Fiscal Policy and Sudden Stops in Open Economies

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Abstract

This paper examines the effects of fiscal policy during sudden stop crises and how they differ across countries. Using a quarterly panel dataset of 45 advanced and emerging economies, I find that government spending multipliers on consumption, the trade balance, and the real exchange rate are higher during sudden stops in capital inflows for emerging economies but not for advanced economies, and that this cross-country heterogeneity in fiscal policy transmission around crises is strongly associated with the share of foreign-currency external debt. To rationalize this, I build a small open economy New Keynesian model with incomplete markets where the state-dependence of fiscal policy is driven by the currency denomination of external debt. When debt is owed in foreign currency a sudden stop generates a debt-deflation mechanism due to currency mismatch. A fiscal expansion that appreciates the real exchange rate therefore relaxes the borrowing constraint and crowds in consumption. However, when households borrow abroad in local currency, this mechanism is absent and the difference in fiscal multipliers across financial states disappears.

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1 Introduction

Sudden stops in capital inflows have been a common form of financial crisis since the 1980s following a trend of larger international capital market integration. While initially dubbed an emerging market (EM) phenomenon, especially after the disruptive crises in Latin America, Russia, and East Asian countries in the 1990s, more recent experience has shown that advanced economies (AEs) are also subject to such risks, renewing attention on the topic. During the Global Financial Crisis and the European sovereign debt crisis, advanced economies in Europe and North America also experienced large sudden-stop-like episodes, with costly consequences for output growth and consumption.[1] While the empirical and theoretical literatures have focused on the amplification mechanisms around these crises and the effects of monetary, exchange rate, and macroprudential policy, the role of fiscal policy has been relatively less explored. In a recent study, Liu (2022) shows that government spending multipliers can be larger during sudden stops than in normal times. But does this result differ across countries, and if so, why?

In this paper, I provide empirical evidence that government spending multipliers are significantly larger during sudden stops crises in EMs but this state dependence is not present in AEs. Furthermore, I show that the crucial feature driving the cross-country heterogeneity in fiscal policy transmission around crises is the currency denomination of external debt. To rationalize this, I build a small open economy New Keynesian model where the state dependence of fiscal policy around sudden stops is driven solely by this single dimension. When debt is owed in foreign currency as in many EMs, exchange rate depreciation following sudden stop shocks causes debt revaluation. Thus, a fiscal expansion that appreciates the real exchange rate relaxes the borrowing constraint and crowds in consumption. Alternatively, when households borrow abroad in local currency, this mechanism is absent and the difference in multipliers across financial states disappears.

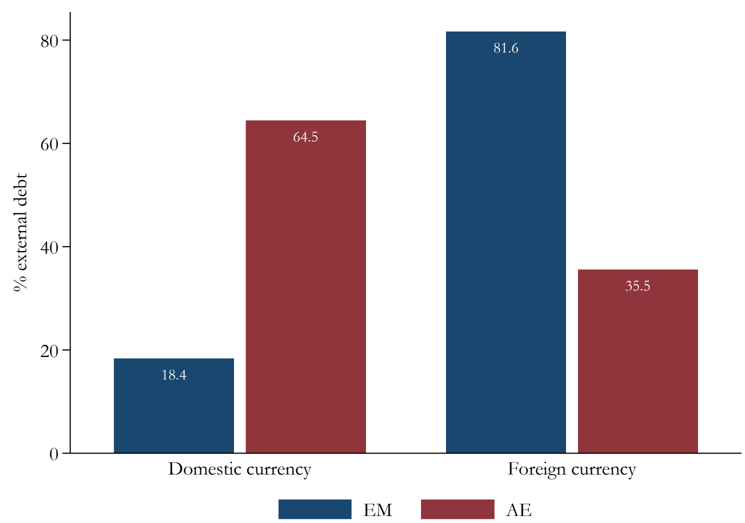
In the empirical analysis, I build a quarterly dataset covering 45 advanced and emerging economies with identified sudden stop episodes. To motivate the analysis, I show an important stylized fact: sudden stop cycles are deeper for EMs relative to AEs *over and above* their usual higher cyclical variance, amidst a significant fiscal contraction. Then, I estimate government spending multipliers using local projections (Jordà, 2005). I find that the state-dependence of multipliers around sudden stop crises proposed by Liu (2022) is primarily an emerging market characteristic and does not hold for advanced economies. During sudden stop crises in EMs, government spending is significantly more effective in stimulating private consumption, appreciating the real exchange rate, and decreasing the trade balance

[1] See Figures A.10 and A.11 in Appendix A for examples of sudden stop recessions in AEs.

than during normal times. This non-linearity is however absent in AEs: the responses of key macroeconomic variables to a government spending shock do not vary significantly depending on whether the stimulus happens during a capital flow reversal or not.

What characteristic of EMs drives the state-dependence of fiscal policy? Emerging and advanced economies vary along several dimensions. I systematically test competing explanations for this cross-country heterogeneity by interacting fiscal shock estimations with foreign currency debt shares, exchange rate regimes, and income levels. The results clearly show that neither exchange rate regimes nor income levels can account for the differential multipliers during sudden stops, while the share of foreign-currency denominated debt emerges as a crucial determinant. As shown in Figure 1, this reflects the persistent "original sin" reality where approximately 80% of EM external debt remains foreign-currency denominated (compared to just 35% for advanced economies) (Eichengreen, Hausmann and Panizza, 2005).[2]

Figure 1: Original sin: currency denomination of external debt



Notes: Data from Bénétrix et al. (2019). Average for countries in each income group for 2017 (last year in the sample).

To rationalize the transmission mechanism, I the build a small open economy (SOE) New Keynesian model in the spirit of Galí and Monacelli (2005) with incomplete markets and financial frictions, where households can either issue external debt in foreign or local currency. Sudden stops are captured by a debt-elastic risk premium similar to Motyovski (2020), which depends on the ratio of external debt to domestic income relative to a risk tolerance thresh-

[2]Importantly, when controlling for exchange rate regimes, the state-dependence of multipliers persists for EMs under both fixed and flexible arrangements, and similar results hold when accounting for GDP per capita differences—confirming that currency mismatch in external liabilities, not other country characteristics, drives the differential effectiveness of fiscal policy during sudden stops.

old from international financial markets. A shock to the tolerance of international creditors increases borrowing costs and drives capital outflows, deleveraging, and a deep recession.

Varying this setup along the single dimension of the currency denomination of debt allows me to explain my main empirical findings. When households owe debt in foreign currency, the sudden stop shock is amplified due to currency mismatch. Exchange rate depreciation generates a Fisherian debt-deflation mechanism as the real burden of liabilities increase, causing a deep contraction in consumption. A temporary fiscal shock that appreciates the real exchange rate is thus able to relax the borrowing constraint of households by reducing the risk premium, relieving deleveraging pressure and allowing for more consumption smoothing. A second order solution to the model allows me to show this by shocking it at different points in the state space. A fiscal shock when international risk tolerance is significantly lower than its steady state value generates considerably larger multipliers on consumption and the trade balance relative to a shock at the ergodic mean.

On the other hand, in the alternative case with local currency external debt, a sudden stop shock still generates a recession, but the amplification mechanism from currency mismatch is absent. Real exchange rate depreciation does not feed back into the risk premium, thus making the deleveraging pressure and associated contraction in consumption lower relative to the baseline case. Multipliers from a fiscal shock are therefore not materially different under a sudden stop scenario relative to normal times in the model, as shown in my empirical estimation for multipliers in advanced economies.

Related literature. The paper is related to the existing literature along several lines. Firstly, it adds to the empirical literature on the state-dependence of government spending multipliers. Several studies find that multipliers can be larger in recessions than in expansions (Auerbach and Gorodnichenko, 2012*a*,*b*), when the interest rate is at the zero lower bound (Ramey and Zubairy, 2018), can depend on the source of fluctuations (Ghassibe and Zanetti, 2022) or on the sign of fiscal shocks (Barnichon, Debortoli and Matthes, 2021). In the context of open economies, Ilzetzki, Mendoza and Végh (2013) and Miyamoto, Nguyen and Sheremirov (2019) show that the effect of government spending on output can vary significantly depending on country characteristics such as income levels and institutional setups, and emphasize the role of the real exchange rate as an important transmission mechanism for the effectiveness of fiscal policy.[3] Finally, Liu (2022) is the first paper to show that multipliers can be higher during sudden stops than in normal times.

[3]Other studies looking at the effects of government spending on the real exchange rate include Corsetti et al. (2012), Born, Juessen and Müller (2013), and Monacelli and Perotti (2010), in the context of advanced economies. More recently, Broner et al. (2022) and Priftis and Zimic (2020) show that deficit-financed public spending has larger effects when debt is issued to foreign investors compared to local investors.

I build on the latter empirical insight. Looking at a larger sample, I find that the state-dependence of multipliers during sudden stops differ across countries and is strongly associated with the currency composition of external debt. I also contribute to the empirical literature on the cyclical behavioral of countries around sudden stop events, as in Calvo, Izquierdo and Mejia (2004), Mendoza (2010), and Bianchi and Mendoza (2020). By using quarterly data, relative to annual data in the existing literature, I find a new stylized fact: sudden stop cycles in emerging markets are deeper than in advanced economies, even when accounting for their usual larger cyclical variance.

Theoretically, the paper is related to the literature on Fisherian models on sudden stops (see Bianchi and Mendoza (2020) for a recent review). These models feature an occasionally-binding collateral constraint linked to market prices and a pecuniary externality drives the debt-deflation mechanism. Examples are Mendoza (2002), Mendoza (2010), Bianchi (2011), and Korinek and Mendoza (2014). Liu (2022) explores government spending effects in sudden stops in this context, with a model featuring wage rigidities and a non-tradable sector. Differently from these papers, I study the role of fiscal policy in the context of a New Keynesian model with nominal price rigidities.[4] As in Fisherian models, the real exchange rate is a central determinant of the effect of fiscal policy in my setup, but I show that this crucially depends on the denomination of external debt.

Finally, the paper builds on the literature on small open economy New Keynesian models in the spirit of Galí and Monacelli (2005) and De Paoli (2009). My model is closely related to Motyovski (2020), which also use a debt-elastic risk premium to study a foreign shock and the balance sheet effects of currency mismatch. In a model with heterogeneous agents, de Ferra, Mitman and Romei (2020) explores the effects of household debt revaluation and the currency composition of foreign debt during a capital flow reversal, as in this paper, while Cugat (2019) and Iyer (2017) use more limited heterogeneity to analyze sudden stops in a New Keynesian framework. These papers mostly look at the redistributive effects around SOE financial crises, with a primary focus on optimal monetary and exchange rate policy. The novelty here therefore lies on analyzing the effects of fiscal policy around sudden stops, while monetary policy remains in the background.

The paper is organized as follows. Section 2 motivates the empirical study and provides econometric evidence of how multipliers vary across countries and financial states. Section 3 presents the model and its calibration. Section 4 discusses the model results and discusses how they are consistent with the empirical findings. Finally, Section 5 concludes the paper.

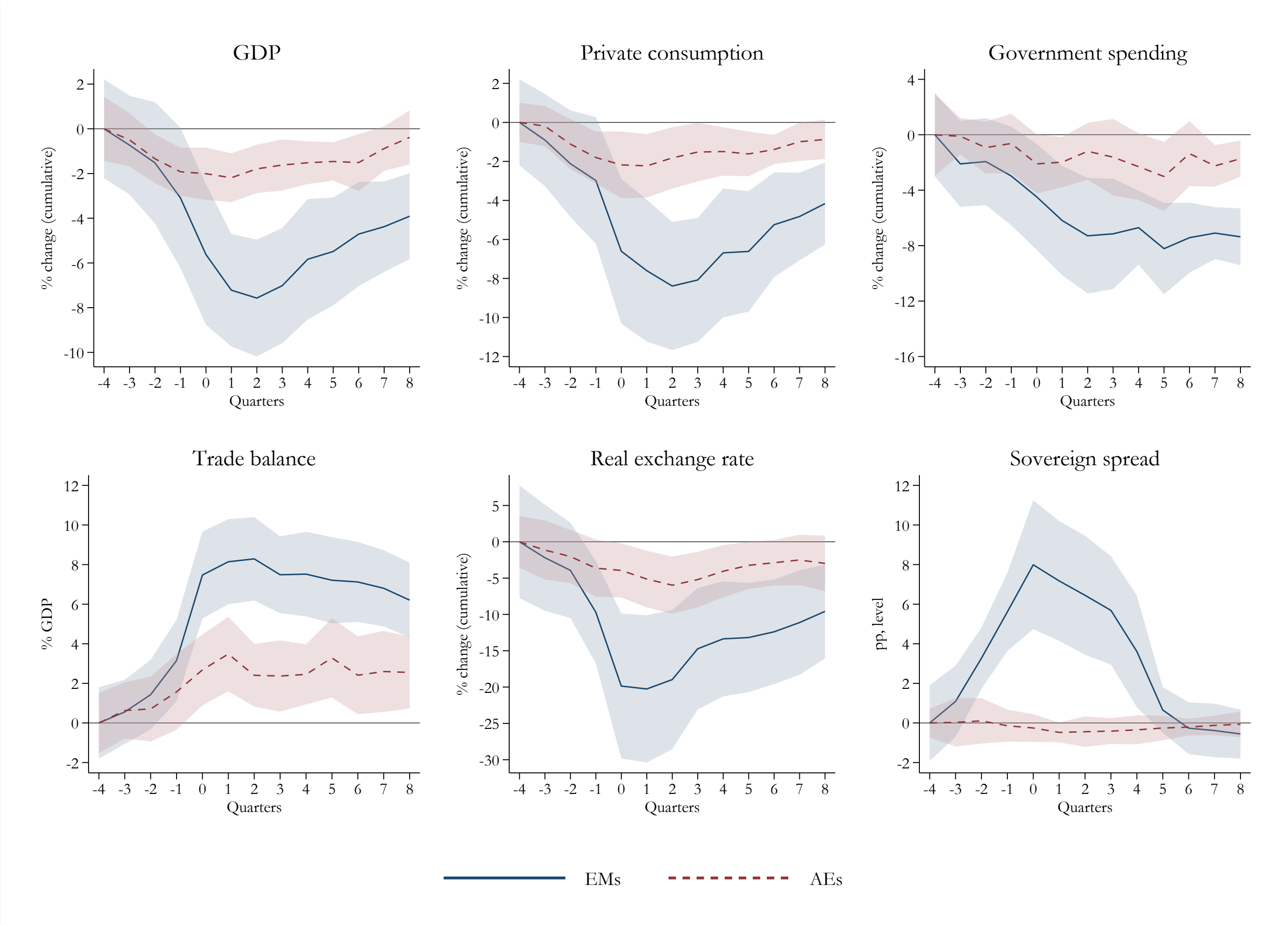
[4]This simpler setup allows the model to be solved through perturbation methods, where the state-dependence of multipliers is obtained from a second-order solution.

2 Empirical Analysis

2.1 Motivation

What is the cyclical behavior of different economies under sudden stops and how does government spending fare during these crises? To examine this, I follow a common strategy in the empirical literature on sudden stops (i.e. Mendoza (2010), Korinek and Mendoza (2014), and Bianchi and Mendoza (2020)), and construct event-study windows for Hodrick-Prescott (HP) filtered cyclical components of key macroeconomic variables around identified sudden stop episodes.[5]

Figure 2: Event Study: Average path of key macroeconomic variables during Sudden Stops



Notes: The panel shows the mean paths of key aggregate variables in sudden stop (SS) recessions across EMs and AEs. Time 0 indicates the beginning of a sudden stop crisis, defined as a country experiencing a current account to GDP reversal higher than 1.5 times its standard deviation. A contraction in the real exchange rate is a depreciation. All variables are HP filtered with a smoothing parameter of 1,600 and indexed to 4 quarters before the SS episode. Shaded bands indicate the cross-country standard deviation for each period for each income group.

[5]Section 2.2 below discusses the panel dataset used and how sudden stop episodes are identified.

Figure 2 shows the average "sudden stop cycle" for both EMs and AEs. Sudden stops are associated with sharp economic downturns, with contractions in GDP and private consumption, a positive adjustment in the trade balance, and a depreciation of the real exchange rate across all countries. The magnitudes of these adjustments are larger for EMs on average: relative to one year before the crisis occurs, the deviations from trend in GDP (private consumption) contract by a total of around 7.5 percentage points (pp) (8.5pp) in EMs and 2.3pp (2.2pp) for AEs, the trade balance adjusts by 8pp of GDP for EMs and 3pp of GDP for AEs, and the real exchange depreciates by around 20% for EMs and 5% for AEs.

While the sharper cyclical response in EMs have usually been assigned to the fact that business cycles are also larger in these countries (Bianchi and Mendoza, 2020), I show that, even when accounting for country-specific cyclical standard deviations, EMs fare worse during sudden stops – that is, emerging market economies experience deeper sudden stop cycles *over and above* their usual larger cyclical variance, as shown in Table 1. Could differences in fiscal policy responses and their effectiveness account for part of this?

In addition to the usual aggregate variables analyzed in previous event studies, I look at how government spending fares under sudden stops. The top-right plot in Figure 2 shows that, on average, public spending experiences a larger contraction in EMs relative to AEs, amidst a spike in sovereign risk which does not happen for advanced economies.[6] The fiscal contraction in EMs is also larger when accounting for its usual cyclical variance (third column of Table 1). This stylized fact – coupled with existing empirical evidence in Ortiz et al. (2009) showing that EM economies that respond to sudden stop crises with a tightening of fiscal policy experience larger falls in output, even when controlling for sovereign risk – points to the relevance of fiscal policy in mitigating or amplifying the macroeconomic impact of such financial shocks in open economies.

Table 1: Sudden stop cycles relative to cyclical standard deviations

	GDP	Consumption	Gov. spending
EMs	-1.17	-1.15	-0.84
AEs	-0.94	-0.90	-0.71

Notes: The values above measure the overall contraction in the cyclical components of the variables during sudden stop episodes relative to country-specific standard deviations.

