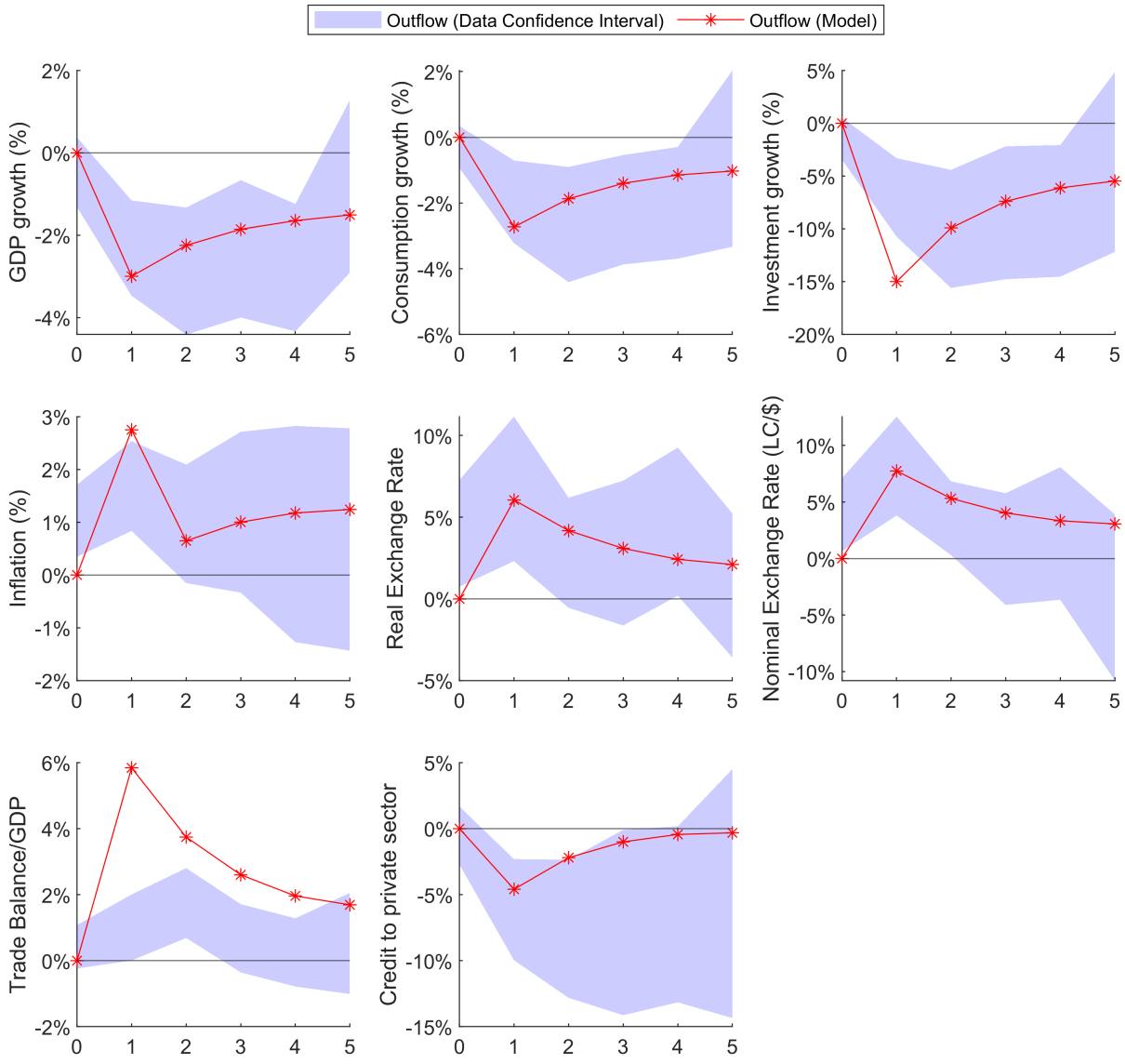


Figure 14: Model implied local projections for large outflow episodes

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

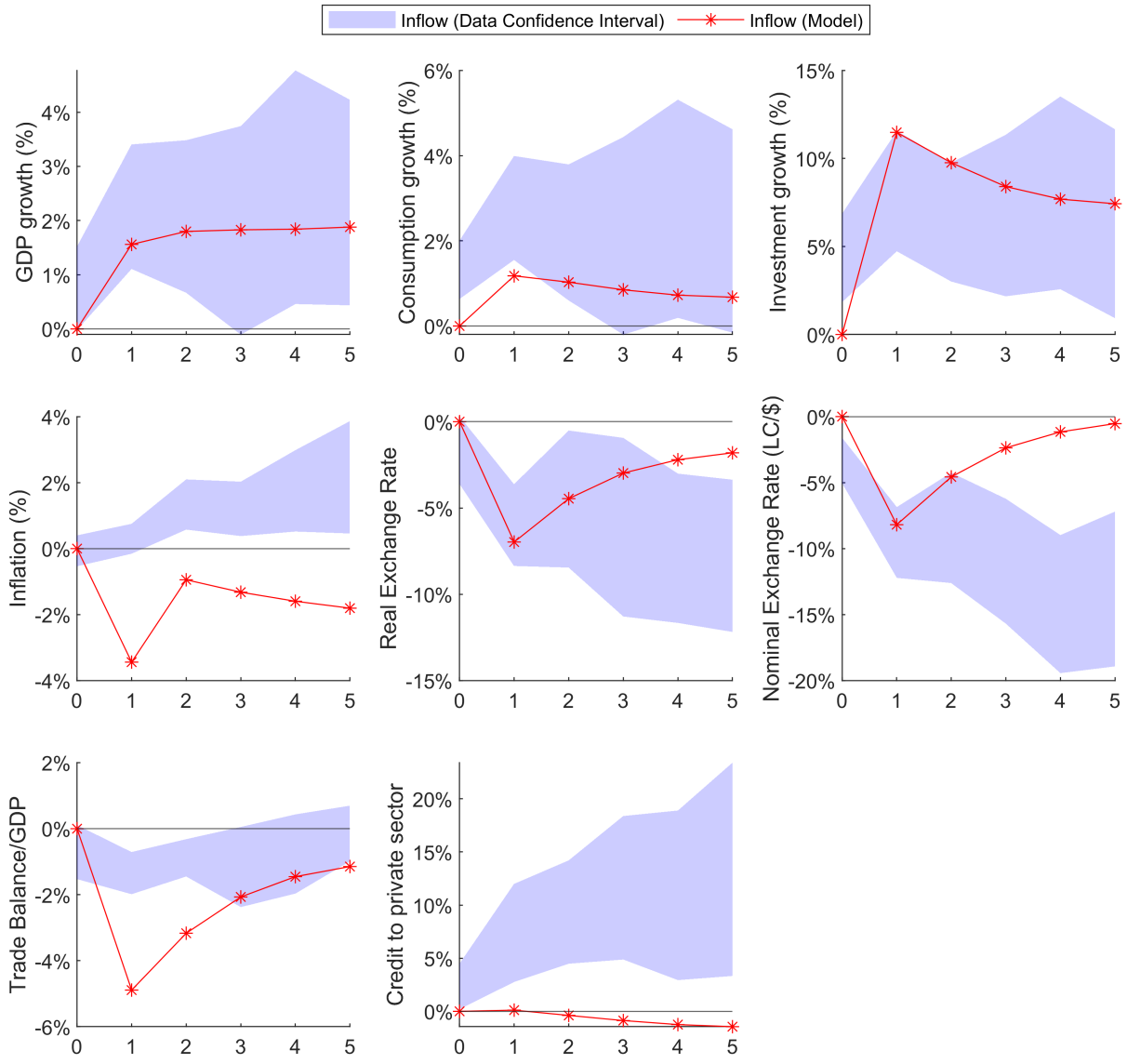


Figure 15: Model implied local projections for large inflow episodes

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 19 and 20 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 19 shows that there is a leftward shift in the distribution of μ_t with the optimal use of monetary policy.[21] 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 20 shows that there is a rightward shift in the distribution of B_t with the optimal use of

[21]The frequency for $\mu_t = 0$ is around 0.75 under optimal monetary policy and 0.83 under the Taylor rule. We cut figure 19 at 0.008 to better show the other bins.

