

Exchange Rate Exposure and Firm Dynamics

Juliana Salomao

Liliana Varela*

May 2021

This paper develops a heterogeneous firm-dynamics model to jointly study firms' currency debt composition and investment choices. In our model, foreign currency borrowing arises from a dynamic trade-off between exposure to currency risk and growth. The model endogenously generates selection of productive firms into foreign currency borrowing. Among them, firms with high marginal product of capital use foreign loans more intensively. We assess econometrically the model's predicted pattern of foreign currency borrowing using firm-level census data from the deregulation of these loans in Hungary, calibrate the model and quantify the aggregate impact of this financing. Our counterfactual exercises show that understanding the characteristics of firms borrowing in foreign currency is critical to assess the aggregate consequences of this financing.

JEL-Codes: F31, F34, F36, F46.

Keywords: firm dynamics, foreign currency debt, currency mismatch, uncovered interest rate parity.

*Juliana Salomao: University of Minnesota, jsalomao@umn.edu. Liliana Varela: London School of Economics, l.v.varela@lse.ac.uk. We thank the editor and four anonymous referees for helpful remarks and suggestions. We are grateful to Laura Alfaro, Manuel Amador, Cristina Arellano, Javier Bianchi, Ariel Burstein, Vasco Carvalho, Doireann Fitzgerald, Loukas Karabarbounis, Sebnem Kalemli-Ozcan, Monika Piazzesi, Diego Perez, Vincenzo Quadrini, Romain Ranciere, Martin Schneider, Chris Telmer, Aaron Tornell, Emil Verner, James Weston, Kei-Mu Yi and Jing Zhang for helpful comments, as well as participants at several seminars and conferences for helpful comments and suggestions.

1 Introduction

Capital flows play a critical role for economic growth. The textbook neoclassical growth model predicts that capital inflows into developing economies lead to higher capital accumulation and income per capita. Yet the international economic literature has associated these flows with deeper boom-and-bust cycles, and financial crises. One of the sources of these financial crises has been foreign currency borrowing by the corporate sector, as many firms employing this financing do not export or use financial instruments to shield their balance sheets from exchange rate shocks. In this paper, we assess theoretically and empirically the micro and macro channels leading firms to borrow in foreign currency.

This paper makes three contributions. First, we develop a heterogeneous firm-dynamics model to microfund the emergence and heterogeneity in firms' foreign currency borrowing decisions, and to show that this financing arises from a dynamic trade-off between currency risk and growth. Second, we exploit an arguably exogenous policy reform – the deregulation of foreign currency loans in Hungary that revoked a legal restriction banning firms from using foreign loans – to identify and test econometrically the model's predicted pattern of foreign borrowing across firms. Finally, we employ our dynamic model as a laboratory to quantify the aggregate impact of this financing in normal and crisis times, and to show how exchange rate market interventions affect firms' foreign currency borrowing choices and, in this way, the aggregate consequences of this financing. Our framework assesses then the implications of foreign currency loans by building up from firm-level decisions to country aggregates.

In our dynamic model, firms jointly choose the currency composition of their debt and their investment. Firms might borrow in foreign currency to take advantage from uncovered interest rate parity (UIP) deviations to increase investment. Yet this financing exposes firms to balance sheet effects that can lead to default. Critically, we demonstrate that this trade-off endogenously generates heterogeneity in foreign borrowing decisions across firms. At the extensive margin, only highly productive firms can tolerate the exchange rate risk and borrow in foreign currency. At the intensive margin, productive and capital-scarce firms – with high return to investment – employ this financing relatively more.

We test econometrically the model's firm-level implications by employing census data on firms' balance sheets and credit by currency denomination. We validate the model by simulating firm-level panel data and estimating – in parallel – reduced-form regressions using the simulated and the Hungarian data. This exercise allows us to test *qualitatively* and *quantitatively* the model's firm-level responses and to provide first evidence of the trade-off between currency risk and growth implied in firms' foreign borrowing decisions.

Next, we use our dynamic model to quantify the aggregate impact of foreign currency borrowing in a set of counterfactual exercises. First, we show that, despite exposing firms to balance sheet effects, foreign loans can lead to higher capital accumulation and lower default, as firms become larger and more resilient to shocks. Next, we study the impact of currency crises and show that the effect of depreciations on firms' default is non-monotonic. Higher capital accumulation during *good times* might allow firms to survive better moderate currency shocks. Finally, we assess the impact of two exchange rate market interventions – mimicking a full peg and implicit bailout guarantees –, and show that they can affect the extensive and intensive margins of foreign borrowing. These interventions might not only encourage firms to tilt their liabilities towards foreign loans, but they can also allow less productive

and, thus, riskier firms to use this financing.

Our paper makes three contributions to the literature on currency crises. First, this literature uses macro models with representative agents to account for emergence of currency mismatch, but it has so far paid little attention to the micro-level trade-offs driving firms' decisions. Our paper fills in this gap by building a heterogeneous firm-dynamics model to dissect firms' portfolio choices. Second, there is an empirical literature evaluating the consequences of large depreciations on firms' balance sheets, but little is known about the characteristics of firms using these loans. Our paper complements these studies by using firm-level census data to identify their characteristics and document the extensive and intensive margins of foreign borrowing. Finally, we quantify the impact of foreign borrowing and assess how different exchange rate policies affect the distribution of foreign loans and their aggregate implications.

We start by building a firm-dynamics model in which firms jointly make financing and investment decisions. Firms are heterogeneous in capital stock, level of foreign and local currency debts, and face idiosyncratic productivity shocks and global shocks. Firms operate domestically and can finance their investment using debt, which can be denominated in local or foreign currency. Debt is non-contingent, so firms can default. A firm's idiosyncratic risk of default endogenously determines its cost of funds. Debt markets are perfectly competitive and the supply of funds to each firm is unlimited. The exchange rate is determined using an affine model of exchange rate determination in which the ratio of the local and foreign investors' pricing kernels defines the exchange rate change. The model endogeneously generates UIP deviations that arise from the difference in the pricing of the global risk of local and foreign investors. Firms' currency-debt composition is driven by a trade-off between aggregate UIP deviations and firms' default probability. While UIP deviations can make the foreign rate relatively lower, foreign loans expose firms to the currency risk, affecting their default probability and, thus, costs of funds. A firm borrows in foreign currency to the extent in which the increase in its default probability does not exceed the lower relative cost arising from the UIP deviation.¹

The model offers two firm-level implications about the pattern of foreign currency borrowing. First, at the extensive margin, there is endogenous *selection* into foreign currency borrowing, as – given the states – only high productivity firms find it optimal to use this financing. Given the persistence of the productivity shock, more productive firms today are less sensitive to default in the next period for any given choice of capital and local and foreign currency debts. This lower default sensitivity allows them to tolerate the currency risk and use foreign loans without significantly increasing their financing costs. Second, at the intensive margin, higher UIP deviations encourage foreign currency borrowing. This effect is particularly important for high marginal product of capital (MPK) firms that exploit the lower foreign rate to increase their investment and reach faster their optimal scale.

To assess the model's implications, we combine two datasets: APEH, which provides information on firms' balance sheets reported to tax authorities for the population of firms (Nemzeti Adó és Vámhivatal 2011), and KHR-Credit Register, which reports information on all loans by currency denomination with Hungarian financial institutions (Magyar Nemzeti Bank 2011). The coverage of our database is unique

¹It is worth noting that, by assuming an infinite supply of funds to each firm, our model focuses on the relationship between UIP deviations and foreign borrowing, and is silent about how restrictions in the quantity supplied of foreign funds would affect a firm's choice. This modeling choice is consistent with our empirical analysis, as the availability of foreign credit substantially increased in Hungary in the period under study, and Hungarian firms using this financing were typically small and medium-size firms (see Section 2). It is then not unlikely that supply of funds for each individual firm was unlimited.

as it reports information for all firms in all economic activities over more than a decade (1996-2010) and allows building comprehensive measures of leverage by currency denomination and controlling for firms' exports and imports. It constitutes an advance over previous studies that, focusing on small samples of exporters and publicly-listed firms and lacking information on leverage, cannot account for the extensive and intensive foreign loans and their emergence among non-tradable domestic firms, which are the majority of firms using these loans in emerging markets.

We start by documenting that foreign currency borrowing expanded rapidly in Hungary after their deregulation in 2001. By 2005, the share of foreign loans on total banking loans exceeded 45% and one-third of the firms borrowing in Hungary held foreign currency loans. These firms were typically domestically owned (90%) and accounted for 40% of aggregate value added and 34% of employment. Interestingly, these firms were highly exposed to exchange rate movements, as three quarters of them were non-exporters (73% of firms) and did not use financial instruments to hedge the currency risk.

We validate the model's cross-sectional predictions of foreign borrowing in three different ways. First, we calibrate the model to the period following the deregulation of foreign loans in Hungary and show that it successfully matches several non-targeted moments of the distribution of foreign borrowing.

Second, we test econometrically the model's predicted pattern of foreign borrowing across firms. To evaluate the first implication – namely, whether firms employing foreign loans are more productive–, we exploit the deregulation of foreign currency loans as an exogenous source of time variation. In line with this first implication, we find that a one percent increase in a firm's pre-reform productivity raises the probability of borrowing in foreign currency by 1.2 percentage points. Similarly, the share of foreign currency loans increases in firms' initial productivity. Our results also point that firms using this financing associate with 7% higher investment. To test the second implication of the model, we exploit UIP deviations across time to check how firms respond to changes in it. We find that UIP deviations associate with higher foreign currency borrowing and investment, particularly for high MPK firms. The estimated coefficients are economically significant and imply that a 10% increase in the UIP deviation, as seen in Hungary between 2005 and 2006, led to more than a thousand firms to borrow in foreign currency and a 30% increase in their foreign currency share. Third, to test whether the model captures well firm-level responses, we employ it to simulate firm-level panel data and use it to estimate the same reduced-form regressions than we did in the empirics. The model reproduces well the coefficients estimated with the Hungarian data, which shows that it mimics firms' *qualitative* responses (sign) and follows closely firms' *quantitative* responses (size).

Our dynamic model and empirical results argue for a theory of foreign currency borrowing in which high productivity firms employ this financing to the level of risk that they can tolerate. This indicates that firms do not use foreign loans to gamble for resurrection. In the appendix, we use our simulated data to show that – even though our model allows for this force – gambling for survival does not drive firms' foreign currency debt choices. Our empirical evidence confirms our theory.

Having validated the model, we next use it as a laboratory to quantify the aggregate implications of foreign currency borrowing and to assess whether the distribution of foreign loans across firms affects its aggregate consequences. We conduct three set of exercises.

In our first set of exercises, we quantify the impact of foreign currency borrowing by comparing two economies with and without this financing. We show that economies allowing for foreign currency loans

have 8% higher capital growth, as lower financing costs promotes investment. Interesting, whilst foreign borrowing exposes firms to balance sheet effects, they default less. The reason is that higher capital accumulation allows firms to grow and become more resilient to idiosyncratic and aggregate shocks. Next, we assess if the characteristics of firms using foreign loans affect the aggregate consequences of this financing. We show that, when firms use foreign loans irrespectively of their capital and productivity, the investment rate lowers, default surges, and the economy has 18% lower capital accumulation.

In our second set of exercises, we study the impact of depreciations on firms' borrowing in foreign currency in two steps. First, we exploit the 10% exogenous depreciation of Hungarian Forint during the Global Financial Crisis in 2008/09 to evaluate its impact on firms' balance sheets. We use the simulated and the Hungarian data to show econometrically that firms borrowing in foreign currency experience negative balance sheet effects – as they lower their investment, leverage and switch to local currency loans – but they do not exit more. Yet this low exit depends on the size of the depreciation. In a second exercise, we consider a large depreciation of 100% and show that firms indebted in foreign currency exit more. These results show that, in contrast with the common belief that depreciations necessarily entail higher exit, this relationship is non-monotonic. For moderate depreciations, firms using foreign loans might be able to survive currency shocks better, as higher capital accumulation makes them more resilient to shocks. For sufficiently large depreciations, the increase in debt repayment can be high enough that firms cannot fulfill their commitments and exit market. This non-monotonic relationship provides additional support for the mechanism proposed in this paper by showing that, in a dynamic setting with capital accumulation, firms might choose to borrow in foreign currency in order to accumulate more capital and become more resilient to shocks.

In our last set of exercises, we conduct two numerical exercises to mimic exchange rate market interventions and to assess how they affect firms' incentives to borrow in foreign currency. First, we study fixed pegs and show that the absence of currency risk leads least productive firms to start using foreign currency loans and exclusively use this financing. This implies a large expansion of the extensive and intensive margins of foreign borrowing. Second, we mimic implicit bailout guarantees taking the form of limits to depreciations and show that they encourage firms to switch their debt towards foreign currency loans and substantially reduce the productivity threshold to use this financing. Hence, exchange rate market interventions have non-trivial effects on the allocation of foreign loans across firms and, thus, on the aggregate consequences of this financing.

The empirical identification of the use of foreign loans in Hungary is based on the initial characteristics of firms employing these loans. To test that the observed effects correspond to firms' initial productivity and capital and not something else, we conduct a full set of robustness tests. First, in our baseline specification, we exclude exporters and foreign-owned firms, as they might use foreign loans for trade purposes and show that results hold true when including them.² Second, results are not driven by sector-specific trends or demand shocks, as they are robust to including sector-year fixed effects. Third, results are robust to controlling for valuation effects and to controlling for the country risk premium. Finally, the general context around the deregulation of foreign currency loans and its timing minimizes reverse causality concerns, as it was part of a general program of transition economies to join the Eu-

²Note, however, this does not significantly affect the sample size, as the majority of firms using foreign loans are non-exporters and domestically owned.

ropean Union (EU) and there were no other reforms that could affect firms' currency borrowing decisions.

Related Literature. This paper relates to the literature studying currency crises and contributes to it theoretically, empirically and quantitatively. The theoretical literature has built macro models with representative agents to account for the emergence of currency mismatch (see Jeanne 2003; Caballero and Krishnamurthy 2003; Schneider and Tornell 2004; Rappoport 2008; Kalantzis 2015; among others). However, it has so far paid little attention to the cross-sectional heterogeneity in these choices. Our paper contributes to this literature by building a firm-dynamics model to dissect the trade-offs in firms' currency debt decisions and assessing the distribution of foreign loans and its aggregate consequences.

