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Pablo Anaya Longaric

Foreign currency exposure and the financial channel of exchange rates

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Abstract

Exchange rate movements affect the economy through changes in net exports, i.e. the trade channel, and through valuation changes in assets and liabilities denominated in foreign currencies, i.e. the financial channel. In this paper, I investigate the macroeconomic and financial effects of U.S. dollar (USD) exchange rate fluctuations in small open economies. Specifically, I examine how the financial channel affects the overall impact of exchange rate fluctuations and assess to what extent foreign currency exposure determines the financial channel's strength. My empirical analysis indicates that, if foreign currency exposure is high, an appreciation of the domestic currency against the USD is *expansionary* and loosens financial conditions, which is consistent with the financial channel of exchange rates. Moreover, I estimate a small open economy New Keynesian model, in which a fraction of the domestic banks' liabilities is denominated in USD. In line with the empirical results, the model shows that an appreciation against the USD can be expansionary depending on the strength of the financial channel, which is linked to the level of foreign currency exposure. Finally, the model indicates that the financial channel amplifies the effects of foreign monetary policy shocks.

JEL Classification: E44, F31, F41

Keywords: Exchange rates, financial and trade channels, local projections - instrumental variable, open economy DSGE model.

Non-technical summary

The onset of the Global Financial Crisis, and the resulting implementation of extraordinarily expansionary monetary have renewed the interest in the effects of global and foreign shocks in small open economies (SOEs). One important international transmission mechanism of such shocks are U.S. dollar (USD) exchange rate fluctuations. But, how do exchange rate movements affect macroeconomic and financial conditions? Exchange rate movements can affect the economy through exports and imports (the trade channel) and through valuation effects of assets and liabilities denominated in foreign currency (the financial channel). It has been conventional wisdom in international macroeconomics that a domestic appreciation has contractionary effects on the economy due to a decrease in net exports, other things being equal. However, because of the increasing degree of global financial integration, foreign currency exposure - in this paper defined as debt in a foreign currency - has gained more attention, and therefore the relevance of exchange rate movements operating through the financial channel has increased. Crucially, the financial channel can potentially work in the opposite direction of the trade channel, since, under foreign currency exposure, a domestic appreciation decreases the value of liabilities relative to assets. This strengthens the external balance sheet, which loosens financial conditions and ultimately stimulates investment and GDP.

In this paper, I empirically assess the macroeconomic and financial effects of USD exchange rate movements in a sample of seventeen SOEs.[1] In particular, I study how the financial channel affects the overall impact of exchange rate fluctuations, and under which conditions it dominates the trade channel. To do so, I employ Local Projection - Instrumental Variable methods and an estimated Small Open Economy New Keynesian model.

As a first step, I construct an external instrument to identify exogenous movements of the SOEs' currencies against the USD. Then, I use Local Projections to estimate the macroeconomic and financial effects of a domestic appreciation against the USD in the countries in my sample. To assess the strength of the trade and financial channels, I estimate these effects taking into account several indicators that reflect the intensity of international financial linkages and international trade. I analyze whether the effects of an appreciation against the USD depend on foreign currency exposure, measured by the amount of liabilities denominated in USD as percent of GDP. I find that in countries with relatively high liabilities in USD, the financial channel dominates, as the domestic appreciation against the USD leads to an increase of real GDP, real investment, real consumption, and to a loosening of financial conditions, despite the decrease in net exports. By contrast, in countries with relatively low liabilities in USD or with high trade openness (measured as the sum of exports and imports as a fraction of GDP), the appreciation is contractionary, as implied by the trade channel.

Next, I estimate an open economy New Keynesian model with financial frictions, in which a fraction of the domestic banks' debt is denominated in USD. As it is the case in standard open economy DSGE

[1]The small open economies in my sample are: Brazil, Chile, Colombia, the Czech Republic, Hungary, India, Indonesia, Israel, Korea, Mexico, Peru, the Philippines, Poland, Russia, South Africa, Thailand, and Turkey.

models, fluctuations in the exchange rate have an effect on the trade balance, as relative prices of exports and imports change. However, in my model, exchange rate fluctuations also affect the banks' balance sheets as their assets are denominated in domestic currency and their liabilities are denominated in part in USD. Thus, an appreciation of the domestic currency reduces the value of foreign currency exposure, strengthening borrowers' balance sheets, which in turn exerts upward pressure on the value of the local currency. This feature of the model allows a careful analysis of the effects of exchange rate movements through the financial channel. For the estimation of the model I use Brazilian data and then analyze the effects of a UIP risk-premium shock. In line with the empirical results, I find that the level of foreign currency exposure is an important determinant of the strength of the financial channel. Moreover, the estimated DSGE model indicates that the trade channel, trough trade openness, also determines whether an appreciation is expansionary or contractionary. This analysis suggests that it is the interaction between the financial and trade channels that determines the effects of exchange rate appreciations in SOEs. Finally, I also find that the foreign currency exposure and the financial channel amplify the effects of foreign monetary policy in SOEs.

1 Introduction

The onset of the Global Financial Crisis, the implementation of extraordinarily expansionary monetary policies across the world and the recent monetary tightening in the U.S. have renewed the interest in the effects of global and foreign shocks in small open economies (SOEs). One important international transmission mechanism of such shocks are USD exchange rate fluctuations (Iacoviello and Navarro, 2019; Ben Zeev, 2019). But, how do exchange rate movements affect macroeconomic and financial conditions? Exchange rate movements can affect the economy through exports and imports (the trade channel) and through valuation effects of assets and liabilities denominated in foreign currency (the financial channel). It has been conventional wisdom in international macroeconomics that a domestic appreciation has contractionary effects on the economy due to a decrease in net exports, other things being equal.[2] However, because of the ever higher degree of financial integration,[3] foreign currency exposure has gained more attention (Bénétrix et al., 2015), and therefore the relevance of exchange rate movements operating through the financial channel has increased (Bruno and Shin, 2015b; Hofmann et al., 2017). Crucially, the financial channel can potentially work in the opposite direction of the trade channel (Avdjiev et al., 2019), since it operates through the liability side of a country's external balance sheet. Thus, under foreign currency exposure, a domestic appreciation decreases the value of liabilities relative to assets. This strengthens the external balance sheet, which loosens financial conditions and ultimately stimulates investment and GDP (Avdjiev et al., 2019).[4]

The aim of this paper is to empirically assess the macroeconomic and financial effects of USD exchange rate movements in small open economies (SOEs).[5] In particular, I study how the financial channel affects the overall impact of exchange rate fluctuations, under which conditions it dominates the trade channel, and to what extent foreign currency exposure – i.e. liabilities denominated in USD – determines its strength. After showing the effects of the financial channel, I evaluate whether it amplifies or dampens the effects of foreign monetary policy shocks. I structure the analysis to answer the following consecutive research questions: *(i)* What are the overall macroeconomic and financial effects of USD exchange rate movements in SOEs? *(ii)* Under which conditions does the financial channel dominate the trade channel? *(iii)* What are the financial channel's implications for the propagation of foreign monetary policy shocks into a SOE? I focus on the USD exchange rate since it is by far the most important currency in international trade and finance, that is why it is well suited to capture effects working through trade and financial market relations. To answer the questions, I propose a new identification scheme for USD exchange rate shocks to individual SOEs and use Local Projections - Instrumental Variable (henceforth LP-IV) methods. Furthermore, to obtain a structural interpretation of the empirical findings and be able to

[2] Under certain conditions, a domestic appreciation can also be expansionary in the absence of the financial channel. See Section 3.

[3] For details, see Figure 1 in Section 3, which shows the rise of financial openness over the past two decades, defined as the sum of assets and liabilities in foreign currency as a percent of GDP.

[4] See Section 3 for details.

[5] The small open economies in my sample are: Brazil, Chile, Colombia, the Czech Republic, Hungary, India, Indonesia, Israel, Korea, Mexico, Peru, the Philippines, Poland, Russia, South Africa, Thailand, and Turkey.

analyze the trade and financial channels in detail, I estimate a small open economy New Keynesian model with financial frictions and currency mismatch in the banks' balance sheets.

Exchange rate movements are highly endogenous to macroeconomic conditions, therefore it is challenging to empirically assess their effects. To deal with this problem, I construct an external instrument and identify exchange rate shocks that are specifically related to the USD exchange rate and are exogenous to the set of SOEs in my sample. The shocks that I identify can be interpreted as changes in the bilateral USD exchange rate unrelated to individual SOEs' fundamentals or global driving forces, or as exogenous foreign asset demand shocks, or as financial shocks affecting foreign exchange market (Engel, 2014; Itskhoki and Mukhin, 2017). In contrast to the existing literature (Iacoviello and Navarro, 2019; Ben Zeev, 2019), this identification scheme allows me to study how exchange rates - through the financial and trade channels - affect the economy independently from the effects than could arise from exchange rate movements due to monetary policy or global credit supply shocks.

I proceed as follows. I consider the effective exchange rate of the USD against a basket of currencies of other advanced economies (like the Euro Area, UK, Japan, among others). This series should be unrelated to the fundamentals of the SOEs in my sample for two reasons. First, the exchange rates of these SOEs are not used to construct the USD exchange rate against major currencies. Second, under the small open economy assumption, the countries in my sample are too small to influence this exchange rate. I regress this series on interest rate differentials, as in the uncovered interest rate parity (UIP) condition, on macroeconomic variables of the countries in the basket of currencies, and on global driving forces affecting the currencies and macroeconomic conditions in the U.S. and in the other advanced economies. The resulting residuals are orthogonal to those fundamentals and hence represent shocks to the UIP condition between the U.S. and other major economies (U.S. risk premium shocks).[6] These UIP shocks are often used in the DSGE literature to proxy exchange rate shocks (see, e.g. Kollmann, 2005). I then use the residual series as an external instrument in a panel LP-IV setting. Having identified the UIP shock, I study how exogenous USD exchange rate movements unrelated to SOEs' fundamentals and global conditions affect real and financial variables in SOEs.

The empirical analysis reveals the following results. For a panel of SOEs, I find that a domestic appreciation against the USD *increases* real GDP and loosens financial conditions in SOEs. This finding indicates the importance of the financial channel. The appreciation goes hand-in-hand with a rise in domestic real investment, equity prices, credit and cross-border bank flows. Moreover, the increase in real GDP occurs despite a deterioration of the trade balance consistent with the trade channel. To examine the determinants of this result, I assess the sensitivity of the baseline results to several indicators that reflect the intensity of international financial linkages and international trade. First, I analyze whether the results depend on foreign currency exposure, measured by the amount of liabilities denominated in USD as percent of GDP. I find that in countries with relatively high liabilities in USD (e.g. Brazil, Colombia, or the Philippines), the financial channel dominates, as the domestic appreciation against the USD leads to

[6]Note that I use the terms UIP shock and risk premium shock interchangeably.

an increase of real GDP, real investment, real consumption, and to a loosening of financial conditions, despite the decrease in net exports. By contrast, in countries with relatively low liabilities in USD (e.g. Poland, Hungary or India), the appreciation is contractionary, as implied by the trade channel. Further, I investigate whether the results depend on the amount of foreign assets denominated in USD, for which I do not find evidence. Finally, I assess whether on variables that should indicate the strength of the trade channel, such as trade openness and the intensity of trade with the U.S., determine the relative strength of the channels. I find that an appreciation against the USD is contractionary in countries with higher trade openness, or that have tighter trade linkages with the U.S. Summing up, for my sample of SOEs, I find that an appreciation can be expansionary due to the financial channel of exchange rates, whose strength is determined by exposure to USD liabilities. By contrast, the same shock is contractionary for countries wigh a higher degree of trade openness.

Next, I estimate an open economy New Keynesian model with financial frictions, in which a fraction of the domestic banks' debt is denominated in USD, similar to Aoki et al. (2016), Mimir and Sunel (2019) and Akinci and Queralto (2021). As it is the case in standard open economy DSGE models, fluctuations in the exchange rate have an effect on the trade balance, as relative prices of exports and imports change. However, in my model, exchange rate fluctuations also affect the banks' balance sheets as their assets are denominated in domestic currency and their liabilities are denominated in part in USD. Thus, an appreciation of the domestic currency reduces the value of foreign currency exposure, strengthening borrowers' balance sheets, which in turn exerts upward pressure on the value of the local currency. This feature of the model allows a careful analysis of the effects of exchange rate movements through the financial channel. Since the model accounts for both a trade and a financial channel, I can study to what extent exposure to USD liabilities and trade openness determine the relative strength of the channels. Finally, with the estimated open economy New Keynesian model at hand, I also investigate how the financial channel of exchange rates affect the transmission of foreign monetary policy shocks.

For the estimation of the model I use Brazilian data and then analyze the effects of a UIP risk-premium shock. In line with the empirical results, I find that the level of foreign currency exposure is an important determinant of the strength of the financial channel. Moreover, the estimated DSGE model for Brazil indicates that the trade channel, trough trade openness, also determines whether an appreciation is expansionary or contractionary. Specifically, I show that a shock to the UIP condition, which induces a domestic appreciation against the USD, is expansionary in Brazil. However, if Brazil would become more open to trade, the expansionary effects of the appreciation become weaker, and eventually disappear. Thus, the model based analysis suggests that it is the interaction between the financial and trade channels that determines the effects of exchange rate appreciations in SOEs. Finally, I also find that the foreign currency exposure and the financial channel amplify the effects of foreign monetary policy, in line with the results of Iacoviello and Navarro (2019).

The results from the LP-IV and the New Keynesian model estimation indicate that the financial channel can potentially challenge the conventional wisdom about the effects of a domestic appreciation, which is solely based on the relationship between exchange rates and the trade balance. The resulting decrease in net exports does not necessarily lead to a macroeconomic contraction, since – under foreign currency exposure – financial conditions loosen, and investment and real GDP may increase. The level of liabilities denominated in USD is an important factor driving these results: the higher foreign currency exposure is, the stronger the financial channel. My findings have several implications. First, it is necessary to consider the level of foreign currency exposure and thus the strength of the financial channel to understand the effect of exchange rate movements. Second, the financial channel has strong effects on domestic financial conditions and potentially amplifies the effects of foreign shocks. Since policy-markers are often concerned with financial stability and the transmission of foreign shocks, they need to consider the financial channel in order to design and implement policies aimed at ensuring the stability of the domestic financial system and dampening the effects of foreign shocks. Finally, as documented by other studies (e.g. Aoki et al., 2016; Mimir and Sunel, 2019), the financial channel and its effects potentially justify the implementation of active macroprudential policies to manage the effects arising from the interaction between USD exchange rate fluctuations, foreign currency debt and domestic financial conditions.

The remainder of the paper is structured as follows. In Section 2, I review the related literature. In Section 3, I describe the channels through which exchange rate movements affect macroeconomic conditions. Section 4 contains a description of the data, the construction of the external instrument that I use to identify exogenous exchange rate movements and the results from the LP-IVs. Section 5 describes the New Keynesian model setup, its estimation and the results drawn from this analysis. The last section concludes.

2 Related literature

My work is related to different strands of the existing literature. Naturally, it relates to papers that also study the effects of exchange rate movements on macroeconomic and financial conditions using SVARs (see e.g. Choudhri et al., 2005; Farrant and Peersman, 2006; Kim and Ying, 2007; Fratzscher et al., 2010; Forbes et al., 2018, Corbo and Di Casola, 2018). These studies, however, use Choleski decomposition or sign restrictions to identify exogenous exchange rate shocks. Just by ordering the exchange rate last, however, a Choleski decomposition offers no assurance that the exchange rate shock is indeed unrelated to other fundamentals, possibly not captured in the VAR. Sign restrictions, on the other hand, are often not satisfying as, for instance, monetary policy shocks and exchange rate shocks could theoretically imply the same sign pattern on standard variables in the VAR. My identification strategy, in contrast, relies on an external instrument that is unrelated to the fundamentals of the SOEs in my sample and to common driving forces.

A similar approach is used in a recent study by Lane and Stracca (2017). They study the effects of exchange rate movements on macroeconomic conditions in Euro area counties, mainly focusing on the trade channel. To identify the exogenous movements in the exchange rate in individual countries, they use

Euro area-wide effective exchange rate as an external instrument. My paper, in contrast, focuses on SOEs outside the euro area and not only on macroeconomic effects, but also on financial variables that affect shock transmission through the external balance sheet of countries. Further, my paper is also related to the body of work studying the effects of exchange rate movements through the trade channel. Surveys of this extensive literature can be found in Auboin and Ruta (2012) or Leigh et al. (2017).

The models I employ to answer my research questions offer an overall assessment of the effects of currency movements on macroeconomic and financial conditions, hence my paper directly connects to the recent and fast growing literature on the financial channel. Georgiadis and Mehl (2016), for instance, find that the impact of an expansionary domestic monetary policy shock is amplified in countries with large net long foreign currency exposure. This is so because a monetary loosening triggers a depreciation of the domestic exchange rate, which in turn strengthens the external balance sheets of such countries. Bruno and Shin (2015b) and Hofmann et al. (2017) show theoretically that if a valuation mismatch in private sector balance sheets in emerging market economies (EMEs) exists, movements in the bilateral USD exchange rate can affect financial conditions in EMEs, and thus real variables. They refer to this as the 'risk-taking channel' of exchange rate appreciation. Hofmann et al. (2017) and Bruno and Shin (2015b) find some empirical evidence for this channel with cross-country panel regression and a Choleski identified VAR. Specifically, Hofmann et al. (2017) show that a currency appreciation against the USD is on average associated with a compression of EMEs' sovereign bond yields and larger portfolio inflows into EMEs. I extend their research by applying a comprehensive model that allows to capture the effects of both, the trade and financial channels, and by identifying (exogenous) exchange rate movements in a more compelling way than a Choleski decomposition. Related to these studies, Avdjiev et al. (2019) study the effects of movements in the USD exchange rate on cross-border banking flows and investment. They conduct this analysis using, again, a Cholesky identified panel SVAR and panel regressions. Iacoviello and Navarro (2019) and Ben Zeev (2019) also study the trade and financial channels, but in contrast to my study, they investigate the effects of a U.S. monetary policy shock and a global liquidity shock, respectively. Also, Bernoth and Herwartz (2019) study the effects of exchange rate movements on sovereign risk in EMEs, and find that a depreciation of the domestic currency against the USD increases sovereign risk. Moreover, they show evidence showing that foreign currency exposure is a key determinant for the size of the fall in risk. Further, my work is related to the global financial cycle and on international spillovers of U.S. monetary policy, for instance Rey (2016), Miranda-Agrippino and Rey (2015), Bruno and Shin (2015a), Georgiadis (2015), and Anaya et al. (2017), among others.

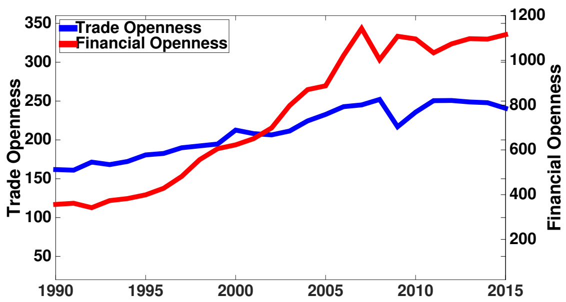
Moreover, my paper broadly relates to an extensive body of work on open economy New Keynesian models (Galí and Monacelli, 2005, Farhi and Werning, 2014, among others), and on their estimation (Adolfson et al., 2007, Justiniano and Preston, 2010). My DSGE model extends recent work by Aoki et al. (2016), Akinci and Queralto (2021), and Mimir and Sunel (2019), who study the effects of foreign shocks and the implementation of optimal policy responses in a calibrated open economy DSGE setting with currency mismatch in the bank's liabilities. Furthermore, my paper also relates to Copaciu et al. (2015), who develop and estimate a model for the Romanian economy where part of the debt is denominated in euro, and to Gourinchas (2018) who develops and estimates a model for the Chilean economy and assesses the role of trade and financial openness in the transmission of foreign shocks. Finally, this paper is also related to Dalgic (2018), who uses an open economy DSGE model to investigate the role of households' savings in foreign currency on as an insurance arrangement.

3 The trade and financial channel of exchange rate movements

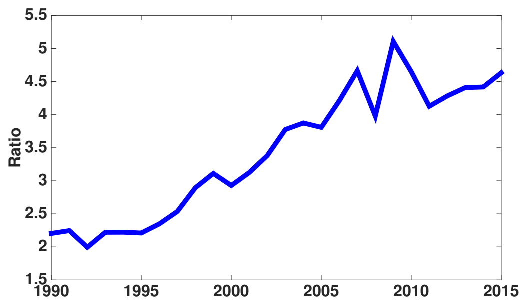
To answer this paper's research questions, first it is necessary to explain the mechanisms through which the financial and trade channels affect the economy, and what are their effects on macroeconomic and financial variables.

Figure 1: Financial and Trade Openness

(a) Financial and Trade Openness



(b) Ratio Financial Openness to Trade Openness



Note: Panel (a) shows financial openness (red line, defined as foreign liabilities + assets as a percent of GDP, with the value in 1960 = 100) and trade openness (blue line, defined as exports + imports as a percent of GDP, with the value in 1960 = 100) for a broad group of advanced economies and emerging market economies. Panel (b) shows the ratio of financial openness to trade openness. Source: Own elaboration with data from the BIS. For details see BIS (2017).

3.1 The trade channel

The trade channel, or expenditure switching channel, reflects the relationship between exchange rate fluctuations and the trade balance. This channel is the key transmission mechanism of exchange rates in frameworks such as, e.g. the Mundell-Fleming model and open economy New Keynesian models. Consider, for example, a deviation from the UIP condition that causes the domestic exchange rate to appreciate. This raises the price of exports while it decreases the price of imports. If the Marshall-Lerner condition holds,[7] the appreciation leads to demand substitution away from domestic goods towards foreign goods, thus lowering the trade balance and GDP. [8]

[7]The Marshall-Lerner condition states that an exchange rate appreciation deteriorates the balance of trade if the absolute sum of the long-term export and import demand elasticities is greater than one.

[8]However, as highlighted by Lane and Stracca (2017), an appreciation of the exchange rate can also be expansionary through the trade channel if the following effects dominate the decrease in net exports. The appreciation (1) lowers the price of imported intermediaries sufficiently much such that the production of tradables is considerably less expensive, which in turns increases

3.2 The financial channel

The so-called financial channel has become more relevant over time, as global financial integration has increased. Figure 1 shows the evolution of financial and trade openness, defined as foreign liabilities and assets over GDP, and exports and imports over GDP, respectively, for a broad group of advanced economies and EMEs.[9] Panel (a) shows that trade openness has increased in the past three decades, however, financial openness has outpaced trade, and roughly tripled since 1990. This development is shown in Figure 1b. The ratio of financial openness to trade openness has more than doubled from 1995 to 2015. This hints to the potentially rising relevance of the financial channel.

Moreover, after the Asian financial crisis, EMEs started to increase their net foreign currency positions by accumulating foreign exchange reserves through current account surpluses and a shift from debt liabilities to equity-type liabilities (Lane and Shambaugh, 2010; Hausmann and Panizza, 2011; Bénétrix et al., 2015). This improvement in the net currency exposure masks heterogeneity across sectors in the economy (Avdjiev et al., 2015). While governments and central banks in EMEs have increasingly accumulated foreign exchange reserves, the private sector can still be a large debtor in foreign currency, in particular in USD.[10] This USD-denominated debt is often backed by assets and cash-flows in local currency, creating a valuation mismatch on corporate balance sheets.[11] These developments have not only been confined to EMEs. Assets and liabilities denominated in foreign currency have also increased in countries like Canada, Sweden, South Korea and others (Bénétrix et al., 2020). However, as Kearns and Patel (2016) argue, EMEs are particularly vulnerable to adverse effects arising from currency mismatch in their external balance sheets due to their relatively less developed financial systems and the consequent tendency to have unhedged foreign currency debt.[12]

The financial channel captures the idea that exchange rate fluctuations affect macroeconomic and financial conditions also through valuation effects in a country's external balance sheet. Thus, the currency denominations of the assets and liabilities in the external balance sheet and possible currency mismatches determine whether, for instance, an appreciation of the domestic exchange rate is potentially expansionary or contractionary through this channel.

