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Devaluations, Deposit Dollarization, and Household Heterogeneity *

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Abstract

We study the aggregate and re-distributive effects of currency devaluations in a small open economy heterogeneous households model with leverage-constrained banks. Our framework captures three stylized facts about liability dollarization in emerging economies: i) banks and firms borrow in foreign currency; ii) households save in dollar-denominated local bank deposits; and iii) such deposits are mainly held by wealthier households. The resulting currency mismatch causes an erosion of banks' net worth during a devaluation, depressing credit supply. The ensuing macroeconomic downturn is amplified by a strong reduction of consumption among poorer households in response to rising borrowing costs and falling labor income. Richer households are partially insured, as they are holding a larger share of their wealth in foreign currency denominated assets. We show that a larger currency hedging by wealthier households deepens the recession and amplifies the negative spillovers for poorer agents. When deposit dollarization is high, welfare gains can arise if monetary policy dampens a depreciation.

Keywords: Dollarization, Currency Depreciation, Household Heterogeneity, Redistribution

JEL classifications: E21, F32, F41

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1 Introduction

In many emerging market economies, a significant share of banks' foreign currency debt is represented by dollar deposits held by domestic households, a phenomenon known as 'deposit dollarization'. For example, figure 1 reports the share of deposits denominated in foreign currency in several Latin American countries.[1] While there is substantial cross-sectional variation, in many economies deposit dollarization has remained above 25% for the past two decades. A sequence of papers, like Bocola and Lorenzoni [2020] and Gopinath and Stein [2021], suggest that domestic savers play an important role for the presence of private debt denominated in foreign currency on local firms' and banks' balance sheets, since high demand for dollar deposits might negatively affect the supply of local currency debt. The presence of this debt represents a serious financial stability risk. When the exchange rate depreciates, the currency mismatch between local currency assets and foreign currency liabilities generates a decline in the net worth of financial and non-financial firms and, when financial frictions constrain the borrowing capacity of these firms, can generate a severe recession.[2]

While, in the context of international macroeconomic models, the role of liability dollarization in financial and non-financial firms has been extensively studied in the literature[3], the interaction between deposit dollarization and the heterogeneous exposure of households to currency crises has not been explored yet. The main contribution of our work is to show that, through the banks' balance sheet, insurance by wealthier households against currency depreciation, obtained with foreign currency deposits, can result in more adverse outcomes for poorer households during a devaluation, causing a deeper downturn. In fact, due to banks' currency mismatch, a currency depreciation causes financial intermediaries to reduce credit supply, depressing aggregate demand and wages while increasing borrowing costs. Poor households have to cut consumption strongly in response, worsening the recession. At the same time wealthier households are partially insured through their dollar deposits. The assumption of heterogeneity in the currency composition of households' portfolios is consistent with household data. In particular, as shown by Drenik et al. [2018], across several emerging economies high income households hold a larger share of their savings in foreign currency deposits. In figure 2, using micro data from Uruguay, we see a similar

[1]The data are from Levy-Yeyati [2021], see the appendix for details. The selection of countries is driven by data availability.

[2]Some classical empirically-minded papers highlighting the interaction between foreign currency debt and balance sheet effects in devaluations are, for example, Eichengreen and Hausmann [1999], Calvo and Reinhart [2000], Calvo and Reinhart [2002], Hausmann et al. [2001].

[3]See the literature review for a detailed discussion.

relationship between liquid savings and the share of liquid savings held in dollars.[4] While the top quintile of the wealth distribution holds almost 70% of their savings in dollars, poorer households, with zero or negative wealth, have essentially no direct exposure to foreign currencies.

We study the aggregate and re-distributive effects of exchange rate fluctuations in a model which captures three stylized facts about dollarization: i) generally, a sizable share of firm and bank borrowing is denominated in foreign currency; ii) foreign currency debt is matched by dollar deposits held by domestic households and iii) such deposits are mainly held by wealthier households. In particular, we introduce two non-standard elements into a small open economy New Keynesian model. First, we assume that households are heterogeneous in terms of their income process, and face incomplete markets and a borrowing constraint, as is standard in heterogeneous agents new Keynesian (HANK) models in closed economies. Second, we assume that households borrow and lend through a leveraged financial intermediary facing an agency problem in the spirit of Gertler and Karadi [2011], which also uses funds to finance domestic capital.[5] Households can save in bank deposits, denominated in local or foreign currency, and in foreign bonds denominated in foreign currency. However, we assume that households can borrow, potentially in both currencies, only from domestic banks. The presence of a constrained bank generates an endogenous spread between households' saving rate and borrowing rate. Such spread also implies a sizable mass of households with zero liquid wealth who behave temporarily like hand-to-mouth (HtM) agents, in addition to households who are borrowing constraint in their consumption-savings choice. We calibrate our model in line with the evidence on deposit dollarization from Latin America. As a result, a sizable portion of banks' deposits are denominated in foreign currency and are provided by domestic households, with wealthier agents saving a larger share of their assets in dollars, in line with figure 2. On the other hand, poor households with negative liquid wealth borrow only in domestic currency.[6]

Our main experiment consists in studying the effects of an exchange rate depreciation brought about by an increase in the foreign interest rate. Since financial intermediaries lend to households and firms in local currency, while they borrow both in local and foreign currencies, such depreci-

[4] Data are from the 2013 Uruguayan household financial survey, which reports granular information on the currency denomination of households assets and liabilities

[5] For simplicity, we assume that the bank is the agent holding the currency mismatch on its books. As discussed in Bocola and Lorenzoni [2020], this assumption can capture either direct bank exposure to currency mismatch or indirect credit risk exposure, occurring when banks lend in dollars to domestic firms who are then more likely to default during a devaluation. See Ferrante [2019] for an explicit model of how default by firms or households can amplify, through the balance sheet of financial intermediaries, the macroeconomic effect of financial shocks.

[6] The assumption on the currency in which households borrow is not crucial for our results, as we discuss later in the paper.

ation results in a decline in banks net worth, depressing domestic investments through a financial accelerator channel, and causing a decline in output. In our model, the interaction between the banking sector and the heterogeneity in households' marginal propensity to consume (MPC) amplifies the contractionary effects of the currency depreciation through two main channels. First, when their net worth is eroded, financial intermediaries reduce the supply of credit to firms and households, causing an increase in lending rates. As a result, borrowing households face a steeper increase in interest rates compared to savers, and, due to their high MPC, cut spending sharply depressing aggregate demand. We call this mechanism the *borrowing rate channel* of a currency depreciation. Second, lower hours, lower wages and higher import prices, due to the contractionary depreciation, cause households' real income to decline through a *labor income channel*.[7] As a result, poorer households with high MPC, and in particular constrained borrowers and HtM agents with zero liquid wealth, reduce consumption steeply exacerbating the downturn. Because of these channels, households in the left tail of the wealth distribution suffer more during a currency devaluation, while wealthier households are partially insured through their savings in dollars. The interaction of the borrowing rate channel and of the labor income channel produces a drop in aggregate consumption twice as large as in a representative agent new Keynesian (RANK) model with constrained banks, and a decline in output 30% larger. Conversely, absent frictions in the banking sector, a small open economy HANK model would imply an expansion in output and a higher path for domestic consumption, due to the increase in exports following the depreciation of the exchange rate (a standard *expenditure switching channel* in open economy models).[8]

We illustrate these new mechanisms with several quantitative exercises, and look at the implications for the consumption response of different types of households. In particular, we show that, by negatively affecting the demand of borrowers, the higher path of banks' lending rate accounts for about one third of the decline in aggregate consumption. The remaining two thirds are due to the lower path of real labor income, since this channel affects all workers in the economy (not only borrowers). Furthermore, to quantify the general equilibrium effects of the borrowing rate channel, we show that in an alternative model, with a fixed spread on households' loans, the decline in consumption and output is about 50% smaller than in our baseline. In fact, without the

[7] This mechanism operates in the same way of what Auclert et al. [2021] define the *real income channel*. In particular, in an open economy HANK model without financial intermediaries, Auclert et al. [2021] show under what parameter restrictions this channel can either make a devaluation contractionary or expansionary. In our paper, we show that currency mismatch and financial frictions in the banking sector can cause a large decline in labor income and ignite a negative real income channel even when these restrictions are violated.

[8] Furthermore, the jump in CPI inflation decreases the real value of households' debt and of banks' debt, providing a modest boost to demand via a debt devaluation channel.

spike in borrowing spreads, the consumption of borrowers declines much less than in the baseline, supporting aggregate demand and wages, and hence also diminishing the negative effects of the labor income channel.

Through market clearing, our assumptions on households currency portfolio compositions determine also banks' exposure to exchange rate fluctuations. As in Bocola and Lorenzoni [2020] and Gopinath and Stein [2021], a larger households demand for dollar deposits results in a more severe currency mismatch for financial intermediaries. In particular, we show that a calibration of the model with a larger share of dollar deposits held by wealthier households results in a larger decline in consumption and investment, as banks have a larger currency mismatch enhancing the financial accelerator mechanism. Consequently, poorer households are more negatively affected by a larger increase in spreads and a larger decline in labor income. Hence, a novel implication of our model is that stronger hedging by richer households, against a currency depreciation, can result not only in a deeper recession during a currency crisis, but also in more negative re-distributive effects for poorer households.

Finally, we consider the implications of our framework for monetary policy. Given the negative effects of a currency devaluation, there is potential scope for the central bank to fight the depreciation by raising domestic interest rates. However, higher rates can be, holding the currency mismatch effect fixed, contractionary, since they depress asset prices and amplify the negative effects of banks' financial accelerator on aggregate demand. As a result, a monetary policy rule reacting to changes in the nominal exchange rate can make the recession even worse, implying welfare losses for most households. We find that, under our baseline calibration, significantly leaning against the exchange rate depreciation is welfare detrimental for a majority of households. However, when the dollar share in deposits is calibrated to match values from high dollarization countries, the benefits from stabilizing the exchange rate can be large, and a certain degree of exchange rate smoothing can be welfare improving.

1.1 Related Literature

Our modelling of the household sector places our paper into the literature surrounding the Bewley-Imrohorouglu-Aiyagari-Huggett model (Bewley [1986], Imrohoroğlu [1989], Huggett [1993], Aiyagari [1994]). More specifically, we are building on the insights of papers merging these household models with the new Keynesian framework (Oh and Reis [2012], Guerrieri and Lorenzoni [2017], Gornemann et al. [2016], McKay and Reis [2016], Bayer et al. [2019], Kaplan et al. [2018]). Closest to our work is a set of papers that either integrate a constrained financial sector or an open economy setting into an heterogeneous agents model. In the former group Lee et al. [2020] study the role of bank leverage regulation for consumption insurance, Mendicino et al. [2021] analyse the distributional effects of bank capital losses, and Lee [2020] investigates the effects of quantitative easing. Relative to these papers we consider an open economy setting with currency mismatch in household and bank portfolios and study the effects of foreign interest rate shocks. In the latter group of papers Drenik [2015] studies worker re-allocation between sectors during a devaluation; Giagheddu [2020] shows that fiscal devaluations can have sizable distributional effects; De Ferra et al. [2020] analyse the role of currency mismatch in households savings during a devaluation in a model without frictions in the financial sector; Zhou [2020] decomposes the aggregate consumption response in an open economy setting in the spirit of Auclert [2019]; Oskolkov [2021] analysis how domestic monetary policy changes redistributive effects of foreign interest rate changes between sectors; Hong [2020a] and Auclert et al. [2021] study how household heterogeneity in marginal propensities to consume and market incompleteness alters the transmission of shocks in open economy models. Relative to these papers we include a constrained financial sector into our model and show that the resulting interaction with the household sector plays a crucial role in shaping the effects of a devaluation in an emerging market economy.

Our work also contributes to the literature that studies the effects of currency devaluations in emerging markets and the role of currency mismatch and monetary policy in these circumstance. Krugman [1999], Céspedes et al. [2004], Aghion et al. [2001], Aghion et al. [2004], Chang and Velasco [2001], Schneider and Tornell [2004], Tornell and Westermann [2005], Gertler et al. [2007], Bocola and Lorenzoni [2020], Oskolkov and Sorá [2022], discuss various channels through which financial frictions (partially in combination with currency choices) can give rise to financial and currency crisis in emerging market economies. Relatedly, we also relate to the literature analysing the effects of U.S. monetary policy changes on emerging market economies. See, for example, Rey [2015], Iacoviello and Navarro [2019], Miranda-Agrippino and Rey [2020] for some recent empirical contributions. Akinci and Queralto [2018] and Aoki et al. [2016] provide quantitative model stressing the role of financial frictions in explaining these findings and analyse the role fiscal and monetary policy can play in shaping a country's response. To this line of work we add by showing how household heterogeneity in the presence of market incompleteness alters the effects of financial frictions. In addition, our model allows us to take a more detailed look at the winners and losers of devaluations.

Section 2 discusses the model, while section 3 discusses its calibration. Section 4 presents the effects of a temporary rise in foreign interest rates in our small open economy, where after Section 5 looks at the gains from exchange rate stabilization through monetary policy after which Section 6 concludes.

2 Model

Our model is a new Keynesian small open economy with financial intermediaries and households facing income risk and incomplete markets. Financial intermediaries raise deposits, in either local or foreign currency, from domestic households, and invest these funds in domestic productive capital and in loans to households, which again can be in both currencies.[9] Banks face an agency problem as in Gertler and Karadi [2011], which implies an endogenous spread between the banks' lending rate and the deposit rate. Importantly, the spreads will fluctuate endogenously when bank net worth changes. Households can save either in bank deposits or in foreign bonds, but they can borrow only through bank loans, subject to a borrowing constraint. As we allow portfolios to differ across different households and banks, fluctuations in the exchange rate will have redistributive effects. These redistributive effects have aggregate implications by affecting the net worth of banks and households, and by interacting with the heterogeneity in marginal propensities to consume across households.[10]

2.1 Households

There is a unit mass of households in our economy. A household i derives utility from consumption of a bundle of home and foreign goods of quantity C_{it}, and derives disutility from labor h_{it}, according to

$$\mathbb{E}_{i,0} \sum_{t=0}^{\infty} \beta^t \left[U\left(C_{it}\right) - v(h_{it}) \right]$$

where C_{it} is given by a CES aggregate of home and foreign good

$$C_{i,t} = \left[\chi \left(c_{i,t}^{H} \right)^{\frac{\rho-1}{\rho}} + (1-\chi) \left(c_{i,t}^{F} \right)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{1}$$

[9] Potentially, banks could also raise deposits in foreign currency from foreign investors, but this does not happen in our calibration.

[10] In the following, we will use $\mathbb{E}_t$ to denote the expectations operator in period t with respect to aggregate risk and $\mathbb{E}_{it}$ to denote the expectations operator in period t with respect to aggregate and idiosyncratic risk for individual i.

and

$$U(C_{it}) = \frac{C_{it}^{1-\sigma}}{(1-\sigma)} \text{ and } v(h_{it}) = \frac{h_{it}^{1+\varphi}}{1+\varphi}. \tag{2}$$

The parameter ρ governs the elasticity of substitution between the two goods, while χ measures the degree of home bias in households' consumption preferences. The parameter σ governs the risk aversion, while φ represents the inverse Frisch elasticity. Households can save and borrow in nominal domestic currency bonds, $\tilde{b}_{i,t}^H$ or in nominal foreign bonds $\tilde{b}_{i,t}^F$, subject to the following borrowing constraint on the total amount borrowed

$$\tilde{b}_{i,t} = \tilde{b}_{i,t}^H + e_t \tilde{b}_{i,t}^F \geq -\bar{b} \tag{3}$$

where e_t is nominal exchange rate.

The households' budget constraint is

$$P_t^H c_{i,t}^H + P_t^F c_{i,t}^F + \tilde{b}_{i,t}^H + e_t \tilde{b}_{i,t}^F = (1-\kappa_{i,t})\omega_{i,t} W_t h_{i,t} + \kappa_{i,t} \Pi_t^E + \tilde{R}_t^H \tilde{b}_{i,t-1}^H + e_t \tilde{R}_t^F \tilde{b}_{i,t-1}^F \tag{4}$$

where P_t^H is the price of home goods, P_t^F of foreign good, W_t is the nominal wage expressed in local currency, $\Pi_t^{\mathbb{E}}$ represents dividends from banks and non-financial firms. $\tilde{R}_t^H$ and $\tilde{R}_t^F$ are the one period nominal interest rates on domestic and foreign currency bonds, respectively, between period $t-1$ and t. Every period, a household is either a "worker" or a "capitalist". Individual households transition between being a worker and being a capitalist at random. Workers supply labor, whose quantity is set by a union as explained below, and are subject to idiosyncratic labor productivity shocks ω_{it}, but they do not receive profits from banks and firms, that is $\kappa_{i,t} = 0$. Capitalists do not work and their income comes only from dividends, that is $\kappa_{i,t} = 1$. We assume that (ω_j, κ_j) follows a markov chain with finitely many states and transition matrix $\mathbb{P}$.[11]

A key assumption in our model is that households can borrow, in either currency, only through an intermediary by asking for a loan. On the other hand, households can save either in bank deposits, which are issued in both currencies, or by purchasing foreign currency bonds issued by foreigners. We are implicitly assuming that only the financial intermediary has access to international markets to raise funds at the world interest rate, whereas households have to go through the bank in order to borrow. At the same time, financial intermediaries face an agency friction which limits their arbitraging capabilities. As a result, the interest rate will be different according to whether households are saving in bank deposits and foreign currency bonds or borrowing through

[11] We also assume that the average productivity of households is 1 to simplify notation going forward.

bank loans, with the former being lower than the latter. As a result we define

$$\tilde{R}^H_{t+1} = \begin{cases} \tilde{R}^H_{Dt+1} & \text{if } \tilde{b}^H_{i,t} \geq 0 \\ \tilde{R}^H_{Lt+1} & \text{if } \tilde{b}^H_{i,t} < 0 \end{cases} \tag{5}$$

$$\tilde{R}^F_{t+1} = \begin{cases} \tilde{R}^F_{Dt+1} & \text{if } \tilde{b}^F_{i,t} \geq 0 \\ \tilde{R}^F_{Lt+1} & \text{if } \tilde{b}^F_{i,t} < 0 \end{cases} \tag{6}$$

The interest rate on foreign bonds, $\tilde{R}^*_{t+1}$, is exogenously determined as is standard in small open economy models.[12] An arbitrage condition implies that $\tilde{R}^F_{Dt+1} = \tilde{R}^*_{t+1}$, while the interest rate on domestic bank deposits is given by $\tilde{R}^H_{Dt+1}$. The interest rate on bank loans, in either local or foreign currency, are given by $\tilde{R}^H_{Lt+1}$ and $\tilde{R}^F_{Lt+1}$, respectively. As mentioned above, financial frictions in the banking sector will generate spreads between lending and borrowing rates, implying that $\tilde{R}^H_{Dt+1} \leq \tilde{R}^H_{Lt+1}$ and $\tilde{R}^F_{Dt+1} \leq \tilde{R}^F_{Lt+1}$. Finally, as we solve the model using first order perturbation, in equilibrium no household will hold a strictly negative position in one bond and a strictly positive position in the other bond, a fact we will use to simplify things below.