There is also an empirical literature that documents the consequences of large depreciations on firms' balance sheets using country cases. Among others, Aguiar (2005) reports that Mexican firms indebted in foreign currency reduced investment during the Tequila crisis, and Kim, Tesar, and Zhang (2015) show that Korean firms were more likely to exit during the Asian crisis.³ Our paper starts by studying the characteristics of firms employing foreign loans. In doing this, it is closest to Ranciere, Tornell, and Vamvakidis (2010) who, using survey data on Eastern European firms, document that firms using foreign loans tend to produce in the non-tradable sector. Similarly, our data indicates that 73% of firms using foreign loans do not export, and 65% are non-exporters and non-importers. Our paper also relates to Maggiori, Neiman, and Schreger (2020), who using cross-country security-level data, find that firms issuing debt in foreign currency tend to be larger.

Our paper contributes to these empirical studies in three aspects. First, our firm-level census data is arguably richer, as reports all firms' balance sheet, trade and credit, and allows us to document additional relevant characteristics of firms sorting into the foreign-denominated loan market. In particular, we are able to document the extensive and intensive margins of foreign borrowing and the important role of firm productivity. Second, we are able to observe firms' leverage, which - in turn - informs about the mechanism implied in foreign currency borrowing. In particular, while models based on bailout guarantees imply that firms do not internalize the default cost and over-borrow, our data suggests otherwise. Firms that borrow in foreign currency have moderate leverage and similar leverage ratios to firms using only local loans. This finding is consistent with our model's mechanism under which there is no excessive leverage because firms and creditors fully understand the default cost. Third, this is the first paper that uses an arguably exogenous policy reform with a difference-in-difference approach to identify the characteristics of firms borrowing in foreign currency. This empirical strategy allows us to avoid endogeneity concerns (simultaneity bias) that could arise from firms using foreign currency loans to invest in technology. In particular, both more credit availability in foreign currency and lower financing terms of foreign loans (due to the UIP deviation) could provide better credit conditions and induce technology adoption. The deregulation of foreign currency loans in Hungary allows us to identify

³Recently, Alfaro, Asis, Chari, and Panizza (2017) document large increases in foreign currency borrowing in emerging markets after the Great Recession and a rise in their financial fragility. Niepmann and Schmidt-Eisenlohr (2019) show that depreciations increase the probability that a firm becomes past due on its loans. Focusing on exporters, Kohn, Leibovici, and Szkup (2020) show that financially-constrained firms can reallocate sales across markets in order to reduce negative balance sheet effects. Baskaya, di Giovanni, Kalemli-Ozcan, and Ulu (2017) document that exogenous capital inflows to emerging markets affect the credit supply and that Turkish firms can borrow at lower rates in foreign currency. Our paper also relates to Ahnert, Forbes, Friedrich, and Reinhardt (2018) who study the role of FX regulations on banks and firms.

firms’ productivity level before their access foreign loans (pre-reform) and, thus, avoid this potential simultaneity bias. Although so far there is no paper documenting that foreign loans could lead to more technology adoption, the innovation literature shows that better credit conditions promote innovation activities (see Gorodnichenko and Schnitzer 2013; Savignac 2008; Aghion, Berman, Eymard, Askenazy, and Cetto 2012, among others). This is the reason why the identification of the characteristics of firms using foreign loans needs to account for this potential source of bias. Note, finally, that – by following this identification strategy and having exogenous productivity shocks in the model – this paper focuses on identifying the characteristics of firms selecting into foreign currency borrowing, and is silent about any potential link with innovation activities.⁴

Our paper also contributes to the currency crises literature by quantifying –for the first time– the impact of foreign currency loans and using counterfactual exercises to assess how different policies affect the distribution of foreign loans across firms and, through it, their aggregate consequences.

This paper is also related to the literature documenting UIP deviations across countries (Hassan 2013; Lustig and Verdelhan 2007; Lustig, Roussanov, and Verdelhan 2011; and Kalemli-Ozcan and Varela 2019, among others). Our paper shows – both theoretically and empirically – that these deviations can induce firms to opt for foreign currency loans. In this way, our paper differs from the systemic bailout literature in which the mispricing leading to foreign borrowing is systemic bailouts (as Schneider and Tornell 2004), while in our framework it only arises due to UIP deviations. We also relate to the literature that develops models with endogenous UIP deviations, as Gourinchas and Tornell (2004), Lustig and Verdelhan (2006), Hassan (2013), Maggiori (2017), Farhi and Gabaix (2016), Gopinath and Stein (2018), in which these deviations arise from distortions in investors’ beliefs, differences in country size and financial development, disaster or consumption risk, and demand for safe assets.

The paper is organized as follows. Section 2 describes the Hungarian data. Sections 3 and 4 present the model and the calibration. Section 5 tests the model’s firm-level implications. Section 6 conducts numerical exercises to study the aggregate impact of foreign borrowing. Section 7 concludes.

2 Data and Main Descriptive Statistics

We analyze firms’ financing and investment decisions using firm-level data on the entire population of Hungarian firms. We combine two different datasets: APEH (Nemzeti Adó és Vámhivatal 2011), which contains panel data on firms’ balance sheets and financial statements reported to the National Tax and Customs Authority, and the KHR- Credit Registry data (Magyar Nemzeti Bank 2011), which reports panel data on all corporate loans with financial institutions in Hungary. These datasets are provided by the National Bank of Hungary (Magyar Nemzeti Bank, MNB).

The APEH database covers the population of firms in all economic activities that are subject to capital taxation between 1992-2010. This database offers information on sales, value added, investment,

⁴Note that the exogenous treatment of technology is consistent in the model and empirical analysis. The model assumes that technologies are exogenous. The empirical analysis employs firms’ pre-reform productivity to study their post-reform foreign currency borrowing choices and, thus, implicitly assumes that technology is exogenously given at the moment of making foreign borrowing choices.

assets, exports, employment and materials. Firm size varies significantly in the database, spanning from single-employee firms to large corporations. Since micro-enterprises are typically subject to measurement error problems, we retain firms that have at least three employees. We restrict our analysis to non-financial corporations on the agricultural, mining, manufacturing and service sectors.⁵ Our analysis covers more than 86% of firms, and captures more than 89% of the value added and 92% of the employment of these sectors. To obtain real values, we use price indexes at four-digit NACE activities for materials, investment, value added and production. The information on firms' debt comes from the KHR- Credit Register database, which reports information on all corporate credit in the Hungarian banking system by currency denomination between 2005 and 2010. We use these two databases to obtain measures of leverage (debt over assets), foreign currency borrowing share (foreign currency debt over total debt) and revenue total factor productivity (RTFP).⁶

In Hungary, foreign currency borrowing expanded rapidly after the deregulation of international financial flows in 2001, which liberalized foreign currency denominated loans for domestically-owned firms.⁷ Foreign loans were channelled through the domestic banking system, which was mainly dominated by foreign-owned banks (Kiraly, Vargheli, and Banai 2009). Banks were not directly exposed to the currency risk, as their open positions in foreign currency were limited by banks' regulations (Ranciere, Tornell, and Vamvakidis 2010). By 2005, one-third of firms employing bank credit held foreign-currency loans. Foreign currency borrowing firms made up for a non-negligible share of aggregate outcomes, accounting for 40% of value added and 34% of employment in the economy (Table B.18 in Appendix B). Importantly, the use of foreign currency loans was highly correlated with UIP deviations, as shown by Figure 1. The UIP deviation is computed with respect to the Euro at one-year horizon for the period 2005Q4 to 2015Q4 as $Dev_t \equiv \frac{s_t}{E(s_{t+1})} \frac{(1+r_t)}{(1+r_t^*)}$, and is adjusted by sovereign default risk using credit default swaps.⁸ As shown in Appendix B.1, this correlation is robust to considering different time horizons (3 and 24 months) and currencies (Swiss Franc and U.S. dollars), without adjusting for sovereign default risk and controlling for valuation effects in the share of foreign loans (i.e. computing it using the exchange rate of the last quarter 2005 and keeping it fixed for the entire period).⁹

Table 1 shows firms borrowing in foreign currency used this financing intensively, as their share of foreign currency loans on total loans was 64% in 2005. Remarkably, most of these firms were non-tradable firms: 73% were non-exporters, 65.3% were non-exporters and non-importers, and 71% produced in non-tradable sectors (see also Tables B.17 and B.19 in Appendix B). Moreover, 90% of these firms were domestically-owned firms. As such, firms using foreign loans were typically not naturally

⁵We exclude firms in financial and real estate activities, public administration, education and health, as these activities are subject to especial regulations. Appendix B and Table B.17 describe the sectors under analysis in detail.

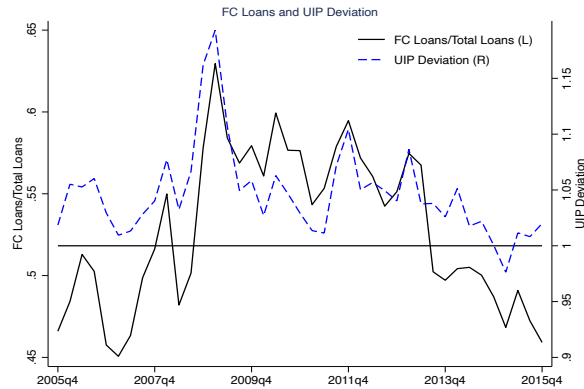
⁶The RTFP measure is computed using the methodology of Petrin and Levinsohn (2011) with the correction of Wooldridge (2009) to estimate the parameters of the production function. We additionally conduct robustness tests using the methodology of Olley and Pakes (1996) and labor productivity (value added over labor). Unfortunately, given the lack of information on firms' prices, we are only able to measure RTFP. See Foster, Haltiwanger, and Syverson (2008) for a discussion of the distinction between physical and revenue TFP.

⁷We describe the deregulation in Section 5.1.1 and Appendix C. See also Varela (2018) for a detailed description.

⁸We construct the UIP deviation using one-year Hungarian and German government bond data from Global Financial Data (Global Financial Data 2016), one-year sovereign credit default swap from Markit (Markit 2016), and the exchange rate and one-year expectations of exchange rate from Consensus Forecast (Consensus Economics 2019). The series of foreign currency loans come from the NBH (Magyar Nemzeti Bank 2019).

⁹We construct this measure with respect to the Euro as three-quarters of foreign currency loans were in this currency.

Figure 1: HUNGARY: UIP DEVIATIONS AND FOREIGN CURRENCY BORROWING



Notes: Left axis: share of foreign currency loans on total loans in the corporate sector. Right axis: UIP deviations (1 year) with respect to the Euro adjusting the country's sovereign risk. Source: DataStream, Markit, Consensus Forecast and NBH.

hedged. Notably, these firms did not employ derivative contracts to hedge the currency risk, as reported by Bodnar (2006).¹⁰ This absence of natural and financial hedging and their high foreign currency share shows that firms using foreign loans were highly exposed to exchange rate movements.

Table 1: CHARACTERISTICS OF FIRMS HOLDING FOREIGN CURRENCY LOANS IN 2005

	Non FC Debt	FC Debt
	(1)	(2)
Share of FC Debt	0	64
Share of Non-Exporters	91	73
Interest Rate	13.4	12.3
Employment	17	45
Log RTFP	6.5	6.7
Corr(FC Share, Log RTFP)	-	0.02
Corr(FC Share, Log Capital)	-	-0.05
Number of firms	147,166	13,493

Notes: Rows 1-3 are in %. The difference in means and correlation are statistically significant at one percentage point. Source: APEH, Credit Register data and BEEP Survey.

Foreign currency loans were mainly held by small and medium firms with less than 250 employees, which accounted for two-thirds of these loans (Table B.18 in Appendix B). Firms borrowing in foreign currency were –on average– more productive and paid lower interest rates, as shown in Table 1.¹¹ Interestingly, their share of foreign currency loan positively relates with their productivity and negatively with their capital stock. These features suggest that capital-scarce and productive firms were taking advantage of lower financing terms of foreign currency loans to invest more and reach faster their optimal scale. In the next sections, we develop a heterogenous firm-dynamic model that formalizes the trade-off

¹⁰In 2005, Bodnar (2006) conducts a survey on firms' hedging behavior in Hungary. She finds that only 4% of firms indebted in foreign currency employed foreign currency derivatives. This finding is not uncommon in developing economies. For example, data from the Central Bank of Peru reveals that only 6% of firms borrowing in foreign currency employ financial instruments to hedge the exchange rate risk, and a similar pattern is found in Chile and Turkey.

¹¹In all these variables, the difference in means is statistically significant at one percentage point.

between currency risk and growth, and employ the Hungarian data to test it.

3 Model

Our firm-dynamics model has three main ingredients. First, there are heterogeneous firms that can raise external funds to invest and choose the currency composition of their debt. Second, the exchange rate is determined by an affine term structure model of interest rates. The stochastic nature of the exchange rate makes foreign currency borrowing risky and firms using these loans susceptible to default. Third, there are endogenous UIP deviations that affect the relative interest rates in local and foreign currency, and can make foreign borrowing relatively more attractive. We employ the model to study firms' optimal currency debt composition and the distribution of foreign currency borrowing across firms.

3.1 Environment

There is a continuum of heterogeneous incumbent firms that produce employing a decreasing returns to scale technology: $F(Z, z, k) = Z z k^\alpha$, where z and k denote a firm's productivity and capital, and $\alpha \in (0, 1)$. Z represents an time-variant aggregate productivity that negatively correlates with the exchange rate, such that a depreciation lowers firms' revenues mimicking a decline in aggregate demand. Firms' idiosyncratic productivity is stochastic and follows

$$\log z' = \rho_z \log z + \sigma_z \epsilon_z. \quad (1)$$

The transitory productivity shock is $\epsilon_z \sim N(0, 1)$. The good is sold domestically at a price p denominated in local currency. The exchange rate s –in units of local currency per foreign currency– is stochastic and determined by the pricing kernel of the local and foreign investors, which in turn are affected by a global state factor (ω). In each period, firms pay a fixed operational cost c_f and a cost $\psi(k, k')$ to adjust their capital. Capital depreciates at rate δ .

Firms can finance their investment using retained earnings and/or external loans.¹² These loans take the form of one-period bonds, which can be denominated in local or foreign currency (b and b^*). Local and foreign currency bonds are issued at discounts q and q^* , where $q, q^* < 1$. Firms can then raise funds for $qb + q^*b^*$ in exchange for a promise to pay back the face value of the debt in the next period. Firms can default on their debt obligations, in which case they exit the market. There is a fixed credit cost c to raise external funds.¹³ In each period, there is a mass of potential entrants, which together with the endogenous exit make the distribution of firms endogenous. Firms are heterogeneous in four dimensions: productivity, capital, and local and foreign currency debts. Firms' problem are solved in partial equilibrium. Appendix A presents all analytical derivations.

