

Stubborn dollarization: Love for the Dollar and Fear of the Peso

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ABSTRACT

I model financial dollarization in an emerging market -the denomination of household savings and corporate debt in US dollars- as a phenomenon which arises endogenously within a country from the interaction between domestic agents. In the model, the dollar offers households and entrepreneurs a hedge against exchange rate pass-through into prices and income risk. Households have a higher risk aversion and/or stronger hedging motives for wanting to save in dollars. As a result, entrepreneurs issue debt in dollars, cheaper than in local currency, and are exposed to exchange rate risk, while households save in dollars and are insured against this risk in exchange for a lower return. Dollarization then emerges within the country from the risk-sharing of domestic agents, rather than with the developed world. A decrease in the foreign supply of dollars to the country can reinforce the hedging properties of the dollar and increase domestic dollarization. The model can rationalize four empirical facts: first, countries that exhibit high dollarization of domestic savings also exhibit high dollarization of domestic corporate debt; second, higher dollarization is related to a higher pass-through into prices; third, dollarized economies feature a negative correlation of real GDP growth and dollar appreciations; fourth, their local currencies offer a higher risk premium over the dollar. At the household-level, evidence from Uruguay is consistent with the model's portfolio predictions that indicate that an agent's dollar demand increases with a higher pass-through into prices and with a stronger negative correlation between their income and dollar appreciations.

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1 Introduction

Since the end of the Bretton Woods system, emerging market economies have struggled with two questions: whether and how to allow the use of the US dollar as a *de facto* second currency¹ in a context in which households persistently turn to this currency for saving; and the extent to which they should be open to external capital flows. Financial dollarization is generally perceived negatively because it induces a currency mismatch in the portfolio of banks that receive dollar deposits but hold peso assets, or of firms that issue dollar debt but perceive a peso revenue. A large dollar appreciation can therefore trigger solvency issues for these agents. Capital controls are commonly advocated to reduce the volatility of the exchange rate caused by fluctuations in foreign flows of capital (Gabaix and Maggiori 2015) and to help prevent *sudden stops* (sharp reversals in capital inflows) that might induce large dollar appreciations.

In this paper I first explore the reasons behind the dollarization of household portfolios, which which is the counterpart of corporate dollar debt. In a context in which the US dollar dominates international trade and finance (Iltetzki et al 2019), there has been a resurgence of dollar debt financing by firms and it is domestic households who provide much of this financing. I identify different hedging motives for saving in dollars based on the behavior of the exchange rate vis-à-vis prices and income processes: the dollar is a natural hedge against consumption risk due to dollar currency pricing (Gopinath et al 2020) and it also provides insurance against the dual occurrence of financial and currency crises that is typical of these economies (Bocola and Lorenzoni 2020). When they save in dollars, local currency depreciations induce a domestic wealth transfer from firms to households. I also show how, in equilibrium, dollarization can take place in a country even when (and especially when) capital controls are introduced. Capital controls affect the incentives that households have for saving in dollars and, from this perspective, may lessen the problem of “stubborn dollarization”. On the other hand, when risk-sharing with the rest of the world is restricted, dollarization within countries emerges as an escape valve for domestic agents that seek the dollar.

I characterize net dollar positions as closed form expressions in a simple two-period portfolio problem that accounts for uncovered interest parity (UIP) deviations and hedging reasons that make the dollar an attractive currency for saving. Building from this portfolio choice, I present a tractable discrete time general equilibrium model that rationalizes both the dollar positions of households and firms in emerging market countries, as well as the risk premium of the local currency. The resulting equilibrium has the following implication: the UIP deviation emerges in favor of a higher local currency return when the agents’ aggregate hedging motives for saving in dollars exceed the

¹De facto dollarization refers to the use of a foreign currency, alongside the domestic currency, as a means of exchange (for transaction purposes, i.e., as currency substitution) or as a means of saving (i.e., asset substitution). My focus is on the latter.

net foreign liability position of the host country in dollars. Two mechanisms explain why firms insure the households by borrowing the dollars that the households save in. On the one hand, both agents are exposed to exchange rate risk that dollar savings can hedge against, but the firms have a higher tolerance for risk (this is the “risk-aversion” channel). On the other hand, households are more negatively exposed to exchange rate risk than firms (this is the “risk-exposure” channel). Both channels can result in firms taking the short position in dollars and households the long position.

The model can microfound several stylized empirical facts observed in the dollarization literature (Reinhart et al 2014, Rennhack and Nozaki 2006, Ize and Levy-Yeyati 2003). First, there is a very strong correlation between household dollar savings and corporate dollar debt. Second, countries that exhibit a higher pass-through of exchange rate depreciations into consumer prices have higher dollarization. Third, there is a negative correlation between real GDP growth and dollar appreciation in all countries that exhibit dollarization. Fourth, in dollarized economies the local currency offers higher average returns relative to the dollar, and this deviation from UIP is larger for the more dollarized countries.

Moreover, I explore the implications on dollarization and UIP deviations from introducing capital controls that limit the inflows of dollars into the country and I rationalize why these policies can endogenously lead to increased dollar debt of the corporate sector. When the supply of dollars from foreign investors decreases, the variance of the exchange rate and UIP is reduced and this increases the hedging motives that the agents have for wanting to save in dollars. In equilibrium, this results in larger UIP deviations and increases dollarization within the country. While the net aggregate dollar position of the country is reduced, the individual dollar positions increase, with households saving more in dollars and firms taking more dollar debt.

Finally, I take the predictions to the data. To this end, I derive a continuous-time version of the portfolio model to derive an expression for dollar demand as a function of sufficient statistics which have clearly measurable analogues, such as the extent to which the household’s consumption basket is priced in dollars. Calibrating this to country-level moments can explain why dollarization is more prevalent in certain countries, such as Peru or Paraguay, and less in Chile or Mexico. The attractiveness of the dollar as a safeguard against income shocks emerges as the main driver behind the cross-sectional macro patterns of dollarization. At the micro-level, I use household-level data from a Uruguay financial survey and find that the pass-through of exchange rate into prices and into wages affects the decision to dollarize in the way the model predicts. Notably, these predictions imply levels of risk aversion for these countries that are consistent with the standard macro estimates.

Related Literature This research relates to several strands of the literature. Recently, there has been a resurgence in studies on financial dollarization from a portfolio perspective. This paper is most closely related to Bocola and Lorenzoni (2020) and Dalgic (2018) who explore the interactions between domestic savers and borrowers of dollars in a general equilibrium setting that features dual currency and financial crises. They endogenize this correlation by introducing financial constraints that generate a balance sheet channel of currency depreciations: capital investors with net dollar liabilities see their net worth decline and face borrowing limits as a consequence. The negative correlation between income and exchange rate depreciations incentivizes agents to save in dollars as an insurance mechanism, and risk neutral borrowers are willing to provide this insurance in exchange for a cheaper form of debt. A distinctive feature of my paper is the modeling of dollar borrowers as risk averse entrepreneurs that own firms and have lower risk aversion than households. The mechanisms that lead to an equilibrium with dollarization and UIP deviations relate to differences in risk aversion and in the agents' exposure to risk with regard to consumption and income (Athanasoulis and Shiller 2001). In line with Gopinath and Stein (2018) who explore the complementarity between dollar invoicing and financial dollarization, I account for the impact of dollar pricing on both households' and firms' portfolio choices. Other related work that precedes my paper in studying portfolio construction with respect to currencies is Campbell et al (2003).

Recent papers have addressed the cross-section of liability dollarization in the corporate sector of emerging markets. Salomao and Varela (2018) endogenize the currency composition of debt for firms that are not naturally hedged against currency risk and thus are exposed to exchange rate volatility that feeds into default probabilities via balance sheet effects. More productive firms with a high return to investment are the ones that borrow more heavily in dollars and they test this prediction using Hungarian data. From an empirical perspective, Gutierrez et al (2020) and Brauning and Ivashina (2019) show that exporting firms borrow more heavily in dollars than non-exporting firms but liability dollarization is prevalent in both the tradable and non-tradable sectors. In line with this observation, I show evidence that exporting firms have larger negative net dollar positions than non-exporting firms in a set of Latin American countries. My model can speak to the net position of both types and rationalize an equilibrium in which the corporate sector borrows in dollars.

In close connection to the literature that studies the exposure to currency risk from balance sheet effects are papers that look at the role of government interventions to protect economies from depreciation shocks. Gabaix and Maggiori (2015) suggest a theory of exchange rate determination based on capital flows that alter financiers' balance sheets and study the effects of FX intervention and capital controls on exchange rates in this framework. In my model, capital controls affect the volatility of the exchange rate while still allowing for a dollarized equilibrium within the country that features UIP deviations, as entrepreneurs are willing to ensure households against negative currency shocks by taking the negative net dollar position in exchange for a risk premia (a cheaper

dollar). This occurs in a context in which banking regulations that limit the currency exposure of banks, have firms playing the role of the financiers when international risk-sharing is restricted. This observation is in line with the finding by Keller (2018) that Peruvian banks who need to comply with the regulations but are unable to hedge their currency risk with foreign investors end up increasing their dollar lending to firms.

The rest of the paper is organized as follows. Section 2 documents a set of facts that highlight drivers of financial dollarization in emerging markets and its heterogeneous pattern across countries. Section 3 brings them together in a simple two-period model that features heterogeneous agents, microfound their dollar demand and discusses the conditions under which dollarization can arise in general equilibrium. Section 4 builds a continuous-time portfolio model à la Merton to microfound the net currency position of a household and an entrepreneur in closed-form expressions that are functions of sufficient statistics that one can take to the data. Section 5 contrasts the predictions from this model using country-level data for a cross-section of Latin American countries and household-level data from Uruguay. Finally, Section 6 concludes.

2 Financial dollarization in emerging markets: empirical facts

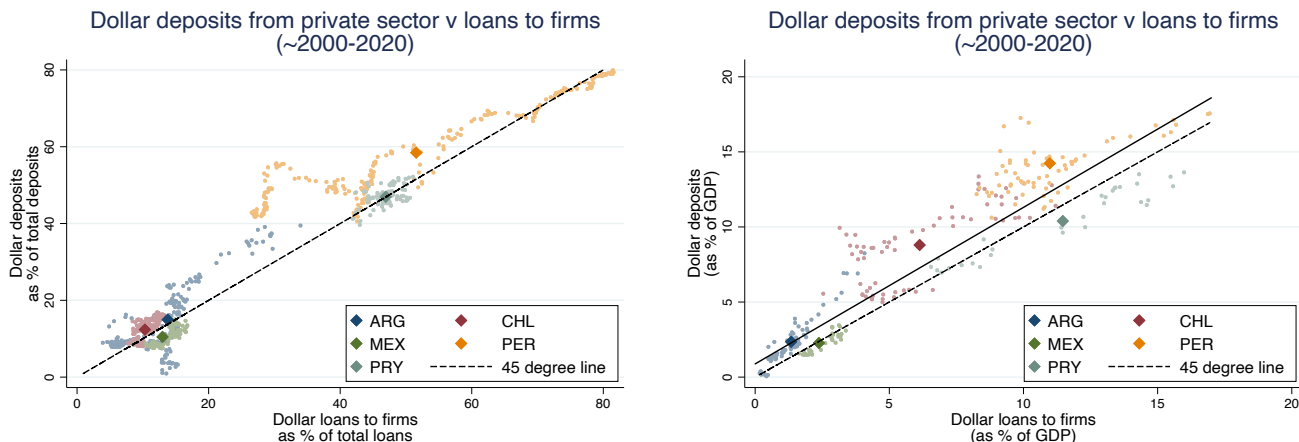
There are two ways in which financial dollarization tends to manifest in emerging countries: households save in dollars and firms borrow in dollars. In many of these economies, households have access to domestic bank accounts which can be denominated in the US currency. These accounts offer rates that are much lower than the interest from local currency denominated accounts. Several papers have documented the pervasiveness of this form of financial dollarization in countries where the dollar is regarded as a safe currency that can preserve the real value of savings amidst episodes of exchange rate depreciation (De Nicolo et al 2003, Reinhart et al 2014). On the other hand, increasing attention has been paid to the rising shares (and levels) of corporate dollar debt (Bruno and Shin 2015, McCauley et al 2015). Low nominal lending rates in the US dollar compared to the local currency, particularly since the GFC, has seen many firms take advantage of this cheaper form of borrowing.

While these facts are not new to this type of economy (the early literature on financial dollarization dates back to the 1980s), only a couple of recent studies (Gopinath and Stein 2018, Dalgic 2018, Bocola and Lorenzoni 2020) have looked at the interaction that takes place within a country between dollar savings by households and dollar borrowing by firms. Instead, most of the literature has focused on the risk-sharing that takes place between a representative agent and foreign investors, where international markets supply or demand dollars as needed (Maggiore 2017, Du and Schreger 2017). Yet evidence shows that the following fact is true of emerging economies:

Fact 1 There exists a very strong correlation between *domestic* supply of dollars by households and demand of dollars by firms, where banks located within each country act as intermediaries.

Figure 1 summarizes this empirical finding for five countries of Latin America. I gather monthly aggregate data on dollar deposits and loans from local financial institutions spanning the past two decades. Within this sample, countries like Chile and Mexico have historically exhibited lower levels of dollarization, while countries like Peru and Paraguay have had an average dollarization of more than 50%. Notably, dollarization of domestic deposits and corporate loans correlate strongly, both on average throughout this period and over time within each country (left panel). The empirical pattern on the cross-section of emerging countries was already recognized at the start of the century by Ize and Levy Yeyati (2003) and has more recently regained attention in the international literature (Dalgic 2018 and Bocola and Lorenzoni 2020). The correlation persists when looking at the *levels* of dollar deposits and loans as a share of GDP, while ignoring the quantity of domestic-currency deposits and loans (right panel).

Figure 1: Dollarization of deposits and corporate loans



Note: Small markers are monthly observations on aggregate deposits and loans by the private sector, obtained from the consolidated balance sheet of the domestic banking sector reported by the Central Banks of each country. For deposits, I consider banks’ liabilities with households whenever reported, or with the (resident) private sector otherwise. For corporate loans, I consider banks’ assets held against the (resident) private sector; the data disaggregates loans by type rather than borrower, so I aggregate the categories that are typically related to corporate borrowing and exclude credit for consumption and mortgages. When countries report a quantity in “foreign currency”, I assume this is mostly the US dollar. The bigger diamond markers are averages for each country over the sample period.

This observation is reminiscent of the Feldstein-Horioka (1980) puzzle: just as domestic savings matter for domestic investment, dollar deposits by households seem to fuel the dollar loans that local banks extend to firms. However, rather than a puzzle, this is a consequence of institutional regulations that require banks to match their dollar liabilities with dollar assets, coupled with capital controls that prevent them from transacting dollars in the international markets. Such regulations were instituted following the financial crises in the 90’s that saw the banking system suffer from exchange rate exposure due to large currency mismatches in their balance sheet. Banks cannot rely substantially on the international markets to comply with this regulation, as evidenced by the fact that, for the median country, 72% of dollar liabilities are sourced from domestic deposits² (see Figure 8 in the Appendix). On the one hand, the use of derivatives to hedge against exchange rate risk is limited in these countries given that such secondary markets are poorly developed. For example, Gutierrez et al (2020) find that there is limited hedging of exchange rate exposure by Peruvian banks. On the other hand, capital controls play a role in limiting the amount of international risk-sharing that could take place in the context of these regulations, as impaired banks seek to match households’ dollar deposits by extending cheaper dollar loans to firms within the country. Keller (2018) provides empirical evidence that capital controls in Peru induce dollar

²One caveat: some countries do not distinguish between domestic deposits held by residents v non-residents. I assume that the bulk of dollar deposits in these banks is made by nationals.

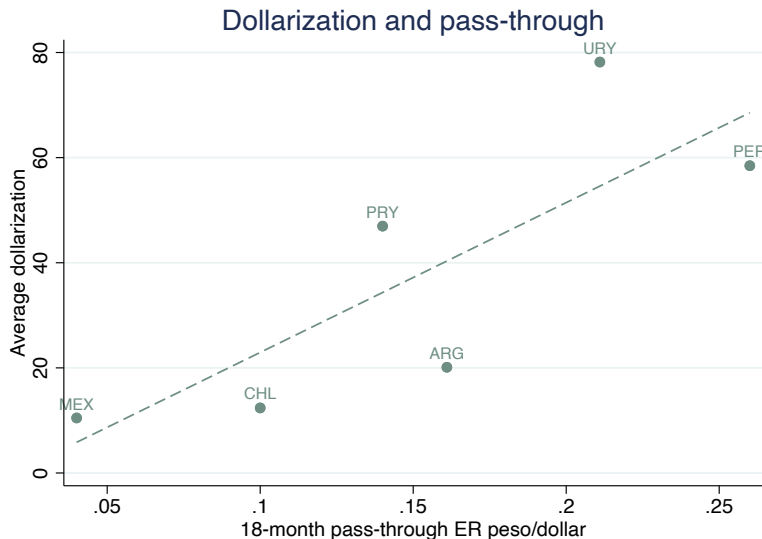
lending of banks to firms.

Moreover, capital controls can also play a role in limiting the amount of risk-sharing with foreign investors that households and firms can undertake themselves, by-passing local banks. Evidence based on country-level data gathered from the Central Banks and the BIS suggests that the share of dollar loans taken by firms from local banks is more than 50% of total dollar corporate borrowing in these economies (see Figure 9 in the Appendix). Likewise, similar data sources indicate that households' dollar deposits within their countries predominate over those held at foreign institutions (Figure 10 in the Appendix).

In light of this evidence, I study the conditions under which dollarization of both savings by households and of corporate debt can arise as a *domestic* equilibrium within a country. In my model, firms are modeled as risk-averse entrepreneurs that, like the households, have consumption preferences and make portfolio currency choices. This is meant to reflect the fact that many small and medium-sized firms in emerging markets are family-owned enterprises, and it stands in contrast to the other recent papers in the literature, Bocola and Lorenzoni (2020) and Dalgic (2018). My starting point is the modeling of a portfolio choice of households and entrepreneurs that is able to capture two key hedging properties of the dollar in emerging countries: it provides insurance against pass-through of dollar appreciations into consumer prices, as well as against negative income shocks. These properties are reflected in the following two facts:

Fact 2 Countries that exhibit a higher pass-through of exchange rate depreciation into consumer prices have higher average dollarization (Figure 2).

Figure 2: Pass-through and dollarization



Note: Exchange rate pass-through into prices is computed using monthly CPI data and regressing monthly inflation against monthly depreciations with 18 lags. Average dollarization is the mean of % dollar deposits over the entire two-decade period. CPI data is sourced from the Central Banks; series of exchange rates against the dollar are obtained from the IFS.

Fact 3 Bad times in these dollarized countries are times when the local currency depreciates, as evidenced by a negative correlation between real GDP growth and dollar appreciation. (Table 1).