Looking first at the intra-period consumption choice we get the following first order condition:

$$\frac{(1-\chi)\left(c^F_{i,t}\right)^{\frac{-1}{\rho}}}{\chi\left(c^H_{i,t}\right)^{\frac{-1}{\rho}}} = \frac{P^F_t}{P^H_t} =: S_t, \tag{7}$$

which together with equation 1 pins down, given a quantity of final consumption, the demanded mix of the two goods. As a result we obtain the price of a unit of final consumption, $P_t = \left[P_t^{H(1-\rho)}\chi^\rho + (1-\chi)^\rho P_t^{F(1-\rho)}\right]^{\frac{1}{1-\rho}}$.[13] Given that preferences are homothetic, equation 7 implies that the share of home and foreign goods in the consumption basket will be the same across households and will depend on the relative price of foreign goods with respect to home goods, S_t, a proxy for the real exchange rate.

If we define the portfolio share of foreign bonds as

$$x_{it} = \frac{e_t \tilde{b}^F_{i,t}}{\tilde{b}_{it}} \tag{8}$$

[12]The supply of foreign currency bonds from abroad is assumed to be fully elastic. Notice, that, different from many representative agent small open economy models, we do not need to add an adjustment cost of the form discussed in Schmitt-Grohe and Uribe [2003] to induce stationarity. This is the case, as incomplete markets in combination with idiosyncratic risk induce an upward sloping long run savings demand function in our model.

[13]We will also use P_t to define the CPI index in our model, ignoring differences between the ideal and more empirical-minded expressions.

and the real value of bonds as $b_{it} = \tilde{b}_{it}/P_t$, we can rewrite the budget constraint in real terms as

$$C_{i,t} + b_{it} = (1-\kappa_{i,t})\omega_{i,t}\frac{W_t}{P_t}l_{i,t} + \tilde{R}_{bt}\frac{b_{it-1}}{\pi_t} + \kappa_{i,t}\frac{\Pi_t^{\mathbb{E}}}{P_t} \tag{9}$$

where $\pi_t = P_t/P_{t-1}$ is CPI inflation and $\tilde{R}_{bt+1} = \left((1-x_{it})\,\tilde{R}^H_{t+1} + x_{it}\frac{e_{t+1}}{e_t}\tilde{R}^F_{t+1}\right)$ is the total nominal return on households bond portfolio.

As a result, the intertemporal first order conditions are given by

$$C_{it}^{-\sigma}\begin{cases} = \beta\mathbb{E}_{it}C_{it+1}^{-\sigma}\frac{\tilde{R}^H_{D,t+1}}{\pi_{t+1}} & \text{if } \tilde{b}_{i,t} > 0 \\ \in [\beta\mathbb{E}_{it}C_{it+1}^{-\sigma}\frac{\tilde{R}^H_{D,t+1}}{\pi_{t+1}}, \beta\mathbb{E}_{it}C_{it+1}^{-\sigma}\frac{\tilde{R}^H_{L,t+1}}{\pi_{t+1}}] & \text{if } \tilde{b}_{i,t} = 0 \\ = \beta\mathbb{E}_{it}C_{it+1}^{-\sigma}\frac{\tilde{R}^H_{L,t+1}}{\pi_{t+1}} & \text{if } -\bar{b} < \tilde{b}_{i,t} < 0 \\ \geq \beta\mathbb{E}_{it}C_{it+1}^{-\sigma}\frac{\tilde{R}^H_{L,t+1}}{\pi_{t+1}} & \text{if } \tilde{b}_{i,t} = -\bar{b} \end{cases} \tag{10}$$

$$\mathbb{E}_{it}C_{it+1}^{-\sigma}\tilde{R}^H_{t+1} = \mathbb{E}_{it}C_{it+1}^{-\sigma}\frac{e_{t+1}}{e_t}\tilde{R}^F_{t+1} = \mathbb{E}_{it}C_{it+1}^{-\sigma}\tilde{R}_{bt+1} \tag{11}$$

Equation 10 is the Euler equation for domestic currency bond holdings. The first and third row of this equation show that households face different interest rates when saving or borrowing. A relevant implication of the presence of the financially constrained intermediaries in our model is that, given the spread between the borrowing and lending rates, some agents will choose not to hold any bonds or borrow (the second case in the Euler equation). These households will behave temporarily like hand-to-mouth households and their high MPC will be important for the aggregate effects of macroeconomic shocks. The same applies to households at the borrowing constraint (the fourth case).[14] In addition, we can grasp from the Euler equation that changes in the interest rates and the spreads will change the number of such agents. Equation 11 represents a standard uncovered interest parity (UIP) relationship between bonds in domestic and foreign currency.[15]

The ex-ante real interest rate will be given by $R_t = \mathbb{E}_t\frac{\tilde{R}^H_{Dt+1}}{\pi^{t+1}}$,[16] while the real exchange rate will be

$$Q_t = \frac{e_t}{P_t} \tag{12}$$

Furthermore, if we define P_t^{F*} as the foreign price of foreign goods, then the law of one price implies

[14]The HtM behavior is not permanent as a large enough change in labor income can move them into a region of the state in which the Euler equation holds with equality.

[15]For a model in which financial frictions also generate a spread between the interest rates of bonds in domestic and foreign currencies see, for example, Aoki et al. [2016] or Akinci and Queralto [2018].

[16]We solve our model using first order perturbation. Because of this the expected real return on bonds and deposits will be identical.

$P_t^F = e_t P_t^{F*}$ so that we can normalize $P_t^{F*} = 1$ and obtain $P_t^F = e_t$.

Finally, as described below, hours supplied by workers will be determined by a union, generating homogeneous labor supply across workers.

2.2 Banker

There is a unit measure of bankers, which act as financial intermediaries. A banker i raises deposits in both currencies from households, D_{it}^H and D_{it}^F, and invests these funds, together with the bank's net worth, in capital K_{it} and household loans in both currencies, L_{it}^H and L_{it}^F. Bankers are risk-neutral and discount the future with a discount factor $\frac{1}{R_t}$. In addition, bankers are subject to an agency problem as in Gertler and Karadi [2011]. In particular, after raising deposits, financial intermediaries can abscond a fraction θ_k of capital and a fraction θ_l of loans. The unwillingness of households to deposit their funds in a bank that will take off with their money imposes an incentive constraint on the intermediaries' choices.[17] As in Gertler and Karadi [2011], bankers exit with a probability $1 - \sigma_b$ every period. Exiting bankers pay dividends to capitalists and are replaced by new bankers who begin operations with an initial endowment of domestic good.

Define the real value of loans and deposits as $l_{it}^j = L_{it}^j / P_t$ and $d_{it}^j = D_{it}^j / P_t$ for $j = H, F$, and define total real households loans as $l_{it} = l_{it}^H + e_t l_{it}^F$, and total real deposits as $d_{it} = d_{it}^H + e_t d_{it}^F$. Then we can write the banker's budget constraint as

$$q_t^k K_{it} + l_{it} \ \leq n_{it} + d_{it} \tag{13}$$

where n_{it} represents the bank's real net worth and K_{it} represents the banker's capital holdings with real price q_t^k. The evolution of the net worth of an individual bank will be given by the difference between the returns on bank assets, represented by physical capital and loans to households, and the interest payments on bank liabilities, that is deposits, according to

$$n_{it+1} = R_{t+1}^k q_t^k K_{it} + \left(R_{Lt+1}^H l_{it}^H + e_{t+1} R_{Lt+1}^F l_{it}^F\right) - \left(R_{Dt+1}^H d_{it}^H + e_{t+1} R_{Dt+1}^F d_{it}^F\right) \tag{14}$$

where return on capital is given by $R_{t+1}^k = \left(r_{t+1}^k + (1-\delta) q_{t+1}^k\right) / q_t^k$, with r_t^k being the real rental rate of capital, and the real return on loans and deposits are given by $R_{Lt+1}^j = \frac{\tilde{R}_{Lt+1}^j}{\pi_{t+1}}$ and $R_{Dt+1}^j = \frac{\tilde{R}_{Dt+1}^j}{\pi_{t+1}}$ for $j = H, F$.

[17] The incentive constraint effectively puts an upper bound on leverage and consequently a limit to the bankers' arbitrage capacity, resulting in a time varying spread between the returns on banks assets and liabilities.

Due to the agency friction, bankers earn a spread on their investments.[18] Because of this spread, they find it optimal to postpone dividend payments until they exit. Hence, we can write the value function of the banker as

$$V_{it} = \max_{K_{it}, l_{it}^H, l_{it}^F, d_{it}^H, d_{it}^F} \mathbb{E}_t \frac{1}{R_t} \left[(1 - \sigma_b) n_{it+1} + \sigma_b V_{it+1} \right]$$

subject to equations 13, 14 and to the incentive constraint

$$V_{it} \geq \theta_k q_t^k K_{it} + \theta_l l_{it} \tag{15}$$

which guarantees that the value of operating a bank is larger than the value of the funds the banker can abscond.

It can be shown that the banker's value function is linear in net worth, according to $V_{it} = \varphi_t n_{it}$, where φ_t only depends on aggregate variables. As a result, the first order conditions for capital, loans (in both currencies) and deposits (in both currencies) are

$$\mathbb{E}_t \Omega_{t+1} R_{t+1}^k - \upsilon_t = \theta_k \mu_t \tag{16}$$

$$\mathbb{E}_t \Omega_{t+1} R_{Lt+1}^H - \upsilon_t = \theta_L \mu_t \tag{17}$$

$$\mathbb{E}_t \Omega_{t+1} \frac{e_{t+1}}{e_t} R_{Lt+1}^F - \upsilon_t = \theta_L \mu_t \tag{18}$$

$$\mathbb{E}_t \Omega_{t+1} R_{Dt+1}^H = \upsilon_t \tag{19}$$

$$\mathbb{E}_t \Omega_{t+1} \frac{e_{t+1}}{e_t} R_{Dt+1}^F = \upsilon_t \tag{20}$$

where μ_t is the multiplier on the incentive constraint, υ_t is the multiplier on the bank's balance sheet and $\Omega_{t+1} = \frac{1}{R_t} \left(1 - \sigma_b + \sigma_b \varphi_{t+1} \right)$.

[18] In our calibration the constraint will always be binding.

The first order conditions deliver the following no-arbitrage relationships[19]

$$\mathbb{E}_t \Omega_{t+1} \left(R^k_{t+1} - R^H_{Dt+1} \right) = \frac{\theta_k}{\theta_l} \mathbb{E}_t \Omega_{t+1} \left(R^H_{Lt+1} - R^H_{Dt+1} \right) \tag{21}$$

$$\mathbb{E}_t \Omega_{t+1} R^H_{Dt+1} = \mathbb{E}_t \Omega_{t+1} \frac{e_{t+1}}{e_t} R^F_{Dt+1} \tag{22}$$

$$\mathbb{E}_t \Omega_{t+1} R^H_{Lt+1} = \mathbb{E}_t \Omega_{t+1} \frac{e_{t+1}}{e_t} R^F_{Lt+1} \tag{23}$$

Equation 21 requires that the ratio between the spreads on bank assets is equal to the ratio between the parameters governing the severity of the agency problem for each asset type. Furthermore, equation 21 also implies that the two spreads will co-move following a shock. This mechanism will be important to link the standard financial accelerator channel to redistributive effects operating through the interest rates faced by borrowers. Equations 22 and 23 re-state the same UIP relationships obtained from the households' first order conditions.

We can rewrite the incentive constraint to obtain the following leverage constraint

$$\phi_t \leq \frac{\mathbb{E}_t \Omega_{t+1} R^H_{Dt+1}}{\theta_k - \mathbb{E}_t \Omega_{t+1} \left(R^k_{t+1} - R^H_{Dt+1} \right)} \tag{24}$$

where ϕ_t represents "incentive-adjusted" leverage

$$\phi_t = \left(\frac{q^k_t K_{it} + \frac{\theta_L}{\theta_K} l_{it}}{n_{it}} \right) \tag{25}$$

The equations above show that banks' total lending depends on bank net worth and on bank leverage, which moves together with credit spreads. In addition, equation 24 shows that, if the incentive constraint binds, all banks will choose the same leverage, implying that banks' choices for assets and liabilities will be linear in net worth.[20] Hence, we can aggregate equation 25 to obtain

$$q^k_t K_t + \frac{\theta_L}{\theta_K} l_t = \phi_t N_t \tag{26}$$

where N_t is aggregate bank net worth, K_t is aggregate capital and l_t are aggregate loans.

[19] Here we assume that both loans to households and claims to capital are held by the banks, which will be the case for all model calibrations we are looking at.

[20] The argument can be extended to the case of a constraint that is slack in some states of the world. However, given our calibration, this will never be the case in a steady state equilibrium or its surroundings.

New entrant bankers replace every period the portion $(1-\sigma_b)$ of exiting ones, and they are endowed with a total endowment ξ_b of the home good.[21] As a result, if we define the share of loans in foreign currency as $x^L_{bt} = \frac{e_t l^F_t}{l_t}$, and the share of deposits in foreign currency as $x^D_{bt} = \frac{e_t d^F_t}{d_t}$, we can rewrite equation 14 as the evolution of real aggregate net worth

$$N_{t+1} = \sigma_b \left\{ R^k_{t+1} q^k_t K_{it} + R_{Lt+1} l_{it} - R_{Dt+1} d_{it} \right\} + \xi_b \frac{P^H_t}{P_t} \tag{27}$$

where the variables $R_{Lt+1} = (1 - x^L_{bt}) R^H_{Lt+1} + x^L_{bt} \frac{e_{t+1}}{e_t} R^F_{Lt+1}$ and $R_{Dt+1} = (1 - x^D_{bt}) R^H_{Dt+1} + x^D_{bt} \frac{e_{t+1}}{e_t} R^F_{Dt+1}$ represent the total returns on bank's assets and deposits respectively. Even though, up to first order, the banker's first order conditions do not pin down a portfolio allocation across assets denominated in different currencies, they would imply that x^D_{bt} and x^L_{bt} is the same for all bankers if we were to consider a higher order solution. Hence we are going to assume that the currency composition of assets and liabilities is the same across bankers. As shown below, x^D_{bt} and x^L_{bt} will be linked to the households' portfolio positions through market clearing. Importantly, the higher x^D_{bt} the larger will be the bank's currency mismatch and its negative exposure to exchange rates fluctuations. In fact, equations 26 and 27 show that, depending on banks currency mismatch, unexpected fluctuations in exchange rates can have implications for lending conditions by affecting aggregate bank net worth. When the domestic currency depreciates e_t increases, negatively affecting N_t. Once net worth drops, and leverage increases, equations 24 requires the spread on the return to capital to increase, putting downward pressure on the capital stock and the price of capital. As a result, net worth declines even further, igniting the financial accelerator mechanism. Importantly, in our model, equation 21 requires the spread on households loans to increase as well, causing important redistributive effects, as we will show in our quantitative experiments.

Finally, exiting bankers pay dividends Π^N_t to the capitalist households, according to

$$\Pi^N_t = (1-\sigma_b) \left\{ R^k_t q^k_{t-1} K_{t-1} + R_{Lt} l_{t-1} - R_{Dt+1} d_{t-1} \right\} \tag{28}$$

[21] As a result, each new banker enters with $\frac{\xi_b}{1-\sigma_b}$ units.

2.3 Production

Final home good Y_t^H is a CES composite of different intermediate varieties, given by

$$Y_t^H = \left[\int Y_t^H (i)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{29}$$

so that the demand for each variety will be given by

$$Y_t^H (i) = \left(\frac{P_{H,t} (i)}{P_{H,t}} \right)^{-\varepsilon} Y_t \tag{30}$$

where the aggregate price levels for the two types of goods are given by

$$P_{H,t} = \left[\int (P_{H,t} (i))^{1-\varepsilon} \, di \right]^{\frac{1}{1-\varepsilon}} \tag{31}$$

Intermediate good is produced with Cobb-Douglas technology by monopolistically competitive intermediate-goods firms

$$Y_t^H = K_{t-1}^{\alpha} H_t^{(1-\alpha)} \tag{32}$$

where H_t is aggregate labor demand. If we define P_t^m as marginal costs, then real wages and the real rental rate on capital are given by

$$\frac{W_t}{P_t} = \frac{P_t^m}{P_t} (1-\alpha) \frac{Y_t^H}{H_t} \tag{33}$$

$$r_t^k = \frac{P_t^m}{P_t} \alpha \frac{Y_t^H}{K_{t-1}} \tag{34}$$

Intermediate-goods firms are run by risk-neutral managers discounting the future at rate $1/R_t$. As is standard in New-Keynesian models, they can reset prices only occasionally, with probability $(1-\gamma^p)$, as in Calvo (1983). As a result, their problem will consist in choosing the price $\bar{P}_{H,t} (i)$, in order to solve

$$\max \mathbb{E}_t \sum_{j=0}^{\infty} \lambda_p^j \left(\frac{1}{R_t} \right)^j \left[\frac{\bar{P}_{H,t} (i)}{P_{t+j}^H} - \frac{P_{t+j}^m (i)}{P_{t+j}^H} \right] Y_{t+j}^H (i)$$

Profits, arising from monopolistic competition in the final domestic good sector are going to be given by

$$\Pi_t^p = Y_t^H (1 - P_t^m) . \tag{35}$$

2.4 Labor Unions

We assume that labor markets are controlled by labor unions, who set the wage for different types of labor services subject to Rotemberg adjustment costs following the approach in Hagedorn et al. [2019] and De Ferra et al. [2020]. In particular, unions require each household to provide the same amount of hours H_t in order to maximize the welfare of the average household. This allows us to introduce nominal wage rigidities into our model in a way that is easy to compare to representative agent models. In addition, this frameworks allows us to abstract from heterogeneous labor supply. Households provide labor services to a continuum of identical labor unions who sell them to competitive labor packers. These aggregate the services and rent them out to intermediate good producers. Labor packer combines labor using a CES technology with elasticity ϵ^w. Unions set wages to maximize profits subject to Rotemberg costs with a scale Γ^W. The union's optimization delivers the following wage Phillips curve:

$$\theta^w(\pi_t^w - \bar{\pi}^w)\pi_t^w = (1-\epsilon^w)\frac{W_t}{P_t} + \epsilon^w \frac{H_t^{\phi}}{C_t^{-\sigma}} + \Gamma^W \mathbb{E}_t \frac{1}{R_t}(\pi_{t+1}^w - \bar{\pi}^w)\pi_{t+1}^w.$$

Here, H_t is the labor supply for all workers working for the union, which results in $h_{i,t} = H_t$ for all i. C_t is total consumption and π_t^w is wage inflation and $\bar{\pi}^w$ is average gross wage inflation in the economy, which we set equal to one in steady state.[22]

2.5 Capital producers

Capital producers have a technology allowing them to produce new capital goods I_t by using home goods and installed capital, and subject to convex adjustment costs $\Psi(I_t, K_t) = \frac{\gamma_I}{2}(I_t/K_{t-1} - \delta)^2 K_{t-1}$. Define $\bar{q}_t^k$ as the price of new capital in terms of home goods, then their optimization problem can be written as

$$\max_{I_t} P_t^H \left[\bar{q}_t^k I_t - [I_t + \Psi(I_t, K_{t-1})]\right]$$

and the implied first order condition is

$$\bar{q}_t^k = \left[1 + \frac{\partial \Psi(I_t, K_{t-1})}{\partial I_t}\right], \tag{36}$$

[22]We use total consumption in the problem of the union to simplify the comparison with the representative agents model. Replacing total consumption with total worker consumption leads to quantitatively similar outcomes. Results are available upon request.

