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This paper develops a firm-dynamics model with endogenous currency debt composition to study financing and investment decisions in developing economies. In our model, foreign currency borrowing arises from a trade-off between exposure to currency risk and growth. There is cross-sectional heterogeneity in these decisions in two dimensions. First, there is selection into foreign currency borrowing, as only productive firms employ it. Second, there is heterogeneity in firms' share of foreign currency loans, driven by their potential growth. We assess econometrically the pattern of foreign currency borrowing using firm-level census data on Hungary, calibrate the model and quantify its aggregate impact.

JEL-Codes: F30, F34, F36.
Keywords: firm dynamics, foreign currency debt, currency mismatch, uncovered interest rate parity.

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1 Introduction

Capital flows play a critical role for economic growth. The textbook neoclassical growth model predicts that capital flows into developing economies lead to higher capital accumulation and income per capita. Yet these flows have been associated with higher volatility and financial crises. One of the sources of financial crises has been foreign currency borrowing by the corporate sector, as many firms employing this financing do not export or use hedging instruments to shield their balance sheets from exchange rate shocks.[1] In this paper, we study firms' portfolio choices to assess why firms in developing economies might choose to borrow in foreign currency and be exposed to the currency risk, and quantify the firm- and aggregate-level implications of these decisions.

This paper shows theoretically and empirically that firms' foreign currency borrowing choices arise from a dynamic trade-off between optimal exposure to the currency risk and growth. We develop a firm-dynamics model, in which heterogenous firms jointly choose the currency composition of their debt and their investment. In our model, firms might optimally choose to borrow in foreign currency to take advantage of deviations from the risk-free uncovered interest rate parity (UIP). The relatively lower foreign borrowing rate allows firms to increase their investment and grow faster. Crucially, the model predicts heterogeneous foreign currency borrowing decisions at the extensive and intensive margins. At the extensive margin, there is *selection* into foreign currency borrowing, as only productive firms find it optimal to be exposed to the currency risk. At the intensive margin, there is heterogeneity in the share of foreign currency loans across firms, driven by firms' potential growth. We assess the model in three different ways. First, we employ detailed firm-level census data on firms' balance sheets and debt by currency denomination in Hungary over 1996-2010 and confirm econometrically the model's predicted pattern of foreign currency borrowing. Second, we calibrate the model and show that it matches key moments of the firm distribution of foreign currency borrowing. Third, we simulate firm-level panel data and estimate reduced-form regressions using the simulated and the Hungarian data to assess quantitatively the model's firm-level responses. Finally, we conduct several counterfactual exercises to quantify the aggregate impact of foreign currency borrowing.

Our paper contributes to the literature studying the impact of international capital flows on growth and financial crises in developing economies. This literature uses macro models with a representative agent to describe the emergence of foreign currency borrowing and studies empirically the effects of currency depreciations on firms' balance sheets.[2] Yet there is so far little understanding about the trade-offs driving firms' foreign currency borrowing decisions and the heterogeneity of these choices observed in data. Our paper fills this gap by proposing a mechanism –namely, firms' trade-off between exposure to currency risk and growth– that can explain firms' foreign currency debt choices, and by testing it using firm-level census data over a long panel. Additionally, we employ our firm-dynamics model to quantify the impact of foreign currency borrowing, and show that the heterogeneity in these

[1]Foreign currency borrowing has been associated with several crises in emerging markets during the nineties (Tequila and Asian crises, among others) and has recently surged in the aftermath of the Great Recession. In 2014, the share of foreign currency loans in the corporate sector exceeded 50% of total loans in many developing economies, for example Serbia, Bulgaria, Croatia, Romania, Hungary and Peru (see Figure B.1 in the Appendix B).

[2]See for example Aguiar (2005); Kim, Tesar, and Zhang (2015); Eichengreen and Hausmann (2005); and Jeanne (2003); among others. We review the literature below.

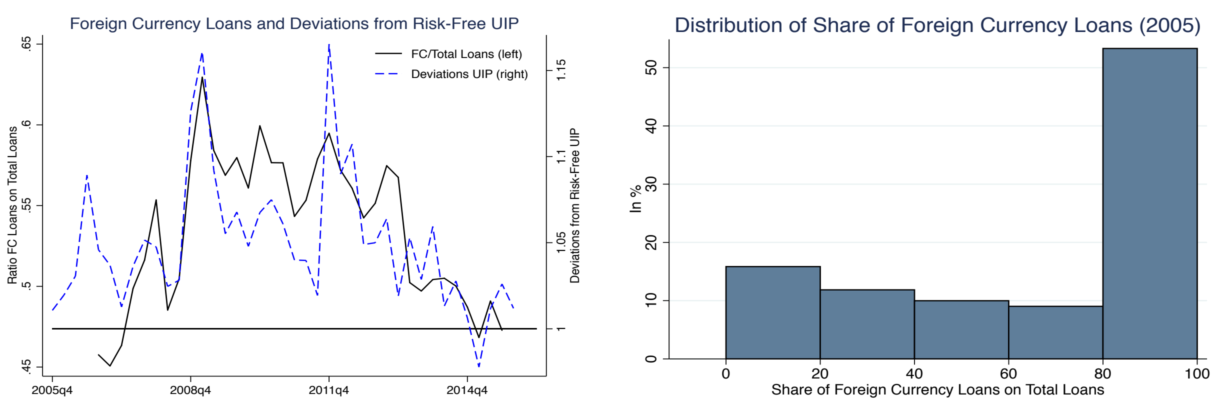
decisions is critical to understand its aggregate implications.

Our Hungarian firm-level census data combines two different datasets: APEH, which provides information on firms' balance sheets reported to tax authorities for the entire population of firms, and Credit Register, which reports information on all firms' loans by currency denomination with financial institutions in Hungary. The coverage of our database is unique as it reports information for all firms in all economic activities over more than a decade (1996-2010). It allows us to build comprehensive measures of leverage by currency denomination, and advances the previous literature that focuses on manufacturing firms, listed companies or exporters.

We start by documenting that foreign currency borrowing expanded rapidly in Hungary after the deregulation of these loans in 2001. By 2005, the share of these loans on total loans exceeded 45% and one-third of the firms borrowing in Hungary held foreign currency loans. Firms using this financing made up for a non-negligible share of aggregate outcomes, as they accounted for 40% of aggregate value added and 34% of employment. Importantly, firms borrowing in foreign currency 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. These firms were mainly domestically-owned and did not employ this financing with trade purposes.

The use of foreign currency loans was associated with aggregate deviations from the risk-free UIP over time. The left panel in Figure 1 shows that, between 2006Q4 and 2015Q4, the share of foreign currency loans in the corporate sector was correlated with UIP deviations.[3] Yet there was substantial heterogeneity in foreign currency borrowing decisions across firms, as illustrated in the right panel of Figure 1, which plots the distribution of the share of foreign currency loans of firms employing this financing.

Figure 1: Hungary: Deviations from Risk-Free UIP and Foreign Currency Borrowing



Notes: The left graph shows the share of foreign currency loans on total loans in the corporate sector (left axis) and the deviations from the risk-free UIP with respect to the Euro (right axis) for Hungary between 2005Q4 to 2015Q4. The right graph plots the distribution of the share of foreign currency loans for Hungarian firms in 2005. Source: CHF Lending Monitor, GFD, Consensus Forecast, and Credit Register.

To analyze this heterogeneity, we build a firm-dynamics model with endogenous debt composition that jointly studies firms' financing and investment decisions. In our model, firms are heterogeneous in capital stock, level of foreign and local currency debts, and face idiosyncratic productivity shocks

[3]We compute the deviation from the risk-free UIP with respect to the Euro at one-year horizon, as $\text{Dev}_t \equiv \frac{s_t}{E(s_{t+1})}\frac{(1+r_t)}{(1+r_t^*)}$. Appendix B.1 describes this measure and presents several robustness.

and aggregate exchange rate shocks. Firms operate domestically and can finance their investment using debt. Loans can be denominated in local and foreign currency and are non-contingent, so firms can default. Debt contracts are non-exclusive such that if a firm defaults, it does so in local and foreign currency debts simultaneously. A firm's idiosyncratic risk of default endogenously determines its cost of funds. Importantly, optimal currency-debt composition is driven by a trade-off between aggregate deviations from the risk-free UIP and firms' idiosyncratic cost of funds. In particular, UIP deviations create a wedge between the domestic and foreign risk-free rates that make the latter relatively lower and foreign borrowing attractive. However, foreign currency loans add an additional risk to firms as they expose them to exchange rate shocks. This currency risk raises a firm's idiosyncratic default probability and, hence, its *overall* cost of funds. As a result, a firm borrows in foreign currency to the extent that the increase in the idiosyncratic cost of funds –when using foreign loans– does not exceed the lower relative cost stemming from the aggregate deviation from the UIP.

The model offers two firm-level implications about the pattern of foreign currency borrowing and investment across firms that we test in data. First, at the extensive margin, there is *selection* into foreign currency borrowing, as only firms above a certain productivity threshold optimally choose to borrow in foreign currency. Given the persistence of the productivity shock, more productive firms today are less sensitive to default in the next period for any given level of capital, local and foreign currency debts. This lower default sensitivity allows them to better tolerate the exposure to currency risk (i.e. without significantly increasing their costs of funds) and borrow in foreign currency. There is a productivity level below which the exposure to currency risk increases a firm's default probability and cost of funds sufficiently such that the optimal decision is to only issue local currency debt. Second, at the intensive margin, higher deviations from the UIP promote foreign currency borrowing, particularly of productive firms with low capital (i.e. firms with high marginal product of capital -MPK). Higher UIP deviations increase the benefit of issuing foreign currency bonds, which allow firms to tolerate higher exposure to currency risk and hold higher levels of foreign debt. Firms with high MPK have higher return to investment and can exploit the relative lower foreign currency rate to increase their investment and reach faster their optimal scale of production. This trade-off between exposure to currency risk and potential growth is the mechanism that drives firms' foreign currency borrowing decisions.

We assess the model in three different ways. First, we calibrate the model to the period following the deregulation of foreign currency loans in Hungary in 2001. A key feature of this calibration is that Hungary was not in a stationary equilibrium with foreign currency loans in the early 2000s, but it was in a transition period of adopting this financing. To mimic this transition period, we adopt the following simulation strategy. First, we simulate an economy without foreign currency debt to obtain the stationary distribution of firms prior to the reform, as an initial condition. Next, we compute the firm-level optimal policies from the model with foreign currency debt. Finally, we simulate the same number of firms that we observe in Hungary from the distribution without foreign currency borrowing, and feed the firm-level policies of the model with foreign currency borrowing and the realized exchange rate shocks in Hungary between 2001 and 2010. This simulation strategy allows us to obtain firm-level panel data for the years upon the deregulation of foreign loans that follows the path of the exchange rate in Hungary.

The model successfully matches several non-targeted moments of the distribution of Hungarian firms on investment and borrowing. The model matches the average productivity and capital of firms that borrow in either local, foreign currency or both. It tracks closely the share of firms borrowing in foreign currency, the share of foreign loans and the investment rate of each of these three groups of firms.

Second, we evaluate the model's predicted patterns of foreign currency borrowing and investment econometrically using our Hungarian data. To evaluate the first implication of the model –namely, whether firms employing foreign currency loans are more productive and grow faster–, we exploit the deregulation of foreign currency loans in Hungary of 2001 as an exogenous source of time variation. In line with this first implication, we find that more productive firms prior to the reform have a higher probability of borrowing in foreign currency after it. The estimated coefficient implies that a one percent increase in a firm's productivity raises the probability of borrowing in foreign currency by 0.013 percentage points. Similarly, the share of foreign currency loans increases in firms' pre-reform productivity, and implies an elasticity of 0.02. Our results also point that firms using this financing have higher investment rates and growth, as predicted by the model. Within the five years following the reform, Hungarian firms borrowing in foreign currency saw a differential expansion of 5% and 4% in their investment rate and sales, after including a full set of controls. Next, we show that firms borrowing in foreign currency pay a one percentage point lower interest rate, as the model implies.