To have a clearer picture of the mechanisms at play, it is crucial to look at how government spending affects the broader economy around sudden stop crises – that is, the size of

[6]Sovereign risk is measured by the Emerging Market Bond Index (EMBI) spreads by J.P. Morgan for EMs and the difference between 10-year government bond yields and 10-year US treasuries for AEs.

government spending multipliers on private activity. In recent work, Liu (2022) uses a panel of 30 advanced and emerging economies and shows that government spending policy exhibits state-dependence around sudden stops. But does this result differ across countries? And if so, why? For example, Ilzetzki, Mendoza and Végh (2013) and Miyamoto, Nguyen and Sheremirov (2019) show that government spending multipliers can vary significantly depending on country-specific characteristics such as income levels, policy regimes, and institutional setups.

To answer this question, I build an expanded panel dataset of 45 AEs and EMs and show that such non-linearity in fiscal multipliers around sudden stops only hold for emerging market economies. Instead of income levels or exchange rate regimes, I find that cross-country heterogeneity is closely associated with the currency composition of external debt.

The remainder of this section proceeds as follows: section 2.2 describes the data and identification of sudden stop episodes; section 2.3 discusses the methodology for estimating multipliers; section 2.4 presents and discusses the results.

2.2 Data

To estimate government spending multipliers, I build a panel dataset across countries where quarterly macroeconomic data series are sufficiently large, covering the period between 1Q1980 and 4Q2017. The main macroeconomic variables used in the estimation are GDP, government consumption, private consumption, private investment, the trade balance (i.e. net exports), the current account to GDP ratio, and the real effective exchange rate. All quantity variables used are in real terms, seasonally adjusted, and in local currency units. The main data sources used are the International Monetary Fund's (IMF) *International Financial Statistics* database, the IMF *Balance of Payments and International Investment Position Statistics* database, and the OECD *Main Economic Indicators* database.[7] To test what accounts for the cross-country heterogeneity in multiplier state-dependence, I look at (1) the foreign currency share of external liabilities, (2) income levels proxied by GDP per capita relative to the US, and (3) exchange rate regimes. For the foreign currency share of external debt, I use a novel dataset from Bénétrix et al. (2019). For income levels, I take annual values from the IMF *World Economic Outlook* database. Finally, for exchange rate regimes, I use the data from Ilzetzki, Reinhart and Rogoff (2019) to separate periods for each country into a binary classification of floating and pegged regimes.[8]

[7] Table A.1 in Appendix A outlines the sources for each variable.

[8] As in Liu (2022), I use the coarse classifications in Ilzetzki, Reinhart and Rogoff (2019) and classify countries with no legal tender, pre-announced and de facto pegs, and crawling pegs narrower than or equal to +/- 2% as pegged regimes and the remaining classifications as flexible regimes.

This yields a panel dataset of 45 countries, including 24 emerging market economies and 21 advanced economies.[9] Table 2 below provides summary statistics for key variables in the dataset while Table A.2 in Appendix A lists the individual countries and their respective sample sizes. The key moments and values in Table 2 are in line with international business-cycle facts in Uribe and Schmitt-Grohé (2017) and Aguiar and Gopinath (2007): business cycles are more volatile in emerging relative to advanced economies, consumption is more volatile than output in EMs, and the current account is countercyclical across countries and even more so for emerging ones. Also as expected, the share of government spending in GDP is higher for more advanced economies and public spending is more procyclical in EMs. Finally, as in Ilzetzki, Mendoza and Végh (2013), government consumption is more volatile than output across the board, but more so for emerging market economies.

Table 2: Summary statistics

	All countries	**Emerging**	**Advanced**
Gov. spending/GDP	16.7%	14.8%	19.0%
Standard deviation			
GDP	2.32	2.86	1.52
Consumption	2.63	3.30	1.51
Investment	7.86	9.67	5.08
Gov. spending	4.54	5.92	2.10
TB/GDP	2.13	2.46	1.68
Std. deviation relative to GDP			
Consumption	1.13	1.16	0.99
Gov. spending	1.96	2.07	1.38
Correlation with GDP			
Gov. spending	0.27	0.31	0.08
CA/GDP	-0.14	-0.15	-0.06
REER	0.11	0.14	0.02
Observations	4,576	2,422	2,154
No. of countries	45	24	21
No. of SS episodes	57	36	21

Notes: This table lists summary values and moments across the full sample and separately for each income group. Quantity variables are detrended using a HP filter with a smoothing parameter of 1,600. Standard deviations are in percentages.

[9] The classification into each income group (i.e. EMs or AEs) follows Miyamoto, Nguyen and Sheremirov (2019) and is based on the World Bank country classifications for the year 2000, around the midpoint for my sample. See World Bank database for historical classifications by income at `https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups`.

Sudden stop identification. In line with the empirical literature on sudden stops, I define a sudden stop episode as a large current account reversal which occurs during a recession.[10] The two criteria used for identification are:

1. The four-quarter change in the current account to GDP ratio is larger than 1.5 std. dev.

2. Real GDP is more than 1 std. dev. below trend

This yields specific sudden stop dates for each country which I then construct a 9-quarter event window around, with 2 quarters before and 6 quarters after. I obtain a total of 57 sudden stop episodes (36 in EMs and 21 in AEs).[11]

As expected, sudden stops are more prevalent in emerging market economies but I identify sufficient crises in both EMs and AEs for a robust estimation of multipliers across states. I am able to capture some of the most well-known crisis events such as the Latin American episodes around the Mexican 1994-95 crisis, the East Asian and Russian crises of the late 1990s, the Argentine crisis in 2001-02 and the more recent episodes in advanced economies following the Global Financial Crisis and the European sovereign debt crisis in the early 2010s.

2.3 Methodology

To estimate government spending multipliers, I use a common two-stage approach: first, I identify fiscal shocks from the data using a structural vector autoregression (SVAR) as in Blanchard and Perotti (2002) and, secondly, I use the estimated shocks as an instrumental variable (IV) for government spending to estimate multipliers through the one-step IV estimation pioneered by Ramey and Zubairy (2018) using Jordà (2005) local projections. This procedure allows for estimating cumulative multipliers across several horizons directly from the regression and can easily incorporate interaction terms to estimate state-dependent effects.

As we want to estimate multipliers on output and its components, I firstly convert the quantity variables to a share of HP-filtered trend GDP in order to have variables in the same unit:

$$y_{i,t} = \frac{Y_{i,t}}{\overline{GDP}_{i,t}}, \tag{2.1}$$

[10]For examples, see Calvo, Izquierdo and Mejia (2004), Bianchi and Mendoza (2020), and Liu (2022)

[11]Table A.2 in Appendix A lists the individual SS episodes for each country and their respective dates.

where i represents each country, t is the time indicator, $Y_{i,t}$ is the relevant variable (i.e. GDP, consumption, investment, etc.), $\overline{GDP}_{i,t}$ is trend output, and $y_{i,t}$ are the transformed variables used in the estimation. To estimate the effect of public spending on the real exchange rate, I use the log-difference in the real effective exchange rate (REER) index, where $\Delta REER_{i,t} = \log(REER_{i,t}) - \log(REER_{i,t-1})$. Subsequently, I proceed in the two steps outlined above.

First stage: Identifying fiscal shocks An important debate in the literature on multipliers is on how to correctly identify fiscal shocks, given two possible directions of causation between government spending and economic activity.[12] Two leading procedures are usually employed: (1) the SVAR approach from Blanchard and Perotti (2002) (BP) and (2) the "narrative approach" adopted by Ramey (2011) and Ramey and Zubairy (2018), which uses narrative evidence on military spending in order to produce shocks that are unanticipated by private agents and exogenous to the state of the economy. I follow the first approach. The identifying assumption in the BP procedure is that fiscal policy takes time to react to the state of the economy, and therefore we can run a VAR with a Cholesky decomposition to eliminate the endogenous responses of fiscal policy and use the estimated residuals as an instrument for spending shocks.

This method has received criticism by Ramey (2011) and others, who argue that, while fiscal policy does not usually react contemporaneously to economic activity, such shocks may be anticipated by private agents and therefore narrative evidence is necessary to control for the expectations channel. However, the narrative approach is highly restrictive from a data collection perspective and only applicable to a small subset of advanced countries, thus rendering it unrealistic when analyzing a large panel of heterogeneous countries. Moreover, the use of data in quarterly frequency for the BP approach and the fact that fiscal spending is usually volatile during financial crises alleviates the identification problem: it is reasonable to assume that spending policy responds with a one-quarter lag to the economy, while a full-year lag is less realistic when using data at annual frequency, and the unpredictability of fiscal policy in crisis episodes makes the expectations issue less problematic.[13]

Therefore, I follow Liu (2022), Ilzetzki, Mendoza and Végh (2013), and Corsetti et al. (2012) which apply the BP method to open economies by estimating the following four-variable SVAR separately for each country:

[12] See Ramey (2019) for a recent review of this literature.
[13] See Ilzetzki, Mendoza and Végh (2013) for a detailed discussion of the latter issue.

$$AZ_{i,t} = \sum_{k=1}^{4} C_k Z_{i,t-k} + Bu_{i,t}, \tag{2.2}$$

where $Z_{i,t} = \left[g_{i,t}, GDP_{i,t}, CA_{i,t}, \Delta REER_{i,t}\right]'$ and $g_{i,t}$ and $GDP_{i,t}$ are real government consumption and GDP, respectively, $CA_{i,t}$ is the current account to GDP ratio, and $\Delta REER_{i,t}$ is the aforementioned log-difference in the real exchange rate index. The ordering of variables for the Cholesky decomposition follows from Kim and Roubini (2008) and I include four lags. A and C_k are the coefficient matrices to be estimated for contemporaneous and dynamic effects, respectively, while B is a diagonal matrix for the variance of structural shocks and thus the vector $u_{i,t}$ are the orthogonal residuals. From this estimation, I use $\hat{u}^{g}_{i,t}$ as the instrument for exogenous fiscal shocks.

Second stage: Estimating multipliers I then use local projections to estimate the government spending multipliers for each macroeconomic variable y – namely, GDP, private consumption, investment, the trade balance, and the real exchange rate. We can firstly estimate the following linear panel IV specification across all states (both sudden stop crises and normal times):

$$\sum_{j=0}^{h} y_{t+j} = \gamma + \delta_t + \alpha_i + m_{y,h} \sum_{j=0}^{h} g_{i,t+j} + \psi_h(L) Z_{i,t-1} + u_{i,t+h}, \tag{2.3}$$

where h are time horizons, γ is a constant, δ_t is a time trend, α_i are country fixed effects, $Z_{i,t-1}$ is the control vector of lagged variables, and $\psi_h(L)$ is the polynomial of the lag operator of degree four. The main endogenous variable g is instrumented by the fiscal shocks $\hat{u}^{g}_{i,t}$ extracted in the first-stage, and the coefficient $m_{y,h}$ can be directly interpreted as the cumulative multiplier for variable y at horizon h.

Then, as in Ramey and Zubairy (2018) and Liu (2022), I adapt the linear specification to account for state-dependent effects with the following non-linear specification:

$$\begin{aligned}\sum_{j=0}^{h} y_{t+j} = \gamma + \delta_t + I_{i,t-1}&\left[\alpha_i^{SS} + m_{y,h}^{SS} \sum_{j=0}^{h} g_{i,t+j} + \psi_h^{SS}(L) Z_{i,t-1}\right] \\ &+ (1 - I_{i,t-1})\left[\alpha_i^{N} + m_{y,h}^{N} \sum_{j=0}^{h} g_{i,t+j} + \psi_h^{N}(L) Z_{i,t-1}\right] + u_{i,t+h},\end{aligned} \tag{2.4}$$

where I is a dummy variable indicating whether a country is experiencing a sudden stop crisis or not (i.e. $I = 1$ in an SS episode and 0 otherwise). Given this interaction, $m^{SS}_{y,h}$ and $m^{N}_{y,h}$ represent cumulative government spending multipliers in sudden stops and in normal times, respectively, for each variable y.

Finally, for a given sample, I test for the interaction of the estimated multipliers with a given explanatory variable X_t to understand what drives the cross-country heterogeneity in state-dependent multipliers. In our case, X_t is either the share of FX external debt, income levels, or the exchange rate regime. We thus adapt the non-linear specification in 2.4 to include an additional interaction term:

$$
\begin{aligned}
\sum_{j=0}^{h} y_{t+j} = \gamma + \delta_t + I_{i,t-1} \Bigg[& \alpha_i^{SS} + m_{y,h}^{SS,G} \sum_{j=0}^{h} g_{i,t+j} + m_{y,h}^{SS,GX} \sum_{j=0}^{h} g_{i,t+j} \cdot X_{i,t-1} \\
& + \beta_{y,h}^{SS,X} X_{i,t-1} + \psi_{y,h}^{SS}(L) Z_{i,t-1} \Bigg] \\
& + (1 - I_{i,t-1}) \Bigg[\alpha_i^{N} + m_{y,h}^{N,G} \sum_{j=0}^{h} g_{i,t+j} + m_{y,h}^{N,GX} \sum_{j=0}^{h} g_{i,t+j} \cdot X_{i,t-1} \\
& + \beta_{y,h}^{N,X} X_{i,t-1} + \psi_{y,h}^{N}(L) Z_{i,t-1} \Bigg] + u_{i,t+h}
\end{aligned}
\tag{2.5}
$$

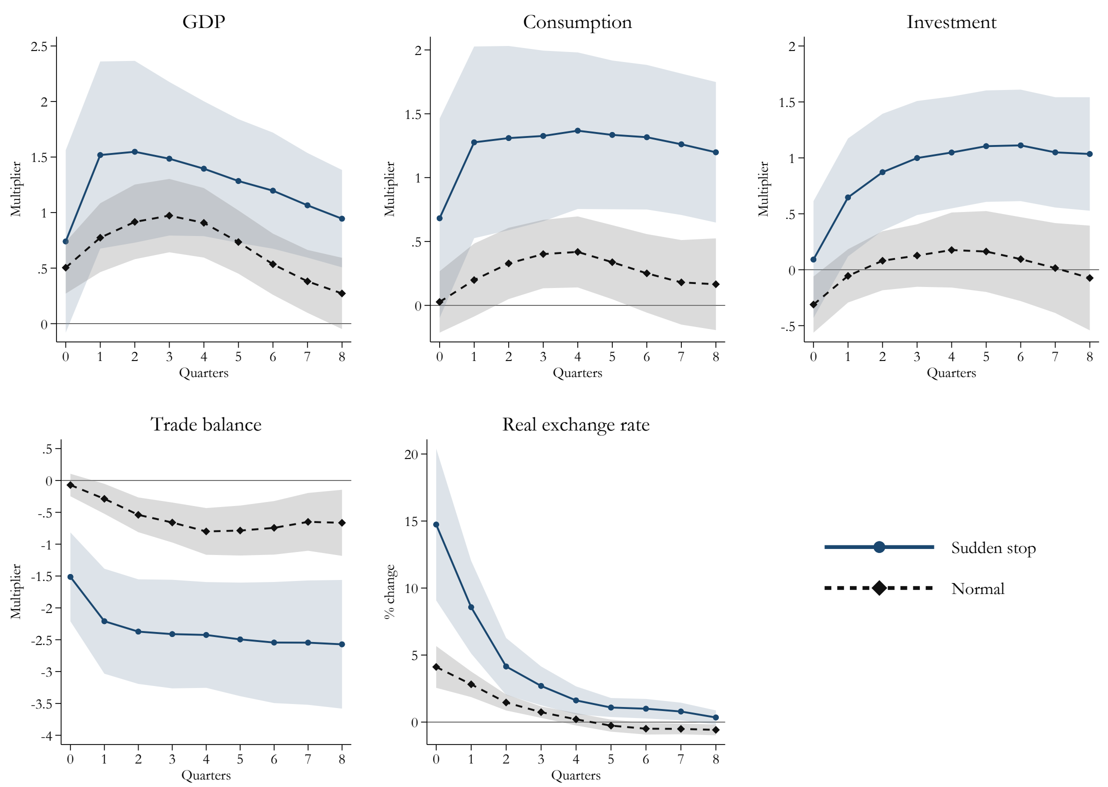
Here, spending multipliers at each state are given by $m^{SS}_{y,h} \equiv m^{SS,G}_{y,h} + m^{SS,GX}_{y,h} \cdot X_{t-1}$ and $m^{N}_{y,h} \equiv m^{N,G}_{y,h} + m^{N,GX}_{y,h} \cdot X_{t-1}$. That is, if we expect the variable X to explain the cross-sectional heterogeneity in multipliers during sudden stops, we need $m^{SS,GX}_{y,h} \neq 0$. For example, if spending multipliers during sudden stops are increasing in the foreign currency share of external liabilities, then $m^{SS,GX}_{y,h} > 0$.

2.4 Results

The empirical analysis produces two sets of results. First, I split the sample between EMs and AEs and estimate state-dependent multipliers for each sub-panel. I find that the state-dependence of multipliers in sudden stops found in Liu (2022) is fundamentally an emerging market phenomenon and does not hold for advanced economies. Second, I find that the foreign-currency share of external debt is a crucial determinant of this cross-country heterogeneity in state-dependence of fiscal policy around sudden stops.

Result 1: EMs vs. AEs. The estimated multipliers for EMs are reported on Figure 3 and Table A.3 in Appendix A. A positive government spending shock crowds in consumption at all states. Importantly, the multiplier on consumption is significantly larger during sudden stops than in normal times at the 1 and 2-year horizons at the 5% and 1% level, respectively, as shown in the second and third columns on Table A.3. The consumption multiplier peaks four quarters after the shock at around 1.4 during sudden stops, but is only 0.4 outside of crisis episodes. This matches the central empirical result in Liu (2022) for a panel of both EMs and AEs.