Avdjiev et al. (2019) argue that the key empirical regularity behind the financial channel is that an appreciation of a country's currency against the USD is associated with an increase of borrowing denominated in USD in that country. Thus, Avdjiev et al. (2019) indicate that the financial channel mainly operates through the liability side of the balance sheet of domestic borrowers. Therefore, if a country has (net) foreign currency exposure, specially in USD, an exchange rate appreciation against the USD

overall net exports, and (2) consumption rises significantly due to overall lower price of imports. Generally speaking, the trade channel suggests that an appreciation of the exchange rate is contractionary (see Iacoviello and Navarro, 2019; Ben Zeev, 2019).

[9] For details on the construction of the data, see BIS (2017).

[10] The stock of USD-denominated debt of non-banks in EMEs was estimated to be $ 3.3 trillion as of March 2015 (McCauley, McGuire and Sushko, 2015).

[11] A comprehensive discussion of valuation mismatches in EMEs' corporate balance sheets can be found in Avdjiev et al. (2015).

[12] Moreover, due to the same reason, EMEs may be more dependent on foreign funds. Chapter 3 in this dissertation deals with this latter issue.

can potentially be expansionary, as the value of liabilities decreases relative to the (in domestic currency denominated) assets.

Moreover, there are two ways in which the financial channel – working through the liabilities in the external balance sheet – affects the impact of exchange rate fluctuations: via supply and demand for USD (Avdjiev et al., 2019). On the supply side, Bruno and Shin (2015b), and Hofmann et al. (2017) suggest that an appreciation of the local currency against the USD affects financial conditions by making borrowers' balance sheets look stronger and thus by increasing their creditworthiness. In turn, the willingness of foreign creditors to extend credit increases for any given exposure limit,[13] which raises capital and banking inflows and subsequently credit supply. This mechanism is what Hofmann et al. (2017) call the 'risk taking channel' of currency appreciation. On the demand side, Avdjiev et al. (2019) point out that a domestic borrower who had borrowed in USD, will see her balance sheet strengthen as the domestic currency appreciates and the USD depreciates.[14] In any case, the financial channel - working through the liabilities - implies that an exchange rate appreciation against the USD increases capital and banking flows, and loosens financial conditions, which stimulates investment and GDP.

On the other hand, it is conceivable that a domestic appreciation can also be contractionary through the financial channel. This would be the case if a country's assets are denominated in USD, and its liabilities mostly denominated in domestic currency. An appreciation of the home currency against the dollar would trigger a relative decrease in the value of the assets, and thus financial conditions worsen, which reinforces the contractionary trade-channel (Georgiadis and Mehl, 2016). However, Kearns and Patel (2016) argue that the valuation effects on the liabilities side have a larger impact on the economy in EMEs, since assets in USD are held by long-term investors, such as foreign exchange reserve managers, pension funds and central banks. Thus, valuation changes in assets are likely to lead to smaller changes in spending and, consequently, exposure to USD liabilities may be the main determinant of the financial channel's strength.

4 Data, identification strategy and results

4.1 Data on exchange rates, macroeconomic and financial conditions

The data set that I use consists of quarterly data, covering 17 SOEs from 1998 - 2019. The panel for the empirical analysis in unbalanced. The countries in my sample resemble the sample of many studies on EMEs (see, for instance, Aizenman et al., 2016) and contains the following EMEs and other SOEs: Brazil, Chile, Colombia, the Czech Republic, Hungary, India, Indonesia, Israel, Korea, Mexico, Peru, the Philippines, Poland, Russia, South Africa, Thailand, and Turkey. For the LP-IV analysis, I use times series for real GDP, real private consumption, real gross fixed capital formation, trade balance as a percentage of

[13] Such exposure limits can be associated with value-at-risk constraints in the (global) banking sector (Bruno and Shin, 2015b) or if fund investments of asset managers with a global reach fluctuate with recent market conditions (see Hofmann et al., 2017).

[14] Avdjiev et al. (2019) also argue that, even an exporting firm whose receivables are in USD and obligations in domestic currency would incur in USD liabilities if the USD is expected to depreciate more, in order to hedge further currency risks. This would lead to the same outcome as explained above.

GDP, equity prices (MSCI equity price index), credit to the private sector as a percentage of GDP, the nominal policy interest rate, the consumer price index, and the VIX. I also use the gross cross-border banking data of the Bank for International Settlements (BIS), and the shadow Federal Funds Rate by Wu and Xia (2016).[15] All series are seasonally adjusted. Furthermore, I use the data on the amount of assets and liabilities in USD (as percent of GDP) by Bénétrix et al. (2015) and by Bénétrix et al. (2020).[16] I also use the financial vulnerability index and data on the trade intensity with the U.S. constructed by Iacoviello and Navarro (2019).

To construct the instrument for the exogenous exchange rate movements I use the USD effective exchange rate against major economies,[17] the VIX and time series for real GDP, consumer price index, policy interest rate of the U.S. and the other eight other major economies, as well as equity price indices and a commodity price index. For the period of the zero lower bound, I use shadow rates for all the countries for which the data are publicly available.[18]

4.2 An instrument to identify exogenous exchange rate movements

Since the focus of this paper is on USD exchange rate fluctuations against SOEs' currencies, I need an instrument to identify exogenous exchange rate movements specific to the USD. Besides fulfilling the LP-IV conditions discussed below (Stock and Watson, 2018), such an instrument needs to be in line with certain economic considerations in order to be useful for the empirical analysis. First, the instrument should move the USD exchange rate against all currencies in the sample, and therefore represent an overall appreciation or depreciation of the USD against all the SOEs' currencies. Second, the instrument should be exogenous to each single SOE's fundamentals; and third, in order to have a shock specific to the USD exchange rate, the instrument should also be exogenous to U.S. fundamentals.

Two candidate instruments for SOEs' USD exchange rate shocks arise after these considerations: shocks to the UIP condition of the U.S., and U.S. monetary policy shocks, i.e. changes in the U.S. monetary policy stance unexplained by the Fed's systematic response to economic (and financial) conditions. There are several reasons why these instruments are well suited to proxy exogenous USD exchange rate fluctuations in SOE. On the one hand, there is empirical evidence showing that risk premium shocks to the UIP condition explain the lion's share of the exchange rate variance of the USD against several major currencies (Balakrishnan et al., 2016). Moreover, these shocks also account for a large share of the

[15] The details on the data and the sources are on Table A.1 in Appendix A.

[16] The data by Bénétrix et al. (2020) end in 2017. Thus I use the last value of assets and liabilities in 2017 for the rest of my sample. One exception is the data for Hungary. Due to the large discrepancies between Bénétrix et al. (2020) and Bénétrix et al. (2015) in the estimation of liabilities in USD for Hungary, in this case I use the data estimated by Bénétrix et al. (2015), which end in 2013. I use the value of 2013 for the rest of the sample.

[17] The major currencies index includes the euro area, Canada, Japan, United Kingdom, Switzerland, Australia, and Sweden.

[18] As mentioned above, for the U.S. I use the shadow FFR by Wu and Xia (2016). Moreover, for the euro area and the U.K., I use the shadow rate by Xia and Wu (2018), and for Japan I use Leo Krippner's estimates, available at: https://www.rbnz.govt.nz/research-and-publications/research-programme/additional-research/measures-of-the-stance-of-united-states-monetary-policy/comparison-of-international-monetary-policy-measures

variation in the real and nominal exchange rates in calibrated and estimated DSGE models (Kollmann, 2002, 2005; Adolfson et al., 2007; Copaciu et al., 2015; Mimir and Sunel, 2019). Finally, it has been shown that introducing these shocks in DSGE models is important to account for the volatility and persistence of exchange rate fluctuations observed empirically (Engel, 2014; Adolfson et al., 2007). On the other hand, U.S. monetary policy shocks can also be used, since, for example, a monetary loosening in the U.S. would cause an overall depreciation of the USD, other things being equal. Moreover, monetary policy surprises are also seen as important drivers of the exchange rate and have been widely used to study exchange rate movements (Engel, 2014).

In my analysis I focus on risk premium shocks to the U.S. UIP condition as the instrument for shocks to the SOEs' exchange rate for the following three reasons. First, the literature on open economy DSGE models uses shocks to the UIP condition as proxies for exchange rate shocks.[19] These can be interpreted as exogenous foreign asset demand shocks, financial shocks affecting foreign exchange market (Engel, 2014; Itskhoki and Mukhin, 2017), or as reflecting a bias in the economic agents' forecast about future exchange rates (Kollmann, 2005). Moreover, in Section 5, I use a DSGE model to further study the channel of transmission of exchange rate movements proxied by shocks to the UIP condition. Thus I use U.S. UIP shocks in the LP-IV analysis to ensure that the results are consistent with those in Section 5. Second, since I am mainly interested in the effects of USD exchange rate fluctuation on macroeconomic variables in SOEs and because of the financial nature of UIP shocks, they should not have a first order effect on real variables in the SOE in my sample. Third, a U.S. monetary policy shock may produce misleading results because U.S. monetary policy may not only affect foreign economies through changes in the USD exchange rate, but also through a change in U.S. demand for non U.S. goods and services. Changes in U.S. import demand can have a direct impact on the trade balance of single SOEs.[20] Moreover, the interpretation of the resulting exchange rate appreciation against the USD would not be the same, since using U.S. monetary policy shocks as an instrument, I would be identifying the effects of U.S. monetary policy in SOEs working through exchange rate fluctuations. Furthermore, as I will discuss below, the UIP shocks series proves to be a better instrument for exchange rate shocks in SOEs than U.S. monetary policy shocks, since the F-statistics in its first-stage regression is higher than the one in the first-stage regression using U.S. monetary policy shocks. Summing up, using the UIP shock series as an instrument for USD exchange rate shocks in SOEs allows me to isolate the effects of USD fluctuations from those arising from changes in demand and foreign prices. This is necessary to identify and isolate the channels through which exchange rate fluctuations work.

4.2.1 A shock to the U.S. UIP condition

In order to have an instrument that can be used to estimate dynamic causal effects in a LP-IV setting, the instrument η_t must satisfy the following LP-IV conditions (Stock and Watson, 2018):

[19] The literature also interprets UIP shocks as shocks to capital flows, see for instance Farhi and Werning (2014).

[20] However, in a later section, I study to which extent the financial channel affects the transmission of foreign monetary and demand shocks.

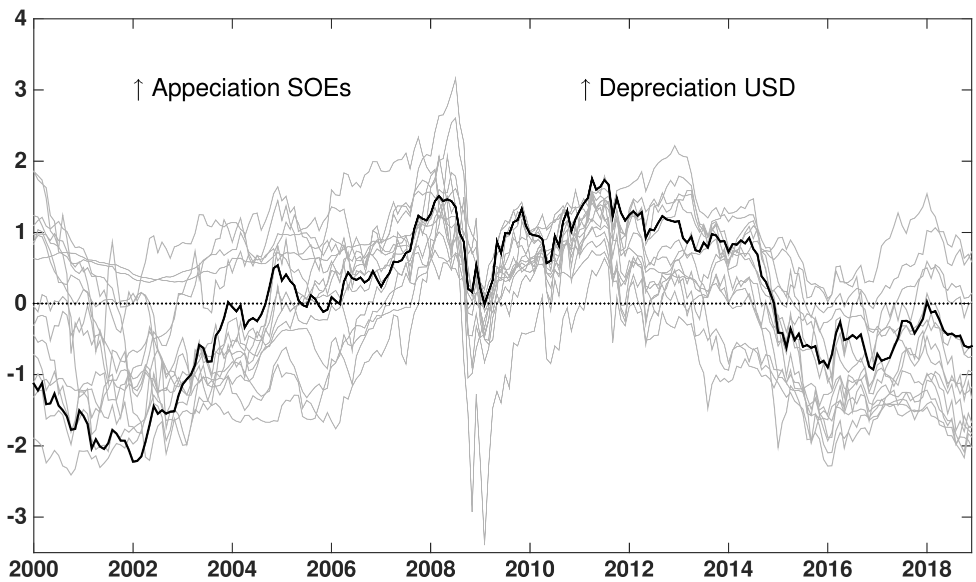
(i) $E(\epsilon_{1,t}\eta_t') \neq 0$ (relevance);

(ii) $E(\epsilon_{2:n,t}\eta_t') = 0$ (contemporaneous exogeneity);

(iii) $E(\epsilon_{t+j}\eta_t') = 0$ for $j \neq 0$ (lead-lag exogeneity);

where $\epsilon_{1,t}$ is the structural shock to be identified and $\epsilon_{2:n,t}$ are all other structural shocks. The relevance condition states that the instrument should be correlated with the structural shock to be identified. Thus, the U.S. UIP shock, which will be used as an instrument, should be correlated with the exchange rate shock in SOEs. To construct the UIP shock specific to the USD, I use the USD exchange rate against a basket of major currencies. This series is useful because there is a (fairly) high correlation between the effective exchange rate of the USD against major currencies and the exchange rates of the SOEs in my sample, ranging between 0.14 and 0.94, and averaging 0.53.[21] Moreover, Figure 2 presents the standardized SOEs' exchange rates against the USD (gray lines), and the USD exchange rate against major currencies (black line). These exchange rates co-move considerably, as large depreciation episodes of the USD exchange rate against major economies coincide with appreciations of the SOEs' currencies. The co-movement is especially visible during and after the global financial crisis in 2008. Therefore, exogenous movements to the USD exchange rate against major currencies can also potentially drive individual SOEs' USD exchange rates. In fact, as I will show later, shocks derived from the U.S. UIP condition against major currencies are a valid instrument for SOEs' exchange rate shocks, as the F-statistic is well above 10.

Figure 2: USD Exchange Rates



Note: The figure shows the standardized monthly nominal effective exchange rate of the USD against major currencies (black line), and the standardized monthly individual exchange rates against the USD of the 17 countries in the sample (gray lines).

[21] Table B.1 in Appendix B shows the correlation coefficients.

Moreover, condition (ii), contemporaneous exogeneity, states that the instrument should be contemporaneously unrelated to all other shocks. In my application this condition is satisfied. On the one hand, to estimate the U.S. risk premium shocks, I use a broad index of currencies and not a bilateral one, say the EUR-USD exchange rate, to make sure that the instrument is specifically related to the USD and not to another currency. Further, I use only major currencies of advanced economies and not an even broader index to minimize the likelihood that the instrument is related to some of the SOEs' fundamentals. Since the currencies of the SOEs in my sample are not used to construct the USD exchange rate against major currencies and assuming that the SOEs in my sample are too small to influence this exchange rate, the constructed UIP shocks are unrelated to SOEs' fundamentals.

On the other hand, as I will explain in detail below, I control for economic and financial conditions in the U.S. and the other major economies, as well as for global conditions. I do so by including interest rates, macroeconomic fundamentals, and financial variables into the estimation of the U.S. risk premium shocks. Thus, these UIP shocks are uncorrelated with other U.S. specific shocks, to shocks specific to the major economies and to global conditions, and therefore satisfy condition (ii).

Finally, condition (iii), lead-lag exogeneity, arises from dynamics and requires that the instrument should be exogenous to past realizations of ϵ and that the instrument should not be correlated to future shocks. To maximize the likelihood that LP-IV condition (iii) is satisfied, I follow Stock and Watson (2018) and include relevant controls in the estimation of the impulse responses using LP-IV.

To estimate the USD risk-premium shock, I start with the risk-premium augmented UIP condition as in Balakrishnan et al. (2016):

$$\mathrm{E}_t e^{us}_{t+1} - e^{us}_t = \beta(i^{us}_{t+1} - i^{c}_{t+1}) + (rp^{us}_t - rp^{c}_t) \tag{1}$$

where e^{us}_t is the USD exchange rate against major currencies, $i^{us}_{t,t+k}$ is the Federal Funds Rate. $i^{c}_{t,t+k}$ is the policy interest rate in country c, rp^{us}_t and rp^{c}_t are country specific risk-premia and β is a coefficient that links the interest rate differentials with exchange rate movements, which I will estimate. Following Akinci and Queralto (2021), I iterate Equation (1) forward T periods:

$$\mathrm{E}_t e^{us}_{t+1+T} - e^{us}_t = \beta \sum_{j=1}^{T} (i^{us}_{t+j} - i^{c}_{t+j}) + (rp^{us}_t - rp^{c}_t) \tag{2}$$

As in Akinci and Queralto (2021), I assume that $e^{us}_t = f_t + \hat{e}^{us}_t$, where f_t is a deterministic time trend and $\hat{e}_t{}^{us}$ is stationary. For sufficiently large T, $\mathrm{E}_t \hat{e}^{us}_{t+1+T} = 0$. Thus, Equation (2) becomes:

$$e^{us}_t = -\beta \sum_{j=1}^{T} \mathrm{E}_t(i^{us}_{t+j} - i^{c}_{t+j}) - (rp^{us}_t - rp^{c}_t) + f_t \tag{3}$$

Next, I define $i^{diff,c} \equiv \sum_{j=1}^{T} \mathrm{E}_t(i^{us}_{t+j} - i^{c}_{t+j})$ and $\tilde{RP}_t \equiv (rp^{us}_t - rp^{c}_t)$ and I generalize Equation (3) to include the USD exchange rate against major currencies, as well as the country specific policy rates in each of the seven major economies in the exchange rate:

$$e_t^{us} = -\beta \sum_{c=1}^{7} i^{diff,c} - \tilde{RP}_t + f_t, \tag{4}$$

after taking first differences and rearrenging, following Kiley (2013), Equation (4) becomes:

$$\Delta e_t^{us} = -\beta \sum_{c=1}^{7} \Delta i^{diff,c} - \Delta \tilde{RP}_t.$$

where $\tilde{RP}_t$ is the risk premia in the U.S. and the other major economies. I re-write $\tilde{RP}_t$ to have the following transformed UIP equation:

$$\Delta e_t^{us} = -\beta \sum_{c=1}^{7} i^{diff,c} - \underbrace{\Delta RP_t}_{\text{endog. risk premium}} - \underbrace{\eta_t}_{\text{UIP shock}},$$

where RP_t is the endogenous risk-premium and η_t is the UIP shock (risk-premium shock). The transformed UIP equation can be estimated as:

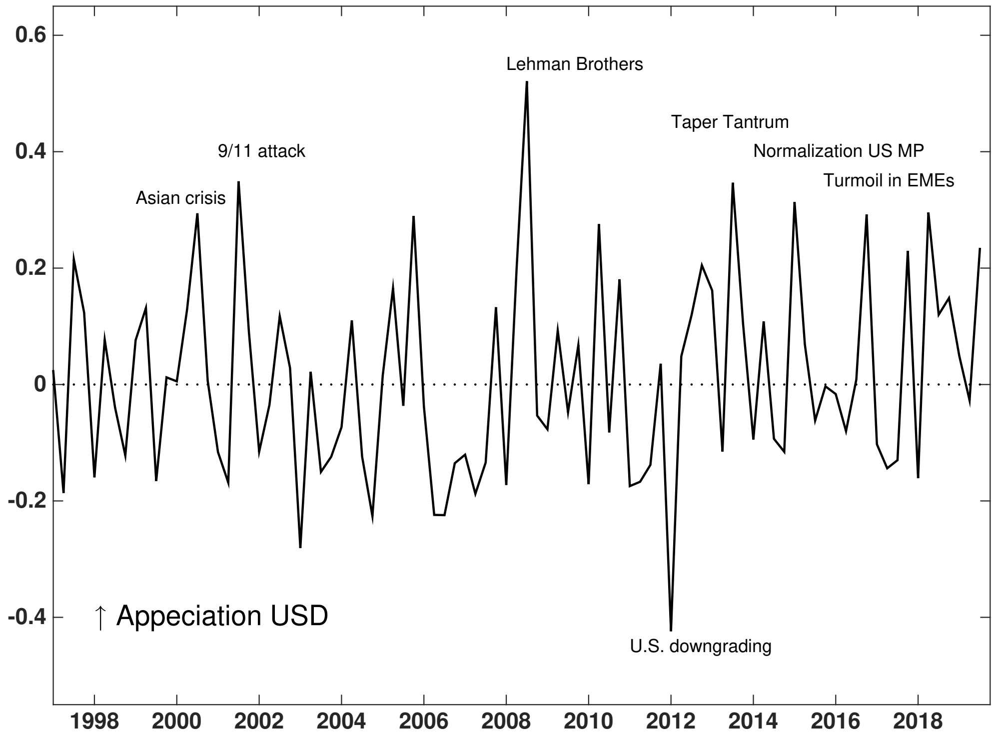
$$\Delta e_{us,t} = \beta_0 + \sum_{c=1}^{7} \beta_c \Delta i^{diff,c} + \sum_{n=1}^{N} \delta_n Z_{nt} + \eta_t, \tag{5}$$

where, Z_{nt} is a set of variables to control for the endogenous risk-premia in the U.S. and the major economies, as well as to control for local and global macroeconomic and financial conditions (see below for details). The estimated residuals from Equation (5) can be interpreted as USD UIP shocks.[22]

The control variables included in the estimation of Equation (5) capture determinants affecting the USD exchange rate against major currencies and affecting global conditions that, in turn, have an impact on SOEs and their bilateral USD exchange rates. To control for endogenous risk premia, and monetary, demand and supply shocks, I include in $Z_{n,t}$ the contemporaneous value and the first lag of GDP growth, inflation rates and policy (shadow) interest rates a for the U.S., and the other major economies, and the lagged first difference of the exchange rate against major currencies. Moreover, I also include the contemporaneous value and the first lag of the first difference of equity prices in the U.S., of commodity prices and the VIX to control for global economic and financial conditions. To avoid overparametrization, I apply a general-to-specific approach and exclude one-by-one all variables for which the estimated

[22]This equation can also be interpreted as a VAR for the U.S. and major economies, where the (nominal effective) exchange rate is ordered last, as it is usual in the SVAR literature that relies on the Cholesky decomposition to identify exogenous exchange rate movements, e.g. An et al. (2014), Hofmann et al. (2017), among others. This approach of identifying exchange rate shocks in a VAR has the advantage of minimizing endogeneity issues in the estimated effects of exchange rates on macroeconomic and financial conditions, as pointed out by Hofmann et al. (2017). However, it also several important limitations. The Cholesky identification implies that the UIP or exchange rate shocks do not have a contemporaneous effect on any of the other variables in the VAR. Thus, financial variables - including asset prices and interest rates - react only with a lag to the exchange rate shocks. This drawback extends to my approach, meaning that Equation 5 assumes that exchange rates react contemporaneously to macroeconomic and financial conditions, but exchange rates do not have a contemporaneous effects on the explanatory variables in the equation.

Figure 3: Estimated U.S. UIP shocks



Note: The figure shows the estimated shocks to the U.S. UIP condition (UIP or risk-premium shocks).

coefficient is not significant at the 30 % level.[23] Nevertheless, the regression still includes more than 20 control variables in the final specification. Including a large number of control variables should not be a problem, because this increases the likelihood that the residuals from Equation (5) capture UIP shocks and not other determinants of exchange rate fluctuations. In Section 4.3, I briefly discuss results using alternative specifications of Equation (5).