Additionally, our results also confirm the second implication of the model, that is, higher UIP deviations promote foreign currency borrowing, particularly of productive firms with low capital. First, the estimated coefficients imply that a one percent increase in the UIP deviation –making foreign currency loans relatively cheaper– associates with a 0.14 and 0.08 percent higher probability of borrowing in foreign currency and share of foreign currency loans. This result implies that a four percentage points increase in the deviation –as seen between 2005 and 2006 in Hungary– leads one thousand more firms to borrow in foreign currency. Second, the expansion in the use of foreign loans is heterogeneous across firms and increases more for more productive firms and, among them, those with low initial capital stock (i.e. high MPK firms). Third, we demonstrate that UIP deviations also associate with higher investment and sales for firms borrowing in foreign currency. Just like the trends in foreign borrowing, this expansion is greater for high MPK firms. This result provides support to the mechanism proposed in this paper, namely firms borrow in foreign currency to increase their investment and reach their optimal scale of production faster.

Third, to assess quantitatively the model's firm-level responses, we employ our model's simulated data and estimate the same reduced-form regressions than with the Hungarian data. The model's responses mimic identically the coefficients estimated with the Hungarian data. Regarding the first implication, the simulated data implies that a one percent increase in a firm's productivity raises the probability of borrowing in foreign currency by 0.024 percentage points and the share of foreign currency loans by 0.01 percent. As above, firms borrowing in foreign currency have higher investment rates and sales after the deregulation of foreign currency loans. In line with the second implication, the simulated data implies that a one percent increase in the UIP deviation associates with a 0.07 and 0.06 percent higher probability of borrowing in foreign currency and share of foreign currency loans. As expected, this expansion is higher for high MPK firms. Therefore, the model tracks very closely the firm-level responses observed in the Hungarian data.

We employ the model to conduct two numerical exercises. First, we compare two economies, one with foreign currency borrowing and one without foreign currency borrowing, and show that economies allowing for foreign currency borrowing have 14% higher sales and 20% more capital at the expense of higher volatility. In these economies, firms are 12% bigger, have 27% higher investment rates, and see a 19% lower default probability. Second, we compare our model with an economy without selection of high productivity firms into foreign currency borrowing, and show that selection is crucial to explain the higher sales and capital of economies allowing for this type of financing. More precisely, if all firms would borrow in foreign currency regardless of their productivity, firms' investment rate would be one third lower and firms would be three times more likely to default. On the aggregate, the economy would see lower sales and capital, as foreign credit is allocated to risky and low productive firms that have lower investment rates and are more likely to default.

To explore the sensitivity of the numerical analysis, we conduct five exercises. First, we assess the sensitivity to the exchange rate pass-through, and show that higher pass-through leads to higher share of foreign currency debt, investment and sales, as debt provides a hedge. Second, we include a stochastic discount factor, allowing risk-free rates to be time-varying and include a premium in bad states. Under this specification, debt is riskier, which leads to a lower share of foreign currency borrowing and higher default rates. Third, we include aggregate shocks into the model that correlate negatively with exchange rate shocks. Lower sales during depreciations increase the risk of borrowing in foreign currency, which decreases the optimal share of foreign currency loans and investment, and raises default. Fourth, we show that the volatility of the exchange rate significantly affects foreign currency borrowing decisions, since reducing by half its volatility substantially increases the share of foreign currency debt and the likelihood to employ this financing. Finally, we show that the ability of investors to observe firms' productivity and screen high productivity firms is crucial to generate gains from foreign currency borrowing, as otherwise foreign currency debt leads to lower investment rates and higher default.

Related Literature. This paper is related to a long literature in international economics studying capital inflows into developing economies and their implications for economic growth. In the late 1990s, a literature emerged focusing on the currency composition of these flows, and studying the consequences of foreign currency borrowing on firms' balance sheets, economic policy and crises (Krugman 1999; Jeanne 2003; Céspedes, Chang, and Velasco 2004; Aghion, Bacchetta, and Banerjee 2001, among others).[4] These early papers built macro models in which market failures generate interest rate differentials that lead a representative firm to turn to foreign currency borrowing (see for example Schneider and Tornell 2004, and Caballero and Krishnamurthy 2003).[5] In this paper, we follow a different approach and focus on firms' debt portfolio problem. In particular, we consider the interest rate differential as exogenous (i.e. deviation from UIP), and assess firms' optimal currency debt composition. Our paper contributes to this literature in three different ways. First, our mechanism –namely, firms' dynamic

[4]There is also strand of literature analyzing empirically the consequences of currency depreciations on firms' balance sheets. See for example Aguiar (2005); Pratap and Urrutia (2004); Gilchrist and Sim (2007); Bleakley and Cowan (2008); Kalemli-Ozcan, Kamil, and Villegas-Sanchez (2010); Kim, Tesar, and Zhang (2015); Rancière and Tornell (2016); and Alfaro, Alejandro, Fadinger, and Liu (2017).

[5]In a recent paper, Bocola and Lorenzoni (2017) show that the risk of financial panic and precautionary motives of households can lead to multiple equilibria and to aggregate deviations from UIP. Rappoport (2008) shows that households' demand of foreign assets to insurance against real shocks can lead to foreign currency borrowing in the corporate sector.

trade-off between exposure to currency risk and growth– can explain the cross-sectional heterogeneity in firms' foreign currency borrowing choices observed in the data. Second, our firm dynamic framework shows that this heterogeneity matters to explain the gains or losses of this financing, and allow us to quantify its firm- and aggregate-level implications. Third, our extensive database enables to study –for the first time– the effects of foreign currency borrowing on the entire population of firms across sectors and over a long period, and construct detailed measures of foreign currency leverage and exposure to exchange rate movements at the firm level.

Our paper also relates to a more recent literature that studies the heterogeneous impact of capital flows across firms. Maggiori, Neiman, and Schreger (2017) find that structure of global portfolios is driven by the currency of denomination of the asset, and that foreigners mostly finance those firms issuing bonds in the foreigners' currency. Baskaya, di Giovanni, Kalemi-Ozcan, and Ulu (2017) document that capital inflows in emerging markets substantially affect the credit supply of domestic banks, leading to a decrease in the lending rate that favor low net worth firms. Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017) show that capital inflows directed to less productive firms can increase in the dispersion of the return to capital and lower aggregate productivity. We show that financial liberalization leading to capital inflows deepens foreign currency borrowing, particularly of productive firms with low initial capital stock.[6][7]

The remainder of this paper is organized as follows. Section 2 describes the Hungarian data. Section 3 presents the model. Section 4 describes the calibration. Section 5 tests the model's firm-level implications using the simulated data and the Hungarian data. Section 6 conducts numerical exercises to study the aggregate impact of foreign currency borrowing. Section 7 describes the sensitivity analysis. Section 8 concludes.

2 Data and Main Descriptive Statistics

We analyze firms' debt and investment decisions using firm-level data on the entire population of Hungarian firms. We combine two different datasets: APEH, which contains information on firms' balance sheets reported to the National Tax and Customs Authority, and the Credit Register data, which reports information on all corporate loans with financial institutions in Hungary. These datasets are provided by the National Bank of Hungary (NBH).

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,

[6]The paper is also related the literature studying firms' hedging decisions and showing that firms might borrow in foreign currency to match the covariance between their assets and liabilities (see for example Froot, Scharfstein, and Stein 1993). Our paper departs from this literature in that we show that, even when this co-variance is zero and firms only earn income in local currency, they might find it optimal to employ foreign currency loans to grow faster.

[7]In this paper, we focus on deviations from the UIP and abstract from covered interest rate parity (CIP) deviations arising after the Great Recession (Du, Tepper, and Verdelhan 2017) for three main reasons. First, as shown by Rime, Schrimpf, and Syrstad (2017), only large global banks can afford the high transaction costs of forward contracts and take advantage of this arbitrage. Second, future contracts play only a marginal role in developing economies. In Hungary, only 4% of firms borrowing in foreign currency employ financial hedges (Bodnár 2006). Finally, note that UIP deviations are the relevant object to study the risk taking behavior of firms, as CIP deviations do not affect risk.

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.[8] 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 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).[9]

In Hungary, foreign currency borrowing expanded rapidly after the deregulation of international financial flows in 2001, which liberalized foreign currency denominated loans for Hungarian firms.[10] By 2005, one-third of firms employing bank credit held foreign-currency loans. These 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.12 in Appendix B).

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
Leverage	4	22
Sales	248	1,348
Capital	100	460
Log RTFP	6.5	6.7
Employment	17	45
Number of firms	147,166	13,493

Notes: Rows 1-3 are in %. Rows 4 and 5 are in millions of Hungarian Forints. The difference in means is statistically significant at one percentage point. Source: APEH and Credit Register data.

Table 1 shows that firms borrowing in foreign currency used this type of financing intensively. In 2005, their share of foreign currency loans on total loans was 64%. Remarkably, most of these firms were non-exporters (73% of firms) and, hence, were not naturally hedged.[11] Furthermore, these firms did not

[8]We 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.11 describe the sectors under analysis in detail.

[9]The 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.

[10]See Appendix C and Varela (2017) for a detailed description of the liberalization of international flows in Hungary.

[11]Interestingly, most of firms borrowing in foreign currency were neither exporters or importers. Table B.13 reports the

employ derivative contracts to hedge the currency risk, as reported by Bodnár (2006).[12] The absence of natural or financial hedging shows that firms borrowing in foreign currency were substantially exposed to exchange rate movements. Firms borrowing in foreign currency were –on average– more productive, larger (sales, capital and employment) and had a greater level of leverage (Table 1). In all these variables, the difference in means is statistically significant at one percentage point.[13]

In the next sections, we study theoretically why firms might optimally choose to borrow in foreign currency and be exposed to the currency risk, and employ the Hungarian data to assess firms' choices.

3 Model

This section develops a firm-dynamics model with endogenous debt composition to jointly study firms' financing and investment decisions. The 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, there are deviations from the risk-free UIP that create a wedge between the domestic and the foreign currency risk-free interest rates. Third, firms face productivity and exchange rate shocks that make external finance risky and firms susceptible to default. We employ the model to study firms' optimal currency debt composition and the distribution of foreign currency borrowing in the cross-section of firms. Sections 3.1-3.6 describe the model's environment and firms' problem, the stationary firm distribution, and firms' optimal currency debt composition.

3.1 Environment

There is a continuum of heterogeneous incumbent firms that produce an homogenous good employing a decreasing returns to scale technology: $F(z,k) = zk^{\alpha}$, where z and k denote a firm's productivity and capital, and $\alpha \in (0,1)$. The good is sold domestically at a price p denominated in local currency. Firms are subject to aggregate exchange rate and idiosyncratic productivity shocks. The dynamic of these shocks is as follows

$$\log s' = \rho_s \log s + \sigma_s \epsilon_s, \tag{1}$$

$$\log z' = \rho_z \log z + \sigma_z \epsilon_z, \tag{2}$$

where s is the nominal exchange rate and is defined in units of local currency per one unit of foreign currency. The transitory shocks are $\epsilon_s \sim N(0,1)$ and $\epsilon_z \sim N(0,1)$. In each period, firms pay a fixed operational cost c_f and a cost $\psi(k,k')$ to adjust their capital. Capital depreciates at a rate δ.

share of exporters, importers, exporters and importers, and neither exporter or importers for firms borrowing in foreign currency by year. In 2005, 65% of firms employing this financing were neither exporters or importers and their foreign currency share was 65% (Tables B.13 and B.14 in Appendix B). Note, finally, that only 10% of firms borrowing in foreign currency were foreign-owned in 2005.

