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The Impact of Deposit Dollarization on Credit Dollarization: Evidence of Natural Hedging and Excessive Risk-Taking Channels

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The Impact of Deposit Dollarization on Credit Dollarization: Evidence of Natural Hedging and Excessive Risk-Taking Channels*

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Abstract

This article studies the impact of deposit dollarization on credit dollarization through the natural hedging and the excessive risk-taking channels. We develop a theoretical model that helps us to describe both channels and how these determine the direction in which deposit dollarization might affect credit dollarization. The model shows that through the natural hedging channel, deposit dollarization positively affects credit dollarization, while through the excessive bank risk-taking channel, deposit dollarization negatively affects credit dollarization. Using regional data of credits and deposits in Peru, we find evidence of these two channels, with the natural hedging channel being the dominant one. In addition, we reveal that less credit market competition and high FX uncertainty amplify the role of the excessive bank risk-taking channel.

Keywords: Bank risk-taking, dollarization, foreign exchange rate risk, limited liability, deposit insurance, bank competition.

JEL Classification: D41, D42, E44, G11, G21.

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1 Introduction

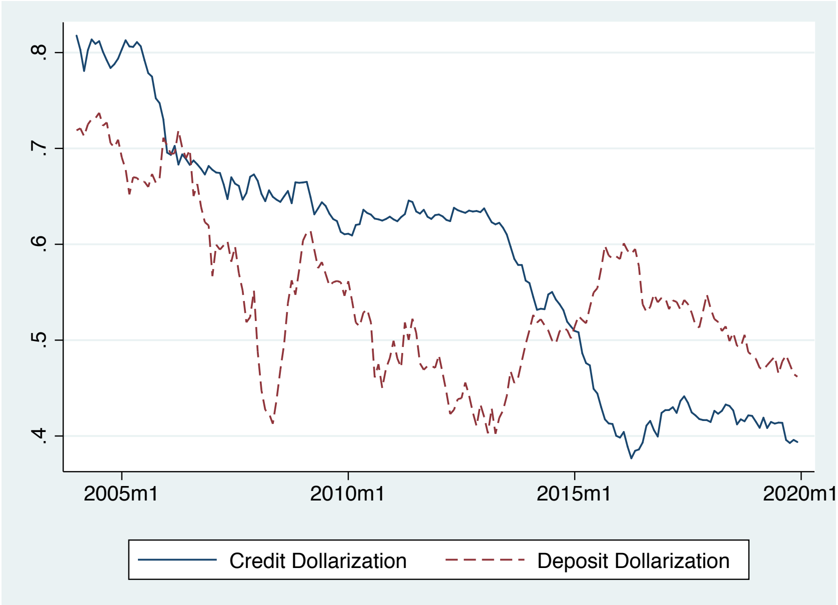
Financial dollarization has always been a motive for theoretical and empirical analysis. Some argue that financial dollarization might weaken financial stability; however, others might disagree (see, e.g., Christiano et al., 2021). Since some might argue that financial dollarization might also diminish the effectiveness of the monetary policy, several authors have looked to explain what factors might drive financial dollarization across countries and within countries. In general, we can find a currency substitution view and a market development view (see, e.g., Corrales and Imam, 2021). To my knowledge, research has focused essentially on firms' and households' behavior to explain both deposit dollarization and credit dollarization, while omitting the implications of the risk-taking decisions of financial intermediaries. This paper aims to fill this gap by focusing on the credit supply side. In particular, we focus on the impact of deposit dollarization in credit dollarization through banks' incentives to naturally hedge foreign currency deposits with foreign currency credit and through banks' incentives to take excessive risk.[1]

To study the impact of deposit dollarization on credit dollarization through both the *natural hedging* and *excessive risk-taking* channels, we first develop a two-period banking model to describe these two channels and to study their implications. Next, we propose an econometric model to test the model's predictions using credit and deposit dollarization data for the Peruvian economy at regional level for the period from January 2004 to December 2019. As shown in figure 1, Peru has featured high dollarization levels. In general, dollarization has been decreasing over time; however, it is still relatively high, which makes for an interesting study case. As observed in figure 1, an important driver of credit dollarization reduction was the 2013 de-dollarization program.[2]

[1]Natural hedging is a management strategy that involves hedging against foreign exchange (FX) risk without using sophisticated financial products such as forwards or derivatives. In this paper, natural hedging involves adjusting the levels of foreign currency loans in response to changes in foreign currency deposits.

[2]The 2013 de-dollarization program implemented by the Central Reserve Bank of Peru in the financial system consists of additional reserve requirements based on limits to foreign currency mortgages and automobile loans. Castillo et al. (2016) and Contreras et al. (2018) quantitatively measure the impact of the 2013 de-dollarization program in Peru. They both find statistically significant evidence that the program diminishes credit dollarization.

Figure 1: *Dynamics of Credit and Deposit Dollarization: Private Banking System*



Source: SBS. Own elaboration.

Our two-period framework is a partial equilibrium model where banks operate in different regions through their branches. Although what follows refers to banks, we specifically model the behavior of branches. Branches can operate in regions with perfectly competitive credit markets or with monopolistic credit markets. Nevertheless, real-life credit market structure is probably somewhere between these two extreme cases; however, this simplification helps us to clearly model the two channels. In general, we assume that banks are risk-neutral and face limited liability and that deposits are fully insured by the government. Banks capture domestic and foreign currency deposits from the public. We assume that banks face a binding foreign currency borrowing limit. This captures the idea that the economy in aggregate might also be constrained regarding its capacity to obtain cheap foreign debt and at the same time this helps us to motivate an exogenous deposit dollarization. The only source of uncertainty is the future foreign exchange (FX) rate. Finally, we assume regional credit markets are segmented.

We summarize first the results of banks in a region with a monopolistic credit market. When banks have a positive foreign exchange (FX) position, not surprisingly, the interaction between the limited liability and the deposit insurance leads to inefficiently high foreign currency loans. In contrast, if banks have a negative enough FX position, foreign currency loans are inefficiently low. This is because with a positive (negative enough) FX position, bank profits are positively (negatively) related to the future exchange rate, and hence the expected return of foreign currency loans conditional on the bank not defaulting is higher (lower) than the unconditional expected return when banks have unlimited liability.

More importantly, in general we find that deposit dollarization reduces credit dollarization. When banks have a positive FX position, more foreign currency deposits (i) reduce the exposure to FX risk and (ii) reduce the borrowing costs. These reduce bank default probability, which in turn reduces bank incentives to excessively issue foreign currency loans. This leads to a negative relationship between deposit and credit dollarization.

The case of a negative FX position is more complex. Foreign currency deposits increase the FX risk exposure and reduce the borrowing costs. While the former pushes bank default probability up, the latter pushes it down. If in equilibrium bank default probability increases, foreign currency loans decrease and domestic currency deposits decrease. Consequently, there is a negative relationship between deposit and credit dollarization. If in equilibrium bank default probability decreases, foreign currency loans increase and domestic deposits increase. Then, if the domestic currency deposit increment is strong enough, deposit dollarization decreases and there is a negative relationship between deposit and credit dollarization. However, if domestic currency deposit increment is not strong enough, deposit dollarization increases and there is a positive relationship between deposit and credit dollarization.

Regarding the banks that operate in a region within a perfectly competitive credit market, since the cost of funding is taken as given, the risk level is the same for all banks. This is, the risk-taking decisions are also the same across banks. In this case, we can see banks' incentives to perform natural hedging. This is, banks with higher deposit dollarization will exhibit also higher credit dollarization to keep unchanged their default probability due to their exposure to FX risk.[3]

To sum up our theoretical model' results, while through, not surprisingly, *natural hedging* channel deposit dollarization leads to higher credit dollarization; through the *excessive bank risk-taking* channel, deposit dollarization leads to lower credit dollarization. In addition, the dependence on external funding (other than local domestic or foreign currency deposits) reduces the impact of deposit dollarization on credit dollarization. This is because the relevance of deposits on banks' balance sheets is smaller, and hence the impact on bank default probability.

In our empirical analysis, we propose an econometric panel model with region-time fixed effects and bank fixed effects in order to control for credit demand shocks and unobservable characteristics of banks (e.g., banks' ability to hedge using derivatives).[4] As a result, from this specification the main sources of deposit dollarization variations that might affect credit dollarization are due to different depositors' preferences across

[3]Notice that since we do not follow the typical minimum variance portfolio approach the natural hedging reasons is only due to the credit competition feature of the credit market.

[4]The region-time fixed effects also allow us to control for regional and aggregate economic cycles, and deposit supply shocks.

banks and to banks' strategies that might vary over time and regions. Regarding the endogeneity problem, we might argue that this is not necessarily an important issue since after the 2013 de-dollarization program that directly restricted the credit dollarization levels we observe that the credit dollarization reduction was not necessarily accompanied by deposit dollarization reduction. In that sense, we might argue that deposit dollarization is essentially determined by the supply from depositors.

According to our empirical results, we find evidence of both the *natural hedging* channel and the *excessive bank risk-taking* channel. Indeed, we find that as expected the *natural hedging* channel dominates.[5]. The positive impact of deposit dollarization on credit dollarization weakens with higher dependence on external funding, which provides further evidence of the *natural hedging* channel. Interestingly, we also find that this positive effect is diminished with lower bank competition and higher FX uncertainty, which according to our theoretical framework, it provides evidence of the *excessive bank risk-taking* channel. It suggests that during high FX uncertainty periods, banks might prefer hedging FX risk using derivatives. Results are robust if we control for bank-time fixed effects, which allows us to control for the 2013 de-dollarization program and the use of FX derivatives.

The motivation of this paper is hence to contribute to a general understanding of several dollarized emerging economies of the relationship between deposit and credit dollarization in the banking system. Typically, natural hedging is studied in non-financial firms (see, Alfaro et al., 2021), but less in banks, which main role is to intermediate rather than to profit from exchange rate movements. Therefore, our results might also be interesting for other emerging economies in that sense that natural hedging is an important tool for managing exchange rate risk in a banking system of an emerging economy with a still underdeveloped derivative market and where the emerging economy currency has still a small participation in the global market.[6]

The remainder of this paper is partitioned as follows. Section 2 presents the literature review. Section 3 develops the theoretical model. In section 4 we perform the empirical analysis. Finally, section 5 concludes.

2 Literature review

This work is related to research that focuses on factors that drive credit and deposit dollarization (or financial dollarization) and with the literature of *bank risk-taking* be-

[5]This is in line with the empirical findings of Gutierrez et al. (2023) for Peru that suggest that banks have strong preferences to closely match their foreign-currency assets and liabilities.