¹²To focus on firms' currency debt decisions, we restrict firms from equity financing. This assumption does not affect the mechanism and allows us to illustrate firms' optimal currency debt composition without incurring in the analysis of firms' optimal financing instruments. Furthermore, it is consistent with the empirical evidence in Hungary, where the vast majority of firms are not publicly traded.

¹³The credit cost is only included to discipline the calibration and does not affect the model's mechanism or its qualitative implications, as shown in Appendix A.2 and Appendix A.8.

3.2 Firms

In each period, incumbent firms choose whether to repay their outstanding debt and produce or to default and exit the market. The value of the firm is determined by the maximum between the value of repayment (V^R) and the value of default (V^D), where the latter is normalized to zero. In particular,

$$V = \max \{V^R, V^D\}. \quad (2)$$

If a firm repays, it chooses its capital and local and foreign currency debts to maximize its value:

$$V^R(\omega_{-1}, \omega, z, v) = \max_{v'} [e + E_{z', \omega'} \tilde{\beta} V(\omega, \omega', z', v')], \quad (3)$$

where $v = \{k, b, b^*\}$ is the set of endogenous state variables. Firms discount the continuation value using the discount factor $\tilde{\beta}$, which is the product of a time-invariant component factor β and a stochastic component m' (i.e. the local currency pricing kernel) that varies with the global shock (ω).¹⁴ Firms' equity payout e is given by

$$e = p [Zzk^\alpha - i(k, k') - \psi(k, k') - c_f] - [b + sb^*] + [qb' + q^*sb'^* - p c_{I_{(b'+b'^*>0)}}]. \quad (4)$$

The first term in equation (4) denotes a firm's revenues net of investment (i), capital adjustment cost (ψ) and fixed operational cost (c_f). Let capital adjustment costs be $\psi(k, k') = c_0 \frac{[k' - (1-\delta)k]^2}{k}$. The second term is current period debt repayment. The last term is new debt issuance net of the fixed credit cost. Following Corsetti and Pesenti (2015), we let the local price of this small open economy be a function of the foreign price: $p = p^* s^\eta$, where η is the exchange rate pass-through into local prices and the foreign price is normalized to one.

The timeline can be summarized as follows. At the beginning of each period, incumbent firms carry capital and debt repayments in local and foreign currency from the previous period. Upon observing the productivity and global shocks, they decide whether to repay the debt and produce or default and exit the market. Repayment occurs whenever value of the firm $-V^R$ is positive and current equity payout (e) is non negative. Active firms receive revenues net of fixed costs, adjustment investment costs and debt repayments, and choose capital and debt for the next period.

Risk-Free Rates and the UIP Condition

Investors can hold risk-free bonds denominated in local or foreign currency. Denoting R and R^* the gross risk-free rate of local and foreign currency bonds, investors' returns should satisfy $1 = E(m'R)$ and $1 = E(m'^*R^*)$, where m' and m'^* are their pricing kernel for local and foreign bonds. As in Bekaert (1996) and Bansal (1997), the ratio of the two pricing kernels determines the exchange rate change:

$$\frac{s'}{s} = \frac{m'^*}{m'}. \quad (5)$$

¹⁴The time-invariant component of the discount factor $-\beta-$ is a reduced-form stand-in for the preference of debt financing that comes from a tax benefit and/or from an exogenous default probability. The stochastic component governs the prices of state-contingent claims, such that they are the same for firms and investors.

To define the structure of the stochastic discount factor, we consider a no-arbitrage model of exchange rate and interest rates. The model is an exponentially-affine pricing kernel model, following Backus, Foresi, and Telmer (2001), Gourinchas and Tornell (2004), Lustig, Roussanov, and Verdelhan (2011) and Farhi, Fraiberger, Gabaix, Ranciere, and Verdelhan (2015). Following Farhi, Fraiberger, Gabaix, Ranciere, and Verdelhan (2015), we consider a minimal structure where the domestic and foreign pricing kernels are log normal and determined by a global state variable (ω).¹⁵ In particular,

$$\begin{aligned} -\log m' &= \tilde{\delta} + \left(\gamma + \frac{\lambda^2}{2} \right) \omega + \lambda \omega^{1/2} \varepsilon'_\omega, \\ -\log m'^* &= \left(1 + \frac{\lambda^{*2}}{2} \right) \omega + \lambda^* \omega^{1/2} \varepsilon'_\omega, \end{aligned} \quad (6)$$

where λ and λ^* are the market valuation of risk for the home and foreign bonds, as they determine the covariance between the shocks to m , m^* and ω and, thus, the risk characteristics of bonds. $\tilde{\delta}$ and γ are constants. As in Cox, Ingersoll, and Ross (1985), the state variable follows a squared root process

$$\omega' = (1 - \varphi)\kappa + \varphi\omega + \sigma_\omega \omega^{\frac{1}{2}} \varepsilon'_\omega, \quad (7)$$

where ε'_ω is distributed normally and independently with mean zero and variance one. Note that this is a first-order autoregression process, where κ is the unconditional mean and φ controls the mean reversion of the process. Together κ and φ control the dynamic behavior of the state variable. Given equations (6) and (7), the global factor ω becomes the foreign interest rate and the domestic interest rate is a function of the latter. We can define the UIP condition as

$$\theta E(s') (1 + r^*) = s(1 + r), \quad (8)$$

where θ represents the UIP deviation. Note that UIP deviation is endogenously generated and is a function of the state variable (ω). For expositional simplicity, we refer to it as θ , but formally it could also be expressed as $\theta(\omega)$. If $\theta = 1$, the UIP condition holds and the exchange rate movement equals the interest rate differential. Otherwise, when $\theta \neq 1$, there are UIP deviations. If $\theta > 1$, the local rate is higher than the foreign rate and foreign currency borrowing is relatively more attractive.

This model endogenously generates deviations from the UIP. Given the different market valuation of risk of local and foreign investors, shocks in the global factor affect the ratio of their pricing kernels and the exchange rate evolution. As shown by Hassan (2013), different valuations of risk can arise partly from countries' asymmetric ability to diversify risk. In particular, since larger countries are less able to diversify risk, they price the risk relatively more. In a small economy setting, this implies $\lambda^* > \lambda$. As

¹⁵We model the process as a function of only one factor for three reasons. First, it helps keeping the state space manageable. The model has six state variables: three endogenous state variables (k, b, b^*), one idiosyncratic exogenous state (z), and each risk factor in the SDF adds two states (ω and ω'). Second, this structure keeps the dynamics of the exchange rate and the interest rate differential transparent and allow us to derive analytical solutions for them. Finally, this single factor follows well the evolution of the exchange rate in Hungary during the period under analysis. As discussed in Section 6.2, this specification mimics the exogenous depreciation of the Hungarian currency and the drop in the foreign interest rate upon the collapse of Lehman Brother in 2008. Note as well that this model captures the dynamics of small open economies, where foreign interest rate shocks affect capital flows and exchange rates (see for example Rey 2015).

we show in Appendix A.1, this yields that a negative shock to the global factor leads to an increase in the ratio of the pricing kernels (m^*/m') and to a currency depreciation. As such, the local currency pays a premium because it depreciates in bad states of the world. In this way, this model endogenously generates UIP deviations that can make foreign loans relatively cheaper $\theta > 1$.

Debt Contract and Debt Pricing

Investors can buy firms' risky bonds denominated in local or foreign currency. Let $\Delta(v)$ be the set of global and productivity shocks for which a firm chooses to default: $\Delta(v) = \{(\omega, z) \text{ s.t. } V^R(\omega_{-1}, \omega, z, v) \leq 0\}$.¹⁶ Firms' bonds prices are sold at a discount, given by

$$q(\omega, z, v') = E_{\omega', z' \notin \Delta(v')} (m') \quad \text{and} \quad q^*(\omega, z, v') = E_{\omega', z' \notin \Delta(v')} (m^*). \quad (9)$$

While UIP deviations can make foreign currency borrowing more attractive, this financing exposes firms to the currency risk, potentially raising their default probability and overall cost of funds. This trade-off drives firms' foreign borrowing decisions as discussed below.¹⁷

Entrant Firms

In each period, there is a constant mass of potential entrants that receives a signal about their productivity in the next period. After observing their signal, potential entrants choose their capital stock. Firms enter if their expected continuation value exceeds the sunk cost of entry (c_e): $V_e(\omega, \chi) \geq p c_e$. The value of entry is as follows

$$V_e(\omega, \chi) = \max_{k'} \left[-p k' + E_{\omega', z'} \tilde{\beta} V(\omega, \omega', z', v') \right].$$

Equilibrium

Appendix A.3 describes the stationary firm-distribution.

3.3 Model Mechanism

This section uses a simplified two-period setting to illustrate the forces driving firms' foreign currency borrowing decisions. This setting has the main forces of the full dynamic model, but it allows us to present the trade-offs implied in firms' decisions in a clear manner. The Euler equations and all additional derivations of the full dynamic model are presented in Appendix A.2. At the end of this section, we discuss these forces in the context of the full dynamic model.

¹⁶For simplicity, we let no recuperation cost post default and firms default in local and foreign debts simultaneously.

¹⁷This specification assumes that banks offer firms a lower rate in foreign currency, and pass on the benefit from the UIP deviations. Importantly, this is consistent with cross-country empirical evidence showing that the interest rate of corporate foreign currency loans is lower (Ranciere, Tornell, and Vamvakidis 2010). This interest rate differential was also present on Hungarian firms. Between 2005 and 2015, there was a 4 percentage points differential (8.04% vs 3.88%) between local and foreign currency loans. This difference could arise from market segmentation in the financial sector.

Forces Driving Foreign Currency Borrowing: An Example using a Two-Period Setting

We simplify some of the ingredients of the model. First, we let firms discount the future at a constant rate β , and the exchange rate be stochastic and log normally distributed. Second, we assume zero pass-through into local prices ($\eta = 0$) such that the local price is fixed, and let aggregate productivity be constant ($Z = 1$). Third, firms are born with zero capital stock and capital fully depreciates after production ($\delta = 1$). Finally, the credit cost is zero ($c_{I_{(b'+b'^*>0)}} = 0$). In the first period, firms can issue bonds to invest. In the second period, the exchange rate is realized and firms choose whether to repay the debt and produce or to default and exit the market. Appendix A.8 presents all the derivations. Formally, a firm's problem can be expressed as

$$\max_{v'=\{k',b',b'^*\}} V^{total}(s, z, v') = [-k' + q(s, z, v')b' + q^*(s, z, v')b'^*s] + \beta E_{z',s'}V(s', z', v'),$$

$$\text{subject to } k' \geq 0, b' \geq 0, b'^* \geq 0.$$

The first term is the revenue from debt issuance net of investment and the second term is the value of the firm in the second period. This value is the maximum between the value of default and its income after debt repayment, that is $V(s', z', v') = \max\{0, z'k'^\alpha - b' - s'b'^*\}$, and allows us to define a productivity threshold below which a firm chooses to default and exit the market, $\tilde{z} \equiv z' < \frac{b'+s'b'^*}{k'^\alpha}$. The first order conditions for local and foreign currency bonds are

$$b' : q(s, z, v') + \frac{\partial q(s, z, v')}{\partial b'}b' + \frac{\partial q^*(s, z, v')}{\partial b'}sb'^* \leq -\beta \frac{\partial V(s', z', v')}{\partial b'}, \quad (10)$$

$$b'^* : q^*(s, z, v')s + \frac{\partial q(s, z, v')}{\partial b'^*}b' + \frac{\partial q^*(s, z, v')}{\partial b'^*}sb'^* \leq -\beta \frac{\partial V(s', z', v')}{\partial b'^*}, \quad (11)$$

where bond prices are given by $q(s, z, v') = (1 - P_{z',s'|z,s}(\Delta(v')))/(1 + r)$ and $q^*(s, z, v') = (1 - P_{z',s'|z,s}(\Delta(v')))/(1 + r^*)$ and $\Delta(v')$ represents the set of productivity and exchange rate shocks for which a firm chooses to default in the second period.¹⁸ After some algebra, we can express the first order condition for foreign currency bonds as

$$\underbrace{q(s, z, v') - \left(\frac{b'}{1+r} + \frac{sb'^*}{1+r^*}\right) \frac{\partial E_{z',s'|z,s}\Delta(v')}{\partial b'} - \beta E_{z',s'|z,s}(1 - \Delta(v'))}_{\text{A. Local Currency Bond Decision}} \quad (12)$$

$$+ \underbrace{\left[\underbrace{(\theta - 1)q(s, z, v')}_{\text{B1. UIP Deviation Effect}} - \underbrace{\left(\frac{b'}{1+r} + \frac{sb'^*}{1+r^*}\right) \left(\frac{\partial E_{z',s'|z,s}\Delta(v')}{\partial b'^*} \frac{1}{E(s'|s)} - \frac{\partial E_{z',s'|z,s}\Delta(v')}{\partial b'} \right)}_{\text{B2. Debt Revenue Effect}} + \beta \frac{1}{E(s'|s)} \text{cov}(s', \Delta(v') | z, s)}_{\text{B3. Debt Repayment Effect}} \right]}_{\text{B. Relative Marginal Benefits and Costs of Foreign Currency Debt}} \leq 0,$$

¹⁸Equations (10) and (11) might hold with inequality because the non-negative constraints of the debt and capital might hold with equality. In other words, the Lagrange multiplier for the constraint might be positive.

where $\frac{\partial E_{z',s'|z,s}\Delta(v')}{\partial b'^*}$ and $\frac{\partial E_{z',s'|z,s}\Delta(v')}{\partial b'}$ are the change in the default probability following an increase in foreign and local currency debt issuance, respectively. We denote this Euler equation as $U(s, z, v') \leq 0$. Equation (12) shows that firms' foreign borrowing choices are a function of the Euler equation for local currency debt (term A in the first line) plus a term that captures the marginal benefits and costs of foreign bonds relative to local currency bonds (term B in the second line).