[12] In 2005, Bodnár (2006) conducts a survey on small and medium enterprises in Hungary about their hedging behavior. She finds that only 4% of firms indebted in foreign currency employed forward instruments to hedge the currency risk.

[13] Interesting, although firms borrowing in foreign currency were relatively larger, two-thirds of them were small and medium firms with less than 250 employees (Table B.12). Appendix B.3 presents additional descriptive statistics of firms borrowing in foreign currency.

Firms can finance their investment using retained earnings and/or external loans.[14] These loans take the form of one-period bonds, which can be denominated in local currency (b) or foreign currency (b^*). Local and foreign currency bonds are issued at discounts q and q^*, where $q, q^* < 1$. In each period, firms can raise funds in domestic and foreign currency for $q\, b + q^*\, b^*$ in exchange for a promise to pay back the face value of the debt in the next period. Firms can default in their debt obligations, in which case they exit the market. There is a fixed credit cost c to raise external funds and an additional fixed cost c^* to borrow in foreign currency.[15] In each period, there is a constant mass of potential entrants, which together with the endogenous exit make the distribution of firms endogenous and dependent of the exchange rate shock. Firms are heterogeneous in productivity, capital, and local and foreign currency debts. Firms' problems are solved in partial equilibrium.

3.2 Incumbent Firms

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

$$V = \max \left\{ V^R, V^D \right\}. \tag{3}$$

For simplicity, we normalize the value of default to zero. If a firm repays and produces, it chooses its investment in physical capital (k') and the levels of local and foreign currency debts (b', b'^*) to maximize its value (V^R):

$$V^R(s, z, \upsilon) = \max_{\upsilon'} \, [e + \beta \, E_{z',s'} V\left(s', z', \upsilon'\right)], \tag{4}$$

where $\upsilon = \{k, b, b^*\}$ is a set of endogenous state variables and e is equity payout, which is given by

$$e = p\,[zk^\alpha - i(k, k') - \psi(k, k') - c_f] - [b + sb^*] + [qb' + q^* sb'^* - p\, c_{I_{(b'+b'^*>0)}} - p\, c^*_{I_{(b'^*>0)}}]. \tag{5}$$

The first term in equation (5) denotes a firm's revenues net of investment (i), capital adjustment cost (ψ), and fixed operational cost (c_f). Let capital adjustment costs be $\psi(k, k') = c_0 \frac{[k' - (1-\delta)k])^2}{k}$, where $c_0 > 0$. The second term denotes current period debt repayment. The last term is the new debt issuance net of the fixed credit and foreign currency credit costs. In this small open economy, we let the local price be defined as 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 ($p^* = 1$). Under this specification, the law of

[14] To focus on firms' currency debt decisions, we restrict firms from equity financing. This assumption does not affect the mechanism proposed in this paper 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.

[15] These credit costs do not affect the model's mechanism nor its implications, and are only included to discipline the calibration. In Appendix A, we show it in three different ways. First, in Appendix A.1, we prove analytically that all the model's implications hold true when credit costs are set to zero. Second, in Appendix A.2, we build a two-period model and show that the model's mechanism and its implications hold true when credit costs are excluded from the analysis. Finally, in Appendix A.3, we simulate the model with foreign currency credit costs equal to zero, and show that the non-targeted moments, and the model's implications and mechanism are valid when these costs are excluded from the analysis.

one price holds whenever $\eta = 1$ and the local price moves one-to-one with the exchange rate. If instead $\eta = 0$ and there is zero exchange rate pass-through, the local price is constant.[16]

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 exchange rate shocks, they decide whether to repay the debt and produce or default and exit the market. Repayment occurs whenever the value of the firm is positive. Active firms receive revenues net of fixed costs, adjustment investment costs and debt repayments, and choose capital and debt for the next period.

Debt Contract and Debt Pricing

There is a mass of infinite creditors that can invest in risk-free bonds or in firms' risky bonds. Risk-free bonds can be denominated in local or foreign currency, and pay interest rates r and r^*, respectively. Investors discount equally each future state of the world at the risk-free rates, and earn zero profits in expectations.[17]

Define $\Delta(\upsilon)$ as the set of exchange rate and productivity shocks for which a firm chooses to default: $\Delta(\upsilon) = \Big\{ (s, z) \, \text{s.t.} \; V^R(s, z, \upsilon) \leq 0 \Big\}$, and $P_{z,s}(\Delta(\upsilon))$ its default probability.[18] The non-arbitrage condition implies that creditors invest in bonds until a firm's idiosyncratic interest rate adjusted by the repayment probability is equal to the free-risk rate. That is,

$$1 + r = \Big(1 - P_{z,s}(\Delta(\upsilon))\Big)(1 + r^b) \qquad \text{and} \qquad 1 + r^* = \Big(1 - P_{z,s}\left(\Delta(\upsilon)\right)\Big)(1 + r^{b*}), \tag{6}$$

where r^b and r^{b*} are a firm's domestic and foreign idiosyncratic interest rates. Let a firm's bonds prices be defined by $q \equiv 1/1 + r^b$ and $q \equiv 1/1 + r^{b*}$. Using equation (6), we can re-write bonds' prices as a function of a firm's default probability. More precisely,

$$q = \frac{1 - P_{z,s}(\Delta(\upsilon))}{1 + r} \qquad \text{and} \qquad q^* = \frac{1 - P_{z,s}(\Delta(\upsilon))}{1 + r^*}. \tag{7}$$

Equation (7) shows that bond prices are affected by a firm's default probability and the risk-free rates. Remark that a firm's default probability affects simultaneously local and foreign bond prices and, hence, its overall cost of funds. Furthermore, risk-free rates affect the relative cost of funds of local and foreign currency bonds. The relationship between the risk-free rates is given by the adjusted UIP:

$$\theta \, E(s'|s) \, (1 + r^*) = s \, (1 + r), \tag{8}$$

where $\theta > 0$ denotes the deviation from the risk-free UIP. If $\theta = 1$, the risk-free UIP holds, and the

[16]Note that, to a first order approximation, η determines the balance sheet effect of the firm. While foreign currency debt repayment moves one-to-one with the exchange rate, net revenues move proportionally to η. In Section 7.1, we illustrate this by showing a sensitivity analysis for different values of η.

[17]In Section 7.2, we relax this assumption and let investors have stochastic discount factors that depend on the aggregate state of the world.

[18]For simplicity, we assume that there is zero recuperation post default and that, when firms default, they do so in both local and foreign currency debts.

expected costs of investing in risk-free bonds in domestic and foreign currency are equal. Instead, if $\theta \neq 1$, there are deviations from the risk-free UIP. In particular, a $\theta > 1$ implies a wedge between the domestic and the foreign risk-free rates that makes the latter relatively lower.[19]

Equations (7) and (8) present a firm's trade-off when choosing the currency composition of their debt. While deviations from the risk-free UIP with $\theta > 1$ make foreign currency borrowing more attractive, this financing exposes firms to the currency risk, increasing their default probability. This trade-off between a relatively lower risk-free rate in foreign currency and the increase in the idiosyncratic costs of funds drives a firm's foreign currency borrowing decisions, as we study in the next sections.[20]

3.3 Entrant Firms

In each period, there is a constant mass of potential entrants that receives a signal χ about their productivity in the next period. This signal follows a Pareto distribution with parameter ι and determines the distribution of the next period idiosyncratic productivity shock. After observing their signal, potential entrants choose their capital stock. The value of entry is as follows

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

To enter, firms need to pay a sunk cost of entry, c_e, denominated in local currency. They enter whenever their expected continuation value exceeds the sunk cost: $V_e(s, \chi) \geq p\, c_e$.

3.4 Stationary Firm Distribution

Given an initial distribution, a recursive equilibrium is a set of functions for (i) firms' value function $V(s, z, \upsilon)$ and $V_e(s, \chi)$, capital holdings $k'(s, z, \upsilon)$, debt $b'(s, z, \upsilon)$, $b'^*(s, z, \upsilon)$ and default set $\Delta(\upsilon)$, and (ii) pricing functions $q(s, z, \upsilon)$ and $q^*(s, z, \upsilon)$ and (iii) bounded sequences of incumbents' measure $\{\Gamma_t\}_{t=1}^{\infty}$ and entrants' measure $\{\Omega_t\}_{t=0}^{\infty}$ and such that:

- given the bond price functions ($q(s, z, \upsilon)$ and $q^*(s, z, \upsilon)$), the value function ($V(s, z, \upsilon)$), capital holdings ($k'(s, z, \upsilon)$), debt ($b'(s, z, \upsilon)$ and $b'^*(s, z, \upsilon)$), and the default set ($\Delta(\upsilon)$) satisfy the firm's

[19] Note that $\theta > 1$ mimics the fact presented in the introduction showing that, in Hungary, there were deviations from the risk-free UIP making foreign currency borrowing relatively cheaper. Between 2005 and 2015, the wedge θ between the risk-free rate in local and foreign currency adjusted by exchange rate fluctuations was higher than one (1.05 on average). Deviations from the risk-free UIP creating a wedge between the local and foreign risk-free rate are not specific of Hungary. Ranciere, Tornell, and Vamvakidis (2010) document first evidence of these type of deviations for a group of ten emerging European economies (Bulgaria, Croatia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic and Ucrania) in the 2000s. Furthermore, several studies find substantial deviations from the UIP for many currencies even during long periods, see for example Chinn and Quayyum (2012), Frankel and Poonawala (2010), Chinn and Frankel (1999), Engel (1996), Ito and Chinn (2007), and Rose and Flood (2001), among others.

[20] Note that this specification assumes that banks offer firms a lower risk-free rate in foreign currency, and pass the benefit from the deviation from UIP to firms. Importantly, this is consistent with the empirical evidence across countries showing that the corporate interest rate in foreign currency loans is lower than that of local currency loans (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 interest rate differential between the corporate loans denominated in local and foreign currency, which rates were 8.04% and 3.88% over this period (NBH). This difference could arise from market segmentation in the financial sector. In this paper, we take this difference as given and focus on the firms' debt portfolio problem.

optimization problem;

- the bond price functions ($q(s,z,\upsilon)$ and $q^*(s,z,\upsilon)$) satisfy the zero expected profit condition for the investors, where the default probabilities and expected recovery rates are consistent with the repayment policy;

- for all Borel sets $Z \times K \subset \Re^+ \times \Re^+$ and $\forall\, t \geq 0$

$$\Omega_{t+1}(Z \times K \times B \times B^*) = M \int_Z \int_{B_e(K,s)} d\Upsilon(\chi) dH(z'|\chi),$$

where $B_e(s,K) = \{\chi \text{ s.t. } k'(s,\chi) \in K, \text{ and } V_e(s,\chi) \geq p\, c_e\}$;

- for all Borel sets $Z \times K \subset \Re^+ \times B \subset \Re^+ \times B^* \subset \Re^+ \times \Re^+$ and $\forall\, t \geq 0$

$$\Gamma_{t+1}(Z \times K \times B \times B^*) = \int_Z \int_{B(K,B,B^*,s)} d\Gamma_t(z,\upsilon) dH(z'|z) + \Omega_{t+1}(Z \times K \times B \times B^*),$$

where $B(s,K,B,B^*) = \{(s,\upsilon)\ s.t.\ V(s,z,\upsilon) > 0, k \in K,\ b \in B, \text{and } b^* \in B^*\}$.