[6]Only 10% of global derivatives turnover is in contracts denominated in the currency of an emerging market economy (EME), much lower than the share of these economies in global GDP or world trade, (see, Upper and Valli, 2016).

havior. We start discussing the literature related to financial dollarization and then the literature about *excessive bank risk-taking*.

In a cross-country panel model, Corrales and Imam (2021) find that the market development view is better than the currency substitution to explain financial dollarization of households and firms, except in low-income countries where inflation plays an important role.[7] They suggest that financial deepening and access to external debt and FX finance, for example, better explain the dynamics of credit and deposit dollarization. With a new data set for 24 transition economies, Basso et al. (2007) find, interestingly, that deposit dollarization is not generally matched by credit dollarization and that access to foreign funds increases credit dollarization but decreases deposit dollarization. This latter is also found in our paper but at a regional level rather than at an aggregate level. They also find that the interest rate differential on loans in domestic currency compared to loans in foreign currency increases credit dollarization; while the differential on deposits in domestic currency compared to deposits in foreign currency reduces deposit dollarization. We contribute to this literature by performing a within-country analysis and studying the bank decisions at a regional level rather than at the aggregate country level.

In addition, some papers suggest that credit dollarization can be also explained by hedging reasons. Luca and Petrova (2008) using data for 21 transition economies study the impact of banks and firms' factors on credit dollarization. They find that credit dollarization depends on banks' natural hedging (i.e., on deposit dollarization) and firms' hedging incentives. Similarly, Calvo (2001, 2002), Ize and Levy-Yeyati (2003) suggest that deposit dollarization might lead to higher credit dollarization to avoid currency mismatched portfolios or FX risk. Similarly, in this paper, we find evidence of this natural hedging but using information at the regional level within an emerging economy such as Peru.

Our research is also related to theoretical papers aiming to explain financial dollarization. Ize and Levy-Yeyati (2003) develop a (minimum variance) portfolio approach. In this case the currency composition is determined on both sides of the bank balance sheet by hedging against inflation and foreign exchange risk. In equilibrium, dollarization is explained by second moments of inflation and real exchange rate rather than first moments (as the currency substitution models). Luca and Petrova (2008) differ from Ize and Levy-Yeyati (2003) by assuming risk-averse banks and hence currency matching becomes an important determinant of credit dollarization. Interestingly, in our paper, where banks are risk-neutral, they still have incentives to hedge against FX risk. Indeed, the natural

[7] Currency substitution view is motivated by the history of high inflation in Latin America. Agents save in foreign currency to protect from exchange rate depreciations or high inflation. Clearly, this view was challenged by the still high dollarization in a context of low inflation. Levy-Yeyati (2006) presents a survey on the different views that might explain financial dollarization: currency substitution view, portfolio view, market failure view and institutional view.

hedging incentives are associated with the perfect competition feature of the credit market and not with the portfolio approach.

Our theoretical framework is closely related to the two-currency banking model developed in Catão and Terrones (2000). They find that foreign currency loans are more attractive the higher the devaluation risk, the higher the availability of tradable collateral, the lower the funding costs of these loans; while domestic currency loans are more attractive the higher the banks' monopoly power,[8] the lower the probability of devaluation and the lower the funding costs: Hence, credit and deposit dollarization are not driven by the variance of macroeconomic variables alone. Indeed, our model yields similar results. We technically depart from Catão and Terrones (2000) since we model two extreme cases of credit market competition levels: perfect competition and monopoly and since we assume banks face limited liability and deposit insurance, which allows us to model banks' incentives to take excessive risk.

In addition, in an econometric panel model using information for 92 developing and transition economies, Arteta (2002) finds evidence that a floating exchange rate regime may increase bank currency mismatches. In particular exchange rate flexibility encourages deposit dollarization more strongly than it encourages credit dollarization generating greater currency mismatches. Similarly, in our empirical analysis we find that FX uncertainty reduces the positive impact of deposit dollarization on credit dollarization. In contrast to Christiano et al. (2021), we claim that this is evidence of the *excessive risk-taking* channel.

A more recent paper Christiano et al. (2021) suggests that financial dollarization works as an efficient risk-sharing device, especially within countries. They find theoretical support for this evidence by developing a two-period model with risk-averse depositors and firms. In contrast to Christiano et al. (2021), we model risk-neutral agents and focus on the credit supply side and describe banks' excessive risk-taking decisions. In addition, Basso et al. (2007) develop a two-period model with risk-averse agents and introduce imperfect competition in the banking market departing from the so-called minimum variance portfolio approach. We depart from Basso et al. (2007) since we model the *excessive bank risk-taking* channel and assume two extreme credit market structures (perfect competition and monopoly) to explain the *natural hedging* and *excessive risk-taking* channel.

This paper follows a branch of the literature that develops a theoretical framework where the interaction between the limited liability and another friction leads to excessive bank risk-taking (see, e.g., Agur and Demertzis, 2012, 2015; Collard et al., 2017; De Nicolò et al., 2012; Sinn, 2003; Pozo, 2023). As in Collard et al. (2017) the interaction between the limited liability and the deposit insurance is used to explain the socially excessive

[8] Banks have relatively strong monopoly power over those borrowers that have less access to foreign borrowing, e.g., households and non-tradable goods firms.

bank risk-taking, and bank risk-taking involves the volume of bank credit and not the type of credit. In contrast to Collard et al. (2017), however, bank default probability is endogenous. This paper attempts to contribute to this branch of the literature by the *excessive risk-taking* channel of the impact of deposit dollarization on credit dollarization.

3 Theoretical Model

We develop a simple two-period partial equilibrium banking model to describe the *natural hedging* channel and the *excessive bank risk-taking* channel of the impact of deposit dollarization on credit dollarization.[9] Indeed, we are modeling bank branches' credit decisions.[10] We assume that banks have branches that operate in different regions with different credit market structures, and that regional credit markets are segmented. We think of regions since in our empirical analysis we aggregate branches' information at regional level.

To describe the *natural hedging* channel and the *excessive risk-taking* channel, we assume that bank branches operate in a perfect competition credit market and in a monopolistic credit market, respectively. So we model two types of bank branches. Although in real-life credit market structure is probably somewhere between these two extreme cases, these help us to clearly illustrate the two channels. Banks that operate in a monopolistic credit market internalize the effects of their credit decisions on the lending interest rate (or inverse demand curve of bank loans).[11] While banks that operate in a competitive market take as given the lending interest rate.[12]

Before we turn to each type of branch, we describe common characteristics. Bank branches capture domestic and foreign currency deposits from domestic currency depositors and foreign currency depositors, respectively. All agents are risk-neutral. We assume branches face limited liability and all deposits are fully insured by the government.[13] Although it is more natural to assume that banks, rather than bank branches, have limited liability, we try to argue that some degree of lending decisions are taken at the branch level, which in turn might be affected by the limited liability and deposit insurance assumptions.

We assume that domestic currency and foreign currency depositors have exogenous

[9]Since our purpose in this paper is to provide a model to interpret what is found in microdata, we focus on the partial equilibrium.

[10]Since we focus on banks' credit decisions, the conclusions provided by this theoretical framework can be empirically testable by controlling by credit demand shocks mainly.

[11]This is because, in the region where the bank is located, there are no feasible competitors and hence the bank is aware that their lending decisions might directly affect the return of the firms' projects and hence the return of its loans.

[12]This is because in the region where they operate, there are many competitors.

[13]Government finances its activities with lump-sum taxes to domestic households.

opportunity gross costs of r and r^f, respectively. Since depositors are risk-neutral and deposits are fully insured by the government, bank branches face a perfectly elastic supply curve of domestic currency and foreign currency deposits at the gross deposits rates of r and r^f, respectively. This means that deposits returns are risk-insensitive.

The exchange rate is defined as the value of the foreign currency in units of the domestic currency. Let e be the current exchange rate and e' be the uncertain next-period exchange rate, which is the only source of uncertainty.[14] We assume that the e'/e follows a lognormal distribution, i.e., $ln(e'/e) \sim \mathcal{N}(\mu, \sigma^2)$.[15] Hence, σ measures the volatility or uncertainty of the exchange rate depreciation rate. As a result, it explains the risk with holding either a positive or a negative FX position.

A bank branch uses foreign currency deposits, d^f, domestic currency deposits, d, domestic currency transfers from other branches, b, and some exogenous initial equity, n, to finance their foreign currency loans, l^f, and domestic currency loans, l:

$$l + el^f = d + ed^f + b + n, \tag{1}$$

with $n > 0$. For simplicity, we assume that b and n are exogenous. In particular, $b > 0$ is associated with regions where there is not enough supply of deposits or with regions with relatively better lending opportunities. While if $b < 0$ is associated with regions where there is a lot of supply of deposits or with regions with relatively poor lending opportunities.[16]

For simplicity, we assume that branches from different banks cannot borrow from each other. In addition, we assume that branches have to pay a gross interest of r for funding provided by other branches. This is, we implicitly assume that there are no additional costs (e.g., administrative costs) from moving resources across regions and that there are no frictions between branches within the same bank. In the second period branches need to transfer back b if $b > 0$, or claim back transfers if $b < 0$.

Furthermore, we assume the expected cost of foreign currency deposits (in domestic currency units) is smaller than the cost of domestic currency deposits, i.e., $\mathbb{E}\{e'/e\}r^f < r$. Then, banks first demand cheap foreign currency deposits and then after depleting foreign currency, banks demand domestic currency deposits. In addition, it is assumed that bank

[14] Notice that we abstract from any idiosyncratic shock on project returns at regional level.

[15] Figure 8 in Appendix A reports the histogram of the annualized expected depreciation rate (left-hand side) and the realized annual depreciation rate in Peru (right-hand side). According to figure 8 it does not seem out of reality to assume that the depreciation rate is normally distributed.

[16] In the general equilibrium, which is not studied here, we should expect that those branches with $b < 0$ are transferring resources to those with $b > 0$. And since at the aggregate a bank has positive equity $N > 0$, those branches with $b > 0$ are also being funded with equity of the bank.

capacity to get foreign currency borrowing is constrained, i.e.,

$$d^f < \bar{d}^f. \tag{2}$$

where $\bar{d}^f$ is exogenous. We assume this constraint always binds. This could be motivated by relatively stronger asymmetric information problems between domestic financial intermediaries and foreign currency depositors. This captures the idea that the economy in aggregate might also be constrained regarding its capacity to obtain cheap foreign debt and at the same time this helps us to motivate an exogenous dollarization. Since the foreign currency borrowing limit binds, in equilibrium the marginal cost of bank lending funding is r.

We focus on bank branches' decisions to supply foreign currency and domestic currency loans. This is, branches optimally choose l and l^f and then d is obtained from equation (1). It is worth mentioning that due to the simplicity of the model, results must be taken with caution.