After estimating Equation (5), I use the estimated residual from this regression (the U.S. UIP shocks) $\widehat{\eta_t}$, as the instrument for exchange rate shocks in the SOEs. Figure 3 shows the estimated USD UIP shocks, where the positive values depict an appreciation of the USD exchange rate, and thus show a negative realization of the shocks from the perspective of the U.S. The large positive and negative realizations of these time series tend to coincide with several events associated with global turmoil or crises in a subset of the SOEs in the sample. For instance, it is well documented that the USD appreciated strongly in the onset of the global financial crisis, during the so-called "Taper Tantrum", or during the recent turmoil in EMEs (Argentina, Turkey, among others). These events are also consistent with ’flight-to-safety’ episodes, which are associated with an appreciation of the USD and a depreciation of SOEs’ currencies.

[23]The interest rate differentials, the lagged exchange rate and U.S. variables are always included in the estimation.

4.2.2 First-stage regressions

From the considerations above, the U.S. UIP shocks satisfy the LP-IV conditions (i)-(iii), and thus are a good instrument for USD exchange rate movements in SOEs. Additionally, to test the relevance condition formally, I compute the F-statistic of the instrument in the first-stage regression of the LP-IV estimations.

The results from the first stage regressions of Equation (6), when real GDP is the dependent variable, are reported in Table 1. The first column presents the estimation results when the U.S. UIP shock is used as an instrument for the SOEs' exchange rate against the USD, and the second column presents when U.S. monetary policy shocks are used as an instrument.

The results shown in Table 1 confirm that the U.S. UIP shocks are a strong instrument, since the F-statistic is well above 10. Moreover, the sign of the coefficient is plausible: a positive risk premium shock which results in an overall depreciation of the USD (the effective exchange rate of the USD decreases), appreciates the SOEs' exchange rate.

Table 1: First stage regressions LP-IV

	First stage regressions instruments
	Baseline: UIP shocks from Equation 5
Instrument: U.S. UIP shock $\widehat{\eta_t}$	-0.15***
1st lag Δ bilateral USD exchange rate	0.26***
2nd lag Δ bilateral USD exchange rate	-0.08
1st lag Δ real GDP	0.40**
2nd Δ real GDP	0.07
1st lag Δ CPI	0.36
2nd lag Δ CPI	0.23
1st lag Δ policy interest rate	0.11*
2nd lag Δ policy interest rate	-0.13**
Δ shadow FFR	-0.09*
1st lag Δ shadow FFR	-0.15
Δ VIX	-0.08***
1st lag Δ VIX	-0.03***
Instrument's F-statistic	21.22
Number of observations	1559
Number of countries	17

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

4.3 Local Projections Instrumental Variables

With the instrument for exchange rate shocks to SOEs at hand, I compute the impulse responses of several macroeconomic and financial variables using the local projection method by Jordà (2005). Specifically, I use LP-IV (see Stock and Watson, 2018) in a panel fixed effects setting, allowing intercepts to vary by country but constraining other coefficients to be the same.[24] This method's advantage compared to instrumental variable structural VAR (SVAR-IV) is that LP methods are more robust to misspecification (Jordà, 2005; Ramey, 2016). Moreover, Stock and Watson (2018) argue that under invertibility of the SVAR's instantaneous impact matrix of the structural shocks, which can be interpreted as no omitted variables in the SVAR, SVAR-IV and LP-IV are both consistent but the former is more efficient. However,

[24] My approach is similar to Lane and Stracca (2017), Auerbach and Gorodnichenko (2012), and Klein (2016).

if invertibility fails, LP-IV is consistent while SVAR-IV is not. Therefore, as pointed out by Winne and Peersman (2018), LP-IV can be a solution to omitted variable bias.[25]

4.3.1 Empirical results: Macroeconomic and financial effects of exchange rate fluctuations

The strategy to answer the first research question, i.e. *What are the overall macroeconomic and financial effects of USD exchange rate movements in SOEs?*, is straight forward. After identifying an exogenous exchange rate movement in SOEs, I study the effects of a currency appreciation on several macroeconomic and financial indicators using LP-IV. Consider, for example, an appreciation of the domestic currency against the USD. From the considerations in Section 3, it can be inferred that an appreciation against the USD should decrease the trade balance through the trade channel, while the effects of the financial channel are more ambiguous. If the empirical results show that an appreciation against the USD increases investment and loosens financial conditions, it can be inferred that the financial channel works through the liability side of the balance sheet. Moreover, if the appreciation is ultimately expansionary, even though the trade balance deteriorates, there is an indication that the financial channel dominates the trade channel on average.

To study this question, I use the following econometric specification, similar to Lane and Stracca (2017). The response of the variable of interest[26] y_t at horizon h can be computing by estimating the following panel regression:

$$y_{i,t+h} - y_{i,t-1} = \alpha_i + \delta_h t + \beta_h \Delta e_{i,t+h} + \Pi_h(L)\Delta y_{i,t-1} + \Xi_h(L)\Delta x_{i,t-1} + u_{i,t+h}, , \tag{6}$$

where i and t country and time indices; α_i are country fixed effects, t is a linear trend, $\Pi_h(L)$ and $\Xi_h(L)$ are polynomials in the lag operator, with $L = 2$ in the baseline estimation. $x_{i,t-1}$ is a set of controls such as real GDP, the exchange rate against the USD, price level, interest rate, VIX, and the (shadow) federal funds rate. All variables, except for the trade balance and interest rates, are transformed by taking their natural logarithm. I consider $h = 0, 1, 2, ..., 12$, measuring the effects up to three years ahead. Accordingly, β_h measures the dynamic average cumulative response of the variable of interest at horizon h to an exchange rate movement $e_{i,t+h}$. Following Ben Zeev (2019), I use standard errors that allow arbitrary correlations of the error term across countries and time. As discussed above, the exchange rates against the USD are highly endogenous variables, thus an OLS estimation of Equation (6) would lead to inconsistent estimates. Consequently, I instrument the exchange rate $e_{i,t+h}$ with the (cumulative) U.S. UIP shocks $\widehat{\eta}_t$ estimated from the U.S. UIP Equation (5). The choice of the variables of interest and

[25] In a further exercise, I estimate mean-group panel SVAR-IV for a subset of the variables I consider in the LP-IV settings. The results are in line with the local projections, as well as with results in the literature (Hofmann et al., 2017, 2019; Avdjiev et al., 2019). A discussion of this estimation, as well as the impulse responses is available in Appendix C.

[26] Either real GDP, real private consumption, real gross fixed capital formation, the trade balance as % of GDP, equity prices, capital inflows, the policy interest rate and the price level.

controls, as well as the empirical model in general is such that the results are comparable to the ones from the DSGE model in Section 5.

Figure 4 presents the cumulative responses of macroeconomic and financial variables[27] to a one percent appreciation of the SOEs' domestic currencies against the USD. Overall, the results are in line with other empirical evidence in the literature (Hofmann et al., 2019; Avdjiev et al., 2019).

Real GDP increases by around 0.25 percent after around 3 quarters. The cumulative impulse response of private consumption is not significantly different from zero, while real investment increased significantly by around one percent after three quarters. The trade balance as a share of GDP deteriorates, reaching a trough of 0.4 percentage points; this effect is in line with the implications of the trade channel. CPI also decreases, probably as a result of lower import prices. Moreover, the short-term interest rate also decreases in the SOEs. This is in line with a central bank's response to lower inflation, but also with "fear of floating", i.e. central banks may decrease their short-term interest rates not only to combat falling inflation, but to stabilize the domestic exchange rate after an appreciation. Moreover, equity prices, credit to the private sector and cross-border bank liabilities increase, showing that the appreciation is associated with an overall loosening of financial conditions.

To make sense of these results, it is possible to attribute the responses of the different variables to the effects of the exchange rates through the trade and financial channel. The decrease of the trade balance and CPI inflation is in line with the trade channel. As the domestic currencies appreciate against the USD, the SOEs' trade balances deteriorate on average, and as imports become cheaper, the inflation decreases. Despite the decrease in the trade balance, there is an overall expansionary effect on GDP and its other components. This, in combination with the increases in cross-border liabilities, credit, equity prices and real investment, suggests (i) that the financial channel is expansionary – thus it works through the valuation effects of the liabilities, in line with Hofmann et al. (2019) and Avdjiev et al. (2019) – and (ii) that the financial channel appears to dominate the trade channel.

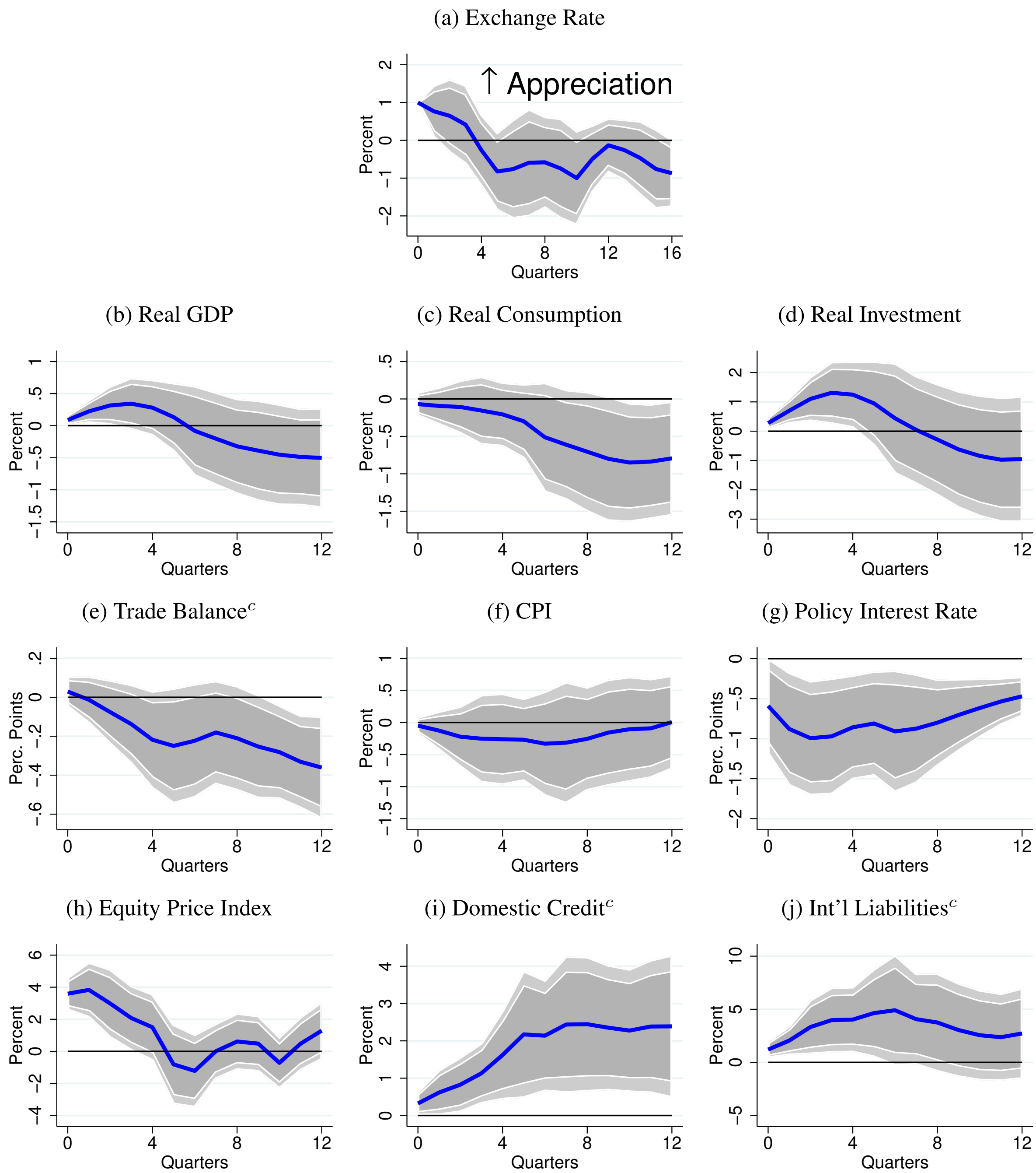
These results are robust to different specifications of Equation (5), i.e. the estimation of the shock, and of Equation (6). In Equation (5), first I include only contemporaneous variables in the estimation. Second, I include the equity price indices of the U.S. and the other major economies. Third, I add a dummy variable for the last two quarters of 2008 to control for the financial crisis. In all these cases, the estimated UIP shocks remain similar, leading to quantitatively similar results.[28] Finally, turning to the estimation of the LP-IVs, I change the lag lengths in Equations (6), and I include other exogenous variables such as commodity prices and U.S. real GDP to control for global demand. The results remain quantitatively robust to those changes. The same is true for the results below.[29]

[27] All responses, except for the equity price index, are cumulative.

[28] Moreover, I also regress the exchange rate against major currencies only on the interest rate differentials. The new shocks series is different from the baseline, and even though the instrument is indeed different, many of the impulse responses remain qualitatively similar. However, the results from this last exercise can be misleading, since the resulting shocks also capture demand and financial shocks in the U.S. and the other advanced economies.

[29] The results from the robustness analysis are in Appendix B. For ease of exposition, I report only the robustness results for GDP.

Figure 4: Responses to a one percent appreciation of the domestic currency against the USD



Note: The figure shows the estimated impulse responses of several macroeconomic and financial variables to a one percent appreciation of the domestic exchange rates for the panel of 17 SOEs. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

^{c} as a fraction of GDP.

4.3.2 Empirical results: The channels

To examine the drivers of the above results, and to answer the second research question, i.e. *Under which conditions does the financial channel dominate the trade channel?*, I need to be able to disentangle the two channels. As stressed by Avdjiev et al. (2019), the external balance sheet is the key variable that determine the strength of the financial channel. Especially relevant for this paper are the liabilities and assets denominated in USD (as percent of GDP).

Again, consider an appreciation of the SOEs' currencies against the USD. As discussed above, it is possible to infer whether the financial channel dominates the trade channel and whether liabilities or assets in foreign currencies determine the strength of the financial channel by interpreting the impulse response functions. Figure 4 shows that an appreciation against the USD is overall expansionary since the rise in real GDP is accompanied by a loosening of financial conditions and an increase in real investment. This suggests that the financial channel dominates the trade channel and that the liability side of the external balance sheet is relatively more important than the asset side in determining the effects of the financial channel.

To take a more detailed look at the results, I exploit the heterogeneity of the SOEs in my sample and I split the sample of countries according to economic characteristics that may be relevant for the relative strength of the financial and the trade channels. Specifically, I assess whether the degree of foreign currency exposure (measured by liabilities in USD), assets in USD, trade openness and trade with the U.S. determine the effects of an appreciation against the USD.

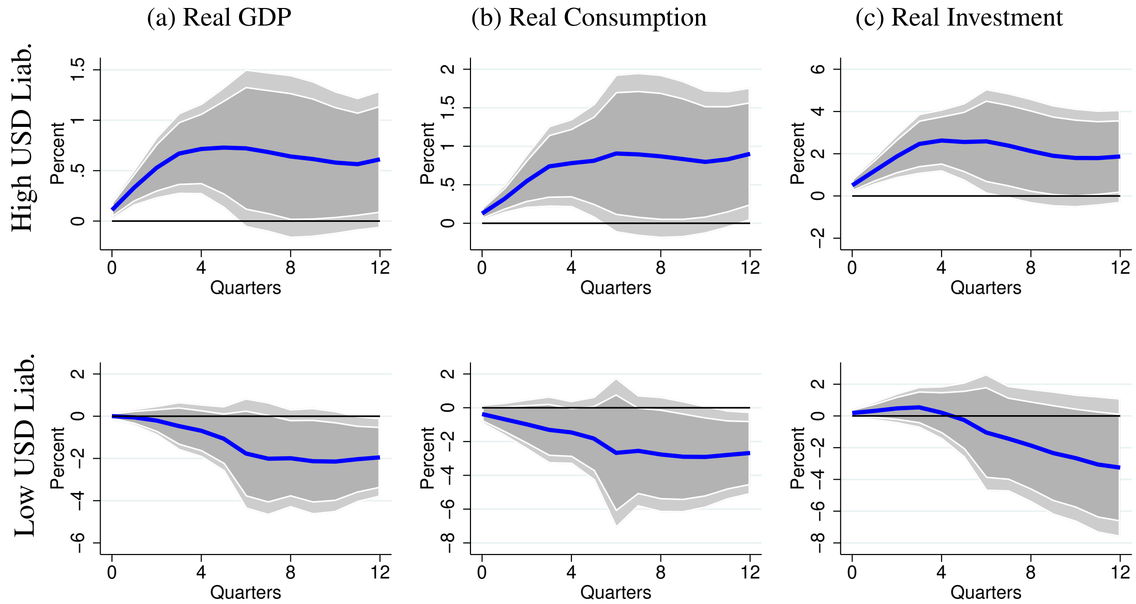
I proceed as follows: I use data on liabilities in USD by Bénétrix et al. (2015) and Bénétrix et al. (2020). I calculate the mean level of liabilities in USD for each country over the period in my sample. Then I divide the countries into two groups: countries with high liabilities in USD, which are those that have an average above the median, and countries with low liabilities in USD. I then re-estimate Equation (6) for the two groups and assess whether the cumulative responses differ from each other. I do the same for assets in USD, the external vulnerability index and the trade intensity index with the U.S. by Iacoviello and Navarro (2019), and for trade openness. The distributions of liabilities and assets in USD are shown in Figures 16 and 17 in Appendix B.

Financial channel - Importance of liabilities in USD

Figure 5 shows the cumulative responses of real GDP, real consumption and real investment to a one percent appreciation of the SOEs' domestic currencies against the USD. The first row shows the cumulative responses for the group of SOEs where exposure to liabilities in USD as percent of GDP, is above median, and the second row when USD exposure is below median.

In the first row, real GDP, real consumption and real investment all increase significantly. The increase in in GDP happens despite a fall in net exports, i.e. the trade balance (see Figure 6), which is compensated by the strong increase in investment. Meanwhile, the responses for countries with debt in USD below

Figure 5: Responses to a one percent appreciation of the domestic currency against the USD by level of liabilities in USD



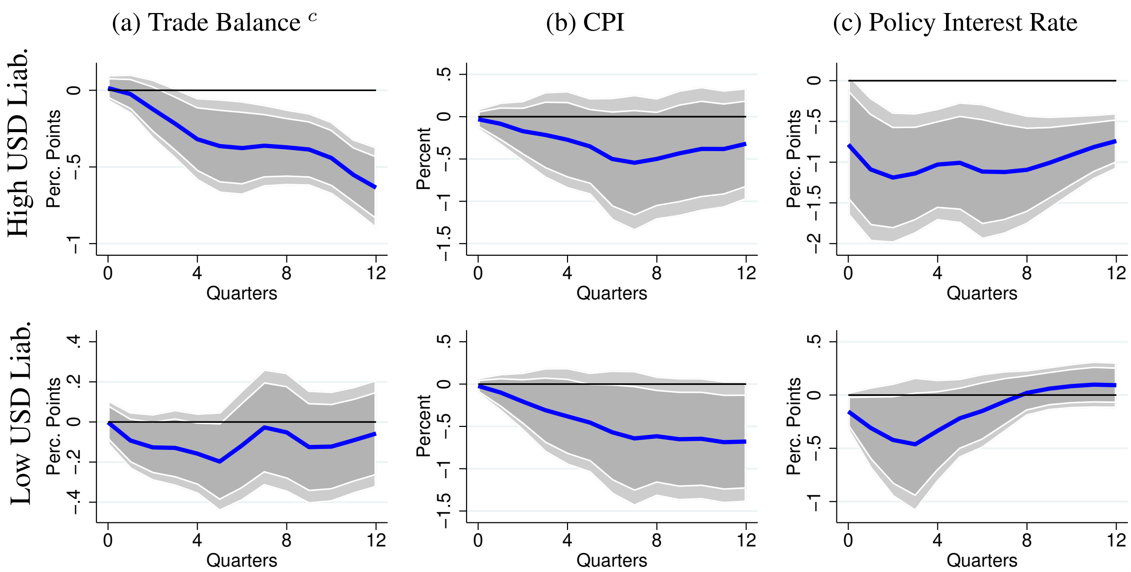
Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when USD liabilities are above median, the second row shows responses when USD liabilities are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

median is different: at first, the response of real GDP and consumption is not significantly different from zero, but the overall cumulative effect is significantly contractionary after 10 quarters, while real investment initially increases slightly significantly.

Figure 6 shows the cumulative responses of the trade balance, CPI and the policy interest rate. Again the first row presents the results when liabilities in USD are above median and the second row when they are below median. In both cases, the trade balance and CPI decrease significantly, showing the effects from the trade channel. The decrease in net exports is of similar magnitude in both groups for the first three quarters, while the decrease in CPI seems stronger, though less significant, in SOEs with low exposure to USD liabilities. Moreover, the policy interest rate decreases in both cases. However, in SOEs with high exposure to USD liabilities the central banks' reaction to the appreciation against the USD is stronger and faster, probably due to the fact that a higher amount of liabilities leads to stronger valuation effects in the balance sheet, thus central banks may be willing to decrease the interest rate more aggressively to combat the appreciation and its valuation effects. When exposure to USD liabilities is below the median, central banks do not decrease the policy rate as quickly, despite the faster decrease of CPI.

Further, Figure 7 shows the responses of equity prices, credit and cross-border bank liabilities to a one percent appreciation of the domestic exchange rate against the USD. In both groups the equity price index increases significantly, though the rise is stronger for countries with high exposure to USD liabilities.

Figure 6: Responses to a one percent appreciation of the domestic currency against the USD by level of liabilities in USD



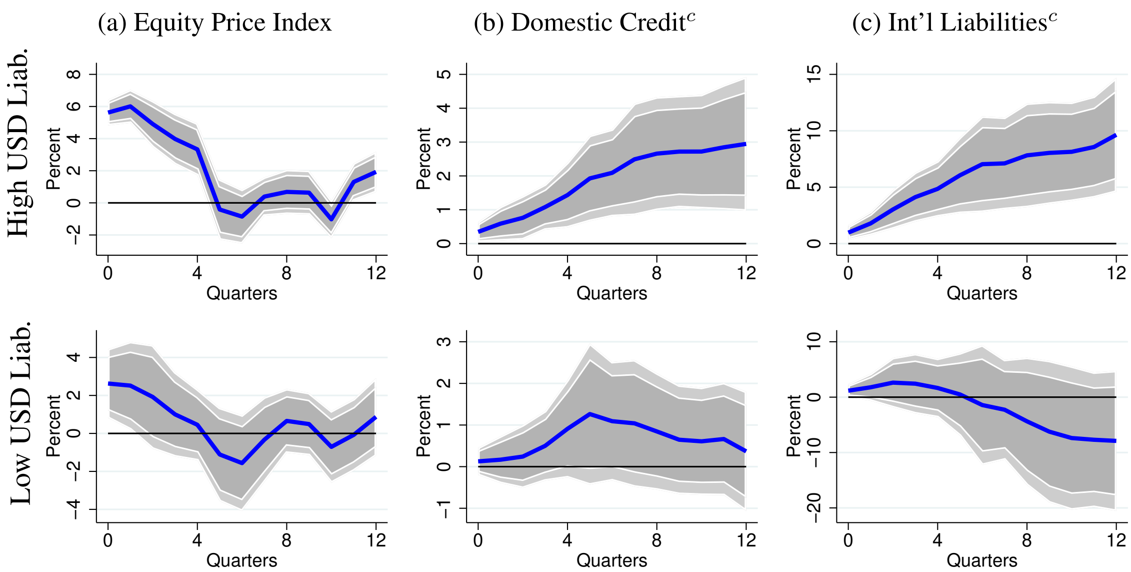
Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when USD liabilities are above median, the second row shows responses when USD liabilities are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.
^{c} as a fraction of GDP.