3.5 *Firms' Optimal Decisions*

We turn now to study firms' optimal investment and financing decisions. To illustrate these choices, we present below the Euler equations for capital, local and foreign currency debts:[21]

$$k': \underbrace{\underbrace{-p\left(1 + \frac{\partial \psi(k,k')}{\partial k'}\right)}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial k'} b' + \frac{\partial q^*(\upsilon')}{\partial k'} s b'^*}_{\text{indirect bond price effect}}}_{\text{total cost}} = \beta \underbrace{E_{z',s'}[p(\alpha z' k'^{\alpha-1} + (1-\delta) - \frac{\partial \psi(k',k'')}{\partial k'})(1-\Delta(\upsilon'))]}_{\text{expected benefit}}, \tag{9}$$

$$b': \quad \underbrace{\underbrace{q(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'} b' + \frac{\partial q^*(\upsilon')}{\partial b'} s b'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \leq \beta \underbrace{E_{z',s'}[1(1-\Delta(\upsilon'))]}_{\text{expected cost}}, \tag{10}$$

$$b'^*: \quad \underbrace{\underbrace{s q^*(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'^*} b' + \frac{\partial q^*(\upsilon')}{\partial b'^*} s b'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \leq \beta \underbrace{E_{z',s'}[s'(1-\Delta(\upsilon'))]}_{\text{expected cost}}. \tag{11}$$

Equation (9) presents the Euler equation for capital and shows that, at the optimum, the total cost of one extra unit of capital should be equal to its expected future benefit. The expected benefit

[21]See Appendix A.1 for the analytical derivations. For expositional simplicity, in equations (9) to (12), we set the fixed credit costs to zero. These fixed costs only affect the decision of a firm to start issuing local or foreign currency debt, but they do not affect firms' marginal decisions once they issue bonds. This allows us to focus on the mechanism of the paper, and to show that the model's implications hold true independently of the fixed credit costs.

is given by the marginal product of capital plus its non-depreciated value net of adjustment costs at states of repayment. Importantly, the total cost of one extra unit of capital is given by the *direct* cost of investment and the *indirect* impact of this investment on a firm's current debt issuance. This indirect effect stems from the endogenous effect of current investment on a firm's bond prices. That is, as a firm's next-period capital affects its future repayment likelihood, current investment affects firms' current cost of funds and, as a result, the overall cost of this investment.

Equations (10) and (11) present the Euler equations for local and foreign currency debts, respectively. These equations show that firms optimally choose to issue local and foreign currency bonds until the funds raised by each type of debt equal their expected future cost. The inequality conditions indicate that if the total benefit of issuing a bond is lower than its cost, firms choose not to issue it. It is important to remark that the benefit of one extra unit of debt depends *directly* on the current bond price of this debt, and *indirectly* on its endogenous effect on the firm's overall cost of funds. Since by issuing debt firms increase their default probability, current debt issuance affects bond prices and, hence, the total benefit of issuing debt. Note as well that higher debt issuance in one currency also affects the price of the bond of the other currency, as the default probability affects both local and foreign bond prices (as shown in equation (7)). The expected cost of bonds is their face value at states of repayment. In the case of foreign currency bonds, their expected cost also depends on the future value of the exchange rate, which highlights its additional risk arising from the exchange rate uncertainty.

Equations (9)-(11) illustrate the role of the endogenous default on firms' investment and financing choices. Since current choices affect next period default probability, they also affect current financing costs and, hence, a firm's current optimal investment and financing decisions. This link between current choices and future default likelihood intertwines firms' investment and currency debt decisions. This implies that local and foreign currency debt issuance are jointly determined for any given level of k. In the next section, we analyze in detail the trade-off that leads firms to choose to borrow in foreign currency.

3.6 Mechanism: Foreign Currency Borrowing Decision

To assess the forces leading firms to borrow in foreign currency, we evaluate the relative benefits and costs of this financing vis-à-vis local currency borrowing. In particular, we focus on the optimal choice of a firm issuing local currency bonds and deciding whether to issue foreign currency debt, for a given level of k, s and z. With this end, we employ the UIP condition in equation (8) and equations (10)-(11) to rewrite the Euler equation of foreign bonds relative to local bonds as follows (see analytical derivation in Appendix A.1):

$$\underbrace{(\theta-1)\frac{\left[1-E_{z',s'}(\Delta(v'))\right]}{(1+r)}}_{\text{relative benefit of FC debt}} - \underbrace{\left[\left(\frac{\partial E_{z',s'}(\Delta(v'))}{\partial b'^*}\frac{1}{E(s'|s)} - \frac{\partial E_{z',s'}(\Delta(v'))}{\partial b'}\right)\left(\frac{b'}{(1+r)}+\frac{sb'^*}{(1+r^*)}\right)+\beta\frac{cov_{|z',s'}(s',1-\Delta(v'))]}{E(s'|s)}\right]}_{\text{relative cost of FC debt}} \leq 0. \tag{12}$$

Equation (12) shows the trade-off faced by a firm choosing whether to start borrowing in foreign currency. The first term arises from the deviation from the UIP and represents the relative benefit of financing at a lower risk-free rate. As expected, the higher the deviation (higher θ), the greater is the benefit of issuing foreign currency bonds.

The second term represents the relative cost of issuing foreign currency bonds vis-à-vis local currency bonds. This cost depends on the relative increase in the default probability stemming from the new exposure to the currency risk ($\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'^{*}}\frac{1}{E(s'|s)} \geq \frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'}$). Importantly, the relative increase in the default probability has a large impact on firms' decisions, as it decreases bond prices of the *entire debt issuance.*

When a firm considers to issue one extra unit of foreign currency debt, it compares the benefit of the lower risk-free rate of that unit (first term) with the increased financing costs of the entire debt stock (second term). If the increase in the default probability is high enough, the cost of foreign currency borrowing could exceed its benefit, and the firm will choose not borrow in foreign currency. Firms issuing foreign currency debt choose levels such that the relative benefit is equal the relative cost of this financing - i.e., equation (12) holds with equality.

-Lemma 1. Selection: Only highly productive firms borrow in foreign currency.

Lemma 1 states that there is selection into foreign currency borrowing, as only firms above a certain productivity threshold optimally choose to issue this financing. Below this threshold, the cost of issuing foreign debt exceeds its benefits and firms choose not to borrow in foreign currency.

To see the intuition behind this lemma, note that a firm's probability of default is equal to the probability that its future equity is lower than zero:

$$E_{z',s'}(\Delta(\upsilon')) = P_{z',s'}(e' < 0) = P_{z',s'}(p[z'k'^{\alpha} - i(k',k'') - \psi(k',k'') - c_f] - [b' + s'b'^{*}] + [q'b'' + s'q'^{*}b''^{*}] < 0).$$

Using this expression, we can define the productivity threshold ($\tilde{z}'$) below which a firm –with state υ' and given the exchange rate realization s'– defaults and exits the market:

$$\tilde{z}' = \frac{p[i(k',k'') + \psi(k',k'') + c_f] + [b' + s'b^{*\prime}] - [q'b'' + s'q^{*\prime}b^{*\prime\prime}]}{pk'^{\alpha}}.$$

Given the persistence of the idiosyncratic productivity shock ($\rho_z > 0$), highly productive firms today expect a high productivity level in the next period and, hence, are more likely to be above $\tilde{z}'$ and not to default. The higher the productivity level, the easier is to tolerate the currency risk and the less increases a firm's default probability when issuing foreign bonds, for a given υ' and s'. Hence, more productive firms find it optimal to borrow in foreign currency and issue these bonds until the benefit of this financing is equal to its costs (i.e equation (12) holds with equality). Foreign currency borrowing then correlates with firms' productivity. Importantly, there is a productivity threshold below which firms do not find optimal to be exposed to the currency risk and borrow in foreign currency, and only issue local denominated bonds. For these firms, the increase in their default probability when borrowing in foreign currency is sufficiently high that the cost of this debt exceeds its benefit (i.e. equation (12) does not bind). In Appendix A.1, we show the analytical derivations behind this result.

-Corollary 1: Firms borrowing in foreign currency have higher investment rates.
Firms borrowing in foreign currency take advantage of the relative lower risk-free rate stemming from UIP deviations and borrow at lower financing terms. Lower borrowing costs allows them to have higher investment rates and reach faster their optimal scale of production.

-Lemma 2. Deviations from the risk-free UIP: Higher UIP deviations promote foreign currency borrowing and decrease the productivity level to employ this financing.
Lemma 2 can be directly seen from equation (12). As shown in equation, higher deviations from the UIP increase the relative benefit of issuing foreign currency bonds (first term). This allows firms to bear a higher relative idiosyncratic cost of this financing (second term), that is, to have higher exposure to currency risk and hold higher levels of foreign debt. Furthermore, the higher these deviations, the lower is the productivity level required to start issuing this financing, i.e. equation (12) binds for lower levels of z.

-Corollary 2: Deviations from the risk-free UIP promote investment of firms issuing foreign bonds.
As the deviation increases, the relative cost of foreign debt decreases, which allow firms employing this financing to increase their investment.

4 Calibration and Validation of the Model

We calibrate the model to match data moments in Hungary in 2005, which is the first year for which our dataset reports information on foreign currency loans at the firm level. Since 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). In particular, we simulate the model to mimic the years between 2001 and 2010 that follows the deregulation of foreign currency borrowing.

We conduct this 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 exchange rate shocks in Hungary between 2001 and 2010 and the firm-level optimal policies of the model with foreign currency. This simulation strategy allows us to create firm-level panel data that tracks the evolution of firms over 2001-2010, and follows the path of the exchange rate in Hungary.

The fourteen parameters of the model are calibrated to Hungarian data on yearly basis. Nine parameters are externally calibrated, and five are internally calibrated to match moments in the data for Hungary in 2005. Given our focus on a small open economy, we let the risk-free rate in foreign currency (r^*) be exogenous and set it to 1.75%, which was the average interest rate of the one year German government bond between 2001 and 2015. We consider it the relevant rate for Hungary, as more than two-thirds of foreign currency loans were denominated in Euros. We set the local currency risk-free rate (r) to 7.35%, which was the average interest rate of the one year government bond in Hungary in the same period. As such, the domestic risk-free interest rate is higher than the foreign interest rate.

We estimate the exchange rate process with respect to the Euro for the period 1992 to 2015 with a log-normal AR(1) process, as in equation (1). The estimated value for the persistence of the exchange rate ρ_s is 0.86, and the dispersion of the shocks σ_s is 0.3. The process is discretized into a thirty five-state Markov chain using a quadratic based procedure (Tauchen and Hussey 1991). We estimate the productivity process at the firm level using the following specification

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

where μ_i and ϕ_{jt} denote firm-fixed and four-digits sector-year fixed effects. This specification follows Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2012) and Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017) and controls for firm-time invariant characteristics and sector time-variant shocks, where the latter controls for demand specific shocks. Based on this regression, we set $\rho_z = 0.63$ and the cross-sectional standard deviation of the residuals $\sigma_z = 0.57$ in equation (2). 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 (Table B.13 in Appendix B). In Section 7.1, we conduct a sensitivity analysis for different levels of η and show that this assumption does not affect the mechanism proposed in this paper nor its aggregate implications.[22]

We jointly calibrate the fixed credit costs (c and c^*), the investment adjustment cost (c_0), the fixed operational cost (c_f) and the discount factor (β) to match main moments of firms in Hungary in 2005. Since many firms are small and do not borrow from banks, we calibrate these parameters to match moments of firms that report bank debt. In particular, we calibrate the credit cost to match the share of firms borrowing (30%), the foreign-currency credit cost to match their share of foreign currency loans on total loans (19%), the investment adjustment cost to match their investment rate (12%), and operational cost to match the default rate (2%).[23] We set β to match the share of firms borrowing only in local currency (21%).[24] Table 2 summarizes the parameters and targeted moments.