3.1 Excessive risk-taking channel

Here, we focus on the case of bank branches that operate in a region that features a monopolistic credit market to describe how deposit dollarization affects credit dollarization through the *excessive bank risk-taking* channel.

We assume the inverse foreign and domestic currency loan demand functions, faced by the bank branch, are $r_l(l)$ and $r_{l,f}(l^f)$, respectively, in units of domestic and foreign currency, respectively, where demand curves have negative slopes, i.e., $r_l' < 0$ and $r_{l,f}' < 0$. The branch's future profits are given by loans' payoffs minus funding costs in domestic currency units, i.e.,

$$max\left\{0, r_l(l)l + e' r_{l,f}(l^f)l^f - r^f e' \bar{d}^f - rd - rb\right\}. \tag{3}$$

For convenience using (1) we rewrite it as,

$$max\left\{0, e'\left[r_{l,f}(l^f)l^f - r^f\bar{d}^f\right] - re(l^f - \bar{d}^f) + (r_l(l) - r)l + rn\right\}. \tag{4}$$

If $r_{l,f}(l^f)l^f > r^f\bar{d}^f$ profits are increasing on the future exchange rate, while if $r_{l,f}(l^f)l^f < r^f\bar{d}^f$, the opposite holds. To solve for the optimal branch decision we focus on two cases, when the branches have a positive FX position and a negative (enough) FX position. Bank branches' expected future profits are:

$$\mathbb{E}\left\{max\{0, e'\left[r_{l,f}(l^f)l^f - r^f\bar{d}^f\right] - re(l^f - \bar{d}^f) + (r_l(l) - r)l + rn\right\}. \tag{5}$$

When there is a positive FX position, i.e., $l^f > \bar{d}^f$, and since, as it will be shown latter, in equilibrium $r^f < r_{l,f}$, then $r_{l,f}(l^f)l^f - r^f\bar{d}^f > 0$. Hence, branch profits are increasing in future exchange rate. If bank branches have a positive FX position, we assume $-re(l^f - \bar{d}^f) + (r_l(l) - r)l + rn < 0$, so there is a $e^* > 0$, which equates branch profits to zero, solved in,

$$e^* \left[r_{l,f}(l^f)l^f - r^f\bar{d}^f\right] - re(l^f - \bar{d}^f) + (r_l(l) - r)l + rn = 0. \tag{6}$$

Since profits are increasing in e', each time $e' < e^*$ branch defaults. So $e^* > 0$ ensures a positive branch default probability. Branch default probability is defined as $p = F(e^*)$, where F is the cumulative density function of e'. Since with positive FX position, higher realization of the next-period exchange rate is associated with non-defaulting events, we can rewrite (5) as,

$$\int_{e^*}^{+\infty} \left(e'\left[r_{l,f}(l^f)l^f - r^f\bar{d}^f\right] - re(l^f - \bar{d}^f) + (r_l(l) - r)l + rn\right) dF(e'). \tag{7}$$

Bank branch optimally choose l and l^f so they maximize (7). The first order condition for l yields,

$$\int_{e^*}^{+\infty} (r_l + r_l'l - r)\, dF(e') + \left(e^*\left[r_{l,f}(l^f)l^f - r^f\bar{d}^f\right] - re(l^f - \bar{d}^f) + (r_l(l) - r)l + rn\right) f(e*)\frac{\partial e^*}{\partial l} = 0.$$

Using (6) it yields,

$$r_l + r_l'l = r.$$

Similarly, we find the first order condition for foreign currency loans yields,

$$\int_{e^*}^{+\infty} \left(e'r_{l,f} + e'r_{l,f}'l^f - er\right) dF(e') = 0.$$

Both first order conditions can be rewritten as,

$$r_l\left[1 - \frac{1}{\epsilon}\right] = r, \qquad \frac{\bar{e}^+}{e} r_{l,f}\left[1 - \frac{1}{\epsilon_f}\right] = r, \tag{8}$$

where $\bar{e}^+ = \mathbb{E}\{e'|nd\}$, $\frac{1}{\epsilon} = -\frac{\partial r_l(l)}{\partial l}\frac{l}{r_l(l)}$ and $\frac{1}{\epsilon_f} = -\frac{\partial r_l(l)}{\partial l}\frac{l}{r_l(l)}$, where $\epsilon(\epsilon_f) > 0$ is the elasticity of domestic (foreign) currency loans demand. We assume that $0 < 1-\frac{1}{\epsilon} < 1$, $0 < 1-\frac{1}{\epsilon_f} < 1$ and so both demands are elastic.

Notice that for a small enough negative FX position, i.e., a relatively small negative value of $l^f - d^f$, still holds that $r_{l,f}(l^f)l^f - r^f\bar{d}^f > 0$, then (8) holds. While for a high enough negative FX position, it should be that $r_{l,f}(l^f)l^f - r^f\bar{d}^f < 0$. Then branch profits are negatively associated with future exchange rate. In this case, we assume $-re(l^f - \bar{d}^f) + (r_l(l) - r)l + rn > 0$, so there is s $e^* > 0$, which equates branch profits to zero and is solved in (6). Since this time profits are decreasing in e', each time $e' > e^*$ branches default. Since $e^* > 0$, bank branch default probability is positive and it is defined as, $p = 1 - F(e^*)$. With negative FX position, a lower realization of the next-period exchange rate is associated with non-defaulting events. In this case, we rewrite (3) as,

$$\int_0^{e^*} \left(e' \left[r_{l,f}(l^f)l^f - r^f \bar{d}^f\right] - re(l^f - \bar{d}^f) + (r_l(l) - r)l + rn\right) dF(e'). \tag{9}$$

As before, the first order conditions for l and l^f yield, respectively:

$$r_l\left[1 + \frac{1}{\epsilon}\right] = r, \qquad \frac{\bar{e}^-}{e} r_{l,f}\left[1 + \frac{1}{\epsilon_f}\right] = r, \tag{10}$$

where $\bar{e}^- = \mathbb{E}\{e'|nd\}$.[17]

Before we discuss the implications of the limited liability and the deposit insurance, we define the socially efficient levels of domestic and foreign currency loans, which corresponds to the unlimited liability assumption, respectively, defined in:[18]

$$r_l\left[1 + \frac{1}{\epsilon}\right] = r, \qquad \frac{\bar{e}}{e} r_{l,f}\left[1 + \frac{1}{\epsilon_f}\right] = r \tag{11}$$

where $\bar{e} = \mathbb{E}\{e'\}$ is the unconditional future exchange rate.

From (8), (10) and (11), we see that the interaction between the limited liability and the deposit insurance does not distort the allocation of the non-risky loans, the domestic currency loans. This is because the expected return of domestic currency loans conditional to no default is the same as its unconditional return.

However, this interaction distorts the allocation of risky loans, the foreign currency loans. Since $\frac{\bar{e}^+}{e} > \frac{\bar{e}}{e} > \frac{\bar{e}^-}{e}$, if bank branches have a positive (negative enough) FX position, their foreign currency loans are inefficiently high (low). For those branches with positive FX positions, higher domestic currency depreciation is associated with non-default events and hence branches overestimate the return of their risky foreign currency loans; while for those with negative FC positions, lower domestic currency depreciation is associated with non-default events and hence branches underestimate the return of their risky foreign currency loans. The intuition is the following: The limited liability makes bank branches focus on those non-defaulting states, overestimating or underestimating the expected risky loans returns, and the deposit insurance avoids the branches can internalize the effects of

[17] Importantly, we assume that $\frac{\bar{e}^-}{e} r_f < r$ so that even in the case of negative FX position, marginal cost of foreign currency deposits is smaller than domestic currency deposits.

[18] The unlimited liability solution is equivalent to assuming limited liability and no deposit insurance (see Pozo, 2023). This is because the deposit insurance does not allow market interest rates to capture the risk taken by banks, while without deposit insurance banks internalize the effects of defaulting through higher market interest rates.

the overestimation or underestimation through risk-sensitive deposit returns. This implies the following proposition,

Proposition 1. *Bank branches with positive FX positions should feature higher excessive credit dollarization than those with a negative enough FX position.*

The inefficiency's size is positively related to branch default probability. The lower the branch default probability, the higher the likelihood that banks receive positive profits and they want to ensure those. In the case of positive FX position, it reduces bank incentives to issue excessive foreign currency loans;[19] while in the case of negative enough FX position, it reduces bank incentives to issue inefficiently low foreign currency loans.

Since a higher future exchange rate uncertainty (or higher depreciation rate uncertainty, σ) leads to a higher bank branch default probability, we can conclude the following: FX uncertainty might inefficiently increase branches' incentives to supply foreign currency loans if the FX position is positive; otherwise, it might inefficiently reduce these incentives to supply foreign currency loans. Thus, we can derive the following proposition:

Proposition 2. *The higher the exchange rate uncertainty, the higher (lower) the credit dollarization for bank branches with positive (negative enough) FX positions.*

Since we are interested in measuring the impact of deposit dollarization on credit dollarization, we focus on the effects of the foreign currency borrowing limit. Since it is not possible to analytically find the signs of partial derivatives, we parameterize the model and provide the intuition of the results.

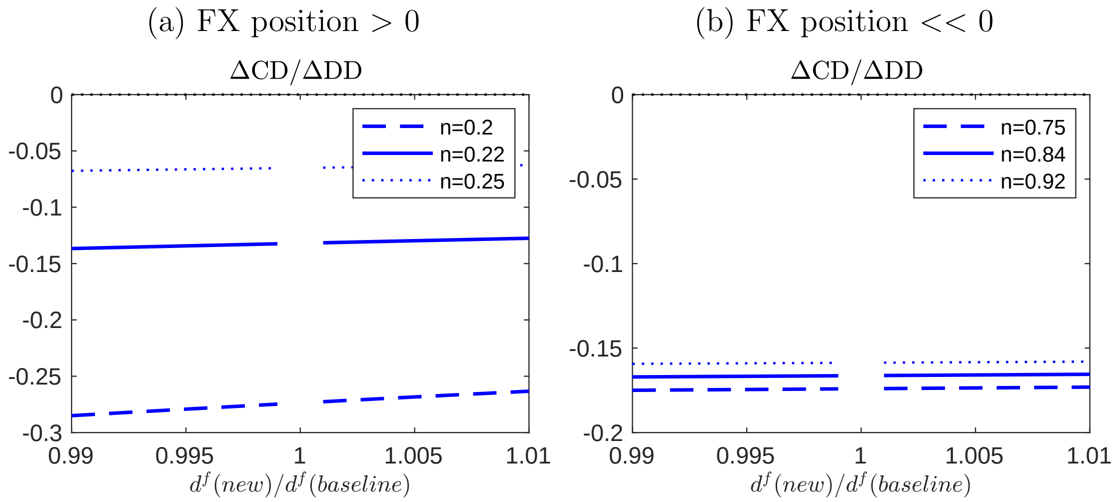
We assume that a period is a quarter. We set $r = 1.010$ and $r^f = r = 1.0076$, which yield an annualized spread of 100 basis points. We set $b = 0$ and the current exchange rate $e = 3$. In addition, we set the elasticity of loan demand as $\epsilon = \epsilon^f = 2.5$. We assume the inverse demand curves of domestic currency and foreign currency loans are $al^{-1/\epsilon}$ and $a^f(l^f)^{-1/\epsilon^f}$, respectively. We normalize $a^f = 1$. We assume that $\mu = -0.5\sigma^2$. So, we normalize the expected depreciation rate to zero, i.e., $\bar{e}/e = 1$. Then, σ will mainly affect the volatility of the future exchange rate, and not its mean, and would help us to calibrate the branch default probability size. The rest of the four parameters $\{n, a, \sigma, \bar{d}^f\}$ are set so that the model matches four predetermined targets for bank branch leverage, (annualized) branch default probability, credit and deposit dollarization. For the case of a positive FX position the target values are 5, 1.2%, 0.75 and 0.31; and for the case of a negative enough FX position 5, 1.2%, 0.16 and 0.65.