Figure 3: Emerging Economies: Fiscal Multipliers in Sudden Stops vs. Normal Time

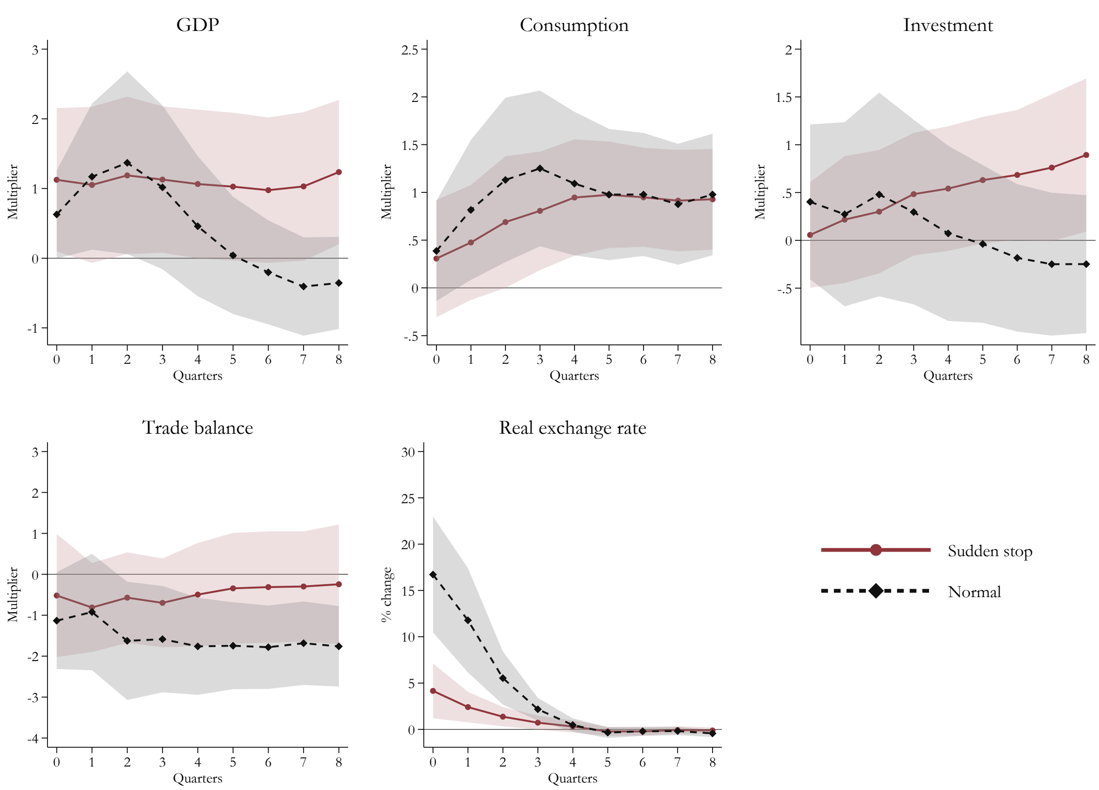


Notes: The multipliers for GDP, consumption, investment and trade balance represent the level change in the present value of these variables caused by a one unit increase in the present value of government spending. The plot for the real exchange rate represents the percentage change in its level caused by a government spending shock. Error bands for both states (i.e. sudden stops and normal) are 90% confidence intervals with HAC standard errors.

As expected from theory, and in line with the results in Miyamoto, Nguyen and Sheremirov (2019) and Ilzetzki, Mendoza and Végh (2013), a rise in fiscal spending appreciates the real exchange rate on impact in EMs. The appreciation effect is significantly stronger during sudden stop episodes. This therefore leads to a larger trade deficit from stimulus during a sudden stop, as shown in the bottom panel of Table A.3. Finally, the multiplier on investment is also significantly higher during sudden stop crises than in normal times, while point estimates for output multipliers are higher in sudden stops but the difference is not statistically significant.

Using considerably more sudden stop episodes in AEs than in Liu (2022), I show that the results for advanced economies differ considerably from those for EMs in that multipliers across different states are not significantly different. The main results are reported in Figure 4 and Table A.4 in Appendix A. The multiplier for consumption is significantly positive across both states.[14] However, they are not significantly different across financial regimes.[15] In fact, point estimates for the consumption multiplier across most horizons are marginally lower under sudden stop episodes. Similarly, while point estimates vary, multipliers for GDP and investment also do not change significantly between normal times and balance of payment crises.

Figure 4: Advanced Economies: Fiscal Multipliers in Sudden Stops vs. Normal Time



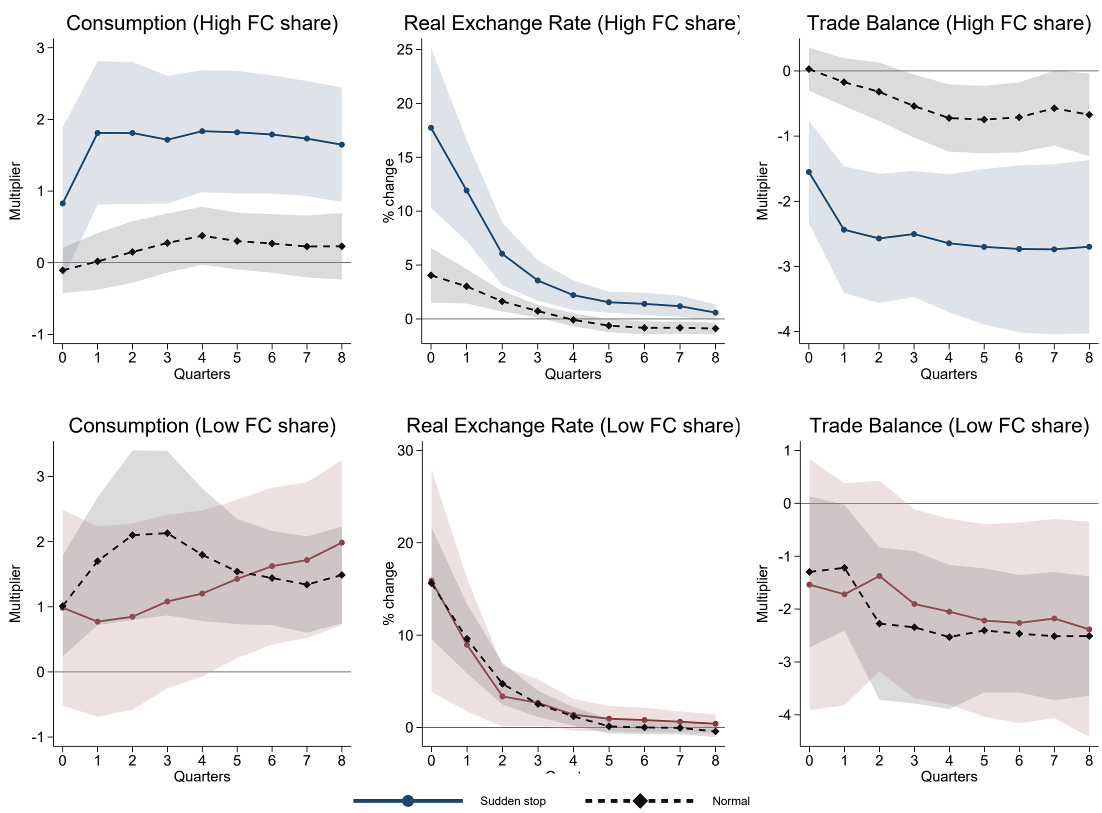
Notes: The multipliers for GDP, consumption, investment and trade balance represent the unit change in the present value of these variables caused by a one unit increase in the present value of government spending. The plot for the real exchange rate represents the percentage change in its level caused by a government spending shock. Error bands for both states (i.e. sudden stops and normal) are 90% confidence intervals with HAC standard errors.

[14]This matches most of the empirical estimates for advanced economies in the literature.

[15]Thisis clearly shown by the p-values of the different between both estimates in the fourth column of Table A.4.

I find that government spending also appreciates the real exchange rate for advanced economies in the short-term across both states, which is in line with the results for relevant horizons in Corsetti et al. (2012), Born, Juessen and Müller (2013), and Auerbach and Gorodnichenko (2015) but at odds with Miyamoto, Nguyen and Sheremirov (2019) and Monacelli and Perotti (2010) who find that a fiscal stimulus causes a depreciation in AEs. Interestingly, my estimates suggest that real exchange rate appreciation from a positive fiscal shock is significantly lower in AEs relative to normal times – the opposite from the EM case. It therefore follows that the trade deficit caused by government spending in EMs is smaller during sudden stops than in normal times, although their difference is not statistically significant as seen in Table A.4.

Figure 5: Fiscal Multipliers in Sudden Stops vs. Normal Times for High vs. Low FC-shares



Notes: Cumulative multipliers for government expenditure shock with low (10th percentile of foreign currency share of external debt) and high (90th percentile of foreign currency share of external debt) FC-shares. Error bands are 90% confidence intervals.

Result 2: foreign-currency external debt & state-dependent multipliers. What drives the heterogeneity in multiplier state-dependence between emerging and advanced economies? To investigate this question systematically, I test three key country characteristics that could explain the differential effectiveness of fiscal policy during sudden stops: (1) the share of foreign-currency denominated external debt, (2) exchange rate regimes, and (3) income levels (GDP per capita).

Using the specification in equation 2.5, I estimate how the state-dependent multipliers interact with each characteristic separately, and then conduct "horse races" between these characteristics to identify which factor most robustly explains the cross-country differences, as in Broner et al. (2022). Figure 5 shows the results of the interaction with foreign-currency share of external debt. For countries with high FC-shares (90th percentile), multipliers are substantially larger during sudden stops than in normal times for consumption, the real exchange rate, and the trade balance. In contrast, for countries with low FC-shares (10th percentile), the difference between multipliers across states largely disappears, consistent with the patterns observed for advanced economies.

The explanatory power of exchange rate regimes and income levels is examined in Figures A.1 and A.2 in Appendix A. While there are some differences in multipliers across these dimensions, the differential state-dependence persists even when controlling for these factors. More importantly, when I conduct horse race regressions including both foreign-currency share and exchange rate regimes (Figure A.3) or foreign-currency share and GDP per capita (Figure A.4), the state-dependence associated with FC share remains robust.

These results provide compelling evidence that the currency composition of external debt is the critical factor explaining why fiscal policy transmission differs across countries during sudden stops. Balance sheet effects from currency mismatch appear to be the key channel through which fiscal policy effectiveness is amplified during capital flow reversals.

Additional results I also test for the existence of sign-dependence in shocks, as in Liu (2022) – that is, whether multipliers vary depending on whether the fiscal shocks are negative or positive. For the EM sample, this yields an interesting finding: multipliers are asymmetric as the state-dependence of consumption and trade balance multipliers holds for negative fiscal shocks but not for positive ones. This suggests that the non-linearity in the baseline results are driven by negative shocks in EMs: fiscal austerity during sudden stops is costlier than fiscal stimulus is beneficial, as seen in Figure A.5 in Appendix A. Consumption multipliers for negative fiscal shocks under sudden stops have a multiplier of up to almost 4 one quarter after the shock. A similar test for the AE sample does not yield the same asymmetry (see Figure A.6, although consumption multipliers during normal times are higher than during sudden stops under negative fiscal shocks, albeit to a statistically insignificant extent given large confidence bands.

Finally, in order to ensure that the non-linearity in the multipliers in the baseline estimation is specific to sudden stop crises with large capital outflows rather than usual recessions, I also test the state-dependence of multipliers across "normal recessions" and normal times, where the former is defined as periods in which the cyclical component of GDP is one standard deviation below its trend.[16] The results are reported in Figures A.7 and A.8 in Appendix A. The non-linearity in multipliers across normal times and standard recessions is not present for either EMs or AEs, pointing to the fact that the state-dependence of multipliers estimated in the paper are a indeed driven by the financial channel central to sudden stop crises.

3 Model

The model draws on the literature of New Keynesian small open economy models. It builds on the complete markets version in Galí and Monacelli (2005) and introduces incomplete international financial markets as in De Paoli (2009), where households can smooth consumption by saving or borrowing through a single, internationally-traded one-period non-contingent bond. In order to explore whether the currency denomination of foreign liabilities can account for the state-dependence of multipliers estimated in Section 2, two polar cases are considered: the baseline specification assumes that internationally-traded bonds are denominated in foreign currency, while an alternative setup has foreign credit denominated in domestic currency.

Foreign asset supply is pinned down by a debt-elastic risk premium which also ensures the stationary dynamics of the model (see Schmitt-Grohé and Uribe (2003)). The risk premium depends on the difference between the ratio of external debt to domestic income relative to a debt tolerance threshold by international financial markets. A sudden stop shock is modelled as an exogenous shock to the risk tolerance of foreign creditors, which sets recessionary dynamics in motion given a capital flow reversal. Under FC-denominated debt, the sudden stop shock through the risk premium can replicate the widely studied balance sheet effects akin to a Fisherian debt-deflation, which are absent in the LC-denominated case.

Households consume both home-produced and foreign-produced goods, and there is home bias in consumption. The production-side of the economy consists of monopolistically competitive intermediate-good producing firms which are subject to nominal price rigidities and perfectly competitive final good producers with linear production technology in labor. Monetary policy either sets the nominal interest rate on local currency bonds or controls the nominal exchange rate. Fiscal policy follows a balanced budget, thus abstracting from the government's fiscal financing problem.

In order to replicate the empirical findings in Section 2, where consumption increases and the real exchange rate appreciates following a positive government spending shock across

[16] This is relevant given a strand in the empirical literature on multipliers showing larger multipliers in recessions vs. expansions, espcially in the context of the US. See, for example, Auerbach and Gorodnichenko (2012*a*) and Auerbach and Gorodnichenko (2012*b*).

both emerging and advanced economies, I assume that the representative household has Greenwood, Hercowitz and Huffman (1988) (GHH) preferences. Non-separability in consumption and labor yields complementarity between the two (see Monacelli and Perotti (2008) and Bilbiie (2011)). The wealth effect on labor supply from higher taxes is negligible, so that a temporary rise in fiscal spending causes an increase in consumption. This can also be modelled with the presence of hand-to-mouth consumers with no access to financial markets, but I choose the former strategy in order to maintain a representative agent setup and keep the model as simple as possible.[17]

3.1 Households

3.1.1 Intratemporal problem

Households consume a CES composite of home and foreign-produced (imported) goods, with elasticity of substitution η. Consumption of home and foreign goods are denoted by $c_{H,t}$ and $c_{F,t}$, respectively. Trade openness is captured by the parameter γ and therefore $(1-\gamma)$ represents home bias in consumption.

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

The intratemporal problem for the representative household is an expenditure minimization problem where the household decides how to allocate its consumption expenditure between home and foreign goods. The solution to this problem yields the following demand functions:

$$c_{H,t} = (1-\gamma)\left(\frac{P_{H,t}}{P_t}\right)^{-\eta} c_t,$$

$$c_{F,t} = \gamma\left(\frac{P_{F,t}}{P_t}\right)^{-\eta} c_t,$$

where P_t is the domestic CPI, defined as $P_t = \left[(1-\gamma)P_{H,t}^{1-\eta} + \gamma P_{F,t}^{1-\eta}\right]^{\frac{1}{1-\eta}}$ and $P_{H,t}$ and $P_{F,t}$ are the prices of home and foreign goods expressed in domestic currency, respectively. The law

[17] See Galí, López-Salido and Vallés (2007) and Bilbiie, Monacelli and Perotti (2013) for examples of fiscal policy with hand-to-mouth households in a closed economy context. Iyer (2017) and Cugat (2019) apply such limited household heterogeneity to small open economy models, but with a focus on monetary policy.

of one price holds for imported goods:

$$P_{F,t} = e_t P_t^*,$$

where P_t^* is the foreign CPI, and e_t is the nominal exchange rate.

The price of home goods in terms of the domestic CPI can be written as $p_{H,t} = \frac{P_{H,t}}{P_t}$ and the real exchange rate is defined as $s_t = e_t \frac{P_t^*}{P_t}$. Plugging these into the definition for CPI, we obtain:

$$p_{H,t} = \left[\frac{1 - \gamma s_t^{1-\eta}}{1-\gamma} \right]^{\frac{1}{1-\eta}}, \tag{3.1}$$

such that imports ($\gamma > 0$) drive a wedge between the PPI ($P_{H,t}$) and the CPI, which depends on the real exchange rate s_t. Therefore, the demand functions for the household can be written as:

$$c_{H,t} = (1-\gamma)(p_{H,t})^{-\eta} c_t \tag{3.2}$$

$$c_{F,t} = \gamma (s_t)^{-\eta} c_t. \tag{3.3}$$

In order to include the nominal exchange rate in the set of endogenous variables of the model, we can rewrite the definition for the real exchange rate as

$$\frac{s_t}{s_{t-1}} = \frac{e_t}{e_{t-1}} \frac{\pi_t^*}{\pi_t} = \frac{\Delta e_t}{\pi_t}, \tag{3.4}$$

where $\pi_t^* = \frac{P_t^*}{P_{t-1}^*}$ is foreign CPI inflation which I assume to be constant over time ($\pi_t^* = 1$), $\pi_t = \frac{P_t}{P_{t-1}}$ is domestic CPI inflation, and Δe_t is the nominal depreciation rate of domestic currency. Finally, the terms of trade tot_t is defined as the relative price of imports to exports, $P_{F,t}/P_{H,t}$, which can be written as:

$$tot_t = \left(\frac{P_{F,t}}{P_t} \right) \left(\frac{P_t}{P_{H,t}} \right) = \frac{s_t}{p_{H,t}} \tag{3.5}$$

3.1.2 Intertemporal problem

Risk-averse households maximize lifetime utility which depends on consumption c_t and their labor supply h_t. Preferences are non-separable and per-period utility takes the GHH form. Households can smooth consumption by saving and borrowing through both a local-currency denominated nominal bond B_t and a foreign-currency denominated nominal bond

B_t^*. In the baseline setup of the model, FC-denominated bonds are traded internationally while LC-denominated bonds are restricted for domestic transactions between households. In the alternative setup, foreign assets are denominated in local currency. The household problem is therefore defined by

$$\max_{c_t, h_t, B_t, B_t^*} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\sigma} \left(c_t - \chi \frac{h_t^{1+\phi}}{1+\phi} \right)^{1-\sigma}$$

$$\text{s.t.} \quad P_t c_t + B_t + e_t B_t^* = (1+i_{t-1}) B_{t-1} + (1+i_{t-1}^*) \Psi_{t-1} e_t B_{t-1}^* + P_t w_t h_t - P_t T_t + P_t \Gamma_t,$$

where B_t pays domestic interest rate $(1+i_t)$ and the household is subject to a risk premium Ψ_t which it must pay on top of the foreign interest rate $(1+i_t^*)$ on FC-denominated bonds (see Section 3.4.4 for a description of the risk premium function). $\beta \in (0,1)$ is the households' subjective discount factor, ϕ is the inverse of the Frisch elasticity of labor supply, and parameters σ and χ are the relative risk aversion and the weight on labor disutility, respectively. T_t is the lump-sum tax collected by the government and w_t denotes the real wage rate. Households own firms and receive real dividends from firm profits Γ_t.