Real profits of the capital producer are given by

$$\Pi_t^I = \frac{P_t^H}{P_t}\left[\bar{q}_t^k I_t - \left[I_t + \Psi\left(I_t, K_{t-1}\right)\right]\right]. \tag{37}$$

For ease of notation, we also define $q_t^k = \frac{\bar{q}_t^k P_t^H}{P_t}$, which is the price of capital in units of the consumption good.

Finally, the aggregate capital stock evolves according to

$$K_t = (1-\delta) K_{t-1} + I_t \tag{38}$$

2.6 Trade

We employ a stylized characterization of the foreign economy in order to capture, in a very simple way, an inverse relationship between exports and the terms of trade. We assume that the rest of the world's demand of the home good is a decreasing function of the relative price $S_t = P_t^H/P_t^F$, according to

$$C_t^{H*} = \bar{\rho} S_t^{-\rho} \tag{39}$$

$\bar{\rho}$ determines the scale of foreign demand while ρ is the elasticity of this demand with respect to S_t.[23] Following a currency depreciation, S_t declines stimulating exports through a classic expenditure switching channel.

Meanwhile, we assume that the supply of import goods by the rest of the world is perfectly elastic and sold at the fixed price P_t^{F*} (denoted in foreign currency units).[24]

2.7 Monetary policy

The monetary authority sets the nominal rate on a local currency bond offered to households[25] according to a standard Taylor rule responding to domestic inflation

$$log(i_t) = log(R_{ss}) + \kappa_\pi log(\pi_t^H). \tag{40}$$

No arbitrage implies $i_t = \tilde{R}_{Dt+1}^H$.[26]

[23]We assume throughout the paper that imports and exports have the same trade elasticity, ρ, for simplicity. Our notation reflects this assumption.

[24]See the discussion at the end of subsection 2.1 for details.

[25]We focus on an equilibrium in which the supply of this bond goes to zero.

[26]In section 4, we will experiment by allowing for the central bank to react also to changes in the nominal exchange

2.8 Market Clearing

Total capitalists' income Π_t includes bank dividends Π_t^N, profits from intermediate good producers, Π_t^p, and profits from capital producers, Π_t^I, that is

$$\Pi_t = \Pi_t^N + \Pi_t^p + \Pi_t^I. \tag{41}$$

Denoting the mass of entrepreneurs as m_κ, each entrepreneur receives $\Pi_t^E = \frac{\Pi_t}{m_\kappa}$.

Define $\Gamma_t(i)$ as the distribution of agents over the relevant state variable ω_{it} and total bond holding b_{it}, that is $\Gamma_t(i) = \Gamma_t(\omega_{it}, b_{it})$. In addition, define households' total savings in home bonds and foreign bonds as

$$B_t^{H+} = \int 1_{b_{i,t}\geq 0} b_{i,t}(1 - x_{i,t})\, d\Gamma_t(i) \tag{42}$$

$$B_t^{F+} = \int 1_{b_{i,t}\geq 0} b_{i,t} x_{i,t} d\Gamma_t(i)$$

and households total borrowing in home and foreign bonds as

$$B_t^{H-} = \int 1_{b_{i,t}<0} b_{i,t}(1 - x_{i,t})\, d\Gamma_t(i) \tag{43}$$

$$B_t^{F-} = \int 1_{b_{i,t}<0} b_{i,t} x_{i,t} d\Gamma_t(i)$$

where $x_{i,t}$ represents household's i bond portfolio share in foreign bonds.

Then the market clearing for local currency bonds is given by

$$d_t^H = B_t^{H+} \tag{44}$$

$$l_t^H = -B_t^{H-} \tag{45}$$

meaning that local currency deposits and loans are supplied only by domestic banks. In addition, since we assume that also foreign currency loans are available only through the intermediary, we have that[27]

$$l_t^F = -B_t^{F-}. \tag{46}$$

rate.

[27] In our baseline calibration, in line with the evidence for Uruguay, households will not borrow in foreign currency, so that $l_t^F = 0$.

Aggregate households consumption of home and foreign goods are given by

$$C_t^H = \int c_{i,t}^H d\Gamma_t(i) \tag{47}$$

$$C_t^F = \int c_{i,t}^F d\Gamma_t(i) \tag{48}$$

and the market clearing for the home good requires

$$C_t^H + C_t^{H*} + I_t + \Psi(I_t, K_t) = Y_t^H + \xi^b \tag{49}$$

while market clearing in labor market requires

$$\int \omega_{i,t} h_{i,t} d\Gamma_t(i) = H_t \tag{50}$$

Finally, the balance of payment, implied by aggregating households and banks budget constraints, is given by

$$P_t^H C_t^{H*} - P_t^F C_t^F = e_t(B_t^* - \tilde{R}_{Dt}^F B_{t-1}^*) \tag{51}$$

where $B_t^* = \left(B_t^+ P_t - D_t\right)$ represents net foreign asset positions, $B_t^+ = B_t^{H+} + B_t^{F+}$ and $D_t = D_t^H + D_t^F$.

3 Calibration

We solve the model using the method described in Reiter [2009] by first solving non-linearly for the state state and then computing a first order approximation around it.[28] Table 1 summarizes the parameters used in our baseline calibration. Most parameters are set to match steady state targets in line with a typical Latin American country such as Uruguay, for which we have cross-sectional data on households dollar assets. For the parameters lacking empirical evidence for emerging economies we use common values from the literature.

[28]When solving for the decision rules and distribution we add more points around the borrowing constraint and zero assets.

Table 1: **Calibration**

Parameters	Description	Value	Target/Source
R^*	World Interest Rate	1.01	4% annualized
β	HHs Discount Factor	0.977	NFAP/GDP=1.16 (Uruguay)
σ	Risk Aversion	1	
φ	Inverse Frisch Elasticity	1	
χ	Home Bias	.73	Export/GDP=20%
ρ	Trade Elasticity	1.5	
$\bar{\rho}$	Export Shifter	.49	Terms of trade=1 in SS
γ_p	Price Stickiness	0.85	
Γ_W	Wage Rotemberg Cost	200	Wage Contract 1 Year
ε	CES Elasticity	11	
κ_π	Taylor rule coefficient on inflation	1.5	
ψ_I	Investment Adj. Cost	5	
ξ_b/N_{ss}	Banker Endowment/Net Worth	1.2%	Leverage=6
θ_l	Diversion rate Loans	.70	Spread L=800bp Ann
θ_k	Diversion rate K	.23	Spread K=200bp Ann
σ_k	Banker's survival rate	0.95	
$\bar{b}$	Borrowing Limit	-1.9	30% Borrowers (Uruguay)
ω_j, $\mathbb{P}$	Income Process		see text

Production and Trade: The production side of our economy and most of its calibration is very standard. We set the depreciation rate of capital (δ) to 0.025 and the curvature with respect to capital (α_k) in the production function to 0.33. We set the trade elasticities for exports and imports to 1.5.[29] We calibrate the scale parameter of foreign demand $\bar{\psi}$ to obtain an import to GDP ratio of 20 percent, in line with data for Uruguay after 2000. We assume a Calvo parameter of 0.85, implying a slope of the Phillips Curve around 0.03, a commonly found value in the literature. We set the wage Rotemberg cost parameter to 200, roughly in line to first order with a duration of one year in labor contracts in the corresponding Calvo based Phillips curve. We set the elasticity between varieties of the home good (ϵ) and between labor varieties (ϵ_w) to 11, while calibrating the scale parameter of the investment adjustment costs to 5. Finally, the world interest rate is set to 4 percent annualized in steady state.

Bankers: We assume a spread between deposits and the return of capital of 2 percent annualized, as is standard in models with financial frictions in investment, and of 8 percent annualized for household loans, in line with the evidence for bank loans in Uruguay over the past 15 years.[30] We

[29] We chose a trade elasticity at the higher end of estimates used in the business cycle literature. Our main results are robust to lowering this value. If anything, as a strong response of exports cushions the effects of a devaluation on production, we found that lowering this elasticity amplified the recession in the HANK model.

[30] See the World Bank, Bank Lending Deposit Spread for Uruguay [DDEI02UYA156NWDB]

assume that $\sigma_b = 0.95$ implying a 5% dividend payout rate for banks. The endowment of new bankers is set to about 1 percent of aggregate net worth to target a leverage ratio of 6.[31] Our parameters for the banking sector are in line with values used in the literature (see, for example, Akinci and Queralto [2018] and references therein).

Households We calibrate households' risk aversion to 1 and the Frisch elasticity to 1, standard values in the heterogeneous agents literature. The household discount factor is chosen to match a ratio of net foreign positions to GDP in Uruguay of 1.16. Turning to the income process' transition matrix $\mathbb{P}$ and worker productivity levels we proceed as follows. We assume that there are four states, with the first three reserved for workers, while the fourth one captures the entrepreneurial state. To calibrate the income process conditional on remaining a worker we choose the matrix and productivity levels to approximate an AR(1) in logs income process with values for volatility (0.017) and persistence (0.966) following the method of Rouwenhorst [2021].[32] The borrowing limit is set to obtain that 30 percent of households are borrowers, a value in line with the Uruguayan micro data. The persistence of the entrepreneurial state is set to 0.966, the same as the one of the earning state we are approximating. While the share of the self employed and entrepreneurs is close to 30 percent in Uruguay according to the world bank, we target 1 percent of households as capitalists as we view this state as capturing very successful entrepreneurs driving wealth and income inequality following, for example, Bayer et al. [2019]. To complete the probability matrix we assume that the chance of becoming an entrepreneur is the same for all workers and that after loosing the entrepreneur state a household draws his productivity uniformly from the other states. Our calibration implies that about 8% of households are at the borrowing constraint, 22% are unconstrained borrowers, 27% have zero liquid wealth, 52% are savers and 1% are capitalists. Table 2 displays the resulting transition matrix and states.[33]

Policy We assume that the central bank sets the nominal interest rate on deposits following a standard Taylor-type rule responding to inflation in the price of the home good with a coefficient

[31] This ratio should be thought of as an average of firms' and banks' leverage.

[32] We chose these parameters of the income process based on Floden and Lindé [2001] estimates for the U.S. for concreteness. They are well in line with other estimates from the literature, both the U.S. as well as emerging market economies. See, for example, Drenik [2015] for Argentina, Hong [2020a] for Peru, and Villalvazo [2020] for Mexico. We are not aware of corresponding estimates for Uruguay.

[33] One key statistic for heterogeneous agent models of the business cycle is the average MPC. The quarterly average MPC in our steady state is around 27 percent. Data limitations prevent us from obtaining an estimate for Uruguay. However, using the approximation discussed in Auclert [2019], our model value implies an annual MPC of 71 percent close to the value found in Hong [2020b] for Peru.

Table 2: Idiosyncratic Risk Parameterization

	Level ω	Transition probabilities, $\mathbb{P}\left((\omega,\kappa),(\omega',\kappa')\right)$			
		$(\omega_1',0)$	$(\omega_2',0)$	$(\omega_3',0)$	$(0,1)$
$(\omega_1,0)$	0.437	0.9660	0.0334	0.0003	0.0003
$(\omega_2,0)$	0.892	0.0167	0.9662	0.0167	0.0003
$(\omega_3,0)$	1.819	0.0003	0.0334	0.9660	0.0003
$(0,1)$	0	0.0113	0.0113	0.0113	0.9660

Notes: Please see text for the calibration targets.

of 1.5. In section 4 we will experiment with a different specification of the policy rule responding to the exchange rate.

Households and Banks Portfolios As mentioned in the introduction, in many emerging economies, and in particular in Uruguay, wealthier households have a larger share of their savings in dollars, whereas borrowing households mainly use local currency. Given that, up to first order, steady state portfolios are not determined in our setting, in our baseline we assume that the share of dollar deposits is a linear function of wealth, that is $x_i = \bar{\lambda} + \lambda b$, where λ is calibrated to match the implied slope of dollar holdings reported in figure 1, based on the data from the Financial Survey of Uruguayan Households. In line with the data from Uruguay, we assume that households borrow only in local currency, that is $x_i = 0$ if $b < 0$. The parameter $\bar{\lambda}$ is calibrated to obtain that in steady state 40% of aggregate bank deposits are in foreign currency. This number is in line with the average deposit dollarization in Latin American countries reported in figure 1.[34][35]

4 The Effects of Foreign Interest Rate Shocks

In this section we study the aggregate and distributional effects of a temporary foreign interest rate shocks in detail. We begin by contrasting the impulse responses to such a shock between our HANK model and alternative settings with the goal of highlighting different transmission channels (Subsection 4.1). Then, we show what drives the consumption response of different households by decomposing their consumption dynamics and we quantify the role of the endogenous spread in household borrowing(Subsection 4.2). Finally, we discuss the role of household portfolios in shaping model dynamics by changing the portfolio rule (Subsection 4.3).

[34] In particular, the values consistent with figure 2 are $\bar{\lambda} = 0.46$ and $\lambda = 0.006$

[35] As shown in figure 1, Uruguay actually has one of the highest dollarization rates in Latin America, at around 80 percent of demand deposits. In our baseline, we chose a more conservative calibration target more in line with the typical dollarization rate in emerging economies.

4.1 Transmission of a Foreign Interest Rate Shock

In order to study the implications of exchange rate fluctuations in our model, we consider a shock that increases the foreign interest rate R^*_{t+1} by a 100 basis points annualized, with a persistence of 0.85.[36] Higher foreign rates cause households to want to increase their savings, putting upward pressure on local real rates and downward pressure on the exchange rate. To unpack the multiple channels affecting the transmission of the foreign interest rate shock in our main model we solve a sequence of simpler models. This allows us to illustrate the role of different transmission and amplification channels.

4.1.1 Transmission in RANK Models

We begin with a standard RANK version of our open economy model in which, a) there is no constrained financial intermediary and b) a representative agent replaces the heterogeneous households. The representative agent chooses both the capital stock and the net foreign asset position of the country. We calibrate the model to have the same aggregate steady state as our HANK model. In particular, we assume a constant wedge in the first order conditions for capital in order have the same capital stock as in our baseline.[37] In addition, we add a small cost for holding foreign bonds to induce stationarity around the same net foreign asset positions as in the baseline.[38]

The black dotted line in figure 3 shows the response of this economy to the foreign interest rate shock. There are two main channels through which this shock propagates. First, as foreign interest rates rise, households want to save more abroad. This rise in desired saving, holding everything else fixed, would result in a decline of aggregate consumption and investment and a rise in the domestic real rate. This is a standard *intertemporal channel* common to most open economy DSGE models. Second, the upward pressure on the foreign relative to the domestic interest rate causes the real exchange rate to depreciate by 1%, making the domestic good more attractive to purchase relative to the foreign good. As a result of this *expenditure switching channel*, households lower demand for imports, as they rebalance their consumption basket towards the local good, and, at the same time, higher foreign demand increases exports by 2%. The first channel depresses output, whereas the second one stimulates domestic production. Given our calibration, the second channel prevails,

[36] This persistence is in line with the values used for foreign interest rate shocks in other papers using open economy models, such as Auclert et al. [2021] and references therein.

[37] The wedge can be viewed as a tax on capital whose proceeds are payed back to the household through a lump sum transfer.

[38] More details on the alternative model can be found in the appendix

and the economy experiences an expansion, with output increasing about 0.25% on impact.[39].

Importantly, in the frictionless RANK model, the absence of the leverage constrained bank and heterogeneous households eliminates most of the effects coming from currency exposure induced redistribution. Given incomplete international asset markets the size and currency composition of the net foreign asset position can induce a redistribution between the representative household and foreigners, but, given our calibration and the absence of any significant friction in trading bonds internationally, this effect turns out to be tiny.[40]

In Figure 3 we also report the impulse responses for an open economy RANK model with constrained financial intermediaries exposed to currency mismatch (dashed purple line). Once again, this model is calibrated to obtain the same aggregate steady state allocation as in our main HANK model. Importantly, we assume that the financial intermediary has the same deposit dollarization rate as in the baseline.[41] The financial friction in the banking sector introduces two additional transmission channels for the foreign interest rate shock. First, the rise in real rates means that the funding cost of banks increases, reducing the aggregate demand for capital and leading to a drop in q_t^K. As shown in figure 4, lower asset prices (and lower R_t^k) cause a deterioration in banks' net worth, tightening the banker's incentive constraint and igniting the standard *financial accelerator channel* described, for example, in Gertler and Karadi [2011], which pushes up the spread on capital and amplifies the drop in investment and output. Second, as a fraction of deposits is denominated in foreign currency, the exchange rate depreciation further reduces the bank's net worth through a *currency mismatch channel*. In fact, a weaker domestic currency (a higher e_t) causes the real cost of repaying bank deposits, R_{Dt} to jump on impact, further contributing to the decline in N_t. This channel interacts with the financial accelerator, amplifying the drop in investment, which declines by about 6% in the RANK with banks, compared to only 1% in the frictionless RANK. The negative effects of the two channels, operating through the banking sector, outweigh the positive effect of the expenditure switching channel, causing output to decline by about 0.75%.[42]

[39]The relative strength of the two channels depends on the parameters affecting preferences, monetary policy, and foreign demand, as discussed, for example, in Auclert et al. [2021] or in Akinci and Queralto [2018].