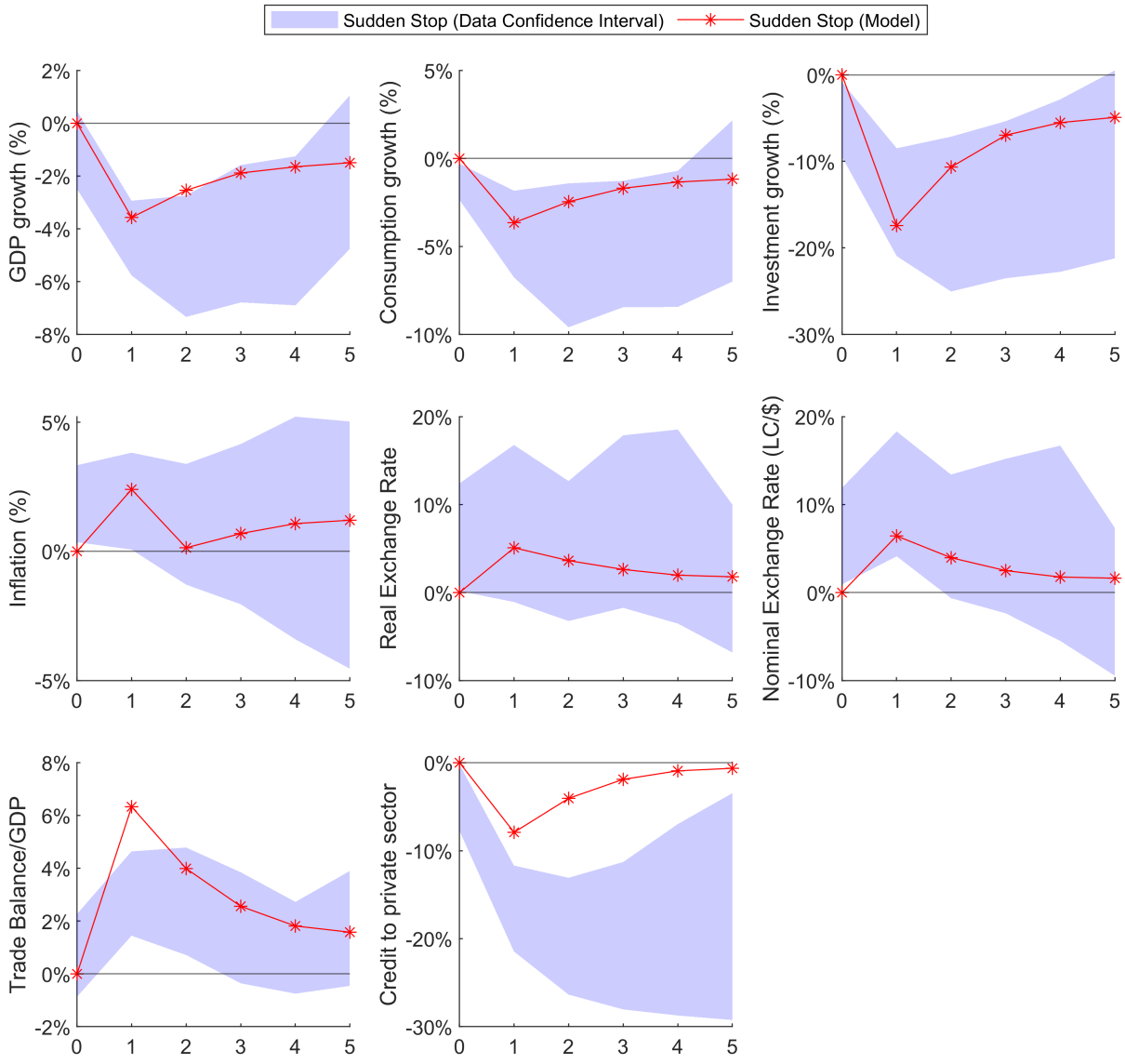


Figure 16: Model implied local projections for sudden stops

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

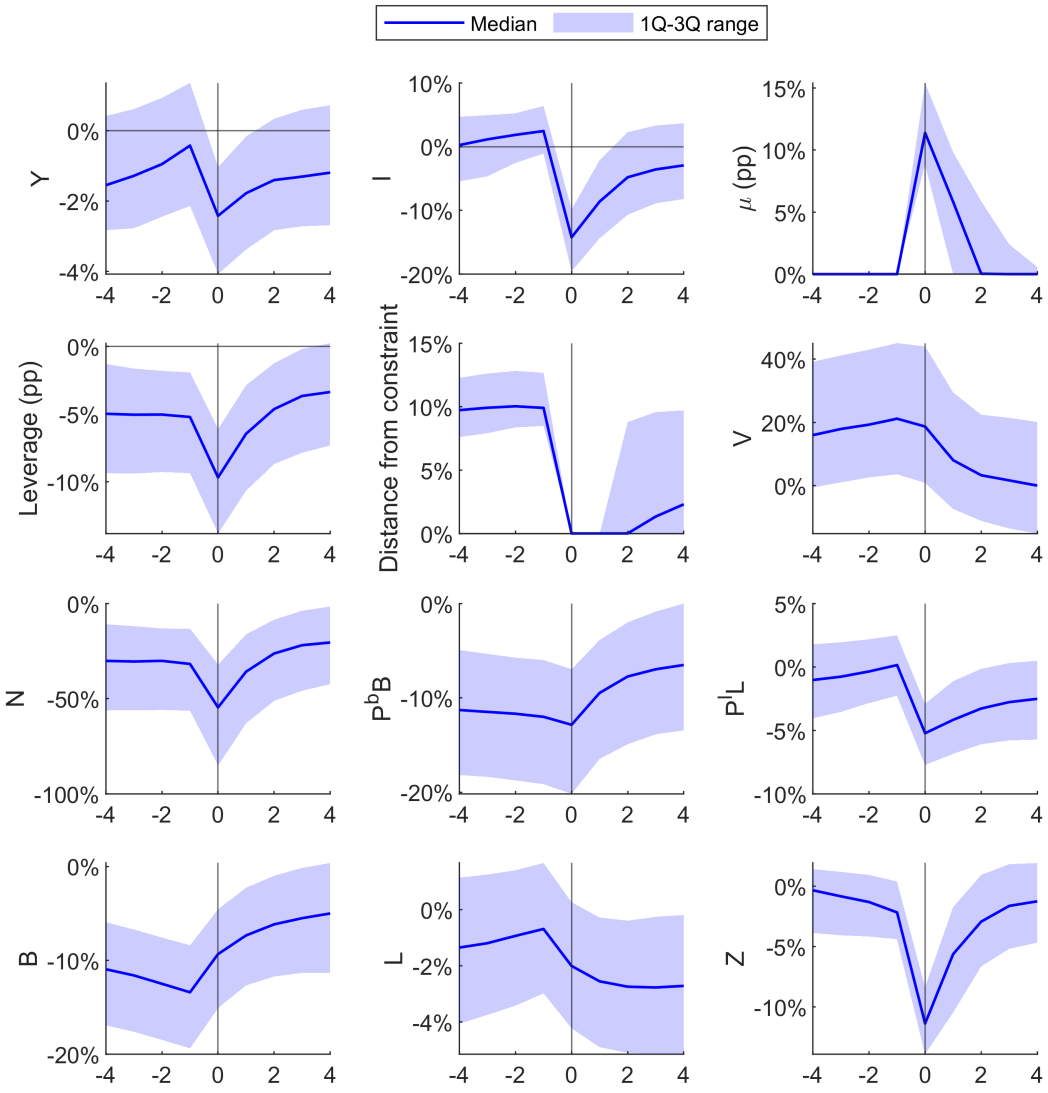


Figure 17: Baseline dynamics around sudden stops

monetary policy. Then, we take the difference between variables and plot them in Figure 21.

The first graph in Figure 21 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