The foreign interest rate follows an exogenous AR(1) process

$$(1+i_t^*) = (1-\rho_i)\frac{1}{\beta} + \rho_i(1+i_{t-1}^*) + \epsilon_t^i, \tag{3.6}$$

where $\epsilon_t^i \sim N(0, \sigma_i^2)$ is a foreign interest rate shock.

The household budget constraint can be written in real terms, yielding

$$c_t + b_t + s_t b_t^* = \frac{(1+i_{t-1})}{\pi_t} b_{t-1} + \frac{(1+i_{t-1}^*)}{\pi_t^*} \Psi_{t-1} s_t b_{t-1}^* + w_t h_t - T_t + \Gamma_t,$$

where $b_t = \frac{B_t}{P_t}$ and $b_t^* = \frac{B_t^*}{P_t^*}$.

The solution to the households' intertemporal problem is:

$$\lambda_t = \left(c_t - \chi \frac{h_t^{1+\phi}}{1+\phi} \right)^{-\sigma}, \tag{3.7}$$

$$1 = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \frac{(1+i_t)}{\pi_{t+1}} \right], \tag{3.8}$$

$$1 = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \frac{(1+i_t^*)}{\pi_{t+1}^*} \Psi_t \frac{s_{t+1}}{s_t} \right], \tag{3.9}$$

$$\chi h_t^{\phi} = w_t, \tag{3.10}$$

where λ_t is the Lagrangian multiplier, (3.7) is the first order condition with respect to consumption, (3.8) is the Euler equation for LC-denominated bonds, (3.9) is the Euler equation for FC-denominated bonds, and (3.10) is the household's labor supply condition. We can see that consumption and labor supply are complements under GHH preferences by taking the derivative with respect to h_t in (3.7), yielding $U_{ch} > 0$. Thus, the marginal utility of consumption increases when households increase their labor supply.

The real domestic interest rate is defined as

$$1 + r_t = \frac{(1 + i_t)}{E_t \pi_{t+1}}, \tag{3.11}$$

and $1 + r_t^* = 1 + i_t^*$ given that $\pi_t^* = 1$.

Combining (3.8), (3.9), and (3.11) gives us the real uncovered interest rate parity (UIP) condition signalling no-arbitrage between LC and FC-denominated bonds:

$$1 + r_t = (1 + r_t^*)\Psi_t \frac{E_t s_{t+1}}{s_t}$$

This condition implies that the household is indifferent between holding LC or FC-denominated bonds, as their expected returns are equalized. Therefore, portfolio choice is not modelled here and is defined by the supply of foreign credit, as discussed above, where foreign borrowing is either FC or LC-denominated.

3.1.3 Intuition

Given that my empirical findings suggest that, following a government spending shock, consumption increases and the real exchange rate appreciates across countries, we have a violation of the implications of international business cycle models with complete markets as in Backus, Kehoe and Kydland (1992), Galí and Monacelli (2005), and others. In these models, given perfect international risk sharing, the unconditional relationship between consumption and the real exchange rate is negative. Conditional a government spending shock, the intuition is the following: a rise in government spending increases demand for the home good (due to home bias in government consumption), causing the price of the home good to increase relative to the foreign one, and therefore causing an exchange rate appreciation. In addition, this calls for a corresponding increase in taxes in present value terms, so that the household faces a negative wealth shock, with a decrease in labor supply and consumption.

I address this issue in two ways. Firstly, the presence of incomplete markets and a debt-elastic risk premium in my model implies imperfect international risk sharing and a much less tight link between consumption and the real exchange rate, which only holds in expectation. Secondly, as discussed in Monacelli and Perotti (2008), the presence of GHH preferences ensures a positive response of consumption to a government spending shock, under standard parameterization. Under GHH preferences, the negative wealth effect on labor supply faced by the household from an increase in taxes is negligible so that the labor supply curve does not shift out (such that real wages do not decline). Furthermore, firms face an outward shift in their demand curves, which they respond to by increasing production given that prices cannot be increased due to nominal rigidities, thus shifting out the demand for labor and raising the real wage rate. Labor hours increase along the supply curve and therefore the marginal utility of consumption increases given consumption-hours complementarity, as discussed in the previous section. As a result, consumption must increase to restore the initial value for λ_t. In this way, we are able to reconcile a positive consumption response and real exchange rate appreciation to government spending, as seen in the data.

3.2 Firms

3.2.1 Final-good firms

The model has a representative final-good firm that operates a CES aggregation technology for production of the final domestic good $Y_{H,t}$:

$$Y_{H,t} = \left[\int_0^1 Y_{H,t}(i)^{\frac{\varepsilon-1}{\varepsilon}} \, di \right]^{\frac{\varepsilon}{\varepsilon-1}},$$

where $Y_{H,t}(i)$ is an intermediate good produced by intermediate-good firm i, with price $P_{H,t}(i)$. Final-good firms operate in perfect competition. The problem of the final-good firm is:

$$\max_{Y_{H,t}, \{Y_{H,t}(i)\}_{i \in [0,1]}} P_{H,t} Y_{H,t} - \int_0^1 P_{H,t}(i) Y_{H,t}(i) di$$

$$\text{s.t.} \quad Y_{H,t} = \left[\int_0^1 Y_{H,t}(i)^{\frac{\varepsilon-1}{\varepsilon}} \, di \right]^{\frac{\varepsilon}{\varepsilon-1}}.$$

This yields the demand function for an individual intermediate good $Y_{H,t}(i)$

$$Y_{H,t}(i) = Y_{H,t} \left(\frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\varepsilon},$$

where $P_{H,t}$ is the equilibrium price of the final home good, expressed a

$$P_{H,t} = \left[\int_0^1 P_{H,t}(i)^{1-\varepsilon} \, di \right]^{\frac{1}{1-\varepsilon}}.$$

3.2.2 Intermediate-good firms

There is a continuum $i \in [0,1]$ of firms producing a differentiated domestic intermediate good (i.e. input) operating in a linear production technology in labor:

$$Y_{H,t}(i) = A_t h_t(i), \tag{3.12}$$

where A_t is total factor productivity, following an exogenous AR(1) process

$$\log(A_t) = (1-\rho_a)\log(\bar{A}) + \rho_a \log(A_{t-1}) + \epsilon_t^A, \tag{3.13}$$

and $\epsilon_t^A \sim N(0, \sigma_A^2)$ is a productivity shock.

Firms are monopolistically competitive, setting the price of their intermediate good subject to the demand of the final-good firm. In addition, they are subject to nominal price rigidities à la Rotemberg (1982), where they pay a quadratic adjustment cost $AC_t(i)$ in nominal terms whenever they adjust prices relative to the benchmark $\bar{\pi}$.

$$AC_t(i) = \frac{\theta}{2}\left(\frac{P_{H,t}(i)}{P_{H,t-1}(i)} - \bar{\pi}\right)^2 P_{H,t} Y_{H,t}$$

The profit maximization problem for the intermediate-good firm therefore is

$$\max_{\{P_{H,t}(i), h_t(i), Y_{H,t}(i)\}_{t=0}^{\infty}} \mathbb{E}_0 \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[\frac{P_{H,t}(i)}{P_t} Y_{H,t}(i) - w_t h_t(i) - \frac{AC_t(i)}{P_t} \right] \right\}$$
$$\text{s.t.} \quad \begin{cases} Y_{H,t}(i) = Y_{H,t}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\varepsilon} \\ Y_{H,t}(i) = A_t h_t(i). \end{cases}$$

In a symmetric equilibrium where firms choose the same price, inputs, and output, the solution to this problem yields[18]

$$w_t = A_t mc_t = mc_t \frac{Y_{H,t}}{h_t} \tag{3.14}$$

[18]See Appendix B.3 for a detailed version of this derivation.

and the standard New Keynesian Phillips Curve

$$\pi_{H,t}(\pi_{H,t}-\bar{\pi}) = \beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\pi_{H,t+1}(\pi_{H,t+1}-\bar{\pi})\frac{p_{H,t+1}Y_{H,t+1}}{p_{H,t}Y_{H,t}}\right] + \frac{\varepsilon}{\theta}\left(\frac{mc_t}{p_{H,t}} - \frac{\varepsilon-1}{\varepsilon}\right) \tag{3.15}$$

where mc_t is the real marginal cost of producing one additional unit of output, and

$$\pi_{H,t} = \frac{P_{H,t}}{P_{H,t-1}} = \frac{p_{H,t}}{p_{H,t-1}}\pi_t. \tag{3.16}$$

Using (3.14), we get the equilibrium real profits/dividends Γ_t rebated to households by intermediate-good firms:

$$\Gamma_t = p_{H,t}Y_{H,t} - w_t h_t - \frac{\theta}{2}(\pi_{H,t}-\bar{\pi})^2 p_{H,t}Y_{H,t}.$$

3.3 Government

3.3.1 Fiscal policy

The government consumption bundle is composed only of the domestic good (i.e. it has perfect home bias), and the government follows a balanced budget, financing expenditure g_t by raising lump-sum taxes.

$$p_{H,t}g_t = T_t,$$

where g_t follows an exogenous AR(1) process:

$$\log(g_t) = (1-\rho_g)\log(\bar{g}) + \rho_g \log(g_{t-1}) + \epsilon_t^g, \tag{3.17}$$

and $\epsilon_t^g \sim N(0, \sigma_g^2)$ is a government spending shock.

3.3.2 Monetary policy

The monetary authority sets the nominal domestic interest rate according to the following Taylor-type rule:

$$\frac{1+i_t}{1+i} = \left(\frac{\pi_{H,t}}{\bar{\pi}}\right)^{\phi_\pi}\left(\frac{Y_t}{\bar{Y}}\right)^{\phi_y}\left(\frac{\Delta e_t}{\Delta e}\right)^{\phi_e}\exp(\epsilon_t^m), \tag{3.18}$$

where $\epsilon_t^m \sim N(0, \sigma_m^2)$ is a monetary policy shock, and real output Y_t is defined as domestic production deflated by the CPI,

$$Y_t = \frac{P_{H,t}}{P_t} Y_{H,t} = p_{H,t} Y_{H,t}. \tag{3.19}$$

The Taylor-rule specification allows for different policy regimes, when adjusting the reaction parameters ϕ_π and ϕ_e. A CPI inflation targeting rule assuming freely-floating exchange rates has $\phi_\pi > 1$ and $\phi_e = \frac{\gamma}{1-\gamma}\phi_\pi$.[19] That is, the monetary authority reacts to exchange rate movements insofar as the pass-through to import prices affects the CPI, but otherwise allows the exchange rate to float. If we have $\phi_e = 0$ we get a fully domestic-focused PPI inflation targeting regime. With $\phi_e > \frac{\gamma}{1-\gamma}\phi_\pi$ we get a managed floating regime, where monetary policy reacts to nominal exchange rate depreciation over and above its direct effect on CPI inflation. Finally, with $\phi_e \to \infty$, we get a fixed exchange rate regime.

3.4 Market clearing

3.4.1 Goods market

The market clearing condition for the market for the home good is

$$Y_{H,t} = c_{H,t} + c_{H,t}^* + g_t + \frac{\theta}{2}(\pi_{H,t} - \bar{\pi})^2 Y_{H,t}, \tag{3.20}$$

given that inflation carries a resource cost under Rotemberg pricing. $c_{H,t}^*$ is the foreign demand for the home good, which is obtained from the intratemporal problem for the foreign household symmetric to the one in Section 3.1.1. Thus,

$$c_{H,t}^* = \gamma^* \left(\frac{P_{H,t}}{e_t P_t^*} \right)^{-\eta} c_t^*$$

which can be re-written as

$$c_{H,t}^* = \gamma^* \left(\frac{1}{tot_t} \right)^{-\eta} y_t^* = \gamma^* (tot_t)^\eta y_t^*, \tag{3.21}$$

[19]This follows from (3.1), (3.4), and (3.16).

where γ^* is the parameter for trade openness of the foreign economy, and y_t^* represents foreign demand, which follows an exogenous AR(1) process

$$\log(y_t^*) = \rho_y \log(y_{t-1}^*) + \epsilon_t^y, \tag{3.22}$$

and $\epsilon_t^y \sim N(0, \sigma_y^2)$ is a foreign demand shock.

3.4.2 Asset market

Both LC and FC bonds are in net zero supply globally – that is, $\hat{B}_t + B_t = 0$ and $\hat{B}_t^* + B_t^* = 0$, where $\hat{B}_t$ and $\hat{B}_t^*$ are the foreigner's bond holdings. The opposite side of the internationally-traded bond for the home economy is necessarily taken by the foreign economy. As discussed, I consider two polar scenarios for asset supply. In the baseline specification, foreign asset supply is foreign currency denominated and LC bonds are used for domestic transactions between households. Thus, in equilibrium, $B_t = 0$ and B_t^* is the net foreign asset (NFA) position of the domestic economy (or b_t^* in real terms). Under the alternative specification, LC bonds are traded internationally while FC bonds are not, and are thus restricted to zero in equilibrium, $B_t^* = 0$, and B_t denotes the NFA position of the economy (or b_t in real terms).

3.4.3 External balance

The real trade balance is defined as

$$nx_t = \frac{P_{H,t}}{P_t} c_{H,t}^* - \frac{P_{F,t}}{P_t} c_{F,t} = p_{H,t} c_{H,t}^* - s_t c_{F,t}, \tag{3.23}$$

where real exports xp_t are defined as

$$xp_t = p_{H,t} c_{H,t}^*, \tag{3.24}$$

and real imports mp_t are

$$mp_t = s_t c_{F,t}. \tag{3.25}$$

Using the household budget constraint in real terms from Section 3.1.2, and substituting in the government budget constraint in Section 3.3.1 and firm dividends in Section 3.2.2, we get

$$\begin{aligned}\left[b_t - (1 + r_{t-1}) b_{t-1}\right] + \left[s_t b_t^* - (1 + i_{t-1}^*) \Psi_{t-1} s_t b_{t-1}^*\right] &= Y_t - p_{H,t} g_t - c_t - \frac{\theta}{2}(\pi_{H,t} - \bar{\pi})^2 Y_t \\ &= nx_t\end{aligned}$$

The above gives us a law of motion for the NFA position of the economy – that is, the change in the NFA position of the economy equals the trade balance nx_t plus net interest income (i.e. the current account balance). Given the asset market clearing condition discussed above, we will have either one of the following two specifications for this equation:

$$\begin{aligned} s_t b_t^* - (1+i_{t-1}^*)\Psi_{t-1} s_t b_{t-1}^* &= nx_t \\ \text{or} \qquad b_t - (1+r_{t-1}) b_{t-1} &= nx_t \end{aligned} \tag{3.26}$$

3.4.4 Risk premium

The debt-elastic risk-premium function defines the sensitivity of foreigner's supply of credit to the home economy to its NFA position. Similar to Schmitt-Grohé and Uribe (2003), it captures the idea that the domestic economy faces a higher borrowing cost if its external debt is higher than a certain threshold tolerated by international financial markets.

The premium function has been widely used in the international macroeconomics literature to capture financial frictions, especially for emerging economies.[20] It is also a crucial element ensuring the stationary dynamics of the model when solved stochastically. The premium function in the model follows Motyovski (2020):

$$\Psi_t = e^{-\delta\left(\frac{B_t + e_t B_t^*}{P_{H,t} Y_{H,t}} - \zeta_t\right)},$$

such that it depends on the ratio of external debt in either foreign of local currency to nominal domestic income. ζ_t represents the debt tolerance threshold (i.e. a level of the NFA to GDP ratio) of international financial markets, which follows an exogenous AR(1) process

$$\zeta_t = (1-\rho_\zeta)\bar{\zeta} + \rho_\zeta \zeta_{t-1} + \epsilon_t^\zeta \tag{3.27}$$

and $\epsilon_t^\zeta \sim N(0, \sigma_\zeta^2)$ is a "sudden stop shock". That is, a shock to the risk tolerance of financial markets which worsens international lending conditions and leads to a reversal of capital inflows. The parameter δ represents the sensitivity of the risk premium to differences between the economy's NFA position and the level tolerated by creditors. A higher value for δ imply larger financial frictions.

We can rewrite the premium function above in real terms as

[20] Examples include Mendoza (1991), Schmitt-Grohé and Uribe (2003), De Paoli (2009), and García-Cicco, Pancrazi and Uribe (2010).

$$\Psi_t = e^{-\delta\left(\frac{b_t + s_t b_t^*}{p_{H,t} Y_{H,t}} - \zeta_t\right)} = e^{-\delta\left(\frac{b_t + s_t b_t^*}{Y_t} - \zeta_t\right)}$$

Therefore, in the baseline specification with currency mismatch in foreign borrowing (where we have $b_t = 0$), and in the alternative model with domestic-currency borrowing ($b_t^* = 0$), we have the following two possible versions of the risk premium function, respectively:

$$\begin{aligned} \Psi_t &= e^{-\delta\left(\frac{s_t b_t^*}{Y_t} - \zeta_t\right)} \\ \text{or} \quad \Psi_t &= e^{-\delta\left(\frac{b_t}{Y_t} - \zeta_t\right)} \end{aligned} \tag{3.28}$$

In steady state, $\zeta_t = \frac{b^*}{Y} = \frac{b}{Y}$, given that the steady-state real exchange rate is normalized to $s = 1$. Therefore, we have the steady-state value for the risk premium $\Psi = 1$ – that is, there is no premium as the NFA position of the home country is equal to the tolerance threshold. I assume an asymmetric steady state where the home economy is a net external debtor, such that $b^* < 0$ (or $b < 0$). A positive shock to ζ_t (i.e. a worsening of risk tolerance) increases the risk premium given that the NFA position of the home economy will be larger than the tolerance in absolute terms (i.e. $\frac{s_t b_t^*}{Y_t} < \zeta_t$ or $\frac{b_t}{Y_t} < \zeta_t$) such that $\Psi_t > 1$, forcing a deleveraging by households.