[22]Furthermore, this assumption allows us to focus on the most striking feature of the data, namely why firms whose prices are fixed in local currency choose to borrow in foreign currency and be exposed to the currency risk. For further references on the literature about imperfect pass-through for exporter and importer firms, see Burstein and Gopinath (2014); Gopinath, Itskhoki, and Rigobon (2010); Amiti, Itskhoki, and Konings (2014), and Berman, Martin, and Mayer (2012); and Goldberg and Tille (2016).

[23]The default probability in Hungary was estimated by Bauer and Endresz (2016), who reports 2% for 2005.

[24]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.

Table 2: Parameter Values

	Parameter Values	
	Value	Target
Parameters selected independently		
Foreign currency risk-free rate	$r^* = 1.76\%$	German Bund, 1 year rate
Domestic currency risk-free rate	$r = 7.35\%$	Hungarian Government Bond, 1 year rate
Exchange rate shock	$\rho_s = 0.86$ $\sigma_s = 0.3$	Euro-HUF Forint rate
Firm productivity	$\rho_z = 0.63$ $\sigma_z = 0.57$	Hungarian firms
Return to scale	$\alpha = 0.6$	Hungarian firms
Depreciation rate	$\delta = 10\%$	
Exchange rate pass-through	$\eta = 0$	
Jointly calibrated parameters		
Discount factor	$\beta = 0.85$	Share of firms holding only LC debt
Fixed cost of credit	$c = 0.7$	Share of firms borrowing
Fixed cost of FC debt	$c^* = 0.12$	FC share of borrowing firms
Fixed operational costs	$c_f = 2$	Default rate
Investment adjustment cost	$c_0 = 0.2$	Investment rate of borrowing firms

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

4.1 Validation of the Model

4.1.1 Non-Targeted Moments

To assess whether the model matches firms' foreign currency borrowing decisions and their investment patterns, we break down firms with credit into three groups 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. We evaluate the following non-targeted moments: the share of firms in each group, their relative productivity and capital, their investment rate, and their share of foreign currency loans on total loans.

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 (columns 1 and 2). First, the model tracks closely the share of firms borrowing both in local and foreign currency, and only borrowing in foreign currency. The share of firms employing both types of financing is 6% both in the model and the data. The share of firms only issuing foreign bonds is 2% in the model and 3% in the data.

Second, the model matches closely the average productivity and capital of each group. Relatively to the average of firms with credit –which are normalized to one–, firms that borrow in foreign currency are more productive both in the model and the data. In particular, firms that employ local and foreign currency funds are 2% more productive in the model and the data; while firms that only borrow in foreign currency are 7% more productive in the model and 5% in the data. Firms that only borrow in

Table 3: Non-Targeted Moments (2005)

Moment	Group	Model	Data
		(1)	(2)
Firm share (%)	LC & FC debt	6	6
	FC debt only	2	3
Relative productivity*	LC debt only	0.97	0.99
	LC & FC debt	1.02	1.02
	FC debt only	1.07	1.05
Relative capital*	LC debt only	1	0.97
	LC & FC debt	1.02	1.06
	FC debt only	0.91	0.99
Investment rate (%)	LC debt only	9	9
	LC & FC debt	18	18
	FC debt only	22	19
FC Share (%)	LC & FC debt	59	50
	FC debt only	100	100
Leverage (%)	LC debt only	52	17
	LC & FC debt	45	25
	FC debt only	25	18

Notes: This table shows data and model moments for different groups of firms in 2005. We simulate approximately 160,000 firms from the stationary distribution of no foreign currency. In this simulation, we use the realized exchange 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.

local currency are less productive in the model and the data. Firms that only employ foreign currency loans report lower level of capital both in the model and the data. Their high productivity and low capital suggests that these firms have high MPK, which is consistent with an intensive use of cheap foreign currency loans to expand their investment, as discussed in the next paragraph.

Third, the model matches closely the investment rate of each group and shows that firms' issuing foreign denominated bonds have higher investment rates. More precisely, firms borrowing only in local currency have 9% investment rate both in the model and the data; firms employing both types of financing see investment rates of 18% both in the model and the data; and firms only using foreign borrowing have 22% and 18% in the model and the data.

Finally, the model predicts that firms borrowing in both currencies have a foreign currency share of 59%, while this share is 50% in the data. Interesting, neither in the model or in the Hungarian data, firms only borrowing in foreign currency report very high level of leverage. This suggests that these firms do not use foreign currency loans to over-borrow, but they optimally choose this financing to exploit the lower relative cost arising from UIP deviations to the risk level that they can tolerate.[25]

4.1.2 Mechanism: Foreign Currency Borrowing Decision

As shown in Section 3.6, foreign currency borrowing is driven by a trade-off between aggregate deviations from the risk-free UIP and firms' idiosyncratic cost of funds. While deviations from the UIP make foreign loans relatively more attractive, this financing exposes firms to exchange rate shocks increasing their default probability and overall financing costs. Hence, firms might find optimal to borrow in foreign currency to the extent that the increase in their idiosyncratic cost of funds does not exceed the lower relative cost stemming from the deviation from the UIP.

To illustrate this mechanism, we plot in Figure 2 the local and foreign bond price schedules for the average productivity shock fixing the exchange rate and the states (k, b, b^*) at the average firm. Two features are important to highlight from this figure. First, for low levels of debt, the price of foreign currency bonds is higher than domestic bonds $(q^* > q)$, as firms' default probability is low and the risk-free rate in foreign currency is relatively lower. Second, when firms increase their debt holdings, their risk of default increases and their bond prices drop. Importantly, the price of foreign currency bonds drops at lower levels of debt, since these bonds expose firms to the currency risk and increase their default probability relatively more. To illustrate firms' foreign currency borrowing choices, we turn now to present the two lemmas stated in Section 3.6.

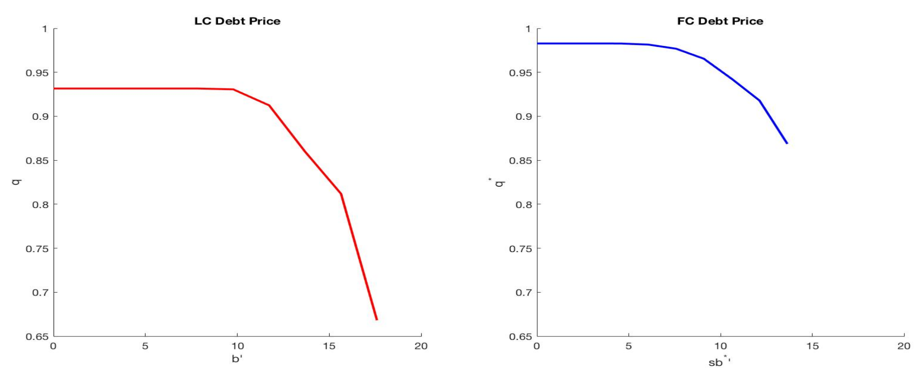


Figure 2: Domestic and Foreign Currency Bond Price

Notes: The left and right graphs plot the local and foreign currency bond prices on the local and foreign currency debt levels, respectively, for the average productivity shock and fixing the exchange rate and the states (k, b, b^*) at the average firm.

[25]The higher level of leverage implied by the model is a common feature in the corporate finance literature and is refereed as the "low leverage puzzle", see Graham (2000) and Strebulaev and Yang (2013) among others. In our results, we do not observe firms borrowing in foreign currency to gamble for survival. This behavior would imply that firms have a high probability of default while issuing foreign currency debt. However, our equilibrium policy functions show that firms never achieve high leverage because their bond prices drop dramatically. This pattern is consistent with our simulated results reporting that firms holding foreign currency debt are the most productive and have a low probability of default.

-Lemma 1. Selection: Only highly productive firms borrow in foreign currency.

To illustrate this lemma, we plot in Figure 3 the local and foreign currency bond price schedule fixing the states (k, b, b^*) at the average firm for high and low productivity firms (left panel). As discussed above, when a firm increases its foreign currency debt holding, its risk of default rises and bond prices decreases. The drop in bond prices is slower for more productive firms, as they are able to tolerate higher shares of foreign currency debt without significantly increasing their probability of default. There is a productivity threshold below which firms might not find optimal to borrow, as exposure to exchange rate shocks becomes very risky. Therefore, only more productive firms choose to borrow in foreign currency. Figure 3 (right panel) plots the policy of the share of foreign currency debt on total debt $(\frac{s'b'^*}{b'+s'b'^*})$ for different productivity shocks. This figure shows that only above a certain productivity level firms choose to issue foreign currency bonds and that the share of foreign loans on total loans increases in firms' productivity. Importantly, as these firms enjoy lower financing costs and have a lower required rate of return for capital, they can invest and grow more.

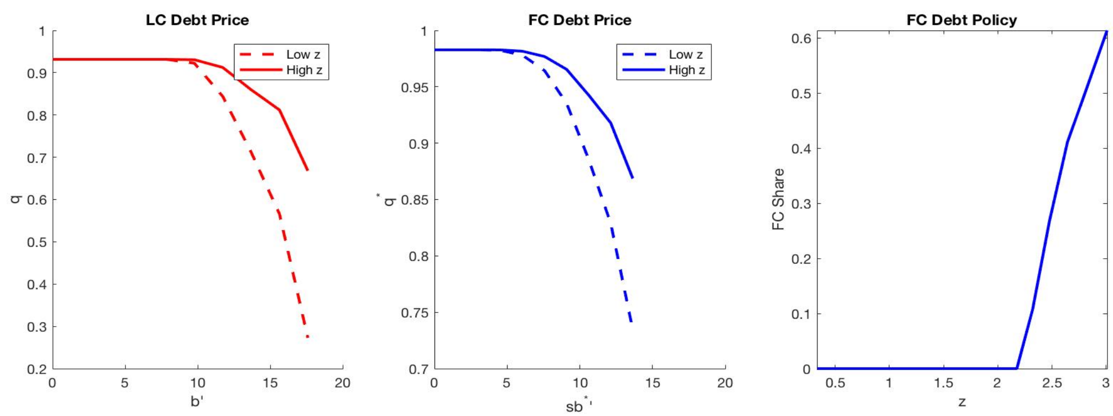


Figure 3: Domestic and Foreign Currency Bond Price

Notes: The left and center graphs plot the local and foreign currency bond prices on the local and foreign currency debt levels, respectively, for high and low productive firms and fixing the exchange rate and the states (k, b, b^*) at the average firm. The right graph plots the policy of the share of foreign currency debt for different productivity shocks.

-Lemma 2. Deviations from the risk-free UIP: Higher UIP deviations promote foreign currency borrowing and decrease the productivity level to employ this financing.

Higher UIP deviations increase the wedge between local and the foreign interest rate, which encourages firms to issue foreign currency denominated bonds. As the relative risk-free rate in foreign currency decreases, more firms are able to issue this financing and the productivity threshold decreases. To illustrate this, Figure 4 displays the policy of the share of foreign currency debt for different productivity shocks, fixing the state (k, b, b^*) at the average firm. The solid line implies a UIP deviation of 1.05 ($\theta = 1.05$), which was the average deviation observed in Hungary between 2005 and 2015, and the dashed line implies a UIP deviation of 1.07. This figure shows that a higher deviation lowers the productivity threshold to employ foreign loans, as it increases the benefit of issuing this financing. Furthermore, for a given productivity level, the higher the deviation, the higher is the share of foreign currency loans. Note that, as the deviation increases, the relative cost of borrowing decreases for foreign currency borrowing firms, which promotes their investment.