According to figure 2 (solid blue lines) changes in the foreign currency borrowing limit lead to a negative relationship between deposit and credit dollarization independently if

[19] An extensive discussion of how bank default probability affects bank's incentives to take excessive risk, i.e., the *excessive risk-taking* channel, is in Pozo (2023).

the FX position is positive or negative.

Figure 2: *Deposit dollarization (DD) and credit dollarization (CD)*



DD: deposit dollarization. CD: credit dollarization. ΔCD (ΔDD) is the absolute deviation of credit (deposit) dollarization due to a change in $\bar{d}^f$. $n = 0.23$ correspond to our baseline parameterization. Higher n leads to higher θ (outside funds dependence).

From (8) and (10) the foreign currency borrowing limit does not affect domestic currency loans, but only foreign currency loans, indirectly, through the branch default probability and hence through the *excessive risk-taking* channel. Notice also that for a given loan level, higher availability of relatively cheaper foreign currency deposits reduces branches' demand for domestic currency loans.

If bank branches have a positive FX position, more foreign currency deposits ($\bar{d}^f$) (i) reduce the exposure to FX risk and (ii) reduce the borrowing costs since foreign currency deposits are relatively cheaper. Thus, foreign currency deposits reduce branches' default probability, which in turn reduces the overestimation of foreign currency loan return. This diminishes branches' incentives to excessively supply foreign currency loans and excessively demand domestic currency deposits. Hence, deposit dollarization increases and credit dollarization decrease. As a result, there is a negative relationship between deposit and credit dollarization.

When bank branches have a negative enough FX position, more foreign currency deposits (i.e., higher $\bar{d}^f$) (i) increase the exposure to the FX risk and (ii) reduce the borrowing costs. While (i) pushes default probability up, (ii) pushes it down.

If in equilibrium we observe that bank default probability increases (as in our baseline parameterization), bank branches' underestimation of foreign currency loan returns increases and hence foreign currency loans decrease. This reduces the demand for domestic currency deposits. Hence, as in the positive FX position case, deposit dollarization increases and credit dollarization decrease. This results in a negative relationship between deposit and credit dollarization.

However, if in equilibrium bank default probability decreases, foreign currency loans increase and domestic currency deposits increase. Then, if the domestic currency deposit increment is strong enough, deposit dollarization decreases and there is still a negative relationship between deposit and credit dollarization. But, if the domestic currency deposit increment is not strong enough, deposit dollarization increases and hence there is a positive relationship between deposit and credit dollarization. So, the higher the uncovered interest parity deviation, the higher the likelihood of observing a smaller bank branch default probability after a higher foreign currency borrowing limit.

We can summarize these results in the following proposition:

Proposition 3. *When banks have a positive or negative enough FX position, in general, higher deposit dollarization (driven by higher $\bar{d}^f$) reduces (or is negatively associated with) foreign currency loans and credit dollarization.*

We define $\theta = \frac{l+el^f}{d+ed^f}$ as the bank branch dependence on external funding. If bank branch receives outside region funding ($b+n>0$), $\theta>1$, otherwise $\theta<1$. This is, the larger the θ, the higher the dependence on external funding.

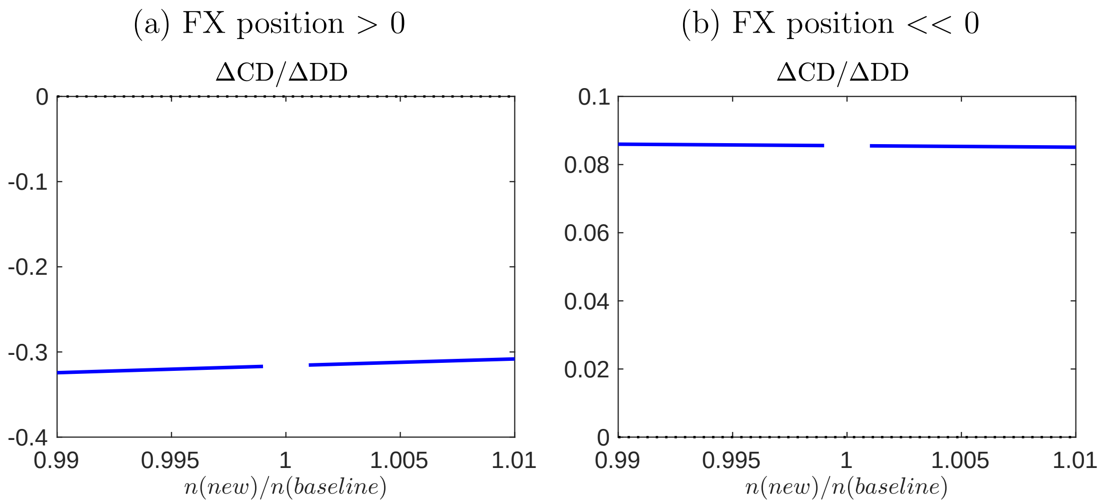
Regarding the two sources of external funding, b and n. Ceteris paribus bank equity replaces domestic currency deposits and hence increases deposit dollarization. Also, cheaper bank equity increases bank profits and thus reduces branch default probability. Hence, for bank branches with a positive (negative) FX position, the overestimation (underestimation) of foreign currency loans returns is diminished. As a result, we should observe a reduction (increase) of the foreign currency loans and a reduction (increase) in credit dollarization. This implies that with a positive FX position, we should observe a negative relationship between deposit and credit dollarization; while with a negative enough FX position a positive one. Indeed, in our baseline parameterization and letting n moves up and down, as it is done according to figure 3, we verify these arguments.

Interestingly, according to equation (4) the dependence on other branches' funds, b, does not affect bank branches' profits.[20] Hence, the only impact of a higher b is just an identical reduction of d and hence higher deposit dollarization with no changes in credit dollarization.[21]

[20]This is because it perfectly cancels out with the domestic currency deposit payments if $b>0$, or perfectly substitutes domestic currency deposits if $b<0$.

[21]Notice that if branches do not have to pay an interest rate from borrowing from other branches, the results change. If $b>0$, these are identical to bank equity and hence the previous conclusions for bank equity hold. If $b<0$, a higher external dependence implies a less negative b which leads to higher profits and lower branch default probability. Then, qualitatively results are expected to be the same as in $b>0$.

Figure 3: *Deposit dollarization (DD) and credit dollarization (CD)*



DD: deposit dollarization. CD: credit dollarization. ΔCD (ΔDD) is the absolute deviation of credit (deposit) dollarization due to a change in initial equity, n. Higher n leads to higher θ (outside funds dependence).

We can summarize the results in the following proposition,

Proposition 4. *An increase in the dependence on external funding (mainly driven by higher branch net worth) increases (decreases) credit dollarization if branches have a positive (negative enough) FX position.*

Regarding the role of the external funding dependence on the impact of deposit dollarization on credit dollarization. According to figure 2 the higher the external dependence (driven by higher branch equity) reduces the negative impact of deposit dollarization on credit dollarization independen. This is because the higher the dependence on external funding the smaller the participation of domestic and foreign currency deposits, and hence the smaller the impact of deposit dollarization changes on credit dollarization. We can summarize the results in,

Proposition 5. *The dependence on external funding diminishes the negative impact of deposit dollarization on credit dollarization.*

3.2 Hedging channel

Here, we focus on bank branches that operate in a region that features a perfectly competitive credit market to describe how deposit dollarization might affect credit dollarization through the *natural hedging channel*.

The only difference with the previous specification is that bank branches take as given the lending rates. Bank branches future profits are as in equation 4 but this time domestic currency and foreign currency lending rates are $r_l(L)$ and $r_{l,f}(L^f)$, respectively, where L and L^f are aggregate domestic and foreign currency loans, respectively.

Following a similar procedure that in section 3.1, we find that when bank branches have a positive FX position, the first-order conditions for domestic and foreign currency loans are,

$$r_l(L) = r, \qquad \frac{\bar{e}^+}{e} r_{l,f}(L^f) = r, \tag{12}$$

And in a region where banks have a negative enough FX position, the corresponding first-order conditions for domestic and foreign currency loans are,

$$r_l(L) = r, \qquad \frac{\bar{e}^-}{e} r_{l,f}(L^f) = r, \tag{13}$$

In equilibrium $r_l(L)$ and $r_{l,f}(L^f)$ are the same across all branches. According to equations (12-13) the level of risk (or the bank branch default probability) has to be the same with positive FX position branches and within negative enough FX position branches. Intuitively, it is expected that higher deposit dollarization leads to higher credit dollarization in order to manage the exposure of the FX risk and hence to keep the level of branch failure probability. Similar to proposition 1 we can state the following,

Proposition 6. *In a credit market with perfect competition, bank branches with higher deposit dollarization exhibit higher credit dollarization.*

Regarding the impact of higher external funding dependence. Higher bank equity n pushes up bank profits and allow banks to tolerate more exposure to FX risk. In the case of a positive FX position, it leads to higher foreign currency loans and hence to higher credit dollarization. Then,

Proposition 7. *In a credit market with perfect competition, bank branches with positive (negative) FX position, the dependence on external funding increases (decreases) credit dollarization.*

As in the case of branches in monopolistic credit markets, the dependence on external funding decreases the impact of deposit dollarization on bank profits. This implies that the adjustment of credit dollarization after a change in deposit dollarization becomes smaller. It leads to the following proposition,

Proposition 8. *The higher the dependence on external funding, the weaker the positive impact of deposit dollarization on credit dollarization.*

We summarize all the propositions in table 1. According to our results, deposit dollarization might have a negative impact on credit dollarization through the *excessive* *risk-taking* channel and a positive impact through the *natural hedging* channel. In addition, the impact of the external funding dependence on credit dollarization is positive when branches have a positive FX position and negative when branches have a negative FX position. Furthermore, the role of external funding dependence on the impact of deposit dollarization on credit dollarization depends on the channel. Through the *excessive risk-taking* channel this dependence reduces the negative impact of deposit dollarization on credit dollarization, while through the *natural hedging* channel this dependence reduces the positive impact of deposit dollarization on credit dollarization.