Moreover, credit as well as cross-border liabilities increase significantly when USD exposure is above the median, and they increase insignificantly when they are below the median.

Summing up, these results shed light on the conditions under which the financial channel is strongest. When exposure to USD liabilities is relatively high, an appreciation of the domestic exchange rate against the USD leads – on average – to overall expansionary effects. When exposure to USD liabilities is relatively low, it appears that the trade channel dominates the financial channel, since the overall effect is – on average – slightly contractionary. In the latter case, the decrease in the trade balance appears to cause the decrease of real GDP and real consumption. At the same time, the reaction of the financial variables - equity price index, credit and cross-border banking liabilities- is smaller. Thus, the bottom line of this exercise is that the financial channel seems to dominate the contractionary effects from the trade channel in countries where USD liabilities are relatively high, i.e. where the balance sheet effects of a currency appreciation are potentially more powerful.

As a robustness check for role of exposures to liabilities denominated in USD, I re-estimate Equation (6) dividing the SOEs in my sample according to the external vulnerability index by Iacoviello and Navarro (2019). This index is supposed to reflect a country's financial health. It is constructed as an equally-weighted average of inflation, current account deficit as a share of GDP, external debt minus foreign reserves (as a share of GDP), and foreign exchange reserves. The results are very similar to the ones presented above, and can be found in Appendix B.

Figure 7: Responses to a one percent appreciation of the domestic currency against the USD by level of liabilities in USD



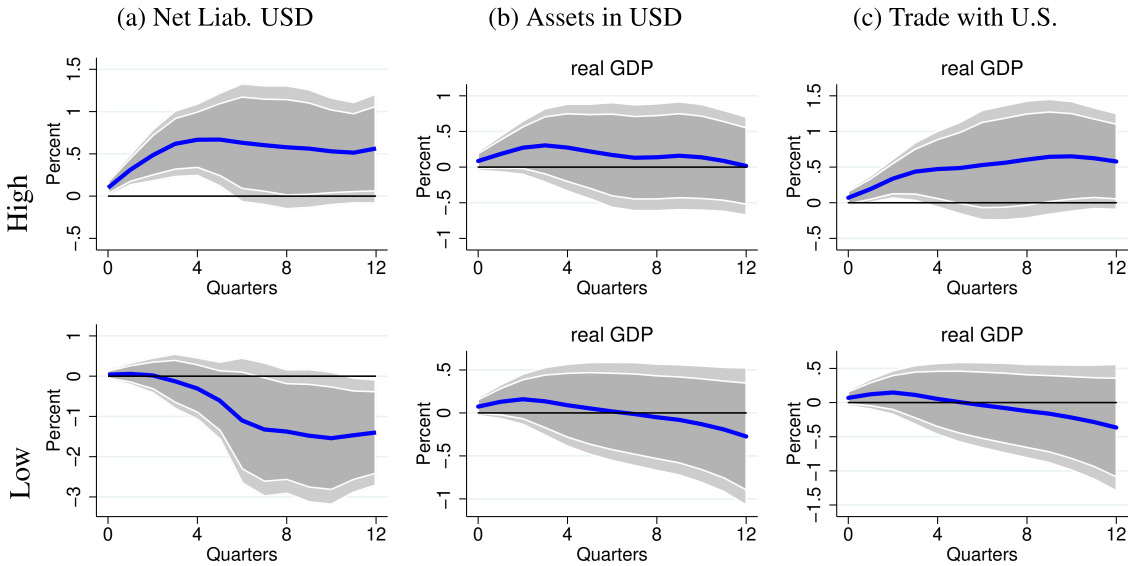
Note: The figure shows the estimated cumulative impulse responses of several financial variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when USD liabilities are above median, the second row shows responses when USD liabilities are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.
^{c} as a fraction of GDP.

Assets in USD

Next, to further analyze the financial channel, I again re-estimate Equation (6) grouping the SOEs by other indicators related to the financial and trade channel. First, I divide the countries by the amount of net liabilities in USD. Panel (a) in Figure 8 shows the cumulative response of GDP for countries with high net liabilities in USD (upper figure) and the lower figure shows the response for low net liabilities in USD (lower figure). As in the previous cases, the effect of an appreciation against the USD is expansionary in countries with high net liabilities in USD, while the effect is not significant for countries with low liabilities in USD.

Second, I group the SOEs by the amount assets denominated in USD. If the assets in the external balance sheet matter for the strength and direction of the financial channel, an appreciation of the domestic currency should have a contractionary effect when assets are relatively high. Panel (b) of Figure (8) show the responses of GDP in two groups, countries with relatively high amount of assets in USD are relatively high (upper figure) and countries with low assets (lower figure). In both cases, the appreciation increases real GDP, but the rise is not significant. The lack of significant difference between the responses in both states seems to suggest that assets in USD are less important for the strength of the financial channel.

Figure 8: Responses to a one percent appreciation of the domestic currency against the USD by other country characteristics



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the responses when net liabilities in USD are above median (upper figure) and below median (lower figure). Panel (b) shows the responses when assets in USD are above median (upper figure) and below median (lower figure). Panel (c) shows the responses when trade with the U.S. is above median (upper figure) and below median (lower figure). The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

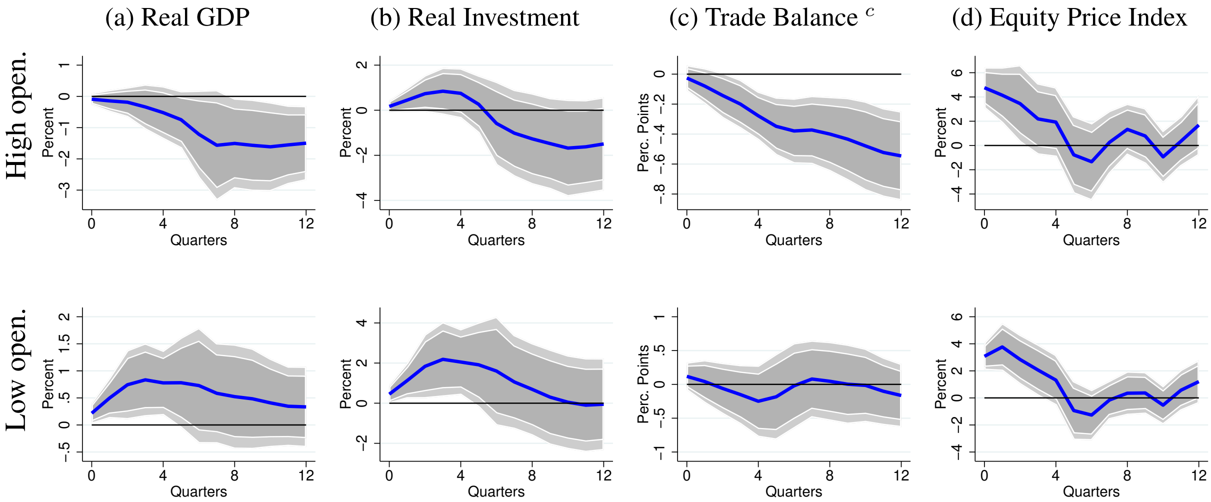
The trade channel

Moreover, I use trade openness and the trade intensity with the U.S. to gauge the strength of the trade channel. Figure (9) shows the impulse responses conditioned on trade openness. In countries that are relatively more open to trade (i.e. with openness above the median in the sample), and appreciation is contractionary, despite the increase in investment. This is due to a significant decrease in the trade balance. By contrast, in countries less open to trade, the appreciation is expansionary. In both groups of countries, investment and equity prices increase significantly. Panel (c) of Figure (8) shows the responses of real GDP by trade intensity with the U.S. I do not find significantly different responses in these cases.

However, there are some caveats of this empirical analysis. First, the identified shock, as well as the overall empirical model, may not be suitable to shed light into the trade channel in its full extent. The fact that countries have multiple trading partners, the trade weighted exchange rate could be more relevant for trade than the bilateral exchange rate against the USD (Hofmann et al., 2019; Kearns and Patel, 2016). To a certain extent, this could hinder the study the trade channel with my empirical strategy, since the shock that I identify is related to the SOEs' bilateral exchange rate against the USD. Still, as mentioned above and pointed out by Gopinath (2015), international trade is conducted in very few currencies, and the USD is the most dominant.[30] Thus, despite the limitations described above, I can examine the strength of the

[30] Trade invoicing in USD, i.e. Dominant Currency Pricing (DCP) has further implications on how exchange rate movements

Figure 9: Responses to a one percent appreciation of the domestic currency against the USD by trade openness



Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when USD liabilities are above median, the second row shows responses when USD liabilities are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.
^{c} as a fraction of GDP.

trade channel by conditioning the responses on trade openness, and on the trade intensity with the U.S. (Iacoviello and Navarro, 2019). Second and most importantly, this empirical exercise may not be suited to disentangle the confounding effects that arise from the trade and financial channels simultaneously. Some of the countries with high liabilities in USD are very open to trade, too. Similarly, some countries with low liabilities in USD are also relatively closed to international trade. Hence, despite the usefulness of the empirical model in showing the effects through the trade and financial channels, the model does not fully separate these two, and thus does not allow to have a detailed study of the two opposing channels.[31]

Therefore, in the next section, I use an estimated DSGE model where the financial and trade channels are explicitly modeled, and where the exchange rate against the USD has a direct impact on exports and imports, and on the external balance sheet of the economy. Thus, the DSGE model may be more appropriate to disentangle the trade and financial channels, than the LP-IV with the identified instrument.

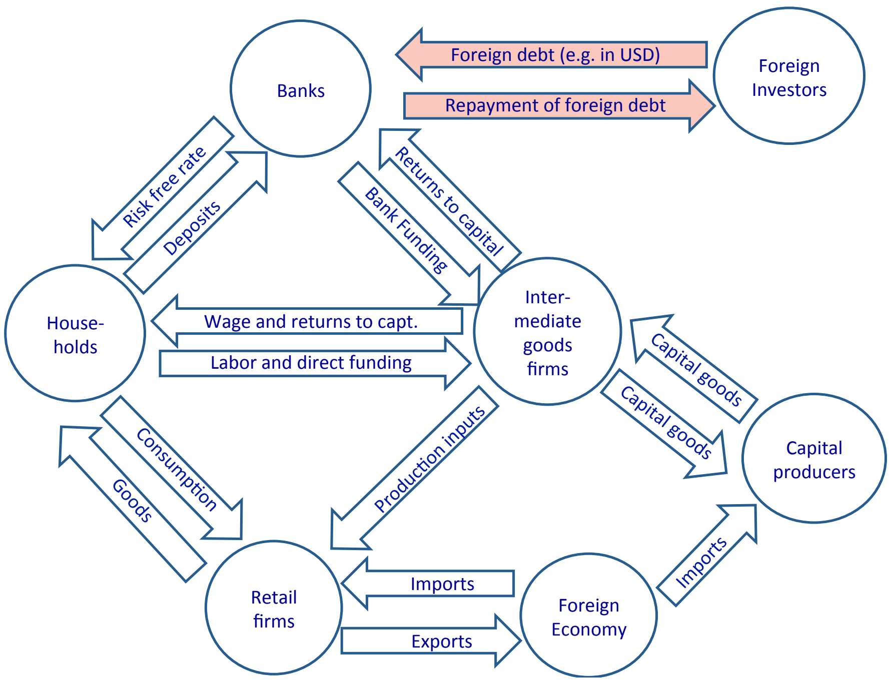
impact the economy though the trade channel, also depending on the degree of DCP. For instance, under full DCP, i.e. all trade is invoiced in USD, an *overall depreciation* of the USD against all other currencies will increase imports since the price of imported goods and services decrease from the perspective of the importers. Thus, households and firms will increase their demand for imported goods, which in turn increases global trade.

[31]This conclusion is supported by the inspection of the other variables in the model, when dividing the groups by trade openness. In these cases, there is no particular pattern that would indicate the relative strength of either channel. For details, see Appendix B.

5 A DSGE model for a SOE with liabilities in foreign currency

In Section 4, I have shown empirically that exchange rate appreciations can be expansionary depending on the level foreign of currency exposure. In this section I use an open economy DSGE model to deepen the precious analysis, to look closer at financial channel of exchange rates and to have a structural interpretation of the empirical results. Thus, with the estimated DSGE model at hand, I can further address the second research question, *(ii) Under which conditions does the financial channel dominate the trade channel?* and I can examine whether the financial channel of exchange rates has an effect on the transmission of foreign monetary policy shocks, and thus answer the third research question, *(iii) What are the financial channel's implications for the propagation of foreign monetary policy shocks into a SOE?*

Figure 10: Structure of the model



I extend a standard New Keynesian small open economy model (see, for instance, Adolfson et al., 2007; Justiniano and Preston, 2010), by including financial frictions where banks can borrow funds in foreign currency (USD) while their assets are denominated in domestic currency, similar to Aoki et al. (2016).[32] This adds a potentially powerful financial channel to the existing trade linkages in standard open economy models. Moreover, the presence of liabilities in USD introduces a feedback mechanism between exchange rate movements and banks' balance sheets, which translates into a loosening of financial conditions when the domestic exchange rate appreciates. Thus, the model is able to take into account the level of USD liabilities as the key determinant of the strength of the financial channel, in line with the

[32] Akinci and Queralto (2021) and Mimir and Sunel (2019) build open economy DSGE models with a similar financial friction.

empirical evidence presented in Section 4.[33]

The model is structured as follows (see Figure 10). The representative household buys consumption goods from final goods producers, which consist of domestically produced and imported consumption goods. Also, the household sells its labor to the intermediate goods firms. To save, it holds deposits in banks, which are denominated in local currency and yield the risk-free rate. Therefore there is no exchange rate risk for the household, and its deposits are fully insured. The household can also directly finance intermediate goods firms, however, it is less efficient than banks in doing so. Moreover, the investment good is composed of domestic and imported goods. Capital producers produce new investment goods and repair depreciated capital, which they sell to intermediate goods firms. Intermediate goods producers have capital and labor as inputs for production. Furthermore, they receive funding from domestic banks.

Banks have two sources of financing, domestic deposits from the household (denominated in domestic currency), and foreign debt from foreign investors, which is denominated in foreign currency (USD). Since banks' assets are denominated in local currency and part of their liabilities are denominated in USD, they do face exchange rate risk. Moreover, they also face a financial friction similar to the one in Gertler and Karadi (2011), and Gertler and Kiyotaki (2010). Further, I assume that it is easier for banks to run away with foreign funds, which implies the financial friction is more binding for deposits in foreign currency.

5.1 Model

I the following section I briefly the key elements of the model, especially those of the financial frictions, the key feature for my analysis.[34]

5.1.1 Firms

There is a continuum of domestic monopolistic firms i that produce an intermediate, differentiated good using capital k_t and labor l_t, and subject to an aggregate stationary productivity shock A_t:

$$y_t^H(i) = A_t k_{t-1}(i)^\alpha l_t(i)^{1-\alpha} \tag{7}$$

where $\alpha \in (0, 1)$.

The monopolistic intermediate goods producers face quadratic price adjustment costs (Rotemberg, 1982). They set their prices $P_t(i)$ to maximize the expected discounted value of profit $\Pi_{t+j}^H(i)$:

[33] My model does not allow for domestic agents to own assets in USD. However, while the data shows that the countries in my sample do in fact have assets in USD, the results from Section 4 suggest that assets do not play a major role in explaining the strength of the financial channel.

[34] For a detailed derivation of this kind of models, I refer to Adolfson et al. (2007), or Mimir and Sunel (2019). See the appendix for the full list of equilibrium equations.

$$\max_{P_t^H(i)} \mathrm{E}_0 \sum_{j=0}^{\infty} \Lambda_{t,t+j} \left(\frac{\Pi_{t+j}^H(i)}{P_{t+j}} \right)$$

subject to:

$$\Pi_{t+j}^H(i) = P_{t+j}^H(i) y_{t+j}^H(i) + e_{t+j} P_{t+j}^{H*}(i) ex_{t+j}^H(i) - MC_{t+j} y_{t+j}^H(i) - P_{t+j} \frac{\kappa}{2} \left(\frac{P_{t+j}^H(i)}{P_{t+j-1}^H(i)} - 1 \right)^2$$

and the demand function for good i: $y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\eta} Y_t$. $\Lambda_{t,t+j}$ is the stochastic discount factor. e_{t+j} is the nominal exchange rate, $P_{t+j}^{H*}(i)$ is the price of the domestic good abroad, $ex_{t+j}^H(i)$ is exports of the domestic good, and κ is the price adjustment cost parameter.

In a symmetric equilibrium, $P_t^H(i) = P_t^H$, so that the solution of the profit maximization yields:

$$p_t^H = \frac{\eta}{\eta - 1} mc_t - \frac{\kappa}{\eta - 1} \frac{\pi_t^H(\pi_t^H - 1)}{y_t^H} + \frac{\kappa}{\eta - 1} \mathrm{E_t} \left(\frac{\pi_{t+1}^H(\pi_{t+1}^H - 1)}{y_t^H} \right) \tag{8}$$

where p_t^H is the price level of domestically produced goods divided by the CPI price level, π_t^H is the inflation rate of the domestically produced goods, and π_t is the gross CPI inflation rate in period t. Real marginal costs, from the cost minimization problem, are:

$$mc_t = \tilde{\xi}_t^c \frac{1}{A_t} \left(\frac{w_t}{1-\alpha} \right)^{1-\alpha} \left(\frac{Z_t}{\alpha} \right)^{\alpha} \tag{9}$$

Z_t and w_t are the real rental price of capital and the real wage respectively, and $\tilde{\xi}_t^c$ is a cost-push shock.

Similarly, the solution of the imported goods firms' problem is given by:

$$p_t^F = \frac{\eta}{\eta - 1} s_t - \frac{\kappa}{\eta - 1} \frac{\pi_t^F(\pi_t^F - 1)}{y_t^F} + \frac{\kappa}{\eta - 1} \mathrm{E_t} \left(\frac{\pi_{t+1}^F(\pi_{t+1}^F - 1)}{y_t^F} \right)$$

where where p_t^F is the price level of imported goods divided by the CPI price level, π_t^F is the inflation rate of the imported goods, and s_t is the real exchange rate.

These intermediate goods are combined into final domestic and imported goods through the Dixit-Stiglitz aggregator:

$$y_t^H = \left[\int_0^1 y_t^H(i)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}} \qquad y_t^F = \left[\int_0^1 y_t^F(i)^{1-\frac{1}{\eta}} di \right]^{\frac{1}{1-\frac{1}{\eta}}}$$

with $\eta > 1$.

5.1.2 Households

The domestic representative household consists of a continuum of bankers and workers. Each banker manages a bank until it retires with probability $(1-\sigma)$. After retirement, the bankers transfer their remaining net worth to the household, and are replaced by the same amount of bankers. Each new banker receives a fraction of total assets as start-up funds. It is also assumed that bankers are more efficient than workers in providing funds to firms since workers pay extra management costs. Moreover, besides investing directly in firms, workers can deposit currency at the banks, but cannot hold directly foreign debt nor borrow from foreigners.

The representative household chooses consumption c_t, labor supply l_t, direct capital ownership k_t^h, and bank deposits d_t to maximize the expected utility:

$$\mathrm{E}_0\left[\tilde{\xi}_t^g \sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t - h_c c_{t-1})^{1-\sigma_c} - 1}{1-\sigma_c} - \frac{\zeta_0}{1+\zeta} l_t^{1+\zeta} \right)\right] \tag{10}$$

subject to the budget constraint:

$$c_t + q_t k_t^h + \chi(k_t^h) + d_t = w_t l_t + \Pi_t + (Z_t + (1-\delta)q_t)k_{t-1}^h + R_{t-1} d_{t-1}, \tag{11}$$

where $h_c \in (0,1]$ is external consumption habit, $\sigma_c > 1$ is the intertemporal elasticity of substitution, $\zeta > 0$ is the inverse Frisch elasticity of labor supply, ζ_0 is the utility weight of labor, q_t is equity price, d_t the real value of deposits, $\chi(k_t^h)$ represents the cost disadvantage of the households in providing funding firms, R_t is the gross real interest rate, Π_t is profits, $\beta \in (0,1)$ is the discount factor and $\tilde{\xi}_t^g$ is a preference shock.

Moreover, the consumption good is an aggregate of domestically produced and imported goods, as in Galí and Monacelli (2005) or Adolfson et al. (2007):

$$c_t = \left[\omega^{\frac{1}{\gamma_c}} \left(c_t^H\right)^{\frac{\gamma_c - 1}{\gamma_c}} + (1-\omega)^{\frac{1}{\gamma_c}} \left(c_t^F\right)^{\frac{\gamma_c - 1}{\gamma_c}}\right]^{\frac{\gamma_c}{\gamma_c - 1}},$$

where $\omega \in (0,1)$ is the home bias parameter, and $\gamma_c > 0$ is the elasticity of substitution between domestic and imported goods.

5.1.3 Banks

As stated above, banks fund intermediate goods firms, i.e. buy equity in intermediate goods firms. Banks finance their operations by accepting deposits from domestic households, by borrowing from abroad and by using their own net worth. Each banker retires at some point and brings back its net worth to the household. To motivate a limit on the bank's ability to raise funds, I follow Aoki et al. (2016), who introduce a moral hazard problem similar to the one in Gertler and Karadi (2011) and Gertler and Kiyotaki (2010). After raising funds, the bank decides whether to operate honestly or divert funds. When bankers decide to divert funds, creditors will force them to bankruptcy and bankers will loose the franchise completely. Thus, the bankers' decision of diverting funds or to act honestly depends on the value of future dividends that they would get if she is honest, and on the value of the assets that could be diverted. The objective of the banks is the expected present value of future net worth n_{t+j}:

$$V_t = \mathrm{E}_0 \left[\sum_{j=1}^{\infty} \Lambda_{t,t+j} \sigma^{j-1} (1-\sigma) n_{t+j} \right], \tag{12}$$

where $\sigma^{j-1}(1-\sigma)$ is the probability of retirement. The aggregate flow of funds constraint of banks is given by:

$$n_t = (Z_t + (1-\delta)Q_t)k^b_{t-1} - R_{t-1}d_{t-1} - s_t R^*_{t-1} d^*_{t-1}, \tag{13}$$

where k^b_t, d_t, R^*_t and d^*_t are the individual bank's capital holdings, domestic deposits, the foreign interest rate and foreign debt.