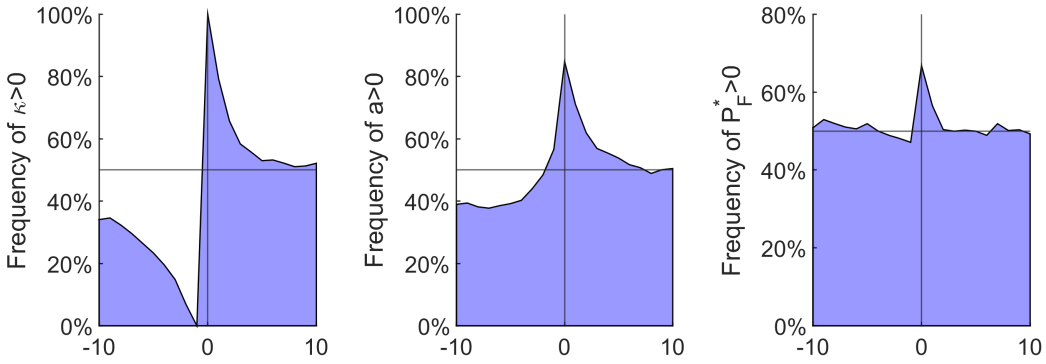


Figure 18: Distribution of shocks around sudden stops

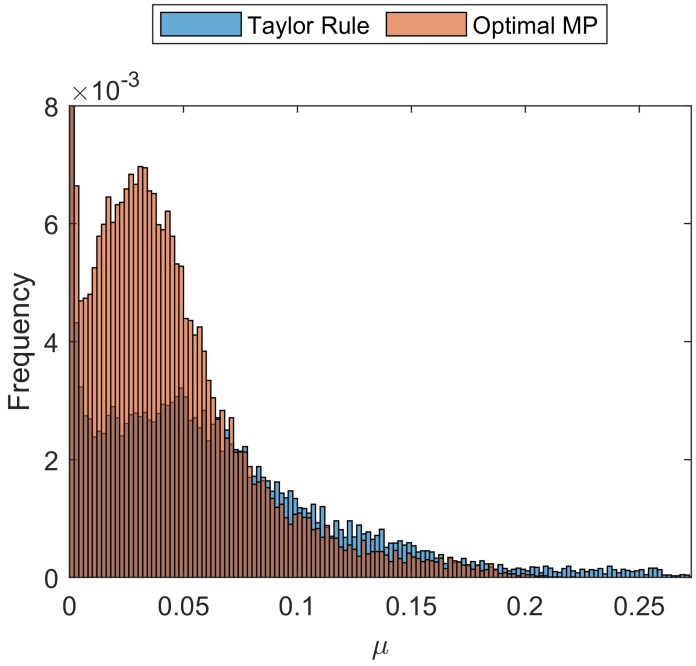


Figure 19: Density of μ under the Taylor Rule and Optimal MP

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.