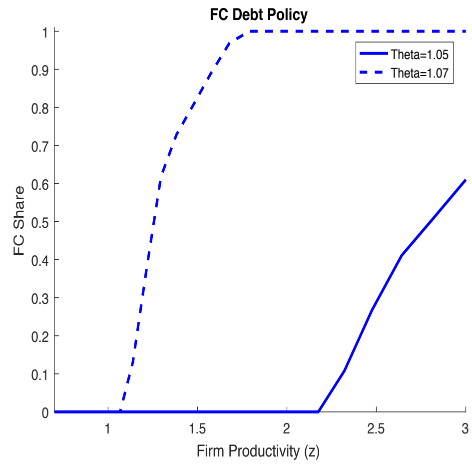


Figure 4: Deviation from the risk-free UIP and Share of Foreign Currency Loans

Notes: This figure plots the policy of the share of foreign currency debt for different productivity shocks and deviations from the risk-free UIP, fixing the state (k, b, b^*) at the average firm.

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 predictions in the data, to quantify the firm-level responses implied by the model's simulated data, and to compare the size of firms' responses in the model and the Hungarian data.

In Section 5.1, we assess selection of productive firms into foreign currency borrowing and test whether firms choosing this financing have higher investment (Lemma 1 and Corollary 1). In Section 5.2, we test if UIP deviations promote foreign currency borrowing and investment (Lemma 2 and Corollary 2). In Section 5.3, we check whether firms borrowing in foreign currency face lower financing costs, as implied by the model.

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

We first study the characteristics of firms borrowing in foreign currency and analyze next whether they correlate with higher investment.

5.1.1 Firms' Characteristics

The model predicts that foreign currency borrowing correlates with firms' productivity. Table 3 showed that, in 2005, firms borrowing in foreign currency were more productive and had higher shares of foreign currency debt, both in the model and the data. A potential issue of the Hungarian data presented in Table 3 is that firms borrowing in foreign currency could be using these loans to increase their productivity, which could question the causality of the empirical results. To address this reverse causality concern, we exploit the deregulation of foreign currency loans in Hungary in 2001. This policy reform serves as an exogenous source of time variation to test whether firms starting to borrow in foreign currency after the deregulation were indeed more productive prior to it.

An important feature of the regulations in place prior to 2001 is that they were implemented asymmetrically between foreign-owned companies and domestically-owned firms. While foreign firms were legally allowed to hold foreign denominated loans, domestic firms could only borrow locally in national currency (Varela 2017).[26] The deregulation remove the ban on domestic firms' foreign currency loans and allow them to employ this financing. In this section, we exploit this reform to study the pre-reform characteristics of firms choosing to borrow in foreign currency, once these loans were legally allowed for them. In particular, we restrict our analysis to domestic firms and study whether foreign currency borrowing increases in domestic firms' pre-reform productivity.[27]

We address Lemma 1 by studying firms' probability of borrowing in foreign currency and share of foreign currency loans on total loans. We estimate the following linear probability regression using the simulated data:

$$\text{FC Dummy}_i = \beta \, \log \mathrm{z}_i + \varepsilon_i, \tag{13}$$

where FC Dummy_i is a dummy indicating whether a firm had a foreign currency loan in 2005, and z_i represents the firm's productivity in the year 2000 prior to the deregulation of foreign currency loans. We create the foreign currency loan dummy for 2005 because the Hungarian debt data only starts in 2005 and this allow us to make a direct comparison with the Hungarian debt data. The coefficient β captures whether firms that were more productive prior to deregulation of foreign currency borrowing have a higher probability of using this financing after it.

Similarly, we estimate the following regression using the Hungarian data:

$$\text{FC Dummy}_i = \beta \, \log \text{RTFP}_i + \mu_j + \varepsilon_{ij}, \tag{14}$$

where RTFP denotes firms' revenue TFP. μ_j represent four-digit NACE industries fixed effects that allow comparing firms within industries and control for sectoral time-invariant characteristics. We cluster standard errors at four-digit industries to account for cross-sectional serial correlation within sectors.

[26] Varela (2017) describes that, prior to 2001, regulations in the foreign exchange market were the main tool of capital controls in Hungary. These operations were regulated by the Act XCV of 1995, which –by imposing severe restrictions on the foreign exchange market– restricted domestically-owned firms to borrow locally in national currency. Under this law, only foreign companies were allowed to hold foreign currency denominated loans. The deregulation of capital controls in 2001 removed these restrictions, enabling domestic firms to obtain foreign denominated loans. After the deregulation, foreign currency borrowing expanded substantially for domestic firms. Appendix C summarizes this reform.

[27] We restrict our analysis to domestic firms only in Section 5.1. In the rest of the paper, we work with all (domestic and foreign) firms in Hungary.

To assess firms' currency debt composition, we replace in equations (13) and (14) the foreign currency dummy with firms' log share of foreign currency loans.

Results

Table 4 presents the estimated coefficients for the simulated and the Hungarian data regressions. Columns 1 and 2 report the regressions using the simulated data. The estimated coefficient in column 1 shows that the model implies that a one percent increase in a firm's productivity raises the probability of borrowing in foreign currency by 0.027 percentage points. The coefficient remains stable after controlling for firms' initial capital stock. Columns 3 and 4 report the results using the Hungarian data. Column 3 shows that the estimated coefficient for firms' productivity is statistically significant and similar in magnitude than that estimated using the simulated data in column 1. In particular, a one percent increase in a firm's RTFP raises the probability of borrowing in foreign currency by 0.024 percentage points. Albeit smaller, the coefficient remains significant when controlling for firms' initial capital stock (column 4).

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	0.027***	0.024***	0.024***	0.013***	0.012***	0.011***	0.006***	0.002*
	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.001)
Log capital		0.007***		0.036***		0.002***		0.013***
		(0.001)		(0.002)		(0.000)		(0.001)
Sector FE			Yes	Yes			Yes	Yes
R^2	0.008	0.009	0.029	0.060	0.006	0.006	0.026	0.042
N	156,806	156,806	37,051	37,051	156,806	156,806	37,051	37,051

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

Columns 5-8 report the results on the log of the share of foreign currency loans. The model implies that a one percent increase in firms' productivity raises the average share of foreign currency loans by 0.01 percent (column 5). As above, the coefficient in column 6 remains stable when including firms' initial capital stock as a control. The regressions estimated using the Hungarian data confirm these results, as shown in columns 7 and 8. The coefficient on RTFP –presented in column 7– is statistically significant and close to the estimate using the model data. In particular, a one percent increase in Hungarian firms' productivity raises firms' share of foreign currency loans by 0.006 percent. The estimated coefficient is robust to controlling for firms' capital (column 8).[28]

[28]It is worth remarking on the value of R^2. In these regressions, R^2 captures how much of the variation in foreign currency borrowing in 2005 is explained by firms' productivity in 2000. In the regressions estimated employing the simulated data, we do not observe a high R^2 because productivity is stochastic and persistence decreases over time. In the regressions estimated with the Hungarian data, the low R^2 is additionally explained by the presence of unobserved heterogeneity in the data.

Table B.2 (in Appendix B.2) presents a full set of robustness tests. Panels A and B report the results for the foreign currency debt dummy and the share of foreign currency loans, respectively. Column 1 includes as a regressor firms' age to account for the finding that younger firms are usually more credit constrained (Cooley and Quadrini 2001, among others). The estimated coefficient indicates that age correlates negatively with firms' probability of borrowing in foreign currency and their foreign currency shares, suggesting that younger firms are more prone to take the currency risk and borrow in foreign currency. Column 2 shows that results are robust to estimating firms' RTFP using the methodology of Olley and Pakes (1996) to estimate the coefficients of the production function, and column 3 to using labor productivity as a proxy for firms' productivity. Column 4 excludes exporters and shows that results are robust when only considering non-exporters. Column 5 illustrates that results are robust to using averages between 1998 and 2000 as pre-reform firms' characteristics. This section averaged foreign currency loans across different foreign currencies, in Appendix B.5 we conduct a similar analysis and break down loans by their currency denomination. We show that all the model's implications hold true when decomposing foreign borrowing decisions by currency.

5.1.2 Firms' Growth

Corollary 1 predicts that firms borrowing in foreign currency have a higher investment rate as they can borrow at cheaper financing terms. As a result, these firms should also see higher level of sales.

Similar to the previous exercise, we exploit the deregulation of foreign currency loans in 2001 as a source of time variation and study whether domestic firms borrowing in foreign currency have higher investment rates and sales within the five years before and after the reform. We consider the following regression:

$$\log Y_{it} = \beta\,(\mathrm{R}_t \,\mathrm{x}\, \mathrm{FC\,Dummy}_i) + R_t + \phi_i + \varepsilon_{it},$$

where $\log Y_{it}$ denotes log investment rate and sales between 1996-2005, R_t is a dummy for the post-reform period ($\mathrm{R}_t > 1$ if year$\geq$ 2001, and 0 otherwise), and ϕ_i are firm-fixed effects that allow capturing the evolution of firms over time.

A potential concern with this specification is that firms can be in different trends. We showed above that firms borrowing in foreign currency had higher levels of capital and were more productive, characteristics that could imply higher growth. To account for pre-existing trends, we follow Gruber (1994) and Chinn (2005) and add to our specification a time trend (T_t) and a time trend interacted with the foreign currency debt dummy ($T_t \,\mathrm{x}\, \mathrm{FC\,Dummy}_i$). The final regression that we estimate is:

$$\log Y_{it} = \beta\,(\mathrm{R}_t \,\mathrm{x}\, \mathrm{FC\,Dummy}_i) + R_t + \phi_i + T_t + (T_t \,\mathrm{x}\, \mathrm{FC\,Dummy}_i) + \varepsilon_{it}. \quad (15)$$

The coefficient of interest is β and captures whether firms borrowing in foreign currency have higher investment rates and sales after the reform, once pre-existing trends are taking into account. Standard errors are clustered at year and four-digit sector when employing the Hungarian data.

Results

Table 5 presents the results for the investment rate and sales. Columns 1 and 2 report the coefficients for the simulated data. These coefficients are positive and statistically significant, confirming that firms borrowing in foreign currency had higher investment rates. After the inclusion of pre-growth trends in column 2, the model implies that these firms had a 13.9 percent higher investment rate within the five years following the deregulation. Columns 3 and 4 confirm this pattern for the Hungarian data. After the inclusion of all controls, the estimated coefficient implies that Hungarian firms borrowing in foreign currency had a 4.6 percent higher investment rate (column 4).

Table 5: Foreign Currency Borrowing and Firms' Growth

	Log Investment Rate				Log Sales			
	Model		Data		Model		Data	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R* FC dummy	0.319***	0.139**	0.214***	0.046*	0.639***	0.055***	0.280***	0.038***
	(0.032)	(0.061)	(0.018)	(0.025)	(0.005)	(0.010)	(0.013)	(0.014)
R	0.002	0.117***	0.180***	0.207***	-0.190***	0.002	0.222***	0.013**
	(0.007)	(0.013)	(0.031)	(0.026)	(0.001)	(0.002)	(0.010)	(0.006)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time trend		Yes		Yes		Yes		Yes
FC d.* Time t.		Yes		Yes		Yes		Yes
R^2	0.218	0.218	0.488	0.505	0.571	0.570	0.834	0.836
N	1,568,060	1,568,060	432,864	432,864	1,568,060	1,568,060	436,062	436,062

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.