Table 1: Correlation (real) GDP annual growth and % Δ ER

Country	ARG	CHL	MEX	PER	PAR	URY
$corr(\% \Delta Y, \% \Delta ER)$	-0.545	-0.421	-0.075	-0.171	-0.59	-0.544

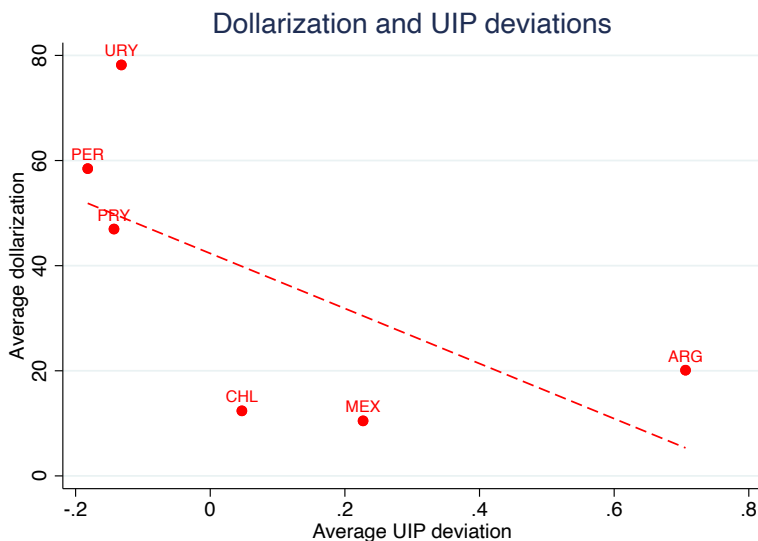
Note: based on IFS data on exchange rates against the US dollar, and real GDP; author's calculations.

While these empirical observations are not new to the literature, I obtain an expression for the optimal dollar demand of an agent that is able to incorporate and clearly highlight both hedging properties. How these differ between households and entrepreneurs is what determines, in combination with their tolerance for risk, that an equilibrium can arise in which households pay an opportunity cost for saving in the currency that offers the lower return (the dollar) in exchange for insurance against exchange rate risk, while firms remain exposed to inflation and income risk in exchange for a cheaper form of debt. Notably, both agents would rather save in local currency if they only cared about expected returns, given the risk premium that it offers relative to the dollar. In this sense, a higher average return of the local currency would lead to lower dollarization. However, in equilibrium, the difference in exposure to exchange rate risk (that the dollar can

insure against) and in risk tolerance between the two types of agents, is what explains the third, and rather counterintuitive, fact:

Fact 4 Countries that exhibit higher dollarization are also the countries in which the peso offers a higher risk premium (Figure 3).

Figure 3: UIP deviations and dollarization



Note: Data on interest rates for local currency and foreign currency deposits is from the IFS. Average UIP deviations are computed using monthly data and averaging monthly deviations over the two-decade period. A positive value indicates that the mean average return of the dollar (interest plus depreciation of the local currency against the dollar) is higher than the return of the local currency. Average dollarization is the mean of % dollar deposits.

This observation was recently noted by Bocola and Lorenzoni (2020) and it can only be rationalized in general equilibrium. In my model, I derive simple conditions that, intuitively, indicate that the local currency will offer a higher risk premium and dollarization will be higher when 1) aggregate hedging motives for wanting to save in dollars exceed the foreign supply of dollars; and 2) households feature a stronger preference for dollars compared to entrepreneurs, and a higher risk aversion.

In the next section, I develop a two-period general equilibrium model in a small open economy that features the two types of agents, representing households and firms, that interact with one another in the domestic financial market for dollar bonds. The starting point of this model is the portfolio choice that captures the driving forces of dollarization implied by the empirical evidence: UIP deviations, pass-through into prices and income correlations with exchange rate depreciations. Building from this microfoundation, a general equilibrium model is required to

understand 1) what mechanisms are behind the larger average returns of the local currency, with households taking the positive position in dollars and firms the negative one, and 2) what the effects are from introducing capital controls that limit the amount of risk-sharing that the agents can undertake with the rest of the world. In a world of capital controls, dollarization within the country substitutes for international risk-sharing.

3 Dollarization in general equilibrium: a two-period model

To understand how financial portfolio decisions of the private sector can generate the UIP deviations and the levels of dollarization that we observe in the data, I set up a simple two-period heterogeneous-agent model in a small open economy. A household and an entrepreneur differ in their risk preferences and sources of income: the household is more risk averse than the entrepreneur and each receives a different endowment of non-tradable and tradable goods³. The endowment processes feature distinct (productivity) shocks. I search for an equilibrium in which households lend to entrepreneurs in dollars and the local currency features a risk premium over the dollar. Because of this higher return offered by the local currency, households are incurring an opportunity cost from saving in dollars. They are willing to do this in exchange for insurance against times when the local currency depreciates and they experience a negative income shock as well as higher consumption prices. I propose two conditions under which entrepreneurs are willing to provide this insurance:

1. Entrepreneurs have a lower risk aversion than households. Agents that are subject to the same negative correlation between their income and depreciations of the exchange rate, and the same pass-through into their consumption prices, would engage in this arrangement if one type (entrepreneur) is less risk averse than the other (household).
2. Entrepreneurs have less risk exposure to exchange rate depreciations than households. This can come about if entrepreneurs perceive an income which correlates positively with the dollar -for instance, from owning a firm that sells tradable goods priced in dollars-, which generates different needs to hedge dollar risk in their portfolios compared to households. Even if the agents have identical risk preferences, they can still increase their utility by engaging in this insurance scheme.

Setup There are two types of representative agents, the household and the entrepreneur, and two periods.

³In this model, an entrepreneur is a type of household that features lower risk aversion and an income process that correlates either positively with the dollar, or at least not as negatively as the household's income. This reflects the reality of many emerging markets in which small and medium firms are owned by wealthier households with a higher tolerance for risk, and the fact that in a world of dollar pricing, many of these perceive a dollar revenue.

In period $t = 0$, the agents, who are born with some level of wealth W_0^i (nominal, in pesos), invest in dollar and in peso-denominated bonds, where peso bonds are in zero net supply while dollar bonds exist in positive net supply b_1^* that is provided (exogenously) by foreign investors⁴. They invest in order to maximize utility from consumption in period $t = 1$. There are three types of consumption goods: a non-tradable home good is the numeraire, a tradable home good has (stochastic) price p_1^H and a tradable foreign good has (stochastic) price $\epsilon_1 p_1^F$. Units of home non-tradable represent “pesos” and units of foreign non-tradable are “dollars”. The exchange rate converts dollars into pesos, so an increase in ϵ_1 is a depreciation of the local currency. The household receives in period $t = 1$ a (stochastic) endowment y_1^h of domestic goods, while the entrepreneur receives a (stochastic) endowment y_1^e . Uncertainty at $t = 0$ comes about from the unknown realization at $t = 1$ of these exogenous endowments.

The agents have mean-variance preferences⁵ so the period $t = 0$ portfolio problem is:

$$\max_{c_1^i(s) \forall s, \theta^{i, \$}} E_0[c_1^i] - \frac{\gamma^i}{2} Var_0[c_1^i] \quad (1)$$

$$c_1^i(s) = (R_{real}^{LC}(s) + \theta^{\$}(R_{real}^{\$}(s) - R_{real}^{LC}(s))) \frac{W_0^i}{P_0} + y_1^i(s) \quad \forall s, \quad (2)$$

where $\theta^{i, \$}$ is the share of real wealth from period $t = 0$ that is allocated to dollar bonds. The general price level, P_t , expressed in pesos, is defined as the price of one unit of aggregate consumption $c_1 = c_1^h + c_1^e$. The real interest rate (i.e., in terms of the consumption basket) for the peso bond is $R_{real}^{LC} \equiv \frac{P_0}{P_1} \frac{1}{q_0^{LC}}$ and for the dollar bond, $R_{real}^{\$} \equiv \frac{P_0}{P_1} \frac{\epsilon_1}{\epsilon_0 q_0^{\$}}$. Note that in period $t = 0$, the price of the bonds q_0^{LC} and $q_0^{\$}$ is given, while the exchange rate and the price level in period $t = 1$ are uncertain. Agent i 's real income, which depends on the share $\nu^{i,j}(\cdot)$ that she receives from the endowment of good j , is:

$$y_1^i(s) \equiv \frac{\nu_1^{i, NT}(s) y_1^{i, NT}(s) + p_1^H(s) \nu_1^{i, H}(s) y_1^{i, H}(s)}{P_1(s)} \quad (3)$$

I assume Cobb-Douglas aggregation of consumption where δ is the share spent on home non-tradables and α is the share of tradable expenditure allocated to home goods:

⁴This assumption can be relaxed, but it is meant to capture the fact that foreign investors generally hold dollar debt and savings, but are less willing to trade peso-denominated instruments. A positive supply of dollars to the country reflects the net dollar savings (net foreign asset position) that the private sector of emerging markets holds in international markets.

⁵The assumption of mean-variance preferences makes it possible to derive closed-form expressions that are the discrete time analogous to the continuous-time formulas that are presented in Section 4.

$$c_1^i = (c_1^{i,NT})^\delta \left((c_1^{i,H})^\alpha (c_1^{i,F})^{1-\alpha} \right)^{1-\delta} \quad (4)$$

Market clearing There are three markets, one for each type of consumption good, that need to be cleared in period $t = 1$. In the market for home tradable goods, $c_1^{H,*}$ represents exports of the home country and, in the market for foreign tradables, $y_1^F - c_1^{F,*}$ are imports. The country's trade balance is defined by:

$$NX_1 \equiv p_1^H c_1^{H,*} - \epsilon_1 p_1^F (y_1^F - c_1^{F,*}) = \underbrace{-\epsilon_1 b_1^*}_{\Delta NFA}, \quad (5)$$

where b_1^* captures foreign holdings of dollar bonds⁶. There are two financial markets to be cleared in period 0: the peso-bond market clears within the small open economy while dollar bonds can be traded in international markets:

$$\frac{(1 - \theta^{s,h})W_0^h}{q_0^{LC}} + \frac{(1 - \theta^{s,e})W_0^e}{q_0^{LC}} = 0 \quad (6)$$

$$\frac{\theta^{s,h}W_0^h}{\epsilon_0 q_0^\$} + \frac{\theta^{s,e}W_0^e}{\epsilon_0 q_0^\$} = b_1^* \quad (7)$$

Unless otherwise stated, I assume that the agents have positive wealth to invest in period $t = 0$. Note that, since aggregate wealth (net savings from period $t = 0$) is equal to the peso value of net dollar assets from abroad $\epsilon_0 q_0^\$ b_1^*$, this is equivalent to assuming that the foreign supply of dollars b_1^* is positive⁷. In other words, a hypothetical trade balance from period $t = 0$ is positive and thus the private sector of this country is a net creditor to the rest of the world, so foreign investors supply dollars for local agents to save in. In period $t = 1$ a negative trade balance can be financed with these savings from period $t = 0$.

⁶The current account (net exports plus interest on foreign asset position) equals the change in net foreign assets: a current account surplus is associated to an outflow of capital and a corresponding increase in the country's net foreign asset position. A more familiar notation using interest rates is: $NX_1 = \frac{1}{1+i_1^\$} \underbrace{(b_2^* - b_1^*)}_{\Delta NFA} - \frac{i_1^\$}{1+i_1^\$} b_1^*$. So:

$(1 + i_1^\$)NX_1 + i_1^\$ b_1^* = \underbrace{(b_2^* - b_1^*)}_{\Delta NFA}$. Since $b_2^* = 0$, this simplifies to $NX_1 = -b_1^*$. In period 1, a negative trade balance is financed with the net savings from period 0.

⁷While this is not a necessary assumption (in continuous time we require wealth to be positive but not so in discrete time), I will be working within this framework to illustrate what leads to dollarization and UIP deviations in favor of the local currency in general equilibrium, and how capital controls that limit the outflow of dollars (in this model, the net foreign asset position of period $t = 0$) can induce higher levels of dollarization within the country.

Finally, foreign consumption demands are also derived from Cobb-Douglas preferences:

$$c_1^* = (c_1^{NT,*})^{\delta^*} \left((c_1^{H,*})^{\alpha^*} (c_1^{F,*})^{1-\alpha^*} \right)^{1-\delta^*} \quad (8)$$

Foreign consumers optimally distribute their net income in period $t = 1$, expressed in dollars, into the three available goods, a foreign non-tradable and two tradable ones. This income is given by:

$$P_1^* c_1^* = y_1^{NT,*} + p_1^F y_1^{F,*} - b_1^* \quad (9)$$

Equilibrium The following definition describes the conditions that an equilibrium must satisfy.

Definition 1 *An equilibrium is given by bond prices q_0^{LC} and $q_0^{\$}$, consumption prices p_1^H and ϵ_1 , asset choices $\theta^{\$,i}$, $W_0^{\$}$, and consumption $c_1^{NT,i}$, $c_1^{H,i}$, $c_1^{F,i}$, where $i \in \{h, e\}$, such that:*

1. *Agents maximize utility through optimal consumption and portfolio choices*
2. *Markets for bonds and consumption goods clear*

Solution The solution to the period $t = 0$ maximization problem 1 yields the following proposition.

Proposition 1 *The optimal real wealth allocated to dollars in period $t = 0$ by agent i is:*

$$\theta^{i,\$} \frac{W_0^i}{P_0} = \frac{1}{\gamma^i} \underbrace{\frac{E_0 [R_{real}^{\$} - R_{real}^{LC}]}{Var_0 [R_{real}^{\$} - R_{real}^{LC}]}_{\equiv \kappa_{UIP}} + \frac{W_0^i}{P_0} \underbrace{\frac{Cov_0 [R_{real}^{LC}, R_{real}^{LC} - R_{real}^{\$}]}{Var_0 [R_{real}^{\$} - R_{real}^{LC}]}_{\equiv \kappa_{price}} + \underbrace{\frac{Cov_0 [R_{real}^{LC} - R_{real}^{\$}, y_1^i]}{Var_0 [R_{real}^{\$} - R_{real}^{LC}]}_{\equiv \kappa_{income}^i} \quad (10)$$

The first term in 10 is a linear function of (real) UIP deviations. When the peso offers a risk premium over the dollar, this term is negative and drives dollarization down. How sensitive an agent is to higher returns from the local currency depends on her risk aversion and the volatility of the returns. The second and third terms capture hedging motives for saving in dollars. First, the dollar is a good hedge against exchange rate depreciations that pass-through into prices since dollar savings appreciate together with the exchange rate to counteract the inflationary force. Second, it is also a hedge against bad times of low income whenever these are negatively correlated to the real returns of the dollar bond. I will refer to κ_{price} and κ_{income}^i as the price-level and income hedging terms, respectively. When these hedging terms are positive and large, demand for dollars increases. Superscript i indicates which terms are agent-specific; in particular, I assume that agents share

⁸An alternative would be to reformulate the agent's problem in terms of $b_1^{LC,i}$ and $b_1^{\$,i}$.

the same consumption preferences so they have an identical price-hedging motive⁹.

It is useful to verify what the optimal dollar demand $\theta^{i,\$}$ simplifies to when the agent only consumes home non-tradable and when she only consumes foreign tradable, to illustrate how the optimal allocation into dollar bonds depends on the joint distribution of the price level P_1 , the exchange rate ϵ_1 and the agent's income y_1^i . From the intratemporal consumption problem of period $t = 1$, one obtains standard Marshallian demands:

$$c_1^{i,NT} = \delta P_1 c_1^i \quad (11)$$

$$c_1^{i,H} = \frac{(1 - \delta)\alpha P_1 c_1^i}{p_1^H} \quad (12)$$

$$c_1^{i,F} = \frac{(1 - \delta)(1 - \alpha)P_1 c_1^i}{\epsilon_1 p_1^F} \quad (13)$$

Given that the agents have the same preferences for home and foreign goods, the price level is:

$$P_1 = \left(\frac{1}{\delta}\right)^\delta \left(\frac{\left(\frac{p_1^H}{\alpha}\right)^\alpha \left(\frac{\epsilon_1 p_1^F}{1 - \alpha}\right)^{1 - \alpha}}{1 - \delta}\right)^{1 - \delta} \quad (14)$$

Case 1: the agent only consumes home non-tradable. In this case, the price-level hedging term is zero (because the pass-through is zero) and the income term can be expressed in terms of the covariance of the exchange rate and real income. When this covariance is negative (bad times of lower income are times when the exchange rate depreciates), the agent chooses a higher level of dollar savings.

$$\kappa_{\text{price}} = 0 \quad (15)$$

$$\kappa_{\text{income}} = -q_0^\$ \frac{\text{Cov}(\epsilon_1/\epsilon_0, y_1)}{\text{Var}(\epsilon_1/\epsilon_0)} \quad (16)$$

Case 2: the agent only consumes foreign tradable with a fixed price p_1^F . In this case, the exchange rate pass-through and the price-level hedging term are one given that the agent consumes a basket that is priced entirely in dollars and fluctuates one to one with depreciations of the local currency. The income term still contributes to higher dollarization if the exchange rate and real income are

⁹This assumption can be relaxed, but it simplifies the derivation of the price level and evidence from the empirical exercise of Section 4 for the case of Uruguay suggests that indeed the pass-through into prices does not vary much on average across households of different income quantiles.

negatively correlated.

$$\kappa_{\text{price}} = 1 \quad (17)$$

$$\kappa_{\text{income}} = q_0^{LC} \frac{\text{Cov}(\epsilon_0/\epsilon_1, y_1)}{\text{Var}(\epsilon_0/\epsilon_1)} \quad (18)$$

From the market clearing of dollar bonds, one can readily derive conditions under which the equilibrium features households saving in dollars, entrepreneurs taking on dollar debt and a risk premium from saving in pesos. These are summarized in Proposition 2. Without reasons to hedge there can't be a scenario of dollarization and UIP deviations within the country like we observe in this type of economies. Moreover, the presence of these terms leads to dollarization when capital controls restrict the foreign supply of dollars to the point of financial autarky.

Proposition 2 *The equilibrium dollar demand of agent i satisfies:*

$$\theta^{\$} \frac{W_0^i}{P_0} = \frac{W_0}{P_0} \left\{ \frac{\gamma^{-i}}{\gamma^h + \gamma^e} + \left(\frac{W_0^i}{W_0} - \frac{\gamma^{-i}}{\gamma^h + \gamma^e} \right) \kappa_{\text{price}} - \frac{\gamma^{-i}}{\gamma^h + \gamma^e} \frac{\kappa_{\text{income}}^{-i}}{W_0/P_0} + \frac{\gamma^i}{\gamma^h + \gamma^e} \frac{\kappa_{\text{income}}^i}{W_0/P_0} \right\} \quad (19)$$

Where $W_0 = W_0^h + W_0^e$ is aggregate wealth, equal to the peso value at $t = 0$ of the foreign supply of dollars, $\epsilon_0 q_0^{\$} b_1^*$, and γ^{-i} is the other agent's risk aversion coefficient.

The equilibrium (real) UIP deviation satisfies:

$$E_0 [R_{\text{real}}^{\$} - R_{\text{real}}^{LC}] = \frac{\left(\frac{W_0}{P_0} - \frac{W_0}{P_0} \kappa_{\text{price}} - (\kappa_{\text{income}}^h + \kappa_{\text{income}}^e) \right)}{\frac{1}{\gamma^h} + \frac{1}{\gamma^e}} \text{Var}_0 [R_{\text{real}}^{\$} - R_{\text{real}}^{LC}] \quad (20)$$

From these conditions follow two observations. First, the higher the pass-through into prices, the higher κ_{price} is and the higher the risk premium offered by the peso. In general equilibrium, a higher pass-through will lead an agent to increase her dollar savings if $\frac{W_0^i}{W_0} > \frac{\gamma^{-i}}{\gamma^h + \gamma^e}$; that is, if the fraction of this agent's wealth is higher than the degree to which the other agent is risk averse. This is because the wealthier the agent, the more she wants to preserve the real value of period 0 wealth from depreciations. Second, the more negative the correlation of an agent's income and dollar returns, the larger κ_{income}^i is and thus the higher the risk premium that the peso bond must offer in order to induce the agent to save in local currency. As κ_{income}^i increases in magnitude, agent i increases her dollar savings in proportion to her own risk aversion. Instead, she decreases her dollar savings in proportion to the other agent's risk aversion when the other agent's income correlation increases.