[40]In the RANK model the path of consumption is essentially determined by the path of the real rate and permanent income. Given the magnitude of the net foreign asset position in steady state and the size of the induced price changes, the effect of the revaluation of the net foreign asset position on permanent income is very small.

[41]Additional details on this alternative model can be found in the appendix.

[42]We chose a fairly simple small open economy model as the basis of our analysis to not over-complicate the discussion. We have experimented with some extensions like imported intermediate goods and domestic currency pricing. While these extensions can result in slightly different dynamics and magnitudes, we found that our key results for the HANK and RANK models are fully robust to the inclusion of these. Results are available upon request.

4.1.2 Transmission in HANK Models

As a the next step we add a HANK small open economy model, but without banks, to the comparison. Compared to our RANK model without banks, the heterogeneous households introduce several new channels for the transmission of interest rate shocks, which depend on the distribution of assets and income across households. The red dashed line in figure 3 reports the response of a "bank-less" HANK model, that is a HANK model with frictionless intermediaries. Once again the model is calibrated to essentially obtain the same steady state as in the baseline. The details of this alternative model can be found in the appendix. In particular, we add another wedge between the real rate applied to savings and the borrowing rate to target the same steady state spread we obtain in the model with banks.[43] In this model, absent financial frictions, higher exports cause an expansion in output as in the frictionless RANK model. However, here the decline in aggregate consumption is only half as large, and consumption of the domestic good actually experiences a sustained increase. This is partly due to a positive effect from the *real income channel*: as real income from labor income increases temporarily, high MPC households tend to increase their consumption in the same period, an effect that is largely absent in the RANK model.

To understand better the behavior of consumption in the HANK model, in figure 5 we report the average percentage response of consumption for five relevant groups of households in our model.[44] In addition, we report the behavior of two sources of households' income: labor income, together with its components of wages and hours, and dividend income. Higher export demand causes hours to increase. Nominal wages increase as well, but the initial spike in CPI inflation causes real wages to decline. However, the effect on hours dominates, causing real labor income to increase for all workers. Because of their high marginal propensity to consume, higher labor income causes the consumption of both types of hand-to-mouth households to increase on impact. In the bank-less HANK, several other forces sustain workers' consumption in the aftermath of a depreciation. As CPI inflation jumps on impact, borrowers also benefit from a *Fisher channel* which reduces the real value of their debt. In addition, savers, who hold a large share of their assets in foreign assets, benefit from the stronger dollar as they receive a windfall gain in real payments. Despite these channels, the consumption of unconstrained borrowers and savers declines modestly because of the

[43] Again, we can think of this as a proportional tax on lending to borrowers, whose proceeds are rebated back lump sum.

[44] This figure takes averages over repeated cross-sections, i.e. we select households into each group based on where they are in a given period. Therefore, changes in the average reflect both contemporaneous behavior as well as flows between the five groups over time.

intertemporal effect of higher interest rates. Finally, the consumption of capitalists declines partly because of higher interest rates and partly because of lower real dividends, but their contribution to changes in aggregate consumption is relatively small. Summing up, given our calibration, an open economy HANK model without banks would generate a much smaller decline in consumption vis-a-vis a comparable RANK model, with some households actually consuming more on impact, because of the positive effects of the real income channel, of the Fisher channel, and of the currency composition of households' portfolios.

Returning to figure 3, compared to the bank-less RANK, the higher path of inflation causes the monetary authority to raise rates faster, pushing up the real rate and causing a larger decline in investment. In addition, higher domestic real rates result in a smaller depreciation of the real exchange rate and in a smaller increase in exports. As a result, the expansion in output in the two models is of a very similar size.

Finally, the blue line in figure 3 reports the impulse responses of our baseline model, which combines all the ingredients of the previous models together: i) the small open economy framework, ii) financial frictions in the banking sector and iii) heterogeneous households. The result is a stronger decline in economic activity, relative to all the previously discussed versions. In fact, rather than dampening the negative effects arising from the banks' agency problem, as one might have guessed from comparing the red and the purple line in figure 3, combining the HANK component with a leveraged intermediary notably amplifies the downturn following a foreign interest rate shock. There are two main reasons for why this occurs.

First, as discussed above, the financial accelerator channel and the currency mismatch channel, operating through the banking sector, lead to a decline in output, which, unlike in the bank-less HANK model, causes a *negative real income channel*. As shown in figure 5, lower output and lower labor demand cause hours and wages to decline. As a result, real labor income declines by more than 2%. The consumption of zero asset hand-to-mouth agents declines one for one with labor income, while constrained borrowers' consumption declines even more on impact. By contrast, these agents experience higher wealth and consumption in the bank-less HANK model (dashed line in figure 5).

The second amplification channel is unique to our baseline model. As banks' net worth declines, in response to higher interest rates, financial intermediaries reduce the supply of credit, so that both the spread on loans to firms and the spread on households' loans increase (bottom of figure 4). Higher spreads translate in higher rates faced by borrowers, as shown by the path of R_{Lt+1} in figure

4.[45]. Figure 5 shows that unconstrained borrowers react immediately to higher borrowing costs, through an intertemporal motive, and their consumption declines on average by more than 3.5% on impact, much more than in the bank-less HANK. Furthermore, also constrained borrowers have to face a higher interest payment on their loans, which causes their consumption to plummet by more than 5% in the second period. [46] We call this mechanism, which generates negative spillovers for wealth poor agents from a currency depreciation, the *borrowing rate channel*. Importantly, in contrast with the mechanism studied in De Ferra et al. [2020], this channel strongly affects poor households even if their portfolio is not directly exposed to exchange rate fluctuations (in our calibration households only borrow in local currency). Furthermore, in presence of nominal rigidities, the negative effect on aggregate demand from the borrowing rate channel amplifies the decline in wages and hours, strengthening the real income channel.[47][48]

The two channels, and their interaction, cause aggregate consumption to drop twice as much as in the RANK model with banks.[49] While the behavior of imports is similar across the four models, domestic consumption declines much more in our baseline model, causing output to decline more than 1%, compared with only about 0.75% in the RANK model with financial frictions. Hence, the interaction between leverage constraint banks and heterogeneous households generates a powerful amplification mechanism for episodes of currency depreciation.

4.2 Quantifying the Channels

One of the main contributions of this paper is to show that the interaction between a HANK framework and a frictional banking sector is important to study the impact on aggregate consumption of a foreign interest rate shock in an emerging economy. In this section, we quantify the main channels

[45] On impact income from lending, R_{Lt}, declines because of the Fisher channel, further affecting banks' net worth.

[46] The consumption path of savers is slightly higher than in the bank-less model, since these agents mainly react to the path of the real rate, which is lower than in the bank-less HANK model.

[47] Figure A1 and A2 report the cross-sectional response of consumption in period 1 for the two types of HANK models considered. Figure A1 shows how the decline in consumption for borrowers and hand-to-mouth agents is much larger in our baseline model compared to the bank-less HANK. Figure A2 shows how the consumption of wealthier agents is similar in the two models, with richer households actually increasing their consumption because of the wind fall increase in their real asset income.

[48] We are showing average percentage changes in consumption in this discussion. As different groups of households have different levels of consumption and different masses of individuals, these numbers are not fully informative for their impact on aggregate consumption. Looking at the impact the response to the shock 12 percent of the decline in consumption are due to constrained borrowers, 28 percent each are due to unconstrained borrowers and zero wealth hand to mouth consumers, while savers account for 27 percent due to their larger group size. The remaining roughly 4 percent are explained by the entrepreneurs.

[49] For reference, in steady state constrained borrowers account for about 3 percent of total consumption, unconstrained borrowers for about 10 percent, hand-to-mouth agents for about 17 percent, savers for 57 percent and capitalist for about 13 percent

affecting households' income and the interest rates they face when saving/borrowing, which drive the total response in consumption.

In figure 6, we simulate the households' response to the path of a single real income stream or of a single real interest rate obtained from the main experiment of figure 3, while keeping all the other prices and quantities constant at their steady state value.[50] This type of exercise allows us to isolate the contribution of the four main channels affecting households' consumption in our model.

The red dashed line captures the impact of the decline in real labor income (as reported in figure 5) on households' consumption. Hand-to-mouth households of both types, who cannot adjust bond holdings in response to lower income, reduce consumption one-for-one with the decline in labor earnings. The average consumption of unconstrained borrowers declines by about 1% on impact, whereas workers with positive savings, who have a lower MPC, cut consumption on average by only 0.3%. Capitalists are unaffected since they do not earn labor income and they have a low probability of becoming a worker. All told, lower labor income accounts for about two thirds of the decline in aggregate consumption (top left panel of figure 6). Lower real dividend income (black dotted line) only slightly affects the consumption of capitalists, and its decline has a very small impact on C_t overall.

Next, we consider the effect of higher real interest rates caused by the foreign shock. The purple starred line isolates the effect of higher real borrowing rates on consumption. The agents reducing demand more on impact are the unconstrained borrowers, who react to the higher present and future cost of borrowing. Constrained households do not adjust consumption immediately, as their demand is not determined by a forward looking Euler equation, but in the second period, when the interest payment on their debt jumps, they cut consumption steeply. It is interesting to notice that savers react slightly to higher borrowing rates as well. This is the case both because of savers attaching some probability to becoming borrowers in the near future as well as to composition effects as the rising borrowing rate induces some borrowers to become savers. In total, the borrowing rate channel accounts for about one third of the aggregate drop in C_t. On the other hand, in response to the higher rate on savings (green dashed line), savers cut consumption because of a standard intertemporal channel, while capitalists' consumption increases since the value of their wealth becomes persistently higher. As a result, the total impact on consumption of this channel is modest.

[50] For example, we let dividends follow their path implied by the main model after an interest rate shock, but leave wages, interest rates etc. at their steady state value. Households know the entire path on impact. We keep solving these responses using linearization.

Summing up, figure 6 suggests that the presence of constrained intermediaries negatively affects aggregate consumption mainly through the labor income channel and the borrowing rate channel. Of course, this decomposition ignores that the different price paths are jointly determined by the response of the economy to the interest rate shock. Introducing, for example, taxes that would remove some of these dynamics will have additional feedback loops. Focusing on the interaction between the bank and the borrowers' consumption, one of the key novelties of the paper, we perform one more experiment to highlight this component. We simulate a version of our model in which the spread on household loans is assumed to be fixed, hence eliminating the extra increase in households' borrowing costs originating from the banking sector.[51] Figure 7 shows that, in this alternative model, the decline in consumption is about half as large as in the baseline model, hence showing a larger role for the borrowing rate channel compared to figure 6.

To understand why keeping the spread fixed has such a large impact on the economy, it is useful to look at figure 8. Without the spike in the loans spread occurring in the baseline model, the decline in borrowers consumption is much smaller. Higher aggregate demand, compared with the baseline, implies a smaller decline in labor income, which translates into a higher income and consumption for all workers, relative to the economy with a varying spread, underlining an important interaction between the borrowing rate channel and the labor income channel. Furthermore, a higher path for output and hours pushes up the marginal product of capital, r_t^k, and its price, q_t^k, generating a smaller decline in banks' net worth. As a result, the spread on firms' loans increases less than in the baseline, stimulating investment. All told, figure 7 and 8 show that the borrowing rate channel, and its spillovers on wages and asset prices, is responsible for more than half of the decline in domestic output.[52]

4.3 The Role of Portfolios

In our model, the limited supply of local currency deposits by domestic households causes the currency mismatch on banks balance sheets through the market clearing for local currency bonds (equation 44). In our baseline calibration, in line with the evidence for several emerging economies, it is mostly wealthier households who save in foreign currency deposits. As we will show next,

[51] The fixed wedge between banks' return on loans and the risk free rate could be obtained, for example, either with a tax on loans (rebated lump sum to banks) or with a non-pecuniary cost for holding loans.

[52] After a bit more than a year the recovery from the shock in the economy with a fixed spread falls mildly behind the recovery in our main model. This is the case as the constant spread results in lower income for the bank, holding everything else fixed, in the recovery. As such networth starts being marginally lower after 5 quarters delaying the recovery of investment and capital.

increased holdings of dollar deposits by wealthier households, while providing larger individual insurance, result in larger economic downturns and worse implications for poorer households. The notion that an insurance motive by domestic savers can be a driver of banks' liability dollarization is in line with the theory presented in Bocola and Lorenzoni [2020]. A novel contribution of our work is to study the re-distributive implications of the hedging strategies of richer households.

In figure 9, we compare the responses of our model with an alternative calibration where households portfolios are adjusted to obtain a higher bank deposit dollarization rate of 80% (red dashed line). This alternative calibration is obtained by increasing by the same amount the dollar deposits held by savers.[53] Due to the larger currency mismatch in the banking sector, the resulting recession is much deeper than in the baseline. The decline in net worth is twice as large as in our baseline model, causing much larger spikes in the spreads on capital and on loans. As a result, investment and consumption decline by about 12% and 1.7%, respectively, compared with 6% and 1% in the baseline. The decline in output is more than twice as large as in the baseline. Figure 10 illustrates the re-distributive effects of changing the currency composition of savers' assets. Compared to our baseline model, the larger collapse in aggregate consumption is driven by a sharp decline in the consumption of hand-to-mouth agents of both types, due to a stronger labor income channel and a stronger borrowing rate channel. What is particularly interesting in figure 10, is that the path of consumption for savers, and especially for capitalists, is actually higher than in the baseline, because of the larger windfall wealth gains caused by an appreciation of the dollar. Hence, better insurance for some agents worsens the aggregate and distributional effects of the foreign interest rate shock. Conversely, figure 9 and 10 also show that a calibration with no dollar debt on banks' balance sheet causes a much less severe recession. In this case, as shown in figure 10, poorer households fare better than in the baseline whereas richer households fare slightly worse.

In figure 9 and 10 we altered the level of dollar deposits while keeping the relative distribution constant. We now investigate the implications of changing the distribution of dollar securities in our economy. The red dashed line in figure 11 represents the impulse responses of a version of our model in which we assume that households borrow only in foreign currency, as in De Ferra et al. [2020]. Compared to our baseline calibration, we are adding direct exposure to a depreciation for poorer households, while we are giving banks hedging against the devaluations by providing them with dollar denominated loans.[54] As expected, due to the foreign currency denomination of their

[53] In particular, we increase the constant parameter $\bar{\lambda}$ in the linear function governing the distribution of foreign assets, while keeping the slope coefficient equal to its value in the baseline calibration.

[54] In this experiment we assume that the distribution of dollar deposits across savers is the same as in the baseline.

debt, the consumption of borrowers, and in particular of those at the borrowing constraint, drops more than in our baseline calibration on impact (middle panel of figure 11). Given that loans to households represents only a small share of a bank's assets in our calibration, banks' net worth receives only a modest boost compared to our main model which results in a very similar path for investment.[55] As a result, on impact consumption drops about 20 percent more and output about 10 percent more.

Next, we quantify the insurance effect of dollar holdings for savers by considering an alternative version of our model in which households hold only local currency assets (dash-dotted purple line in figure 11).[56] Following the devaluation, the consumption of savers drops about 25 percent more than in the baseline on impact and then follows a shallower path, while capitalists experience an even larger change in their consumption profile. Due to general equilibrium effects, operating through wages and prices, also other household types cut consumption more than in the baseline. Aggregate consumption falls about 20 percent more than in our baseline, and lower domestic aggregate demand results in lower domestic rates and in an even larger depreciation of the local currency, causing, on the one hand, a larger boost to exports and, on the other hand, a slightly lower path for bank net worth.. All told, output declines about 5 percent more than in the baseline on impact.

5 The Gains from Exchange Rate Stabilization

In this part of the paper we look at the role of monetary policy during a devaluation. The central bank in our model can fight an exchange rate depreciation by raising domestic interest rates. A smaller devaluation of the local currency might have benefits as it reduces the negative effects of the currency mismatch on banks' balance sheet. However, higher rates, holding the effect of currency mismatch fixed, depress aggregate demand and asset prices. The central bank in our small open economy might, therefore, face a non trivial choice in how much to stabilize currency swings. To

[55] In our baseline calibration, household debt accounts for about 5 percent of annual GDP. In Uruguay, this number is around 9 percent over the past 10 years, but it includes also mortgages which are not part of our model.

[56] We assume that the currency mismatch for banks is the same as in the baseline, but in this case banks borrow in dollars from abroad, while households are able to issue local currency bonds to foreigners.

investigate this trade-off we now expand our monetary policy rule as follows[57]

$$log(i_t) = log(R_{ss}) + \kappa_\pi log(\pi_t^H) + \kappa_e log\left(\frac{e_t}{e_{t-1}}\right).$$

This rule allows monetary policy to smooth the fluctuations in the nominal exchange rate. As κ_e increases the emerging economy approaches an exchange rate peg, whereas $\kappa_e = 0$ corresponds to our baseline economy. To begin our discussion, figure 12 shows the impulse responses of the baseline economy for different calibrations of the monetary policy rule ($\kappa_e = 0, 0.5, 5$). Relative to the calibration we discussed before ($\kappa_e = 0$) a stronger response to the change in the nominal exchange rate ($\kappa_e = 5$) results in a higher path of the policy rate - in fact, in both of the cases shown, we see a monetary tightening on impact. As a result, the real exchange rate depreciates less. While the smaller depreciation provides some protection of banks' balance sheets from currency risk, we see that rate hike more than offsets these gains - bank networth, output, investment, and consumption all decline. Lower net worth implies a more severe labor income channel and borrowing rate channel, negatively affecting the consumption of poorer households (bottom of figure 12). At the same time savers face slightly higher returns on their savings, but are negatively affected by the decline in labor income and the smaller wealth transfer through their portfolios (Not shown). At the same time, for the $\kappa_e = 0.5$ case the recovery seems somewhat faster than for $\kappa_e = 0$ signaling a trade-off between the depth of the recession and the speed of a following recovery. As we discuss below, this result helps to explain why some modest response to changes in the exchange rate might be broadly welfare improving. We conclude that with 40 percent of deposits being in foreign currency, it is difficult to obtain meaningful gains from stabilizing the exchange rate.