As discussed in Section 4.1, the impact under the baseline case is much more amplified given currency mismatch. The real exchange rate depreciation following the sudden stop shock leads to a debt revaluation effect which further tightens the borrowing constraint, forcing a sharper deleveraging by households and a larger external adjustment, with a sharper corresponding fall in consumption and output. The sharper adjustment feeds back into the risk premium, generating a financial amplification mechanism is akin to a Fisherian debt-deflation. Under the case with LC-denominated external debt, this amplification is absent: the deleveraging following a sudden stop shock does not generate feedback in the risk premium function, such that the adjustment is smaller and faster.

3.5 Competitive equilibrium

The competitive equilibrium of the model is defined by equations (3.1) to (3.28). The full set of optimality conditions determining the equilibrium are also listed in Appendix B.1. Equilibrium in the baseline economy is characterized by a sequence of prices and quantities such that households maximize their utility, firms maximize profits, and all markets clear, given initial conditions, exogenous processes, and the Taylor rule.

3.6 Calibration and solution method

In order to use the model to explore the mechanism and build intuition around how the currency denomination of external debt – a salient feature differentiating EM and AE economies – can generate state-dependence of fiscal multipliers, I do not calibrate the model to match empirical targets of a specific economy and period, but instead use standard parameterization from the international business cycle literature for a model small open economy. Thus, the baseline and alternative specifications of the model only differ along one dimension – the currency denomination of external debt – while all parameters remain unchanged.

Table 3 reports the values for the main parameters of the model. Most are drawn from Galí and Monacelli (2005) and De Paoli (2009), while parameters dictating the sudden stop process are taken from Motyovski (2020). The sudden stop shock is specified with a large persistence in order to mimic a binding borrowing constraint as in Fisherian models (see Bianchi and Mendoza (2020) and Liu (2022)). Forward-looking households realize that credit scarcity will persist and the borrowing constraint will bind for longer and therefore choose to deleverage instead of smoothing consumption. The persistence of the government spending shock is chosen so that government spending returns to steady state within 8 quarters – i.e. a temporary increase in spending. The Rotemberg cost parameter θ matches a Calvo parameter of 0.66 in De Paoli (2009), characterizing an average length of price contract of 3 quarters. Finally, the benchmark calibration of the Taylor rule assumes CPI inflation targeting and a floating exchange rate regime: monetary policy reacts to the exchange rate only insofar as it affects the CPI, the most relevant case for most open economies today.

Given that we are interested in modelling sudden stop dynamics where the economy is a net external debtor, the model is solved around a non-symmetric steady state where the NFA position $b^* < 0$. I consider a steady state with no inflation and real exchange rate appreciation/depreciation (i.e. the RER is normalized to $s = 1$ and $\bar{\pi} = 1$). The steady state risk premium consistent with this equilibrium is $\Psi = 1$ and therefore $\zeta = \frac{b^*}{Y}$. The labor disutility parameter χ is chosen to normalize steady state labor and output is also normalized ($Y = 1$). The steady state NFA to GDP ratio is chosen to be -1.5 – that is, net foreign liabilities are equivalent to 150% of GDP in quarterly frequency (37.5% of GDP in annual terms), as in Motyovski (2020). A full description of the steady state is available in Appendix B.2.

The model is solved numerically using a perturbation approach as is common in the New Keynesian literature. To examine the sudden stop shock across the two specifications of the model, I compute impulse response functions from a first-order approximation. A sudden

Table 3: Calibration and steady-state values

Parameters	**Value**	**Source/Target**
Subjective discount factor	$\beta = 0.99$	Galí and Monacelli (2005)
Relative risk aversion	$\sigma = 2$	Standard value
Inverse Frisch elasticity	$\phi = 0.47$	De Paoli (2009)
Labor disutility parameter	$\chi = 0.83$	From SS calculation
EOS b/w Home/Foreign good	$\eta = 1.5$	De Paoli (2009)
Openness	$\gamma = 0.25$	De Paoli (2009)
Openness of Foreign economy	$\gamma^* = 0.21$	From SS calculation
Sensitivity of risk premium	$\delta = 0.1$	Motyovski (2020)
Steady-state NFA tolerance	$\zeta = -1.5$	Motyovski (2020)
EOS b/w home varieties	$\epsilon = 6$	Galí and Monacelli (2005)
Rotemberg cost parameter	$\theta = 28$	To match Calvo parameter of 0.66 as in De Paoli (2009)
Persistence of gov. spending	$\rho_g = 0.5$	Returns to SS within 8 quarters
Persistence of sudden stop shock	$\rho_\zeta = 0.95$	Motyovski (2020)
TR reaction: PPI Inflation	$\phi_\pi = 1.5$	Standard value
TR reaction: exchange rate	$\phi_e = 0.5$	Standard value
TR reaction: output	$\phi_y = 0$	Standard value
Steady state values	**Value**	**Source/Target**
Output	$Y = 1$	Normalized to 1
Real exchange rate	$s = 1$	Normalized to 1
Labor supply	$h = 1$	Normalized to 1
Government spending	$g = 0.2$	Standard value
Net foreign assets	$b = -1.5$	Motyovski (2020)
Consumption	$c = 0.78$	From SS calculation

Notes: The persistence parameters for TFP, the foreign interest rate, and foreign demand are not shown here given that I do not shock these functions in the model results.

stop shock is defined as a reduction in the debt tolerance of international creditors of 33% on impact – i.e. debt tolerance shifts from 150% to 100% of steady-state GDP (equivalent to a shift from 37.5% to 25% of GDP in annual terms).

To allow for non-linearities in government spending multipliers, I then solve the model up to the second-order and compute generalized impulse response functions (GIRFs) from a government spending shock equivalent to 1% of GDP (i.e. 5% of steady-state government spending).[21] To replicate the empirical strategy of comparing multipliers under sudden stop crises relative to "normal times", I compare the response of the key variables to a fiscal shock at different points in the state space. Responses to a shock outside of a crisis (i.e. at "normal times") are computed at the ergodic mean while the fiscal shock during a sudden stop occurs when debt tolerance 33% below the steady-state. I then compute multipliers from the GIRFs, as described in Section 4.2.

4 Model results

In this section, I discuss the dynamics of a sudden stop shock from a first-order approximation of the model under the both foreign-currency and local-currency denominated external debt. I then report the responses of variables and multipliers to a government spending shock under crisis and non-crisis states for each model specification and explain why they differ considerably.

4.1 Sudden stop shock

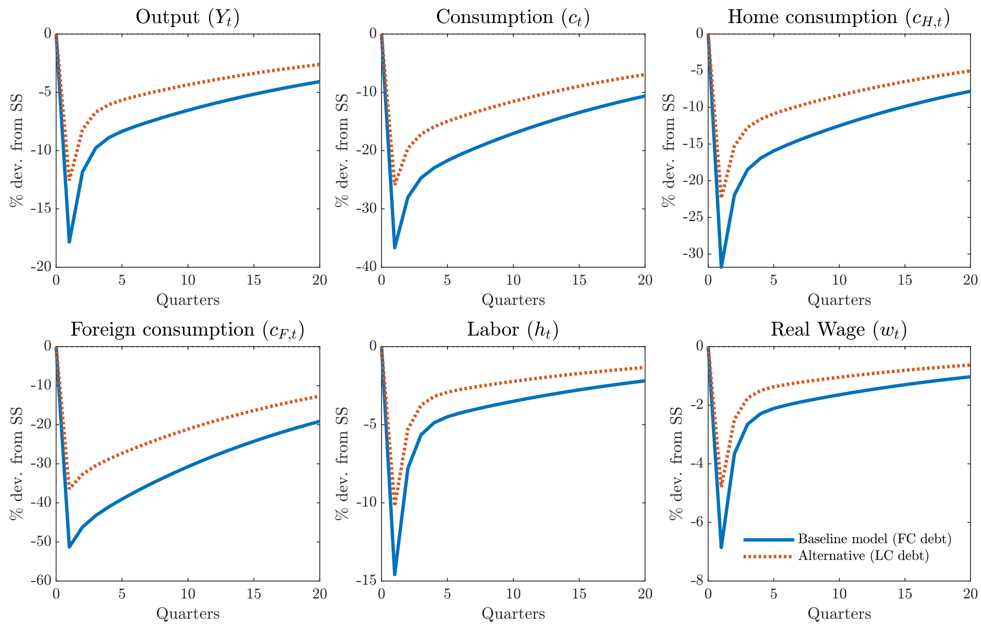
A sudden stop shock in the model operates via the risk premium channel. An equivalent shock, under identical parameterization, generates a larger amplification under the baseline case with foreign-currency denominated debt. I firstly discuss the mechanisms driving the responses of the variables across both cases, followed by why we see a larger amplification in our baseline case.

The impulse responses of the main endogenous variables in the model are presented in Figures 6, 7, and 8. An unexpected decline in the debt/risk tolerance of international financial markets raises the risk premium, leading to nominal and real exchange rate depreciation. As a result, a CPI targeting central bank raises the nominal (and real) interest rate. Due to higher borrowing costs, which remains highly persistent given the shock specification,

[21]The GIRF is computed over a simulation of 1,000 periods, with 200 periods of burning-in to get the ergodic distribution.

forward-looking households choose to deleverage instead of smoothing consumption. Thus, overall consumption falls considerably in both specifications, as shown in Figure 6, and we see a sharp increase in the net foreign asset position of the home economy, as shown in Figure 7 (and therefore an associated positive current account adjustment on impact).

Figure 6: Impulse responses of endogenous variables to a sudden stop shock

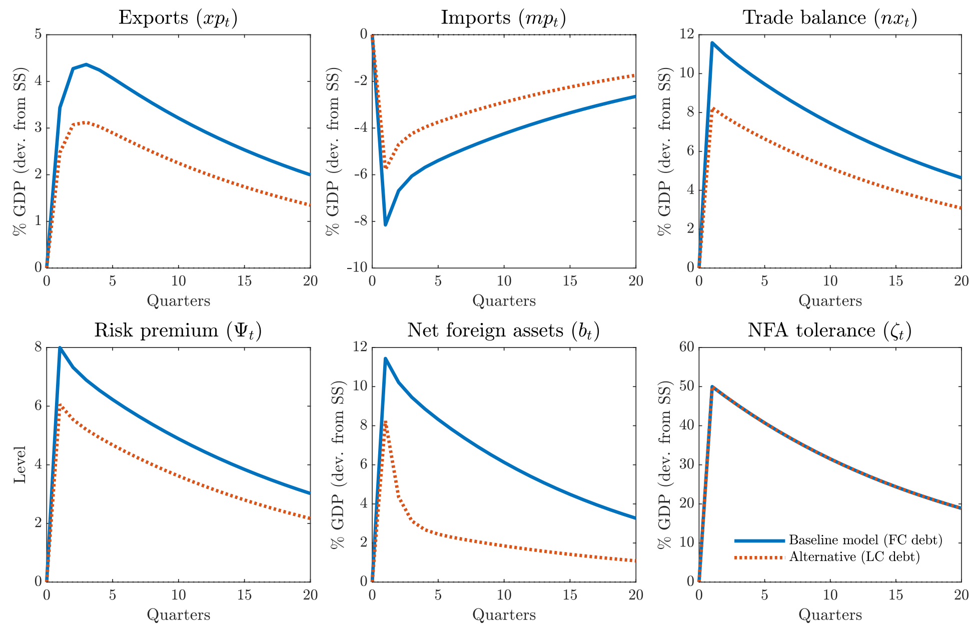


Notes: The plotted IRFs represent the responses of endogenous variables to an exogenous shock to the risk tolerance of international financial markets ζ_t of 33%.

Lower aggregate demand in the home economy leads to a fall in output due to nominal rigidities: firms cannot automatically adjust prices and react to lower demand by cutting production, causing a reduction in labor demand. The presence of GHH preferences and the negligible wealth effect on labor supply implies that the shift in labor demand is met with a reduction in labor supply along its curve, yielding a reduction in employment (h_t) and the real wage rate (w_t). The decline in real wages further compounds the drag in consumption.

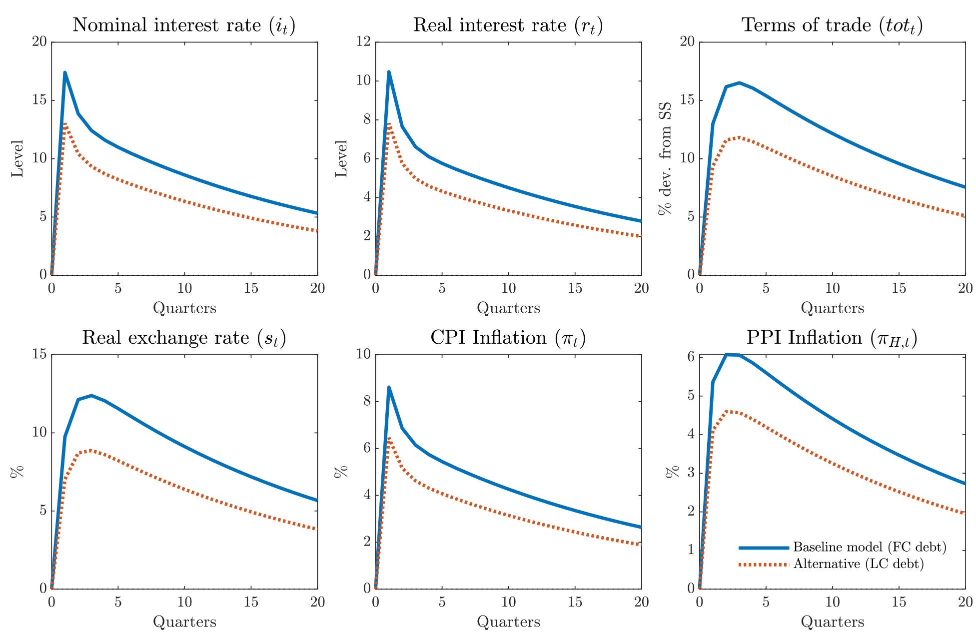
Real exchange rate depreciation causes expenditure switching towards home-produced goods given a larger relative increase in the price of foreign-produced goods. While demand for both goods fall sharply, the demand for foreign-produced goods $(c_{F,t})$ falls by a larger amount relative to home consumption $(c_{H,t})$, which drags down imports (mp_t). Conversely, real depreciation boosts exports given a higher demand for the home-produced good from the foreign economy due to its lower price in foreign-currency terms. This yields a sharp trade balance improvement, as seen in Figure 7. The increase in the trade balance, however, is not enough to counteract falling domestic demand and therefore output still experiences an overall decline.

Figure 7: Impulse responses of endogenous variables to a sudden stop shock



Notes: The plotted IRFs represent the responses of endogenous variables to an exogenous shock to the risk tolerance of international financial markets ζ_t of 33%.

Figure 8: Impulse responses of endogenous variables to a sudden stop shock



Notes: The plotted IRFs represent the responses of endogenous variables to an exogenous shock to the risk tolerance of international financial markets ζ_t of 33%.

While the dynamics of the shock are qualitatively similar across both specifications, we can see a considerable amplification of the same shock under the baseline model with external debt denominated in foreign currency – the empirically relevant case for most emerging economies – relative to the alternative case with local-currency denominated debt as in most advanced economies. Why? As debt is FC-denominated but domestic income is in local currency, we have a *currency mismatch* in the liabilities of households under the baseline economy. The depreciation of the real exchange rate following a sudden stop shock leads to a debt revaluation effect by increasing the local-currency value of liabilities, causing a sharper deleveraging process and overall external adjustment. This feeds back into further real exchange rate depreciation and tightening of the borrowing constraint via the risk premium function, generating adverse balance sheet effects in a financial amplification mechanism similar to debt-deflation as proposed by Fisher (1933). The larger and longer deleveraging carried out by households in this specification implies an associated larger decline in demand and output.

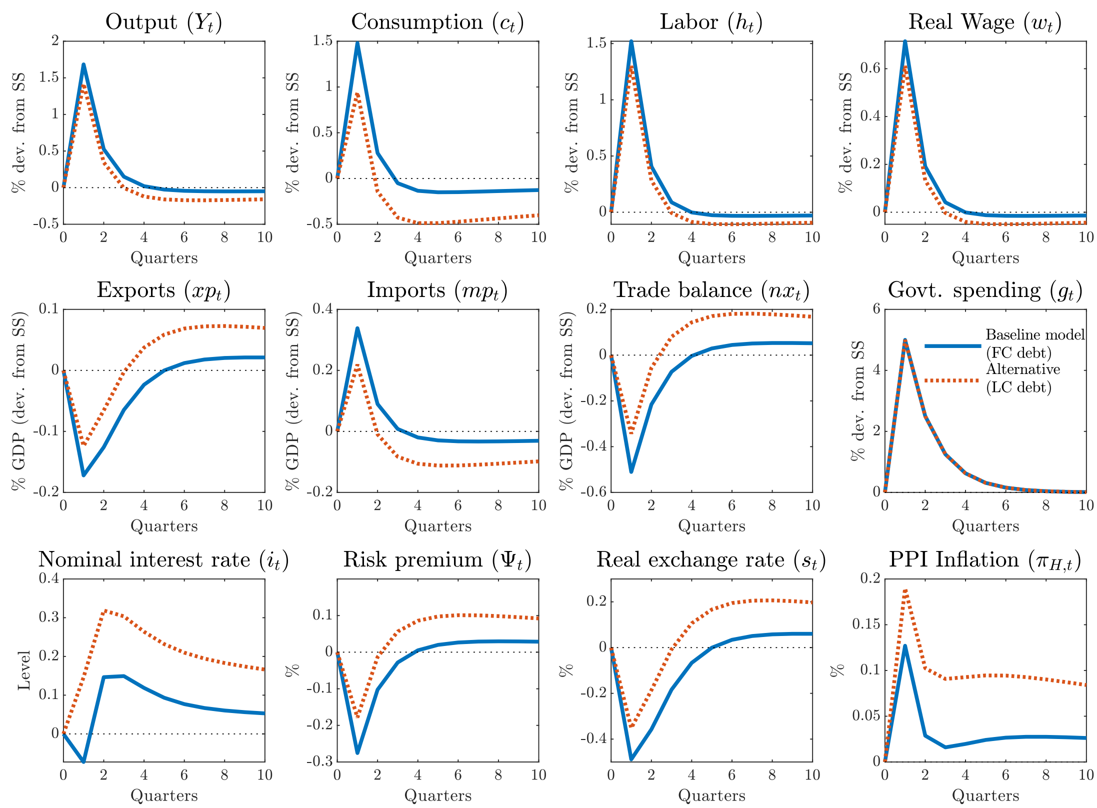
In the alternative case, however, households do not face a currency mismatch problem as external debt and income are denominated in the same currency. Therefore, the weaker real exchange rate following a shock to the risk premium does not feed back into the borrowing constraint, making the depreciation pressure smaller and the monetary policy reaction milder relative to the baseline case. The smaller increase in the risk premium therefore means that households can enjoy more consumption smoothing relative to the baseline model, experiencing a smaller need for deleveraging, a faster return to its steady-state net foreign asset position, and a smaller overall recession.