Risk-sharing and risk-exposure channels These intuitions point towards two key features of heterogeneity within the country that lead to an equilibrium of domestic dollarization. On the one

hand, the agents might share the same reasons for wanting to save in dollars, namely to protect the real value of their savings against pass-through from exchange rate depreciations, and to insure themselves against bad times of low income. Nonetheless, if entrepreneurs are sufficiently less risk averse than households, then they are willing to provide that insurance to households in exchange for dollar borrowing being cheaper. On the other hand, the agents might share the same risk aversion, in which case for households to save in dollars despite the peso offering higher returns, they must hold a strong enough hedging reason compared to the entrepreneurs for wanting to save in dollars. The following propositions summarize these intuitions by describing the conditions that lead to dollarization within the country.

Proposition 3 *In equilibrium, households save in dollars and entrepreneurs borrow in dollars if the following conditions are satisfied (I assume $b_1^* > 0$, and $W_0^i > 0$ for both agents):*

$$\frac{\gamma^e}{\gamma^h + \gamma^e} \left(1 - \kappa_{price} - \frac{\kappa_{income}^h + \kappa_{income}^e}{W_0/P_0} \right) + \frac{W_0^h}{W_0} \kappa_{price} + \frac{\kappa_{income}^h}{W_0/P_0} > 0 \quad (21)$$

$$\frac{\gamma^h}{\gamma^h + \gamma^e} \left(1 - \kappa_{price} - \frac{\kappa_{income}^h + \kappa_{income}^e}{W_0/P_0} \right) + \frac{W_0^e}{W_0} \kappa_{price} + \frac{\kappa_{income}^e}{W_0/P_0} < 0 \quad (22)$$

The risk-aversion channel implies that, if the agents are equally exposed to pass-through and income shocks (same positive κ_{price} and κ_{income}), the entrepreneur insures the household if $\gamma^h \gg \gamma^e$ (i.e., the entrepreneur is sufficiently less risk averse):

$$\theta^{\$} \frac{W_0^i}{P_0} = \frac{W_0}{P_0} \left\{ \frac{\gamma^{-i}}{\gamma^h + \gamma^e} + \underbrace{\left(\frac{W_0^i}{W_0} - \frac{\gamma^{-i}}{\gamma^h + \gamma^e} \right)}_{\substack{+ \text{ for household} \\ - \text{ for entrepreneur}}} \kappa_{price} + \underbrace{\frac{\gamma^i - \gamma^{-i}}{\gamma^h + \gamma^e}}_{\substack{+ \text{ for household} \\ - \text{ for entrepreneur}}} \frac{\kappa_{income}}{W_0/P_0} \right\} \quad (23)$$

The risk-exposure channel implies that, if the agents share the same risk aversion, the entrepreneur insures the household if $\kappa_{income}^h \gg \kappa_{income}^e$ (i.e., the household has a stronger hedging motive to save in dollars based on income exposure to exchange rate risk):

$$\theta^{\$} \frac{W_0^i}{P_0} = \frac{W_0}{P_0} \left\{ \frac{1}{2} + \left(\frac{W_0^i}{W_0} - \frac{1}{2} \right) \kappa_{price} + \frac{1}{2} \underbrace{\left(\frac{\kappa_{income}^i}{W_0/P_0} - \frac{\kappa_{income}^{-i}}{W_0/P_0} \right)}_{\substack{+ \text{ for the household} \\ - \text{ for the entrepreneur}}} \right\} \quad (24)$$

Proposition 4 *In equilibrium, the peso offers a risk premium over the dollar if the aggregate hedging motives for holding dollars exceed the real value of the net supply of dollars from foreign*

investors:

$$\frac{W_0}{P_0} \kappa_{price} + \kappa_{income}^h + \kappa_{income}^e > \frac{W_0}{P_0} = \frac{\epsilon_0 q_0^{\$} b_1^*}{P_0} \quad (25)$$

Condition 25 indicates that the hedging motives in favor of saving in dollars need to be large enough for the local currency to offer a risk premium. That is, for an agent to be willing to save in the currency that offers a lower return, it must be that this currency is attractive in terms of how returns correlate to prices and to “bad times” for consumption. In particular, these reasons have to be, on the aggregate, larger than the real value of dollars that are supplied externally. Conditional on this being satisfied, conditions 21 and 22 hold when the risk aversion of the entrepreneur is small enough relative to the household’s, and the household features stronger hedging motives in favor of dollar saving.

Suppose, for instance, that the agents’ income is uncorrelated with the return of the bonds (i.e., the income hedging term κ_{income}^i is zero for both agents). In equilibrium, UIP fails in favor of the peso as long as the price hedging term is large enough ($\kappa_{price} > 1$). For the household to be saving in dollars and the entrepreneur to be taking on dollar debt, it must be that the household’s risk aversion is large enough relative to the entrepreneur’s (top Figure 4). Specifically, the conditions that have to be satisfied are the following (note that the right hand terms in these inequalities are positive when $\kappa_{price} > 1$):

$$\frac{\gamma^e}{\gamma^h + \gamma^e} < \frac{W_0^h}{W_0} \frac{\kappa_{price}}{\kappa_{price} - 1} \quad (26)$$

$$\frac{\gamma^h}{\gamma^h + \gamma^e} > \frac{W_0^e}{W_0} \frac{\kappa_{price}}{\kappa_{price} - 1} \quad (27)$$

Notably, this is a situation that generates dollarization of the type that we observe while both agents share the same incentive to hold the dollar as a means to safeguard real returns from inflation. The entrepreneur’s lower risk aversion implies that she responds more to the cheaper currency and is willing to insure the household against adverse price movements. I call this the “risk-sharing” channel.

Instead, suppose that the price hedging term κ_{price} is zero. Then for the local currency to offer a risk premium, we must have:

$$\kappa_{income}^h + \kappa_{income}^e > \frac{W_0}{P_0} \quad (28)$$

So at least one of the agents must have a negative income covariance with respect to the dollar

returns, relative to the covariance with the peso returns (which implies a positive κ_{income}). Moreover, if we want households to feature dollar savings and entrepreneurs to feature dollar debt, the conditions that have to be satisfied are:

$$\kappa_{\text{income}}^h > \frac{\gamma^e}{\gamma^h} \left(\kappa_{\text{income}}^e - \frac{W_0}{P_0} \right) \quad (29)$$

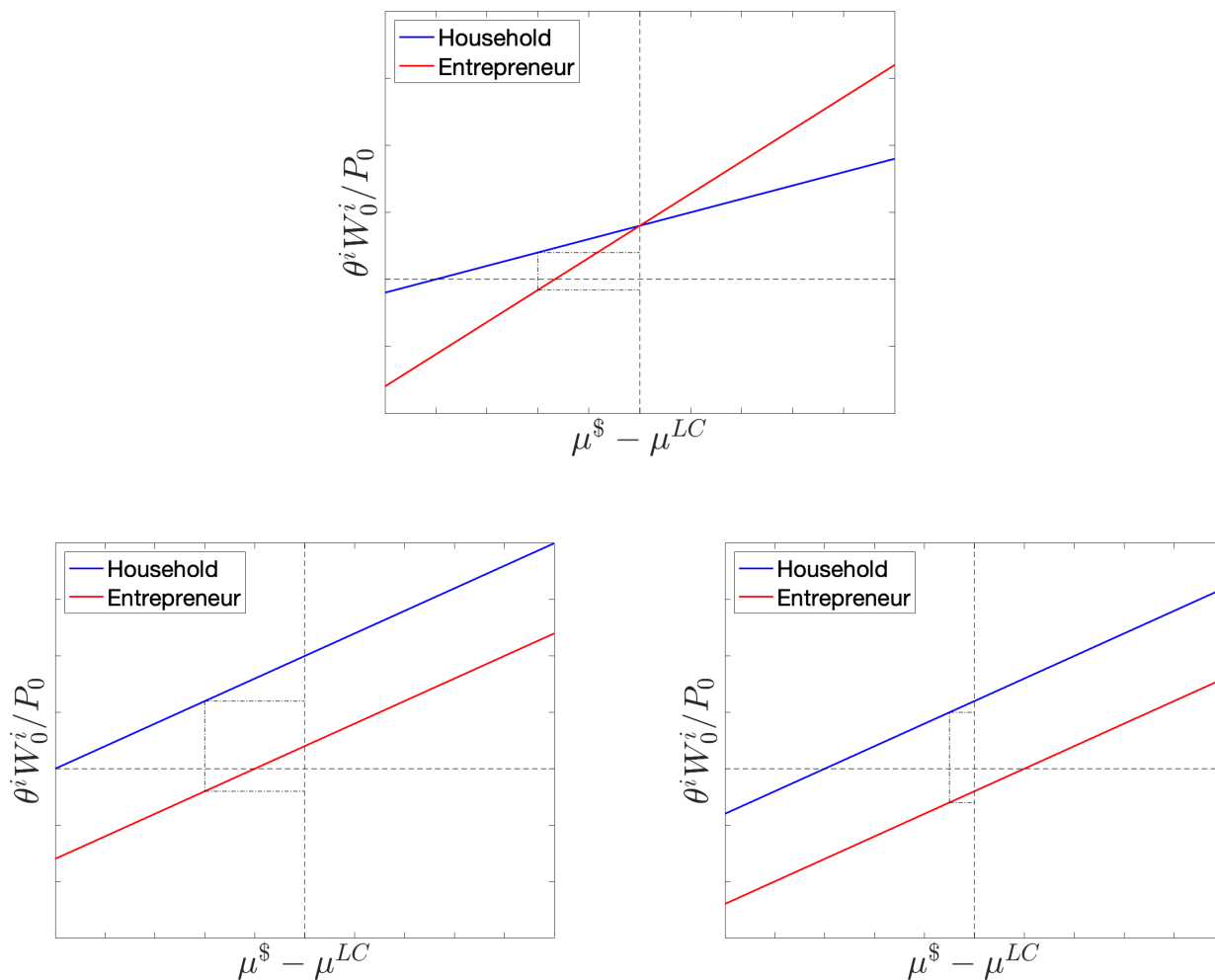
$$\kappa_{\text{income}}^e < \frac{\gamma^h}{\gamma^e} \left(\kappa_{\text{income}}^h - \frac{W_0}{P_0} \right) \quad (30)$$

That is, the income hedging motive of the household has to be sufficiently larger than the entrepreneur's. This will hold if the covariance of her income with the real returns of the dollar is sufficiently negative. Note that this doesn't preclude a case in which both have a negative covariance term for income and thus an income hedging motive that increases their demand for dollar savings (bottom Figure 4). Moreover, this situation can arise even if the agents share the same risk aversion. I refer to this as the "risk-exposure channel".

These observations can explain the empirical patterns summarized in Facts 1 to 4 from Section 2: countries that exhibit higher dollarization and a higher local currency premium are those in which the households' hedging motives and risk aversion are high enough relative to the agents that own the firms in the economy. The households' dollar savings are the counterpart of the entrepreneurs' dollar debt (Fact 1). The risk-sharing channel implies that, when entrepreneurs are sufficiently less risk averse relative to households, dollarization of deposits increases with pass-through into prices (Fact 2), and when the households' income processes are negatively correlated to depreciations (Fact 3)¹⁰. The risk exposure channel implies that dollarization of deposit increases when the income-hedging motive to save in dollars of the households is higher than that of the agents that own the firms. Countries that exhibit higher dollarization are countries in which these hedging motives for very risk-averse households determine that the local currencies offer in equilibrium a risk premium over the dollar (Fact 4).

¹⁰I assume that the correlation of the country's GDP growth to depreciations of the local currency is reflective of the households' risk exposure to these depreciations

Figure 4: Risk-aversion and risk-exposure channels



Note: The lines represent the optimal dollar demand of the agents (blue is the household, red the entrepreneur) as a function of UIP deviations: $\theta^{s,i} \frac{W_0^i}{P_0} = \frac{1}{\gamma^i} \frac{\mu^s - \mu^{LC}}{\text{Var}_0[R_{real}^s - R_{real}^{LC}]} + \frac{W_0^i}{P_0} \kappa_{price} + \kappa_{income}^i$. UIP deviations are presented in the x-axis, where $\mu^s - \mu^{LC} \equiv E_0 [R_{real}^s - R_{real}^{LC}]$. The dotted lines indicate where equilibrium is achieved and it satisfies $\frac{\theta^{s,h} W_0^h}{P_0} + \frac{\theta^{s,e} W_0^e}{P_0} = \frac{b_1^* \epsilon_0^s}{P_0} > 0$. The top figure illustrates the “risk-sharing” channel - the higher risk aversion of the household means that the slope of optimal dollar demand is smaller. The bottom figures illustrate the “risk-exposure” channel - the left figure assumes both agents have an income-hedging reason to save in dollars; the right figure assumes the entrepreneur’s risk-exposure from income has the opposite sign so that exchange rate depreciations are positively correlated to their income process.

Capital controls and dollarization Capital controls in this model can be seen as a restriction in the net supply of dollars from abroad, b_1^* . A decrease in this dollar supply affects the levels of dollarization within the country. An interesting theoretical case is that of financial autarky, in which the country must keep a balanced trade. The country’s net dollar savings from period 0 are zero and, assuming that individual wealth is non-negative, this implies that individual net dollar savings are zero. However, this does not preclude the agents from taking on debt in one currency

and saving in the other. In this case, the agents take opposite positions in both the dollar and the peso market.

The equilibrium UIP deviation and net dollar savings from agent i in a context of financial autarky are:

$$E_0 [R_{real}^{\$} - R_{real}^{LC}] = -\frac{\kappa_{income}^h + \kappa_{income}^e}{\left(\frac{1}{\gamma^h} + \frac{1}{\gamma^e}\right)} Var_0 [R_{real}^{\$} - R_{real}^{LC}] \quad (31)$$

$$\theta^{\$,i} \frac{W_0^i}{P_0} = \frac{P_0}{\epsilon_0 q_0^{\$}} \left(-\frac{\gamma^{-i}}{\gamma^h + \gamma^e} (\kappa_{income}^h + \kappa_{income}^e) + \kappa_{income}^i \right) \quad (32)$$

Notably, there is no price-hedging term. The agent can derive a profit from the fact that the real returns of the bonds are stochastic, and the extent to which income is negatively correlated to the relative real returns makes her more or less likely to take this investment. However, real net wealth is zero and so preserving its value from depreciations is not a concern here.

In equilibrium, since dollars bonds are in zero net supply, one agent has to save in dollars and the other must take on dollar debt. We can have a situation in which the household saves in dollars while the entrepreneur has dollar debt and the peso offers a risk premium, if the following conditions are satisfied:

$$\kappa_{income}^h + \kappa_{income}^e > 0 \quad (33)$$

$$\kappa_{income}^h > \frac{\gamma^e}{\gamma^h} \kappa_{income}^e \quad (34)$$

Importantly, the private sector of a country can feature dollarization of the type that we observe provided that the income hedging motives of the two agents are distinct enough from one another (the household's being stronger) and that at least one of them has a strong income hedging reason for saving in dollars (i.e, κ_{income}^i is positive). Once again, this does not preclude a case in which both agents have a reason to save in dollars to insure against negative income movements (i.e, κ_{income}^i is positive for both agents), but it does require that the household's motive be stronger, and even more if the entrepreneur doesn't have a higher tolerance for risk than the household. In this scenario, even if the agents cannot engage in financial transactions with foreign investors, dollarization within a country arises from risk-sharing across domestic heterogeneous agents.

So far the analysis has relied on conditions that concern the hedging motives for dollarizing. These are functions of the joint distribution of prices and endowments. To understand the effect that stricter capital controls (a decrease in b_1^*) can have on equilibrium UIP and dollarization, we need to solve for the equilibrium prices. The following proposition summarizes the results (derivations

are in the Appendix).

Proposition 5 *The equilibrium prices of the home tradable good p_1^H , the foreign tradable good p_1^F , the exchange rate ϵ_1 and the price of the dollar bond $q_0^\$$ are:*

$$\epsilon_1 = \frac{y_1^{NT} \frac{(1-\delta)(1-\alpha)}{\delta}}{b_1^* + \frac{(1-\delta^*)(1-\alpha^*)}{\delta^*} y_1^{NT,*}} \quad (35)$$

$$p_1^H = \frac{\epsilon_1 \frac{(1-\delta^*)(1-\alpha^*)}{\delta^*} y_1^{NT,*} + \frac{(1-\delta)\alpha}{\delta} y_1^{NT}}{y_1^H} \quad (36)$$

$$\epsilon_1 p_1^F = \frac{\frac{(1-\delta)(1-\alpha)}{\delta} y_1^{NT} + \epsilon_1 \frac{(1-\delta^*)\alpha^*}{\delta^*} y_1^{NT,*}}{y_1^F} \quad (37)$$

$$q_0^\$ = \frac{W_0}{b_1^* \epsilon_0} \quad (38)$$

$$q_0^{LC} : \theta^{\$,h}(p_1^H, \epsilon_1, q_0^\$; \alpha, \delta, \gamma^h, W_0^h) W_0^h + \theta^{\$,e}(p_1^H, \epsilon_1, q_0^\$; \alpha, \delta, \gamma^e, W_0^e) W_0^e = W_0 \quad (39)$$

The equilibrium price of peso bonds, q_0^{LC} , is characterized by the market clearing condition of the bond market and the optimal $\theta^{\$,i}$ of each agent, given by 10, where the mean, variance and covariance terms are derived from the equilibrium ϵ_1 , p_1^H and p_1^F .

Note that when $b_1^* > 0$, there is an inflow of dollars from abroad in period 1 and the country runs a trade deficit that is financed with net savings from period 0. The exchange rate, the price of foreign non-tradable (dollars) in terms of home non-tradable (pesos), increases (the peso depreciates) with a decrease in the net foreign supply of dollars from period 0 and in the endowment of $y_1^{NT,*}$ from period 1, as dollars become more scarce. Together with a depreciation of the local currency, the price of both tradable goods, expressed in pesos, increases and there is a positive pass-through into prices from exchange rate depreciations¹¹.

The effect of a decreasing net supply of dollars from abroad on the nominal return of dollar bonds will depend on two opposing forces: on the one hand, the nominal interest rate of dollar bonds decreases (price increases) as dollar bonds become more scarce; on the other hand, the local currency depreciates against the dollar and makes the dollar bond more attractive in terms of its peso returns. In net, the depreciation of the currency is not enough to compensate for the decrease in the interest rate and thus the nominal return in pesos of the dollar bond declines. The return of the peso bond decreases together with the decline in the availability of savings instruments. In net, nominal UIP deviations will respond to these two opposing forces (lower dollar and peso returns). Real UIP deviations depend additionally on the degree of pass-through into prices, which further reinforces the decline in the real returns of the bonds.