Table 1: *Summary of Main Results*

	Type 1: Excessive Risk-taking Channel		Type 2: Natural Hedging Channel	
	FX position> 0	FX position<<0	FX position>0	FX position<<0
Impact on Credit Dollarization				
dd	-	-	+	+
θ	+	-	+	-
Effect on the Impact of Deposit Dollarization on Credit Dollarization				
θ	+	+	-	-

Changes in θ are driven by n.

4 Empirical Analysis

In this section, we propose an econometric model to test the predictions of the theoretical model and hence measure the impact of deposit dollarization on credit dollarization using regional bank branches' information for the Peruvian economy. Notice that, as in the theoretical framework, we assume that branches in regions can make individual decisions about credit, deposits and risk-taking.

4.1 Data

We collect information on credit and deposits in domestic and foreign currency at the region-bank-time level at a monthly frequency from the Superintendency of Banks, Insurance and Pension Funds (SBS). The period analyzed spans from 2004:m1 to 2019:m12. This is to only account for the inflation targeting regimen and to avoid the Covid-19 effects, due to the diverse and quantitatively important shocks that face the economy.[22] We focus on monthly information since we believe to capture bank capacity to update

[22]The no inflation targeting regimen featured higher exchange rate volatility and high-interest rate volatility

currency composition of loans might be a short-term decision. In this opportunity, we focus on banks, which represent an important share of the total credit of the financial system. During this period the number of banks fluctuated between 10 and 16. We consider 25 regions (24 regions and the Constitutional Province of Callao).[23]

We use the regional credit and deposit information to construct the ratios of deposit and credit dollarization, dd and cd, and the total credit to total deposits ratio, θ. And we use credit information at province level to build up our three measures of bank competition in a regional credit market. Our first measure is called the number of banks (N). And we use two concentration measures as proxies of bank competition: the share of the four largest loans, C4, and the Herfindahl-Hirschman Index (HHI). The higher the number of banks or the lower the concentration measures, the higher the competition level. To build up these three measures we follow the methodology implemented in Jimenéz et al. (2003) and Pozo and Rojas (2023).

Our regional competition measures have to reflect the degree of competition that each bank faces in each of the provincial credit markets where it operates. Hence, we construct a regional aggregate competition measure faced by each bank using a weighted average, where the weights are the market loan share each bank holds in each province. For instance, the competition measure of "number of banks" for a bank i in a region r at time t, N_{irt}, is defined as the number of its credit competitors in the representative provincial credit market. This competition measure is calculated as a weighted average (by total loans at region r) of bank-province-competitors across all of a bank's provincial operations, where the provinces belong to region r. Similarly, C4_{irt} denotes the share of the 4 largest banks in the representative provincial credit market for bank i in a region r at time t, calculated as the weighted average (by total loans at region r) of the C4 over all provinces (located at region r) where the bank i grants loans at time t. Finally, HHI_{irt} is the Herfindahl-Hirschmann Index of concentration for the representative province of bank i in region r at time t, calculated as the weighted average (by total loans) of the HHI over all provinces (located at region r) where the institution i grants loans at time t. The HHI in each province is computed as the sum of squared bank loan market shares.

Table 2 presents the descriptive statistics for the variables used. On average for bank branches with a positive FX position, credit dollarization is 34%, while deposit dollarization is 35%.[24] This feature changes for bank branches with negative FX position, credit dollarization decreases and deposit dollarization increases. In addition, statistics report high dispersion and hence high heterogeneity of both credit and deposit dollarization.

[23]We exclude loans (deposits) issued (captures) to (from) foreigners. Foreign credit (deposit) represents on average 1.3% (1.7%) of total credit (deposits) over the period from 2004 to 2019.

[24]The FX position is defined as the difference between foreign currency credit minus foreign currency deposits.

Indeed, in this empirical analysis, we exploit that heterogeneity.

According to proposition 1 the fact that the credit dollarization is higher with a positive FX position can be partially explained by the *excessive risk-taking* channel. In addition, according to table 8 in Appendix B we observe that all regions exhibit some degree of deposit and credit dollarization. Indeed, Lima and Callao are the regions that on average report the highest levels of credit and deposit dollarization.

Table 2 also reports on average the foreign currency loans share of bank branches, $size_{irt}$. This share is larger for bank branches with positive FX positions. This suggests that bank branches with positive FX positions are relatively larger than banks with negative FX positions. Regarding the credit to deposit ratio (the external funding dependence), θ_{irt}, this is clearly larger and more volatile for bank branches with positive FX positions.

Also, table 2 reports bank competition measures in the domestic currency credit market and foreign currency credit market. Interestingly, it seems that on average there is more competition in the domestic currency market. For example, it shows that the number of banks in the domestic currency loans markets, N_{irt}, is on average 8.47; while in the foreign currency loans market this is 7.20. Similarly, our two concentration measures are smaller in the domestic currency loans market, suggesting more competition in this market. Also, in general, our competition measures between bank branches with positive and negative FX positions are very similar.

Finally, table 2 reports some measures of FX uncertainty. In particular, we use the standard deviation of the depreciation rate. We construct it as follows: we compute the daily depreciation rate and then we take the standard deviation of a moving window of 23 (+11/-11) working days, finally, we take the average of the standard deviations for each month $\text{sd}_{23d,it}$. Similarly, we build another FX uncertainty measure using a moving window of 45 (-22/+22) days, $\text{sd}_{45d,it}$, and of 7 months, $\text{sd}_{7m,it}$, for this latter we compute monthly deprecations rates. As expected, our FX uncertainty measures built using daily depreciation rates are very similar but higher than the measures built using monthly depreciation rates.

Table 2: *Descriptive statistics for bank-region-month observations*

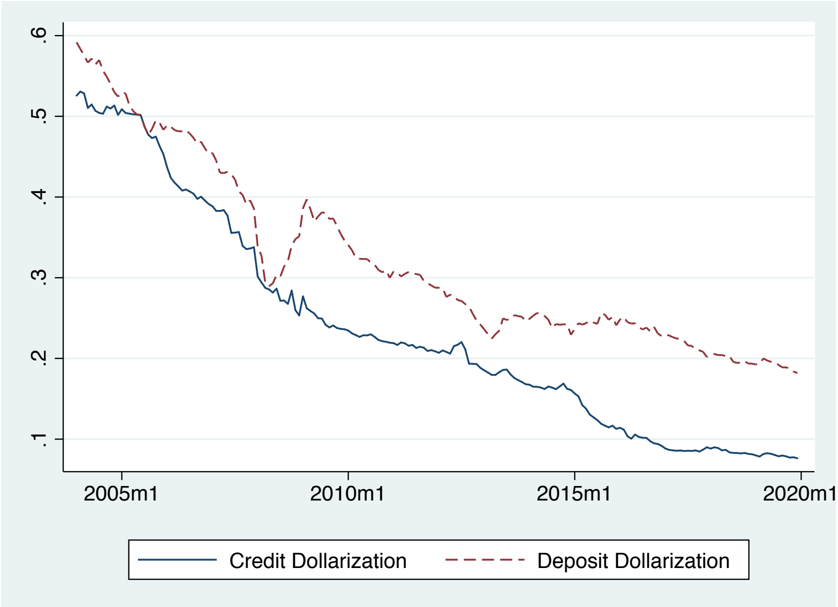
Variables	Obs	Mean	S.D.	Minimum	Maximum
Positive FX position					
cd_{irt}	11853	0.34	0.23	0.01	0.97
dd_{irt}	11853	0.35	0.17	0.01	0.99
$\text{size}_{f,irt}$	11853	0.21	0.21	0.00	0.93
θ_{irt}	11853	3.54	4.07	0.16	49.87
N_{irt}	11853	8.47	2.82	2.00	16.00
C4_{irt}	11853	0.85	0.07	0.66	1.00
HHI_{irt}	11853	0.24	0.06	0.15	0.80
$\text{N}_{f,irt}$	11853	7.20	2.16	1.27	14.00
$\text{C4}_{f,irt}$	11853	0.96	0.04	0.75	1.00
$\text{HHI}_{f,irt}$	11853	0.35	0.10	0.18	0.96
Negative FX position					
cd_{irt}	14322	0.22	0.22	0.01	0.99
dd_{irt}	14322	0.38	0.18	0.01	0.99
$\text{size}_{f,irt}$	14322	0.16	0.22	0.00	1.00
θ_{irt}	14322	1.41	1.56	0.00	30.31
N_{irt}	14322	8.45	3.65	1.00	16.00
C4_{irt}	14322	0.86	0.08	0.66	1.00
HHI_{irt}	14322	0.27	0.15	0.15	1.00
$\text{N}_{f,irt}$	14322	6.98	2.92	1.00	14.00
$\text{C4}_{f,irt}$	14322	0.96	0.05	0.75	1.00
$\text{HHI}_{f,irt}$	14322	0.39	0.18	0.18	1.00
$\text{sd}_{23d,it}$	192	0.22	0.15	0.02	0.84
$\text{sd}_{45d,it}$	192	0.23	0.15	0.02	0.71
$\text{sd}_{7m,it}$	192	0.04	0.03	0.00	0.12

Source: SBS. Own elaboration. S.D. Standard deviation. $size_{f,irt} = l^f_{irt}/l^f_{rt}$. We omit extreme values. We omit N=C4=HHI= 0, dd$<$ 0.005, dd$>$ 0.995, cd$<$ 0.005, cd$>$ 0.995, $\theta > 50$. Due to few observations we do not consider the following banks: Boston, Chartered and Paribas.

Figure 4 shows that the average regional credit and deposit dollarization has been declining systematically. This helps us to see the regional impact of the 2013 de-dollarization program. In particular, this implies that the negative impact on credit dollarization due to the 2013 de-dollarization program was essentially in Lima and probably in other large credit markets.

Figure 5 presents a scatter plot of credit dollarization vs. deposit dollarization at its bank-region-time level. It reports that there is a lot of heterogeneity in both deposit and credit dollarization. And it seems that there is a positive relationship.