The relative marginal benefits and costs of foreign borrowing – term B – is composed by three effects. The *UIP Deviation Effect* that arises from differences in the relative risk-free rates whenever $\theta \neq 1$. The *Debt Revenue Effect* that represents the change in the default probability from issuing foreign currency bonds relative to local currency bonds. As such, it captures the difference in revenue from issuing foreign bonds vis-à-vis local bonds. The *Debt Repayment Effect* that reflects how the second-period exchange rate affects the value of future debt repayment and, hence, a firm's default probability. This effect represents the impact of foreign borrowing on the continuation value of the firm.¹⁹

We now analyze whether these three effects constitute benefits or costs from issuing foreign bonds. The UIP deviation effect is a benefit whenever $\theta > 1$. In this case, the risk-free rate in foreign currency is relatively lower than in local currency (see equation (8)) and firms can take advantage from UIP deviations to issue foreign bonds at a lower risk-free rate. The debt repayment effect is also a benefit because appreciations reduce the value of future debt repayment and lower a firm's default probability. Put it differently, when s' is low, the default set ($\Delta(v')|z, s$) is smaller and, hence, the co-movement between the future exchange rate and the default probability is non-negative ($cov(s', (\Delta(v')|s, z)) \geq 0$). Therefore, the UIP deviation and continuation value effects are positive and represent marginal benefits of issuing foreign bonds.

The debt revenue effect can be a cost or a benefit depending on whether a firm has a low or high default probability. As we show in Appendix A.8, this effect implies a cost for firms with low/moderate default probability (about less than 50% in log normal distributions). For these firms, the default probability increases more per unit of foreign currency debt than local currency debt and, thus, $\frac{\partial E_{z',s'|z,s}\Delta(v')}{\partial b'^*} \frac{1}{E(s'|s)} \geq \frac{\partial E_{z',s'|z,s}\Delta(v')}{\partial b'}$. That is, for these firms, the exposure exchange rate increases their default risk more and leads to a higher risk premium. Because the bond price decreases relatively more per unit of foreign debt issuance, foreign currency borrowing is more costly than local borrowing. In contrast, for firms with high default probability, the debt revenue effect can be a benefit. For these firms, the default probability increases relatively less by borrowing in foreign currency, $\frac{\partial E_{z',s'|z,s}\Delta(v')}{\partial b'^*} \frac{1}{E(s'|s)} < \frac{\partial E_{z',s'|z,s}\Delta(v')}{\partial b'}$. Intuitively, these firms might borrow in foreign currency to gamble for survival because a large appreciation can reduce their foreign debt repayment and allow them to not default. Importantly, we show in Appendix A.5 that, in our the full dynamic model calibrated to Hungary, we do not observe firms with high default probability or gambling for survival. The reason is

¹⁹Note that this effect hinges on a segmentation in the loan markets. Specifically, in this two-period model lenders extending foreign currency loans are only concerned about being repaid in foreign currency units. If foreign currency lenders anticipate being paid with lower probability when the real value of their claims is higher and firms have the same discount factor as lenders, this effect would be eliminated. In the dynamic model, where discount rate is stochastic and connected to the exchange rate, foreign currency lenders do value more payments in states when the currency depreciates. However, we assume that $\beta < 1$ such that the firm discounts the future more than the lender. This assumption implies a benefit of issuing debt - both local and currency - and this effect is not eliminated.

that firms are risk averse for non-zero default probabilities and, thus, avoid the high default region.²⁰ Therefore, in our analysis, all firms have a low/moderate default probability and the debt revenue effect implies a cost. For this reason, the rest of this section focuses on this case.

In sum, the net benefit from issuing foreign bonds (term B) depends on the relative magnitudes of the marginal benefits arising from the lower risk-free rate and the lower debt repayment in case of appreciations – UIP deviation and debt repayment effects –, and the marginal cost stemming from differential increase in the default probability –debt revenue effect.

There are two cases in which a firm borrows in foreign currency and equation (12) holds with equality. The first case would be a firm borrowing in local and foreign currencies. In this case, the first order condition for b' – equation (10) – holds with equality and the first line of equation (12) is equal to zero. Hence, the decision to borrow in foreign currency boils down to the second line of equation (12) being equal to zero. Or, put it differently, it depends on the marginal benefits of issuing foreign bonds being equal to their marginal costs. A second case would be a firm that chooses not to borrow in local currency and only raises foreign funds. In this case, the first order condition for local currency bonds b' is negative – equation (10) – and the firm only borrows in foreign currency if the second line of equation (12) is positive (and equal in size than the first line). Hence, for these firms, the marginal benefits stemming from the UIP deviation and debt repayment effects need to be higher than marginal cost of issuing foreign bonds –debt revenue channel.

Importantly, since for a given state s and a value in the choice set k' , b' and b'^* , highly productive firms have a lower default probability, the net benefit of foreign currency borrowing increases with current productivity. Therefore, foreign currency borrowing decisions correlate with firms' productivity. We present below two lemmas that summarize firms' foreign currency borrowing decisions.

-Lemma 1: Define a vector of choices $\bar{v}' = (\bar{k}', \bar{b}', \bar{b}'^*)$, $\bar{z} \equiv \frac{\bar{b}' + s' \bar{b}'^*}{k' \alpha}$ the default threshold implied by this vector, and suppose that $(\log \bar{z} - \rho_z \log z) < -\sigma_z^2 \bar{\kappa} \quad \forall z$, where $\bar{\kappa} \equiv \frac{(\bar{b}' + s' \bar{b}'^*) \beta (1+r)}{(\bar{b}' + E(s'|s) \theta \bar{b}'^*)}$. Then, the net marginal benefit of borrowing in foreign currency, given by $U(s, z, \bar{v}')$, is increasing in z . Formally,

$$\text{if } z_0 < z_1 \text{ then } U(s, z_0, \bar{v}') < U(s, z_1, \bar{v}').$$

Therefore, more productive firms are more likely to select into foreign currency debt and hold higher levels of foreign currency debt.²¹ The condition $(\log \bar{z} - \rho_z \log z) < -\sigma_z^2 \bar{\kappa}$ implies that firms' choices lead to a low/moderate probability of default. Note that, because $\sigma_z^2 \bar{\kappa}$ is small, this inequality is likely satisfied if $\log \bar{z} \ll \rho_z \log z$.²² This implies that a firm's expected productivity needs to be significantly

²⁰In Appendix A.8, we use the two-period model to show analytically that firms are risk neutral for zero default probability and become risk averse for default probabilities above zero. Hence, firms generally do not make equilibrium choices that could entail high default probabilities. A firm would only get to a high default state if it suddenly gets a large negative productivity shock that catapults it to this state. Although the probability of a large shock depends on the numerical parametrization, they are usually unlikely in log normal distributions.

²¹Because the choices of k' , b' and b'^* are simultaneous, as productivity rises firms might choose a different mix of b' and k' in which case the choice of b'^* might not monotonically increase with z .

²²As shown in Appendix A.8.3, the term $\sigma_z^2 \bar{\kappa}$ is small. In our calibration for Hungary, σ_z^2 is 0.32 and $\bar{\kappa}$ is likely lower than one, as $\beta(1+r)$ is lower than one and $\frac{(\bar{b}' + s' \bar{b}'^*)}{(\bar{b}' + E(s'|s) \theta \bar{b}'^*)}$ would be around one if the distribution of exchange rate shock is centered around its conditional mean.

higher than its default threshold to borrow in foreign currency. Because productivity is persistent, firms with high current productivity and a low/moderate default probability borrow in foreign currency.

To see the intuition behind this lemma, note that the higher a firm's productivity, the easier is to tolerate the currency risk (i.e. have a non-negative value in the second period) and the lower is the increase in its default probability when issuing foreign bonds, for a given choice of \bar{v}' and exchange rate shock s . Therefore, the cost stemming from the debt revenue effect is lower for currently more productive firms, making these firms more likely to choose to borrow in foreign currency. Importantly, there is a productivity threshold below which the increase in default probability is sufficiently high that the optimal decision is not to issue foreign currency bonds.

-Lemma 2: Define a vector of choices $\bar{v}' = (\bar{k}', \bar{b}', \bar{b}'^*)$, $\bar{z} \equiv \frac{\bar{b}' + s' \bar{b}'^*}{\bar{k}'^\alpha}$ the default threshold implied by this vector, and suppose that $(\log \bar{z} - \rho_z \log z) < 0 \quad \forall z$. Then, the net marginal benefit of borrowing in foreign currency, given by $U(s, z, \bar{v}')$, is increasing in z faster for higher levels of UIP deviation. Formally,

$$\text{if } \theta_1 > \theta_0 \text{ and } z_0 < z_1 \text{ then } U_{\theta_1}(s, z_1, \bar{v}') - U_{\theta_1}(s, z_0, \bar{v}') > U_{\theta_0}(s, z_1, \bar{v}') - U_{\theta_0}(s, z_0, \bar{v}').$$

This lemma implies that the higher UIP deviation, the higher is the net benefit of issuing foreign currency bonds. Therefore, firms with relatively lower productivity may also find beneficial to use this financing.²³

The forces outlined in the two-period setting are also present in the full dynamic model. Our full dynamic model offers four additional ingredients. First, the exchange rate depreciates in bad states of the world. Intuitively, a decrease in the foreign rate increases the ratio of the foreign and local pricing kernels, inducing a depreciation ($m'^*/m' = s'/s$). The local currency pays a premium because it depreciates during bad states of the world. This dynamic endogenously generates UIP deviations that can make foreign currency borrowing relatively cheaper and $\theta > 1$. Second, the presence of a time-varying aggregate productivity that negatively correlates with the exchange rate reduces firms' sales during depreciations. This effect makes foreign currency borrowing decisions riskier for firms, as during depreciations foreign debt repayment increases and sales decline. Third, the owners of firms discount cash flows under a stochastic discount factor that increases their aversion to risk. Lastly, adjustment costs of capital make firms' transition to their optimal scale slow and debt risky given the suboptimal size of firms. Importantly, given the cyclical nature of firms' pay-offs, the risk aversion of firms' owners and the adjustment costs of capital, foreign currency borrowing decisions are riskier for firms in the full dynamic model. This reinforces the correlation between productivity and firms' foreign borrowing decisions stated in Lemma 1. In Appendix A.2, we discuss our two lemmas in the context of the full dynamic setting.

In the next section, we calibrate our full dynamic model to check whether it matches moments of the distribution of foreign loans across firms. In the rest of the paper, we employ it to quantify the impact of foreign borrowing at the firm and aggregate levels.

²³In Appendix A.6, we employ our dynamic model to disentangle the importance of the UIP deviation effect from the continuation value and debt revenue effects on firms' foreign currency borrowing decisions. Our quantitative results indicate that the former is the main force leading firms to issue foreign debt.

4 Calibration and Non-Targeted Moments

We calibrate the model to match data moments in Hungary in 2005 –i.e. the first year for which the dataset reports information on foreign currency loans. Because Hungary only fully deregulated these loans in 2001 and was transitioning in 2005, we calibrate the model to mimic this transition period (instead of focusing on a stationary equilibrium with foreign loans).

We conduct the simulation in three steps. First, we simulate an economy without foreign currency debt and find the stationary distribution of firms. This first step gives an initial condition for the economy prior to the deregulation of foreign currency loans. Second, we solve an economy with foreign currency borrowing and obtain firms’ optimal capital, and local and foreign currency debt policies. Finally, we simulate approximately 160,000 firms starting from the distribution without foreign currency debt (which is the number of firms we observe in Hungary), using the realized foreign interest rate shocks between 1995 and 2015 and using the firm-level optimal policies of the model with foreign currency for the post 2001 simulation. This simulation strategy allows us to create firm-level panel data that tracks the evolution of firms, and follows the path of the exchange rate in Hungary.

The seventeen parameters of the model are calibrated to Hungarian data on yearly basis. Thirteen parameters are externally calibrated and four are internally calibrated to match moments of the firm-level data for Hungary in 2005. We parametrize the parameters governing the global factor to the one year German government bond between 1997 and 2015. The mean of the foreign rate is $\kappa = 0.007$, the mean reversion parameter is $\varphi = 0.58$, and σ_ω is 0.196. We obtain $\tilde{\delta}$ and γ using the model’s implied relationship between the domestic and foreign rates: $r_t = \tilde{\delta} + \gamma r_t^*$.²⁴ Estimating this regression, we obtain $\tilde{\delta} = 0.043$ and $\gamma = 1.065$.²⁵ We deduct the credit default swaps from the government bond prices to obtain the risk-free rates. We choose $\lambda = 1.4$ and $\lambda^* = 2.7$ to match the mean UIP deviation and mean depreciation rate in Hungary between 2002 and 2015. It is worth mentioning that despite these parameters are chosen to match the mean, they also match well the volatility of the UIP deviation and depreciation rate and, hence, the relative dynamics of these two factors.

We follow Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2018) and Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017) and estimate the firms’ productivity process as

$$\log z_{ijt} = \rho_z \log z_{ijt-1} + \phi_i + \mu_{jt} + \varepsilon_{ijt},$$

where i , j and t denote firm, four-digit NACE industries and time. ϕ_i represent firm-fixed and μ_{jt} are four-digits industry and year fixed effects interacted. Based on this regression, we set $\rho_z = 0.63$ and $\sigma_z = 0.57$. We let the depreciation rate (δ) be 10% and the elasticity of capital (α) be 0.6, which is the value estimated for Hungarian firms. We set the exchange rate pass-through onto local firms’ prices to zero ($\eta = 0$), as two-third of firms borrowing in foreign currency in Hungary are non-exporters and non-importers and their prices are set in the local market.

²⁴We use quarterly data from Global Financial Data for one year Hungarian and German government bonds. Data is annualized using average over the quarters.

²⁵Note that $\gamma > 1$ is in line with a macro literature showing that foreign interest rate shocks propagate in Emerging markets by increasing the spread and the domestic interest rate relatively more, see Neumeyer and Perri (2005), Tornell and Westermann (2005), Uribe and Yue (2006) and Varela (2017) among others.

To characterize the relationship between aggregate productivity and the exchange rate, we let $Z' = (\frac{s'}{s})^\zeta$ and regress the log of aggregate productivity on the log of exchange rate change. Using TFP data from the Penn World Table 9.0 for Hungary (Feenstra, Inklaar, and Timmer 2015) and the end-of-year HUF/EUR exchange rate from the NBH between 1991 and 2015 (Magyar Nemzeti Bank 2019), we obtain $\zeta = -0.43$, indicating that currency depreciations associate with decreases in aggregate productivity.

We jointly calibrate the fixed credit cost (c), the investment adjustment cost (c_0), the fixed operational cost (c_f) and the time-invariant discount factor (β) to match main moments of firms in Hungary in 2005.²⁶ In particular, we calibrate the credit cost to match the share of firms borrowing (30%), the investment adjustment cost to match their investment rate (12%), operational cost to match the default rate (2%), and the discount factor β to match firms' leverage (7%).²⁷ Table 2 summarizes the parameters and targeted moments.