¹¹Notice that if p_1^H is set in dollars, then the same equilibrium conditions would hold, but for $\epsilon_1 p_1^H$.

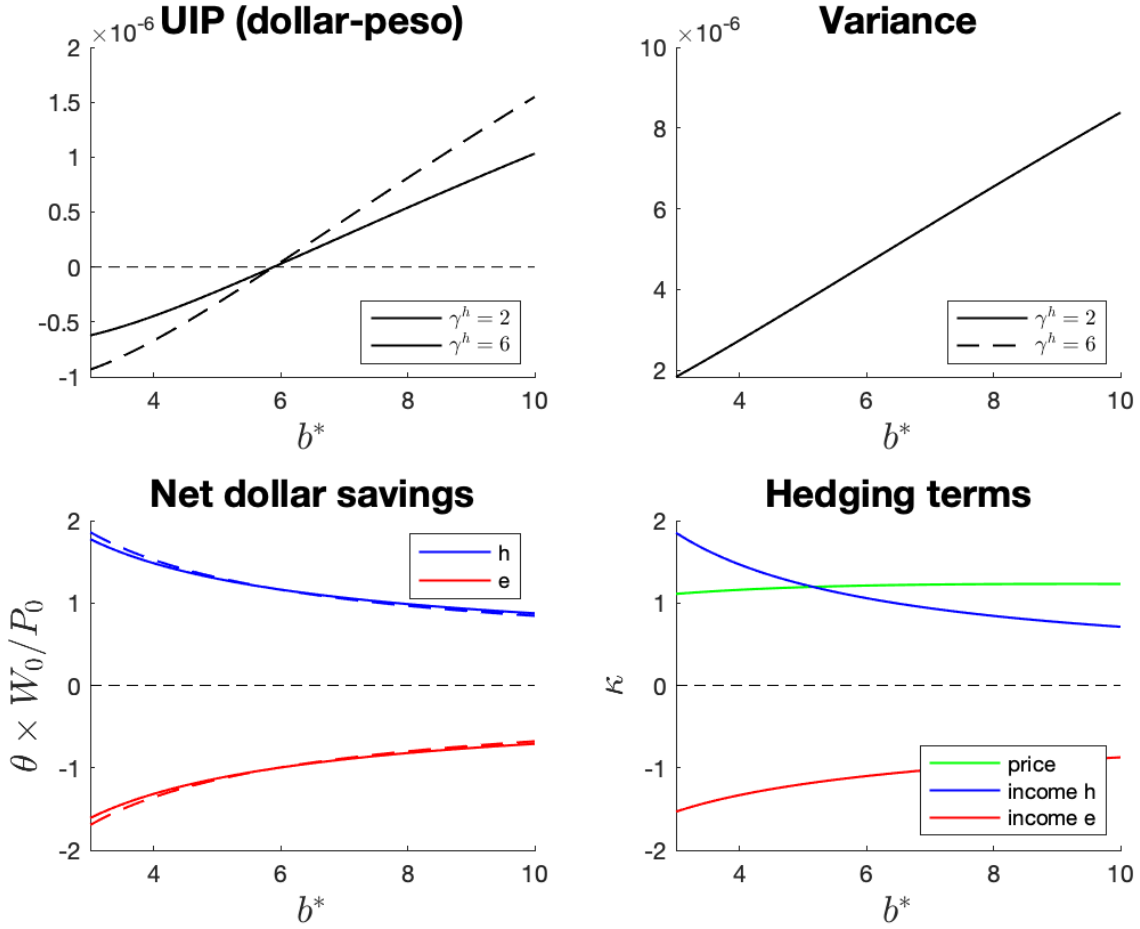
Numerical example Figure 5 shows the numerical results from a simple calibration that is summarized in Table 2. We consider a case in which 20% of an agent’s expenditure is in non-tradables and 50% of tradable consumption is allocated to home tradable goods. The process of endowments, local and foreign, for period 1 follows a lognormal distribution with mean normalized to one and a variance of 0.001. We abstract from any mechanical forces generated by differences in wealth by assuming that each agent holds half of aggregate wealth from period 0, and that this equals foreign investors’ wealth. A negative correlation between the productivity shocks of non-tradable and tradable goods is what generates the different income covariance with dollar returns for agents endowed with different types of goods. The entrepreneur has a risk aversion of 2, and we solve for the equilibrium when the household has the same risk aversion of 2 and a higher one of 6.

Table 2: Calibration

Variables	Values
Risk-aversion	$\gamma^h \in \{2, 6\}, \gamma^e = 2$
Share of home tradable consumption	$\alpha = \alpha^* = 0.5$
Share of non-tradable consumption	$\delta = \delta^* = 0.2$
Initial aggregate wealth	$W_0 = W_0^* = 2$
Share of aggregate wealth for agent i	$\frac{W_0^h}{W_0} = \frac{W_0^e}{W_0} = 0.5$
Mean endowment of home tradable and non-tradable	$\mu_1^{NT} = \mu_1^H = 1$
Variance of home tradable and non-tradable endowments	$\sigma_1^{NT} = \sigma_1^H = 0.001$
Correlation of growth of endowment processes	$Corr(\log(y_1^{NT}), \log(y_1^H)) = -0.5$

Figure 5 shows the effects that a decrease in b_1^* has on (real) UIP deviations and the levels of dollarization within the country. A lower supply of dollars from abroad strengthens the income hedging motives that the household has for saving in dollars and that the entrepreneur has for borrowing in dollars. The key to this is the decrease in the variance of the relative returns of the two bonds (the denominator of the hedging terms in 10). In equilibrium, this stronger “risk exposure” channel through income results in an increase in the risk premium of the peso, which motivates a higher dollar borrowing for the entrepreneur, even if she is exposed to pass-through into prices as much as the household is. The dotted lines indicate how the results change when the risk aversion of the household triples. When the supply of dollars from abroad is sufficiently scarce and the peso offers higher average returns, the deviation of UIP in equilibrium increases with a higher risk aversion of the household since the agent is less sensitive to lower returns from the dollar (and viceversa if the dollar offers a risk premium). This results in higher levels of dollarization via the “risk-aversion” channel.

Figure 5: Capital controls increase domestic dollarization



Note: The top-left figure depicts real UIP deviations $E_0 [R_{real}^{\$} - R_{real}^{LC}]$ in equilibrium as a function of b^* , the foreign supply of dollars. The top-right figure represents the variance of relative returns $Var_0 [R_{real}^{\$} - R_{real}^{LC}]$. The bottom-left shows the equilibrium dollar savings of the household (in blue) and the dollar debt of the entrepreneur (in red), $\theta^{i,\$} \frac{W_0^i}{P_0}$. The bottom-right figure shows the equilibrium values of the hedging terms, κ_{price} (same for both agents) and κ_{income}^i (positive for the household, which indicates that $Cov_0 [R_{real}^{\$} - R_{real}^{LC}, y_1^i] < 0$, the relative returns of the *dollar* covary negatively with income for this agent).

Before we take these predictions to the data, in the next section I revisit the portfolio choice problem of this model. The appeal of mean-variance preferences used so far is that they are able to capture the trade-off between expected return and risk in a way that is tractable for a general equilibrium analysis. However, there are caveats to this specification that motivate a reformulation of the problem in continuous time. First, it only represents an expected utility maximization for the special case of quadratic utility, while for more general functions it can be understood as a second-order approximation. Moreover, it is inherently a single-period problem, whereas we think of most investment problems as involving longer horizons with periodic portfolio rebalancing (Brandt 2010). So for the purposes of taking the model predictions on the optimal level of dollarization to the data, in the following section I present a more general formulation of the portfolio choice of an agent.

4 Portfolio choice in continuous time

A Merton-style portfolio model is the continuous-time analogue of the simpler agent maximization problem presented in Section 3. It has the advantage of delivering an expression for the optimal share of wealth invested in dollars that is analogous to expression 10 but where the hedging terms are clear functions of risk aversion, pass-through into prices and pass-through into income, all of which are well known and measurable statistics. As noted in Section 3, these hedging motives can explain why one might observe significant levels of dollarization even when the local currency offers a higher return on average. Moreover, this is a more flexible framework that features CRRA preferences, it allows for both income and dividend payments, and it can be extended to account for other potential drivers of dollarization such as the presence of inflation-indexed assets. In this section, I introduce the additional model ingredients of a continuous-time reformulation of the problem, and describe the intuition behind the closed-form expressions of optimal dollar demand.

Consumption prices Prices are modeled as Ito processes with constant drift and volatility terms. The exchange rate ϵ_t , expressed as the amount of pesos equivalent to one dollar, evolves with drift μ_t^ϵ and volatility σ_t^ϵ . The correlation coefficients between the Brownian shocks of the exchange rate and the prices of home and foreign tradables goods are $\rho_{\epsilon,H}$ and $\rho_{\epsilon,F}$, respectively.

$$\frac{d\epsilon_t}{\epsilon_t} = \mu_t^\epsilon dt + \sigma_t^\epsilon dB_t^\epsilon \quad (40)$$

$$\frac{dp_t^H}{p_t^H} = \mu_t^H dt + \sigma_t^H dB_t^H \quad (41)$$

$$\frac{dp_t^F}{p_t^F} = \mu_t^F dt + \sigma_t^F dB_t^F \quad (42)$$

Bonds There are two types of bonds available to the agents, one denominated in pesos with return r_t^{LC} and price q_t^{LC} , and one denominated in dollars with return $r_t^\$$ and price $q_t^\$$. Both bonds are free of default risk. I denote $\tilde{q}_t^\$ = q_t^\$ \epsilon_t$ as the price of the dollar bond expressed in pesos.

$$\frac{dq_t^{LC}}{q_t^{LC}} = r_t^{LC} dt \quad (43)$$

$$\frac{d\tilde{q}_t^\$}{\tilde{q}_t^\$} = [r_t^\$ + \mu_t^\epsilon] dt + \sigma_t^\epsilon dB_t^\epsilon \quad (44)$$

Notice that the expected return in pesos of this bond is given by the sum of the return in dollars plus the expected depreciation of the peso against the dollar, and it inherits the volatility of the exchange rate. The risk premium in pesos of the dollar bond is then given by $\frac{1}{dt} E_t \left[\frac{d\tilde{q}_t^\$}{\tilde{q}_t^\$} - \frac{dq_t^{LC}}{q_t^{LC}} \right] = r_t^\$ + \mu_t^\epsilon - r_t^{LC}$. If UIP holds, this is zero and both assets pay the same amount of pesos in expectation.

Productive assets A productive asset is a claim over a tree that produces one type of perishable home good (tradable or non-tradable). The returns for such an asset follow an Ito process, where Π_t are dividends and q_t is the price of the asset.

$$\frac{\Pi_t dt + dq_t}{q_t} = \left[\frac{\Pi_t}{q_t} + r_t^q \right] dt + \sigma_t^q dB_t^q \quad (45)$$

Portfolio problem with labor income The baseline case features an agent that invests in bonds and receives exogenous labor income. The agent has an infinite life horizon and is born with financial wealth $W_0 > 0$ at time 0. The household's financial wealth at any time t is given by the value of his portfolio, with $b_t^\$$ the amount of dollar-denominated bonds and b_t^{LC} the amount of peso bonds. Wealth is expressed in pesos (units of non-tradable home good):

$$W_t = b_t^{LC} q_t^{LC} + b_t^\$ \tilde{q}_t^\$ \quad (46)$$

The budget equation describes the evolution of financial wealth for this agent, where $\theta_t^\$$ is the share of wealth invested in the dollar bond and $y_t W_t$ is labor income¹²; y_t follows a an Ito process with drift μ_t^y and volatility σ_t^y and features a correlation $\rho_{\epsilon,y}$ with the Brownian shock of the exchange rate.

¹²We require labor income to be proportional to wealth to be able to solve the portfolio problem in closed form. This proportionality property can be justified by assuming that the agent invests in (non-tradable human) capital, where this investment is proportional to wealth. That is, agents have access to a technology that converts wealth into capital and each unit of capital produces y_t units of non-tradable good.

$$dW_t = \left\{ \theta_t^{\$} \frac{d\tilde{q}_t^{\$}}{\tilde{q}_t^{\$}} + (1 - \theta_t^{\$}) \frac{dq_t^{LC}}{q_t^{LC}} \right\} W_t + y_t W_t dt - P_t c_t dt \quad (47)$$

$$\frac{dy_t}{y_t} = \mu_t^y dt + \sigma_t^y dB_t^y \quad (48)$$

The agent chooses how much to invest in each type of bond and how much to consume in order to maximize expected discounted CRRA utility:

$$E_0 \left\{ \int_0^{\infty} e^{-\rho t} \frac{C_t^{1-\gamma}}{1-\gamma} dt \right\} \quad (49)$$

The following Lemma describes how the agent's value function depends on the state variables that affect her optimal portfolio decision.

Lemma 1 *An agent's value function, under CRRA preferences, adopts the functional form:*

$$V_t = \phi_t^{1-\gamma} \frac{(W_t/P_t)^{1-\gamma}}{1-\gamma} \quad (50)$$

Where ϕ_t captures all other relevant state variables, aside from the price level P_t and wealth W_t , that influence the agent's portfolio choice (and note that it also depends on γ).

Proposition 6 describes the optimal net position in dollars, $\theta_t^{\$}$, that results from this portfolio problem.

Proposition 6 *Under the assumption of constant investment opportunities¹³, the optimal share of wealth invested in dollar bonds for an agent that perceives exogenous labor income y_t is:*

$$\theta_t^{\$} = \underbrace{\frac{r^{\$} + \mu^{\epsilon} - r^{LC}}{\gamma(\sigma^{\epsilon})^2}}_{\text{Myopic demand}} + \underbrace{\frac{\nu_t^P}{\gamma} P_t \beta_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}}}_{\text{Pass-through hedge}} + \underbrace{\frac{\nu_t^y}{\gamma} y_t \beta_{\frac{dy}{y}, \frac{d\epsilon}{\epsilon}}}_{\text{Income hedge}} \quad (51)$$

Where γ is the coefficient of risk aversion. ν_t^s captures aversion to risk to a state variable s and $\beta_{\frac{ds}{s}, \frac{d\epsilon}{\epsilon}}$ is the regression coefficient of innovations in the growth of this state variable on innovations in the depreciation of the local currency (return innovations of the dollar bond). These parameters can be expressed as follows:

¹³Constant rates of return of the bonds ($r^{\$}$ and r^{LC}), and constant drift and volatility of: exchange rate depreciations (μ^{ϵ} and σ^{ϵ}), inflation (μ^P and σ^P) and income growth (μ^y and σ^y).

$$\gamma \equiv -\frac{W_t V_{WW}}{V_W} \quad (52)$$

$$\frac{\nu_t^P}{\gamma} P_t \equiv \frac{1}{\gamma} \frac{V_{WP}}{V_W} P_t = \frac{\gamma - 1}{\gamma} \quad (53)$$

$$\frac{\nu_t^y}{\gamma} y_t \equiv \frac{1}{\gamma} \frac{V_{Wy}}{V_W} y_t = \frac{1 - \gamma}{\gamma} \frac{\phi_y}{\phi_t} y_t \quad (54)$$

$$\beta_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}} = \frac{\sigma^P}{\sigma^\epsilon} \rho_{\epsilon, P} \quad (55)$$

$$\beta_{\frac{dy}{y}, \frac{d\epsilon}{\epsilon}} = \frac{\sigma^y}{\sigma^\epsilon} \rho_{\epsilon, y} \quad (56)$$

Where V_{WW} , V_W and V_{Ws} are partial derivatives with respect to wealth and state variable s .

Expression 51 is the continuous-time version of 10. The first term in 51 is analogous to the standard Merton portfolio result, according to which the share of wealth invested in the asset that is risky in pesos (the dollar bond) is increasing in the dollar risk-premium (return of the dollar relative to the peso), and decreasing in risk aversion and the volatility of the returns (volatility of exchange rate depreciations). According to this, the higher the return of the local currency relative to the dollar, the less dollars an agent wants to hold. If UIP deviations were the only factor that agents took into account, one should observe them shorting the dollar and taking a long position in pesos in countries that feature a peso risk-premium.

It is the other two terms in this expression that can push $\theta_t^{\$}$ to be positive even when the local currency features a risk premium. They capture a hedging motive: an agent with high (low) enough risk aversion will increase (decrease) her holding of dollar bonds if dollar returns covary negatively with the state variables of concern to the investor (i.e., $\beta_{\frac{ds}{s}, \frac{dQ^{\$}}{Q^{\$}}} < 0$). News that expected returns will be higher (i.e., positive shocks to depreciations of the exchange rate) have two effects (Cochrane 2011): a wealth effect, according to which the agent will increase consumption since she will be able to afford more in the future; and a substitution effect according to which it is convenient to consume less now and perceive higher returns tomorrow. The more risk averse the agent is ($\gamma > 1$), the less the substitution effect matters, leading to an increase in consumption today and a decline in marginal utility $V_W = u'(C)$; that is, $V_{Ws} < 0$ and $\nu^s < 0$. If the agent is not very risk averse ($\gamma < 1$), the substitution effect dominates, then consumption declines today and marginal utility increases; that is, $V_{Ws} > 0$ and $\nu^s > 0$. If the agent has logarithmic preferences ($\gamma = 1$), then the substitution and wealth effects offset each other so that $V_{Ws} = 0$ and $\nu^s = 0$. That is, with logarithmic preferences the hedging terms disappear.

Specifically, the second term in 51 captures the role of the dollar as a hedge against movements in

the price level caused by a currency depreciation. A risky investor will hedge against undesirable innovations in the price level by taking a longer position in the dollar asset. The extent to which the agent will use the dollar as a hedge against these price movements depends on how dollarized her consumption basket is. This depends on her preferences which determine the functional form of the price level. The diffusion process that describes the evolution of this price level can be found using Ito's formula. To illustrate, the following Lemma derives the pass-through of the exchange rate into prices under Cobb-Douglas aggregation of the non-tradable and tradable goods.

Lemma 2 *Let there be a single representative agent that aggregates consumption according to:*

$$c_t = (c_t^{NT})^\delta ((c_t^H)^\alpha (c_t^F)^{1-\alpha})^{1-\delta} \quad (57)$$

Moreover, assume that the dollar price of foreign tradable goods is fixed (so that $p_t^F = \bar{p}^F$), and take the price of non-tradables as the numeraire ($p_t^{NT} = 1$). Then the pass-through of the exchange rate into the price level is:

$$\beta_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}} = \frac{\sigma^P}{\sigma^\epsilon} \rho_{P,\epsilon} = (1 - \delta) \left[\alpha \frac{\sigma^H}{\sigma^\epsilon} \rho_{H,\epsilon} + (1 - \alpha) \right], \quad (58)$$

where $\rho_{\epsilon,P}$ is the correlation between the Brownian shock of the price level and that of the exchange rate. The pass-through depends on the share of goods in the tradable basket that are directly priced in dollars ($1 - \alpha$) and on the sensitivity of the price of the tradable home good, priced in pesos, to exchange rate movements.

The third term in 51 indicates that the dollar also plays a hedging role with respect to the agent's income. Provided $\nu^Y < 0$ (i.e, risk aversion is greater than 1), a negative correlation between income and the exchange rate causes the agent to want to hold on to more dollars. If bad times of negative shocks to income are periods when the peso depreciates, the agent can hedge against these shocks by taking a longer position in dollars.