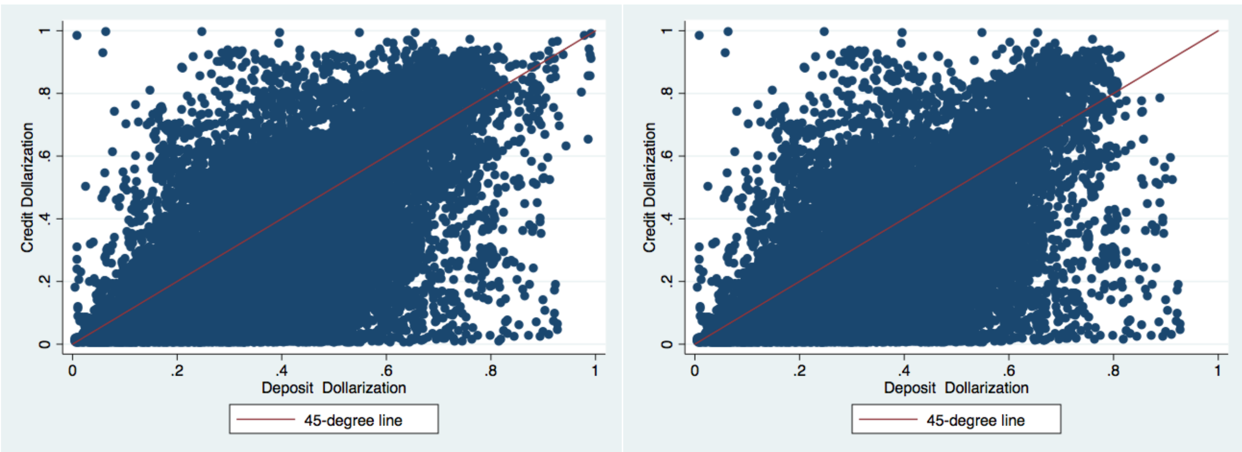
Figure 4: *Dynamics of the average regional Credit and Deposit Dollarization*



The average regional credit and deposit dollarization is computed by taking the average across i and r on dd_{irt} and cd_{irt}, respectively. Source: SBS. Own elaboration.

Figure 5: *Credit vs Deposit Dollarization*

(a) Full Sample (b) Without Lima & Callao

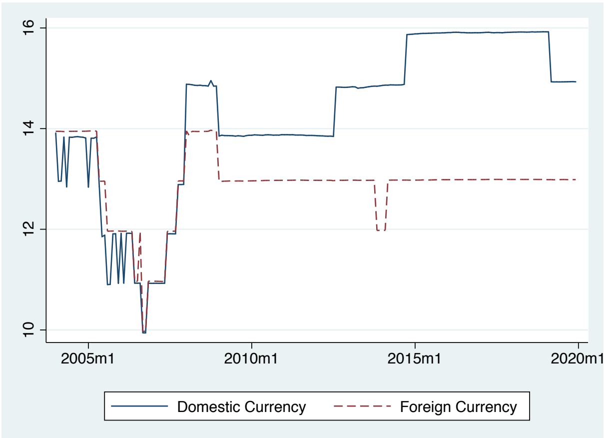


Source: SBS. Own elaboration.

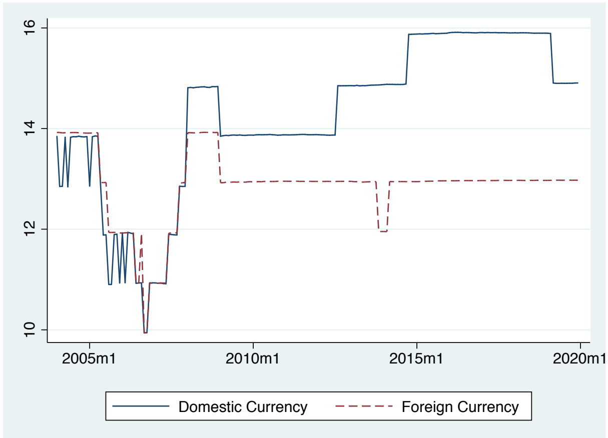
Figure 6 plots two of our competition measures, the number of banks (N) and the share of the four largest loans (C4), for domestic and foreign currency loans market for two large banks (Banks A & B) and for the region of Lima. Both measures report that since the 2008 global financial crisis competition in the domestic currency loans markets increases with respect to the foreign currency loans market. Interestingly, we observe that the 2013 de-dollarization program was accompanied by a higher number of banks in the domestic currency loans market in the representative province where the Bank A operates, which might imply more competition in this market, but at the same time we observe that in the same representative province the participation of the four largest loans in the domestic currency loans market increases, suggesting less competition in this market.

Figure 6: *Competition measures: Number of Banks and C4 in Lima*

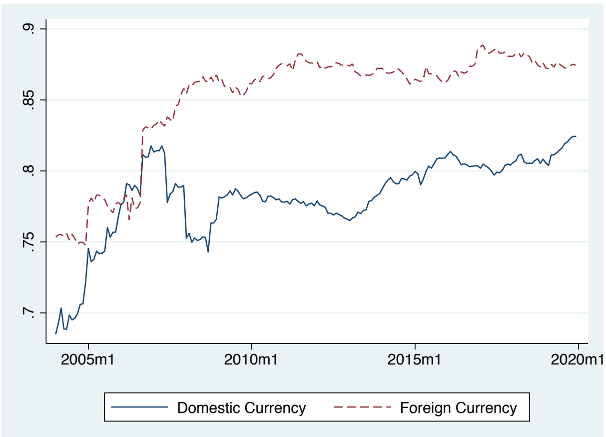
(a) Number of Banks: Bank A



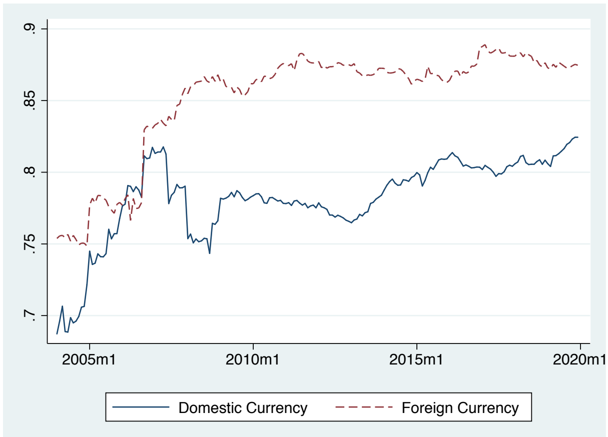
(b) Number of Banks: Bank B



(c) C4: Bank A



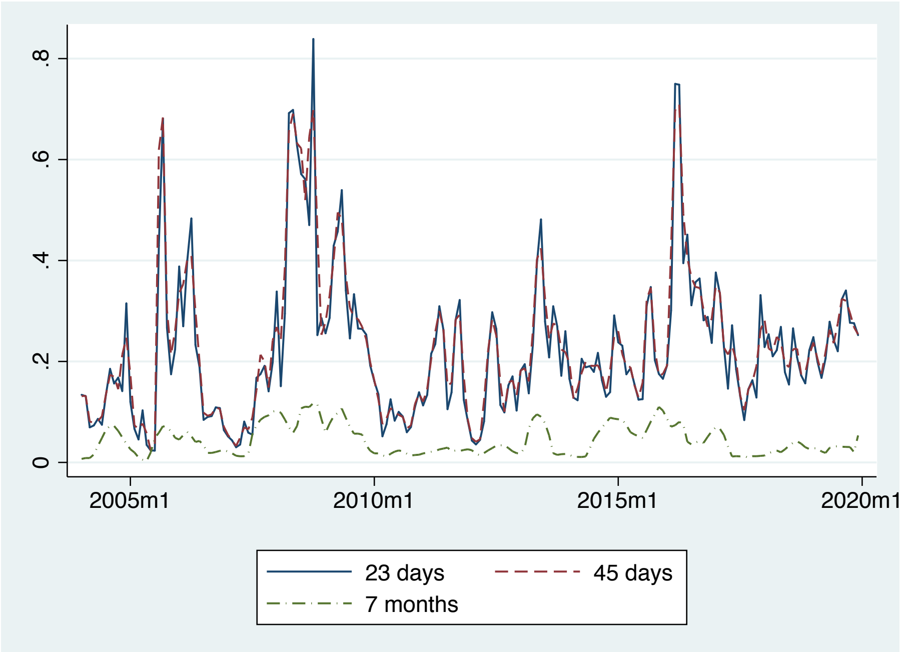
(d) C4: Bank B



Source: SBS. Own elaboration.

Figure 7 our proxy for FX uncertainty, the volatility of the depreciation rate. In general, all our volatility measures increased by the end of the third quarter in 2005, at the start of the 2008 global financial crisis and at the end of the first quarter of 2016.

Figure 7: *FX uncertainty: Depreciation Rate Volatility*



Source: BCRP. Own elaboration.

Next, we present the econometric model and regression results. It is important to mention that for our analysis we omit extreme values.[25] The time period analyzed spans from 2004:m1 to 2019:m12. We use ordinary least squares (OLS) to estimate the parameters in a linear regression panel model among bank, region and time dimensions.

4.2 Empirical Model and Results

The baseline econometric panel model is the following:

$$cd_{irt} = \alpha + \nu_{rt} + \xi_i + \beta_1 cd_{irt-1} + \beta_2 \theta_{irt} + \beta_3 dd_{irt} + \beta_4 \theta_{irt} dd_{irt} + ctrls_{irt} + \epsilon_{irt}, \qquad (14)$$

where i refers to banks, r refers to regions and t to the time (monthly frequency). The dependent variable is cd that denotes the credit dollarization ratio and dd is an explanatory variable that denotes the deposit dollarization ratio.

According to 14 credit dollarization is persistent and depends contemporaneously on deposit dollarization. We control for the credit to deposits ratio (dependence on external funding) that measures branches' dependence and capacity to capture external funding. This ratio looks like a regional bank leverage and hence can be also a measure of banks' capacity and willingness to take excessive risk. In addition, we study the interaction effect

[25] We omit: credit and deposit dollarization ratios lower and higher than 0.005 and 0.995, respectively; observations of N, C4 and HHI equal to zero; credit to deposit ratios, θ, higher than 50; and banks that have very few observations (Boston, Chartered and Paribas).

of the credit to deposit ratio and the deposit dollarization on credit dollarization. This is to see if the impact of deposit dollarization on credit dollarization depends on the size of the external funding dependence. As a control, crtl_{irt}, we have the relative size of bank branches in the foreign currency loans market, $\text{size}_{f,irt}$.