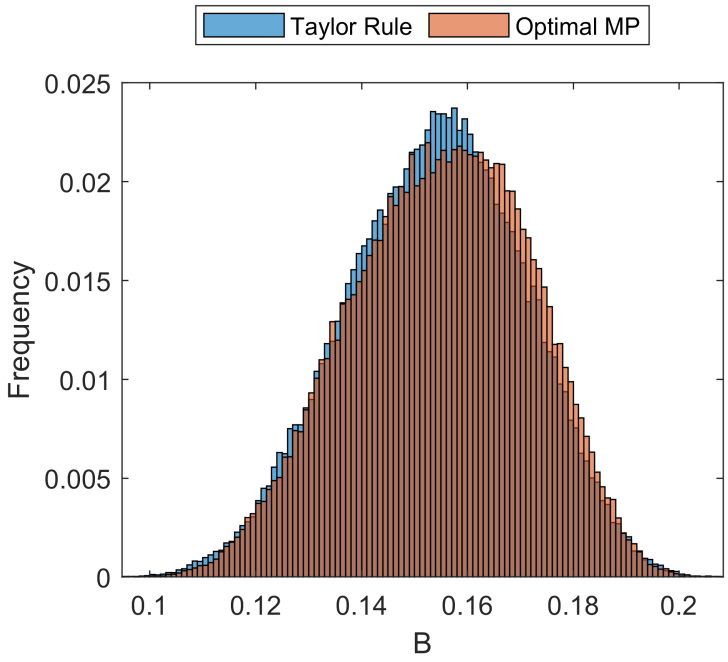


Figure 20: Density of B under the Taylor Rule and Optimal MP

7 Conclusion

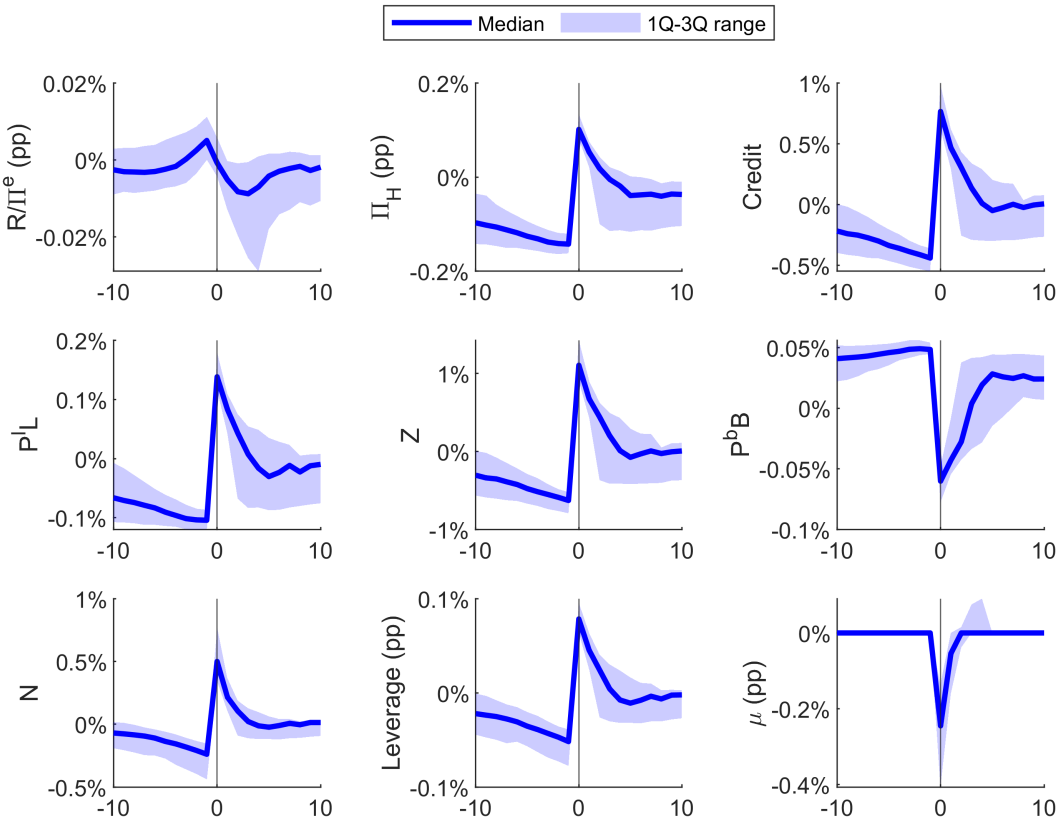


Figure 21: Difference between the Optimal MP case and Constant Inflation case around sudden stops

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Appendix

A Full list of equations

The equilibrium conditions are

$$1 = \mathbb{E}_t \left[\beta \left(\frac{C_{t+1} - \chi \frac{(H_{t+1})^{1+\varphi}}{1+\varphi}}{C_t - \chi \frac{(H_t)^{1+\varphi}}{1+\varphi}} \right)^{-\eta} \frac{R_t}{\Pi_{H,t+1}} \frac{P_{H,t+1}}{P_{H,t}} \right]$$

$$P_{H,t} = \left(E_t P^*_{F,t} \right)^{-\frac{\alpha}{1-\alpha}}$$

$$P^l_t = 1 + \iota \frac{K_t - K_{t-1}}{K_{t-1}}$$

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

$$\frac{1}{\beta} + R^*_t - 1 + \varsigma \left(e^{\frac{P^b_t B^*_t - P^b B^*}{P_H Y_H}} - 1 \right) = \mathbb{E}_t \left[\frac{E_t}{E_{t+1}} \frac{1 + (1-\rho) P^b_{t+1}}{P^b_t} \right]$$

$$P^b_t B^*_t = \left[1 + (1-\rho) P^b_t \right] B^*_{t-1} + \frac{\alpha}{1-\alpha} \left[1 - \frac{\theta}{2} \left(\Pi_{H,t} - 1 \right)^2 \right] P_{H,t} Y_t$$
$$+ (1 - \gamma - \omega) X_t - \left(1 + \frac{\alpha}{1-\alpha} \frac{P_{H,t}}{E_t P^*_{H,t}} \right) E_t \left(P^*_{H,t} \right)^{1-\nu} \alpha^* Y^*$$

$$\left(\frac{\Pi_{H,t}}{\bar{\Pi}} - 1 \right) \frac{\Pi_{H,t}}{\bar{\Pi}} = \frac{\epsilon - 1}{\theta} \left(\frac{1 + \xi\zeta\mu_t}{P_{H,t}} \frac{X_t}{Y_t} - 1 \right) + \mathbb{E}_t \left[\beta \left(\frac{C_{t+1} - \chi \frac{(H_{t+1})^{1+\varphi}}{1+\varphi}}{C_t - \chi \frac{(H_t)^{1+\varphi}}{1+\varphi}} \right)^{-\eta} \left(\frac{\Pi_{H,t+1}}{\bar{\Pi}} - \right. \right.$$