Table 2: PARAMETER VALUES

	Parameter Values	
	Value	Target
<i>Parameters of the Affine Model</i>		
Foreign interest rate	$\kappa = 0.007$	
	$\varphi = 0.58$	German Bund, 1 year rate
	$\sigma_\omega = 0.196$	
Domestic Interest rate	$\bar{\delta} = 0.043$	Hungarian Government Bond, 1 year rate
	$\gamma = 1.065$	
Pricing of risk	$\lambda = 1.4$ $\lambda^* = 2.7$	UIP Deviation and Depreciation Rate
<i>Firm-level Parameters</i>		
Firms' productivity	$\rho_z = 0.63$	Hungarian firms
	$\sigma_z = 0.57$	
Return to scale	$\alpha = 0.6$	Hungarian firms
Depreciation rate	$\delta = 10\%$	
Exchange rate pass-through	$\eta = 0$	
Aggregate productivity	$\zeta = -0.43$	
<i>Jointly calibrated parameters</i>		
Fixed operational costs	$c_f = 4.33$	Default rate
Investment adjustment cost	$c_0 = 0.05$	Investment rate of borrowing firms
Fixed cost of credit	$c = 0.1$	Share of firms borrowing
Constant discount factor	$\beta = 0.998$	Leverage

Notes: This table shows the parameters selected independently and the calibrated parameters with their respective targets.

Non-Targeted Moments

To assess whether the model matches firms' foreign currency borrowing decisions and investment patterns, we break down firms with credit (about 30% of firms) into three mutually exclusive groups

²⁶The credit cost is equivalent to a flotation costs of 0.5% per unit of debt.

²⁷The default probability in Hungary was estimated by Bauer and Endresz (2016), who reports 2% for 2005. Two additional parameters were calibrated: the fixed entry cost and the mass of firms, (c_e, M). They were set such that average entry equals exit, so that over time the firm distribution is stable. Similarly, the entrants' productivity signal is estimated in the same support as the incumbents productivity.

according to their exposure to exchange rate shocks : 1) firms borrowing only in local currency, 2) firms borrowing in both local and foreign currency, and 3) firms borrowing only foreign currency. Table 3 shows that the model is able to replicate closely main moments of the distribution of foreign currency borrowing and main characteristics of each group of firms.

Table 3: NON-TARGETED MOMENTS

Moment	Group	Model (1)	Data (2)
1. Firm share (%)	LC debt only	19	21
	LC & FC debt	5	6
	FC debt only	1	3
2. Relative productivity*	LC debt only	0.98	0.99
	LC & FC debt	1.07	1.02
	FC debt only	1.11	1.05
3. Relative capital*	LC debt only	0.97	0.97
	LC & FC debt	1.09	1.06
	FC debt only	1.05	0.99
4. Investment rate (%)	LC debt only	13	9
	LC & FC debt	25	18
	FC debt only	26	19
5. FC Share (%)	LC debt only	0	0
	LC & FC debt	39	50
	FC debt only	100	100
6. Leverage (%)	LC debt only	21	17
	LC & FC debt	33	23
	FC debt only	20	18
7. LC Leverage (%)	LC debt only	21	17
	LC & FC debt	21	14
	FC debt only	0	0
8. FC Leverage (%)	LC debt only	0	0
	LC & FC debt	12	9
	FC debt only	20	18

Notes: This table shows data and model moments. We simulate approximately 160,000 firms from the stationary distribution of no foreign currency. In this simulation, we use the foreign interest rate shocks between 2001 and 2010 and the optimal policies of the model with foreign currency borrowing to obtain the moments for 2001-2010. *Relative productivity and capital are considered with respect to firms with credit, which are normalized to one.

The model tracks closely the share of firms borrowing only in local currency (19% and 21% in the model and data, respectively), borrowing both in local and foreign currency (5% and 6% in the model and data), and only borrowing in foreign currency (1% and 3% in the model and data).

The model matches closely the productivity and capital of each group. Relatively to all firms with credit –which are normalized to one–, firms that borrow in foreign currency are more productive both in the model and the data. Notably, firms that only borrow in foreign currency are 11% more productive in the model and 5% in the data (row 2). Interestingly, these firms have lower level of capital both in the model and the data (row 3). Their high productivity and low capital indicates that these firms have high MPK, which is consistent with their intensive use of cheap foreign loans to expand their investment (as shown in row 4).

The model follows closely the leverage of each group. Firms borrowing only in local currency have 21% and 17% of leverage in the model and data, respectively (row 6). Firms that borrow in both local and foreign currency have a leverage of 33% and 23% (row 6), a leverage in local currency of 21% and 14% (row 7), and a leverage in foreign currency of 12% and 9% (row 8) in the model and data, respectively. Firms that only borrow in foreign currency have a leverage of 20% and 18% in the model and the data (row 6). Note that, neither in the model nor in the Hungarian data, firms only borrowing in foreign currency have high levels of leverage or leverage in foreign currency. This is interesting because it indicates that firms do not use foreign currency loans to over-borrow.

The patterns presented in Table 3 indicate that foreign currency borrowing correlates with firms' productivity and that firms using this financing have moderate levels of leverage. This provides support to Lemma 1 stating that only high productivity firms borrow in foreign currency and they do so to the level of risk that they can tolerate. However, as discussed in Section 3.3, it is mathematically possible that firms with low productivity and high default probability –that cannot afford to issue local currency bonds– borrow in foreign currency with the expectation that a large appreciation would lower debt repayment and allows them to survive. In the model, this possibility would be captured by the debt revenue effect that would be positive for firms gambling for survival. To evaluate whether these firms exist in our simulation, we use the default policy functions and calculate the differential sensitivity of bond prices to changes in the foreign versus local currency debt. As we show in Appendix A.5, for all firms in the sample, the debt revenue effect is zero or negative, as the probability of default responds equal or more to foreign currency debt than to local currency debt.²⁸ Hence, in our sample, firms do not gamble for survival. To provide additional support to this, we employ the equilibrium decisions of the simulated sample and show that the vast majority of firms raising foreign bonds have zero or close to zero default probability. For example, all across the 14 years of our sample (2001-2015), 97% of firms borrowing in foreign currency and having positive default probability have a default probability less than 10%, and there is no firm with default probability above 45%. These results indicate that foreign currency borrowing firms are not gambling for survival, but they use these loans to the level of risk that they can tolerate. In the next section, we test econometrically Lemmas 1 and 2 using the Hungarian data.

5 Model vs Data: Firm-Level Analysis

In this section, we test the model's predicted patterns of foreign currency borrowing and investment at the firm level. We conduct three exercises estimating in parallel regressions using the simulated and the Hungarian data. These exercises allow us to test econometrically the model's qualitative predictions in the data, and to compare the size of firms' responses of the model with those of the Hungarian data. In Section 5.1, we describe the deregulation of foreign currency loans in Hungary and assess selection into foreign borrowing (Lemma 1). In Section 5.2, we test if UIP deviations promote foreign currency

²⁸In the language of the two-period setting of Section 3.3, $\frac{\partial E_{z',s'|s}\Delta(v')}{\partial b'^*} \frac{1}{E(s'|s)} - \frac{\partial E_{z',s'|s}\Delta(v')}{\partial b'}$ ≥ 0 for all firms issuing foreign bonds. Note that, since we test this hypothesis in the full dynamic model, the formula involves also the stochastic discount factors and the aggregate shock. See Appendix A.5 for details.

borrowing (Lemma 2).

5.1 Access to Foreign Currency Loans: Firms' Characteristics and Investment

5.1.1 Deregulation of Foreign Currency Loans in Hungary

The model implies that only highly productive firms borrow in foreign currency and that they employ this financing to expand their investment. In this section, we exploit the deregulation of foreign currency loans in Hungary in 2001 as an exogenous source of time variation to assess this prediction empirically. This reform allows us to identify firms' pre-reform productivity and, in this way, address empirically the relationship from productivity to foreign loans. Note that, since firms could use foreign loans to invest in technology and increase their productivity, a contemporaneous regression would absorb this relationship from foreign loans to productivity and bias the estimated coefficients. The use of this policy reform allows then identifying firms' productivity prior to the access of foreign loans and addressing this simultaneity bias concern.²⁹

Prior to 2001, foreign currency loans were regulated by the Act XCV of 1995. As Varela (2018) shows, this law treated foreign and domestically-owned firms asymmetrically. Whilst foreign firms were legally allowed to hold foreign denominated loans, home firms were restricted to borrow locally in national currency. In 2001, the ban on home firms' foreign currency loans was removed and home firms were thereafter allow to borrow in foreign currency. Our empirical strategy focuses on those firms that gain access to foreign currency loans upon the reform – namely, home firms – to identify the pre-reform characteristics and the investment behavior of firms using foreign loans. Therefore, we restrict our analysis to home firms to avoid endogeneity concerns.

The general context around the deregulation of foreign currency loans and its timing makes it likely to be exogenous with respect to the main outcome analyzed, i.e. home firms' decisions to borrow in foreign currency. The reform was driven by the accession of transition economies to the EU. The requirements to join the EU were predetermined by the Copenhagen Criteria in 1993 and have been equal for all accessing countries since then. In this sense, the content of the reform was exogenous to the country's political choice. As the agenda was jointly determined by the European Council and the candidate countries, it is unlikely to have been driven by political pressure from Hungarian firms. Furthermore, given the speed of the reform, it is unlikely that firms anticipated it and increased their productivity in advance. Furthermore, the EU did not require any additional reform that could affect Hungarian firms' foreign currency borrowing decisions (see Varela 2018).³⁰ Finally, note that large

²⁹The deregulation of foreign currency loans associates with an increase in the availability of credit in foreign currency and a decrease in financing terms for firms gaining access to this financing. Both forces could enhance technology adoption by making investment in technology more accessible. While the analysis of the channels through which foreign loans could induce technology adoption is interesting, it goes beyond the scope of the paper. All our empirical strategy requires is to use firms' pre-reform productivity to control for this potential source of bias.

³⁰In December 2000, the European Council defined the timing for the accession vote and the last requirements to be met by each candidate. The reform had to take place any time before the accession vote in December 2002. In March 2001, Hungary deregulated foreign currency loans. Note as well that the Hungarian economy was already deeply integrated with the EU, as exports to the EU already accounted for 80% of total exports in 2001, and trade with the EU did not increase upon the reform (Figure B.10). During this period FDI remained constant (Figure B.9).

banks in Hungary were similarly involved in foreign currency corporate lending after the deregulation of this financing. According with data from the NBH, in 2005, the six largest foreign banks and the only public bank lent –on average– 50% of their corporate loans in foreign currency (Appendix C).

5.1.2 Firms’ Characteristics

We assess Lemma 1 and study whether home firms’ productivity correlates with foreign currency borrowing decisions using the following linear probability regression:

$$\text{FC Dummy}_i = \beta \log \text{Productivity}_i + \varepsilon_i, \quad (13)$$

where FC Dummy_i is a dummy indicating whether a firm i had a foreign currency loan in 2005. Productivity_i denotes a firm’s productivity, which is z_i in the model’s simulated data and firm’s RTFP (in 2000) in the Hungarian data.³¹ The regressions estimated for Hungary add three features. First, we include four-digit NACE industries fixed effects that allow comparing firms within narrowly-defined industries. Second, in our baseline specification, we exclude exporters (as they could be naturally hedged) and include them later in a robustness test. Finally, we cluster standard errors at four-digit industries to account for cross-sectional serial correlation within sectors. To assess whether more productive firms employ foreign currency loans more intensively, we re-estimate equation (13) using firms’ log share of foreign currency loans in 2005. The coefficient of interest is β and captures whether initially more productive firms have a higher probability of using this financing and share of foreign currency loans.

Columns 1-4 present in Table 4 present the results for the extensive margin of foreign borrowing where the foreign currency dummy is the independent variable. Both in the simulated and the Hungarian data, the regressions confirm that the probability of borrowing in foreign currency increases in firms’ productivity. The estimated coefficients are similar in magnitude implying that a one percent increase in a firm’s productivity raises its probability of borrowing in foreign currency by 6 and 2 percentage points, in the model and Hungarian data respectively (columns 1 and 3). These results are robust to including capital as a control (columns 2 and 4).

The results for the intensive margin, using the share of foreign loans as independent variable, confirm these trends (columns 5-8). A one percent increase in a firm’s productivity raises its share of foreign loans by 0.013 and 0.003 percent, in the simulated and the Hungarian data (columns 6 and 8).

Table B.2 in Appendix B presents a full set of robustness tests. First, we show that when we include exporters in the analysis, the estimated coefficients remain stable and highly statistically significant. Second, we control for firms’ local currency leverage prior to the deregulation, as firms with better initial access to bank credit might find it easier to access to foreign loans. The coefficients remain highly significant and similar in size than those in the baseline specifications. Third, we show that results are robust to controlling for firms’ age, a common determinant of firms’ borrowing decisions in the firm dynamics literature. Fourth, we show that results hold true when estimating firms’ RTFP using

³¹The difference between physical and revenue TFP is –to a certain degree– second order in our analysis, since –as shown by Foster, Haltiwanger, and Syverson (2008)– these measures are highly correlated in the cross-section. In all our empirical exercises, we only employ RTFP in a given year to proxy firms’ initial productivity and conduct robustness tests for different productivity measures.