Since we are interested in studying bank branch' decisions, we introduce region-time fixed effects, ν_{rt}, in order to control for demand shocks at the regional level. These fixed effects also control for deposit supply shocks, regional (and national) economic cycles and aggregate FX intervention. We use the bank fixed effects, ξ_i, to control for unobservable bank characteristics. And ϵ_{irt} is the random error that has a normal distribution.

As a result, the impact of deposit dollarization that we are going to quantitatively measure here is that coming from deposit dollarization changes due to (i) depositors' preferences across banks and (ii) bank strategies that might vary over time and across regions.

In addition, we are aware that this specification might face an endogeneity problem. This is, credit dollarization might affect deposit dollarization. However, we might argue that deposit dollarization is generally driven by the deposit supply. As evidence of this is the 2013 de-dollarization program, where we observe a clear reduction in credit dollarization that was not accompanied by a reduction of deposit dollarization, figure 1.

Tables 3 reports the results of the model (14). It reports the information for the whole sample, for positive and negative FX positions. And within each of them, we divide the sample for banks with net dependence on external funding or not. This is to allow us to assess if the results hold for different bank branch's conditions.

In general, we find that credit dollarization is highly persistent and that $\beta_3 + \beta_4\bar{\theta} > 0$, which suggests that deposits dollarization has a positive impact on credit dollarization. In the context of our theoretical model, this implies that the *natural hedging* channel dominates. In the full sample, an increase of 100 bps of deposit dollarization leads to an increase of 2 bps of credit dollarization. Although the impact of deposit dollarization on credit dollarization is statistically significant, it does not seem to be economically significant. Also, we find that this impact is similar for bank branches with negative and positive FX positions. In the case of a negative FX position, if we split the sample according to the dependence on external funding, we still find a positive relationship. However, in the latter case, it stops being statistically significant for a negative dependence on external funding, θ<1.

In general, we find that $\beta_2 + \beta_4\bar{d}d < 0$. This is, higher external funding dependence leads to smaller credit dollarization. However, this impact is only statistically significant if we split the sample for positive and negative FX positions. This validates our theoretical results for the case of a negative FX position, but not for the positive FX position case.

However, it is true that for the negative FX position, the negative impact is stronger. This might highlight a limitation of the theoretical model, which does not properly distinguish between external funds from other branches and initial equity. This requires further research.

In addition, results show that the external funding dependence diminishes the positive impact of deposit dollarization on credit dollarization, i.e., $\beta_4 < 0$. Since according to our theoretical framework it holds when modeling the *natural hedging* channel, this provides further evidence that the *natural hedging* channel dominates the *excessive risk-taking* channel.

Finally, as expected, the relative size of bank branches in the foreign currency loans market is positively associated with credit dollarization. The intuition is that the more important the presence of the bank branches in the foreign currency loans market, the more able and capable to manage the foreign currency risk of foreign currency loans and hence the higher the credit dollarization.

It is worth mentioning that even when controlling by bank characteristics that might change over time (non-performing loans ratio, return on assets, risk-weighted assets to capital and foreign debt), results are qualitatively and quantitatively robust. When using lagged explanatory variables, the significance of the results decreases. In this respect, we agree that we should also consider quarterly and annual regression to look for evidence of long-term impact of deposit dollarization on credit dollarization.

Table 3: *Baseline regression results*

	All			FX position >0		FX position <0		
	All	θ>1	θ<1	All	θ>1	All	θ>1	θ<1
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
cd_{irt-1}	0.941***	0.955***	0.922***	0.941***	0.945***	0.925***	0.899***	0.909***
dd_{irt}	0.0188***	0.0156***	0.00667	0.0277***	0.0291***	0.0344***	0.0392***	0.0199
θ_{irt}	0.000356***	0.000475***	-0.00723	0.000402***	0.000437***	0.00175***	0.00109**	-0.0109
$\theta_{irt}\text{dd}_{irt}$	-0.000605	-0.000660	0.0111	-0.00199***	-0.00163***	-0.00757***	-0.00437***	0.0117
$\text{size}_{f,irt}$	0.0308***	0.0277***	0.0314***	0.0296***	0.0232***	0.0159***	0.0224***	0.0177***
Observations	25,756	17,198	6,885	11,092	9,831	13,434	5,307	5,687
R-squared	0.984	0.991	0.981	0.991	0.992	0.982	0.989	0.980

*** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Robust standard errors. $\text{size}_{f,irt} = l^f_{irt}/l^f_{rt}$. We omit the case of FX position >0 & θ<1 due to very few observations. Region-Time FE and Bank FE.

Table 4 shows the results when considering bank-time fixed effects, η_{it}, instead of bank fixed effects, η_i. These bank-time fixed effects might allow us to control for credit supply shocks (e.g., the 2013 de-dollarization program), FX intervention at bank level and the use of derivatives to manage FX risk. According to table 4 results hold when controlling for those events.

Table 4: *Regression results: With Bank-time fixed effects*

	All			FX position >0		FX position <0		
	All	θ>1	θ<1	All	θ>1	All	θ>1	θ<1
	(1)	(2)	(3)	(4)	(5)	(7)	(8)	(9)
cd_{irt-1}	0.939***	0.957***	0.909***	0.941***	0.950***	0.914***	0.906***	0.892***
dd_{irt}	0.0182***	0.0151***	-0.0104	0.0313***	0.0281***	0.0293***	0.0357***	0.00436
θ_{irt}	0.000300**	0.000387***	-0.0123	0.000429**	0.000360**	0.000460	0.00124**	-0.0189*
$\theta_{irt}\text{dd}_{irt}$	-0.000199	-0.000507	0.0367	-0.00230***	-0.00163**	-0.00131	-0.00512***	0.0505*
$\text{size}_{f,irt}$	0.0330***	0.0265***	0.0375***	0.0275***	0.0190***	0.0189***	0.0220***	0.0189***
Observations	25,243	16,746	6,117	10,727	9,445	12,876	4,644	4,934
R-squared	0.986	0.993	0.986	0.994	0.994	0.986	0.992	0.986

*** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Robust standard errors. $\text{size}_{f,irt} = l^f_{irt}/l^f_{rt}$. We omit the case of FX position >0 & θ<1 due to very few observations. Region-Time FE and Bank-Time FE.

Table 5 reports the results when assuming that there is no persistence on credit dollarization i.e., we assume $\beta_1 = 0$ in the model 14. Qualitatively, the results hold. Indeed, the results are more statistically significant. More importantly, in this case, we see an economically significant impact of deposit dollarization on credit dollarization. For example, in the case of a positive (negative) FX position a 100 bps increase in deposit dollarization leads to a 39 (31) bps increase in credit dollarization.

Table 5: *Regression results: No persistence on credit dollarization*

	All			FX position >0		FX position <0		
	All	θ>1	θ<1	All	θ>1	All	θ>1	θ<1
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
dd_{irt}	0.377***	0.455***	0.0478	0.560***	0.630***	0.447***	0.419***	0.120***
θ_{irt}	0.00855***	0.00979***	-0.142***	0.00879***	0.00882***	0.0251***	0.0176***	-0.189***
$\theta_{irt}\text{dd}_{irt}$	-0.0302***	-0.0328***	0.218***	-0.0474***	-0.0458***	-0.0954***	-0.0637***	0.248***
$\text{size}_{f,irt}$	0.400***	0.482***	0.263***	0.417***	0.405***	0.167***	0.238***	0.139***
Observations	25,781	17,221	6,893	11,105	9,845	13,447	5,313	5,693
R-squared	0.809	0.852	0.835	0.895	0.901	0.825	0.878	0.853

*** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Robust standard errors. $\text{size}_{f,irt} = l^f_{irt}/l^f_{rt}$. We omit the case of FX position >0 & θ<1 due to very few observations. Region-Time FE and Bank FE.

So far the baseline model is not able to disentangle or provide evidence of the *excessive bank risk-taking* channel. To do so we propose a model that aims to quantitatively measure the impact of the *excessive bank risk-taking* channel. Our theoretical framework suggests that the closer the credit market is to a monopolistic credit market, the more important the *excessive bank risk-taking* channel and hence we should observe a less positive impact of deposit dollarization on credit dollarization, since recall that in a perfect monopolistic credit market deposit dollarization negatively affects credit dollarization. As a result, we propose the following econometric model where we account for the interaction between bank competition and deposit dollarization.

$$cd_{irt} = \alpha + \nu_{rt} + \xi_{it} + \beta_1 cd_{irt-1} + \beta_2 dd_{irt-1} + \beta_3 z_{irt-1} + \beta_4 z_{irt-1} dd_{irt-1} + \epsilon_{irt}, \qquad (15)$$

where z_{irt} : is the competition measure and this time β_4 captures the impact of the interaction between competition level and deposit dollarization. We use the competition measure presented in the data section: the number of banks, the credit market share of the four largest banks, and the HH Index. In particular, we focus on the competition level of the foreign currency loans market. When considering the number of banks as our competition measure, if $\beta_4 > 0$, it provides evidence of the *excessive bank risk-taking* channel, and when using the other two concentration measures, C4 and HHI as proxies of competition, obtaining $\beta_4 < 0$ provides evidence of the *excessive risk-taking* channel. Notice that this time we use lagged explanatory variables, this is because of the importance of defining the credit market structure before bank branches perform credit decisions.

According to table 6, for any measure of bank competition in the foreign currency loans market, we find that less competition or more concentration (i.e., lower N or higher C4 and HHI) reduces the positive impact of the deposit dollarization on credit dollarization. We can even find a negative impact of deposit dollarization on credit dollarization when bank branches operate in a representative foreign currency loans market with no competitors, i.e., when N=1 o HHI = 1, see columns 1-3, 7 and 9). This supports our theoretical framework, which suggests that in a monopolistic credit market deposit dollarization has a negative impact on credit dollarization, providing evidence of the *excessive risk-taking* channel. As our *excessive risk-taking* channel implies, the lower competition is associated with more capacity to take excessive risk-taking decisions, which in turn reduces the positive effect of deposit dollarization on credit dollarization. Furthermore, results are robust when considering the competition level in the domestic currency loans market and total loans market domestic currency loans competition and total loans market competition and the number of banks, N, as our competition measure.