The two specifications of the model are therefore able to replicate the qualitative differences between sudden stop crises in emerging economies relative to advanced ones, as seen empirically in the event study of Section 2.1. Sudden stop cycles in EMs are more volatile over and above their usual cyclical variance relative to similar crises in AEs, as they experience sharper exchange rate depreciation, output and consumption decline, and a larger trade balance adjustment. As the model shows, the mismatch faced by households given the currency denomination of foreign assets are an important driving mechanism behind this.

4.2 State-dependent multipliers

Given that the financial amplification in the baseline model occurs via the effect of the real exchange rate on households' borrowing constraint, a government spending shock which appreciates the exchange rate can have larger multiplier effects on consumption during crisis episodes relative to shocks from the model's steady state as it is able to relax this constraint by driving down the risk premium at a time when it is highly binding. To examine this mechanism in the two versions of the model, I firstly discuss the dynamics of a government spending shock equivalent to 1% of GDP from a first-order approximation, as shown in Figure 9. Then, I examine the state-dependent effects of fiscal policy by shocking the economy at different points in the state space (Figures 10 and 11).

Figure 9: IRFs for a government spending shock of 1% of GDP



A temporary increase in fiscal spending which lasts approximately 8 quarters from the economy's steady state generates a positive consumption and output response across both versions of the model. The consumption response is however stronger both on impact and in subsequent periods in the baseline version with FC-denominated debt. Perfect home bias in government spending increases demand for the home-produced good, thereby increasing the price of the home good relative to the foreign good price and appreciating the nominal and real exchange rates. The reduction in borrowing costs are larger for the baseline economy, as the risk premium depends on the exchange rate, such that households can borrow further and increase consumption, generating further real appreciation. For the alternative model, this feedback effect is absent such that the risk premium declines by less and the monetary stance is tighter given lower exchange rate appreciation and higher home inflation. Thus, after three quarters, the positive response in consumption fades out and becomes negative.

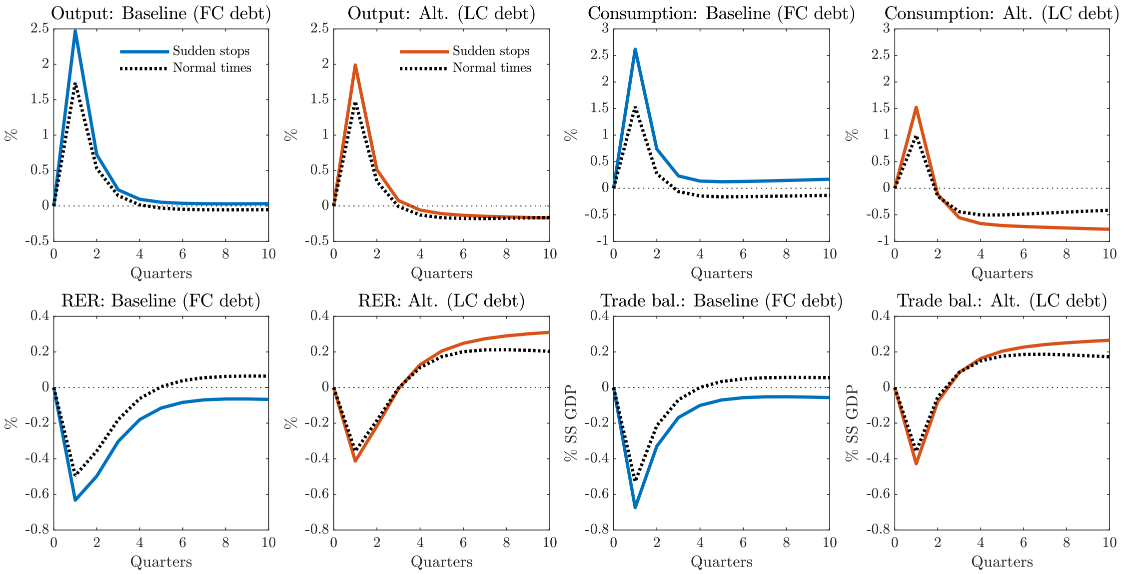
Given the effect of a positive fiscal shock in relaxing the borrowing constraint for a foreign-currency indebted household via real exchange rate appreciation, its impact on consumption is indeed higher when the shock happens during a time when the borrowing contraint is highly binding, as in our definition of a sudden stop. The generalized IRFs computed from a second-order solution of the model show this clearly for the baseline specification in Figure 10. When households owe debt in foreign currency, the response of consumption to a fiscal shock under a sudden stop (blue, solid line) is significantly larger than when the shock happens outside of such crises (black, dotted line).[22] The real exchange rate appreciation relaxes the deleveraging pressure that households face by mitigating the debt revaluation effect and reducing the risk premium, allowing for more consumption smoothing and a positive impact on consumption. This feeds back into the real exchange rate, which appreciates further when the fiscal shock occurs during a sudden stop, thus also pushing down the trade balance further relative to the shock under the ergodic mean.

This state-dependence in the effect of fiscal policy is much less clear for the alternative specification of the model with local-currency external debt. While the consumption response is larger on impact following a fiscal shock during a sudden stop, the crowding out in consumption is also larger in subsequent periods relative to the shock at the ergodic mean. The absence of the financial amplification channel through the risk premium here means that the real exchange rate appreciation is short-lived. Under the sudden stop, the subsequent RER depreciation after fourth quarters is larger, which crowds out consumption further through a tighter monetary stance.

In order to see this more clearly, and to be able to compare the results of the model to the empirical exercise in Section 2, I compute the cumulative multipliers from the government spending shock for consumption and the trade balance. To do this, I follow Mountford and Uhlig (2009) and Ramey and Zubairy (2018) by calculating the ratio of the present value of the integral of the impulse response of each variable to the present value of the integral of the impulse response of government spending, up to each horizon $h = 0, ..., 8$. Present values are computed using the steady state real interest rate. Given that responses are in logs for consumption and government spending, I scale them by their steady-state values (c and g, respectively) in order to get unit responses. For the trade balance, I only scale the denominator (i.e. g) as the trade balance response is already in levels. In this way, I am able to get the unit change in each variable from a one-unit increase in government spending for each relevant horizon, as shown in Figure 11.

[22] As expected, the GIRFs computed at the ergodic mean are similar to the responses obtained from the first-order solution in Figure 9.

Figure 10: State-dependent Generalized IRFs



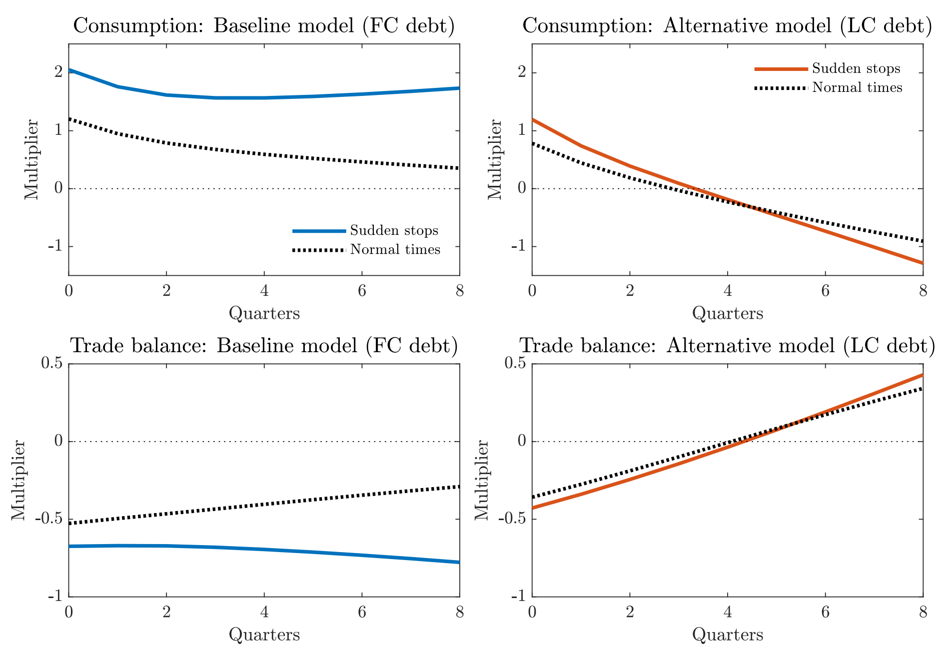
Notes: The figure compares the GIRFs obtained from a government spending shock at the ergodic mean (normal times) to an equivalent shock when NFA tolerance is 33% below its steady-state value. Solid lines represent the GIRFs under a sudden stop (blue for the baseline model and red for the alternative model) while dotted lines plot the GIRFs from the ergodic mean.

The government spending multipliers on consumption and the trade balance are unequivocally larger under sudden stops at all relevant horizons relative to multipliers under normal times for the model with FC-denominated debt, as seen on the left panel of Figure 11. Under sudden stops, multipliers for consumption are around 2 at most horizons, while at normal times, values are around 1.2 on impact and decline to around 0.6 after 4 quarters and 0.3 after 8 quarters. Similarly, trade balance multipliers are more negative under sudden stops relative to normal times. The fiscal effect on the trade balance under a sudden stop is around -0.7 on impact and slightly declines to -0.8 after 8 quarters. During normal times, the multiplier is -0.5 on impact, and -0.4 and -0.3 after 4 and 8 quarters, respectively.

Spending multipliers under the alternative model with local-currency denominated debt do not exhibit the same clear state-dependence and are generally lower in magnitude across both financial states (right panel of Figure 11). Multipliers on consumption are positive on impact across both states and marginally larger under sudden stops relative to normal times (i.e. 1.2 and 0.8, respectively). Given the crowding out effect on consumption at longer horizons shown in Figure 10, cumulative multipliers become negative after 4 quarters, and are *lower* under sudden stops relative to normal times after 8 quarters (-1.3 and -0.9, respectively). The same is the case for the fiscal effect on the trade balance. Cumulative multipliers are not significantly different, become positive at longer horizons, and marginally higher under sudden stops relative to normal times after 8 quarters.

The quantitative results from the model are therefore in line with the empirical findings. Multipliers under sudden stops for consumption and the trade balance are larger during sudden stop shocks for the specification with FC-denominated debt, as in most emerging market economies. This difference disappears in any material way once we denominate foreign debt in local currency, the empirically relevant case for advanced economies, matching the absence of non-linearity in multipliers between sudden stops and normal times found for AEs in the econometric estimation.

Figure 11: State-dependent multipliers under sudden stop crises



Notes: In this panel, $t = 0$ indicates the size of the multiplier on impact, equivalent to $t = 1$ in Figure 10 plotting the GIRFs.

5 Conclusion

This paper explores how the transmission of fiscal policy varies across countries during sudden stop crises. Using a quarterly panel dataset of 45 advanced and emerging economies, I provide empirical evidence that the state-dependence of government spending during sudden stops differs significantly across countries. Fiscal policy is substantially more effective in stimulating consumption, appreciating the exchange rate, and causing a trade deficit during sudden stops relative to normal times in emerging market economies, while this non-linearity is absent in advanced economies. Importantly, I demonstrate that the share of foreign currency-denominated external debt is the crucial determinant behind this cross-country heterogeneity in fiscal policy transmission around financial crises.

A small open economy New Keynesian model with incomplete markets further rationalizes these empirical findings. When households owe debt in foreign currency as in most EMs, a sudden stop is associated with a financial amplification mechanism where exchange rate depreciation raises the real burden of liabilities, generating a deeper demand contraction. A positive fiscal shock that appreciates the real exchange rate counteracts this amplification cycle by mitigating debt revaluation, reducing borrowing costs for households, and therefore crowding in consumption. In contrast, when debt is denominated in local currency as in most advanced economies, this balance sheet channel is absent, and the effects of fiscal policy are not materially different between sudden stops and normal times.

These findings contribute to our understanding of fiscal policy effectiveness during financial crises and highlight the importance of the currency composition of external debt in determining the transmission of fiscal policy in open economies.

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Appendix A Empirics

A.1 Data sources

Table A.1: Data sources

Variable	Source
GDP	**IMF IFS.** Seasonally adjusted real GDP in local currency (NGDP_R_SA_XDC)or nominal SA GDP (NGDP_SA_XDC) adjusted by GDP deflator (NGDP_D_SA_IX).
Private Consumption	**IMF IFS.** Final Consumption Expenditure, Private Sector. Either SA real or SA nominal adjusted by GDP deflator (NCP_R_SA_XDC or NCP_SA_XDC).
Private Investment	**IMF IFS.** Gross Fixed Capital Formation. Either SA real or SA nominal adjusted by GDP deflator (NFI_R_SA_XDC or NFI_SA_XDC).
Government Spending	**IMF IFS.** Final Consumption Expenditure, General Government. Either SA real or SA nominal adjusted by GDP deflator (NCGG_R_SA_XDC or NCGG_SA_XDC).
Current account balance	**IMF IFS, IMF BOP.** BoP, Supplementary Items, Current Account, Net (BCAXF_BP6_USD) divided by nominal GDP in USD. **OECD MEI.** Current account balance, Total, % GDP (B6BLTT02_STSA).
Trade balance	**IMF IFS, IMF BOP.** BoP, Current Account, Goods, Credit/Debit, USD (BXG_BP6_USD and BMG_BP6_USD) divided by nominal GDP in USD.
Real exchange rate	**IMF IFS.** Real Effective Exchange Rate, based on Consumer Price Index (EREER_IX).
Exchange rate regimes	Data from Ilzetzki, Reinhart and Rogoff (2019). Pegged regime: no legal tender, pre-announced and de facto pegs, and crawling pegs narrower than or equal to +/- 2%. Flexible regime: remaining classifications.

A.2 Data coverage and sudden stop episodes

Table A.2 below outlines the list of countries in the baseline sample, the sample length for each country, their income group classification, and the sudden stop episodes identified in the data. The sample contains 45 countries (24 EMs and 21 AEs) and 57 sudden stop episodes (36 episodes for EMs and 21 for AEs).