Table 4: DECISION INTO FOREIGN CURRENCY BORROWING

	Foreign Currency Loan Dummy				Log Share of Foreign Currency Loans			
	Model		Data		Model		Data	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log productivity	0.062*** (0.001)	0.040*** (0.002)	0.020*** (0.002)	0.012*** (0.002)	0.024*** (0.001)	0.013*** (0.001)	0.005*** (0.002)	0.003** (0.001)
Log capital		0.049*** (0.002)		0.032*** (0.002)		0.023*** (0.001)		0.009*** (0.001)
Sector FE			Yes	Yes			Yes	Yes
R^2	0.011	0.016	0.028	0.053	0.008	0.015	0.028	0.035
N	175,286	175,286	33,327	33,327	175,286	175,286	33,327	33,327

Notes: *, **, *** significant at the 10, 5, and 1 percent level. Standard errors in parentheses. Source: APEH and Credit Register.

the methodology of Olley and Pakes (1996) to estimate the coefficients of the production function, and when using labor productivity as a proxy for firms' productivity. Fifth, we also show that results are robust to using averages between 1998 and 2000 as pre-reform firms' characteristics.³²

Finally, in Appendix B.3, we show that regressions with the model simulated data can deliver substantially larger R^2 when one takes into account additional structure present in the model. In particular, the R^2 increases significantly when taking into account that, inside the model, other variables than productivity enter the state vector and policy functions are nonlinear. This, in turn, suggests that while our main results uncover a stable, statistically significant and model-consistent relation between foreign currency borrowing and productivity, there is likely substantial unobserved heterogeneity in the data, resulting in relatively low R^2 (as is common in cross-sectional analyses of firm-level data).³³

5.1.3 Firms' Investment

The model predicts that firms borrowing in foreign currency have higher investment rates as they face lower financing costs. To assess this, we exploit the deregulation of foreign loans to study if firms using these loans have higher investment rates within the five years before and after the reform. We estimate:

$$\log Y_{it} = \beta (R_t \times \text{FC Dummy}_i) + \phi_i + \iota_t + \gamma (T_t \times \text{FC Dummy}_i) + \varepsilon_{it}. \quad (14)$$

where $\log Y_{it}$ denotes log investment rate between 1996-2005, R_t is a dummy for the post-reform period ($R_t = 1$ if year ≥ 2001 , and 0 otherwise), ϕ_i are firm-fixed effects and ι_t are year-fixed effects. Since firms borrowing in foreign currency have higher levels of capital and are more productive, they could be in different trend. To control for pre-existing trends, we follow Gruber (1994) and Chinn (2005) and add a time trend interacted with the foreign currency debt dummy, i.e $T_t \times \text{FC Dummy}_i$. The coefficient of interest β captures if firms borrowing in foreign currency have higher investment rates after the reform, after firms' trends are controlled for. Standard errors are clustered at year and four-digit sector when employing the Hungarian data.

³²Appendix B.5 breaks down loans by currency and shows that all the model's implications hold true.

³³Note that the low R^2 in Hungarian data is common in cross-sectional analysis with heterogeneous firms. See, for example, Alfaro, Antras, Chor, and Conconi (2019), Amiti, Itskhoki, and Konings (2014), Bustos (2011) and Bertrand, Duflo, and Mullainathan (2004), among others.

Table 5 confirms that firms borrowing in foreign currency have higher investment rates. After the inclusion of all controls, the estimated coefficients imply that these firms have 3 and 7 percent higher investment rates in the simulated and Hungarian data (columns 2 and 4).

Table 5: FOREIGN CURRENCY BORROWING AND INVESTMENT

	Log Investment Rate			
	Model		Data	
	(1)	(2)	(3)	(4)
R*FC dummy	0.124*** (0.002)	0.034*** (0.002)	0.207*** (0.020)	0.071*** (0.027)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
FC d.*time trend		Yes		Yes
R^2	0.189	0.229	0.511	0.512
N	898,703	898,703	393,149	393,149

Notes: *, **, *** significant at the 10, 5, and 1 percent level. Standard errors in parentheses. R is a dummy for the period 2001-2005. Period 1996-2005. Source: APEH and Credit Register.

5.2 UIP Deviations: Firms' FC Borrowing and Growth

Lemma 2 predicts that higher UIP deviations promote foreign currency borrowing. Figure 1 presented first evidence that, in Hungary, these deviations correlate with increases in the aggregate share of foreign currency loans. In this section, we study this relationship at the firm-level and assess whether UIP deviations correlate with higher investment.

We assess the relationship between UIP deviations and foreign currency borrowing in three steps. First, we check whether these deviations associate with increases in foreign currency borrowing at the firm-level. Second, we evaluate whether these responses are heterogeneous across firms and correlate with firms' productivity. Finally, we add a second source of cross-sectional heterogeneity and assess whether firms' responses also vary in terms their capital stock. This second layer allow us to evaluate more precisely the mechanism proposed in the paper, namely foreign currency loans allowing high MKP firms to exploit UIP deviations to increase investment. In this way, we exploit three sources of variation: UIP deviations over time and cross-sectional variations in terms of firms' productivity and capital stock.

To test if UIP deviations associate with firms' foreign currency borrowing, we consider:

$$Y_{it} = \beta \log \text{UIP}_t + \phi_i + \varepsilon_{it}, \quad (15)$$

where Y_{it} is either the foreign currency debt dummy or the log foreign currency share for the period 2005-2010, i.e. FC Dummy_{it} or Log FC Share_{it} . To control for valuation effects that could arise from the foreign currency share moving contemporaneously with the exchange rate when using the Hungarian data, we construct the share in each year by employing the exchange rate in the previous year of each of the currencies firms' borrow. $\log \text{UIP}_t$ is the log of the UIP deviation during this period (the log of θ in the model). When using the Hungarian data, we create this variable by computing the one-year UIP deviation for each foreign currency in which Hungarian firms borrow –Euro, Swiss Franc

and U.S. Dollar-, weighted by the aggregate share of loans in each currency.³⁴ Since foreign currency borrowing of exporters and foreign firms might be driving by other considerations, we exclude them in our baseline regressions and add them in robustness tests. The coefficient β captures if higher UIP deviations associate with increases in firms' probability of borrowing in foreign currency and foreign currency share.

To study whether more productive exploit UIP deviations relatively more, we estimate

$$Y_{it} = \beta \log \text{UIP}_t \times \text{Productivity}_i + \phi_i + \iota_t + \varepsilon_{it}, \quad (16)$$

where Productivity_i is log firm's initial productivity (z_i or RTFP_i) and the firm-fixed effects capture all time invariant firm characteristics.³⁵ To control for demand shocks that could affect sectors differently over time, we include four-digit sector and year fixed effects interacted when using the Hungarian data. We cluster the standard errors at year and four-digit sectors. The coefficient β in equation (16) captures if more productive firms increase foreign borrowing more upon UIP deviations. To evaluate whether more productive firms with low capital stock exploit UIP deviations relatively more, we compute each firm's log MPK in 2005, interact it with the UIP deviation, and re-estimate (16) using this interaction term as independent variable.

Columns 1-3 in Table 6 present the results for the model simulated data. The coefficient in column 1 (Panel A) indicates that UIP deviations increase firms' probability of borrowing in foreign currency. As expected, this increase is higher for more productive firms (column 2) and, among them, firms with high MPK (column 3). The regressions for the Hungarian data confirm these trends (column 4-6). The coefficient estimated in column 4 is not only highly statistically significant, but it is also economically important and implies that a 10% increase in the UIP deviation, as seen in Hungary between 2005 and 2006, led to more than a thousand firms to borrow in foreign currency.

Panel B reports the results for the share of foreign currency debt and confirms these trends. The size of the firm-level responses of the UIP deviation on the foreign currency share is similar in the model and the data. In particular, a one percent increase in the UIP deviation leads to a 0.09 and 0.08 percent increase in firms' foreign currency share, in the model and data (columns 1 and 4). As above, this expansion is high for high productivity firms and, among them, those with high MPK.

Firms' investment responses are in line with the increase in foreign borrowing, as shown in Panel C. The model simulated and Hungarian data imply that a one percent increase in the UIP deviation leads to an expansion of 0.15 and 0.14 percent in firms' investment rate (columns 1 and 4). As expected, this expansion is larger for high productivity firms with low capital stock (columns 3 and 6).

These results confirm the model's mechanism by showing that UIP deviations associate with expansions of foreign currency borrowing and investment, specially of high MPK firms. The model reproduces both qualitative and quantitatively well (i.e. sign and size of coefficients) the firm-level responses of the UIP deviation on foreign borrowing and investment (columns 1 and 4). While the model mimics well the qualitative responses by firms' productivity and MPK, the model's estimated coefficients are larger.

³⁴More precisely, $\log \text{UIP}_t = \log(\sum_{st} w_{st} \text{UIP}_{st})$, where s and t are currency and year, and w is the share of foreign loans. In 2015, 75% of corporate loans were denominated in Euros, 19% in Swiss Francs and 6% in U.S. Dollars.

³⁵Note that we do not include firms' current productivity or capital because this would create endogeneity concerns.

Table 6: UIP DEVIATIONS: FC BORROWING DECISIONS

	Model			Data		
	Panel A. FC Dummy					
	(1)	(2)	(3)	(4)	(5)	(6)
Log UIP Dev.	0.351*** (0.011)			0.150*** (0.017)		
Log UIP Dev. x Productivity		1.176*** (0.019)			0.047*** (0.008)	
Log UIP Dev. x MPK			0.979*** (0.035)			0.015*** (0.004)
R^2	0.411	0.416	0.414	0.742	0.688	0.695
N	939,729	939,729	939,729	892,584	892,584	892,584
Panel B. Log Share of Foreign Currency Loans						
	(1)	(2)	(3)	(4)	(5)	(6)
Log UIP Dev.	0.091*** (0.005)			0.084*** (0.010)		
Log UIP Dev. x Productivity		0.445*** (0.009)			0.025*** (0.019)	
Log UIP Dev. x MPK			0.428*** (0.016)			0.012*** (0.003)
R^2	0.338	0.342	0.341	0.716	0.655	0.649
N	939,729	939,729	939,729	892,584	892,584	892,584
Panel C. Log Investment Rate						
	(1)	(2)	(3)	(4)	(5)	(6)
Log UIP Dev.	0.149*** (0.012)			0.136*** (0.026)		
Log UIP Dev. x Productivity		1.260*** (0.018)			0.315*** (0.020)	
Log UIP Dev. x MPK			0.514*** (0.033)			0.092*** (0.023)
R^2	0.138	0.154	0.149	0.575	0.525	0.513
N	916,124	916,124	916,124	436,455	436,455	436,455
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes	Yes
Sector* Year FE					Yes	Yes

Notes: *, **, *** significant at the 10, 5, and 1 percent level. Standard errors in parentheses. Period 2005-2010. Source: APEH and Credit Register.

We conduct five robustness tests. First, we compute UIP deviations without adjusting the sovereign risk premium and show in Table B.3 in Appendix B that the estimated coefficients are robust. Second, we show that results hold true when including exporters and foreign firms (Table B.4). Third, results on the foreign currency share are robust to accounting for valuations effects, as shown in Table B.5 that computes this share with the current exchange rate and the exchange rate in 2005. Fourth, we conduct two different exercises to assess whether for industry's exchange rate pass-through could affect our results. In our first exercise, we replace the four-digit sector-year fixed effects by the log of the producer price index at four-digit industry level and year fixed effects. Results –presented in Table B.6– show that the estimated coefficients remain highly statistically significant and similar in magnitude. In our second exercise, we estimate the exchange rate pass-through for each four-digit industry in Hungary over 1992-2008 and then include this variable as a control. Table B.9 presents the results and shows that

industry exchange rate pass-through does not affect the size or significance of the firm-level responses.³⁶ Finally, we test if these decisions correlate with firms' age. Since young firms are further away from their optimal scale of production, one would expect that young and productive firms take greater advantage of UIP deviations. We create bins by productivity and age and show that young and productive firms have the largest response to UIP deviations (Table B.10).³⁷

6 Aggregate Implications

In this section, we conduct several counterfactual exercises to quantify the aggregate impact of foreign currency borrowing. Section 6.1 assesses the consequences of foreign loans and the importance of firm heterogeneity to understand the aggregate implications of this financing. Section 6.2 studies the impact of depreciations. Section 6.3 evaluates how exchange rate market interventions can affect firms' currency debt composition. To understand the implications of foreign borrowing in the long term, we evaluate the period 2001 to 2015 using the same simulation strategy described in Section 4.³⁸

6.1 The Aggregate Impact of Foreign Currency Loans

6.1.1 Impact of Foreign Currency Borrowing: Growth and Balance Sheet Effects

In this exercise, we quantify the firm-level and aggregate implications of foreign currency borrowing by comparing an economy with and without this financing. In particular, we compare our benchmark model with an economy in which firms are banned from borrowing in foreign currency and can only issue local denominated debt. In this setting, firms can choose their capital and local currency debt for the next period (k' and b'), given the states $(\omega_{-1}, \omega, z, k, b)$.

In the economy with access to foreign currency borrowing, lower financing costs allow firms that borrow to achieve higher investment rates. As shown in columns 1 and 2 of Table 7, firms have 2 percentage points higher investment rates per year (13.7% vs 11.7%). This larger investment translates into an increase in firms' size and a lower default rate. This lower default rate is interesting because it indicates that, despite that foreign loans expose firms to balance sheet effects, they also allow firms to accumulate more capital and become more resilient to productivity and interest rate shocks. In turn, higher investment at the firm-level leads to higher aggregate capital. Between 2001 and 2015, the economy with foreign loans has 8.4% higher capital growth and 7.8% higher sales growth. In the next section, we show that these results strongly depend on the characteristics of firms using foreign loans.

³⁶In particular, we regress for each four-digit industry $\log PPI_{jt} = \eta_j \log S_t + \varepsilon_{jt}$, where j is the industry and η_j captures the elasticity of the producer price index to the exchange rate for each industry. Note that, since the industry pass-through are estimated at four-digits industries, we cannot longer include four-digit fixed effects. Instead, we include two digit and year fixed effects, and present the results with and without the pass-through for comparison (Panels A and B).

³⁷Additionally, to test whether the productivity threshold to borrow in foreign currency drops following UIP deviations (Lemma 2), we estimate a regression on the productivity of firms borrowing in foreign currency on UIP deviations, and show that the average productivity of these firms decreases following UIP deviations (Table B.11).

³⁸See Appendix A.7 for a detailed description of each exercise.

Table 7: AGGREGATE IMPACT OF FOREIGN LOANS AND FIRM HETEROGENEITY

	Benchmark	No FC Borrowing	No Heterogeneity in Prod. and Capital
	(1)	(2)	(3)
<i>Firm-level results</i>			
FC Debt Share	8.8	-	48.8
Investment rate	13.7	11.7	9.1
E(K)	43.2	42.3	49.3
Default rate	2.6	3.1	3.7
<i>Aggregate results (wrt column 1)</i>			
Capital Growth	100.0	91.6	82.1
Sales Growth	100.0	92.2	82.7

Notes: Rows 1, 2 and 3 are in percentage. Rows 5-7 are with respect to column 1. Rows 5 and 6 is the growth between 2001 and 2015. Columns 1-3 show the moments for an economy with and without foreign currency borrowing, and with no heterogeneity in productivity and capital. Period: 2001-2015.