Equation 51 has the advantage over 10 that it is a clear function of statistics that we can measure in the data. In Section 5, I calibrate this expression to the countries in my sample of Latin American economies and contrast the predictions on the optimal levels of deposit dollarization with the observed measures of aggregate dollarization. This exercise takes the observed values at the country-level to be reflective of the optimal choice of a representative household in the country. In a follow-up exercise, I look at evidence from household-level data from Uruguay to analyse whether the constructed measures of pass-through into prices and wages is indeed contributing to a household's dollar demand in the direction and magnitude that the model would predict.

Portfolio problem with dividend income The baseline specification of the portfolio choice in continuous time can be extended to capture the choice of a type of household that owns a firm (an entrepreneur). Instead of perceiving labor income, an agent that is able to invest in a productive asset receives income in the form of dividend payments, $\frac{\Pi_t}{q_t}$. These follow a process for which the correlation of the Brownian shock with the exchange rate is $\rho_{\frac{\Pi}{q}, \epsilon}$:

$$\frac{d\Pi_t/q_t}{\Pi_t/q_t} = \mu_t^{\Pi/q} dt + \sigma_t^{\Pi/q} dB_t^{\Pi/q} \quad (59)$$

The budget equation for this agent features an additional term, τ_t , that denotes the share of wealth invested in the productive asset.

$$dW_t = \left\{ \tau_t \frac{\Pi_t dt + dq_t}{q_t} + \theta_t^{\$} \frac{d\tilde{q}_t^{\$}}{\tilde{q}_t^{\$}} + (1 - \tau_t - \theta_t^{\$}) \frac{dq_t^{LC}}{q_t^{LC}} \right\} W_t - P_t c_t dt \quad (60)$$

Proposition 7 describes the optimal net position in dollars for this agent.

Proposition 7 *Consider an agent that invests a share τ_t in a productive asset that offers dividend payments. Under the assumption of constant investment opportunities, the optimal share of wealth allocated to dollar bonds is:*

$$\theta_t^{\$} = \underbrace{\frac{r^{\$} + \mu^{\epsilon} - r^{LC}}{\gamma(\sigma^{\epsilon})^2}}_{\text{Myopic demand}} + \underbrace{\frac{\nu_t^P}{\gamma} P_t \beta_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}}}_{\text{Pass-through hedge}} + \underbrace{\frac{\nu_t^{\Pi/q}}{\gamma} \frac{\Pi_t}{q_t} \beta_{\frac{d\Pi/q}{\Pi/q}, \frac{d\epsilon}{\epsilon}}}_{\text{Dividend hedge}} - \underbrace{\tau_t \beta_{\frac{dq}{q}, \frac{d\epsilon}{\epsilon}}}_{\text{Substitute}} \quad (61)$$

Where:

$$\frac{\nu_t^{\Pi/q}}{\gamma} \frac{\Pi_t}{q_t} \equiv \frac{1}{\gamma} \frac{V_{W \frac{\Pi}{q}} \Pi_t}{V_W q_t} = \frac{1 - \gamma}{\gamma} \frac{\phi_{\Pi/q} \Pi_t}{\phi q_t} \quad (62)$$

$$\beta_{\frac{dq}{q}, \frac{d\epsilon}{\epsilon}} = \frac{\sigma^q}{\sigma^{\epsilon}} \rho_{\epsilon, q} \quad (63)$$

There are two differences between this optimal net position and that described in 51. First, there is a new term that captures the fact that the productive asset is an imperfect substitute for the dollar bond; the degree of substitutability depends on the relative volatility and the correlation of their returns. Second, dividend income substitutes for labor income; whether a risk averse individual ($\gamma > 1$) wants to hold a longer or shorter position in dollars depends on the sign of the correlation between shocks to dividend income growth and shocks to depreciations of the exchange rate. Note that for such a risk averse individual, $\nu_t^{\Pi/q}$ is negative, so a positive $\beta_{\frac{d\Pi/q}{\Pi/q}, \frac{d\epsilon}{\epsilon}}$ results in an overall negative dividend hedge term that pushes $\theta_t^{\$}$ down. This term can explain why, on the aggregate, exporting firms, who perceive dollar revenue and are therefore naturally hedged against depreciations (i.e., have a more positive beta), hold more dollar debt than non-exporting firms (see

Figure 11 in the Appendix).

Inflation-indexed assets So far, I have considered only two instruments that are available to the household: a safe asset priced in dollars and a safe asset priced in pesos. Some countries, however, have developed inflation-indexed financial instruments designed to hedge against exchange rate risk to substitute for dollar deposits and debt. Chile introduced this type of financial contracts in the 1970's and is one of the most successful cases of CPI-indexation, where nearly 40% deposits and 55% of loans are in CPI-indexed units.

A second extension to the baseline model is able to rationalize this observation. The investor may choose a share $\theta_t^{\$}$ to invest in dollar assets and a share θ_t^P to invest in a CPI-indexed asset that features price $q_{P,LC}$. The expected return of the inflation-indexed asset is equal to the peso interest rate plus expected inflation, and it shares the same volatility as that of the general price level:

$$\frac{dq_{P,LC}}{q_{P,LC}} = (r_{P,LC} + \mu_P)dt + \sigma_P dB^P \quad (64)$$

The optimal dollar share now features a fourth term that accounts for the substitutability between the two available bonds with hedging properties. Part of this hedging can be done by means of the CPI-indexed asset, so the long position in dollars will decrease. The extent to which the inflation-indexed asset is a substitute to the dollar asset depends on the beta of their returns.

$$\theta_t^{\$} = \underbrace{\frac{r^{\$} + \mu^{\epsilon} - r^{LC}}{\gamma \sigma_{\epsilon}^2}}_{\text{Myopic demand}} + \underbrace{\frac{\nu_t^P}{\gamma} \beta_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}}}_{\text{Price level hedge}} + \underbrace{\frac{\nu_t^y}{\gamma} \beta_{\frac{dy}{y}, \frac{d\epsilon}{\epsilon}}}_{\text{Income hedge}} - \underbrace{\theta_t^P \beta_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}}}_{\text{Substitute}} \quad (65)$$

By solving for the optimal shares as a function of returns and volatility terms, we find the final closed-form demands for each type of bond, stated in the following proposition.

Proposition 8 *The optimal shares of wealth allocated to a dollar bond and an inflation-indexed bond are:*

$$\theta_t^{\$} = \frac{1}{1 - \rho_{\epsilon, P}^2} \left[\frac{r^{\$} + \mu_{\epsilon} - r_{LC}}{\gamma \sigma_{\epsilon}^2} - \frac{r_{P,LC} + \mu_P - r_{LC}}{\gamma \sigma_P^2} \beta_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}} \right] \quad (66)$$

$$\theta_t^P = \frac{1}{1 - \rho_{\epsilon, P}^2} \left[\frac{r_{P,LC} + \mu_P - r_{LC}}{\gamma \sigma_P^2} - \frac{r^{\$} + \mu_{\epsilon} - r_{LC}}{\gamma \sigma_{\epsilon}^2} \beta_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}} \right] + \frac{\gamma - 1}{\gamma} \quad (67)$$

The agent will only use the indexed asset to hedge against price movements, and, to the extent that the returns of both assets are correlated, she will substitute towards more indexed assets if they offer a higher risk premium.

5 Country and household-level empirical analyses

5.1 Predicted dollarization across countries

The closed-form expression 51 for the optimal dollar demand of a household offers a clear prediction that can be taken to the data. At the macro level, the six Latin American countries in my sample present a rich heterogenous example with differing levels of deposit dollarization. I use the same monthly data from Figure 1 to obtain measures of observed dollarization, $\theta^{\$}$, and calibrate expression 51 to derive predicted levels of dollarization, $\hat{\theta}^{\$}$. This calibration includes four statistics that can be measured with the data and two degrees of freedom. Table 3 presents the estimated relevant statistics for each country. I use the CPI series of each country to derive a measure of pass-through into prices, $\hat{\beta}_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}}$, and consider real GDP as income for a representative household in these economies to compute the beta of income growth against depreciations of the local currency, $\hat{\beta}_{\frac{dy}{y}, \frac{d\epsilon}{\epsilon}}$. All of these are countries in which real GDP growth declines when their currency depreciates, making the dollar attractive as a hedge against negative income movements which is reflected in the negative value of this beta measure. The series of local and foreign interest rates, and the exchange rate of the local currencies against the dollar are used to estimate the average UIP deviations for the sampled period; a negative value indicates that the peso offers a higher average return relative to the dollar.

Table 3: Country statistics

	ARG	CHL	MEX	PER	PRY	URY
\widehat{UIP}	.7	.05	.23	-.18	-.14	-.13
$\hat{\sigma}_{\epsilon}$	6.12	3.36	3.06	1.41	2.93	3.7
$\hat{\beta}_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}}$.16	.1	.04	.26	.14	.21
$\hat{\beta}_{\frac{dy}{y}, \frac{d\epsilon}{\epsilon}}$	-.36	-.36	-.28	-.55	-.49	-.51

Note: \widehat{UIP} is the average return differential of the dollar relative to the peso, based on monthly data for the entire sample period spanning the last two decades, as in Figure 3 (for Argentina, the sample period begins in 2002m3 so it excludes the period when the country abandoned the currency peg with the dollar). $\hat{\sigma}_{\epsilon}$ is the standard deviation of the exchange rate based on IFS data. $\hat{\beta}_{\frac{dP}{P}, \frac{d\epsilon}{\epsilon}}$ is the long-run pass-through into CPI prices of exchange rate depreciations, computed with 18-lags of monthly data as in Figure 2. $\hat{\beta}_{\frac{dy}{y}, \frac{d\epsilon}{\epsilon}}$ is the beta of regressing real GDP annual growth on exchange rate depreciations, based on IFS data.

The two degrees of freedom in this exercise are the risk aversion of the agent and the coefficient that multiplies the beta of income growth on depreciations, which depends on the sensitivity of the value function to changes in income.¹⁴ For the latter, I rely on micro-level evidence from Uruguay

¹⁴It is straightforward to show that expression 51 solves the Bellman equation of the portfolio problem for some

and calibrate this coefficient to be -1 for all countries. Finally, Table 4 shows the predicted values of dollarization for each country if we assume that they all share the same γ , calibrated to be that which minimizes the mean squared error of predictions across the sample (row 2). Figure 6 depicts these observed and predicted values of dollarization. Notably, the γ required to obtain the best possible fit overall (2.3) is consistent with the standard values in the literature. To achieve a perfect fit, households in the more dollarized economies (Argentina, Peru and Uruguay) would require a higher risk aversion (as high as 3.1 for Uruguay), while the model implies a lower risk aversion for the less dollarized countries (Chile and Mexico).

Table 4: Observed and predicted dollarization

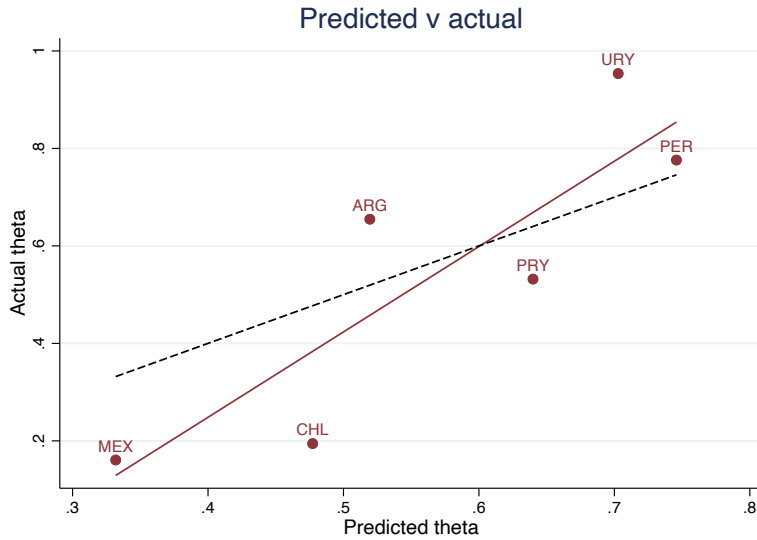
	ARG	CHL	MEX	PER	PRY	URY
θ_c^s	0.65	0.19	0.16	0.78	0.53	0.95
$\hat{\theta}_c^s$ with $\gamma = 2.308$	0.52	0.48	0.35	0.75	0.64	0.70
γ^*	2.9	1.1	1.2	2.4	1.9	3.1

Note: The first row shows the observed measures of dollarization for each country, averaged over the sample period. The second row shows the predicted levels according to the model, where I calibrate γ to be the same for all countries; in particular I compute $\gamma = \underset{\gamma}{\operatorname{argmin}} \sum_c (\hat{\theta}_c^s - \theta_c^s)^2 = 2.308$. The third row shows what γ^* can achieve a perfect match of the predicted and observed measures of dollarization.

I can further decompose the predicted dollarization into the three components that the model suggests are behind an agent's portfolio choice according to expression 51. Figure 7 shows the result from this decomposition and gives a sense of which ones matter more for each economy. Argentina is an example of a country in which important episodes of exchange rate depreciation have implied that the dollar offers a higher expected average return in pesos. The general equilibrium intuitions from Section 3 would suggest that in this country the hedging motives that households have for saving in dollars are not strong enough to justify peso returns that more than compensate for the large depreciations of the currency. In a country like Peru, on the contrary, the local currency offers a higher return and the decomposition results suggest that it is the negative correlation between growth and depreciations that matters more in driving the agents to dollarize their portfolios. Across all countries, this income-hedging motive is behind more than 80% of predicted dollarization. The price-hedging term is large enough to counteract the force of UIP deviations that drive dollarization down for those countries in which the local currency offers a higher mean return, but the income motive is needed to justify the high levels of dollarization that we observe.

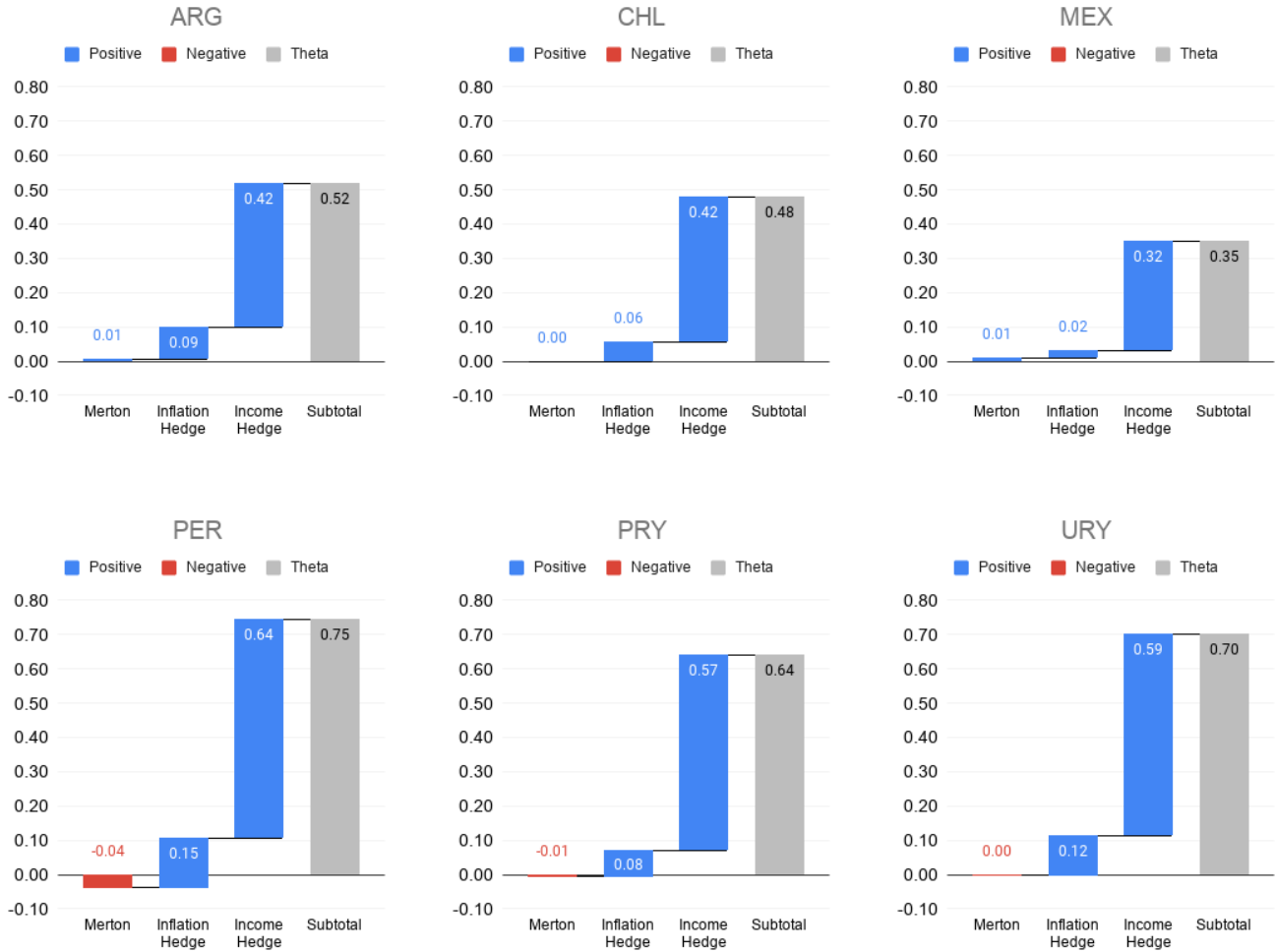
implicit function ϕ_t . Finding an explicit function to calibrate $\frac{\nu_t^y}{\gamma} y_t = \frac{1-\gamma}{\gamma} \frac{\phi_t^y}{\phi_t} y_t$ is less straightforward. One possibility is to find an approximate analytical solution following the methods in Campbell et al (2004) which require one to compute log linear approximations to the optimal consumption-wealth ratio. An alternative, which I follow here, is to rely on the micro level evidence to estimate this coefficient.

Figure 6: Predicted v observed dollarization



Note: $\theta^{\$}$ is the share of household net deposits in dollars. To compute the observed $\theta^{\$}$ I use monthly observations on dollarization of deposits and loans as reported in the consolidated balance sheet of the domestic banking sector provided by the Central Banks of each country. In the model, this variable represents a net position, so I subtract dollar loans for consumption and mortgages from the observed aggregate dollar deposits. Finally, I compute the average monthly value by taking the mean over the sample period for each country. To compute the predicted $\hat{\theta}^{\$}$ I calibrate expression 51. This expression includes four terms that are estimated with monthly data: average UIP deviation, volatility of the exchange rate against the dollar, pass-through of depreciations into prices and the beta of regressing real GDP growth on depreciations. There are two degrees of freedom: the risk aversion of the country, which pins down the coefficients from the first two terms in 51 that multiply the UIP deviation and the pass-through into prices; and the coefficient on the beta of income from the third term. I calibrate the risk aversion to be the same for all countries and equal to the value that minimizes the MSE of predictions (2.3); the coefficient on the beta of real GDP is taken to be -1 based on empirical micro evidence from Uruguay.

Figure 7: Contribution of UIP and hedging motives to dollarization



Note: These plots show how the model prediction on dollarization, $\hat{\theta}^S$, is decomposed into the three terms in expression 51. For details, refer to the note on Figure 6.