When we increase the degree of dollarization to 80 percent we obtain the results reported in figure 13 for the same three choices of κ_e. Here we see more clearly that some leaning against the depreciation might actually be beneficial. Figure 13 shows that, when deposit dollarization is high, a small reaction to exchange rates ($\kappa_e = 0.5$) leads to a modestly larger drop in aggregates in combination with the same fast recovery we saw above. As a consequence, for example, the consumption of hand-to-mouth agents follows a higher trajectory than in the baseline. Increasing the response to the exchange rate further, the spike in domestic interest rates becomes too large, and agents start being worse off. For example, with $\kappa_e = 5$, bank net worth declines more than

[57] We assume that the central bank reacts to the change in the nominal exchange rate as in, for example, Lubik and Schorfheide [2007]. We also experimented using the level of the nominal exchange rate in the rule. However, as the foreign price level is assumed to remain fixed and as the real exchange rate is stationary, this assumption effectively induces history dependence to past inflation misses into the rule, complicating the interpretation of the results.

20% causing a much larger contraction in households' consumption and a much deeper recession.[58] Hence our analysis suggests that the degree of deposit dollarization is an important element to evaluate the trade-offs faced by central banks in emerging economies during a currency crisis.

While looking at the aggregate dynamics is suggestive of potential gains from modestly leaning against the appreciation, in the end we need to attach a valuation to different paths, and we do so by looking at households' welfare. Therefore, in figure 14, we show the average consumption equivalent welfare gains/losses relative to steady state, conditional on a 100 basis points annualized shock to the foreign interest rate, as we increase the degree of exchange rate stabilization pursued by the central bank. A positive value expresses a welfare gain from the occurrence of the shock under the given policy rule. We perform the experiment for our baseline economy (blue line), and for an economy with a deposit dollarization of 80% (purple line). The dashed lines represent the welfare loss/gain achieved with our baseline policy rule reacting only to domestic inflation ($\kappa_e = 0$). We see that, in the baseline calibration, with 40% dollarization, most agents prefer at most a modest response to changes in the nominal exchange rate. This is the case as, at least for low networth households, changes in the path of wage, hours, and the borrowing rate are, by far, the most important for income and, therefore, consumption and welfare. Compared to workers, capitalists, which have an average wealth much larger that the other agents, exhibit an opposite welfare gains profile. Initially, some exchange rate smoothing penalizes them by reducing their windfall gains following a depreciation. As κ_e becomes very large, the central bank reacts to the devaluation by persistently increasing the real return on bonds, hence boosting the income from wealth of this type of agents. [59]

Our policy experiment so far considered welfare changes conditional on the shock as it allows us to summarize the effect of the monetary policy rule on different types of agents. While a full optimal policy analysis is beyond the current paper, to complete our analysis we now take a second order approximation to the households' value functions given the models aggregate dynamics and compute ex-ante welfare in consumption equivalent terms, integrated over different realizations of the shock, while changing the values for κ_e.[60] Figure 15 summarizes the results. The blue line shows the results

[58] Interestingly, comparing figure 13 to figure 12, we can see that for $\kappa_e = 5$ the aggregate dynamics for both dollarization cases are fairly close, in line with the stabilization of the exchange rate reducing the role of currency mismatch for the transmission of the foreign interest rate shock relatively to the response of the domestic real rates.

[59] In addition, for large values of κ_e real dividends increase on impact, supporting the capitalists consumption.

[60] To deal with the large state space we perform a dimension reduction of our state space using a principle component approach. We verified that aggregate first order dynamics of the full model and the model with the state space reduction are extremely close to each other. Gornemann et al. [2016] describes in detail how we dimension reduction when computing the second order approximation.

under our baseline calibration. [61] Unsurprisingly, given our previous discussion, households prefer a modest response - around 0.04 - to exchange rate changes as a further increase turns out to make consumption and the value function more volatile.[62] Entrepreneurs prefer a bit more stabilization then the rest of the households as their income is more sensitive to changes in the exchange rate. Finally, as we can see from the red dotted line, increasing the dollarization reduces the welfare of all agents as the economy becomes more volatile. In addition, in this alternative calibration, there are larger gains from stabilizing the exchange rate as we can see from the rightward shift in the peak of the policy response.

6 Conclusion

We construct a small open economy HANK model with financial frictions in the banking sector and foreign currency deposits by households. We show that there are sizable interaction effects between the currency composition of savers' portfolios, the currency mismatch of domestic banks, and the 'well-being' of borrowers. Calibrating our model to match the distribution of dollar savings for a typical Latin American economy, with wealthier households providing most of the foreign currency deposits to banks, results in a sizable recession following a depreciation of the domestic currency. When the exchange rate devaluates, the real burden of banks dollar deposits increases, eroding bank net worth. As a result, financial intermediaries reduce credit supply, depressing investment and output. Lower labor income and higher spreads on bank loans cause poorer households to reduce spending sharply, amplifying the economic downturn. This process is exacerbated by the degree of currency hedging performed by richer households.

In this framework, the central bank faces a trade-off between smoothing exchange rate fluctuations, by raising domestic interest rates, and exacerbating the distributional effects of banks' financial frictions. Some level of exchange rate stabilization is welfare improving for most agents only for high levels of deposit dollarization.

Our paper points into multiple directions for future research. First of all, our current model takes the currency portfolios of banks and households as given. While we could endogenize our portfolios in ways that would be largely independent of business cycle risk, our framework can

[61] Welfare is expressed relative to steady state, so the fact that all the numbers are negative reflects the cost of living in a risky economy.

[62] Our second order approximation essentially shapes up to be a weighted average of variances of consumption and hours at different horizons. Given that shocks are symmetric around the steady state these variance can be essentially foreseen from the IRFs.

potentially be used to study how the volatility of aggregate and idiosyncratic shocks affects the endogenous portfolio choice of financial firms and households. In addition, it would be interesting to study fully optimal policy in a setting like ours, potentially with a richer selection of shocks. Finally, for simplicity our model assumes that households and firms cannot default on their debt. It could be interesting to see how the feedback loop between currency exposure and credit risk amplifies our propagation channels for a devaluation.

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A Representative Agent Model without Banks

In this setting we remove the bank and replace our heterogenous household with a representative agent who collects all the incomes and chooses consumption and investment. The problem of a representative household is given by

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_b^t \left[U\left(C_t\right) - v\left(H_t\right)\right] \tag{52}$$

$$P_t C_t + \left[B_{Ht}^* + \frac{\zeta^h}{2}\left(B_{Ht}^* - B_{ss}\right)^2\right] + q_t K_t = e_t R_{Bt}^* B_{Ht-1}^* + w_t H_t + q_t K_{t-1}\left(R_t^k - \mu_k\right) + \Pi_t^P + \Pi_t^I + \xi_b \tag{53}$$

where μ_k represents a cost of holding capital, which is rebated lump-sum to households (hence not affecting the aggregate resource constraint).[63] ζ^h is a bond adjustment cost needed to induce stationarity in the net foreign asset position. We calibrate it to a very small value. To keep things brief, we already wrote the problem in terms of final consumption. The household still chooses between home and foreign goods as explained in the main text.

The FOCs are

$$\left[1 + \zeta^h\left(B_t^* - B_{ss}\right)\right] = \beta \mathbb{E}_t \frac{U_{ct+1}}{U_{ct}} \frac{P_t}{P_{t+1}} e_{t+1} R_{Bt+1}^* \tag{54}$$

$$1 = \beta \mathbb{E}_t \frac{U_{ct+1}}{U_{ct}} \frac{P_t}{P_{t+1}} \left(R_{t+1}^k - \mu_k\right) \tag{55}$$

as a result we can rewrite the last two FOCs as

$$\beta E_t \frac{U_{ct+1}}{U_{ct}} \frac{P_t}{P_{t+1}} \left(R_{t+1}^k - \mu_k\right) = \beta E_t \frac{U_{ct+1}}{U_{ct}} \frac{P_t}{P_{t+1}} e_{t+1} \frac{R_{Bt+1}^*}{\left[1 + \zeta^h\left(B_t^* - B_{ss}\right)\right]} \tag{56}$$

The net foreign asset positions (NFAP) are going to be

$$B^* = B_{Ht}^* \tag{57}$$

and the balance of payment equation will be given by

$$\Longrightarrow C_t^{H*} - S_t\left(C_t^F + C_{bt}^F\right) = B_t^* - \frac{S_t}{S_{t-1}} R_{Bt}^* B_{t-1}^* \tag{58}$$

[63] μ_k is set so that the capital stock and investment in steady state are the same as in the HANK model.

In this model there is no role for bank's loans or deposits.

B Representative Agent Model with Banks

The representative household solves the same problem as above, but it does not intermediate capital and saves in the bank's deposits (possibly in both currencies) or in foreign deposits

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_b^t \left[U\left(C_t\right) - v\left(H_t\right)\right] \tag{59}$$

$$P_tC_t + D_t + e_t\left[B_{Ht}^* + \frac{\zeta^h}{2}\left(B_{Ht}^* - B_{ss}\right)^2\right] = R_{Dt}D_{t-1} + e_tR_{Bt}^*B_{Ht-1}^* + w_tH_t + \Pi_t^P + \Pi_t^I + \xi_b \tag{60}$$

The FOCs are

$$\left[1 + \zeta^h\left(B_t^* - B_{ss}\right)\right] = \beta\mathbb{E}_t\frac{U_{ct+1}}{U_{ct}}\frac{P_t}{P_{t+1}}\frac{e_{t+1}}{e_t}R_{Bt+1}^* \tag{61}$$

$$1 = \beta\mathbb{E}_t\frac{U_{ct+1}}{U_{ct}}\frac{P_t}{P_{t+1}}R_{Dt+1} \tag{62}$$

In this case the NFAP are given by

$$B_t^* = B_{Ht}^* - D_t \tag{63}$$

and the balance of payments again satisfies

$$\Longrightarrow C_t^{H*} - S_t\left(C_t^F + C_{bt}^F\right) = B_t^* - \frac{S_t}{S_{t-1}}R_{Bt}^*B_{t-1}^* \tag{64}$$

Finally, to preserve the same steady state as in the baseline, we assume that the bank faces a constant demand for domestic loans $L_t = L_{ss}$.

C Heterogeneous Agent Model without Banks

In this case the problem of the households is the same as in the baseline model. However, the financial intermediary owned by the capitalists does not face a financial constraint. In order to obtain the same steady state of the baseline we make the following assumptions.

The dividends obtained by the capitalists are still

$$\Pi_t = (1 - \sigma_b) \left\{ R_t^k q_{t-1}^k K_{t-1} + R_{Lt} L_{t-1} - R_{Dt} D_{t-1} \right\} + \Pi_t^p + \Pi_t^I \tag{65}$$

We assume a fixed spread, equal to the steady state spread in the baseline, on capital

$$E_t \left(R_{t+1}^k - R_{Dt+1} \right) = \mu_k. \tag{66}$$

We also assume a fixed spread, equal to the steady state spread in the baseline, on loans

$$E_t \left(R_{Lt+1} - R_{Dt+1} \right) = \mu_l. \tag{67}$$

Both spreads can be introduced into the primitive problem as a tax on both types of investment that is rebated lump-sum.

Finally, to pin down deposit demand we keep

$$q_t^k K_t + l_t = n_t + d_t, \tag{68}$$

which together with the law of motion for networth and the equations above pins down aggregate deposit demand.

Finally, as in the baseline, the NFAP are given by

$$B_t^* = B_t^+ - D_t \tag{69}$$

where B_t^+ represents total households savings.

D Data Appendix

D.1 Figure 1

The figure is constructed from data collect by Levy-Yeyati [2021] and downloaded from

https://flar.com/en/news/research-financial-dollarization-and-de-dollarization-new-millennium.

D.2 Figure 2

The data underlying figure 2 was constructed as follows:

- We took all observations from the 2013 Financial Survey of Uruguayan Households (EHFU-2).

- We kept all 37,140 imputed observations from the 3,490 original households. We recoded missing values of b_11, c_deuda_monto, c_15_1, c_15_2, and c_15_3 to 0.We also recoded missing values of b_7 as 0..

- Net Liquid Wealth was constructed as savings (variable b_11) minus debts (variable c_deuda_monto). We also computed the sum of individual loans (variables c_15_1 + c_15_2 + c_15_3), and replaced debt with this value if the loans were greater, in order to ensure that loans in dollars are not greater than total debt.

- Net Dollar Wealth was constructed as savings in dollars (variable b_11 * variable b_7 / 100) minus loans held in dollars (15_1, if c_18_1 =3, + c_15_2, if c_18_2 = 3, + c_15_3, if c_18_3 = 3).

- All variables were scaled to US dollars using the average exchange rate between pesos and dollars in 2013.

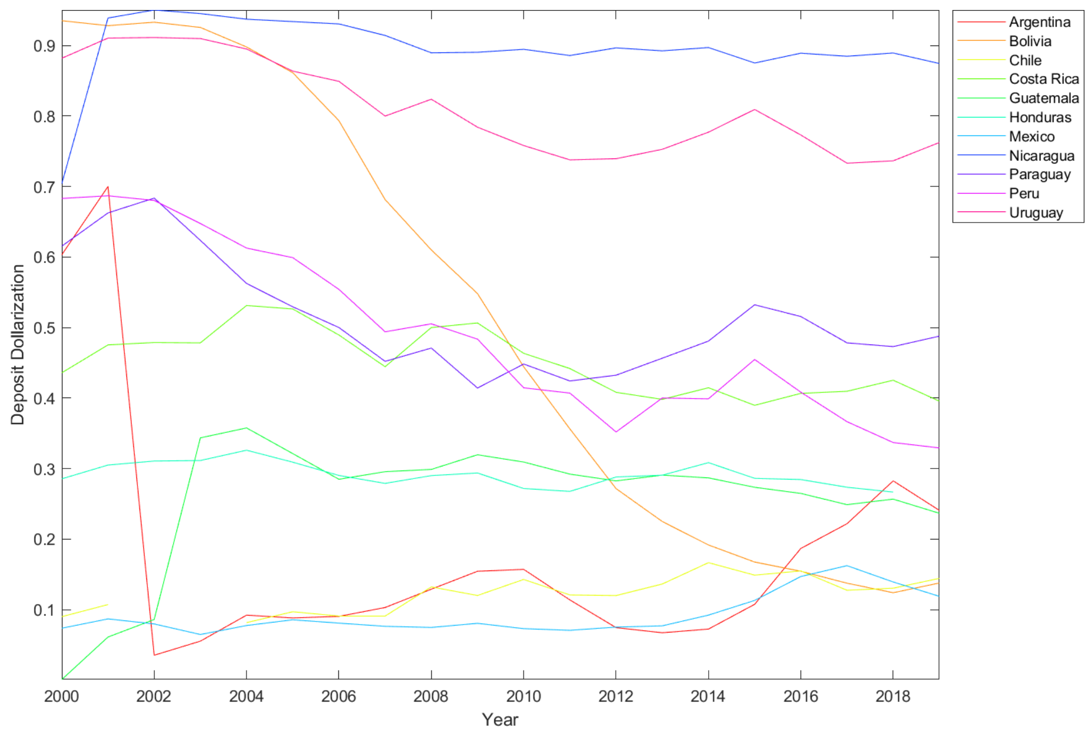

Figure 1: Deposit Dollarization in Latin America

Notes: This figure shows the share of deposits in dollar over time in a selection of Latin American countries. See Appendix D for data source.

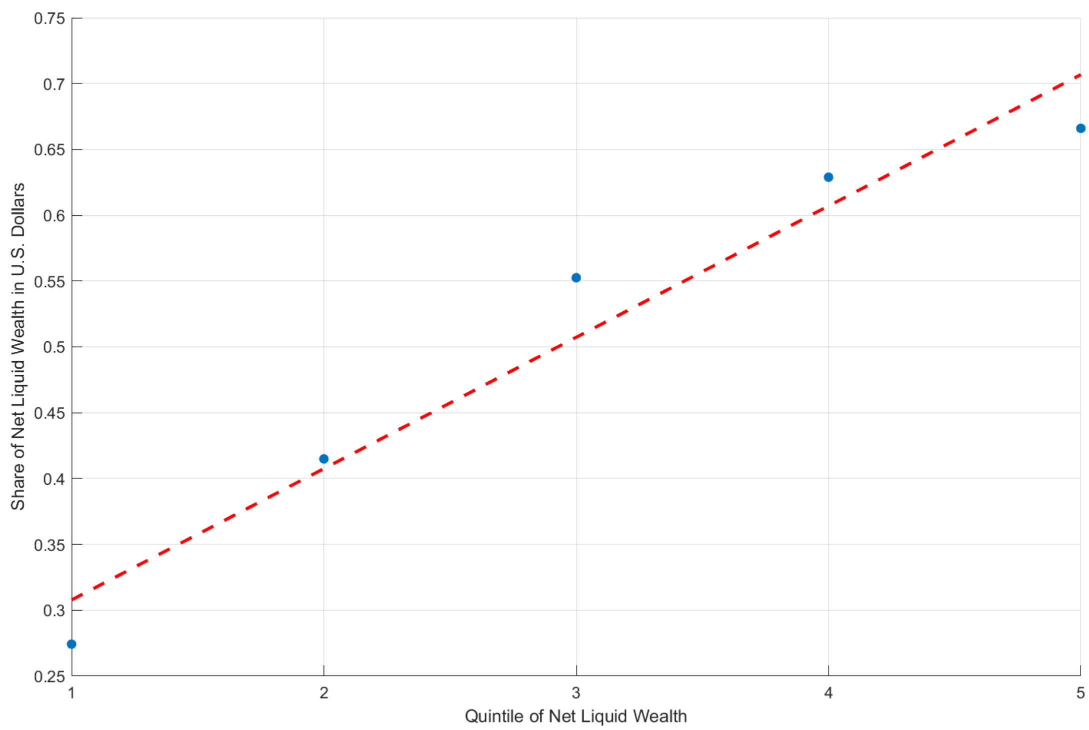

Figure 2: Dollar Deposits by Wealth Quintile in Uruguay

Notes: This figure shows the average share of net liquid wealth (mainly wealth excluding housing) in dollar for the five net liquid wealth quintiles. See Appendix D for data source and construction of the variables.