6.1.2 The Importance of Firm Heterogeneity to Understand the Impact of Foreign Loans

We now turn to assess how the characteristics of firms using foreign loans affect the aggregate implications of this financing by conducting two counterfactuals exercises. In our first exercise, we make all firms use foreign loans independently of their level of productivity and capital. In our second exercise, we shut down heterogeneity in productivity and capital sequentially. For comparison, in these exercises, we set firms' foreign currency leverage to imply the same aggregate share of foreign currency debt than in the benchmark. We match this aggregate share to assess the importance of the distribution of foreign currency loans across firms.

Column 3 in Table 7 presents the results of our first exercise, in which all firms use foreign loans and have the same leverage in foreign currency. The comparison with our benchmark economy reveals that, when firms cannot choose their exposure to the currency risk, their investment rate is more than 4 percentage points lower. This lower investment arises from the higher default rate and bigger size of surviving firms. On the aggregate, the lower investment rate translates into less 18% capital and 17% sales growth.

To understand the forces driving these results, we conduct a second exercise, in which we shut down heterogeneity in capital and productivity sequentially. This exercise is described in detail in Appendix A.6, and it shows that the implications of foreign loans are significantly different when firms with high capital borrow in foreign currency or when high productivity firms use this financing. In particular, when only large firms borrow in foreign currency, the investment rate is in order of magnitude lower than in the benchmark economy. Large firms are closer to their optimal scale and, thus, borrow less in foreign currency and have lower investment rate. Instead, when only high productivity firms borrow in foreign currency, the investment increases and defaults surges because these firms have higher needs of capital, but are less resilient to shocks.

In sum, these exercises show that understanding the characteristics of firms using foreign loans is critical to assess the implications of this financing.

6.2 Currency Crises

Foreign currency borrowing allows firms to increase investment, but it also exposes them to currency mismatch. In this section, we conduct two exercises to study the impact of moderate and large depreciations on firms' balance sheets. In the first exercise, we exploit the 10% depreciation of the Hungarian Forint during the Financial Crisis (2008-10) to evaluate whether the model is able to replicate the behavior of Hungarian firms upon the crisis. In the second exercise, we use the model to assess the possibility of a large depreciation.

-Hungary During the Financial Crisis

Following the bankruptcy of Lehman Brothers in 2008, the Hungarian currency suddenly depreciated against the Euro by more 10% by 2010. We employ this exogenous depreciation in a difference-in-difference estimator to assess empirically whether it led to balance sheets effects. Additionally, we evaluate whether the model is able to reproduce Hungarian firms' responses by estimating the same regressions using the simulated data. Importantly, the model is able to mimic the currency depreciation as the calibration uses the realization of foreign interest rate shocks in those years. Note that the model also reproduces the cyclical nature of firms' payoff, as aggregate productivity negatively correlates with the exchange rate, reducing firms' sales during depreciations.

To study balance sheet effects, we assess whether firms had their investment plans altered, changed the currency composition of their loans and their leverage and experienced higher exit. We estimate the following OLS regression:

$$Y_{it} = \beta (C_t \times \text{FC Leverage}_i) + \phi_i + \mu_{jt} + \varepsilon_{ijt}, \quad (17)$$

where Y_{it} is a vector of $\{\log \text{FC leverage}_{it}, \log \text{Leverage}_{it}, \log \text{Investment Rate}_{it}, \text{Exit}_{it}\}$. C_t is a dummy for the crisis years ($C_t = 0$ if $t < 2008$, and $C_t = 1$ if $t \geq 2008$). FC Leverage_i is the firm's foreign debt-to-assets ratio in the initial year (2005). The sector-year fixed μ_{jt} effects absorb any year-sectoral shock that could affect firms differently across activities (as for example demand-industry specific shocks). β captures the differential impact of the depreciation according with firms' initial foreign debt leverage.

We present the Hungarian data results in columns 2, 4, 6 and 8 of Table 8. The estimated coefficients indicate that firms borrowing in foreign currency experienced negative balance sheet effects, as they lowered their investment rate (55%) and leverage (13%), and changed the composition of debt towards local currency denominated loans (34%). Notably, these firms did not experience higher exit after the depreciation. Instead, the negative and statistically significant coefficient indicates that these firms had lower exit rates.³⁹ Columns 1, 3, 5 and 7 show that our model is able to replicate these results.⁴⁰

³⁹These results are also in line with Verner and Gyongyosi (2020) who find that Hungarian firms borrowing in foreign currency did not experience large drops in sales or employment in the years following the currency depreciation of 2008-2010.

⁴⁰We present a full set of robustness tests in Appendix B. Table B.12 shows that results are robust to: i) replacing the year fixed effects by a crisis dummy, ii) control for the differential pre-growth trends of firms borrowing in foreign currency; and iii) to control for the differential effect of the depreciation on importers and smaller firms. Table B.13 shows that results are robust to including exporters and foreign firms.

Table 8: DEPRECIATION DURING THE FINANCIAL CRISIS

	Log FC Leverage		Log Leverage		Log Investment Rate		Exit	
	Model (1)	Data (2)	Model (3)	Data (4)	Model (5)	Data (6)	Model (7)	Data (8)
Crisis x Log FC Leverage	-0.368*** (0.002)	-0.341*** (0.018)	-0.578*** (0.004)	-0.130*** (0.014)	-0.567*** (0.012)	-0.554*** (0.089)	-0.023** (0.006)	-0.047*** (0.010)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector* Year FE		Yes		Yes		Yes		Yes
R^2	0.413	0.685	0.342	0.510	0.338	0.805	0.296	0.492
N	939,729	764,784	939,729	764,784	916,124	405,842	939,729	764,784

Notes: *, **, *** significant at 10, 5, and 1 percent. Standard errors in parenthesis. FC leverage is the firm's foreign currency debt over total assets in the initial year (2005). Source: APEH and Credit Registry.

The lower exit rate might appear counter-intuitive at a first view, but it is not surprising in light with the model's implications and the lower exit rate reported in Table 7. UIP deviations offer lower financing costs that allow firms to expand their investment and scale of operation. As firms grow faster in "good times", they become more resilient to shocks. Hence, for relatively moderate depreciations, firms might experience negative balance sheet effects, but previous investment might allow them to survive the shock. Our results indicate that this was the case for Hungarian firms during the Global Financial Crisis, but these result could change for larger depreciations. To assess this possibility, we evaluate the exit rate after a large depreciation in which the exchange rate (in units of LC per FC) increases by 100% in 2008. Table A.6 in Appendix A.6 shows that, following this currency crash, the exit rate of firms borrowing in foreign currency is positive, and these firms experience a 3.6% higher exit rate than firms non-borrowing in foreign currency.

-Discussion of Results and Related Literature

The literature on currency crises has documented empirically balance sheet effects following large depreciations. Among others, Aguiar (2005) reports that Mexican firms indebted in foreign currency reduced investment rates during the Tequila crisis in 1994-95, and Kim, Tesar, and Zhang (2015) show that Korean firms using this financing had larger likelihood of exiting during Asian crisis in 1997-98. Besides confirming these results, this section provides novel evidence showing that, upon depreciations, firms deleverage and switch the currency composition of their debt towards local currency loans.

Additionally, and in contrast with the common belief that currency depreciations lead necessarily to higher exit, we show that the relationship between currency depreciations and exit is non-monotonic. For small and moderate depreciations, firms indebted in foreign currency might be able to survive currency shocks better, as higher capital accumulation during good times makes them more resilient to shocks. For sufficiently large depreciations, the increase in debt repayment can be high enough that firms might not be able to fulfill their commitments and exit market. This non-monotonic relationship provides additional support for the mechanism proposed in this paper by showing that, in a dynamic setting with capital accumulation, firms might choose to borrow in foreign currency and be exposed to the currency risk in order to increase investment and reach faster their optimal scale of production.

6.3 Exchange Rate Market Interventions

In this section, we mimic exchange rate market interventions and assess how different exchange rate processes affect firms' incentives to borrow in foreign currency. The exchange rate process affects foreign loans' implicit risk and, by doing so, the currency composition of firms' debt (intensive margin) and the allocation of foreign loans across firms (extensive margin). We conduct two numerical exercises. In the first exercise, we let the exchange rate be constant, as in fixed pegs. In the second exercise, we restrict large depreciations, as a form of implicit bailout guarantees.⁴¹

i) Fixed Peg. We set $s'/s = 1$ and let the exchange rate be constant. This implies that there is no currency risk, but there are still interest rate differentials making foreign loans cheaper (recall that $r_t = \tilde{\delta} + \gamma r_t^*$). As we report in column 2 of Table 9, there is a large expansion of the intensive and extensive margins of foreign borrowing. At the intensive margin, all firms that borrow do so in foreign currency and their foreign currency share is 100%. At the extensive margin, there is a large expansion in access to credit and, thus, credit in foreign currency. In particular, the share of firms borrowing in the economy reaches 90% –a 150% increase with respect to the benchmark– and the productivity threshold to use this financing drops. Intuitively, this expansion in the extensive margin stems from two sources. First, firms that –in the benchmark– could not tolerate the currency risk and only borrowed in local currency can now switch their liabilities towards foreign debt. Second, firms that could not afford to borrow, they can now borrow at a cheaper rate at zero currency risk.

The increase in foreign borrowing can also be seen through the lens of equation (12) that defines the three effects – UIP deviation, debt revenue and continuation value– affecting firms' foreign borrowing decisions and that need to sum positive or zero for firms to issue this financing. Since –for the simulated period– the UIP deviation is 0.8 percentage points higher than in the benchmark, the UIP deviation effect is higher. Furthermore, since there is no currency risk, both the debt revenue and continuation value effects are equal to zero. Therefore, all borrowing firms have a positive relative benefit from issuing foreign currency debt.

Hence, a fixed peg not only makes firms tilt all their liabilities towards foreign currency, but it also allows riskier firms to start using these loans. Remarkably, since more firms can accumulate more capital, the aggregate economy has higher capital growth.

ii) Limit to Depreciations. One way in which governments might intervene the exchange rate market is by limiting the extend in which the currency depreciates. By doing so, they implicitly create bailout guarantees that can affect firms' foreign currency borrowing decisions. In this exercise, we restrict the currency to depreciate more than 10% and set it to $s'/s = \min(m^*/m', 1.1)$.

Column 3 in Table 9 shows that the implicit bailout guarantees strongly encourage firms to borrow in foreign currency. As above, we can use equation (12) to understand the forces driving this increase. First,

⁴¹It is worth mentioning that these exercises do not intent to estimate the welfare gains from each policy or the joint determination of central bank's exchange rate policy and foreign borrowing, which goes beyond the scope of the paper. Instead, they aim to simply uncover how exchange rate market interventions alone affect firms' incentives to issue foreign currency debt along the intensive and extensive margins.

Table 9: EXCHANGE RATE REGIMES

	Benchmark	Full Peg	Limit to Depreciations
	(1)	(2)	(3)
Share of firms borrowing	36.3	89.4	73.7
<i>Firms borrowing in FC</i>			
Share of firms on firms with credit	48.6	100.0	85.1
FC share	47.3	100.0	76.4
Leverage	34.4	49.4	35.3
Productivity threshold	1.43	1.26	1.39
Default rate (wrt to column 1)	100.0	88.3	82.4
<i>Aggregate</i> (wrt column 1)			
Capital Growth	100.0	142.1	93.4
Sales Growth	100.0	126.5	98.8

Notes: Rows 1-4 and 6 are in percentage terms. Rows 7 and 8 are with respect to column 1. Column 2 presents the moments of an economy in which the exchange rate is fixed. In column 3, the exchange rate is not allowed to depreciate more than 10%. The average UIP deviation in the benchmark is $\theta = 1.035$, in the fixed peg $\theta = 1.043$ and in limits to depreciations $\theta = 1.053$, where $\theta = \frac{s}{E(s^*)} \frac{(1+r)}{(1+r^*)}$. Period: 2001 to 2015.

under our parametrization, the UIP deviation effect is higher because these limits lower the expected depreciation and increase the UIP deviation (1.75 percentage points higher than in the benchmark). Second, the debt revenue effect is less negative because default due to large depreciations is no longer a possibility. These effects increase the net benefit of borrowing in foreign currency and encourage firms to use this financing.

At the intensive margin, firms increase their shares of foreign currency debt, reaching on average 77%. At the extensive margin, the share of firms borrowing in the economy doubles with respect to the benchmark (reaching 74% of firms), and 85% of these firms use foreign currency loans. The expansion on the extensive margin can also be seen through the decrease in the productivity threshold to use these loans. Hence, implicit bailout guarantees not only create incentives for firms to switch the currency composition of their debt towards foreign loans, but they also allow riskier firms to use this financing.

These results are in line with Schneider and Tornell (2004) who show that implicit bailout guarantees encourage firms to borrow in foreign currency and can create systemic risk. Our results differ from theirs in three ways. First, while in their model bailout guarantees are the only source leading firms to use foreign loans; in our model these loans arise from UIP deviations and bailout guarantees only magnify their use. Second, in their model, bailout guarantees take the form of government lump-sum transfers that allow creditors and firms to not internalize the default cost and over-borrow. Instead, in our model, there is no excessive leverage as the currency risk is priced correctly, and firms and creditors fully consider the default cost. This is shown in column 3 that indicates that leverage is close to the benchmark and its level is still moderate (35%).⁴² Finally, in Schneider and Tornell (2004), there is

⁴²This moderate level of leverage is consistent with the empirical evidence presented in Table 3 that shows that Hungarian firms only borrowing in foreign currency had a leverage of 18% and those borrowing in both local and foreign currency had a leverage of 25%.

systemic risk because firms without foreign income borrow in foreign currency and engage in excessive leverage. Instead, our model shows that, in a dynamic setting, firms without foreign income could still find it optimal to borrow in foreign currency and might even exit less. What exacerbates risk is that limits to depreciations encourage the least productive firms to use foreign loans and do it to the levels that, otherwise, they would not tolerate.⁴³

6.4 Additional Counterfactual Exercises

We finalize our analysis of foreign currency borrowing decisions by conducting two additional counterfactual exercises. These exercises are discussed in detail in Appendix A.6. In the first exercise, we assess whether the level of a country's economic development could affect foreign borrowing patterns by comparing two economies with low and high level of capital. We show that, in a capital-scarce economy, firms are more prone to borrow in foreign currency and take the currency risk, as lower financing terms allow them to increase investment and grow faster. However, since firms are smaller in size, they are less resilient to shocks and the default rate is higher than in a capital-abundant economy. In the second exercise, we study how exchange rate pass-through affects firms' currency debt composition and show that it can substantially increase both the intensive and extensive margin of foreign borrowing. Since following a depreciation pass-through increases firms' prices and, thus, revenues, it mitigates negative balance sheet effects and encourages more firms to take the currency risk and borrow in foreign currency.