Table 6: *Regression results: The role of competition in foreign currency loan market.*

z :	Number of Banks			C4			HHI		
	All	FX>0	FX<0	All	FX>0	FX<0	All	FX>0	FX<0
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
cd_{irt-1}	0.955***	0.969***	0.936***	0.956***	0.969***	0.938***	0.956***	0.969***	0.938***
dd_{irt-1}	-0.00733	-0.0202**	-0.00593	0.0808**	0.0561*	0.0938*	0.0256***	0.0172	0.0447***
z_{irt-1},	-1.45e-05	-0.000773	-0.000435	0.0142	0.0897	-0.0951	0.0131	0.0265	0.00633
$\text{z}_{irt-1}\text{dd}_{irt-1}$	0.00241***	0.00289**	0.00358***	-0.0735**	-0.0559	-0.0763	-0.0438*	-0.0425	-0.0716**
Observations	25,211	10,735	12,839	25,211	10,735	12,839	25,211	10,735	12,839
R-squared	0.986	0.994	0.986	0.986	0.994	0.986	0.986	0.994	0.986

*** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Robust standard errors. FX: Foreign exchange position. Region-Time FE and Bank FE.

An important FX market condition is the degree of FX uncertainty. Next, we would like to assess the impact of the FX uncertainty on the impact of deposit dollarization on credit dollarization. Then, we see if the natural hedging channel or the *excessive risk-taking* channel becomes more important during high uncertainty periods. To do so, we propose the following econometric panel model that accounts for the interaction between our FX uncertainty measure and deposit dollarization,

$$cd_{irt} = \alpha + \nu_{rt} + \xi_i + \beta_1 cd_{irt-1} + \beta_2 dd_{irt} + \beta_3 sd_{it} dd_{irt} + \epsilon_{irt},$$

where sd_{it} is our measure of future exchange rate uncertainty, the standard deviation of daily depreciation rate for a moving window of 23 (-/+11) working days, 45 (-/+22) working days, and 7 (-/+3) months.

Table 7 shows that the impact of deposit dollarization on credit dollarization is weaker in periods of high FX uncertainty. This might suggest that in high volatility periods the *excessive risk-taking* channel becomes more important. In other words, in high volatility periods, bank branches have more incentives to take more risk since the returns (conditional to no default) are going to be greater. An alternative explanation is that in a high uncertainty period is more costly to naturally hedge or it is more efficient the use derivatives.

Interestingly, according to columns 2 and 3, bank branches with a negative FX position, are less worried about performing natural hedging than branches with positive FX positions, and hence the impact of deposit dollarization is less positive. This might suggest that in high uncertainty periods branches with negative FX positions are more willing to use derivate to hedge instead of performing natural hedging.

Table 7: *Regression results: Exchange rate volatility*

Moving window	23 days			45 days			7 months†		
	All	FX>0	FX<0	All	FX>0	FX<0	All	FX>0	FX<0
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
cd_{irt-1}	0.953***	0.956***	0.928***	0.953***	0.956***	0.928***	0.953***	0.956***	0.929***
dd_{irt}	0.0212***	0.0163***	0.0388***	0.0207***	0.0130**	0.0403***	0.0169***	0.0138**	0.0317***
$\text{dd}_{irt}\text{sd}_{irt}$	-0.0299**	3.06e-05	-0.0685***	-0.0266*	0.0135	-0.0722**	-0.0538	0.0503	-0.175
Observations	25,771	11,107	13,434	25,771	11,107	13,434	25,771	11,107	13,434
R-squared	0.984	0.991	0.982	0.984	0.991	0.982	0.984	0.991	0.982

*** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Robust standard errors. FX: Foreign exchange position. † monthly depreciation. Region-Time FE and Bank FE

To sum up, we find empirical evidence of both the *natural hedging* and *excessive bank risk-taking* channels. And that the former dominates.

5 Conclusions

In this work, we aim to measure the impact of deposit dollarization on credit dollarization through the *natural hedging* and *excessive bank risk-taking* channels. To do so we develop a theoretical framework that describes these two channels and their implications in how deposit dollarization might affect credit dollarization. We find that through the *natural hedging* channel deposit dollarization increases credit dollarization; while through the *excessive bank risk-taking* channel the opposite occurs.

Using monthly regional credit and deposit dollarization data for Peru over the period from 2004:m1 to 2019:m12, we test the main results of the theoretical framework. This is, we find evidence of the presence of both channels and that in equilibrium the *natural hedging* channel dominates. This is, we find that deposit dollarization increases credit dollarization. In addition, we find that lower competition in the foreign currency loans market and higher FX uncertainty diminish the positive impact of deposit dollarization on credit dollarization.

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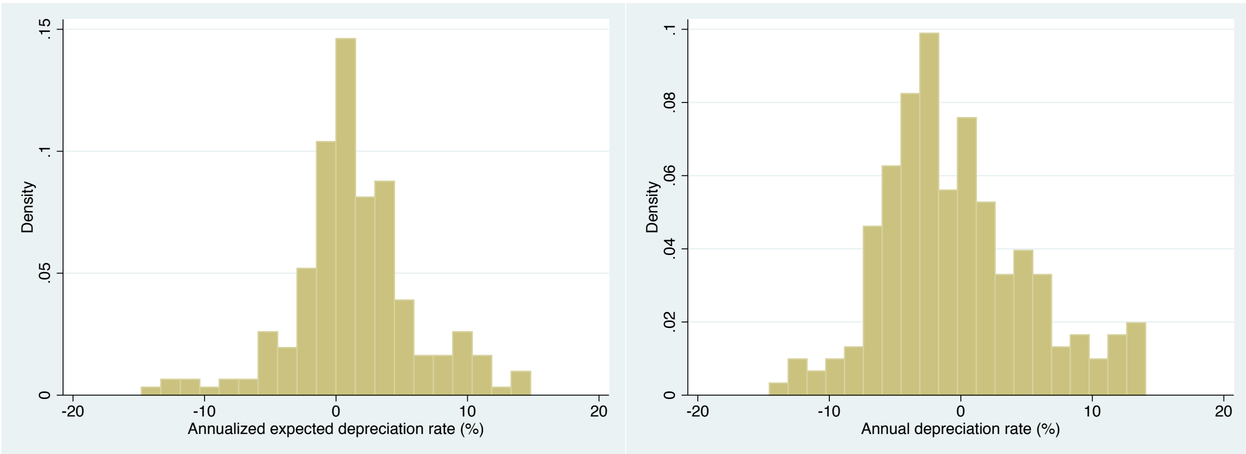
Appendices

A Figures

Figure 8: *Empirical distribution of the expected and realized depreciation rate*



Source: BCRP. Own elaboration. The histogram on the left shows the annualized expected depreciation rate. To build it I use the information of the expected nominal exchange rate from the survey conducted by the BCRP. In particular, I use only the information on agents' expectations up to one year. The histogram on the right shows the realized annual depreciation rate. The expected and the realized depreciation rates correspond to the period: 1999:m7-2017:m2. In both cases I do not consider rates higher and lower than +15% and -15% respectively. This reduces the samples of the expected and realized depreciation rate from 221 to 217 and from 266 to 208 observations respectively.

B Regional Descriptive Statistics

Table 8: *Description statistics for credit and deposit dollarization by regions*

Region	Variables	Obs	Mean	S.D.	Minimum	Maximum
Amazonas	cd_{irt}	173	0.15	0.17	0.01	0.66
	dd_{irt}	173	0.23	0.13	0.02	0.60
Ancash	cd_{irt}	1146	0.29	0.25	0.01	0.99
	dd_{irt}	1146	0.35	0.17	0.01	0.81
Apurimac	cd_{irt}	405	0.11	0.14	0.01	0.66
	dd_{irt}	405	0.19	0.13	0.01	0.59
Arequipa	cd_{irt}	1612	0.30	0.24	0.01	0.99
	dd_{irt}	1612	0.39	0.18	0.01	0.93
Ayacucho	cd_{irt}	669	0.18	0.14	0.01	0.86
	dd_{irt}	669	0.26	0.13	0.05	0.67
Cajamarca	cd_{irt}	1164	0.21	0.19	0.01	0.96
	dd_{irt}	1164	0.31	0.15	0.04	0.88
Callao	cd_{irt}	1602	0.43	0.27	0.01	0.97
	dd_{irt}	1602	0.50	0.19	0.03	0.92
Cusco	cd_{irt}	1112	0.26	0.22	0.01	0.91
	dd_{irt}	1112	0.47	0.14	0.01	0.80
Huancavelica	cd_{irt}	188	0.08	0.08	0.01	0.57
	dd_{irt}	188	0.14	0.10	0.04	0.42
Huanuco	cd_{irt}	775	0.18	0.18	0.01	0.72
	dd_{irt}	775	0.29	0.14	0.01	0.70
Ica	cd_{irt}	1288	0.36	0.23	0.01	0.94
	dd_{irt}	1288	0.38	0.16	0.01	0.90
Junin	cd_{irt}	1169	0.19	0.18	0.01	0.94
	dd_{irt}	1169	0.33	0.15	0.09	0.79
La Libertad	cd_{irt}	1586	0.30	0.22	0.01	0.88
	dd_{irt}	1586	0.40	0.17	0.05	0.91
Lambayeque	cd_{irt}	1340	0.20	0.19	0.01	0.87
	dd_{irt}	1340	0.38	0.16	0.07	0.92
Lima	cd_{irt}	2348	0.45	0.24	0.01	0.99
	dd_{irt}	2348	0.46	0.20	0.03	0.99
Loreto	cd_{irt}	948	0.21	0.17	0.01	0.82
	dd_{irt}	948	0.33	0.14	0.01	0.70
Madre de Dios	cd_{irt}	532	0.14	0.16	0.01	0.87
	dd_{irt}	532	0.25	0.13	0.02	0.76
Moquegua	cd_{irt}	958	0.40	0.28	0.01	0.97
	dd_{irt}	958	0.37	0.15	0.10	0.89
Pasco	cd_{irt}	644	0.22	0.23	0.01	0.96
	dd_{irt}	644	0.29	0.14	0.01	0.74
Piura	cd_{irt}	1411	0.26	0.20	0.01	0.83
	dd_{irt}	1411	0.26	0.20	0.01	0.83
Puno	cd_{irt}	959	0.23	0.20	0.01	0.81
	dd_{irt}	959	0.30	0.12	0.01	0.76
San Martin	cd_{irt}	962	0.12	0.11	0.01	0.58
	dd_{irt}	962	0.25	0.12	0.01	0.61
Tacna	cd_{irt}	1173	0.34	0.23	0.01	0.85
	dd_{irt}	1173	0.39	0.17	0.07	0.83
Tumbes	cd_{irt}	990	0.20	0.21	0.01	0.92
	dd_{irt}	990	0.35	0.14	0.02	0.73
Ucayali	cd_{irt}	1021	0.19	0.16	0.01	0.87
	dd_{irt}	1021	0.25	0.11	0.01	0.71

Source: SBS. S.D.. Standard deviation. Own elaboration. We omit extreme values. We omit N=C4=HHI= 0, dd< 0.005, dd> 0.995, cd< 0.005, cd> 0.995, $\theta > 50$. Due to few observations we do not consider the following banks: Boston, Chartered and Paribas.