Aoki et al. (2016) assume that the ability of banks to divert funds depends on the source of the funds. Banks can divert the fraction of assets given by:

$$\Theta(x_t) = \theta \left(1 + \frac{\gamma}{2} x_t^2 \right), \tag{14}$$

where $\theta > 0$ is the severity of the banks' moral hazard,

$$x_t = \frac{s_t d^*_t}{q_t k^b_t} \tag{15}$$

is the fraction of assets financed by foreign borrowing, and $\gamma > 0$ is the degree of home bias in funding. A positive γ means that banks can divert a larger fraction of assets when they raise foreign funds. Since banks evaluate whether they divert funds by comparing the value of their franchise with the value of divertable funds, the incentive constraint of the bank is given by:

$$V_t \geq \Theta(x_t) q_t k^b_t$$

Thus, banks choose k^b_t, d_t and d^*_t to maximize its value:

$$V_t = \mathrm{E}_t \left[\Lambda_{t,t+1} \left[(1-\sigma) n_{t+1} + \sigma V_{t+1} \right] \right].$$

Following Aoki et al. (2016), the value function can be re-written as:

$$\psi_t \equiv \frac{V_t}{n_t} = \mathrm{E}_t \left[\Lambda_{t,t+1} (1 - \sigma + \sigma \psi_{t+1}) \frac{n_{t+1}}{n_t} \right],$$

where ψ_t is Tobin's q ratio of banks. After defining the leverage multiple as $\phi_t = \frac{q_t k_t}{n_t}$, and using the definition of the balance sheet, the flow of funds constraint can be written as:

$$\frac{n_{t+1}}{n_t} = \left[\frac{Z_{t+1} + (1-\delta)q_{t+1}}{q_t} - R_{t+1}\right]\phi_t + \left[R_{t+1} - \frac{e_{t+1}}{e_t}R^*_{t+1}\Psi_t\right]\phi_t x_t + R_{t+1}.$$

Thus, banks choose ϕ_t and x_t to maximize Tobin's q ratio:

$$\psi_t = \max_{\phi_t, x_t}\left(\mu_t\phi_t + \mu^*_t\phi_t x_t + \nu_t\right),$$

subject to the incentive constraint:

$$V_t \geq \Theta(x_t)\phi_t = \theta\left(1 + \frac{\gamma}{2}x_t^2\right)\phi_t$$

The UIP condition in this model arises from the banks' problem and is given by:

$$\mu^*_t = \mathrm{E_t}\left[\Omega_{t+1}\left(R_{t+1} - \frac{e_{t+1}}{e_t}R^*_{t+1}\Psi_t\right)\right], \tag{16}$$

where μ^*_t is the cost advantage of foreign currency debt over domestic deposits, and the banks' stochastic discount factor is: $\mathrm{E_t}\Omega_{t+1} = \mathrm{E_t}\Lambda_{t,t+1}\left(1 - \sigma + \sigma\psi_{t+1}\right)$. The risk premium is given by:

$$\Psi_t = \exp\left(\psi_1\hat{d}^*_{t+1}\right)\psi_t,$$

where $\log(\psi_{t+1}) = \rho_\psi \log(\psi_t) + \xi^\psi_{t+1}$, and ξ^ψ_{t+1} is the risk premium shock (UIP shock).

Moreover, μ_t, the excess return on capital over home deposit, and ν_t are defined as:

$$\mu_t = \mathrm{E_t}\left[\Omega_{t+1}\left(\frac{Z_{t+1} + (1-\delta)q_{t+1}}{q_t} - R_{t+1}\right)\right], \tag{17}$$

$$\nu_t = \mathrm{E_t}\left[\Omega_{t+1}R_{t+1}\right] \tag{18}$$

In cases, where μ_t and μ^*_t are positive, the incentive constraint is binding and the solution of the banks' problem is given by:

$$\phi_t = \frac{\nu_t}{\Theta(x_t) - (\mu_t + \mu^*_t x_t)} \tag{19}$$

$$\psi_t = \Theta(x_t)\phi_t \tag{20}$$

$$x_t = \frac{1}{\tilde{\mu^*_t}}\left(-1 + \sqrt{1 + \frac{2}{\gamma}\tilde{\mu^*_t}^2}\right), \tag{21}$$

with $\tilde{\mu^*_t} \equiv \frac{\mu^*_t}{\mu_t}$.

Thus, the leverage ratio is a decreasing function of θ and and increasing function of μ_t and μ^*_t; and x_t

is an increasing function of $\tilde{\mu}_t^*$. Intuitively, this means that if $\tilde{\mu}_t^*$ is large, banks will raise more deposits from foreign investors.

5.1.4 Capital producers

Capital producers operate in a perfectly competitive environment. They repair the depreciated capital that they acquire from intermediate goods firms and purchase investment goods, which they transform into capital. Thereafter, they sell their produced capital goods to intermediate goods firms at price q_t.

Capital producers use an investment good that is composed of domestic and imported final goods:

$$i_t = \left[\omega^{\frac{1}{\gamma_c}} \left(i_t^H \right)^{\frac{\gamma_c - 1}{\gamma_c}} + (1-\omega)^{\frac{1}{\gamma_c}} \left(i_t^F \right)^{\frac{\gamma_c - 1}{\gamma_c}} \right]^{\frac{\gamma_c}{\gamma_c - 1}}.$$

The aggregate capital stock accumulates through investment i_t

$$k_{t+1} = \tilde{\xi}_t^i \left(1 - \Phi \left(\frac{i_t}{i_{t-1}} \right) \right) i_t + (1-\delta) k_t, \tag{22}$$

where $\Phi\left(\frac{I_t}{I_{t-1}}\right) = \frac{\kappa_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2$ represents investment adjustment costs, $\delta \in (0,1)$ is the depreciation rate, and $\tilde{\xi}_t^I$ is a stationary investment efficiency shock.

5.1.5 Monetary policy

The policy maker in the domestic economy sets the nominal interest rate following a Taylor rule, which responds to inflation and to deviations of GDP from its steady state. In an alternative specification, I allow the policy maker to also respond to changes in the nominal exchange rate. The Taylor rule is given by:

$$r_t^n - r^n = (1-\rho_i)\left[\omega_i(\pi_t - \pi) + \omega_y(gdp_t - gdp) + \omega_e(\Delta e_t)\right] + \rho_i(r_{t-1}^n - r^n) + \xi_t^{MP} \tag{23}$$

where r_t^n is the nominal interest rate and $\xi_t^{MP} \sim \mathcal{N}(0, \sigma_i)$ is the domestic monetary policy shock. In the baseline specification I assume $\omega_e = 0$.

5.1.6 Market clearing, foreign economy and exogenous disturbances

Equilibrium in the goods market of domestically produced goods requires:

$$y_t^H = c_t^H + i_t^H + g_t^H + ex_t^H + \left(p_t^H\right)^{-\gamma} \frac{\kappa}{2} \left(\pi_t \frac{p_t^H}{p_{t-1}^H} - 1 \right)^2 + \chi(k_t^h) \tag{24}$$

where g_t^H is government consumption. Following Aoki et al. (2016), exports are a function of the real exchange rate and foreign output:

$$ex_t = \left(s_t^{\varphi} y_t^*\right)^{(\rho_{ex})} \left(ex_{t-1}\right)^{1-\rho_{ex}} \tag{25}$$

and φ is the elasticity of export demand.

Similarly, equilibrium in the imported goods market is given by:

$$y_t^F = c_t^F + i_t^F + \left(p_t^F\right)^{-\gamma} \frac{\kappa}{2} \left(\pi_t \frac{p_t^F}{p_{t-1}^F} - 1\right)^2 \tag{26}$$

Moreover, real GDP, net of adjustment costs, is given by:

$$gdp_t = c_t^H + i_t^H + g_t^H + ex_t^H \tag{27}$$

Aggregate capital is $k_t = k_t^h + k_t^b$, and aggregate net worth of banks evolves as:

$$n_t = (\sigma + \xi)(Z_t + (1 - \delta))k_{t-1}^b - \sigma R_t d_{t-1} - \sigma s_t R_{t-1}^* d_{t-1}^*. \tag{28}$$

where ξ are the new bankers' start-up funds, k_t^b is the capital owned by the banks, and d_t^* is net foreign debt (foreign investors' deposits in the domestic banks). Finally, the net financial position of the domestic economy evolves as:

$$d_t^* = R_{t-1}^* d_{t-1}^* + y_t^F - \frac{1}{s_t} ex_t. \tag{29}$$

Following Copaciu et al. (2015), the foreign economy, which is exogenous to the domestic one, consists of a simple closed economy New Keynesian model subject to a demand shock, a cost-push shock, and a monetary policy shock. The former two shocks follow AR(1) processes, while the latter is an i.i.d. process.

The domestic economy is subject to the UIP-risk premium shock and to five other purely domestic shocks: stationary technology shock, stationary investment efficiency shock, cost push shock, preference shock and monetary policy shock. The UIP, technology, investment efficiency, cost push and preference shocks follow an AR(1) process, while the monetary policy shock is an i.i.d. processes. In total, the model is subject to nine different shocks, six of them affect the domestic economy directly

5.2 Estimation of the DSGE model

The model is estimated using Bayesian techniques for Brazilian data. Brazil is one of the countries with highest amount of foreign liabilities in USD in my sample. Moreover, Brazil is a relatively closed economy.[35] The sample period for the estimation is 1997Q1 - 2019Q2. I use nine observable time series:

[35] Figure 18 in Appendix B shows a scatterplot for USD liabilities and trade openness.

real GDP growth, CPI inflation, real consumption growth, real gross fixed capital formation growth, the nominal policy interest rate, the nominal exchange rate against the USD, U.S. real GDP growth, U.S. CPI inflation, and the Federal Funds Rate.[36] I remove the mean of all the observable variables. Moreover, similar to Christiano et al. (2011), I allow for measurement errors in all the observables, except for the nominal interest rates (both in the domestic economy and in the U.S.). I calibrate the variance of the measurement errors for all the variables to be 10% of the standard deviation of the time series, except for inflation, for which I calibrate it to be 25%, again, following Christiano et al. (2011).

Table 2 presents the calibrated parameters. The discount factor is calibrated to match the mean policy interest rates in Brazil over the sample period. Further, I set the steady state for the foreign interest rate at 1.2% to match the mean of the (shadow) FFR. The parameter ω was calibrated so that trade openness in Brazil is 24% of domestic GDP, matching the data. The parameters θ, γ and ξ are calibrated so that the leverage ratio in Brazil equals 8.25, the foreign debt denominated in USD in Brazil amounts to 29% of GDP, and the spread between return on bank assets and deposits equals 2 percentage points. These four key parameters in the model are calibrated and not estimated because the data used for estimation does not allow for their identification. Moreover, I calibrate $\rho_{ex} = 0.2$, which is close to the value in Mimir and Sunel (2019) and is consistent with OLS estimates of a linearized version of Equation (25). I calibrate all other parameters following Aoki et al. (2016) and Mimir and Sunel (2019).

[36] For the period when the Federal Funds Rate was at the zero lower bound, I use the shadow rate by Xia and Wu (2018). Wu and Zhang (2019) also estimate a DSGE model using the shadow rate and show that this is equivalent to taking into account unconventional monetary policies in the model.

Table 2: Calibrated parameters and steady state targets

Parameter	Value - Brazil	Description	Target
β	0.985	Discount factor (quarterly)	mean policy rate
γ_c	0.5	Elastic. H-F. goods	Mimir & Sunel (2019)
$\varkappa$	0.0015	Cost of direct finance	Aoki et al. (2016)
α	0.4	Cost share of capital	Mimir & Sunel (2019)
δ	0.02	Depreciation rate	Aoki et al. (2016)
ψ_1	0.01	For. debt elastic. prem.	literature
η	11	Elasticity of demand	Mimir & Sunel (2019)
ρ_{ex}	0.2	Foreign output in exports	Literature and estim.
ω	0.85	Home bias in c_t and i_t	Trade openness
σ	0.923	Survival probability	Aoki et al. (2016)
ξ	1.2×10^{-4}	Endowment new bankers	ϕ_t, x_t & spread
θ	0.49	Divertable assets	ϕ_t, x_t & spread
γ	5.34	Home bias in funding	ϕ_t, x_t & spread
ω_e	0.10	TR coefficient exch. rate	————————
π_t	1	Gross inflation	Mimir & Sunel (2019)
x_t	0.29	Portion of the banks liab. in USD	Liab. in USD as % of all liab.
ϕ_t	8.25	Leverage ratio	World Bank data
s_t	0.02	Spread bank assets & deposits	Aoki et al. (2016)
R_t^*	1.012	Foreign interest rate/(shadow) FFR	mean

Table 3 present the priors of the estimated parameters of the model. I chose the priors following the literature on the estimation of open economy DSGE models with data for SOEs (see, for instance, Justiniano and Preston, 2010; García-Cicco et al., 2014; Copaciu et al., 2015). Further, I scale the standard deviations of the shocks such that they are of similar order of magnitude (Christiano et al., 2011). Finally, I obtain the estimation results using a Metropolis-Hastings chain with 200,000 draws after a burn in of 50,000 and an acceptance ratio of around 0.30. The estimated parameters are also shown in Table 3. In general, the posterior means seem to be plausible, and are in line with the broad literature on estimated DSGE models. Similarly to García-Cicco et al. (2014), the posterior mean of the investment adjustment cost parameter is close to 1, which would be on the low end of this parameter's estimates in the literature.

Table 3: Priors and posteriors

			Prior		Posterior	
Para.	Description	Dist.	Mean	s.d.	Mean	s.d.
σ_c	Intertemp. elastic. of subst.	gamma	1.2	0.4	0.81	0.16
ζ	Inv. Frisch elas.	norm.	5	0.5	4.39	0.58
h_c	Habit in consumption	beta	0.7	0.1	0.79	0.03
κ	Inv. slope PC	norm.	150	20	216.6	16.3
φ	Elas. exp. dem.	norm.	1	0.05	0.87	0.02
κ_I	Inv. adj. cost	norm.	3	0.5	0.9	0.16
ω_π	TR coeff. inf.	gamma	1.5	0.15	1.20	0.05
$\omega_{\Delta y}$	TR coeff. growth	gamma	0.5	0.15	0.53	0.12
$\omega*_\pi$	U.S. TR coeff. inf.	gamma	1.5	0.15	1.29	0.10
$\omega*_{\Delta y}$	U.S. TR coeff. growth	gamma	0.5	0.15	0.18	0.03
$\gamma*_{\Delta y}$	Elast. of subst. U.S.	gamma	1.2	0.4	2.65	0.45
κ_{π^*}	Inv. slope PC U.S.	norm.	150	50	149.3	44.85
ρ_i	Autoreg. dom. TR	beta	0.7	0.1	0.47	0.04
ρ_A	Autoreg. techn. shock	beta	0.7	0.1	0.66	0.10
ρ_I	Autoreg. inv. effi. shock	beta	0.7	0.1	0.72	0.08
ρ_ψ	Autoreg. risk prem. shock	beta	0.7	0.1	0.92	0.02
ρ_{cp}	Autoreg. cost push shock	beta	0.7	0.1	0.90	0.03
ρ_g	Autoreg. pref. shock	beta	0.7	0.1	0.25	0.07
ρ_{y*}	Autoreg. for. dem. shock	beta	0.7	0.1	0.87	0.02
$\rho_{\pi*}$	Autoreg. for. inf. shock	beta	0.7	0.1	0.39	0.08
ρ_{i*}	Autoreg. for. MP shoc	beta	0.7	0.1	0.88	0.01
$\sigma_i \times 10$	s.d. dom. MP shock	inv. gam.	0.1	2	0.12	0.02
$\sigma_A \times 10$	s.d. stat. tech. shock	inv. gam.	0.1	2	0.07	0.02
σ_I	s.d. stat. inv. effi. shock	inv. gam.	0.1	2	0.46	0.10
$\sigma_\psi \times 10$	s.d. risk prem. shock	inv. gam.	0.1	2	0.08	0.02
σ_{cp}	s.d. cost push shock	inv. gam.	0.1	2	0.07	0.01
σ_g	s.d. pref. shock	inv. gam.	0.1	2	0.04	0.01
$\sigma_{y*} \times 10$	s.d. for. dem. shock	inv. gam.	0.1	2	0.02	0.002
$\sigma_{\pi*} \times 10$	s.d. for. infl. shock	inv. gam.	0.1	2	0.04	0.01
$\sigma_{i*} \times 100$	s.d. for. MP shock	inv. gam.	0.1	2	0.14	0.01

5.2.1 The UIP shock

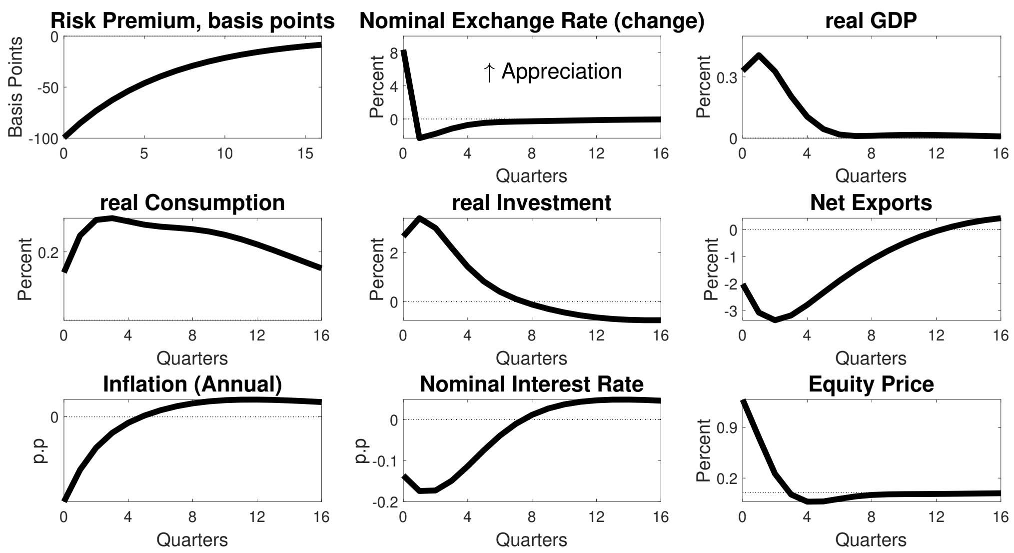
Impulse response analysis - UIP shock

To study the effects of an appreciation of the exchange rate, and again address the first and second research questions of this paper, I follow Copaciu et al. (2015) and analyze the impulse responses of the relevant variables to a shock to the UIP condition.

Figure 11 shows the impulse responses to a 100 basis points[37] decrease in the risk premium. The decrease in the risk premium leads to a nominal exchange rate appreciation. Moreover, this appreciation leads to a decrease in net exports, relative to the steady state value. At the same time, inflation decreases, as expected after an appreciation. These responses are in line with the implications of the trade channel. The central bank reacts to the decrease in inflation by lowering the interest rate.

The appreciation also leads to an increase in equity prices. Investment also rises. Brazil's high foreign currency exposure creates a positive feedback effect between the exchange rate appreciation and the banks' balance sheet, which translates into more favorable financial conditions for investment. Overall, the appreciation turns out to be expansionary in Brazil and contractionary.

Figure 11: Impulse responses from a 100 basis points decrease in the risk premium



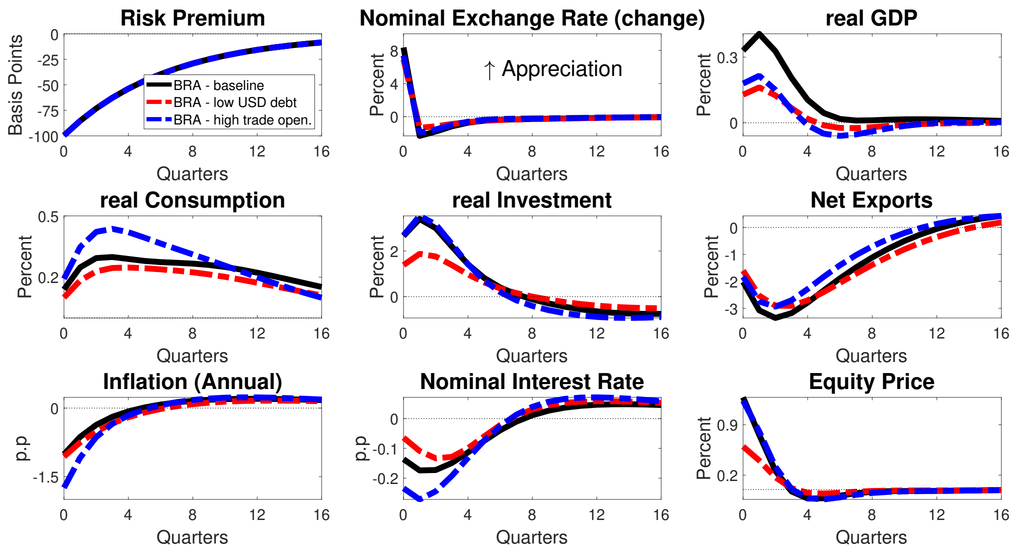
A closer look - Trade and financial channels

The previous results suggest the financial channel dominates the trade channel if liabilities in USD are high and trade openness is low. In this linearized model, the opposite must be true when liabilities in USD

[37] I study the response to a 100 basis points decrease in the risk premium rather than a one percent appreciation of the exchange rate because the UIP shock affects specifically the risk premium. Studying a one percent appreciation would have the similar implications.

are low and trade openness high. To further disentangle the channels, I perform the following exercise: I decrease the level of foreign liabilities in Brazil to amount 15% of total bank liabilities, keeping trade openness at its original value. The results are shown in Figure 12, where the red dotted line depicts this scenario and the black line the baseline results. In this case, the domestic appreciation has weaker effects on consumption, but specially on investment and real GDP. Investment's response to the shock is much weaker (around one percentage point smaller). Equity prices also rise by significantly less than in the baseline.

Figure 12: Impulse responses from a 100 basis points decrease in the risk premium



Next, I double trade openness (blue line), keeping the fraction of bank's debt denominated in USD at the baseline level. When trade openness is higher, the effect of the UIP shock on the exchange rate is weaker. However, inflation and the policy interest rate decrease by more, due to the stronger decrease in CPI because of the higher share of foreign prices in the consumption basket. Moreover, the responses of equity prices and investment remain roughly unchanged, highlighting the importance of foreign currency exposure in determining the financial effects in this model. Crucially, the resulting appreciation increases consumption by more, since households now consume a higher amount of imported goods, whose price has decreased domestically. Net exports decrease by roughly the same amount, but note that in this scenario, the steady state share of exports and imports over GDP is higher; thus there is a stronger reaction in trade. The stronger reaction of trade indeed weakens the expansionary effects of the financial channel. These results show that foreign currency exposure is an important driver of the financial channel's strength, and in turn, on the overall impact of exchange rate movements in SOEs. At the same time, trade openness has a strong impact on the effects of exchange rate appreciation, which complements the results from section 4, adding the trade dimension to the analysis.

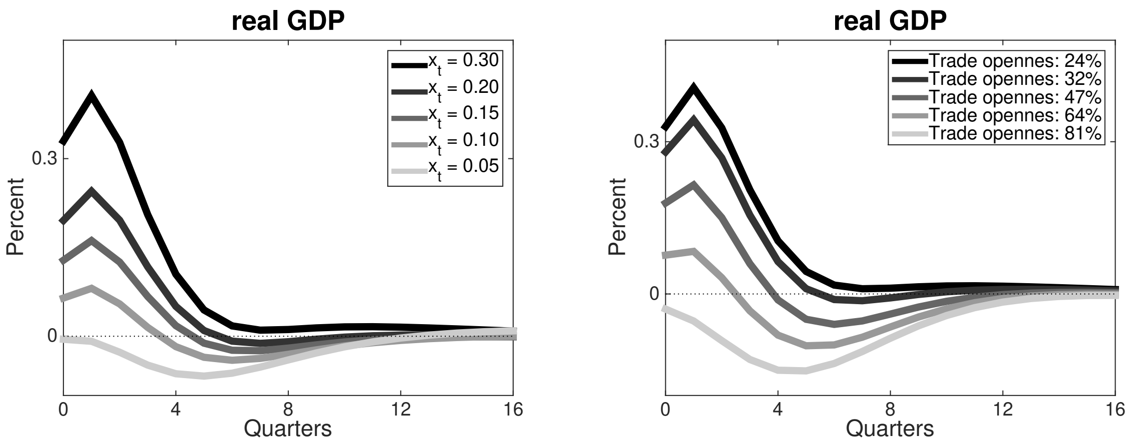
The appreciation's radically different outcomes in these exercised reflect the different levels of liabilities denominated in USD and of trade openness. The bottom line of this exercise is that an appreciation due to a decrease in the risk premium could be expansionary when foreign liabilities denominated in USD are high and trade openness is (relatively) low. The expansionary appreciation is due to the financial channel: since the value of the banks' liabilities is lowered relative to the assets (due to the appreciation), bank equity and credit increase, which relaxes financial constraints. This raises investment, which in turn increases GDP. These effects are not offset by the decrease in net exports. Under lower debt in USD, the financial channel weakens. Finally, if trade openness is higher, the trade channel strenghtens.