5.2 Predicted dollarization across Uruguay households

Expression 51 predicts that dollarization of portfolios should increase if depreciations of the exchange rate pass-through into the price of the household’s consumption basket and if the household’s income is negative correlated to these depreciations. While the macro data shows that there exist cross-country patterns of dollarization that are consistent with the drivers of dollar demand that the model would predict, the evidence relies on country-level estimates of the relevant statistics (pass-through into the general price level and GDP growth). A better test for the micro-founding elements of dollarization requires household-level data that can account for agents having differing pass-through into wages and prices. To that end, I use data on a cross-section of households from Uruguay. Note that we require information on the currency composition of their financial portfolios, the pass-through into the price of the household’s consumption basket, and the pass-through into the household’s income. Because there is no one unique dataset that provides all this information at the household level, I extract and merge information from various sources, summarized in Table 5.

Table 5: Data sources

Source	Key information
Household financial survey 2012	Currency composition savings and debt
Household standard survey 2012	Sector of employment
Household expenditure and income survey 2016	Expenditure by category of goods/services
Central Bank of Uruguay	Price series by category of goods/services; wage index series by sector
International Financial Statistics IMF	Exchange rate data

My starting point is a household financial survey that was conducted in Uruguay in 2012 and provides the crucial information on currency composition of assets and liabilities for a sample of 2553 households (Encuesta Financiera de Hogares del Uruguay - EFHU). The sample of households in this survey is a subset of those interviewed for the standard annual household survey from 2012 (Encuesta Continua de Hogares - ECH) which contains a variable that indicates the sector of employment at the ISIC level of the employed individuals in each household. Table 7 in the Appendix summarizes basic descriptive statistics from this sample. More than 30% of the households report holding almost 100% of their bank deposits in dollars, another 30% hold no dollar savings and more than 10% have at least half of their bank assets in dollars.

While there is no available time series of income for each household, the Central Bank of Uruguay does provide a times series of wage indices by sector. I use this to derive a pass-through of the exchange rate into wages by sector (see Figure 15 in the Appendix) and impute it to each household in the financial survey based on their reported sector of employment. All employed people

in the sample have an ISIC code for their sector of employment, and 73% are employed in sectors for which a wage index is available to compute a pass-through. At the household level, 74%, or a total of 1884 units, have at least one employed member for which I can impute a pass-through. If a household has more than one employed member, I consider an average of the pass-through into their respective wages.

Finally, the household expenditure and income survey (Encuesta Nacional de Gastos e Ingresos de los Hogares - ENGIH) from 2016 contains data on expenditures by category of goods and services, as well as several other variables that are also included in the standard annual household survey of 2012. I use the time series of prices by category of goods and services that the Central Bank of Uruguay publishes to estimate the exchange rate pass-through into prices by category (see Figure 19 in the Appendix), and combine this with the expenditure survey data to derive a pass-through into the consumption basket of each household. Specifically, I compute the share spent in each of twelve categories of goods and services and construct the overall pass-through by taking a weighted average of the pass-through measures for each category:

$$erpt^i = s_1^i ERPT_1 + \dots + s_{12}^i ERPT_{12}$$

Where s_j^i is the share of expenditure allocated to category j by household i (see Figure 20 in the Appendix) and $ERPT_j$ is the long-run pass-through for category j . The variables that the expenditure and standard surveys share (including income, education and composition of the household) can then be used to impute a pass-through measure for each household in the financial survey.

Once we account for those units that have at least one member employed and also report some form of savings, we are left with 1242 observations. Table 6 shows the results from regressing two measures of dollarization on the estimated pass-through into prices and wages at the household-level. θ_1 is constructed based on the share of dollar bank deposits reported by each household, while θ_2 considers as well deposits denominated in euros - it should be noted, though, that for all households the main foreign currency used for savings is the US dollar.

Results suggest that the pass-through into prices has a positive significant impact on dollar savings, and the coefficient is consistent with a risk aversion of around 2.5¹⁵. The pass-through into wages has a negative impact on dollarization (albeit insignificant), so if wage growth decreases when the dollar appreciates, the household increases dollar savings. The sign of both coefficients points in the direction of the drivers that the model highlights are behind the “stubborn” dollarization of countries like Uruguay: the dollar has two attractive hedging properties for the households, as it preserves real savings from inflation that is correlated to depreciations of the domestic currency, and it also offers a higher pay-off (i.e., it appreciates relative to the peso) in “bad” times for income

¹⁵Recall that the coefficient that multiplies the pass-through into prices according to expression 51 is $\frac{\gamma-1}{\gamma}$.

Table 6: Results

	θ_1		θ_2	
Pass-through Prices	0.70*** (.25)	0.67*** (.24)	0.63*** (.25)	0.59*** (.24)
Pass-through Wage	-0.29 (.25)	-1.11 (.47)	-0.36 (.26)	-0.89 (.46)
Demographic Controls	N	Y	N	Y
Poverty Controls	N	Y	N	Y
R^2	.01	.03	.01	.03
N	1242	1242	1242	1242

Note: Standard errors in parentheses. * ($p < 0.05$), ** ($p < 0.01$), *** ($p < 0.001$). θ_1 is the share of bank deposits that households report holding in dollars; θ_2 includes deposits in euros. These are regressed against a household-specific measure of pass-through into the price level of the consumption basket, and a measure of pass-through into the household's labor income. To obtain the former, I take the household's expenditure shares into twelve categories of goods and services as weights to compute a weighted average pass-through into prices. Data on the pass-through into the price level of each category is based on CPI data from the Central Bank. I compute these weighted averages for a sample of households surveyed in 2016 for which expenditure data is available. Then I match these measures of pass-through to the households from the financial survey of 2012 using common variables to both surveys. To obtain a measure of pass-through into wages, I consider the sector of employment of the members of the household (through a variable that indicates the ISIC code) and compute a pass-through into wages for each sector based on wage index data from the Central Bank. Demographic controls in the final regressions include: the share of women in the household, the number of children under 14 years, the number of adults over 60 years, the number of unemployed. Poverty controls include variables that indicate whether the household is the recipient of special state income transfers and food stamps.

growth.

6 Conclusion

This paper explores the conditions under which dollarization can arise within a country, in a context in which regulations limit the currency exposure of banks and the international flows of capital. In a portfolio problem that micro-founds the optimal choice of a household that is choosing how much of her wealth to allocate into a dollar and a peso-denominated bond, three factors emerge as the main drivers. First, dollar demand decreases when the peso offers a risk premium over the dollar. Second, if appreciations of the dollar pass-through into prices, an agent will tend to save more in dollars to preserve the real value of savings. Third, if the dollar tends to appreciate when real income is lower, this will increase dollarization because the agent will save in the currency that promises higher returns in bad times.

The dollarization patterns that we observe in emerging markets can be understood as an equilibrium of risk transfer between households and firms. In this equilibrium, households are saving in dollars and providing these dollars to entrepreneurs that hold dollar debt. Because UIP fails in favor of the peso, the household is incurring a cost from saving in the currency that offers a lower expected return, but she is willing to do so in exchange for insurance against a negative exposure to depreciations. In turn, the entrepreneur takes on a cheaper form of debt in exchange for providing this insurance. This will take place under two possible scenarios: the agents share a reason for wanting to save in dollars, but entrepreneurs have a higher tolerance for risk; or they have the same risk aversion, but they are exposed differently to exchange rate movements (in particular, the household is more negatively exposed than the entrepreneur). In this model, capital controls that prevent the agents from engaging in this form of insurance with foreign investors increase dollarization within the country.

The general equilibrium model can then rationalize four empirical facts. First, countries that exhibit high dollarization of domestic savings also exhibit high dollarization of domestic corporate debt. Second, higher dollarization is related to a higher pass-through into prices. Third, countries with high dollarization have a negative correlation of real GDP growth and dollar appreciations. Fourth, countries with higher dollarization are countries in which dollar returns are lower (i.e., dollar debt is cheaper). This final fact would appear counterintuitive if we only relied on the partial equilibrium intuitions from the portfolio problem that indicate that optimal dollar demand should decrease when the peso offers a higher risk premium over the dollar. Rather, it is a general equilibrium result that arises from the interaction between households and entrepreneurs.

The macro evidence points towards the income hedging motive as a key driver of dollarization

of household's deposits. The predicted levels of dollarization at the country-level are consistent with the observed levels of dollarization with an implied risk aversion of 2.3. Micro-level data from Uruguay is also consistent with the model's predictions on what drives dollarization: the pass-through into prices has a positive significant impact on dollar savings (and the coefficient is consistent with a risk aversion around 2.5), while the pass-through into wages has a negative (although insignificant) impact on dollarization.

7 References

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8 Appendix

8.1 Empirical facts

Figure 8: Dollar liabilities from domestic banks

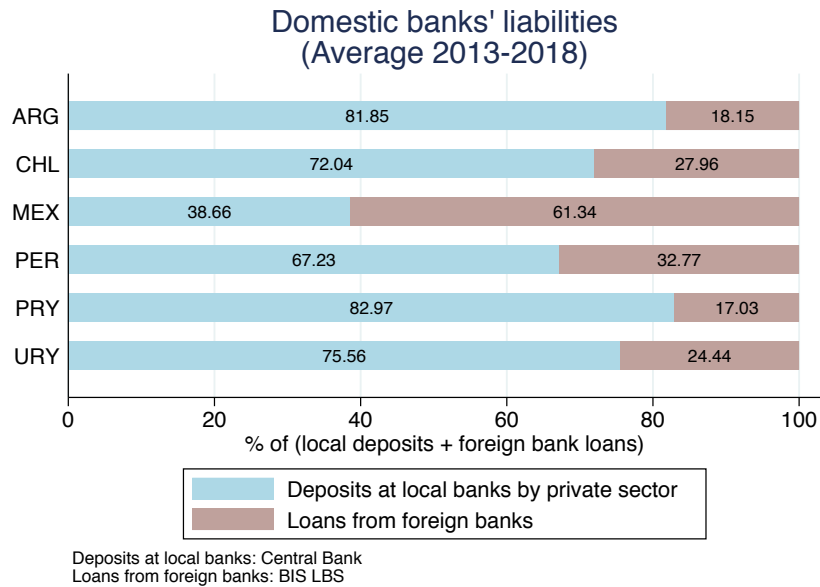


Figure 9: Types of corporate dollar debt

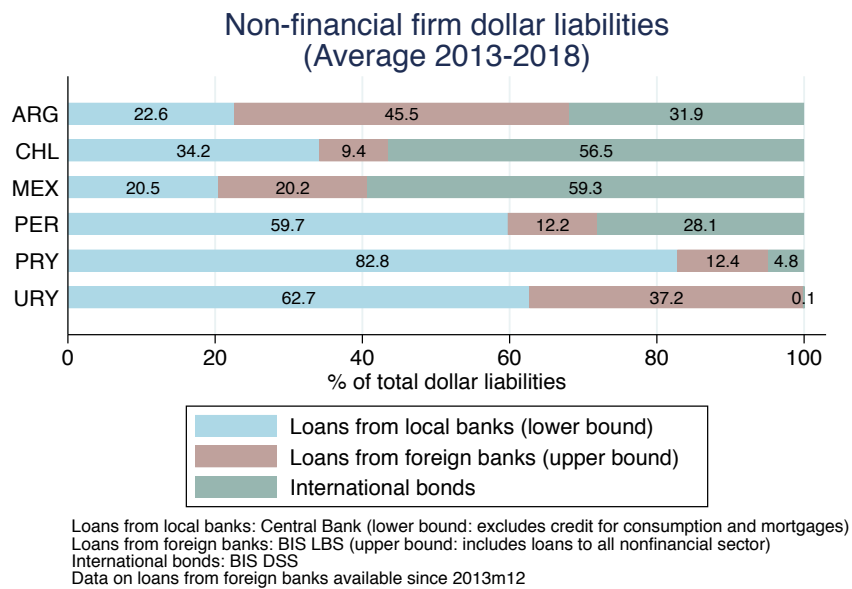


Figure 10: Household dollar deposits

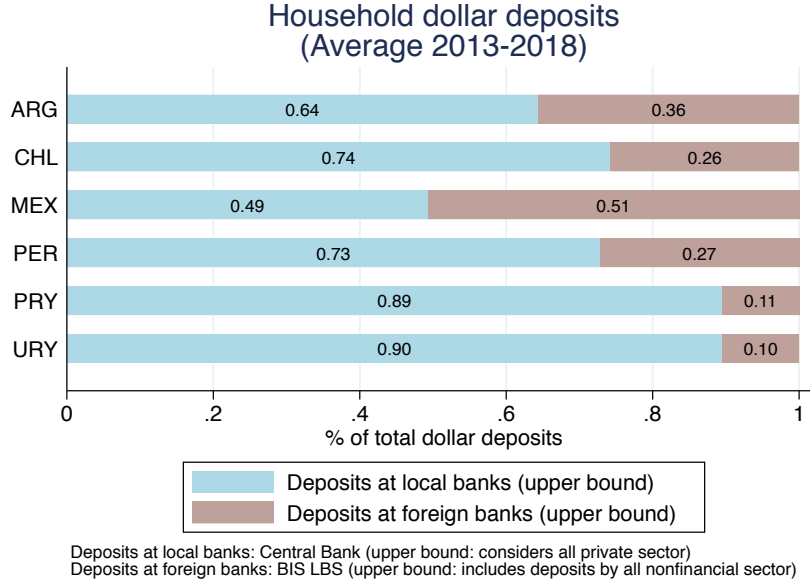
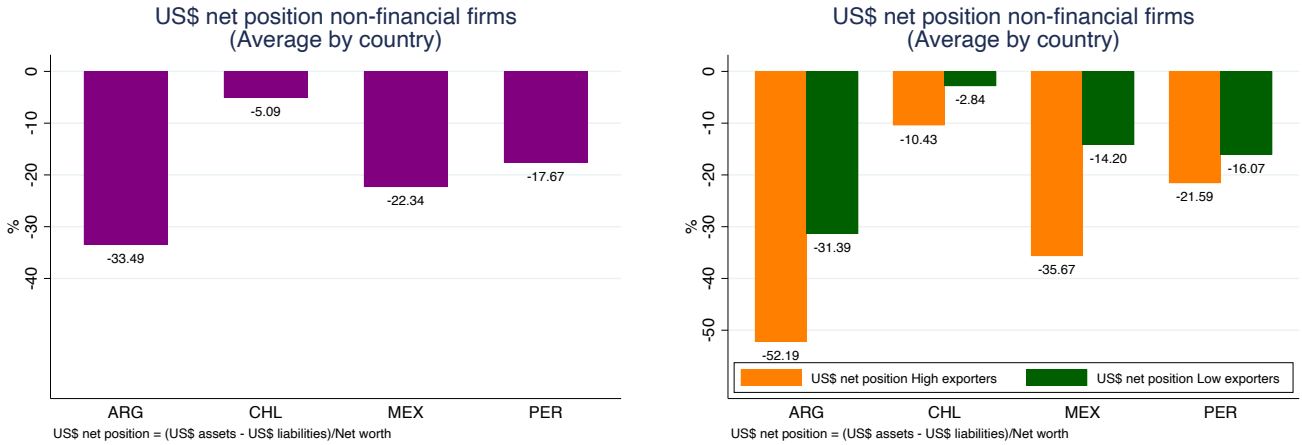


Figure 11: Dollar position of non-financial firms



Note: Non-financial firms have a negative net dollar position (purple), and exporting firms (orange) have a larger negative position than low or non-exporting firms (green). Values are based on author's calculations using data on non-financial firms for the period 1990-2002 from Kamil (2004, IDB).

8.2 Equilibrium conditions

The equilibrium prices can be obtained from the following system of equations:

$$c_1^h = \left(\frac{P_0}{P_1} \frac{1}{q_0^{LC}} + \theta^{s,h} \left(\frac{P_0}{P_1} \frac{\epsilon_1}{\epsilon_0 q_0^s} - \frac{P_0}{P_1} \frac{1}{q_0^{LC}} \right) \right) \frac{W_0^h}{P_0} + y_1^h \quad (68)$$

$$c_1^e = \left(\frac{P_0}{P_1} \frac{1}{q_0^{LC}} + \theta^{s,e} \left(\frac{P_0}{P_1} \frac{\epsilon_1}{\epsilon_0 q_0^s} - \frac{P_0}{P_1} \frac{1}{q_0^{LC}} \right) \right) \frac{W_0^e}{P_0} + y_1^e \quad (69)$$

$$\theta^{s,h} \frac{W_0^h}{P_0} = \frac{\mu^s - \mu^{LC}}{\gamma^h(\sigma_s^2 + \sigma_{LC}^2 - 2\sigma_s\sigma_{LC})} + \frac{W_0^h}{P_0} \frac{\sigma_{LC}^2 - \sigma_{LC,s}}{\sigma_s^2 + \sigma_{LC}^2 - 2\sigma_s\sigma_{LC}} - \frac{\sigma_{s,y_1^h} - \sigma_{LC,y_1^h}}{\sigma_s^2 + \sigma_{LC}^2 - 2\sigma_s\sigma_{LC}} \quad (70)$$

$$\theta^{s,e} \frac{W_0^e}{P_0} = \frac{\mu^s - \mu^{LC}}{\gamma^e(\sigma_s^2 + \sigma_{LC}^2 - 2\sigma_s\sigma_{LC})} + \frac{W_0^e}{P_0} \frac{\sigma_{LC}^2 - \sigma_{LC,s}}{\sigma_s^2 + \sigma_{LC}^2 - 2\sigma_s\sigma_{LC}} - \frac{\sigma_{s,y_1^e} - \sigma_{LC,y_1^e}}{\sigma_s^2 + \sigma_{LC}^2 - 2\sigma_s\sigma_{LC}} \quad (71)$$

$$c_1^{NT,h} = \delta P_1 c_1^h \quad (72)$$

$$c_1^{H,h} = \frac{(1-\delta)\alpha P_1 c_1^h}{p_1^H} \quad (73)$$

$$c_1^{F,h} = \frac{(1-\delta)(1-\alpha)P_1 c_1^h}{\epsilon_1 p_1^F} \quad (74)$$

$$c_1^{NT,e} = \delta P_1 c_1^e \quad (75)$$

$$c_1^{H,e} = \frac{(1-\delta)\alpha P_1 c_1^e}{p_1^H} \quad (76)$$

$$c_1^{F,e} = \frac{(1-\delta)(1-\alpha)P_1 c_1^e}{\epsilon_1 p_1^F} \quad (77)$$

$$P_1 = \left(\frac{1}{\delta} \right)^\delta \left(\frac{p_1^H}{\alpha(1-\delta)} \right)^{\alpha(1-\delta)} \left(\frac{\epsilon_1 p_1^F}{(1-\alpha)(1-\delta)} \right)^{(1-\alpha)(1-\delta)} \quad (78)$$

$$c_1^{NT,h} + c_1^{NT,e} = y_1^{NT} \quad (79)$$

$$c_1^{H,h} + c_1^{H,e} + c_1^{H,*} = y_1^H \quad (80)$$

$$\frac{(1-\theta^{s,h})W_0^h}{q_0^{LC}} + \frac{(1-\theta^{s,e})W_0^e}{q_0^{LC}} = 0 \quad (81)$$

$$\frac{\theta^{s,h}W_0^h}{\epsilon_0 q_0^s} + \frac{\theta^{s,e}W_0^e}{\epsilon_0 q_0^s} = b_1^* \quad (82)$$