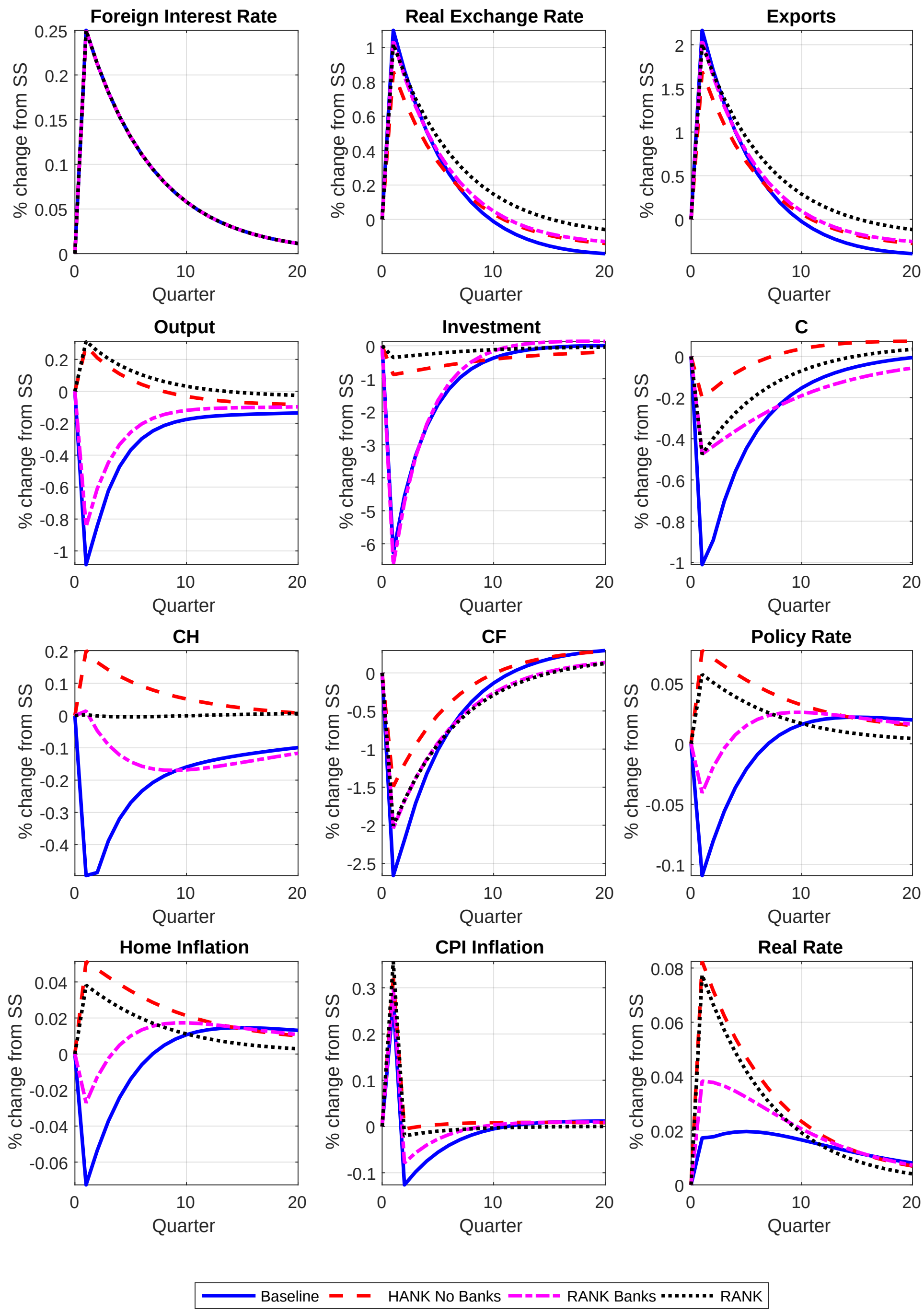

Figure 3: Foreign interest rate shock in Baseline vs other models

Notes: This figure shows the impulse response to a temporary rise in the foreign interest rate by 100 bps annualized in our baseline HANK model as well as the described variants in deviations from the steady state.

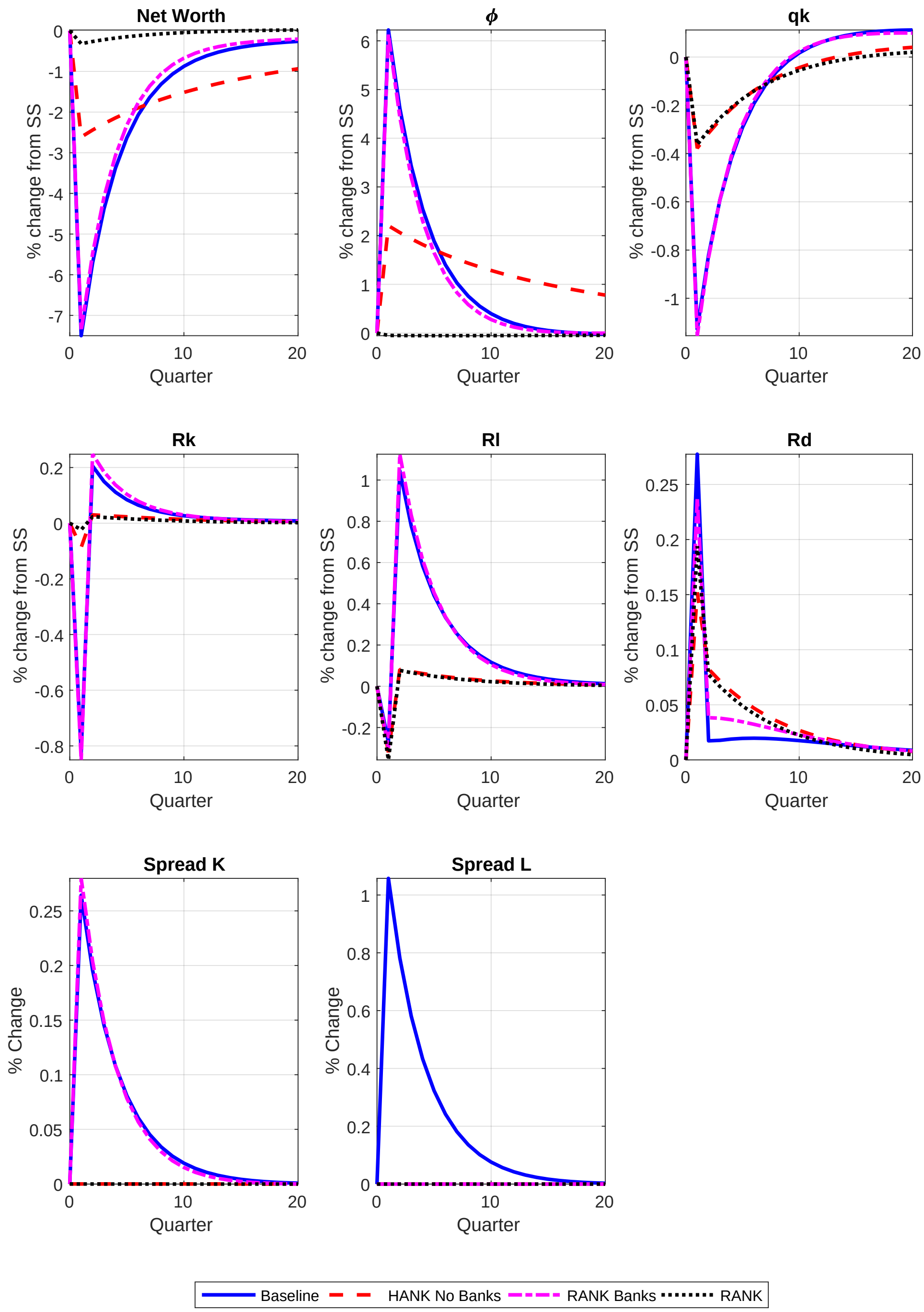

Figure 4: Foreign interest rate shock: bank variables

Notes: This figure shows the impulse response to a temporary rise in the foreign interest rate by 100 bps annualized in our baseline HANK model as well as the described variants in deviations from the steady state. ϕ denotes bank leverage. qk is the price of capital. Rk denotes the return on capital. Rl denotes the loan rate. Rd denotes the deposit rate. Spread K denotes the borrowing spread for capital. Spread L denotes the borrowing spread for loans.

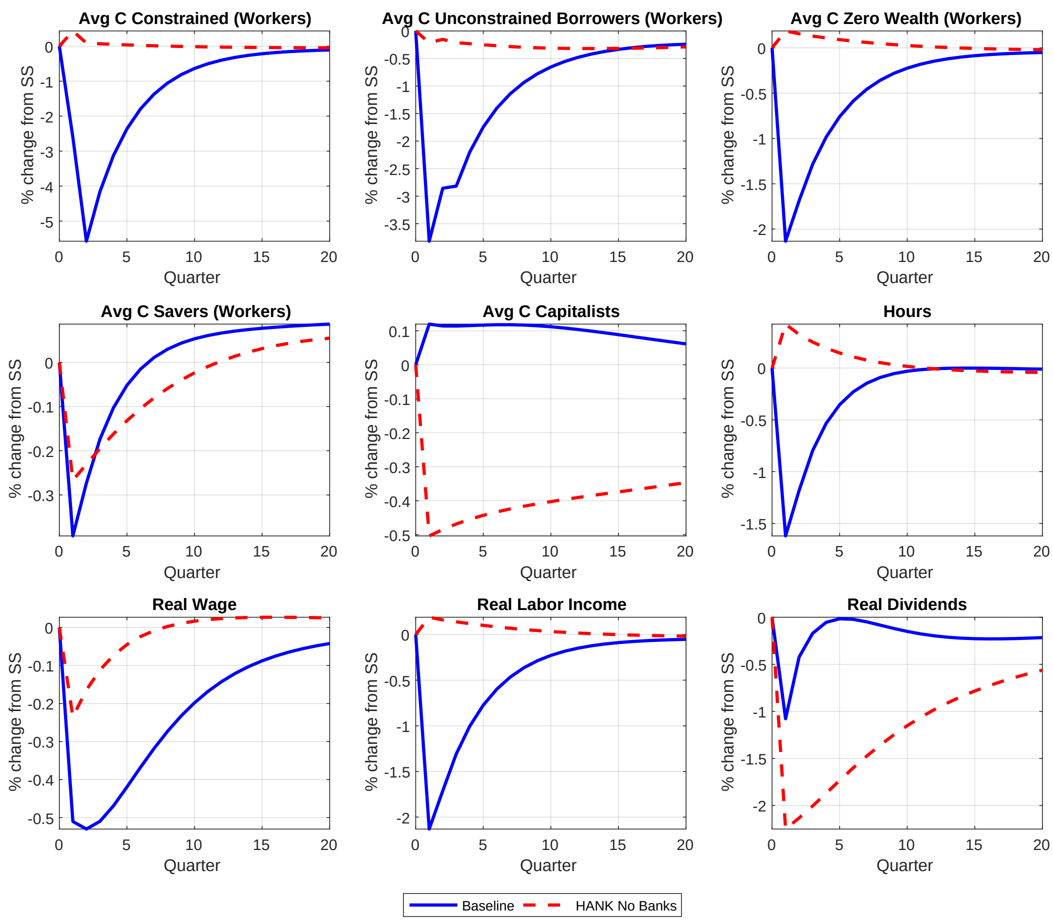

Figure 5: Foreign interest rate shock: Households Consumption

Notes: This figure shows the impulse response to a temporary rise in the foreign interest rate by 100 bps annualized in our baseline HANK model as well as the described variants in deviations from the steady state. Avg C Constrained (Workers) denotes the average consumption decline (in percent) for borrowing constrained workers. Avg C Unconstrained (Workers) denotes the average consumption decline (in percent) for workers with negative wealth who are not at the constraint. Avg C Zero Wealth (Workers) denotes the average consumption decline (in percent) for workers with zero wealth. Avg C Savers (Workers) denotes the average consumption decline (in percent) for workers with positive wealth. Avg C Capitalists denotes the average consumption decline (in percent) for entrepreneurs.

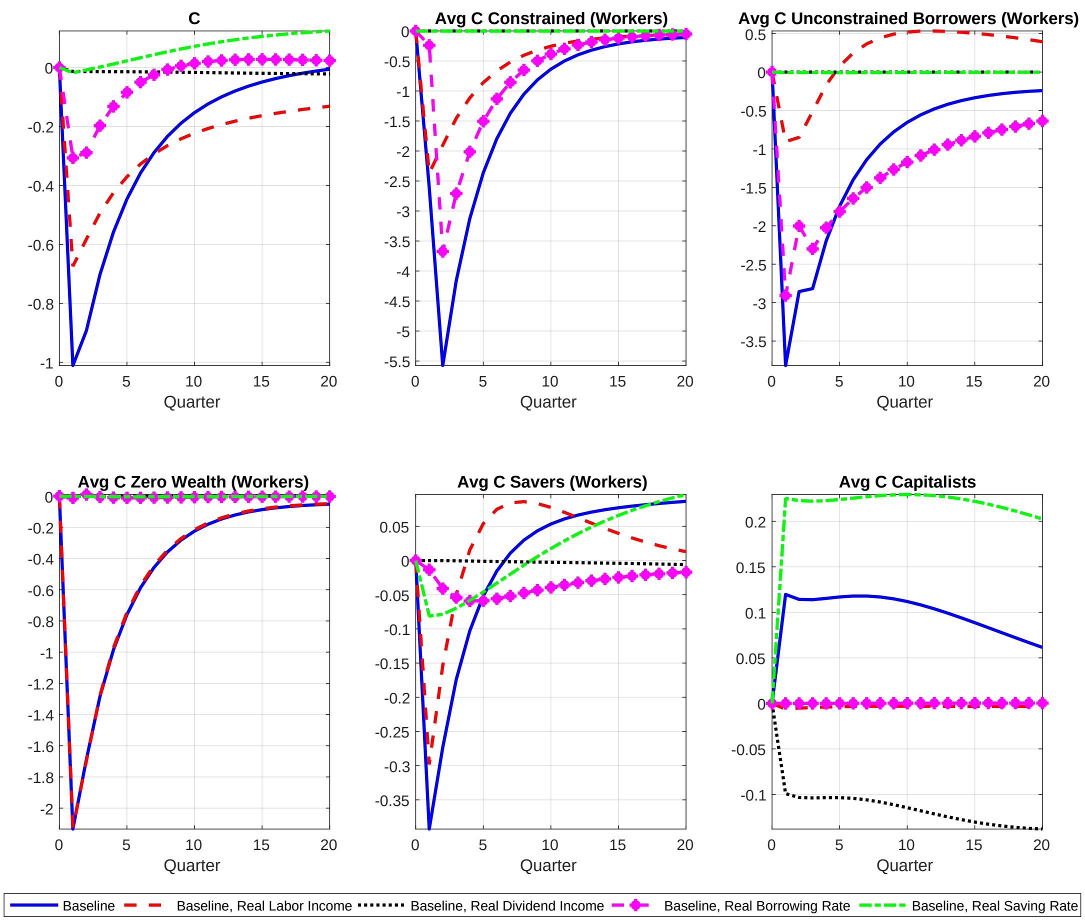

Figure 6: Decomposing the channels affecting households consumption

Notes: This figure shows the impulse response to a temporary rise in the denoted price given by the response to a foreign interest rate by 100 bps annualized in our baseline HANK model. Avg C Constrained (Workers) denotes the average consumption decline (in percent) for borrowing constrained workers. Avg C Unconstrained (Workers) denotes the average consumption decline (in percent) for workers with negative wealth who are not at the constraint. Avg C Zero Wealth (Workers) denotes the average consumption decline (in percent) for workers with zero wealth. Avg C Savers (Workers) denotes the average consumption decline (in percent) for workers with positive wealth. Avg C Capitalists denotes the average consumption decline (in percent) for entrepreneurs.

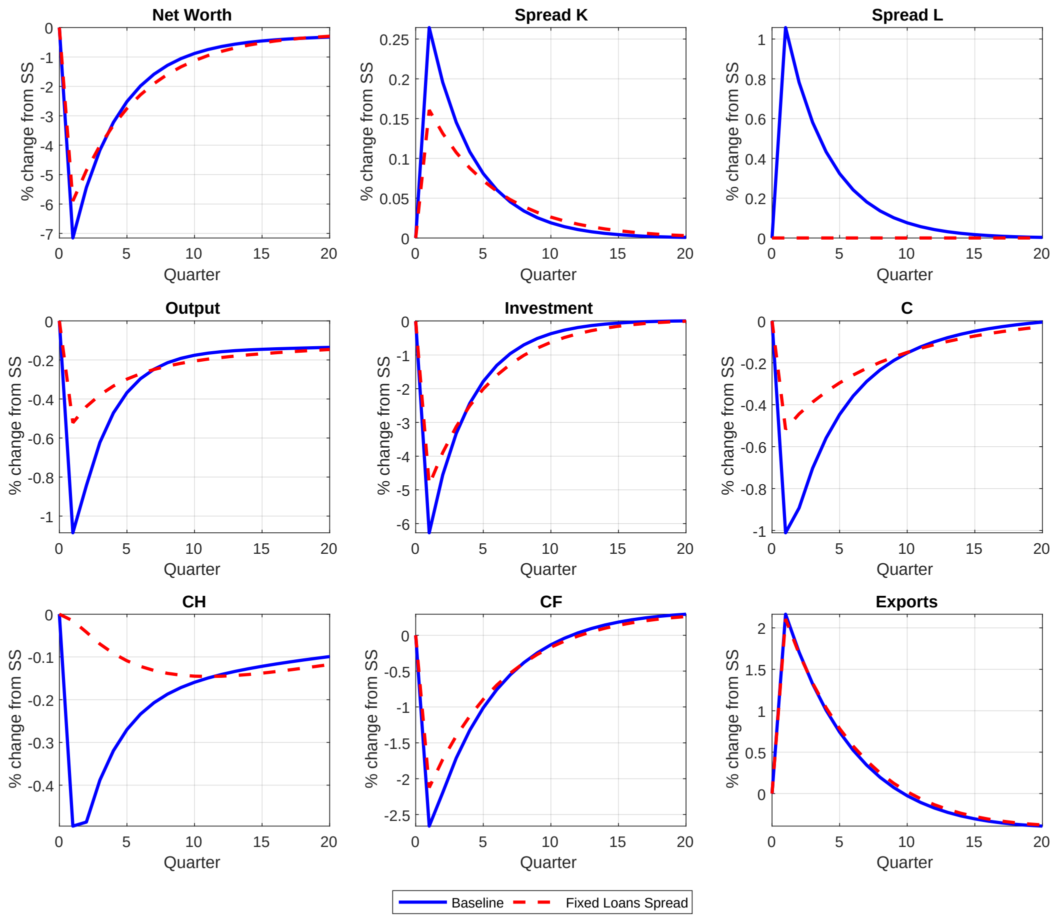

Figure 7: Quantifying the borrowing rate channel

Notes: This figure shows the impulse response to a temporary rise in the foreign interest rate by 100 bps annualized in our baseline HANK model as well as the model with a fixed loan spread. Spread K denotes the borrowing spread for capital. Spread L denotes the borrowing spread for loans. C denotes consumption. CH denotes consumption of the home good. CF denotes consumption of the foreign good.