Columns 5-8 reports the results on sales. Just like the previous trends, firms borrowing in foreign currency enjoy higher levels of sales after the deregulation of foreign currency loans. The model implies that these firms experienced a 5.5 percent higher sales, once pre-growth trends are taken into account (column 6). The estimated coefficient using the Hungarian data is statistically significant and similar on magnitude. After the inclusion of all controls, it implies a 3.8 percent differential increase in sales.

Results presented in this section show that the model reproduces quantitatively well the responses of Hungarian firms borrowing in foreign currency. In the next section, we advance our analysis on firms' foreign currency borrowing decisions by focusing on changes in UIP deviations.

5.2 Deviations from Risk-Free UIP: Firms' FC Borrowing and Growth

Lemma 2 predicts that higher deviations from the risk-free UIP 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. Section 5.2.1 studies this relationship at the firm-level. Section 5.2.2 evaluates Corollary 2 and tests whether these deviations correlate with higher investment. Section 5.2.3 checks if higher UIP deviations lower the productivity threshold to borrow in foreign currency.

5.2.1 Foreign Currency Borrowing Decisions

In this section, we employ the entire dataset of firms between 2005 and 2010 to assess the relationship between UIP deviations and foreign currency borrowing in three steps. First, we check whether these deviations associate with higher foreign currency borrowing at the firm-level. Second, we evaluate whether these responses are heterogenous across firms and correlate with firms' productivity. Finally, we add a second source of heterogeneity and assess whether firms' responses also vary in terms their capital stock. This second layer allows evaluating more precisely the mechanism proposed in the paper, namely whether foreign currency borrowing allows productive firms to accumulate more capital and grow more. Hence, we study whether –conditional on productivity– firms with lower capital stock exploit more UIP deviations to reach faster their optimal scale of production. 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 check whether UIP deviations correlate with increases in firms' foreign currency borrowing, we consider the following specification using the simulated data:

$$Y_{it} = \beta \log \mathrm{UIP}_t + \phi_i + \varepsilon_{it}, \tag{16}$$

where Y_{it} is either the foreign currency debt dummy or the log share of foreign currency borrowing, i.e. FC Dummy$_{it}$ or Log FC Share$_{it}$. Log UIP$_t$ is the log of the deviation from the risk-free UIP (the log of θ in the model). The coefficient β in equation (16) captures whether higher UIP deviations associate with increases firms' probability to borrow in foreign currency and share of foreign currency debt.

To study whether deviations from the UIP affect more productive firms differentially, we estimate

$$Y_{it} = \beta \log(\mathrm{UIP}_t \text{ x } \mathrm{z}_i) + \iota_t + \phi_i + \varepsilon_{it}, \tag{17}$$

where z_i represents the firm's initial productivity (in 2005) and ι_t are year-fixed effects. The coefficient β in equation (17) captures whether more productive firms differentially increase their use of foreign currency loans following deviations from the UIP.

To evaluate whether more productive firms with lower capital stock differentially exploit UIP deviations, we break down firms by quartiles of productivity and capital in the initial year. In particular, we create four bins according with whether firms have "high" or "low" productivity and capital stock in 2005.[29] We create the following four bins: high productivity firms with low capital ($Q_{HL} = 1$, if z^H and k^L), high productivity firms with high capital ($Q_{HH} = 1$, if z^H and k^H), low productivity firms with low capital ($Q_{LL} = 1$, if z^L and k^L), and low productivity firms with high capital ($Q_{LH} = 1$, if z^L and k^H). These four dummies allow us to compare the responses of firms with different levels of capital stock, but similar productivity level. We expect that high productivity firms with low capital (Q_{HL}) (i.e. high MPK firms) present the largest response to UIP deviations, as these firms have low

[29] We create bins with respect to initial values (2005) to address reverse causality concerns, which is crucial when employing the Hungarian data.

idiosyncratic risk and high growth potential. More precisely, we estimate the following regression:

$$Y_{it} = \beta_1 \log(\text{UIP}_t \text{ x } Q_{HLi}) + \beta_2 \log(\text{UIP}_t \text{ x } Q_{HHi}) + \tag{18}$$

$$\beta_3 \log(\text{UIP}_t \text{ x } Q_{LLi}) + \beta_4 \log(\text{UIP}_t \text{ x } Q_{LHi}) + \iota_t + \phi_i + \varepsilon_{it}.$$

The estimated coefficients $\beta_1, \beta_2, \beta_3$ and β_4 in regression (18) capture the differential response of each bin to changes in the UIP deviation.

We next turn to test regressions (16)-(18) employing the Hungarian data. We create the variable UIP_t by computing the one-year deviation from the UIP 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.[30] More precisely, $\text{UIP}_t = \log(\sum_{st} w_{st}\text{UIP}_{st})$, where s and t represent currency and year, and w_{st} is the aggregate share of loans for each currency and year. We create the bins of RTFP and capital with respect to the median firm within the four-digit NACE industries in the initial year (2005). To control for demand specific shocks that can affect sectors differently over time, we include in regressions (17) and (18) four-digit NACE industry and year fixed effects interacted. We cluster the standard errors at year and four-digit NACE industries in all specifications.

Results

Columns 1-3 in Table 6 present the results of regressions (16)-(18) using the model simulated data. The coefficient in column 1 Panel A shows that the model implies that a one percent increase in the UIP deviation raises firms' probability of borrowing in foreign currency by 0.07 percent. This coefficient is economically significant, since in an economy of 160,000 firms a ten percent increase in the deviation from the UIP would lead 1,112 more firms to borrow in foreign currency. As expected, this increase is differentially higher for more productive firms (column 2). Column 3 presents the estimated coefficients for the four bins of firms and shows that firms with high MPK (Q_{HL}) have the highest response to UIP deviations. The model implies that a one percent increase in these deviations raises their probability to borrow in foreign currency by 0.24 percent.

Columns 4-6 report the results for the Hungarian data. The estimated coefficient in column 4 implies that a one percent increase in the UIP deviation raises firms' probability of borrowing in foreign currency by 0.14 percent. Column 5 shows that this expansion increases in firms' productivity. The coefficient is highly statistically significant and close in magnitude to the model's estimated elasticity, in column 2. Just like the simulated data, firms with high MPK (Q_{HL}) have the highest response to UIP deviations (column 6). A one percent increase in this deviation raises the probability of borrowing in foreign currency by about 0.19 percent for this group of firms.

Panel B reports the results for the share of foreign currency debt. Columns 1-3 present the model's responses. Column 1 shows that a one percent increase in the UIP deviation leads to a 0.06 percent increase in firms' foreign currency share. As expected, this expansion increases in firms' productivity (column 2). Results also point to firms with high MPK to differentially increase their foreign currency shares. A one percent increase in the deviation raises their foreign currency share by 0.17 percent.

[30]In Hungary, 75% of corporate loans were denominated in Euros, 19% in Swiss Francs and 6% in U.S. Dollars in 2015.

Table 6: Deviations from the Risk-Free UIP: FC Borrowing Decisions

	Panel A. FC Dummy					
	Model			Data		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.071**			0.139***		
	(0.028)			(0.018)		
Log (Dev. UIP x Productivity)		0.055***			0.035***	
		(0.014)			(0.008)	
Log (Dev. UIP x Q_{HL})			0.246***			0.189***
			(0.029)			(0.032)
Log (Dev. UIP x Q_{HH})			0.230***			0.080**
			(0.025)			(0.041)
Log (Dev. UIP x Q_{LL})			0.180***			0.050*
			(0.025)			(0.030)
Log (Dev. UIP x Q_{LH})			0.177***			0.089**
			(0.016)			(0.041)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes	Yes
Sector* Year FE					Yes	Yes
R^2	0.419	0.501	0.51	0.741	0.696	0.742
N	940,836	940,836	940,836	1,019,461	1,019,461	1,019,461
	Panel B. Log Share of Foreign Currency Loans					
	Model			Data		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.063***			0.076***		
	(0.015)			(0.010)		
Log (Dev. UIP x Productivity)		0.022***			0.022***	
		(0.008)			(0.004)	
Log (Dev. UIP x Q_{HL})			0.177***			0.085***
			(0.018)			(0.016)
Log (Dev. UIP x Q_{HH})			0.148***			0.059***
			(0.015)			(0.021)
Log (Dev. UIP x Q_{LL})			0.170***			-0.000
			(0.015)			(0.017)
Log (Dev. UIP x Q_{LH})			0.117***			0.053**
			(0.010)			(0.023)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes	Yes
Sector* Year FE					Yes	Yes
R^2	0.402	0.515	0.508	0.716	0.664	0.717
N	940,836	940,836	940,836	1,019,461	1,019,461	1,019,461

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

Columns 4-6 confirm these results for Hungarian firms. Column 4 shows that Hungarian firms have a similar elasticity of foreign currency share than that implied by the model. In particular, a one percent increase in the UIP deviation raises the share of foreign currency loans by 0.07 percent (column 4). As above, this expansion is higher for initially more productive firms (column 5) and, among them, those with low initial capital stock (column 6). In particular, a one percent increase in the UIP deviation leads high MPK firms to expand their foreign currency share by 0.08 percent.

These results suggest that firms with initially high MPK differentially exploit UIP deviations to borrow in foreign currency. We conduct three robustness tests. First, we exclude exporters and show that results are robust when considering only non-exporters (Table B.4 in Appendix B). Second, we control for valuation effects on the share of foreign currency loans and show that results are robust when controlling for movements in the exchange rate (Table B.5 in Appendix B).[31] Third, we test whether these decisions correlate with firms' age. Since young firms usually face tighter credit constraints, one would expect that young and productive firms take greater advantage of UIP deviations to borrow more. With this end, we follow a similar procedure as above and create four bins: high productivity and young firms (Q_{HY}), high productivity and old firms (Q_{HO}), low productivity and young firms (Q_{LY}), and low productivity and old firms (Q_{LO}). We then interact these dummies with the variable reporting UIP deviations and estimate equation (18). Table B.6 in Appendix B presents the results. Columns 1-4 show that young and productive firms (Q_{HY}) have the largest response to these deviations among the four groups. Both in the model and the data, the estimated coefficients imply that these firms have a higher probability of borrowing in foreign currency and increase more their share of foreign currency loans following UIP deviations.

5.2.2 Firms' Growth

We assess Corollary 2 by testing whether firms employ foreign currency loans to expand their investment. With this end, we follow a similar exercise than in the previous section and regress (16)-(18) using the log of the investment rate and sales as dependent variables.

Results

Panel A in Table 7 presents the results on firms' investment. Column 1 reports the estimated coefficient of equation (16) employing the simulated data. The model implies that a one percent increase in the UIP deviation leads to an expansion of 0.1 percent in firms' investment rate. As expected, this expansion is higher for more productive firms (column 2) and, among them, those with low initial capital stock (column 3).

Columns 4-6 report the results for Hungarian firms. The estimated coefficient is statistically significance and similar in size to the elasticity implied by the model. Column 4 shows that a one percent increase in the UIP deviation leads to 0.08 percent increase in firms' investment rate. Column 5 shows that the expansion is higher for more productive firms and column 6 shows that –among them– firms

[31] Since movements in the exchange rate affect the share of foreign currency loans automatically (i.e. even in firms hold constant their foreign currency debt), we need to control for this valuation effect. To do this, we construct the share of foreign currency loans in each year by employing the end-of-the year exchange rate of the previous year. For example, for the year 2005, we use the end-of-the year exchange rate of 2004 to convert foreign currency loans into Hungarian Forint.