The (15) variables to solve for are:

$$c_1(s), c_1^{NT}(s), c_1^H(s), c_1^F(s) \text{ for e and h}$$

$$\theta^s \text{ for e and h}$$

$$P_1(s), p_1^H(s), \epsilon_1(s)$$

$$q_0^{LC}, q_0^s$$

From budget constraints, aggregate consumption is:

$$c_1^h + c_1^e = \frac{P_0}{P_1} \frac{1}{q_0^{LC}} \frac{W_0^h + W_0^e}{P_0} + \left(\theta^{s,h} \frac{W_0^h}{P_0} + \theta^{s,e} \frac{W_0^e}{P_0} \right) \left(\frac{P_0}{P_1} \frac{\epsilon_1}{\epsilon_0 q_0^s} - \frac{P_0}{P_1} \frac{1}{q_0^{LC}} \right) + y_1^h + y_1^e$$

$$c_1^h + c_1^e = \frac{1}{q_0^{LC}} \frac{W_0^h + W_0^e}{P_1} + (\theta^{s,h} W_0^h + \theta^{s,e} W_0^e) \left(\frac{1}{P_1} \frac{\epsilon_1}{\epsilon_0 q_0^s} - \frac{1}{P_1} \frac{1}{q_0^{LC}} \right) + y_1^h + y_1^e$$

Recall $P_1(y_1^h + y_1^e) \equiv y_1^{NT} + p_1^H y_1^H$ and $\theta^{s,i} W_0^i = \epsilon_0 q_0^s b_1^{s,i}$ and $W_0 = \theta^{s,h} W_0^h + \theta^{s,e} W_0^e = \epsilon_0 q_0^s b_1^*$:

$$c_1^h + c_1^e = \frac{1}{q_0^{LC}} \frac{\epsilon_0 q_0^s b_1^*}{P_1} + \epsilon_0 q_0^s b_1^* \left(\frac{1}{P_1} \frac{\epsilon_1}{\epsilon_0 q_0^s} - \frac{1}{P_1} \frac{1}{q_0^{LC}} \right) + \frac{y_1^{NT} + p_1^H y_1^H}{P_1}$$

$$P_1 c_1 = \frac{1}{q_0^{LC}} \epsilon_0 q_0^s b_1^* + b_1^* \left(\epsilon_1 - \frac{\epsilon_0 q_0^s}{q_0^{LC}} \right) + y_1^{NT} + p_1^H y_1^H$$

$$P_1 c_1 = b_1^* \epsilon_1 + y_1^{NT} + p_1^H y_1^H$$

Similarly for foreign investors, we could write (expressed in dollars):

$$P_1^* c_1^* = -b_1^* + y_1^{NT,*} + p_1^F y_1^F$$

The balance of payments equation is satisfied:

$$NX_1 \equiv p_1^H c_1^{H,*} - \epsilon_1 p_1^F (y_1^F - c_1^{F,*}) = -\epsilon_1 b_1^*$$

With:

$$c_1^{H,*} = \frac{(1 - \delta^*)(1 - \alpha^*) P_1^* c_1^*}{p_1^H / \epsilon_1} = \frac{(1 - \delta^*)(1 - \alpha^*)(-b_1^* + y_1^{NT,*} + p_1^F y_1^F)}{p_1^H / \epsilon_1}$$

$$c_1^{F,*} = \frac{(1 - \delta^*) \alpha^* P_1^* c_1^*}{p_1^F} = \frac{(1 - \delta^*) \alpha^* (-b_1^* + y_1^{NT,*} + p_1^F y_1^F)}{p_1^F}$$

From the market clearing condition of home non-tradables and the expressions for demand of non-tradables:

$$c_1^{NT,h} + c_1^{NT,e} = y_1^{NT}$$

$$\delta P_1 c_1^h + \delta P_1 c_1^e = y_1^{NT}$$

$$\delta P_1 (c_1^h + c_1^e) = y_1^{NT}$$

$$\delta P_1 c_1 = y_1^{NT}$$

$$\delta (b_1^* \epsilon_1 + y_1^{NT} + p_1^H y_1^H) = y_1^{NT}$$

$$\epsilon_1 = \frac{(1 - \delta)y_1^{NT} - \delta p_1^H y_1^H}{\delta b_1^*}$$

From the market clearing condition of home tradables and the expressions for demand of tradables:

$$\begin{aligned} c_1^{H,h} + c_1^{H,e} &= y_1^H - c_1^{H,*} \\ \frac{(1 - \delta)\alpha P_1 c_1^h}{p_1^H} + \frac{(1 - \delta)\alpha P_1 c_1^e}{p_1^H} &= y_1^H - c_1^{H,*} \\ \frac{(1 - \delta)\alpha P_1 c_1}{p_1^H} &= y_1^H - c_1^{H,*} \\ \frac{(1 - \delta)\alpha(b_1^* \epsilon_1 + y_1^{NT} + p_1^H y_1^H)}{p_1^H} &= y_1^H - c_1^{H,*} \\ (1 - \delta)\alpha b_1^* \epsilon_1 &= (1 - (1 - \delta)\alpha)p_1^H y_1^H - p_1^H c_1^{H,*} - (1 - \delta)\alpha y_1^{NT} \\ \epsilon_1 &= \frac{(1 - (1 - \delta)\alpha)p_1^H y_1^H - p_1^H c_1^{H,*} - (1 - \delta)\alpha y_1^{NT}}{(1 - \delta)\alpha b_1^*} \end{aligned}$$

Equating both expressions for ϵ_1 :

$$\begin{aligned} \frac{(1 - \delta)y_1^{NT} - \delta p_1^H y_1^H}{\delta b_1^*} &= \frac{(1 - (1 - \delta)\alpha)p_1^H y_1^H - p_1^H c_1^{H,*} - (1 - \delta)\alpha y_1^{NT}}{(1 - \delta)\alpha b_1^*} \\ \frac{(1 - \delta)y_1^{NT} - \delta p_1^H y_1^H}{\delta} &= \frac{(1 - (1 - \delta)\alpha)p_1^H y_1^H - p_1^H c_1^{H,*} - (1 - \delta)\alpha y_1^{NT}}{(1 - \delta)\alpha} \\ \frac{(1 - \delta)}{\delta} y_1^{NT} - p_1^H y_1^H &= \frac{(1 - (1 - \delta)\alpha)y_1^H - c_1^{H,*}}{(1 - \delta)\alpha} p_1^H - y_1^{NT} \\ \frac{1}{\delta} y_1^{NT} &= \frac{y_1^H - c_1^{H,*}}{(1 - \delta)\alpha} p_1^H \\ p_1^H &= \frac{(1 - \delta)\alpha}{\delta} \frac{y_1^{NT}}{y_1^H - c_1^{H,*}} \end{aligned}$$

Denoting $c_1^{H,*} = \frac{\nu}{p_1^H/\epsilon_1}$:

$$\begin{aligned} p_1^H &= \frac{(1 - \delta)\alpha}{\delta} \frac{y_1^{NT}}{y_1^H - \frac{\epsilon_1 \nu}{p_1^H}} \\ p_1^H y_1^H - \epsilon_1 \nu &= \frac{(1 - \delta)\alpha}{\delta} y_1^{NT} \\ p_1^H y_1^H &= \frac{(1 - \delta)\alpha}{\delta} y_1^{NT} + \epsilon_1 \nu \end{aligned}$$

Replacing for ϵ_1 :

$$\begin{aligned}\epsilon_1 &= \frac{(1-\delta)y_1^{NT} - \delta p_1^H y_1^H}{\delta b_1^*} \\ \epsilon_1 &= \frac{y_1^{NT}}{b_1^*} \frac{(1-\delta)}{\delta} - \frac{p_1^H y_1^H}{b_1^*} \\ \epsilon_1 &= \frac{y_1^{NT}}{b_1^*} \frac{(1-\delta)(1-\alpha)}{\delta} - \frac{\epsilon_1 \nu}{b_1^*} \\ \left(1 + \frac{\nu}{b_1^*}\right) \epsilon_1 &= \frac{y_1^{NT}}{b_1^*} \frac{(1-\delta)(1-\alpha)}{\delta} \\ (b_1^* + \nu) \epsilon_1 &= y_1^{NT} \frac{(1-\delta)(1-\alpha)}{\delta} \\ \epsilon_1 &= \frac{y_1^{NT}}{b_1^* + \nu} \frac{(1-\delta)(1-\alpha)}{\delta}\end{aligned}$$

Replacing for p_1^H :

$$\begin{aligned}p_1^H y_1^H &= \frac{(1-\delta)\alpha}{\delta} y_1^{NT} + \frac{(1-\delta)(1-\alpha)}{\delta} y_1^{NT} \frac{\nu}{b_1^* + \nu} \\ p_1^H &= \frac{\frac{(1-\delta)\alpha}{\delta} y_1^{NT} + \frac{(1-\delta)(1-\alpha)}{\delta} y_1^{NT} \frac{\nu}{b_1^* + \nu}}{y_1^H} \\ p_1^H &= \frac{(1-\delta)}{\delta} \frac{y_1^{NT}}{y_1^H} \left(\alpha + (1-\alpha) \frac{\nu}{b_1^* + \nu} \right)\end{aligned}$$

The equilibrium price of foreign tradables is:

$$p_1^F = \frac{b_1^* + \frac{1-\delta^*}{\delta^*} y_1^{NT,*}}{y_1^F}$$

Then we can replace in ν :

$$\begin{aligned}\nu &= (1-\delta^*)(1-\alpha^*)(-b_1^* + y_1^{NT,*} + p_1^F y_1^F) \\ \nu &= (1-\delta^*)(1-\alpha^*) \left(-b_1^* + y_1^{NT,*} + b_1^* + \frac{1-\delta^*}{\delta^*} y_1^{NT,*} \right) \\ \nu &= (1-\delta^*)(1-\alpha^*) \left(y_1^{NT,*} + \frac{1-\delta^*}{\delta^*} y_1^{NT,*} \right) \\ \nu &= \frac{(1-\delta^*)(1-\alpha^*)}{\delta^*} y_1^{NT,*}\end{aligned}$$

So then the exchange rate in equilibrium is:

$$\epsilon_1 = \frac{\frac{(1-\delta)(1-\alpha)}{\delta} y_1^{NT}}{\frac{(1-\delta^*)(1-\alpha^*)}{\delta^*} y_1^{NT,*} + b_1^*}$$

A rearrangement of terms in the equilibrium prices of tradables renders the expressions:

$$p_1^H = \frac{\epsilon_1 \frac{(1-\delta^*)(1-\alpha^*)}{\delta^*} y_1^{NT,*} + \frac{(1-\delta)\alpha}{\delta} y_1^{NT}}{y_1^H}$$

$$p_1^F = \frac{\frac{1}{\epsilon_1} \frac{(1-\delta)(1-\alpha)}{\delta} y_1^{NT} + \frac{(1-\delta^*)\alpha^*}{\delta^*} y_1^{NT}}{y_1^F}$$

To derive the price level:

$$P_1 = \underbrace{\left(\frac{1}{\delta}\right)^\delta \left(\frac{1}{\alpha(1-\delta)}\right)^{\alpha(1-\delta)} \left(\frac{1}{(1-\alpha)(1-\delta)}\right)^{(1-\alpha)(1-\delta)}}_{\equiv \Omega(\alpha,\delta)} (p_1^H)^{\alpha(1-\delta)} (\epsilon_1 p_1^F)^{(1-\alpha)(1-\delta)} \quad (83)$$

Replacing the equilibrium expressions for the exchange rate and price of tradables:

$$P_1 = \left(\frac{1}{\delta}\right)^\delta \left(\frac{1}{\alpha(1-\delta)}\right)^{\alpha(1-\delta)} \left(\frac{1}{(1-\alpha)(1-\delta)}\right)^{(1-\alpha)(1-\delta)}$$

$$\left(\frac{\epsilon_1 \frac{(1-\delta^*)(1-\alpha^*)}{\delta^*} y_1^{NT,*} + \frac{(1-\delta)\alpha}{\delta} y_1^{NT}}{y_1^H}\right)^{\alpha(1-\delta)} \left(\frac{\frac{(1-\delta)(1-\alpha)}{\delta} y_1^{NT} + \epsilon_1 \frac{(1-\delta^*)\alpha^*}{\delta^*} y_1^{NT}}{y_1^F}\right)^{(1-\alpha)(1-\delta)}$$

From this expression it is clear that a depreciation of the local currency (an increase in ϵ_1) will pass-through into the price level.

8.3 Predicted dollarization across Uruguay households

Table 7: Summary statistics

	Mean	Std Dev
Number of people	3.09	1.65
Younger than 14	0.56	1.00
Primary	91.89	21.99
Secondary	34.69	39.91
Higher education	26.34	34.70
Employed	55.28	32.70
Unemployed	2.26	9.09
Inactive	30.05	33.62
Observations	2553	

Education and employment stats refer to the share of people in a household that are over 14 yo and: have X level of education/ are employed / etc.

Figure 12: Distribution of dollar and peso savings

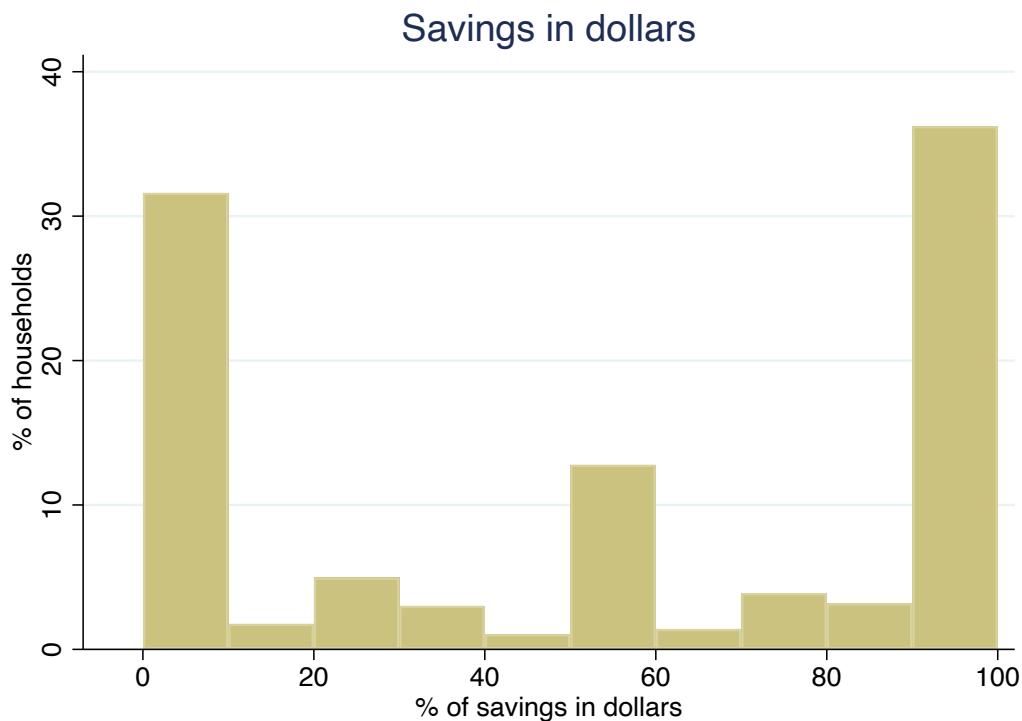


Figure 13: Exchange rate uruguay peso v US dollar

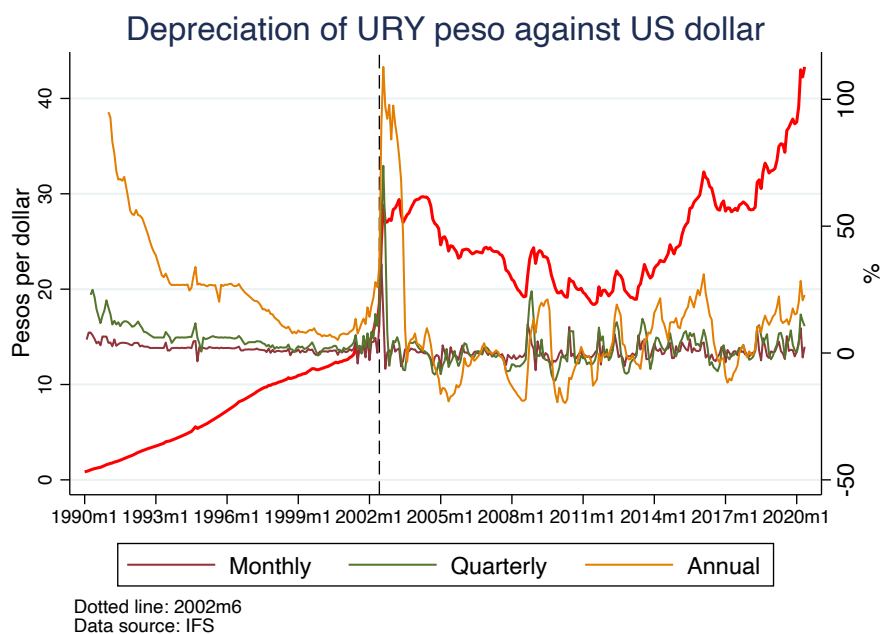


Figure 14: Wage index series

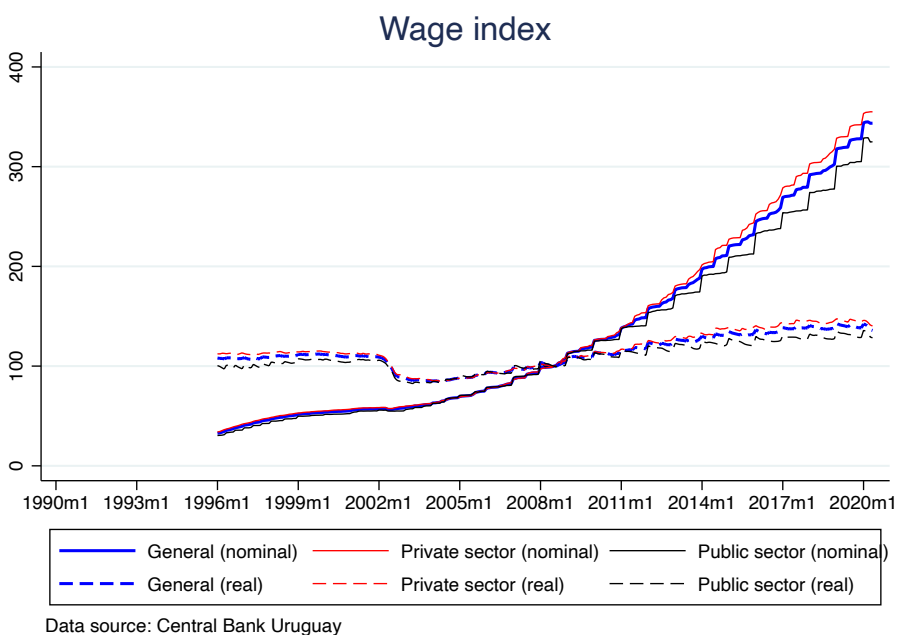


Table 8: Pass-through into wages

	(1)	(2)	(3)
	General	Private sector	Public sector
$\Delta\%$ ER	-0.0357** (0.0138)	-0.0252* (0.0112)	-0.0559* (0.0253)
LRPT	-0.055	-0.061	-0.047
s.e. LRPT	.0579469	.0578943	.0642417
R-squared	.0098264	.0071397	.0088826
Observations	292	292	292