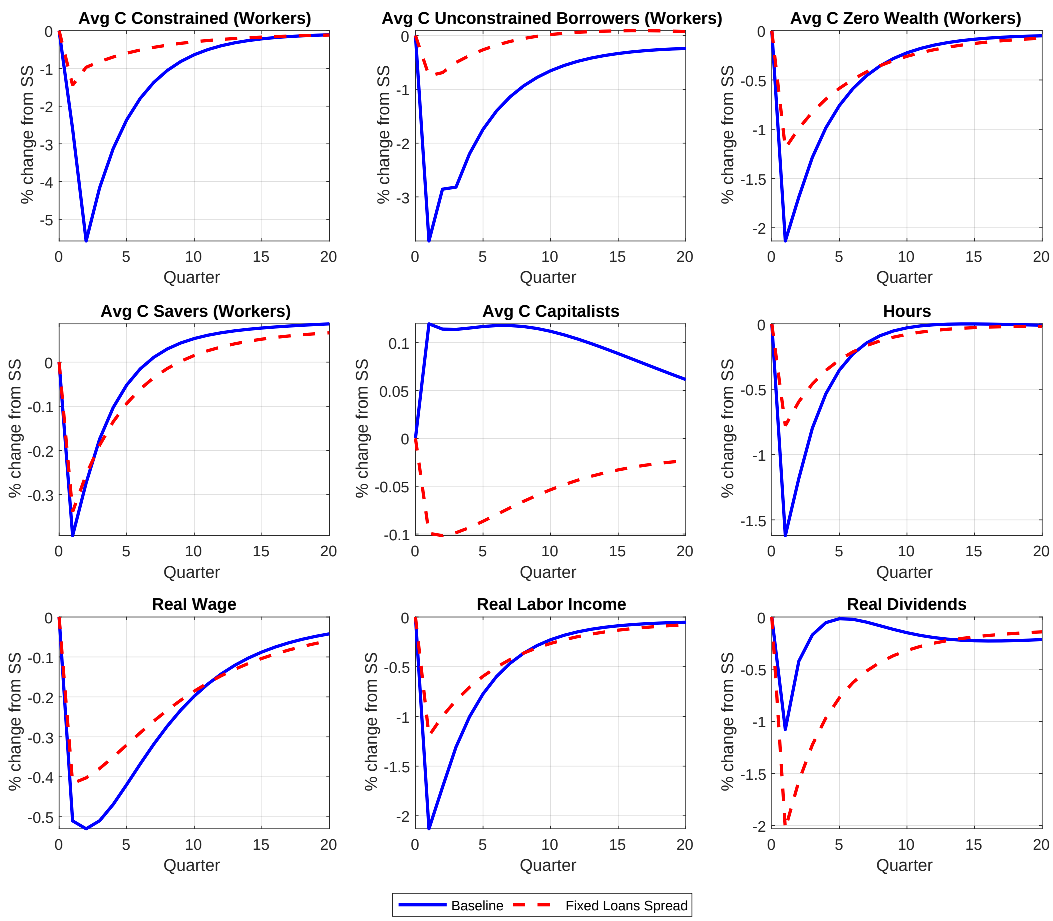

Figure 8: Quantifying the borrowing rate channel: Households Consumption

Notes: This figure shows the impulse response to a temporary rise in the foreign interest rate by 100 bps annualized in our baseline HANK model as well as the model with a fixed loan spread. Avg C Constrained (Workers) denotes the average consumption decline (in percent) for borrowing constrained workers. Avg C Unconstrained (Workers) denotes the average consumption decline (in percent) for workers with negative wealth who are not at the constraint. Avg C Zero Wealth (Workers) denotes the average consumption decline (in percent) for workers with zero wealth. Avg C Savers (Workers) denotes the average consumption decline (in percent) for workers with positive wealth. Avg C Capitalists denotes the average consumption decline (in percent) for entrepreneurs.

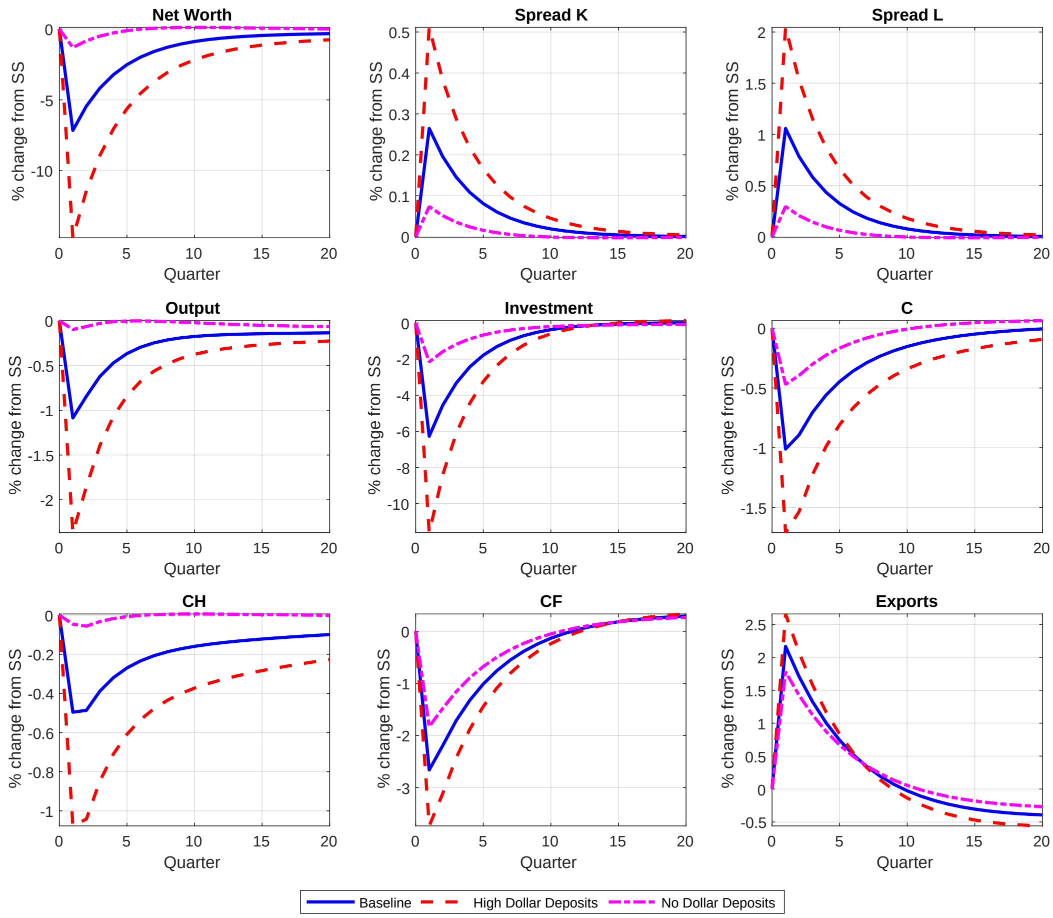

Figure 9: The Role of Households Portfolios

Notes: This figure shows the impulse response to a temporary rise in the foreign interest rate by 100 bps annualized in our baseline HANK model as well as the same model for different level of the dollar share in portfolios. High Dollar Deposits has an average share of 80 percent, while No Dollar Deposits has a share of zero. Spread K denotes the borrowing spread for capital. Spread L denotes the borrowing spread for loans. C denotes consumption. CH denotes consumption of the home good. CF denotes consumption of the foreign good.

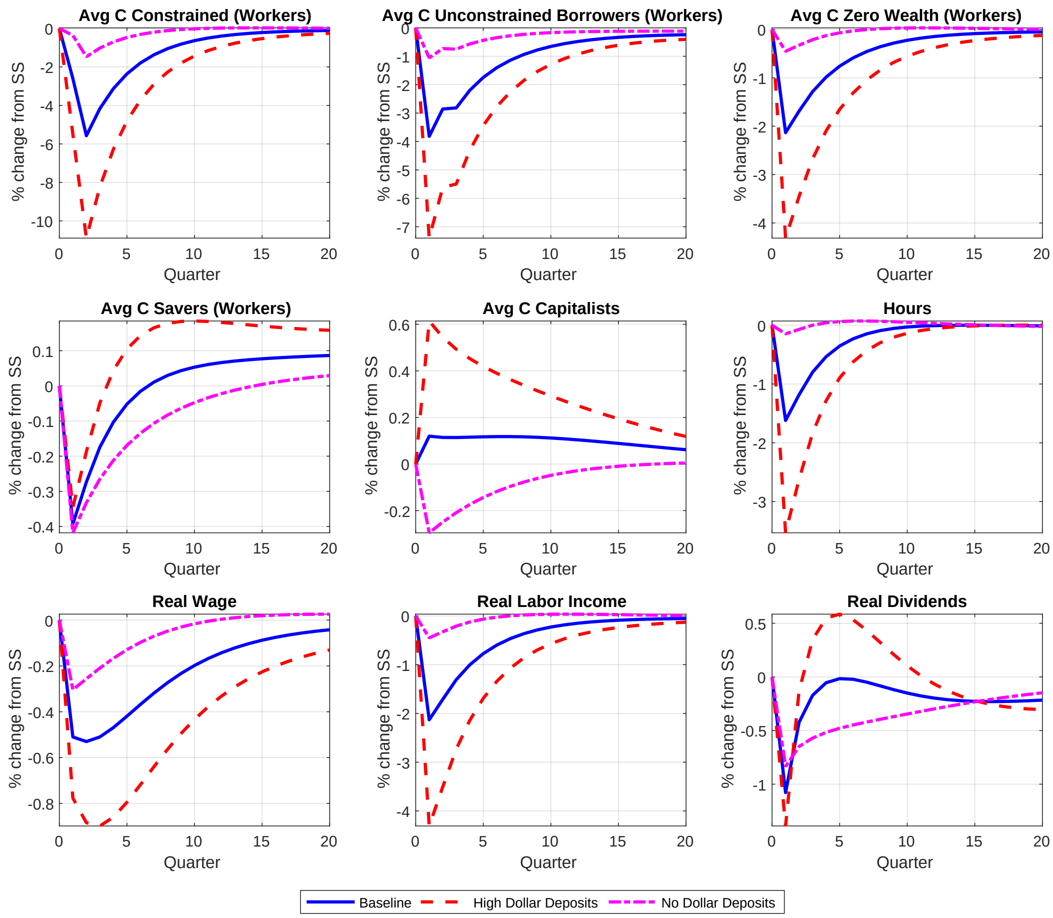

Figure 10: The Role of Households Portfolios: Consumption Dynamic

Notes: This figure shows the impulse response to a temporary rise in the foreign interest rate by 100 bps annualized in our baseline HANK model as well as the same model for different level of the dollar share in portfolios. High Dollar Deposits has an average share of 80 percent, while No Dollar Deposits has a share of zero. Avg C Constrained (Workers) denotes the average consumption decline (in percent) for borrowing constrained workers. Avg C Unconstrained (Workers) denotes the average consumption decline (in percent) for workers with negative wealth who are not at the constraint. Avg C Zero Wealth (Workers) denotes the average consumption decline (in percent) for workers with zero wealth. Avg C Savers (Workers) denotes the average consumption decline (in percent) for workers with positive wealth. Avg C Capitalists denotes the average consumption decline (in percent) for entrepreneurs.

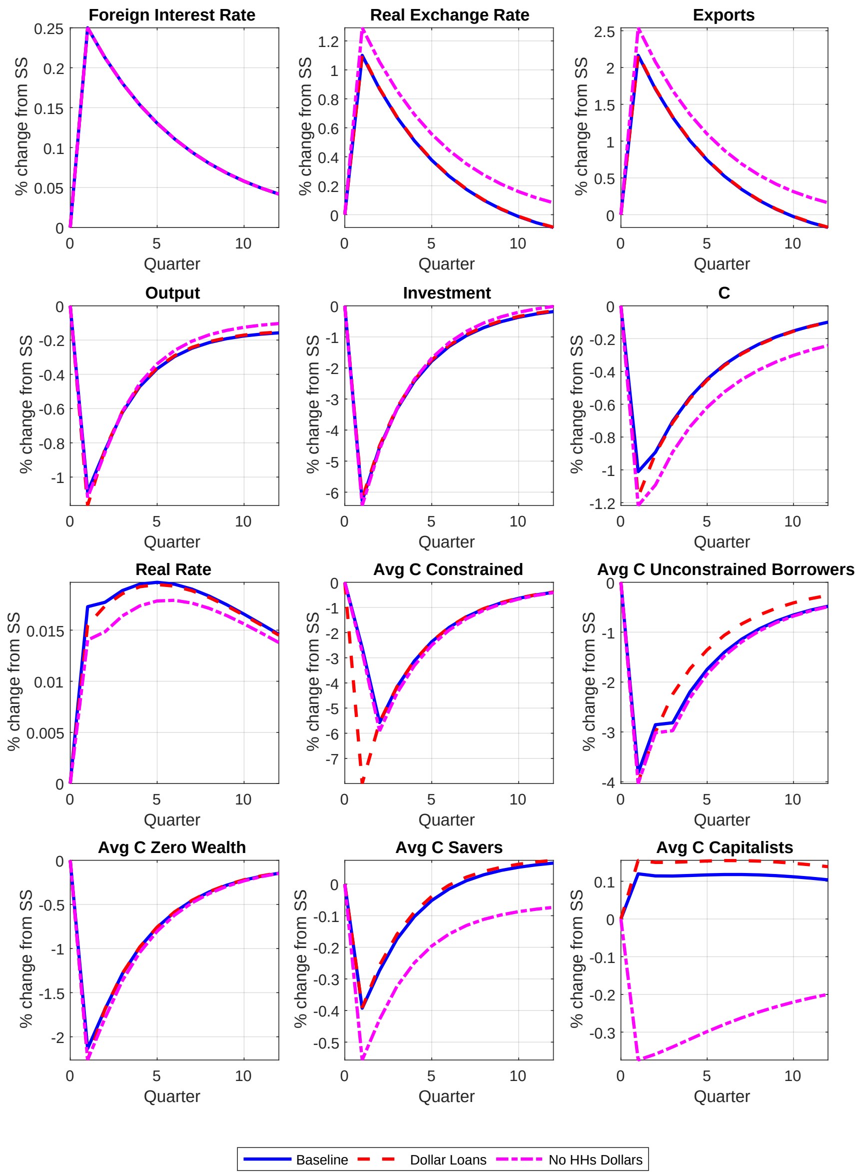

Figure 11: Alternative Households Dollar Exposures

Notes: This figure shows the impulse response to a temporary rise in the foreign interest rate by 100 bps annualized in our baseline HANK model as well as the same model for different dollarization assumptions. Dollar Loans assumes that loans to households are denoted in dollars. No HHs Dollars assumes that households hold no foreign currency deposits but banks borrow in dollar deposits from abroad. C denotes consumption. Avg C Constrained denotes the average consumption decline (in percent) for borrowing constrained workers. Avg C Unconstrained denotes the average consumption decline (in percent) for workers with negative wealth who are not at the constraint. Avg C Zero Wealth denotes the average consumption decline (in percent) for workers with zero wealth. Avg C Savers denotes the average consumption decline (in percent) for workers with positive wealth. Avg C Capitalists denotes the average consumption decline (in percent) for entrepreneurs.

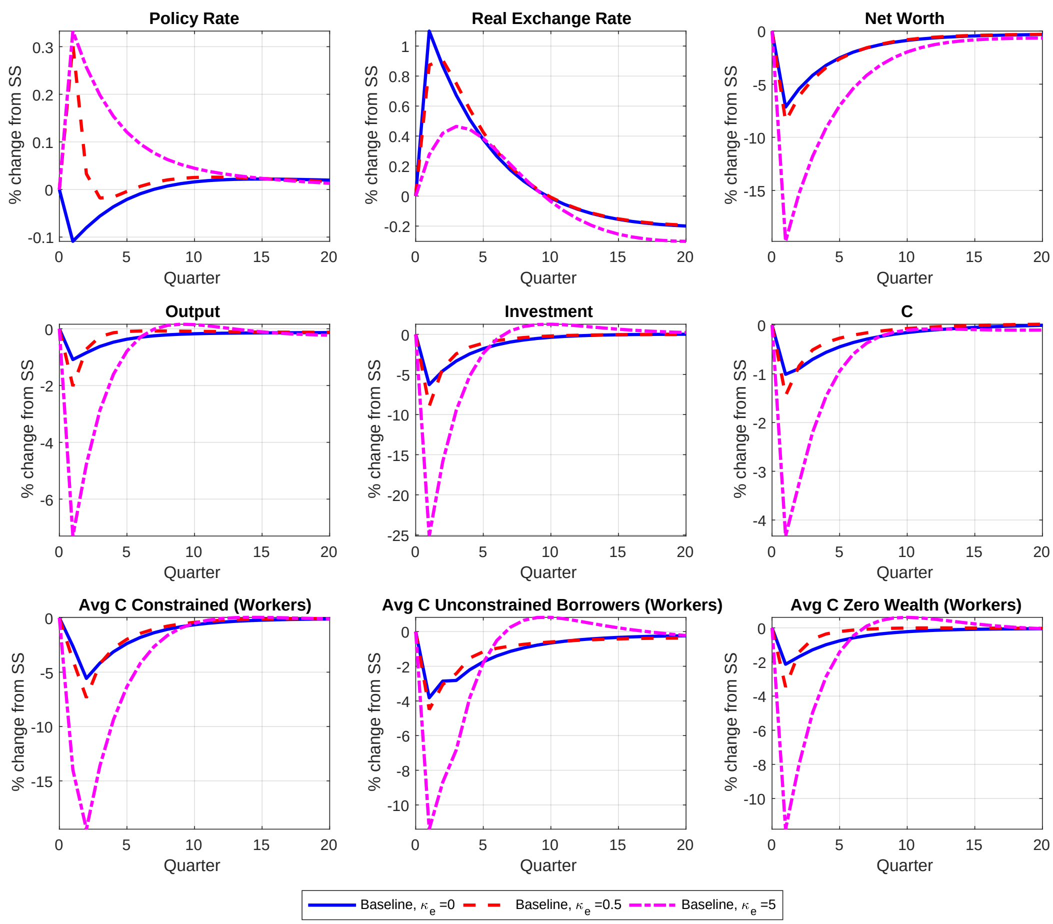

Figure 12: Exchange Rate Stabilization: Baseline Economy

Notes: This figure shows the impulse response to a temporary rise in the foreign interest rate by 100 bps annualized in our baseline HANK model as well as the same model for different responses to the growth rate of the nominal exchange rate. The figure shows the cases for κ_e 0,0.5, and 5. C denotes consumption. Avg C Constrained (Workers) denotes the average consumption decline (in percent) for borrowing constrained workers. Avg C Unconstrained (Workers) denotes the average consumption decline (in percent) for workers with negative wealth who are not at the constraint. Avg C Zero Wealth (Workers) denotes the average consumption decline (in percent) for workers with zero wealth.