7 Conclusion

This paper shows that firms' foreign currency borrowing decisions arise from a dynamic trade-off between exposure to the currency risk and potential growth. We develop a firm dynamics model with endogenous debt composition to jointly study firms' financing and investment decisions. In our model, highly productive firms with low capital choose to borrow in foreign currency and be expose to the currency risk in order to reach faster their optimal scale of production.

We test the model's implications using a unique dataset reporting information on firms' balance sheets and debt by currency denomination in Hungary over 1996-2010. We confirm that there is selection into foreign currency borrowing, as only highly productive firms find it optimal to employ this financing, and that the share of foreign borrowing increases in firms' marginal product of capital. On the aggregate, we show that economies allowing for foreign currency borrowing have higher sales and more capital, at the expense of higher volatility. Our analysis points that selection of productive firms into foreign currency borrowing is crucial to generate gains from this financing, as a weak screening mechanism could lead to lower sales and capital than a closed economy. Our quantitative analysis shows that different

⁴³In Appendix A.6, we study the effect of managed floats where the currency is not allow to depreciate or appreciate more than 10%. This exercise remarks two salient forces implied in foreign borrowing. First, managed floats reduce the intensive margin of foreign borrowing, as they lower the benefit of lower debt repayment in case of appreciations. Second, the extensive margin of foreign borrowing increases, as lower exchange rate volatility allow less productive firms to start using this financing. The overall effect of managed floats on foreign borrowing depends on the strength of these two forces.

countries' characteristics can affect firms' incentives to borrow in foreign currency and, with them, the allocation of foreign currency loans across firms and its aggregate consequences. Understanding the heterogeneity in firms' foreign currency borrowing decisions is then critical to assess the aggregate impact of this financial and the exposure of economies to currency crises.

This paper offers a novel framework to study the aggregate impact of risk factors building from firm-level decisions. In our model, exchange rate risk affects firms' risk taking decisions heterogeneously, which in turn shapes the aggregate impact of the currency shock. This approach can be extended to other questions beyond foreign currency borrowing, as for example firms' choice of interest rate exposure (floating vs fixed rates) or maturity decisions (short vs long term loans).

Data Availability Statements

The model simulated data underlying this article are available in the article and in its online supplementary material. DOI number [https://dx.doi.org/\[doi\]](https://dx.doi.org/[doi]): The Hungarian firm-level underlying this article cannot be shared publicly as it is administrative data and is not available to the general public. It can only be accessed by permission of the Statistical and Research Departments of the National Bank of Hungary (<https://www.mnb.hu/en/research>).

References

- AGHION, P., N. BERMAN, L. EYMARD, P. ASKENAZY, AND G. CETTE (2012): "Credit Constraints and the Cyclicalities of R&D investment: Evidence from France," *Journal of the European Economic Association*, 10(5), 1001–1024.
- AGUIAR, M. (2005): "Investment, devaluation, and foreign currency exposure: The case of Mexico," *Journal of Development Economics*, 78(1), 95–113.
- AHNERT, T., K. FORBES, C. FRIEDRICH, AND D. REINHARDT (2018): "Macroprudential FX regulations: shifting the snowbanks of FX vulnerability?," Bank of England working papers 758, Bank of England.
- ALFARO, L., P. ANTRAS, D. CHOR, AND P. CONCONI (2019): "Internalizing Global Value Chains: A Firm-Level Analysis," *Journal of Political Economy*, 127(2), 508–559.
- ALFARO, L., G. ASIS, A. CHARI, AND U. PANIZZA (2017): "Lessons Unlearned? Corporate Debt in Emerging Markets," Working Paper 23407, National Bureau of Economic Research.
- AMITI, M., O. ITSKHOKI, AND J. KONINGS (2014): "Importers, Exporters, and Exchange Rate Disconnect," *American Economic Review*, 104(7), 1942–78.
- BACKUS, D. K., S. FORESI, AND C. I. TELMER (2001): "Affine Term Structure Models and the Forward Premium Anomaly," *The Journal of Finance*, 56(1), 279–304.
- BANSAL, R. (1997): "An Exploration of the Forward Premium Puzzle in Currency Markets," *The Review of Financial Studies*, 10(2), 369–403.
- BASKAYA, S., J. DI GIOVANNI, S. KALEMI-OZCAN, AND M. ULU (2017): "International Spillovers and Local Credit Cycles," *Mimeo*.

- BAUER, P., AND M. ENDRESZ (2016): “Modelling Bankruptcy using Hungarian Firm-Level Data,” *MNB Occasional Papers* 122.
- BEKAERT, G. (1996): “The Time Variation of Risk and Return in Foreign Exchange Markets: A General Equilibrium Perspective,” *The Review of Financial Studies*, 9(2), 427–470.
- BERTRAND, M., E. DUFLO, AND S. MULLAINATHAN (2004): “How Much Should We Trust Differences-In-Differences Estimates?,” *The Quarterly Journal of Economics*, 119(1), 249–275.
- BLOOM, N., M. FLOETOTTO, N. JAIMOVICH, I. SAPORTA-EKSTEN, AND S. J. TERRY (2018): “Really Uncertain Business Cycles,” *Econometrica*, 86(3), 1031–1065.
- BODNAR, K. (2006): “Survey evidence on the exchange rate exposure of Hungarian SMEs,” *MNB Bulletin (discontinued)*, 1(1), 6–12.
- BUSTOS, P. (2011): “Trade Liberalization, Exports, and Technology Upgrading: Evidence on the Impact of MERCOSUR on Argentinian Firms,” *The American Economic Review*, 101(1), 304–340.
- CABALLERO, R. J., AND A. KRISHNAMURTHY (2003): “Excessive Dollar Debt: Financial Development and Underinsurance,” *Journal of Finance*, 58(2), 867–894.
- CHINN, A. (2005): “Long Run Labor Market Effects of Japanese American Internment during World War II on Working Age Male Internees,” *Journal of Labor Economics*, 23 (3), 491–525.
- CONSENSUS ECONOMICS (2019): “*Consensus Forecast*.” [Data Set]. Accessed via Consensus Economics. Last accessed November 2019.
- CORSETTI, G., AND P. PESENTI (2015): “Endogenous Exchange-Rate Pass-Through and Self-Validating Exchange Rate Regimes,” in *Economic Policies in Emerging-Market Economies Festschrift in Honor of Vittorio Corbo*, ed. by R. J. Caballero, and K. Schmidt-Hebbel, vol. 21 of *Central Banking, Analysis, and Economic Policies Book Series*, chap. 11, pp. 229–261. Central Bank of Chile.
- COX, J., J. INGERSOLL, AND S. ROSS (1985): “A Theory of the Term Structure of Interest Rates,” *Econometrica*, 53(2), 385–407.
- FARHI, E., S. FRAIBERGER, X. GABAIX, R. RANCIERE, AND A. VERDELHAN (2015): “Crash Risk in Currency Markets,” Working Paper 20948, Harvard University OpenScholar.
- FARHI, E., AND X. GABAIX (2016): “Rare Disasters and Exchange Rates,” *The Quarterly Journal of Economics*, 131(1), 1–52.
- FEENSTRA, R., R. INKLAAR, AND M. TIMMER (2015): “The Next Generation of the Penn World Table,” [Dataset]. *American Economic Review*, 10(105), 3150–3182, Accessed via <https://www.rug.nl/ggdc/productivity/pwt/pwt-releases/pwt9.0?lang=en>. Last accessed October 2017.
- FOSTER, L., J. HALTIWANGER, AND C. SYVERSON (2008): “Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?,” *American Economic Review*, 98(1), 394–425.
- GLOBAL FINANCIAL DATA (2016): “*Global Financial Data*.” [Data Set]. Accessed via <https://finaeon.globalfinancialdata.com/>. Last accessed June 2016.
- GOPINATH, G., S. KALEMLI-OZCAN, L. KARABARBOUNIS, AND C. VILLEGAS-SANCHEZ (2017): “Capital Allocation and Productivity in South Europe,” *The Quarterly Journal of Economics*, 132(4), 1915–1967.
- GOPINATH, G., AND J. C. STEIN (2018): “Banking, Trade, and the making of a Dominant Currency,” Working Paper 24485, National Bureau of Economic Research.

- GORODNICHENKO, Y., AND M. SCHNITZER (2013): “Financial Constraints and Innovation: Why Poor Countries Don’t Catch Up,” *Journal of the European Economic Association*, 11(5), 1115–1152.
- GOURINCHAS, P.-O., AND A. TORNELL (2004): “Exchange rate puzzles and distorted beliefs,” *Journal of International Economics*, 64(2), 303–333.
- GRUBER, J. (1994): “The Incidence of Mandated Maternity Benefits,” *American Economic Review*, 84(3), 622–41.
- HASSAN, T. A. (2013): “Country Size, Currency Unions, and International Asset Returns,” *Journal of Finance*, 68(6), 2269–2308.
- JEANNE, O. D. (2003): “Why Do Emerging Economies Borrow in Foreign Currency?,” IMF Working Papers 03/177, International Monetary Fund.
- KALANTZIS, Y. (2015): “Financial fragility in small open economies: firm balance sheets and the sectoral structure,” *Review of Economic Studies*, 82(3).
- KALEMLI-OZCAN, S., AND L. VARELA (2019): “Exchange Rate and Interest Rate Disconnect: The Role of Capital Flows and Risk Premia,” Discussion paper, mimeo.
- KIM, Y. J., L. L. TESAR, AND J. ZHANG (2015): “The impact of foreign liabilities on small firms: Firm-level evidence from the Korean crisis,” *Journal of International Economics*, 97(2), 209–230.
- KIRALY, J., E. VARGHELI, AND A. BANAI (2009): “A Special Aspect of the Past 20 Years: Dominance of foreign Banks in Emerging Europe with Special Regard to Hungary,” *Mimeo*.
- KOHN, D., F. LEIBOVICI, AND M. SZKUP (2020): “Financial frictions and export dynamics in large devaluations,” *Journal of International Economics*, 122(C).
- LUSTIG, H., N. ROUSSANOV, AND A. VERDELHAN (2011): “Common Risk Factors in Currency Markets,” *The Review of Financial Studies*, 24(11), 3731–3777.
- LUSTIG, H., AND A. VERDELHAN (2006): “Investing in Foreign Currency is Like Betting on Your Intertemporal Marginal Rate of Substitution,” *Journal of the European Economic Association*, 4(2-3), 644–655.
- (2007): “The Cross Section of Foreign Currency Risk Premia and Consumption Growth Risk,” *American Economic Review*, 97(1), 89–117.
- MAGGIORI, M. (2017): “Financial Intermediation, International Risk Sharing, and Reserve Currencies,” *American Economic Review*, 107(10), 3038–3071.
- MAGGIORI, M., B. NEIMAN, AND J. SCHREGER (2020): “International Currencies and Capital Allocation,” *Journal of Political Economy*, 128(6), 2019–2066.
- MAGYAR NEMZETI BANK (2011): “*Központi Hitelinformációs Rendszer (KHR)*”. [Data Set]. Last accessed February 2012.
- (2019): “*Statistics- Data- Times Series*”. [Data Set]. Accessed via <https://www.mnb.hu/statisztika>. Last accessed November 2019.
- MARKIT (2016): “*Markit CDS data*”. [Data Set]. Accessed via Wharton Research Data Service. Last accessed October 2017.
- NEMZETI ADÓ ÉS VÁMHIVATAL (2011): “*Társasági Adóalanyok Mérleg- és Eredménykimutatásai*”. Nemzeti Adó és Vámhivatal (Creator). [Data Set]. Accessed via Magyar Nemzeti Bank. Last accessed February 2012.
- NEUMEYER, P. A., AND F. PERRI (2005): “Business cycles in emerging economies: the role of interest rates,” *Journal of Monetary Economics*, 52(2), 345–380.

- NIEPMANN, F., AND T. SCHMIDT-EISENLOHR (2019): “Foreign Currency Loans and Credit Risk: Evidence from U.S. Banks,” Working Paper 14212, CEPR.
- OLLEY, G. S., AND A. PAKES (1996): “The Dynamics of Productivity in the Telecommunications Equipment Industry,” *Econometrica*, 64(6), 1263–97.
- PETRIN, A., AND J. LEVINSOHN (2011): “Measuring Aggregate Productivity Growth Using Plant-Level Data,” NBER Working Papers 11887, RAND Journal of Economics.
- RANCIERE, R., A. TORNELL, AND A. VAMVAKIDIS (2010): “Currency mismatch, systemic risk and growth in emerging Europe,” *Economic Policy*, 25, 597–658.
- RAPPOPORT, V. (2008): “Persistence of dollarization after pricestabilization,” *Journal of Monetary Economics*.
- REY, H. (2015): “Dilemma not trilemma: the global financial cycle and monetary policy independence,” Discussion paper, National Bureau of Economic Research.
- SAVIGNAC, F. (2008): “Impact of Financial Constraints on innovation: What can be learned from a direct measure?,” *Economics of Innovation and New Technology*, 17(6), 553–569.
- SCHNEIDER, M., AND A. TORNELL (2004): “Balance Sheet Effects, Bailout Guarantees and Financial Crises,” *The Review of Economic Studies*, 71(3), 883–913.
- TORNELL, A., AND F. WESTERMANN (2005): *Boom-Bust Cycles and Financial Liberalization*. CESifo Book Series, MIT Press.
- URIBE, M., AND V. Z. YUE (2006): “Country spreads and emerging countries: Who drives whom?,” *Journal of International Economics*, 69(1), 6–36.
- VARELA, L. (2017): “Sector heterogeneity and credit market imperfections in emerging markets,” *Journal of International Money and Finance*, 70(C), 433–451.
- (2018): “Reallocation, Competition and Productivity: Evidence from a Financial Liberalization Episode,” *The Review of Economic Studies*, 85(2), 1279:1313.
- VERNER, E., AND G. GYONGYOSI (2020): “Household Debt Revaluation and the Real Economy: Evidence from a Foreign Currency Debt Crisis,” *American Economic Review*, 110(9), 2667–2702.
- WOOLDRIDGE, J. M. (2009): “On estimating firm-level production functions using proxy variables to control for unobservables,” *Economics Letters*, 104(3), 112–114.