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Pass-through into wages

	(1)	(2)	(3)	(4)
	Manufacturing	Construction	Trade	Hotels and restaurants
$\Delta\%$ ER	-0.0424 (0.0253)	-0.0868 (0.118)	-0.0508 (0.0342)	-0.0303 (0.0368)
LRPT	-0.074	0.036	-0.129	-0.111
s.e. LRPT	.0471986	.0833999	.067639	.0920961
R-squared	.0123133	.0061719	.01129	.0038982
Observations	209	209	209	209

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

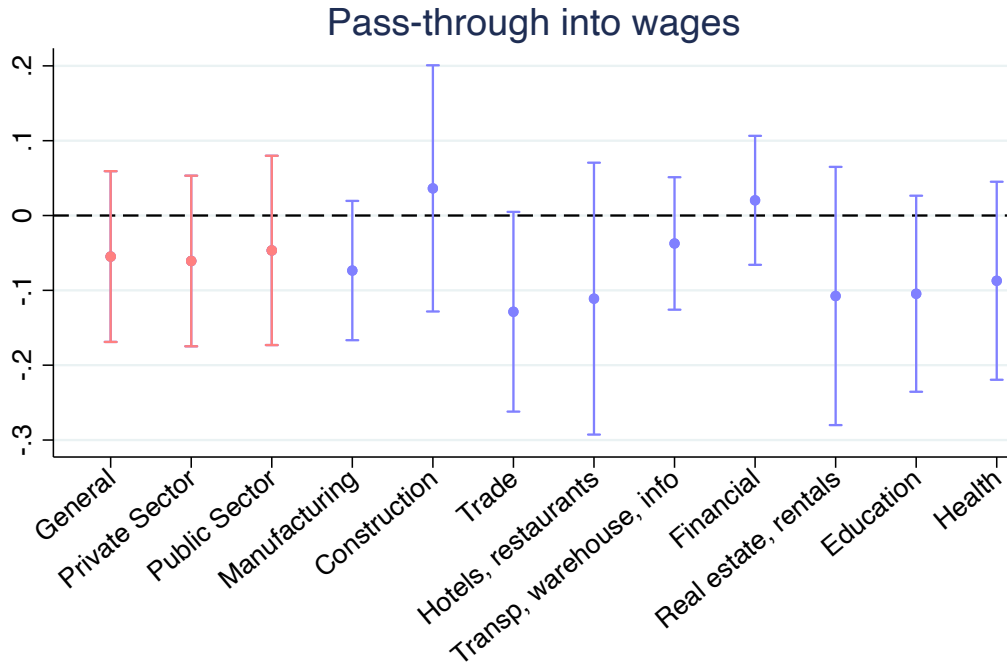
Table 10: Pass-through into wages

	(1)	(2)	(3)	(4)	(5)
	Transp, warehouse, info	Financial	Real estate, rentals	Educ	Health
$\Delta\%$ ER	-0.0213 (0.0278)	0.0231 (0.0391)	-0.0486 (0.0338)	0.0181 (0.0341)	0.00631 (0.0346)
LRPT	-0.037	0.020	-0.108	-0.105	-0.087
s.e. LRPT	.0448733	.0436874	.0874717	.0664055	.0670797
R-squared	.0033858	.00091	.0046832	.0041299	.0004159
Observations	209	209	209	209	209

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 15: Pass-through into wages, by sector (aggregate categories)



Note: nominal wage index used. Long-run pass-through computed using 18 lags with monthly data.

Figure 16: Sector of employment

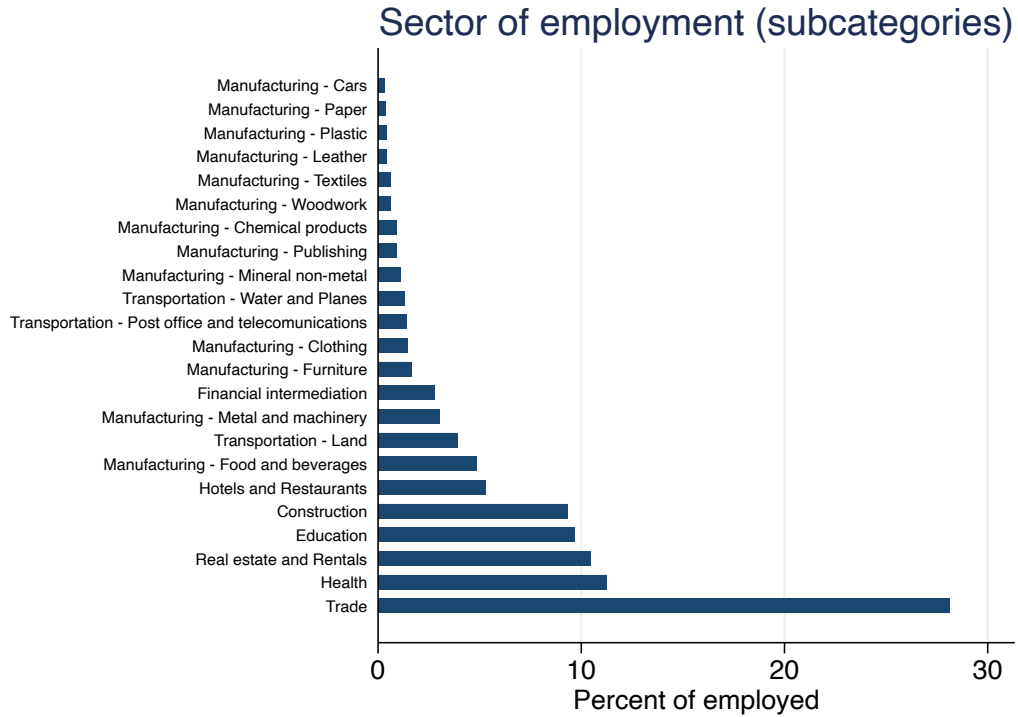


Figure 17: Distribution of pass-through into wages

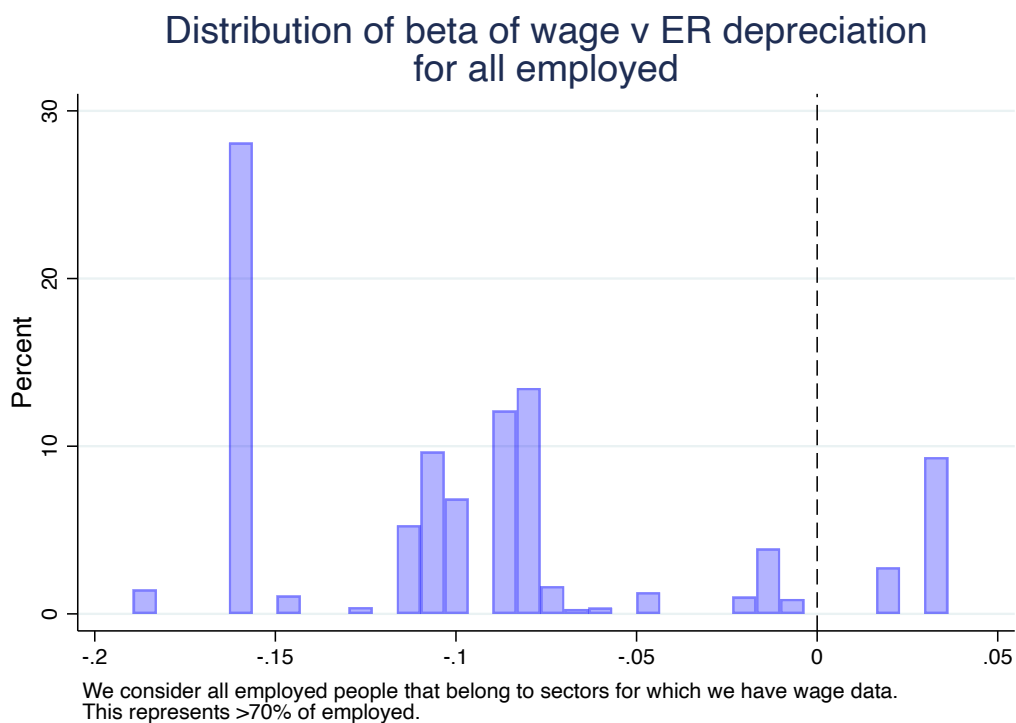


Figure 18: Distribution of income

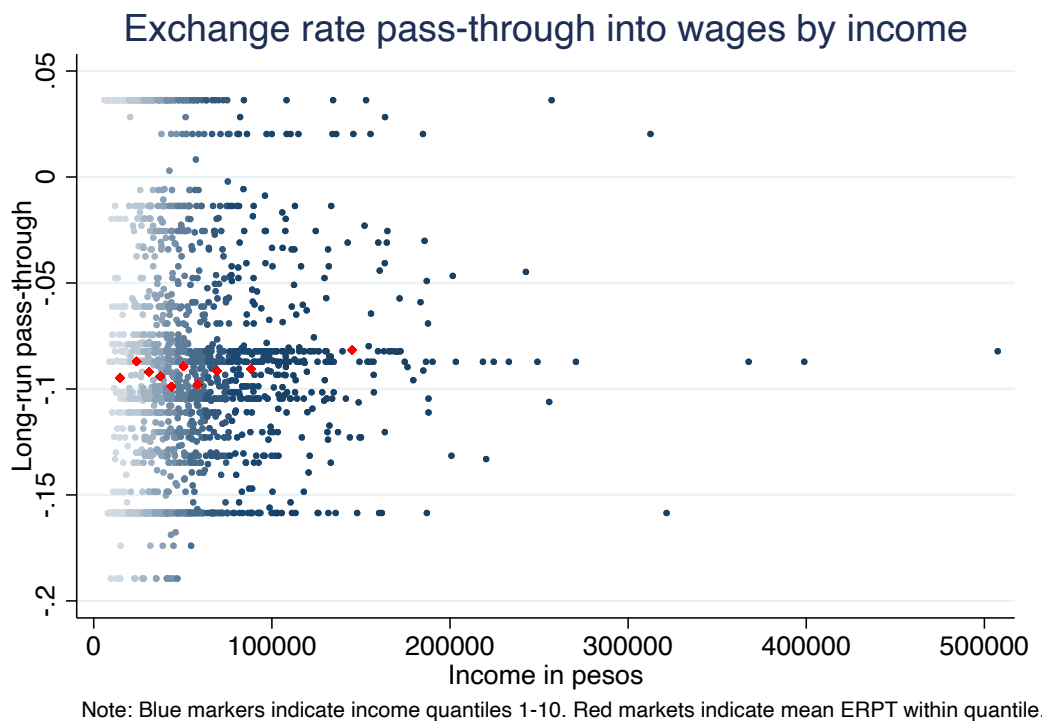


Table 11: Pass-through into prices

	Food	Alcohol, tobacco	Clothing	Rent, utilities
$\Delta\%$ ER	0.0122 (0.0595)	0.0273 (0.0469)	-0.0337 (0.0285)	0.00567 (0.0352)
LRPT	0.793	0.579	0.574	0.407
s.e. LRPT	.2516263	.1894364	.1585597	.2121696
R-squared	.0154959	.0028487	.000579	.002503
Observations	276	276	276	276

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12: Pass-through into prices

	Equipment	Health	Transport	Communications
$\Delta\%$ ER	0.0743* (0.0329)	-0.0111 (0.0184)	0.126* (0.0618)	0.155** (0.0519)
LRPT	0.617	0.472	1.026	1.245
s.e. LRPT	.2419193	.0732344	.2153169	.2057468
R-squared	.0603126	.0020933	.0834793	.0904724
Observations	276	276	276	276

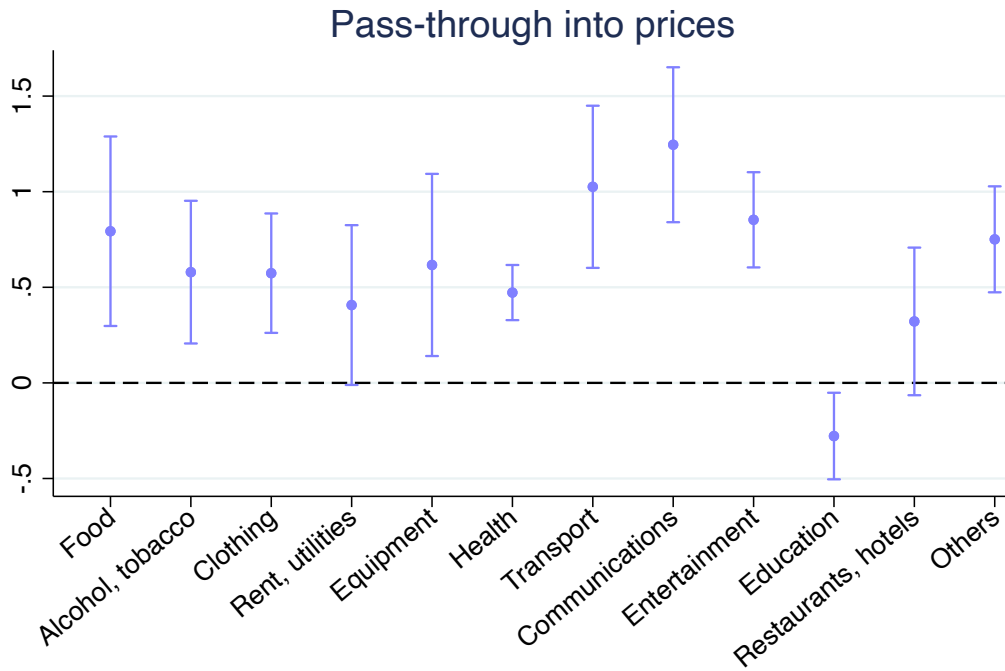
Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 13: Pass-through into prices

	Entertainment	Education	Restaurant, hotels	Others
$\Delta\%$ ER	0.164*** (0.0272)	0.00102 (0.0359)	-0.00710 (0.0169)	0.0191 (0.0117)
LRPT	0.853	-0.278	0.322	0.751
s.e. LRPT	.1263819	.1149281	.1960285	.140705
R-squared	.1449082	.0003072	.0059798	.0348816
Observations	276	276	276	276

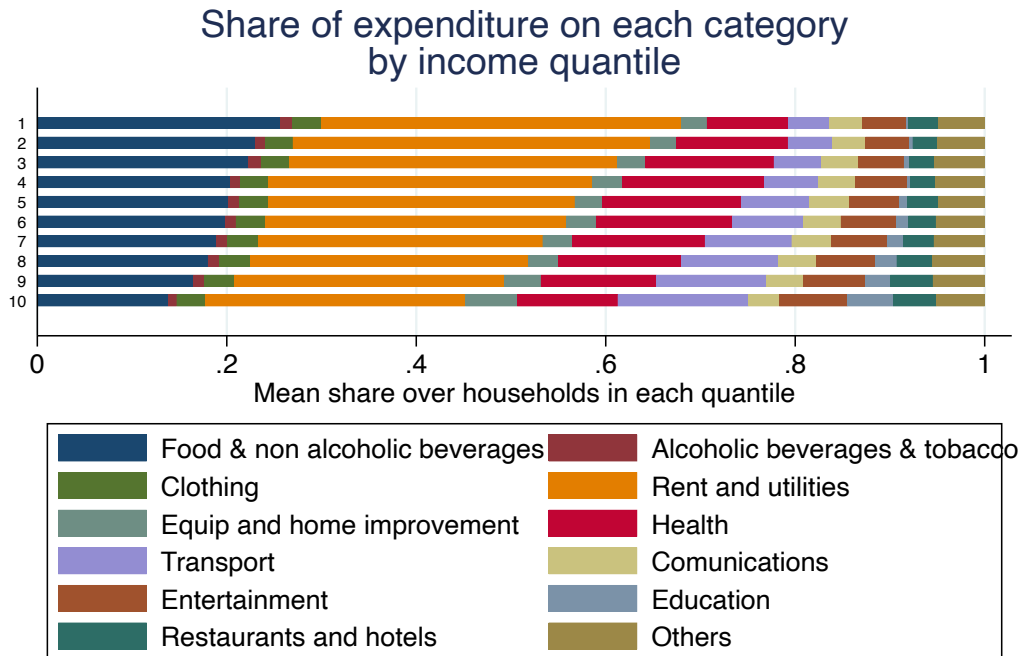
Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 19: Pass-through into prices, by category



Note: long-run pass-through computed using 18 lags with monthly data.

Figure 20: Share of expenditure, by category



A household in quantile n has income between (n-1)th and nth percentiles. No sample weights used.

Figure 21: Pass-through into prices, by category - expenditure survey

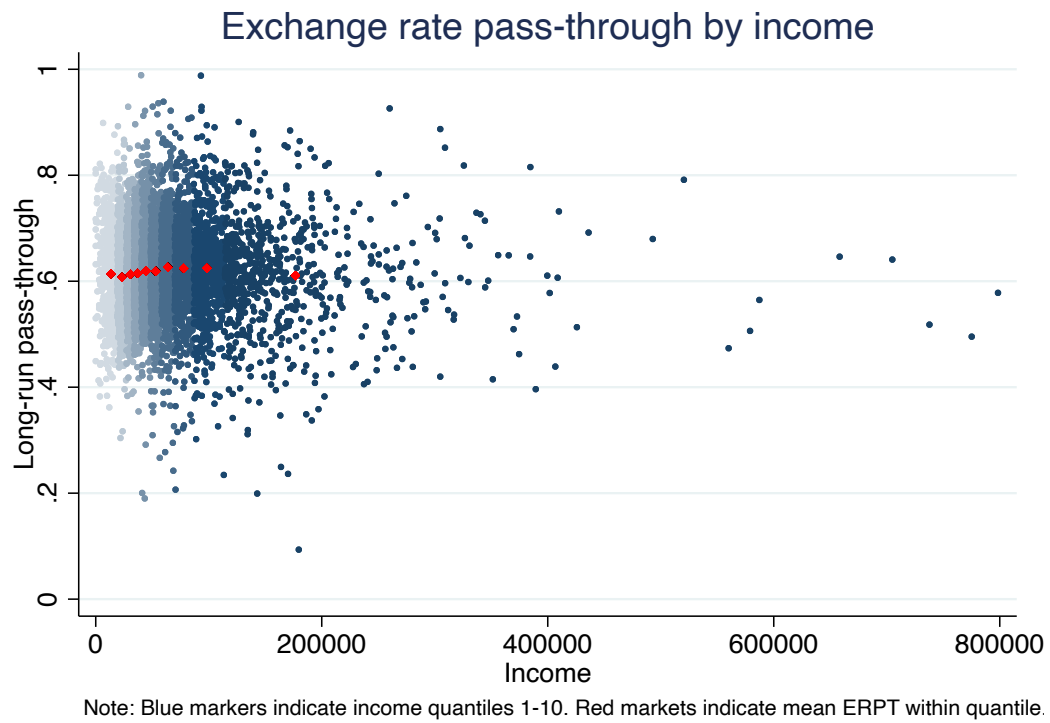


Figure 22: Pass-through into prices, by category - financial survey