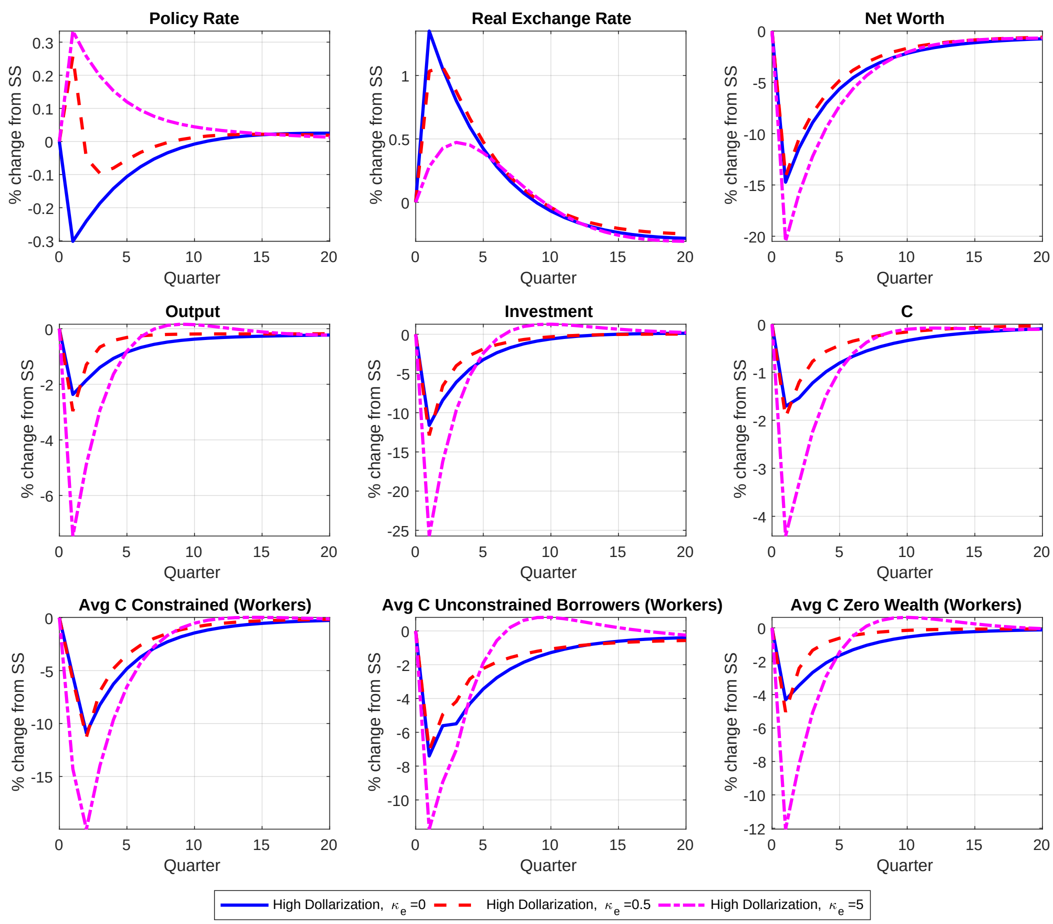

Figure 13: Exchange Rate Stabilization: High Dollarization Economy

Notes: This figure shows the impulse response to a temporary rise in the foreign interest rate by 100 bps annualized in our HANK model with an average deposit dollarization of 80 percent as well as the same model for different responses to the growth rate of the nominal exchange rate. The figure shows the cases for κ_e 0,0.5, and 5. C denotes consumption. Avg C Constrained (Workers) denotes the average consumption decline (in percent) for borrowing constrained workers. Avg C Unconstrained (Workers) denotes the average consumption decline (in percent) for workers with negative wealth who are not at the constraint. Avg C Zero Wealth (Workers) denotes the average consumption decline (in percent) for workers with zero wealth.

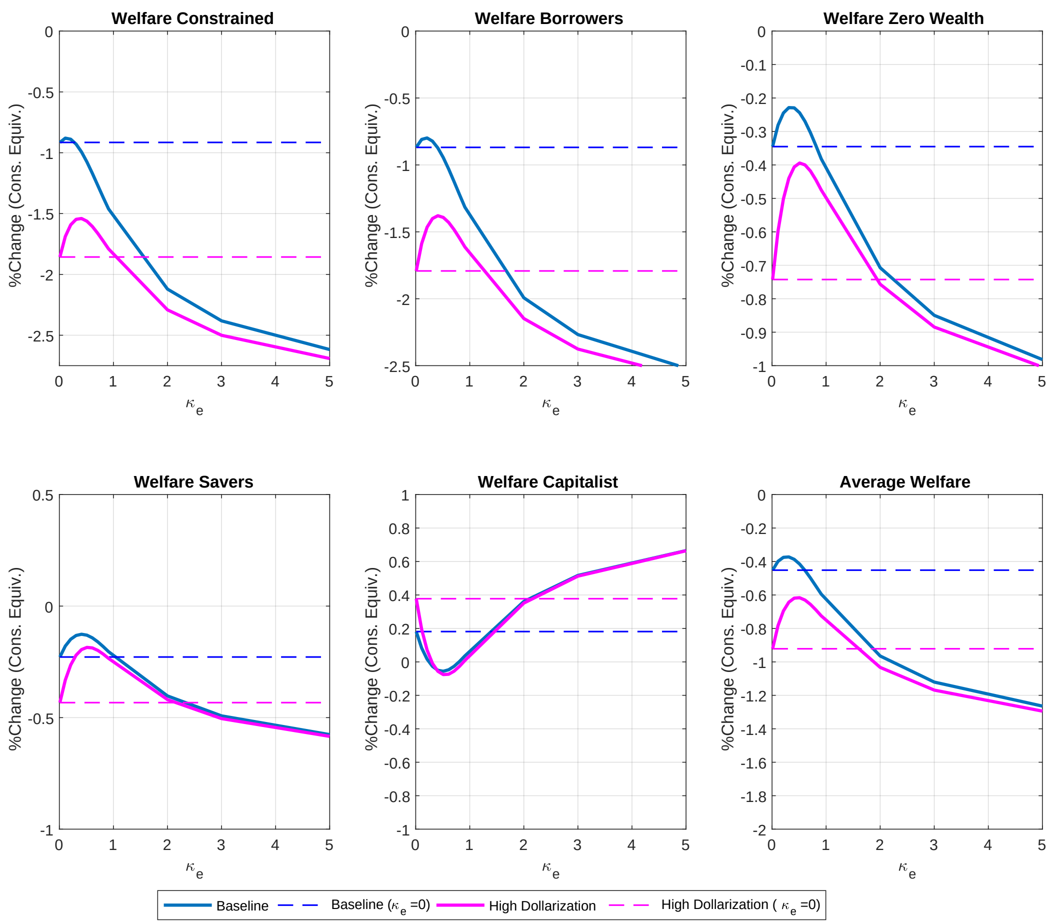

Figure 14: Exchange Rate Stabilization: Welfare 1st Order

Notes: This figure shows the consumption equivalent gain (negative numbers are losses) in percent for different groups of households after a temporary 100 bps annualized rise in the foreign interest rate for different exchange rate stabilization coefficients (κ_e) relative to steady state using a first order approximation. Welfare Constrained denotes the average gain for borrowing constrained workers. Welfare Borrowers denotes the average gain for workers with negative wealth who are not at the constraint. Welfare Zero Wealth denotes the average gain for workers with zero wealth. Welfare Savers denotes the average gain for workers with positive wealth. Welfare Capitalist denotes the average gain for entrepreneurs.

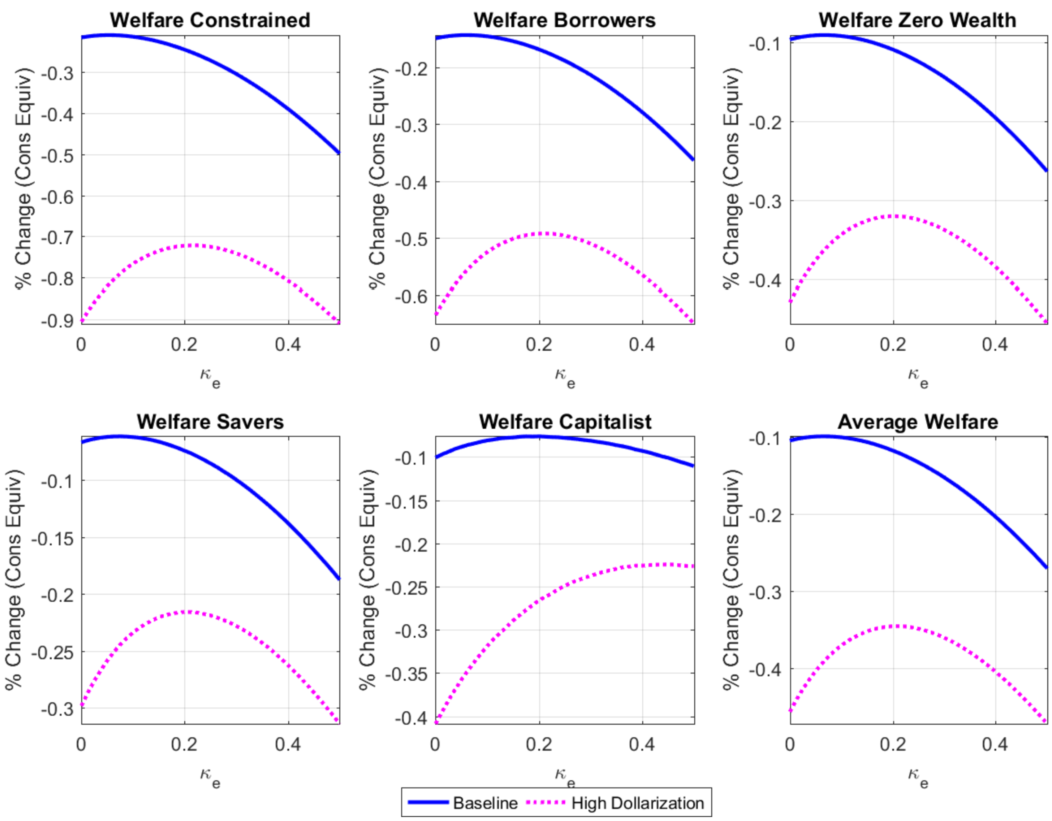

Figure 15: Exchange Rate Stabilization: Welfare 2nd Order

Notes: This figure shows the consumption equivalent gain (negative numbers are losses) in percent for different groups of households in an economy with shocks to the foreign interest rate with standard deviation 100 bps annualized for different exchange rate stabilization coefficients (κ_e) relative to steady state using a second order approximation. Welfare Constrained denotes the average gain for borrowing constrained workers. Welfare Borrowers denotes the average gain for workers with negative wealth who are not at the constraint. Welfare Zero Wealth denotes the average gain for workers with zero wealth. Welfare Savers denotes the average gain for workers with positive wealth. Welfare Capitalist denotes the average gain for entrepreneurs.

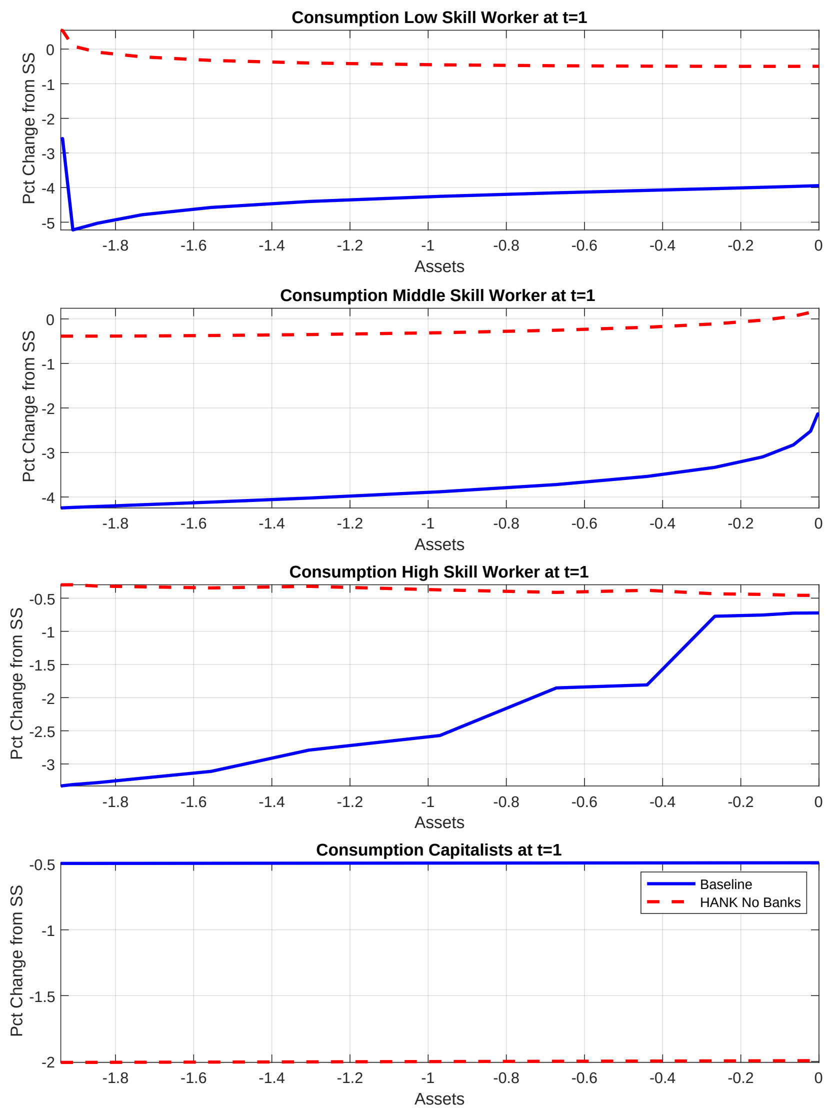

Figure A1: Cross-sectional response to interest rate shock (Borrowers)

Notes: This figure shows the consumption response for borrowers in percent deviation from steady state after a temporary 100 bps annualized rise in the foreign interest rate in the baseline model and the HANK model without Banks in the first period of the shock.

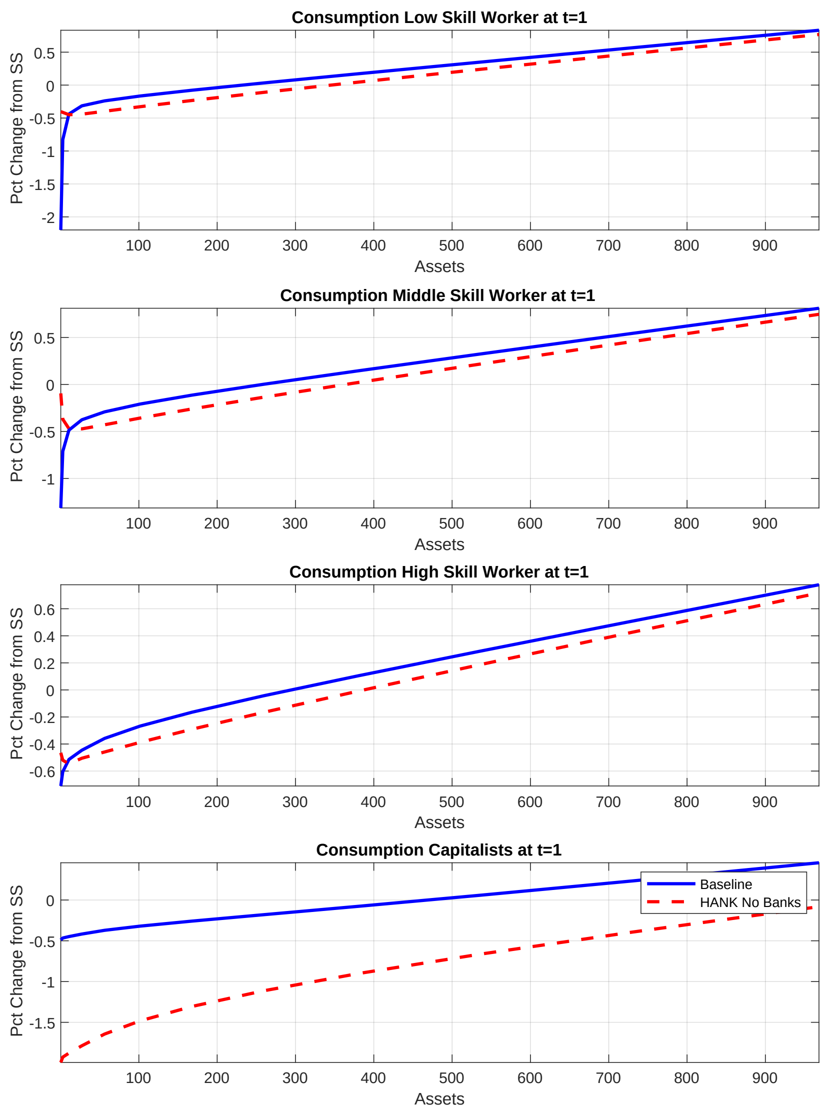

Figure A2: Cross-sectional response to interest rate shock (Savers)

Notes: This figure shows the consumption response for rich savers in percent deviation from steady state after a temporary 100 bps annualized rise in the foreign interest rate in the baseline model and the HANK model without Banks in the first period of the shock.