Table A.2: Data coverage and sudden stop episodes

Country	**Sample period**	**Income group**	**No. SS episodes**	**SS episode dates**
Argentina	1Q1993-4Q2016	EM	1	3Q01-2Q04
Australia	1Q1980-4Q2016	AE	3	4Q86-4Q88; 1Q00-4Q02; 1Q08-3Q10
Austria	1Q1999-4Q2016	AE	2	3Q01-3Q03; 2Q14-2Q16
Belgium	1Q2003-4Q2016	AE	2	1Q09-2Q11; 4Q11-3Q14
Bolivia	1Q1990-4Q2016	EM	1	3Q93-3Q95
Brazil	1Q1995-4Q2016	EM	2	1Q02-4Q04; 2Q15-4Q16
Bulgaria	1Q1996-4Q2016	EM	1	2Q09-2Q11
Canada	1Q1981-4Q2016	AE	0	
Chile	1Q1996-4Q2016	EM	1	4Q08-2Q11
Colombia	1Q1996-4Q2016	EM	1	3Q98-2Q01
Czech Republic	1Q1995-4Q2016	EM	2	3Q97-3Q93; 1Q08-1Q10
Denmark	1Q2005-4Q2016	AE	1	1Q10-1Q12
Ecuador	1Q1994-4Q2016	EM	1	4Q98-3Q01
Estonia	1Q1995-4Q2016	EM	1	2Q08-4Q10
Finland	1Q1999-4Q2016	AE	0	
France	1Q1999-4Q2016	AE	1	4Q14-4Q16
Germany	1Q1999-4Q2016	AE	0	
Greece	1Q1999-4Q2016	AE	1	4Q11-2Q14
Hungary	1Q1995-4Q2016	EM	1	1Q09-2Q11
Indonesia	1Q1990-4Q2016	EM	1	3Q97-1Q00
Italy	1Q1980-4Q2016	AE	1	4Q92-2Q95
Japan	1Q1996-4Q2016	AE	0	
Korea	1Q1980-4Q2016	EM	1	3Q97-2Q00
Latvia	1Q1995-4Q2016	EM	1	3Q08-2Q11
Lithuania	1Q1995-4Q2016	EM	1	2Q08-2Q11
Malaysia	1Q1991-4Q2016	EM	1	1Q98-4Q00

Country	Sample period	Income group	No. SS episodes	SS episode dates
Mexico	1Q1981-4Q2016	EM	3	1Q82-4Q84; 3Q86-4Q88; 3Q94-2Q97
Netherlands	2Q2003-4Q2016	AE	0	
New Zealand	2Q1987-4Q2016	AE	3	3Q97-3Q99; 2Q00-4Q02; 4Q08-1Q11
Norway	1Q1981-4Q2016	AE	0	
Peru	1Q1991-4Q2016	EM	2	3Q98-3Q00; 4Q08-2Q11
Philippines	1Q1981-4Q2016	EM	4	2Q84-4Q87; 4Q90-2Q93; 4Q97-2Q00; 1Q09-1Q11
Poland	1Q1995-4Q2016	EM	1	1Q09-1Q11
Portugal	1Q1980-4Q2016	AE	1	4Q11-4Q13
Romania	1Q1995-4Q2016	EM	1	2Q08-1Q11
Russia	1Q1995-4Q2016	EM	1	2Q98-4Q01
Singapore	1Q1995-4Q2016	AE	2	1Q98-2Q00; 2Q01-1Q05
South Africa	1Q1980-4Q2016	EM	1	4Q84-2Q87
Spain	1Q1980-4Q2016	AE	1	2Q12-2Q14
Sweden	1Q1993-4Q2016	AE	1	3Q93-3Q95
Switzerland	1Q1999-4Q2016	AE	1	1Q09-1Q12
Thailand	1Q1993-4Q2016	EM	2	2Q97-1Q00; 3Q08-3Q10
Turkey	1Q1987-4Q2016	EM	4	2Q88-2Q90; 4Q93-2Q96 4Q00-2Q03; 3Q08-4Q10
United Kingdom	1Q1980-4Q2016	AE	0	
United States	1Q1980-4Q2016	AE	1	4Q08-4Q10

A.3 Results

A.3.1 EMs vs. AEs

Table A.3: Emerging Economies: Estimates of Fiscal Multipliers

	Linear Model	**Nonlinear Model** Sudden Stops	Normal times	p-value of difference
Consumption				
Impact	0.18	0.68	0.03	0.187
	(0.16)	(0.47)	(0.15)	
1 year	0.75	1.37	0.42	0.022**
	(0.17)	(0.37)	(0.17)	
2 years	0.52	1.19	0.17	0.008***
	(0.19)	(0.33)	(0.22)	
Trade Balance				
Impact	-0.40	-1.51	-0.07	0.000***
	(0.13)	(0.42)	(0.11)	
1 year	-1.39	-2.43	-0.80	0.003***
	(0.23)	(0.50)	(0.22)	
2 years	-1.33	-2.57	-0.66	0.005***
	(0.28)	(0.61)	(0.31)	

Notes: The table reports estimates of the cumulative government spending multiplier in levels for the sub-sample of emerging economies. Standard errors are heteroskedasticity and autocorrelation consistent (HAC). The first column shows multipliers for the linear model, the second and third columns show multipliers for each state of the non-linear specification, and the last column shows the p-value for the null hypothesis that multipliers in sudden stops and normal times are equal. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

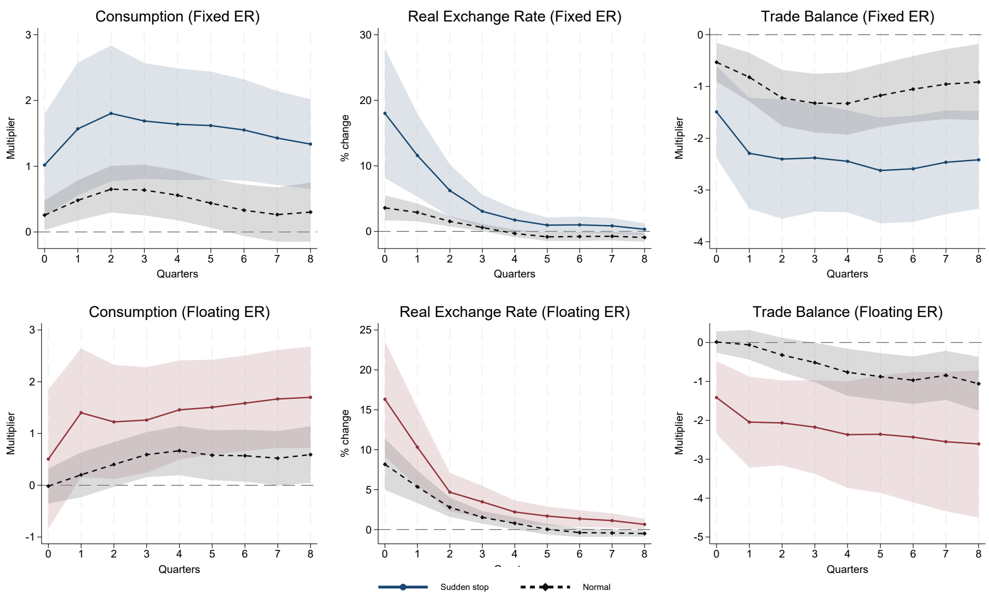
Table A.4: Advanced Economies: Estimates of Fiscal Multipliers

	Linear Model	**Nonlinear Model** Sudden Stops	Normal times	p-value of difference
Consumption				
Impact	0.43	0.31	0.39	0.866
	(0.27)	(0.37)	(0.32)	
1 year	1.09	0.95	1.09	0.784
	(0.37)	(0.37)	(0.46)	
2 years	0.99	0.93	0.98	0.907
	(0.33)	(0.32)	(0.39)	
Trade Balance				
Impact	-1.00	-0.52	-1.13	0.607
	(0.60)	(0.91)	(0.72)	
1 year	-1.56	-0.50	-1.76	0.227
	(0.58)	(0.76)	(0.72)	
2 years	-1.44	-0.24	-1.75	0.137
	(0.53)	(0.89)	(0.60)	

Notes: The table reports estimates of the cumulative government spending multiplier in levels for the sub-sample of advanced economies. Standard errors are HAC. *, **, and *** indicate 10%, 5% and 1% significance, respectively.

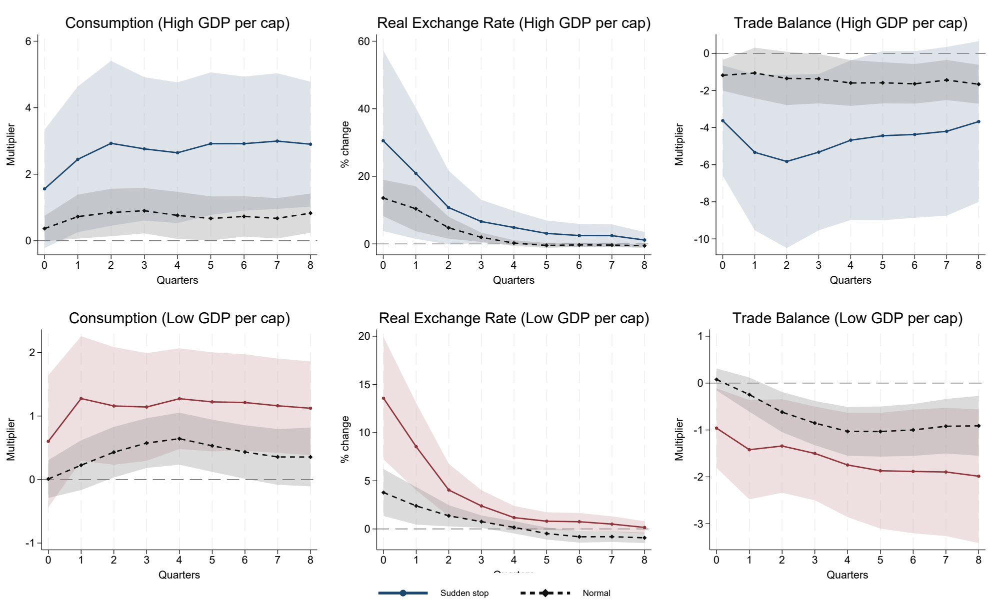
A.3.2 Drivers of cross-country heterogeneity in state-dependence

Figure A.1: Fiscal Multipliers in Sudden Stops vs. Normal Times for Fixed vs. Floating ER regimes



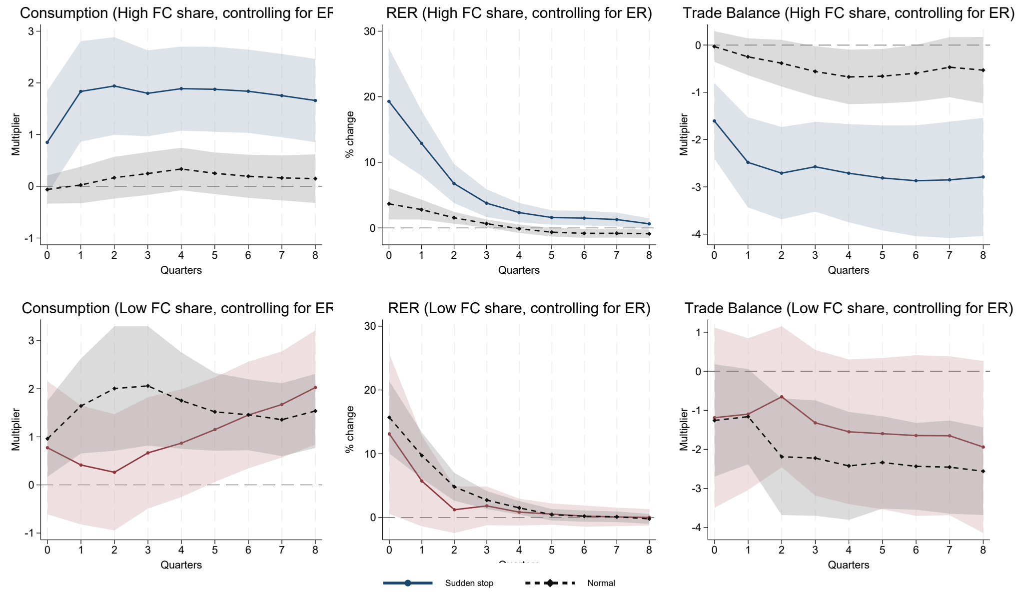
Notes: Error bands are 90% confidence intervals.

Figure A.2: Fiscal Multipliers in Sudden Stops vs. Normal Times for High vs. Low GDP per capita



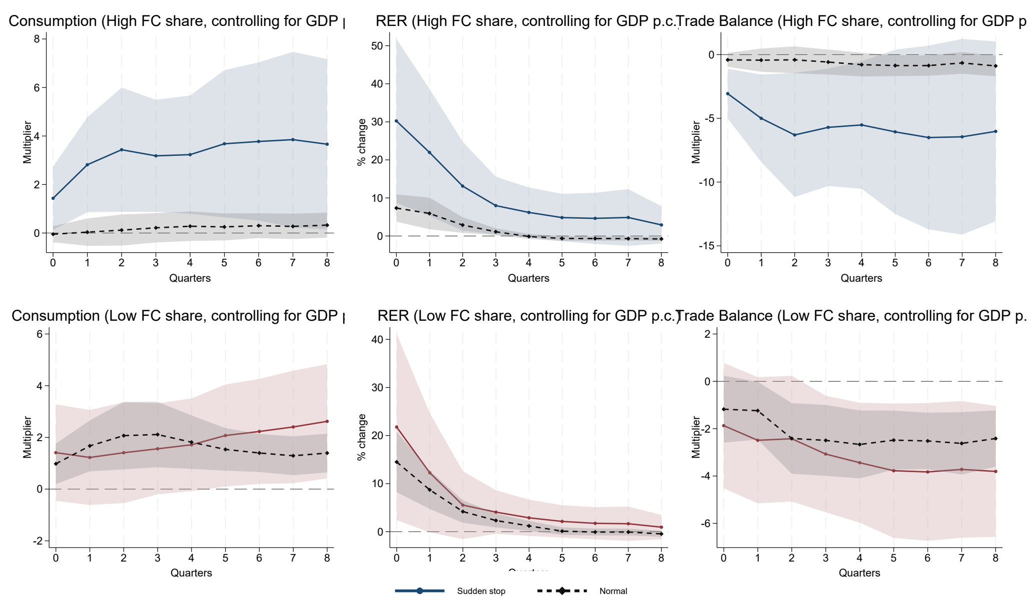
Notes: Cumulative multipliers for government expenditure shock with low (10th percentile) and high (90th percentile) GDP per capita. Error bands are 90% confidence intervals.

Figure A.3: Fiscal Multipliers in SS vs. Normal for High vs. Low FC share controlling for ER regime



Notes: Cumulative multipliers for government expenditure shock with low (10th percentile) and high (90th percentile) FC share. Error bands are 90% confidence intervals.

Figure A.4: Fiscal Multipliers in SS vs. Normal for High vs. Low FC share controlling for GDP per capita



Notes: Cumulative multipliers for government expenditure shock with low (10th percentile) and high (90th percentile) FC share. Error bands are 90% confidence intervals.

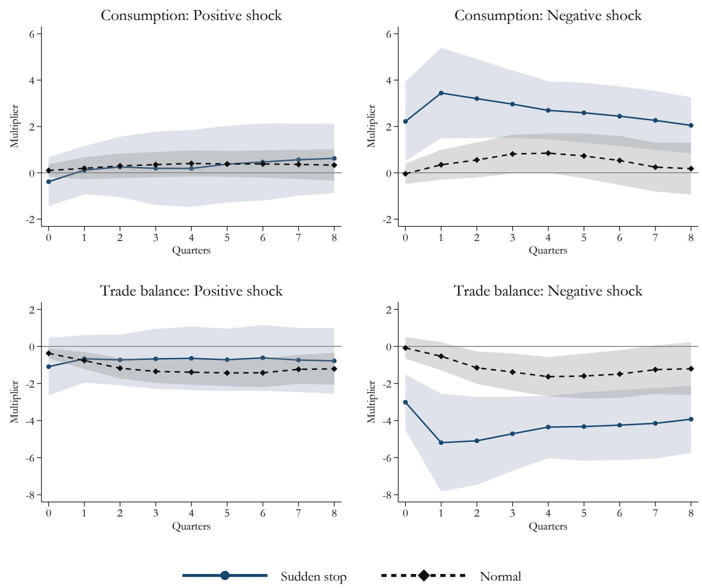
A.3.3 Sign-Dependent Multipliers

The estimation discussed in Section 2.4 where I control for the signs of fiscal shocks to test for asymmetric fiscal multipliers is obtained by using the following specification

$$
\begin{aligned}
\sum_{j=0}^{h} y_{t+j} = \gamma + \delta_t &+ I_{i,t-1} \times 1^{+}_{i,t-1}\left[\alpha_i^{+SS} + m_{y,h}^{+SS}\sum_{j=0}^{h} g_{i,t+j} + \psi_h^{+SS}(L)Z_{i,t-1}\right] \\
&+ I_{i,t-1} \times 1^{-}_{i,t-1}\left[\alpha_i^{-SS} + m_{y,h}^{-SS}\sum_{j=0}^{h} g_{i,t+j} + \psi_h^{-SS}(L)Z_{i,t-1}\right] \\
&+ (1 - I_{i,t-1}) \times 1^{+}_{i,t-1}\left[\alpha_i^{+N} + m_{y,h}^{+N}\sum_{j=0}^{h} g_{i,t+j} + \psi_h^{+N}(L)Z_{i,t-1}\right] \\
&+ (1 - I_{i,t-1}) \times 1^{-}_{i,t-1}\left[\alpha_i^{-N} + m_{y,h}^{-N}\sum_{j=0}^{h} g_{i,t+j} + \psi_h^{-N}(L)Z_{i,t-1}\right] + u_{i,t+h}
\end{aligned}
$$

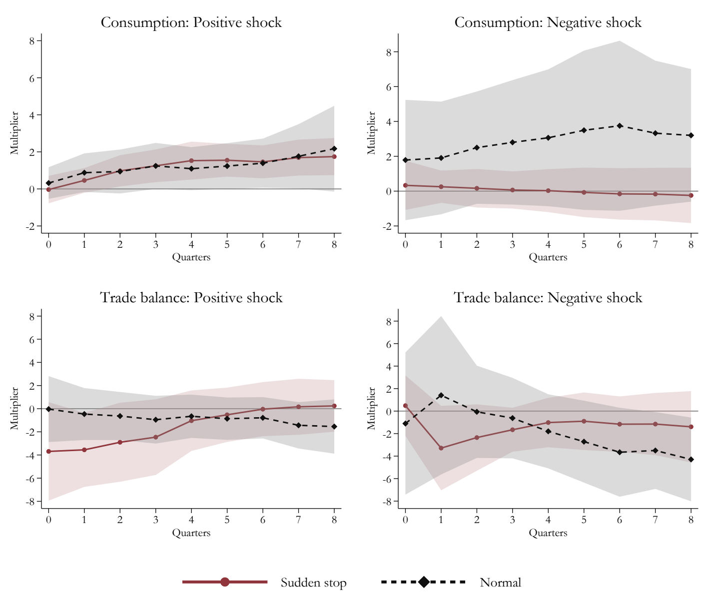
where 1^{+} and 1^{-} denotes whether the 1st stage instrument for the fiscal shock is positive or negative in each period, respectively. I produce a similar asymmetric estimation to the one shown in Figure A.5 for AEs below. Differently than for EMDEs, spending multipliers for AEs do not exhibit sign-dependence.

Figure A.5: Emerging Economies: Sign-Dependent Multipliers in Sudden Stops vs. Normal Time



Notes: Error bands for both states (i.e. sudden stops and normal) are 90% confidence intervals with HAC standard errors.

Figure A.6: Advanced Economies: Sign-Dependent Multipliers in Sudden Stops vs. Normal Times



Notes: Error bands for both states (i.e. sudden stops and normal) are 90% confidence intervals with HAC standard errors.