What the results show is that foreign currency exposure and the financial channel of exchange rate do have a strong impact on how USD exchange rate fluctuations affect economic activity. At the same time, however, the analysis using the open economy New Keynesian model disentagles the channels. To have a closer look at this issue, I computed the response of real GDP to a 100 basis points decrease in the risk premium for Brazil for different degrees of foreign currency exposure (panel a, Figure 13) and for different degrees of trade openness (panel b, Figure 13).

Figure 13: Brazil: Sensitivity to financial and trade openness

(a) Real GDP response to a 100 basis points decrease in the risk premium

(b) Real GDP response to a 100 basis points decrease in the risk premium



Note: Panel (a) shows the responses of real GDP for different degrees of foreign currency exposure, i.e. for different steady state shares of foreign liabilities x_t. Panel (b) shows the responses of real GDP for different degrees of trade openness, i.e. for different calibrations of home bias in consumption and investment ω.

From this exercise, it is clear that the trade and financial channels work in opposite directions. Further, the strength of the financial channel seems to depend on the amount of debt in USD: the higher the degree of exposure to USD debt, the stronger the expansionary effects of exchange rate appreciations. Moreover, these simulations are in line and also complement the insights from form Section 4. There, I have shown evidence that if foreign currency exposure is high, an appreciation has expansionary effects on all of GDP's components, except for net exports. If liabilities in USD are low, and thus the financial channel is weak, the appreciation decreases GDP and consumption. I do not find the contractionary effect on consumption in the model. However, it is important to stress that, the estimation in Section 4 was done for a panel of 17 different SOEs, not for single countries. It is possible that a LP-IV estimation for single countries could deliver the DSGE model's results.[38]. Finally, the model suggest that the interaction between the financial and trade channels determine the effects of an appreciation.

However, there are two important caveats. First, with my model I abstract from assets in foreign currency. However, as Dalgic (2018) shows, households in EMEs – which are the majority of the countries I analyze – hold significant amounts of deposits in USD as an insurance mechanism. This, in turn, weakens the expansionary effects of exchange rate appreciations, as households become poorer and their consumption decreases.[39]

5.3 Implications of the financial channel

The above analysis has shown that UIP shocks, i.e. the main driver of exchange rate, have expansionary effects in this model. Having understood the channels through which the UIP shock works, it is possible to gauge to what extent exchange rate movements – through the financial channel – can dampen of amplify other shocks, such as domestic and foreign monetary policy shocks. This way, I can answer the third research question, namely *(iii) What are the financial channel's implications for the propagation of foreign monetary policy shocks into a SOE?*

5.3.1 Impulse response analysis - U.S. monetary policy shocks

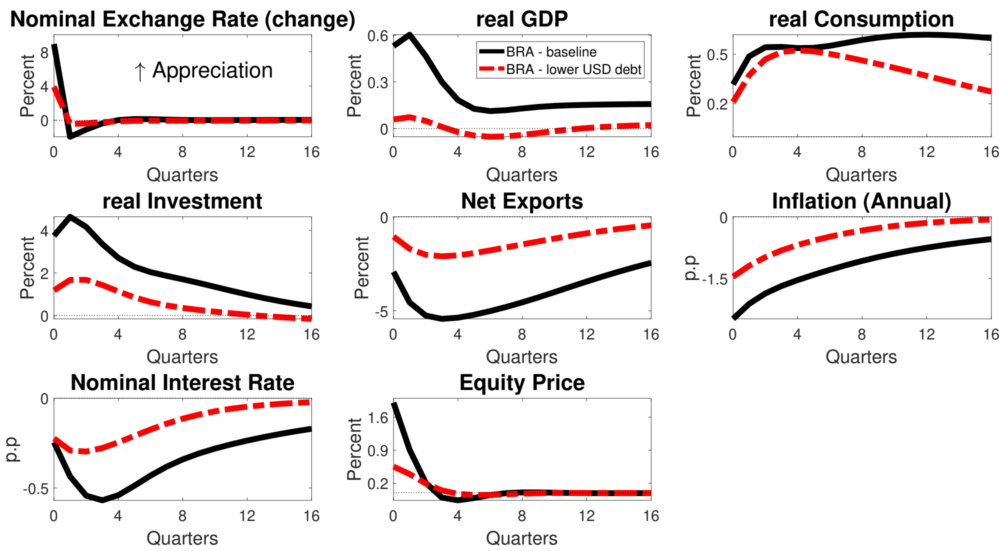
The traditional view on the effects of the exchange rate, i.e. the implications drawn from the Mundell-Fleming model, states that a foreign expansionary monetary policy shock leads to an exchange rate appreciation in the domestic economy, which ultimately leads to lower GDP. The appreciation, in turn, causes inflation to fall. Responding to this, the domestic central bank lowers the policy interest rate, mimicking the foreign monetary policy. However, the financial channel implies that the appreciation of the exchange rate would relax financial constraints which ultimately boosts economic activity. Thus, through the financial channel, the appreciation could lead to an even stronger comovement of financial conditions in the domestic and foreign economy. In this case, international spillovers may be stronger.

I consider the effects of an expansionary U.S. monetary policy shock on Brazil, for the baseline case and for lower USD debt ($x = 0.15$). Figure 14 shows the responses to such a shock. The foreign monetary surprise leads to an appreciation of the domestic economy's nominal exchange rate. The appreciation is much stronger in the case of higher USD liabilities, which also leads to a strong decrease in inflation. The response of the central bank is also stronger in the baseline case, as are the increases in real GDP, real investment, real consumption and equity prices. Overall, as in the previous analysis, the effects

[38] I chose to estimate the panel LP-IV to exploit the cross-sectional dimension, to counteract the relatively short time series dimension.

[39] However, Dalgic (2018) also finds expansionary effects from an appreciation through the financial channel.

Figure 14: Impulse responses from a foreign one percent expansionary monetary policy shock



of an foreign expansionary monetary policy shock are larger, the higher foreign currency exposure is. Thus, these results indicate that foreign monetary policy is amplified by the financial channel of exchange rates. This is in line with the empirical literature. Iacoviello and Navarro (2019) show that high financial vulnerabilities amplify the spill-over effect of U.S. monetary policy in EMEs.

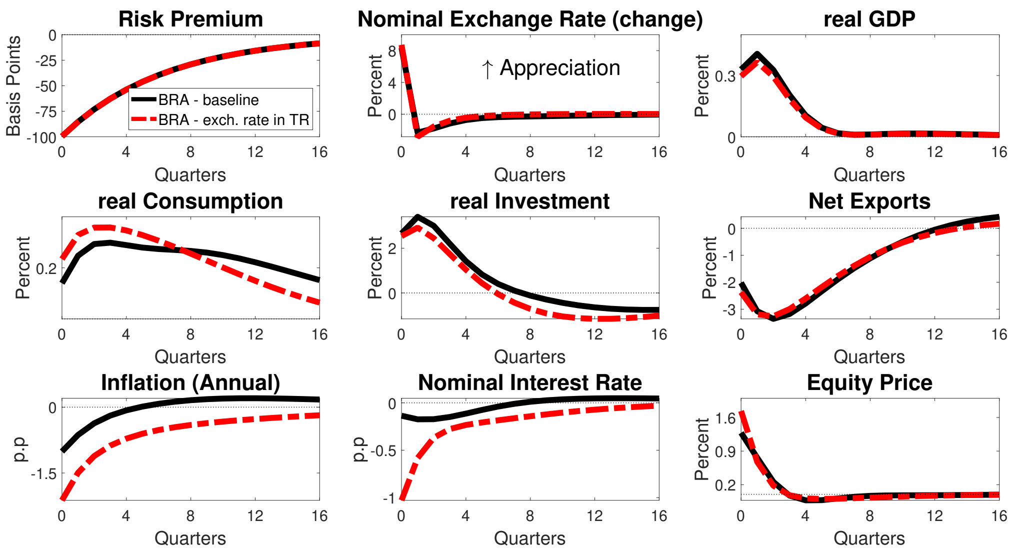
5.3.2 Alternative policy response - Exchange rate in the Taylor Rule

It is widely known that central banks of some SOEs, specially EMEs, do not just follow an inflation target but also try to stabilize the exchange rate with their policy actions. As Agustín Carstens, General Manager of the BIS, said in a speech at the London School of Economics: "Irrespective of the official labeling, emerging market economies' central banks have, in practice, attached a significant weight to the exchange rate in the conduct of their monetary policy [...]"[40]. Since most of the countries in my sample are in fact EMEs, it is necessary to study to what extent having the nominal exchange rate in the Taylor affects the responses to an appreciation and also to a foreign monetary policy expansion. For that purpose I add the nominal exchange rate to the Taylor Rule (see Equation 23) and study the implications of such a modified Taylor Rule. For ease of exposition, I focus on the model estimated with Brazilian data, where the central bank does not respond to exchange rate changes (black line), and compare the responses to the same model allowing the central bank to respond to the exchange rate with a Taylor Rule coefficient $\omega_e = 0.10$ (red line).

Figure 15 shows the impulse responses after a shock to the UIP condition that decreases the risk premium by 100 basis points. When the central bank tries to stabilize the exchange rate in addition to inflation and GDP, the nominal exchange rate increases by roughly the same percentage points, while

[40]The speech is available at: https://www.bis.org/speeches/sp190502.htm

Figure 15: Impulse responses from a 100 basis points decrease in the risk premium



inflation decreases by more. Also, the interest rate decrease is much stronger. This translates into a faster decline of the real interest rate and a stronger increase in consumption. However, in general, responses under this new policy regime do not differ much from the baseline scenario. GDP increases on impact by a bit less, but after four quarters the differences in the responses appear to fade out, and investment's responses are almost identical under both policy regimes. A possible explanation for the very similar results is that, while a stronger decrease in the interest rate helps to some extent to mitigate the appreciation, it reinforces other financial effects. Overall, it does not seem that targeting changes in the exchange rate would help stabilize the economy. Moreover, as pointed out by Akinci and Queralto (2021), who use a similar model, there are considerable welfare losses associated with targeting the exchange rate in addition to inflation. However, a welfare analysis is needed to seriously examine this policy regime, which is beyond the scope of this work.

6 Conclusion

In this paper, I investigated the macroeconomic and financial effects of USD exchange rate fluctuations in a sample of 17 SOEs. In particular, I examined how the financial channel affects the overall impact of exchange rate fluctuations and assessed to what extent foreign currency exposure determines the relative strength of the financial channel. To address the underlying endogeneity of the exchange rate, I constructed an external instrument based on the UIP condition for the USD exchange rate against major currencies. The empirical results indicated that a domestic appreciation against the USD can potentially have expansionary effects. This can be rationalized by the importance of the financial channel. Further, I found that the strength of the financial channel is determined by the level of foreign currency exposure, since the expansionary effect of a domestic appreciation is larger, the higher foreign liabilities in USD are.

I also estimated an open economy New Keynesian model, in which a fraction of the domestic banks' liabilities is denominated in USD. In line with the empirical results, I found that the level of foreign currency exposure is an important determinant of the strength of the financial channel. Further, the model estimates for Brazil indicated that, under foreign currency exposure, a domestic appreciation against the USD is expansionary, but higher openness to international trade can weaken these results. By contrast, under low foreign currency exposure and high trade openness, an appreciation is contractionary, but higher debt in USD can flip the results. Thus, the model based analysis indicated that it is the interaction between the financial and trade channels that determines whether an exchange rate appreciation against the USD is expansionary in SOEs. Finally, I also found that the financial channel amplifies the effects of foreign monetary policy in SOEs. My paper implies that taking the financial channel of exchange rates explicitly into account is of utmost importance to fully understand the macroeconomic and financial effects of exchange rate movements and of foreign shocks, and to design and implement policies aimed at mitigating their effects.

References

Adolfson, M., S. Laseen, J. Lindé and M. Villani (2007): Bayesian estimation of an open economy DSGE model with incomplete pass-through, *Journal of International Economics*, 72(2), 481–511.

Aizenman, J., M. Binici and M.M. Hutchison (2016): The Transmission of Federal Reserve Tapering News to Emerging Financial Markets, *International Journal of Central Banking*, 12(2), 317–356.

Akinci, O. and A. Queralto (2021): Exchange rate dynamics and monetary spillovers with imperfect financial markets, Staff Reports No. 849, Federal Reserve Bank of New York.

An, L., G. Kim and X. Ren (2014): Is devaluation expansionary or contractionary: Evidence based on vector autoregression with sign restrictions, *Journal of Asian Economics*, 34, 27 – 41.

Anaya, P., M. Hachula and C.J. Offermanns (2017): Spillovers of U.S. unconventional monetary policy to emerging markets: The role of capital flows, *Journal of International Money and Finance*, 73(PB), 275–295.

Aoki, K., G. Benigno and N. Kiyotaki (2016). Monetary and Financial Policies in Emeging Markets. Mimeo, Tokyo University, London School of Economics, and Princeton University.

Auboin, M. and M. Ruta (2012): The Relationship between Exchange Rates and International Trade: A Literature Review, CESifo Working Paper Series No. 3868, CESifo Group Munich.

Auerbach, A.J. and Y. Gorodnichenko (2012): Fiscal Multipliers in Recession and Expansion, in: *Fiscal Policy after the Financial Crisis*: National Bureau of Economic Research, Inc, NBER Chapters, pp. 63–98.

Avdjiev, S., V. Bruno, C. Koch and H.S. Shin (2019): The Dollar Exchange Rate as a Global Risk Factor: Evidence from Investment, *IMF Economic Review*, 67(1), 151–173.

Avdjiev, S., R.N. McCauley and H.S. Shin (2015): Breaking free of the triple coincidence in international finance, BIS Working Papers No. 524, Bank for International Settlements.

Balakrishnan, R., S. Laséen and A. Pescatori (2016): U.S. Dollar Dynamics; How Important Are Policy Divergence and FX Risk Premiums?, IMF Working Papers No. 16/125, International Monetary Fund.

Ben Zeev, N. (2019): Global credit supply shocks and exchange rate regimes, *Journal of International Economics*, 116(C), 1–32.

Bénétrix, A.S., D. Gautam, L. Juvenal and M. Schmitz (2020): Cross-Border Currency Exposures. New evidence based on an enhanced and updated dataset, Trinity Economics Papers No. tep0120, Trinity College Dublin, Department of Economics.

Bénétrix, A.S., P.R. Lane and J.C. Shambaugh (2015): International currency exposures, valuation effects and the global financial crisis, *Journal of International Economics*, 96(S1), S98–S109.

Bernoth, K. and H. Herwartz (2019): Exchange Rates, Foreign Currency Exposure and Sovereign Risk, Discussion Papers of DIW Berlin No. 1792, DIW Berlin, German Institute for Economic Research.

Bertaut, C. and R. Judson (2014): Estimating U.S. Cross-Border Securities Positions: New Data and New Methods, International Finance Discussion Papers No. 1113, Board of Governors of the Federal Reserve System.

Bertaut, C.C. and R.W. Tryon (2007): Monthly Estimates of U.S. Cross-border Securities Positions, International Finance Discussion Papers No. 910, Board of Governors of the Federal Reserve System.

BIS (2017): 87th Annual Report, , Bank for International Settlemets.

Bruno, V. and H.S. Shin (2015a): Capital flows and the risk-taking channel of monetary policy, *Journal of Monetary Economics*, 71(C), 119–132.

Bruno, V. and H.S. Shin (2015b): Cross-Border Banking and Global Liquidity, *Review of Economic Studies*, 82(2), 535–564.

Cesa-Bianchi, A., L.F. Cespedes and A. Rebucci (2015): Global Liquidity, House Prices, and the Macroeconomy: Evidence from Advanced and Emerging Economies, *Journal of Money, Credit and Banking*, 47(S1), 301–335.

Choudhri, E.U., H. Faruqee and D.S. Hakura (2005): Explaining the exchange rate pass-through in different prices, *Journal of International Economics*, 65(2), 349–374.

Christiano, L.J., M. Trabandt and K. Walentin (2011): Introducing financial frictions and unemployment into a small open economy model, *Journal of Economic Dynamics and Control*, 35(12), 1999–2041.

Copaciu, M., V. Nalban and C. Bulete (2015): R.E.M. 2.0, An estimated DSGE model for Romania, Dynare Working Papers No. 48, CEPREMAP.

Corbo, V. and P. Di Casola (2018): Conditional exchange rate pass-through: evidence from Sweden, Working Paper Series No. 352, Sveriges Riksbank (Central Bank of Sweden).

Dalgic, H.C. (2018): Financial Dollarization in Emerging Markets: An Insurance Arrangement, CRC TR 224 Discussion Paper Series, University of Bonn and University of Mannheim, Germany.

Engel, C. (2014). *Exchange Rates and Interest Parity*, Vol. 4 of Handbook of International Economics, Chapter 8, pp. 453–522: Elsevier.

Farhi, E. and I. Werning (2014): Dilemma Not Trilemma? Capital Controls and Exchange Rates with Volatile Capital Flows, *IMF Economic Review*, 62(4), 569–605.

Farrant, K. and G. Peersman (2006): Is the Exchange Rate a Shock Absorber or a Source of Shocks? New Empirical Evidence, *Journal of Money, Credit and Banking*, 38(4), 939–961.

Forbes, K., I. Hjortsoe and T. Nenova (2018): The shocks matter: Improving our estimates of exchange rate pass-through, *Journal of International Economics*, 114(C), 255–275.

Fratzscher, M., L. Juvenal and L. Sarno (2010): Asset prices, exchange rates and the current account, *European Economic Review*, 54(5), 643–658.

Galí, J. and T. Monacelli (2005): Monetary Policy and Exchange Rate Volatility in a Small Open Economy, *Review of Economic Studies*, 72(3), 707–734.

García-Cicco, J., M. Kirchner and S. Justel (2014): Financial Frictions and the Transmission of Foreign Shocks in Chile, Working Papers Central Bank of Chile No. 722, Central Bank of Chile.

Georgiadis, G. (2015): Examining Asymmetries In The Transmission Of Monetary Policy In The Euro Area: Evidence From A Mixed Cross-section Global Var Model, *European Economic Review*, 75, 195–215.

Georgiadis, G. and A. Mehl (2016): Financial globalisation and monetary policy effectiveness, *Journal of International Economics*, 103(C), 200–212.

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

Gertler, M. and P. Karadi (2015): Monetary Policy Surprises, Credit Costs, and Economic Activity, *American Economic Journal: Macroeconomics*, 7(1), 44–76.

Gertler, M. and N. Kiyotaki (2010): Financial Intermediation and Credit Policy in Business Cycle Analysis, in: B. M. Friedman and M. Woodford (Eds.), *Handbook of Monetary Economics*: Elsevier, Vol. 3 of Handbook of Monetary Economics, Chapter 11, pp. 547–599.

Gopinath, G. (2015): The International Price System, NBER Working Papers No. 21646, National Bureau of Economic Research, Inc.

Gourinchas, P.O. (2018): Monetary Policy Transmission in Emerging Markets: An Application to Chile, in: E. G. Mendoza, E. PastÃ©n, and D. Saravia (Eds.), *Monetary Policy and Global Spillovers: Mechanisms, Effects and Policy Measures*: Central Bank of Chile, Vol. 25 of Central Banking, Analysis, and Economic Policies Book Series, Chapter 8, pp. 279–324.

Hachula, M. and D. Nautz (2018): The dynamic impact of macroeconomic news on long-term inflation expectations, *Economics Letters*, 165(C), 39–43.

Hausmann, R. and U. Panizza (2011): Redemption or Abstinence? Original Sin, Currency Mismatches and Counter Cyclical Policies in the New Millennium, *Journal of Globalization and Development*, 2(1), 1–35.

Hofmann, B., I. Shim and H.S. Shin (2017): Sovereign yields and the risk-taking channel of currency appreciation, BIS Working Papers No. 538, Bank for International Settlements.

Hofmann, B., I. Shim and H.S. Shin (2019): Bond risk premia and the exchange rate, BIS Working Papers No. 775, Bank for International Settlements.

Iacoviello, M. and G. Navarro (2019): Foreign Effects of Higher U.S. Interest Rates, *Journal of International Money and Finance*, 95.

Itskhoki, O. and D. Mukhin (2017): Exchange Rate Disconnect in General Equilibrium, NBER Working Papers No. 23401, National Bureau of Economic Research, Inc.

Jordà, O. (2005): Estimation and Inference of Impulse Responses by Local Projections, *American Economic Review*, 95(1), 161–182.

Justiniano, A. and B. Preston (2010): Can structural small open-economy models account for the influence of foreign disturbances?, *Journal of International Economics*, 81(1), 61–74.

Kearns, J. and N. Patel (2016): Does the financial channel of exchange rates offset the trade channel?, *BIS Quarterly Review*.

Kiley, M. (2013): Exchange rates, monetary policy statements, and uncovered interest parity: before and after the zero lower bound, Finance and Economics Discussion Series No. 2013-17, Board of Governors of the Federal Reserve System (US).

Kim, Y. and Y.H. Ying (2007): An empirical assessment of currency devaluation in East Asian countries, *Journal of International Money and Finance*, 26(2), 265 – 283.

Klein, M. (2016): Austerity and Private Debt, Annual Conference 2016 (Augsburg): Demographic Change No. 145681, Verein fÃ¼r Socialpolitik / German Economic Association.

Kollmann, R. (2002): Monetary policy rules in the open economy: effects on welfare and business cycles, *Journal of Monetary Economics*, 49(5), 989–1015.

Kollmann, R. (2005): Macroeconomic effects of nominal exchange rate regimes: new insights into the role of price dynamics, *Journal of International Money and Finance*, 24(2), 275–292.

Lane, P.R. and J.C. Shambaugh (2010): Financial Exchange Rates and International Currency Exposures, *American Economic Review*, 100(1), 518–40.

Lane, P.R. and L. Stracca (2017): Expansionary Appreciation, *Economic Policy*.

Leigh, D., W. Lian, M. Poplawski-Ribeiro, R. Szymanski, V. Tsyrennikov and H. Yang (2017): Exchange Rates and Trade; A Disconnect?, IMF Working Papers No. 17/58, International Monetary Fund.

McCauley, R.N., P. McGuire and V. Sushko (2015): Global dollar credit: links to US monetary policy and leverage, *Economic Policy*, 30(82), 187–229.

Mertens, K. and M.O. Ravn (2013): The dynamic effects of personal and corporate income tax changes in the United States, *The American Economic Review*, 103(4), 1212–1247.

Mimir, Y. and E. Sunel (2019): External Shocks, Banks, and Optimal Monetary Policy: A Recipe for Emerging Market Central Banks, *International Journal of Central Banking*, 15(2), 235–299.

Miranda-Agrippino, S. and H. Rey (2015): World Asset Markets and the Global Financial Cycle, NBER Working Papers No. 21722, National Bureau of Economic Research, Inc.

Ramey, V. (2016). *Macroeconomic Shocks and Their Propagation*, Vol. 2 of Handbook of Macroeconomics, Chapter 0, pp. 71–162: Elsevier.

Rey, H. (2016): International Channels of Transmission of Monetary Policy and the Mundellian Trilemma, NBER Working Papers No. 21852, National Bureau of Economic Research, Inc.