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

$$X_t = \left[\frac{Y_t}{A_t} \left(\frac{\chi}{\gamma} \right)^{\frac{\gamma}{1+\varphi}} \left(K_{t-1} \right)^{-\omega} \left(\frac{E_t P^*_{F,t}}{1 - \gamma - \omega} \right)^{1-\gamma-\omega} \right]^{\frac{1}{1-\omega-\frac{\varphi\gamma}{1+\varphi}}}$$

$$\zeta\mu_t + (1-\mu_t) V_t = \mathbb{E}_t \left[(1 - \sigma + \sigma V_{t+1}) \beta \left(\frac{C_{t+1} - \chi \frac{(H_{t+1})^{1+\varphi}}{1+\varphi}}{C_t - \chi \frac{(H_t)^{1+\varphi}}{1+\varphi}} \right)^{-\eta} \frac{\omega \left(1 + \xi\zeta_w \mu_{t+1} \right) \frac{X_{t+1}}{K_t} + \right.$$
$$P^l_t$$

$$\zeta\mu_t + (1-\mu_t) V_t = \mathbb{E}_t \left[(1 - \sigma + \sigma V_{t+1}) \beta \left(\frac{C_{t+1} - \chi \frac{(H_{t+1})^{1+\varphi}}{1+\varphi}}{C_t - \chi \frac{(H_t)^{1+\varphi}}{1+\varphi}} \right)^{-\eta} \frac{1 + (1-\rho) P^b_{t+1}}{P^b_t} \right]$$

$$(1-\mu_t) V_t = \mathbb{E}_t \left[(1 - \sigma + \sigma V_{t+1}) \beta \left(\frac{C_{t+1} - \chi \frac{(H_{t+1})^{1+\varphi}}{1+\varphi}}{C_t - \chi \frac{(H_t)^{1+\varphi}}{1+\varphi}} \right)^{-\eta} \frac{R_t P_{H,t+1}}{\Pi_{H,t+1} P_{H,t}} \right]$$

$$N_t = \sigma \left[\frac{R_{t-1}}{\Pi_t} \left(N_{t-1} - P^l_{t-1} \kappa K_{t-1} - P^b_{t-1} \left(B^g_{t-1} - B^*_{t-1} \right) \right) + \omega \left(1 + \xi\zeta\mu_t \right) X_t \kappa \right.$$

$$0 = \mu_t \left\{ V_t N_t - \zeta \left[P^l_t \kappa K_t + P^b_t \left(B^g_t - B^*_t \right) + \xi (1-\omega) X_t \right] \right\}$$

with $\mu_t \geq 0$ and $V_t N_t - \zeta \left[P_t^l \kappa K_t + P_t^b \left(B_t^g - B_t^* \right) + \xi \left(1 - \omega \right) X_t \right] \geq 0$, and

$$\begin{aligned}
\log\left(P_{F,t}^*\right) &= \rho_P \log\left(P_{F,t-1}^*\right) + \sigma_P \varepsilon_{P,t} \\
\log\left(R_t^*\right) &= \rho_R \log\left(R_{t-1}^*\right) + \sigma_R \varepsilon_{R,t} \\
\log\left(A_t\right) &= \rho_A \log\left(A_{t-1}\right) + \sigma_A \varepsilon_{A,t}
\end{aligned}$$

given policy rules for R_t and B_t^g.

The steady state is

$$\begin{aligned}
P_H &= (E)^{-\frac{\alpha}{1-\alpha}} \\
YP_H &= (1-\alpha)\left[C + \delta K\right] + P_H \left(P_H^*\right)^{-\nu} \alpha^* Y^* \\
\frac{1}{\beta} &= \frac{1 + (1-\rho) P_{t+1}^b}{P_t^b} \\
E &= \left[\left(\frac{\nu}{\nu - 1} \right)^{\nu} \frac{\frac{\alpha}{1-\alpha} + 1 - \gamma - \omega + (\gamma + \omega) \frac{1-\beta}{\beta} \frac{B^* P^b}{GDP}}{\frac{\alpha^*}{1-\alpha} \frac{\nu - \alpha}{\nu - 1} \frac{Y^*}{Y}} \right]^{\frac{1-\alpha}{\nu}} \\
GDP &= (\gamma + \omega) P_H Y \\
P_H^* &= \frac{\nu}{\nu - 1} \frac{P_H}{E}
\end{aligned}$$