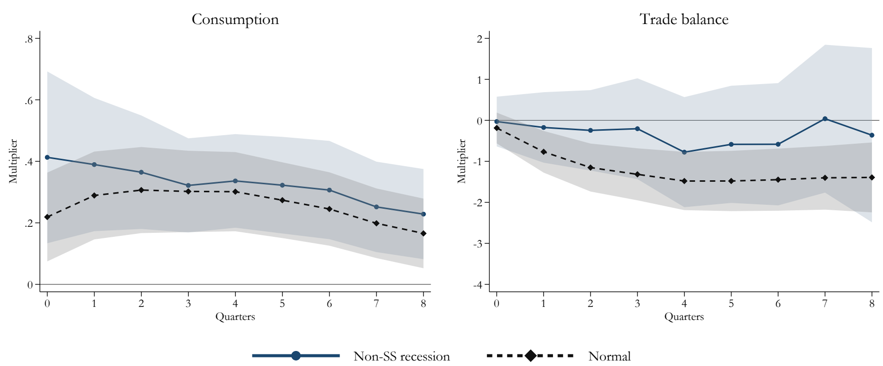
A.3.4 Multipliers in Non-SS Recessions

Finally, in order to compare multipliers in normal (non-sudden stop) recessions vs. normal times, I estimate a similar specification to the baseline one

$$\sum_{j=0}^{h} y_{t+j} = \gamma + \delta_t + I_{i,t-1}\left[\alpha_i^{NR} + m_{y,h}^{NR}\sum_{j=0}^{h} g_{i,t+j} + \psi_h^{NR}(L)Z_{i,t-1}\right]$$
$$+ (1 - I_{i,t-1})\left[\alpha_i^{N} + m_{y,h}^{N}\sum_{j=0}^{h} g_{i,t+j} + \psi_h^{N}(L)Z_{i,t-1}\right] + u_{i,t+h},$$

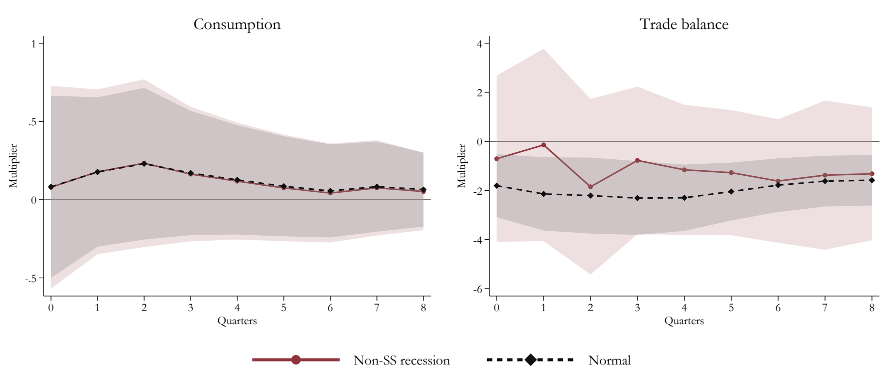
where NR denotes normal recessions (see Section 2.4) and N denotes normal times.

Figure A.7: Emerging Economies: Non-SS Recessions vs. Normal Times



Notes: Error bands for both states (i.e. sudden stops and normal) are 90% confidence intervals with HAC standard errors.

Figure A.8: Advanced Economies: Non-SS Recessions vs. Normal Times



Notes: Error bands for both states (i.e. sudden stops and normal) are 90% confidence intervals with HAC standard errors.

A.4 Event study breakdown

Figures A.9 and A.10 show the country breakdown of the mean path by country groups reported in Figure 2. Each line in the figures represents the cyclical behavioral of individual countries around sudden stop events. Figure A.11 shows the cumulative decline in GDP and consumption for selected AE sudden stop episodes.

Figure A.9: Emerging Economies: Country Breakdown of Event Study

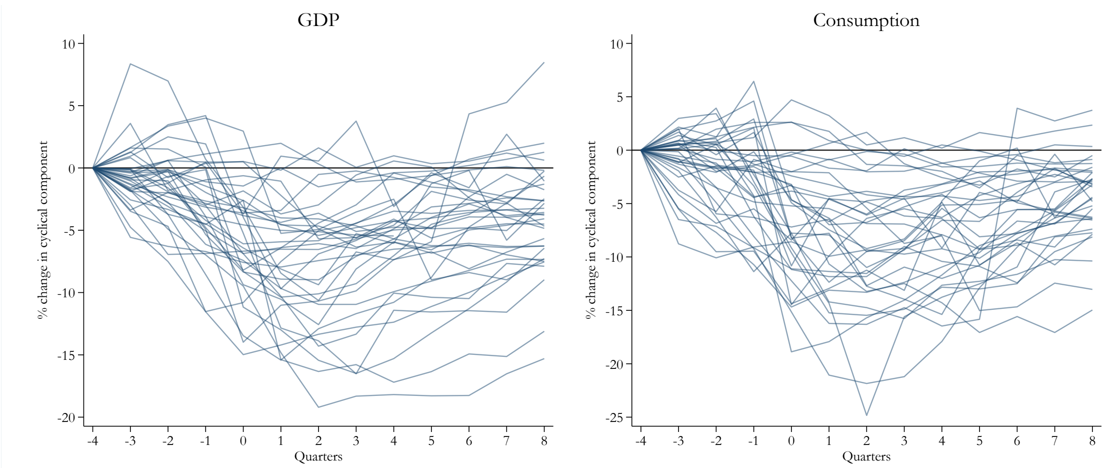


Figure A.10: Advanced Economies: Country Breakdown of Event Study

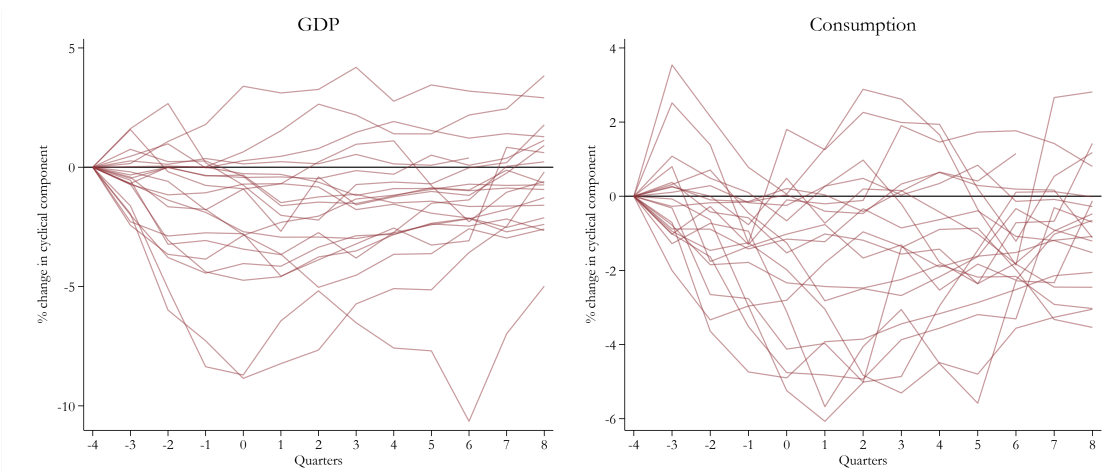
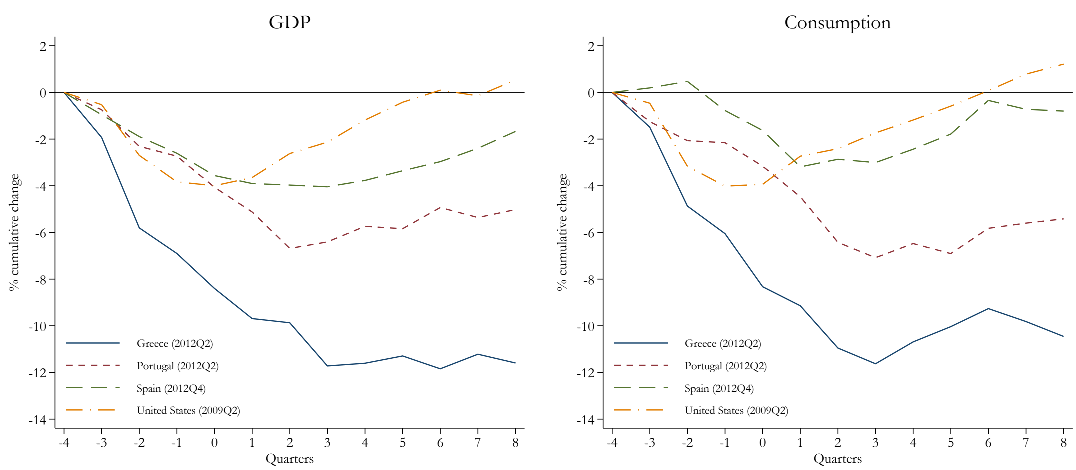


Figure A.11: GDP and Consumption under Selected Sudden Stop Episodes in AEs



Appendix B Model

B.1 Equilibrium Conditions

The optimality conditions determining the competitive equilibrium of the model are given by:

Households

$$\lambda_t = \left(c_t - \chi \frac{h_t^{1+\phi}}{1+\phi}\right)^{-\sigma} \tag{B.1}$$

$$1 = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \frac{(1+i_t)}{\pi_{t+1}}\right] \tag{B.2}$$

$$1 = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \frac{(1+i_t^*)}{\pi_{t+1}^*} \Psi_t \frac{s_{t+1}}{s_t}\right] \tag{B.3}$$

$$\chi h_t^{\phi} = w_t \tag{B.4}$$

$$c_{H,t} = (1-\gamma)(p_{H,t})^{-\eta} c_t \tag{B.5}$$

$$c_{F,t} = \gamma (s_t)^{-\eta} c_t \tag{B.6}$$

Firms

$$Y_{H,t} = A_t h_t \tag{B.7}$$

$$w_t h_t = mc_t Y_{H,t} \tag{B.8}$$

$$\pi_{H,t}(\pi_{H,t} - \bar{\pi}) = \beta E_t \left[\frac{\lambda_{t+1}}{\lambda_t} \pi_{H,t+1}(\pi_{H,t+1} - \bar{\pi}) \frac{p_{H,t+1} Y_{H,t+1}}{p_{H,t} Y_{H,t}}\right] + \frac{\varepsilon}{\theta}\left(\frac{mc_t}{p_{H,t}} - \frac{\varepsilon - 1}{\varepsilon}\right) \tag{B.9}$$

Prices and policy

$$p_{H,t} = \left[\frac{1 - \gamma s_t^{1-\eta}}{1-\gamma}\right]^{\frac{1}{1-\eta}} \tag{B.10}$$

$$\frac{s_t}{s_{t-1}} = \frac{\Delta e_t}{\pi_t} \tag{B.11}$$

$$tot_t = \frac{s_t}{p_{H,t}} \tag{B.12}$$

$$1 + r_t = \frac{(1+i_t)}{E_t \pi_{t+1}} \tag{B.13}$$

$$\pi_{H,t} = \frac{p_{H,t}}{p_{H,t-1}} \pi_t \tag{B.14}$$

$$\frac{1+i_t}{1+i} = \left(\frac{\pi_{H,t}}{\bar{\pi}}\right)^{\phi_\pi} \left(\frac{Y_t}{\bar{Y}}\right)^{\phi_y} \left(\frac{\Delta e_t}{\bar{\Delta e}}\right)^{\phi_e} \exp(\epsilon_t^m) \tag{B.15}$$

$$\Psi_t = e^{-\delta\left(\frac{s_t b_t^*}{Y_t} - \zeta_t\right)}$$
$$\text{or} \quad \Psi_t = e^{-\delta\left(\frac{b_t}{Y_t} - \zeta_t\right)} \tag{B.16}$$

Market clearing

$$Y_t = p_{H,t} Y_{H,t} \tag{B.17}$$

$$Y_{H,t} = c_{H,t} + c_{H,t}^* + g_t + \frac{\theta}{2}(\pi_{H,t} - \bar{\pi})^2 Y_{H,t} \tag{B.18}$$

$$c_{H,t}^* = \gamma^*(tot_t)^\eta y_t^* \tag{B.19}$$

$$nx_t = p_{H,t} c_{H,t}^* - s_t c_{F,t} \tag{B.20}$$

$$xp_t = p_{H,t} c_{H,t}^* \tag{B.21}$$

$$mp_t = s_t c_{F,t} \tag{B.22}$$

$$s_t b_t^* - (1 + i_{t-1}^*)\Psi_{t-1} s_t b_{t-1}^* = nx_t$$
$$\text{or} \qquad b_t - (1 + r_{t-1}) b_{t-1} = nx_t \tag{B.23}$$

Exogenous processes

$$(1 + i_t^*) = (1 - \rho_i)\frac{1}{\beta} + \rho_i(1 + i_{t-1}^*) + \epsilon_t^i \tag{B.24}$$

$$\log(A_t) = (1 - \rho_a)\log(\bar{A}) + \rho_a \log(A_{t-1}) + \epsilon_t^A \tag{B.25}$$

$$\log(g_t) = (1 - \rho_g)\log(\bar{g}) + \rho_g \log(g_{t-1}) + \epsilon_t^g \tag{B.26}$$

$$\log(y_t^*) = \rho_y \log(y_{t-1}^*) + \epsilon_t^y \tag{B.27}$$

$$\zeta_t = (1 - \rho_\zeta)\bar{\zeta} + \rho_\zeta \zeta_{t-1} + \epsilon_t^\zeta \tag{B.28}$$

Therefore, we have 28 equations in 28 endogenous variables:

$$X_t \equiv [\lambda_t, c_t, h_t, c_{H,t}, c_{F,t}, w_t, i_t, r_t, i_t^*, s_t, \Psi_t, \Delta e_t, A_t, Y_{H,t}, p_{H,t}, mc_t, \pi_{H,t}, \pi_t, tot_t, Y_t, g_t, y_t^*, c_{H,t}^*, nx_t, xp_t, mp_t, b_t^*, \zeta_t]$$

The model features five exogenous shocks: $\epsilon_t \equiv [\epsilon_t^i, \epsilon_t^A, \epsilon_t^g, \epsilon_t^y, \epsilon_t^\zeta]$.

B.2 Steady State

I normalize output $Y = 1$, the relative PPI-CPI wedge $p_H = 1$, and hours $h = 1$. By (B.10) and (B.17), this implies

$$s = 1$$

$$Y_H = 1,$$

and by (B.12), we get

$$tot = 1.$$

From the Euler equation (B.2) and (B.13),

$$(1 + r) = \frac{1}{\beta},$$

$$(1 + i) = \frac{\pi}{\beta}.$$

Similarly, the exogenous process (B.24) implies

$$(1 + i^*) = \frac{1}{\beta}.$$

Equations (B.25) and (B.7), together with $h = 1$, yields :

$$A = \bar{A} = 1.$$

By the Taylor rule (B.15), we have

$$\pi_H = \bar{\pi},$$

which I normalize to 1. From (B.14) and (B.11), it follows that

$$\pi = 1,$$

$$\Delta e = 1.$$

By (B.9), (B.8), and (B.4),

$$mc = \frac{\varepsilon - 1}{\varepsilon},$$

$$w = mc \frac{Y_H}{h},$$

$$\chi = \frac{w}{h^\phi},$$

and given that $\varepsilon = 6$, $h = 1$, and $Y_H = 1$, $mc = w = \chi = 0.833$.

I calibrate the annual net foreign asset position to GDP to -0.375, following Motyovski (2020), such that

$$-0.375 = \frac{s \cdot b}{4 \cdot Y}$$

Given that $s = 1$ and $Y = 1$, it follows that

$$b^* = b = -1.5.$$

This holds for both specifications of the model (using b^* and b). From (B.16) and (B.28), it follows that

$$\zeta = \bar{\zeta} = \frac{sb^*}{Y} = \frac{b}{Y} = -1.5$$

$$\Psi = 1$$

From (B.23), we get that

$$nx = \left(1 - \frac{1}{\beta}\right) b^* = 0.015$$

I calibrate steady-state government spending g to be

$$g = \bar{g} = 0.2.$$

Therefore, given that $nx_t = Y_t - p_{H,t} g_t - c_t$ (see Section 3.4.3), we get that

$$c = Y - g - nx = 0.785$$

From (B.5) and (B.6) we then get that

$$c_H = (1 - \gamma)c = 0.589$$

$$c_H = \gamma c = 0.196.$$

From (B.1) we have

$$\lambda = \left(c - \chi \frac{h^{1+\phi}}{1+\phi}\right)^{-\sigma}$$

From (B.18) and (B.19),

$$c_H^* = 1 - c_H - g$$

$$y^* = c_H^*$$

Finally, (B.21) and (B.22) imply

$$xp = c_H$$

$$mp = c_F$$

B.3 Additional derivations

The solution to the intermediate-good firm problem yields the following first order conditions:

$$w_t = A_t mc_t(i)$$

and

$$(1-\varepsilon)\frac{Y_{H,t}}{P_t}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\varepsilon} - \frac{\theta}{P_{H,t-1}(i)}\left(\frac{P_{H,t}(i)}{P_{H,t-1}(i)} - \bar{\pi}\right)\frac{P_{H,t}Y_{H,t}}{P_t} + \varepsilon mc_t(i)\frac{Y_{H,t}}{P_{H,t}}\left(\frac{P_{H,t}(i)}{P_{H,t}}\right)^{-\varepsilon-1} +$$
$$+\beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\theta\frac{P_{H,t+1}(i)}{P_{H,t}(i)^2}\left(\frac{P_{H,t+1}(i)}{P_{H,t}(i)} - \bar{\pi}\right)\frac{P_{H,t+1}Y_{H,t+1}}{P_{t+1}}\right] = 0$$

where $mc_t(i)$ is the Lagrangian multiplier, interpreted as the real marginal cost of producing one additional unit of output.

In a symmetric equilibrium where firms choose the same price, inputs, and output, this becomes:

$$w_t = A_t mc_t = mc_t\frac{Y_{H,t}}{h_t}$$

and we can write the pricing function in terms of $p_{H,t}$, yielding a standard New Keynesian Phillips Curve:

$$\pi_{H,t}(\pi_{H,t} - \bar{\pi}) = \beta E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\pi_{H,t+1}(\pi_{H,t+1} - \bar{\pi})\frac{p_{H,t+1}Y_{H,t+1}}{p_{H,t}Y_{H,t}}\right] + \frac{\varepsilon}{\theta}\left(\frac{mc_t}{p_{H,t}} - \frac{\varepsilon-1}{\varepsilon}\right)$$

where

$$\pi_{H,t} = \frac{P_{H,t}}{P_{H,t-1}} = \frac{p_{H,t}}{p_{H,t-1}}\pi_t.$$