Rotemberg, J. (1982): Monopolistic Price Adjustment And Aggregate Output, *Review of Economic Studies*, 49(4), 517–531.

Stock, J.H. and M.W. Watson (2012): Disentangling the Channels of the 2007-09 Recession, *Brookings Papers on Economic Activity*, 44(1 (Spring), 81–156.

Stock, J.H. and M.W. Watson (2018): Identification and Estimation of Dynamic Causal Effects in Macroeconomics Using External Instruments, *Economic Journal*, 128(610), 917–948.

Stock, J.H., J.H. Wright and M. Yogo (2002): A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments, *Journal of Business & Economic Statistics*, 20(4), 518–529.

Winne, J.D. and G. Peersman (2018): Agricultural Price Shocks and Business Cycles - A Global Warning for Advanced Economies, CESifo Working Paper Series No. 7037, CESifo Group Munich.

Wu, J.C. and F.D. Xia (2016): Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound, *Journal of Money, Credit and Banking*, 48(2-3), 253–291.

Wu, J.C. and J. Zhang (2019): A shadow rate New Keynesian model, *Journal of Economic Dynamics and Control*, 107(C), 1–1.

Xia, D. and J.C. Wu (2018): The negative interest rate policy and the yield curve, BIS Working Papers No. 703, Bank for International Settlements.

Appendix

A Data and sources

Countries and sample

Brazil (1996Q1 - 2019Q3), Chile (1996Q1 - 2019Q3), Colombia (2000Q1 - 2019Q3), Czech Republic (1996Q1 - 2019Q3), Hungary (1996Q1 - 2019Q3), India (1996Q2 - 2019Q3), Indonesia (2000Q1 - 2019Q3), Israel (1996Q1 - 2019Q4), Korea (1996Q1 - 2019Q3), Mexico (1996Q1 - 2019Q3), Peru (1996Q1 - 2019Q3), Philippines (1998Q1 - 2019Q3), Poland (1995Q1 - 2019Q3), Russia (2000Q1 - 2019Q3), South Africa (1996Q1 - 2019Q3), Thailand (1996Q1 - 2019Q4), and Turkey (1998Q1 - 2019Q3)

Sources

Table A.1: Data and sources

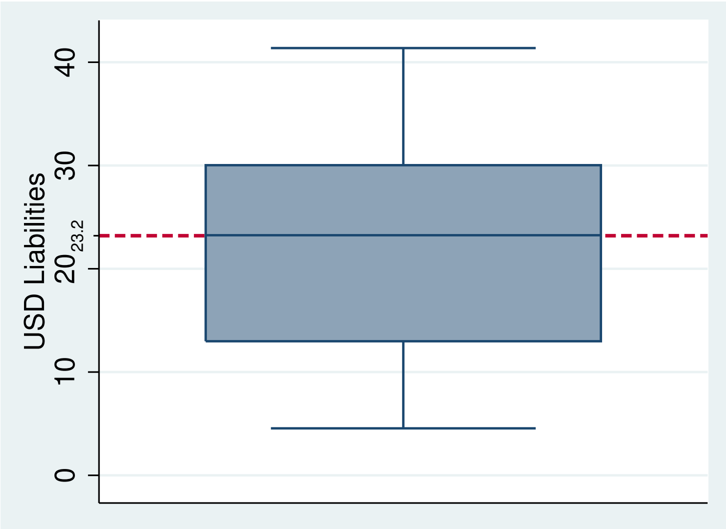
Variable	Construction and source
real GDP	real GDP in domestic currency Source: Datastream
Investment	real gross fixed capital formation in domestic currency Source: Datastream
Consumption	real domestic private consumption in domestic currency Source: Datastream
Trade balance	Trade balance as % of domestic GDP Source: Datastream
Equity price (SOEs)	MSCI equity prices in domestic currency (for the SOEs) Source: Datastream
Equity price (AEs)	S&P 500, Euro Stoxx, S&P/TSX 60, Nikkei, FTSE 100, SMI, OMXS30, S&P/ASX 200 Source: Datastream
Policy rate (SOEs)	Policy interest rate Source: International Financial Statistics, IMF
Policy rate (AEs)	Shadow rates for the U.S., the Euroarea, the U.K. and Japan Source: Wu and Xia (2016); Xia and Wu (2018), Leo Krippner's estimates for Japan: https://www.rbnz.govt.nz/research-and-publications/research-programme/additional-research/measures-of-the-stance-of-united-states-monetary-policy/comparison-of-international-monetary-policy-measures
Lending rate	Lending interest rate Source: International Financial Statistics, IMF
CPI	Consumer price index Source: Datastream
GDP Deflator	GDP deflator Source: Datastream
Credit to the private sector	Credit to the private sector as a percent of GDP Source: Datastream, BIS

VIX	Option-implied volatility index Source: Chicago Board Options Exchange, retrieved from St. Louis FRED
Cross-border banking liabil-ities	Bank for International Settlements (BIS) reporting claims on each of the SOEs Source: BIS
USD exchange rate	Bilateral USD nominal exchange rate Source: Datastream
USD exchange rate against major currencies	USD nominal effective exchange rate against major economies Source: St. Louis FRED
Foreign currency exposure	Liabilities in USD Source: Bénétrix et al. (2015)
Assets in USD	Assets in USD Source: Bénétrix et al. (2015)
Vulnerability	Vulnerability index Source: Iacoviello and Navarro (2019)
Trade with U.S.	Trade intensity with the U.S. Source: Iacoviello and Navarro (2019)
Trade openness	(exports + imports)/nominal GDP Source: World Bank and Datastream

B Appendix for Section 4

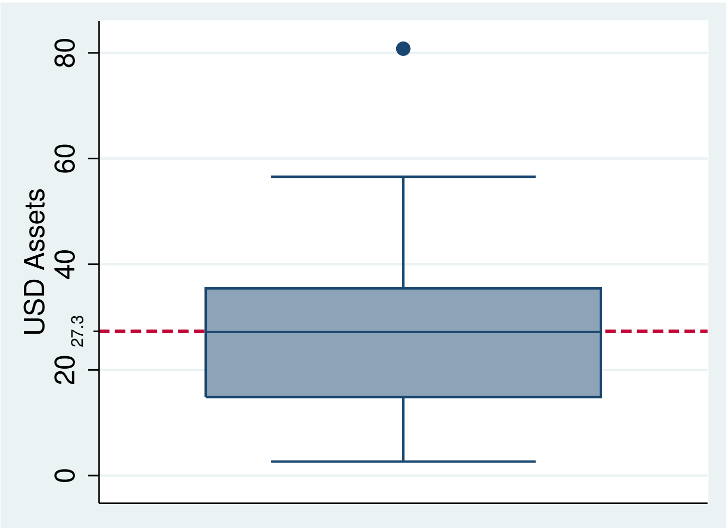
USD Liabilities, assets and trade openness

Figure 16: Liabilities in USD (sample average per country): Distribution



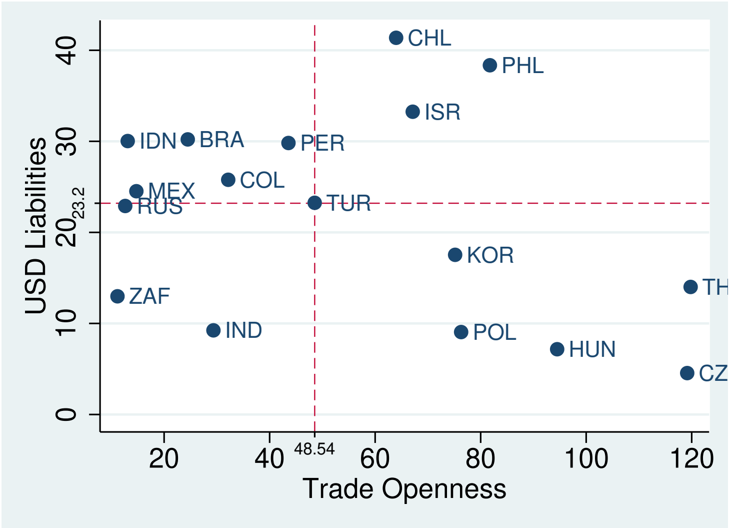
Note: The dashed red line depicts the median.

Figure 17: Assets in USD (sample average per country): Distribution



Note: The dashed red line depicts the median.

Figure 18: Liabilities in USD and trade openness



Note: The dashed lines depict the medians.

Exchange rate correlations

Table B.1: Correlations of the USD exchange rate against major currencies and USD exchange rate against individual SOEs' currencies

Brazil	Chile	Colombia	Czech Rep.	Hungary	India	Indonesia	Israel	Korea
0.61	0.67	0.78	0.94	0.75	0.21	0.22	0.51	0.47
Mexico	Peru	Philippines	Poland	Russia	S. Africa	Thailand	Turkey	
0.16	0.86	0.64	0.84	0.33	0.33	0.74	0.14	

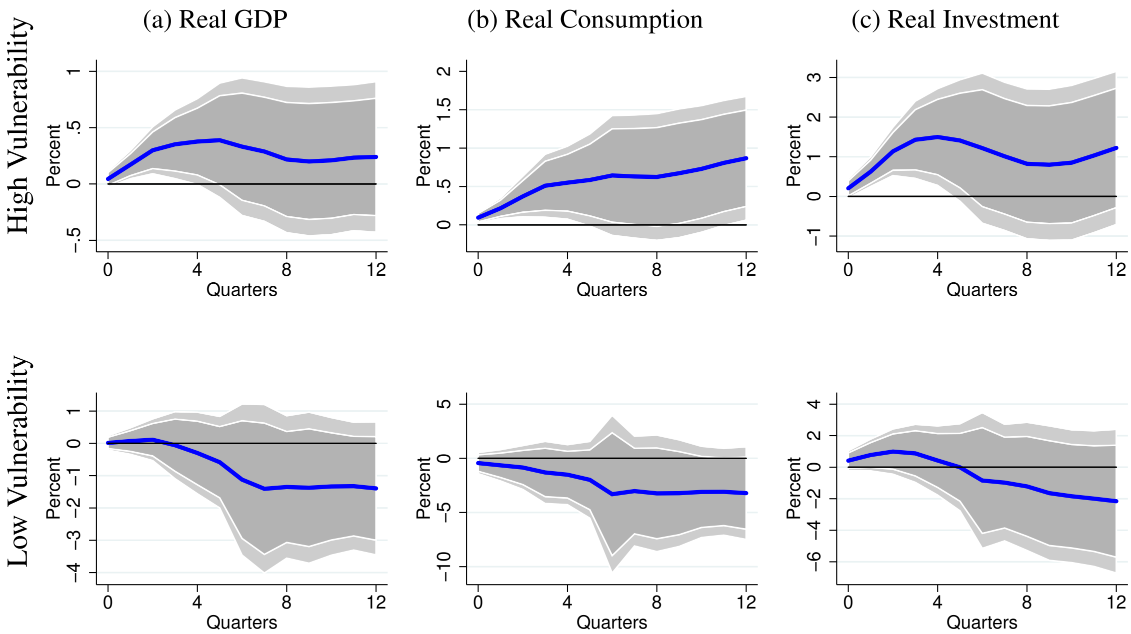
Robustness checks

As a robustness check for role of exposures to liabilities denominated in USD, I re-estimate Equation (6) dividing the SOEs in my sample according to the external vulnerability index by Iacoviello and Navarro (2019). This index is supposed to reflect a country's financial health. It is constructed as an equally-weighted average of inflation, current account deficit as a share of GDP, external debt minus foreign reserves (as a share of GDP), and foreign exchange reserves.

Generally speaking, the vulnerability index provides a broader picture than just inspecting the role of exposure to USD liabilities, since it also includes other macroeconomic indicators and assets in foreign currency.

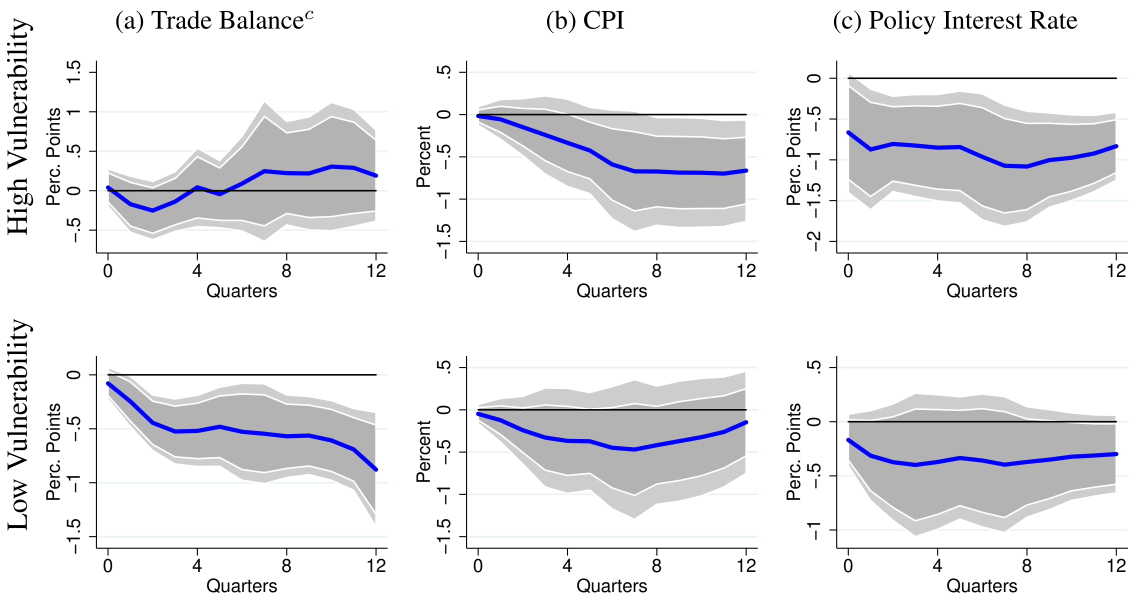
The impulse responses in Figures 19 - 21 are very similar to the ones estimated conditioning on the level of liabilities. This is not surprising because after inspection of the data, the countries in which the vulnerability index is above median coincides very often to the observations where liabilities in USD are above median. The bottom line of this exercise is similar to the one above. When the vulnerability index is relatively high, the financial channel appears to dominate the trade channel, and when the vulnerability index is low, the opposite appears to happen.

Figure 19: Responses to a one percent appreciation of the domestic currency against the USD by external vulnerability index



Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when the external vulnerability index by Iacoviello and Navarro (2019) is above median, the second row shows responses when the index is below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

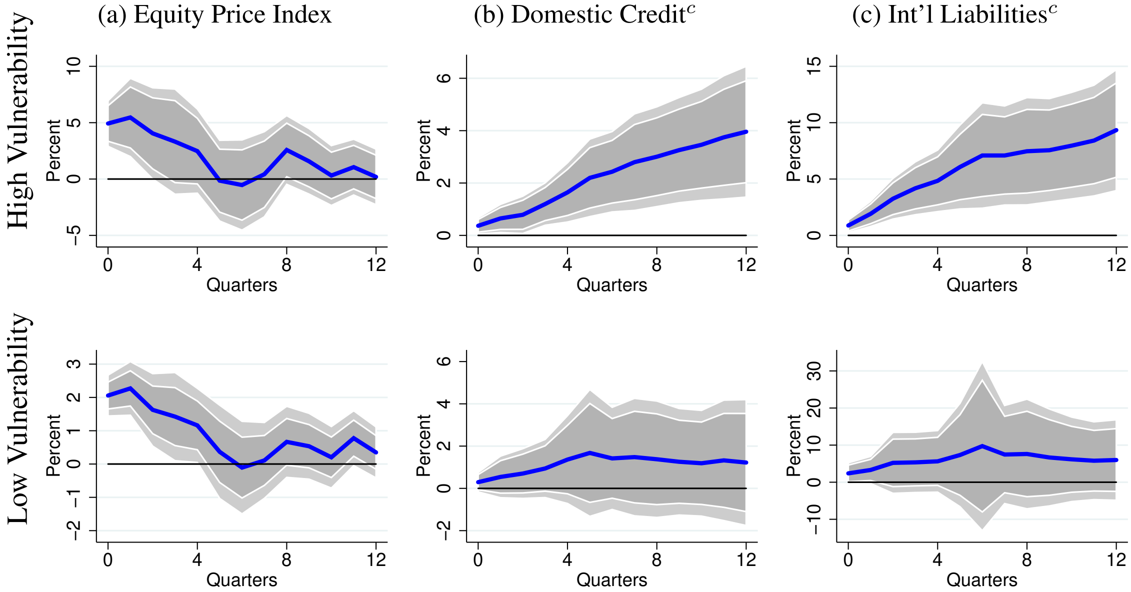
Figure 20: Responses to a one percent appreciation of the domestic currency against the USD by external vulnerability index



Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when the external vulnerability index by Iacoviello and Navarro (2019) is above median, the second row shows responses when the index is below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

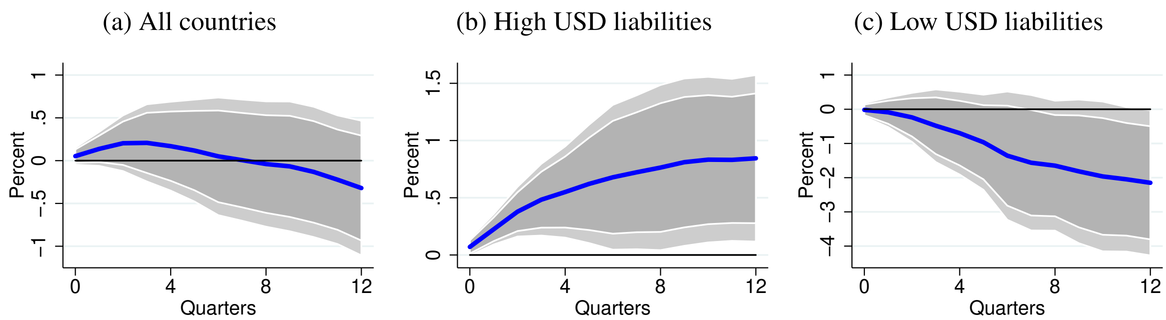
^{c} as a fraction of GDP.

Figure 21: Responses to a one percent appreciation of the domestic currency against the USD by external vulnerability index



Note: The figure shows the estimated cumulative impulse responses of several macroeconomic variables to a one percent appreciation of the domestic exchange rate. The first row shows responses when the external vulnerability index by Iacoviello and Navarro (2019) is above median, the second row shows responses when the index is below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.
^{c} as a fraction of GDP.

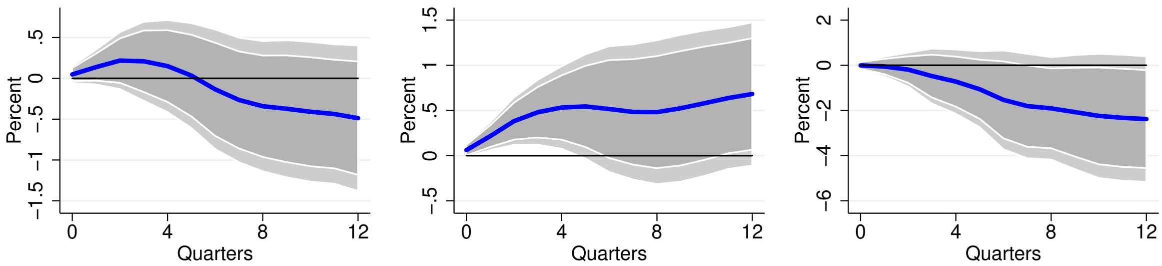
Figure 22: Estimation of the instrument: Only contemporaneous regressors



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 23: Estimation of the instrument: Equity price indices for all major economies

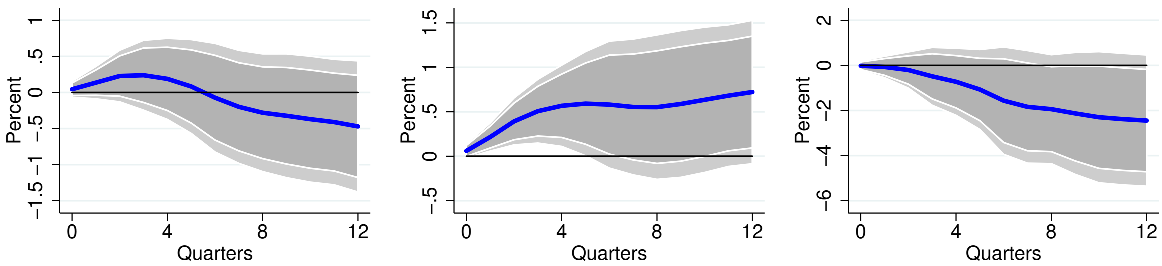
(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 24: Estimation of the instrument: Dummy for the third and fourth quarter in 2008

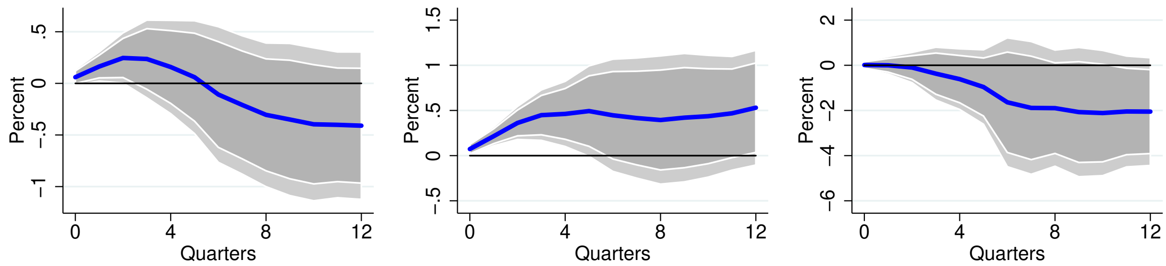
(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 25: LP-IV estimation: Four lags

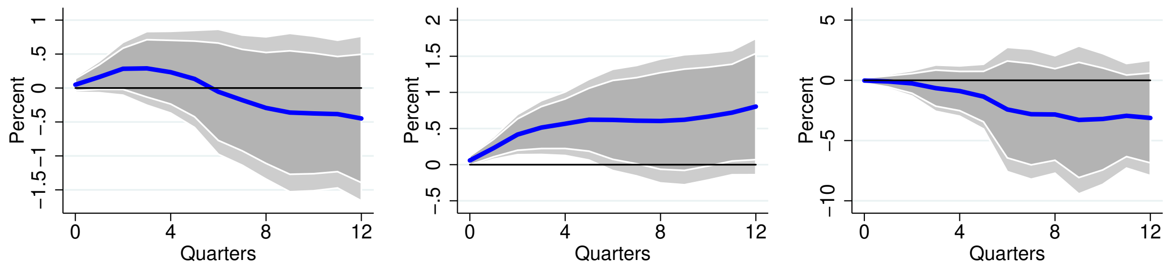
(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 26: LP-IV estimation: Commodity price index as an exogenous variable

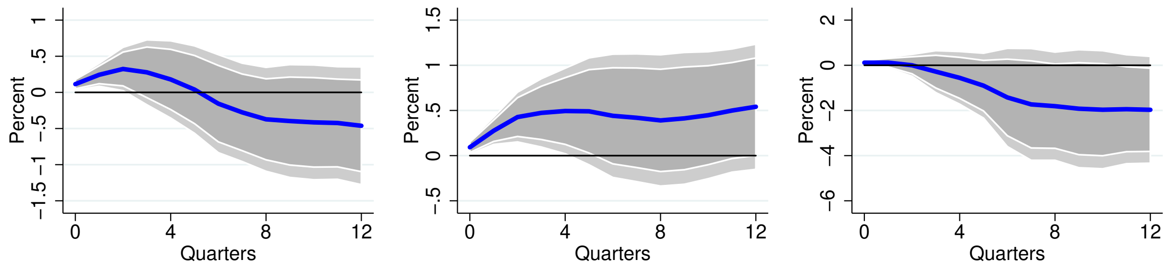
(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

Figure 27: LP-IV estimation: U.S. GDP as an exogenous variable

(a) All countries (b) High USD liabilities (c) Low USD liabilities



Note: The figure shows the estimated cumulative impulse responses of real GDP to a one percent appreciation of the domestic exchange rate. Panel (a) shows the response for all countries. Panel (b) shows the response when liabilities in USD are above median. Panel (b) shows the response when liabilities in USD are below median. The dark gray and light gray areas represent the 90% and 95% confidence bands respectively.

C Panel - Instrumental Variable SVAR

In this section, I discuss the alternative empirical model, namely a panel instrumental variable SVAR similar to Winne and Peersman (2018), as well as the data used in this exercise, and the empirical results.

Using the instrument in an SVAR model

For each SOE, I estimate the following reduced-form VAR model:

$$y_t = c + \Pi(L)y_{t-p} + \Phi(L)x_{t-p} + u_t, \tag{C.1}$$

where in the vector of endogenous variables (y_t) contains the bilateral USD exchange rate, the log of industrial production, log of CPI, the policy interest rate, net exports, bilateral capital flows with the US, and CDS. The choice of variables aims at capturing the overall impact of exchange rate movements on the macroeconomy working through the trade and the financial channel, respectively. The vector x_{t-p} contains the exogenous variables, i.e. the (shadow) Federal Funds Rate and the VIX. The 7×1 vector c includes constant terms, the matrix $\Pi(L)$ in lag polynomials captures the autoregressive part of the model, and the vector u_t contains k serially uncorrelated innovations, or reduced-form shocks, with $V(u_t) = \Sigma_u$. Lag length selection for each EME is based on the AIC selection criteria.

Following Hachula and Nautz (2018), I use the proxy SVAR approach developed by Stock and Watson (2012) and Mertens and Ravn (2013) to identify exchange rate shocks with the instrument I constructed in the main part of the paper. Suppose that the reduced-form innovations u_t of the VAR are related to several uncorrelated structural shocks. One of them is the exchange rate shock, ε_t^{fx}, while the others shocks are in the ε_t^*. The relation between the reduced-form and the structural shocks is as follows:

$$u_t = b^{fx}\varepsilon_t^{fx} + b^*\varepsilon_t^*. \tag{C.2}$$

The vector b^{fx} captures the impact impulse to an exchange rate shock of size one. The other shocks ε_t^* are uncorrelated with ε_t^{fx} and are left unidentified as they play no role for the question that I aim to answer in the study.

Identification of shocks in the proxy VAR exploits their correlation with a set of proxy variables (or external instruments) η_t, whereas the proxy needs to be uncorrelated with the other structural shocks. Similar to the case in the LP-IV estimation, I need an instrument such that:

$$E(\eta_t\varepsilon_t^{fx}) = \phi \neq 0, \tag{C.3a}$$

$$E(\eta_t\varepsilon_t^*) = 0. \tag{C.3b}$$

The instrument η_t is $\hat{\eta}_t$. As explained in the main text, I have constructed the instrument such that it is unrelated to other shocks that drive SOEs' fundamentals and global variables. Under these conditions, the *relative* responses of two variables i and j in the system to a exchange rate shock, b_i^{fx}/b_j^{fx}, can be consistently estimated using the correlation between η_t and the estimated reduced-form residuals. Note that this *relative* response allows to compute the response of all other variables to a shock that affects the bilateral exchange rate against the USD by a pre-scaled size on impact, say a 1% appreciation. Additionally assuming that $\Sigma_\varepsilon = I$, Mertens and Ravn (2013) show how to then fully retrieve b^{fx}.

With the proxy η_t at hand, there are different options for implement the identification of the VAR model. In this paper, I follow Gertler and Karadi (2015) or Cesa-Bianchi et al. (2015) and employ a two stage least square approach. This method starts with the estimated reduced-form residuals of the VAR, u_t. Then, in the first stage, u_t^{fx}, the reduced-form residual in the equation with the USD exchange rate, is regressed on the instrument η_t:

$$u_t^{fx} = \beta\eta_t + \eta_t^1, \tag{C.4}$$

to form the fitted value $\hat{u}_t{}^{fx}$. Intuitively, in this first stage regression the variation in the reduced-form shock of the exchange rate is isolated that is due to exchange rate shock. The second stage regressions are then carried out as follows:

$$u_t^i = \gamma^i \hat{u}_t{}^{fx} + \eta_t^2 \tag{C.5}$$

where $\hat{u}_t{}^{fx}$ is orthogonal to the error term $\eta_{2,t}$ given assumption (C.3b) and u_t^i is the reduced-form residual for each i equation of the VAR. This is done for all equations other than the exchange rate equation. The estimated coefficient $\hat{\gamma^i}$ is a consistent estimate of b_i^{fx}/b_{fx}^{fx}. Along with the assumption that $\Sigma_\epsilon = I$, this then allows to generate impulse response functions to the exchange rate shock.

Usually, it is tested whether there is a sufficiently strong correlation between the instrument and the reduced-form VAR innovations. This is a necessary condition for the instrument to be considered a useful tool for analyzing the underlying drivers of the variables. In particular, if a weak instrument problem is present, the results from the second stage regression will not be informative. I test the relevance of the instrument by adding a constant to equation C.4 and by performing an F-test. The resulting F-statistic in the first stage for the instrument that I obtain is between 10.46 and 62.44, depending on each individual country. This is above the recommended value of ten (see Stock et al., 2002) and indicates that a weak instrument problem is not present.

Data

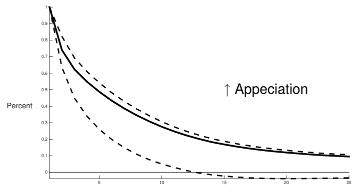
The data set consists of monthly series from 2000 - 2016. The monthly data for the construction of the instruments for the exchange rate movements is obtained from several sources. The USD effective exchange rate against major economies and the VIX were retrieved from the St. Louis Federal Reserve Economic Data, FRED. Further, time series for the industrial production, consumer price index, policy interest rate of the U.S. and the other eight other major economies, were obtained from Datastream. I also use equity price indices and a commodity price index, both retrieved from Datastream.

Moreover, the monthly data for the SVAR analysis were retrieved from Datastream and Bloomberg. One exception is the capital flows. The source of bond and equity flows are the monthly estimates of changes in U.S. holdings of foreign securities provided by the Federal Reserve Board. This dataset is based on estimations based on data reported by the Treasury International Capital Reporting System (TIC). For details, see Bertaut and Tryon (2007) and Bertaut and Judson (2014).

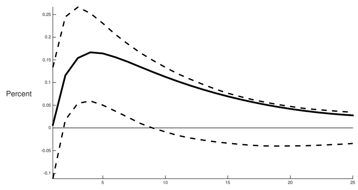
Results Panel SVAR

Similar to Winne and Peersman (2018), I calculate the mean response (and confidence bands) fot the 17 SOEs in my sample. Figure 28 shows the panel results, i.e. the mean impulse responses across countries to a one percent depreciation of the USD . In general, this results strongly hint to the importance of the financial channel, especially the risk-taking channel of Hofmann et al. (2017). The depreciation of the USD, i.e. the appreciation of each SOEs' domestic currency, goes hand-in-hand with increased portfolio inflows (they increase by around 70 million USD on impact), and a decrease of around 3.5 percent in the CDS, the measures for financial conditions and risk respectively. Net exports increase insignificantly on impact due to the value effects after the depreciation of the USD, and decrease significantly by around 0.2 percent after 5 months. The fall in net exports, which would have a negative impact on domestic

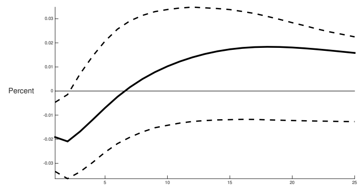
Figure 28: EMEs’ responses to a one percent depreciation of the USD



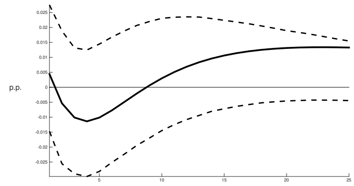
(a) Exchange rate



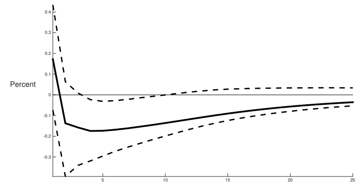
(b) industrial production



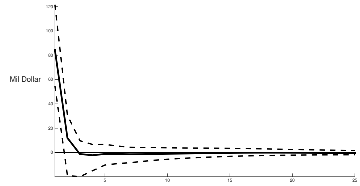
(c) consumer price index



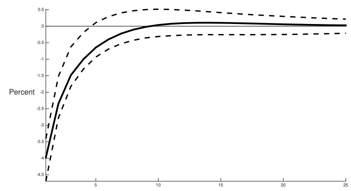
(d) interest rate



(e) net exports



(f) portfolio inflows



(g) credit default swap

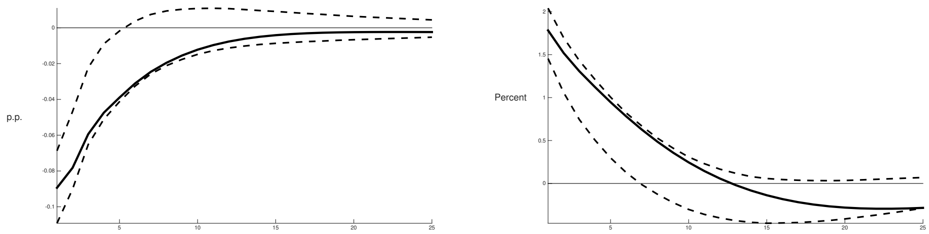
Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the EMEs’ variables to a one percent depreciation of the USD. Confidence bands are based on 1000 bootstrap replications.

GDP (proxied by industrial production), appears to be compensated by the looser financial conditions and decreased risk, as predicted by Hofmann et al. (2017), since IP increases significantly, reaching a peak of around 0.2 percent after 5 months. Finally, prices measured by the CPI decrease on impact due to lower import prices in EMEs, and increase insignificantly, while interest rates do not have a significant reaction. Summing up, an appreciation against the USD goes hand in hand with reduced risk, which in turn attracts capital inflows, loosening financial conditions and boosting output, even though net exports are significantly reduced.

Furthermore, Figure 29 shows the impulse responses of alternative measures of risk and financial conditions. The government bond yield spread decreases on average by 0.8 percentage points after the one percent appreciation vis-a-vis the USD, while equity prices increase significantly by around 1.6 percent. This is in line with the results and considerations above.

To sum up, the results from the proxy SVAR indicate that on average a currency appreciation against the USD is expansionary in the set of SOEs. The results also suggest that the currency appreciation is expansionary because financial effects dominate trade effects that would work in the opposite direction. This is in line with the findings in section 4.

Figure 29: EMEs' responses to a one percent depreciation of the USD - alternative measures of risk and financial conditions



(a) 10-year government bond yield spread (b) equity price index

Note: The figure shows the estimated impulse responses, along with 68 percent confidence bands, of the EMEs' variables to a one percent depreciation of the USD. Confidence bands are based on 1000 bootstrap replications.

D Appendix DSGE model

DSGE model: Equilibrium equations

Firms

$$y_t^H = A_t k_{t-1}^{\alpha} l_t^{1-\alpha} \tag{D.1}$$

$$\frac{(1-\alpha)}{\alpha} = \frac{w_t l_t}{\left(q_{t-1}R_t^k - q_t(1-\delta)\right) k_{t-1}} \tag{D.2}$$

$$R_t^k = \frac{Z_t + (1-\delta)q_t}{q_{t-1}} \tag{D.3}$$

$$mc_t = \tilde{\xi}_t^c \frac{1}{A_t}\left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}\left(\frac{Z_t}{\alpha}\right)^{\alpha} \tag{D.4}$$

$$p_t^H = \frac{\eta}{\eta-1} mc_t - \frac{\kappa}{\eta-1}\frac{\pi_t^H(\pi_t^H-1)}{y_t^H} + \frac{\kappa}{\eta-1}\mathrm{E_t}\left(\frac{\pi_{t+1}^H(\pi_{t+1}^H-1)}{y_t^H}\right) \tag{D.5}$$

$$\pi_t^H = \frac{p_t^H}{p_{t-1}^H}\pi_t \tag{D.6}$$

$$p_t^F = \frac{\eta}{\eta-1} s_t - \frac{\kappa}{\eta-1}\frac{\pi_t^F(\pi_t^F-1)}{y_t^F} + \frac{\kappa}{\eta-1}\mathrm{E_t}\left(\frac{\pi_{t+1}^F(\pi_{t+1}^F-1)}{y_t^F}\right) \tag{D.7}$$

$$\pi_t^F = \frac{p_t^F}{p_{t-1}^F}\pi_t \tag{D.8}$$

$$ex_t = \left(s_t^{\varphi} y_t^*\right)^{(1-\rho_{ex})}\left(ex_{t-1}\right)^{\rho_{ex}} \qquad \text{Exports} \tag{D.9}$$

$$\frac{s_t}{s_{t-1}} = \frac{\Delta e_t \pi_t^*}{\pi_t} \qquad \text{Real exchange rate} \tag{D.10}$$

Households

$$c_t = \left[\omega^{\frac{1}{\gamma_c}}\left(c_t^H\right)^{\frac{\gamma_c-1}{\gamma_c}} + (1-\omega)^{\frac{1}{\gamma_c}}\left(c_t^F\right)^{\frac{\gamma_c-1}{\gamma_c}}\right]^{\frac{\gamma_c}{\gamma_c-1}} \tag{D.11}$$

$$\frac{c_t^H}{c_t^F} = \left(\frac{p_t^H}{p_t^F}\right)^{-\gamma_c}\frac{\omega}{1-\omega} \tag{D.12}$$

$$1 = \left(\omega\left(p_t^H\right)^{1-\gamma_c} + (1-\omega)\left(p_t^F\right)^{1-\gamma_c}\right) \tag{D.13}$$

$$\tilde{\xi}_t^g\left(c_t - hc_{t-1}\right)^{-\sigma_c} = \lambda_t^m \tag{D.14}$$

$$\tilde{\xi}_t^g\frac{\zeta_0 l_t^{\zeta}}{w_t} = \lambda_t^m \tag{D.15}$$

$$R_t \mathrm{E_t}\Lambda_{t,t+1} = 1 \tag{D.16}$$

$$\mathrm{E_t}\Lambda_{t,t+1} = \beta\mathrm{E_t}\frac{\lambda_{t+1}^m}{\lambda_t^m} \tag{D.17}$$

$$\mathrm{E_t}\Lambda_{t,t+1}\frac{R_{t+1}^k q_t}{q_t + \varkappa k_t^h} = 1 \tag{D.18}$$

$$R_t = \frac{r_t^n}{\mathrm{E_t}\pi_{t+1}} \qquad \text{Real interest rate} \tag{D.19}$$

Capital producers

$$i_t = \left[\omega^{\frac{1}{\gamma_c}}\left(i_t^H\right)^{\frac{\gamma_c-1}{\gamma_c}} + (1-\omega)^{\frac{1}{\gamma_c}}\left(i_t^F\right)^{\frac{\gamma_c-1}{\gamma_c}}\right]^{\frac{\gamma_c}{\gamma_c-1}} \tag{D.20}$$

$$\frac{i_t^H}{i_t^F} = \left(\frac{p_t^H}{p_t^F}\right)^{-\gamma_c}\frac{\omega}{1-\omega} \tag{D.21}$$

$$p_t^I = \left(\omega\left(p_t^H\right)^{1-\gamma_c} + (1-\omega)\left(p_t^F\right)^{1-\gamma_c}\right) \tag{D.22}$$

$$p_t^I = q_t\left(1 - \frac{\kappa_I}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2 - \kappa_I\left(\frac{i_t}{i_{t-1}} - 1\right)\left(\frac{i_t}{i_{t-1}}\right)\right) + \mathrm{E_t}\left[\Lambda_{t,t+1}q_{t+1}\kappa_I\left(\frac{i_t}{i_{t-1}} - 1\right)\left(\frac{i_t}{i_{t-1}}\right)^2\right] \tag{D.23}$$

$$k_{t+1} = \tilde{\xi}_t^i\left(1 - \Phi\left(\frac{i_t}{i_{t-1}}\right)\right)i_t + (1-\delta)k_t \tag{D.24}$$

$$\Phi\left(\frac{I_t}{I_{t-1}}\right) = \frac{\kappa_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2$$

Banks

$$\mu_t = \mathrm{E_t}\left[\Omega_{t+1}\left(\frac{Z_{t+1}+(1-\delta)q_{t+1}}{q_t} - R_{t+1}\right)\right] \tag{D.25}$$

$$\mu_t^* = \mathrm{E_t}\left[\Omega_{t+1}\left(R_{t+1} - \frac{e_{t+1}}{e_t}R_{t+1}^*\Psi_t\right)\right], \tag{D.26}$$

$$\Psi_t = \exp\left(\psi_1 \hat{d}_{t+1}^*\right)\psi_t, \tag{D.27}$$

$$\nu_t = \mathrm{E_t}\left[\Omega_{t+1}R_{t+1}\right] \tag{D.28}$$

$$\tilde{\mu_t^*} = \frac{\mu_t^*}{\mu_t} \tag{D.29}$$

$$\phi_t = \frac{\nu_t}{\Theta(x_t) - (\mu_t + \mu_t^* x_t)} \tag{D.30}$$

$$\psi_t = \Theta(x_t)\phi_t \tag{D.31}$$

$$x_t = \frac{1}{\tilde{\mu_t^*}}\left(-1 + \sqrt{1 + \frac{2}{\gamma}\tilde{\mu_t^*}^2}\right) \tag{D.32}$$

$$\Theta(x_t) = \theta\left(1 + \frac{\gamma}{2}x_t^2\right) \tag{D.33}$$

$$\mathrm{E_t}\Omega_{t+1} = \mathrm{E_t}\Lambda_{t,t+1}\left(1 - \sigma + \sigma\psi_{t+1}\right) \tag{D.34}$$

$$x_t = \frac{s_t d_t^*}{q_t k_t^b} \tag{D.35}$$

Aggregation

$$n_t = (\sigma + \xi)(Z_t + (1-\delta))k_{t-1}^b - \sigma R_t d_{t-1} - \sigma s_t R_{t-1}^* d_{t-1}^* \tag{D.36}$$

$$\chi(k_t^h) = \frac{\varkappa}{2}(k_t^h)^2 \tag{D.37}$$

$$qtk_t^b = \phi_t n_t \tag{D.38}$$

$$qtk_t^b = n_t + d_t + s_t d_t^* \tag{D.39}$$

$$h_t = k_t^b + k_t^h \tag{D.40}$$

$$y_t^H = c_t^H + i_t^H + g_t^H + ex_t^H + \left(p_t^H\right)^{-\gamma} \frac{\kappa}{2}\left(\pi_t \frac{p_t^H}{p_{t-1}^H} - 1\right)^2 + \chi(k_t^h) \tag{D.41}$$

$$y_t^F = c_t^F + i_t^F + \left(p_t^F\right)^{-\gamma} \frac{\kappa}{2}\left(\pi_t \frac{p_t^F}{p_{t-1}^F} - 1\right)^2 \tag{D.42}$$

$$gdp_t = c_t^H + i_t^H + g_t^H + ex_t^H \tag{D.43}$$

$$d_t^* = R_{t-1}^* d_{t-1}^* + y_t^F - \frac{1}{s_t} ex_t. \tag{D.44}$$

$$r_t^n - r^n = (1-\rho_i)\left[\omega_i(\pi_t - \pi) + \omega_y(gdp_t - gdp) + \omega_e(\Delta e_t)\right] + \rho_i(r_{t-1}^n - r^n) + \xi_t^{MP} \tag{D.45}$$

$$g_t^H - g^H = \rho_{gov}\left(g_{t-1}^H - g^H\right) \tag{D.46}$$

Foreign economy and shocks

The foreign economy is given by:

$$y_t^* - y^* = \mathrm{E_t}\left(y_{t+1}^* - y^*\right) - \frac{1}{\gamma_{y^*}}\left(R_t^* - R^*\right) + \tilde{\xi}^{y_t^*} \tag{D.47}$$

$$\pi_t^* - \pi^* = \beta^* \mathrm{E_t}\left(\pi_{t+1}^* - \pi^*\right) + \frac{1}{\kappa_{\pi^*}}\left(y_t^* - y^*\right) + \tilde{\xi}^{\pi_t^*} \tag{D.48}$$

$$R_t^* = \frac{r_t^*}{\mathrm{E_t}\pi_t^*} \tag{D.49}$$

$$r_t^* - r^* = (1-\rho_i^*)\left[\omega_i^*(\pi_t^* - \pi^*) + \omega_y^*(y_t^* - y^*)\right] + \rho_i^*(r_{t-1}^* - r^*) + \xi_t^{MP^*} \tag{D.50}$$

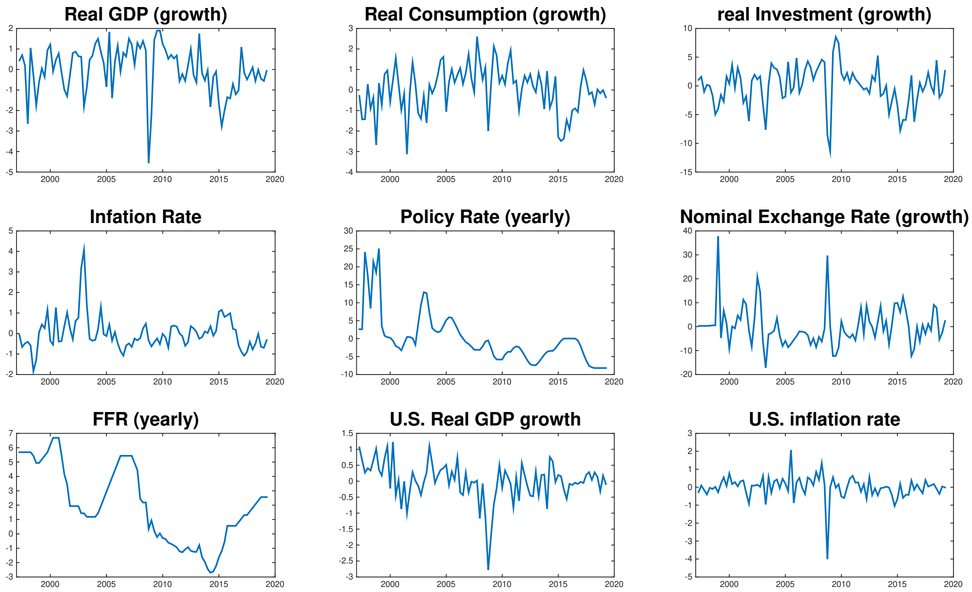
AR(1) processes for all shocks except for the domestic and foreign monetary policy shocks. The processes take the following form:

$$a_t = a = \rho_a\left(a_{t-1} - a\right) + \epsilon_t,$$

where a_t is the exogenous variable of interest and ϵ_t is the shock of interest.

Data for estimation

Figure 30: Brazil: Demeaned data for estimation



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Pablo Anaya Longaric

European Central Bank, Frankfurt am Main, Germany; email: pablo_andres.anaya_longaric@ecb.europa.eu

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website www.ecb.europa.eu

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