Table 7: DEVIATIONS FROM THE RISK-FREE UIP: FIRMS' GROWTH

	Panel A. Log Investment Rate					
	Model			Data		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.099***			0.079*		
	(0.027)			(0.042)		
Log (Dev. UIP x Productivity)		0.190***			0.328***	
		(0.031)			(0.017)	
Log (Dev. UIP x Q_{HL})			4.708***			0.235***
			(0.026)			(0.071)
Log (Dev. UIP x Q_{HH})			1.032***			0.188**
			(0.027)			(0.082)
Log (Dev. UIP x Q_{LL})			0.079***			0.129**
			(0.025)			(0.060)
Log (Dev. UIP x Q_{LH})			-5.598***			-0.019
			(0.027)			(0.071)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes	Yes
Sector* Year FE					Yes	Yes
R^2	0.42	0.412	0.706	0.033	0.042	0.625
N	940,836	940,836	940,836	513,116	513,116	513,116
	Panel B. Log Sales					
	Model			Data		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.152**			0.059*		
	(0.072)			(0.031)		
Log (Dev. UIP x Productivity)		0.210**			0.145***	
		(0.087)			(0.041)	
Log (Dev. UIP x Q_{HL})			9.963***			0.250*
			(0.079)			(0.146)
Log (Dev. UIP x Q_{HH})			6.218***			0.248*
			(0.077)			(0.145)
Log (Dev. UIP x Q_{LL})			-4.649***			0.193
			(0.077)			(0.176)
Log (Dev. UIP x Q_{LH})			-6.584***			0.297
			(0.078)			(0.191)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes	Yes
Sector* Year FE					Yes	Yes
R^2	0.722	0.722	0.873	0.877	0.852	0.905
N	940,836	940,836	940,836	765,611	765,611	765,611

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

with low level of capital have the largest response. The estimated coefficient implies that a one percent increase in the UIP deviation leads to an expansion of 0.23 percent in the investment rate of these firms.

Columns 1-3 in Panel B show the results for sales employing the simulated data. The model implied elasticity of UIP deviations to firms' sales is 0.15 percent (column 1). This elasticity is higher for more productive firms (column 2) and firms with high MPK (column 3). Similarly, UIP deviations correlate with increases in firms' sales in Hungary (columns 4-6). A one percent increase in these deviations leads to a 0.06 percent expansion in firms' sales (column 4). As above, this expansion is higher for productive and, among them, firms with low capital stock (columns 5 and 6).

For robustness, Table B.4 presents the results for non-exporters and shows that they remain true when exporters are excluded from the analysis. As above, we test if young and productive firms expand more their investment rate and sales following UIP deviations. Results –presented in Table B.6, Appendix B– confirm that these firms have the largest response to UIP deviations.

Results in this section show that UIP deviations correlate with a higher probability of borrowing in foreign currency, share of foreign currency loans, investment rate and higher level of sales, as predicted by Lemma 2 and Corollary 2. Confirming the model's mechanism, there is heterogeneity in firms' responses, as more productive firms and, among them, those with high MPK take greater advantage of these deviations.

5.2.3 Productivity Level to Borrow in Foreign Currency

Lemma 2 implies that UIP deviations decrease the productivity level to employ foreign currency loans. To assess this implication, we estimate the following regression for firms borrowing in foreign currency

$$\log Y_{it} = \beta \log \mathrm{UIP}_t + \phi_i + \varepsilon_{it},$$

where Y_{it} is either productivity z_{it} in the model's simulated data or RTFP_{it} in the Hungarian data. The coefficient β captures whether changes in UIP deviations correlate with changes in the average productivity of firms borrowing in foreign currency. A negative coefficient implies that the productive level of the pool of firms borrowing in foreign currency decreases following higher UIP deviations.

Results

Columns 1 and 2 in Table 8 report the results for the simulated and the Hungarian data, respectively. The estimated coefficients are negative in both specifications, which argues for a reduction in the average productivity of firms borrowing in foreign currency and, hence, in the productivity threshold to employ this financing.

5.3 Costs of Funds

A key feature of the model is that firms borrowing in foreign currency enjoy lower costs of funds, as discussed in Section 4.1.2. We assess this implication using the following regression

$$Y_{it} = \beta \, \mathrm{FC\ Dummy}_i + \varepsilon_i,$$

Table 8: PRODUCTIVITY LEVEL TO BORROW IN FOREIGN CURRENCY

	Log Productivity	
	Model (1)	Data (2)
Log Dev. UIP	-5.435*** (0.482)	-0.655*** (0.212)
Firm FE	Yes	Yes
R^2	0.883	0.821
N	119,663	64,556

Notes: *, **, *** significant at 10, 5, and 1 percent. Standard errors in parentheses. Columns 1 and 2 report the results of a regression of log productivity on the log deviation from the risk-free UIP for firms borrowing in foreign currency between 2005-2010. Source: APEH and Credit register.

where Y_{it} denotes the local bond price or the foreign bond price in the model (q and q^*), and the interest rate for Hungarian firms. The data on Hungarian firms' interest rate comes from the Business Environment and Enterprise Performance Surveys (BEEPS) of the World Bank and the European Bank for Reconstruction and Development on Hungary.[32] Since the Hungarian data on interest rates is only available in 2005, we estimate the regression on the simulated data for that year.

Results

Columns 1 and 2 in Table 9 present the results using the simulated data. As expected, firms borrowing in foreign currency can issue bonds at higher prices. Columns 3-5 report the estimated coefficients for Hungarian firms and show that firms borrowing in foreign currency paid lower interest rates. After controlling for firm characteristics and sector-fixed effects in column 5, the estimated coefficient implies that foreign currency borrowing firms pay on average one percentage point lower interest rate.[33]

Table 9: BOND PRICES AND INTEREST RATE

	LC Bond Price	FC Bond Price	Interest Rate		
	Model		Data		
	(1)	(2)	(3)	(4)	(5)
FC Dummy	0.075*** (0.002)	0.592*** (0.005)	-1.068** (0.531)	-0.896* (0.427)	-0.921* (0.555)
Firm Level Controls					Yes
Sector FE				Yes	Yes
R^2	0.005	0.070	0.014	0.033	0.042
N	156,806	156,806	291	291	291

Notes: *, **, *** significant at 10, 5, and 1 percent. Standard errors in parentheses. Firm-level controls in column 5 are age, employment, export status and dummy for foreign-owned firm. Source: BEEPS 2005, Hungary, the World Bank and the European Bank for Reconstruction and Development.

[32] This survey asks firms the interest rate charged for the most recent loan obtained from a local financial institution and whether this loan was in local or foreign currency.

[33] This result is close to Ranciere, Tornell, and Vamvakidis (2010) who using panel data on developing economies shows that firms exposed to currency mismatch pay lower interest rates.

6 Aggregate Implications

In this section, we employ the model to quantify the aggregate impact of foreign currency borrowing and conduct two numerical exercises. First, we compare an economy with and without foreign currency borrowing to study the aggregate implications of this financing. Second, we explore the role of selection of productive firms into foreign currency borrowing. In these experiments, we follow a similar simulation strategy as in the previous sections. In particular, we first compute the stationary distribution of firms in an economy without foreign currency borrowing, and next simulate 160,000 firms using the policies of each experiment and the realized exchange rate shocks in Hungary between 2001 and 2010.[34]

6.1 Foreign Currency Borrowing vs Non-Foreign Currency Borrowing

In this counterfactual exercise, we restrict firms to only borrow in local currency, and ban them from issuing foreign denominated bonds. As such, firms choose their capital and local currency debt for the next period (k' and b'), given the states (s, z, k, b).

Columns 1 and 2 in Table 10 display the results for the economy with and without foreign currency borrowing, respectively. Panel A shows that firms have 22% higher investment rates and 12% more capital when foreign loans are allowed. In particular, the investment rate and the average size are 10.6% and 20 in the economy with foreign currency borrowing (column 1), while they are 8.3% and 17.8 when foreign loans are not allowed (column 2). Importantly, in the economy with foreign borrowing, firms see a 22% lower default rate, as higher investment allows them to accumulate more capital and become more resilient to shocks. Interestingly, this result is consistent with the empirical evidence showing that, following the depreciation of the Hungarian currency during the Great Recession, firms borrowing in foreign currency did not see higher exit rates, even after controlling for a full set of firm and sector characteristics.[35]

Panel B reports the results for the aggregate economy. Column 2 illustrates that the economy without foreign currency borrowing sees 13% lower sales and 18% fewer capital with respect to column 1 where foreign loans are allowed. Note that this economy experiences no volatility, as it is not affected by exchange rate shocks and firm-idiosyncratic shocks average out on the aggregate.

These results illustrate that, despite the exposure to the currency risk, firms grow faster and have a lower default probability when foreign currency borrowing is allowed. This economy sees higher aggregate sales and capital, but at the expense of high volatility.

[34] In Appendix A.4, we present the aggregate implications for a stationary equilibrium with foreign currency borrowing, and show that the results presented in this section remain valid in the stationary equilibrium.

[35] In Appendix B.4, we study the impact of the depreciation of the Hungarian Forint between 2008 and 2010 on firms borrowing in foreign currency. After controlling for a full set of firm and sector characteristics, we show that these firms saw large balance sheet effects, as they decreased their investment, leverage and share of foreign currency loans, but they did not outperform their industry counterparts in terms of sales and did not show higher exit rates.

Table 10: Numerical Exercises

	Benchmark	No FC Borrowing	No Selection
	(1)	(2)	(3)
	Panel A. Firm-level results		
FC debt share	12.1	-	12.1
Investment rate	10.6	8.3	7.6
E(K)	20.0	17.8	23.1
Default rate	2.7	3.3	7.7
Productivity threshold	1.2	-	0.0
	Panel B. Aggregate results (wrt column 1)		
Sales	100.0	87.8	79.6
Capital	100.0	82.8	78.6
Std. dev. sales	100.0	0.0	84.2
Std. dev. capital	100.0	0.0	39.7

Notes: Rows 1, 2 and 3 are in percentage, rows 6-9 are with respect to column 1. Columns 1-3 show the moments for an economy with and without foreign currency borrowing, and with no selection. In each experiment, we simulate approximately 160,000 firms from the stationary distribution without foreign currency loans, using the realized exchange rate shocks in Hungary and the policy functions of each experiment. Results reflect the average of the period between 2001 to 2010.

6.2 Selection into Foreign Currency Borrowing

The model shows that, while UIP deviations can make foreign currency loans attractive, only sufficiently productive firms can tolerate the implied currency risk and employ this financing. In this section, we assess the quantitive importance of selection of productive firms into foreign currency borrowing at aggregate levels. With this end, we let all firms borrow in foreign currency and have a fixed share of this debt. This share is set equal to the equilibrium value in the benchmark calibration (in column 1).

Column 3 in Table 10 presents the results for an economy with no-selection. Panel A shows firms' default rate is three-times larger than under selection (2.7% vs 7.7%), as less productive firms cannot tolerate exchange rate shocks and do not repay their debt. Firms' investment rate is 7.6%, a third lower than in the benchmark calibration of column 1. This lower investment stems from the increase in the idiosyncratic cost of funds, as foreign borrowing raises firms' exposure to the currency risk and default probability. Since only large firms survive, firm size is 9% higher than in the benchmark calibration.

Panel B shows that, on the aggregate, the economy with no selection has 20% lower sales and capital than economies where there is selection. Note that an economy with no selection can have lower sales and capital, and be significantly more volatile than an economy where foreign currency borrowing is not allowed (column 2). Selection of productive firms is, hence, critical to generate gains from foreign currency borrowing.

7 Model: Sensitivity Analysis

In this section, we conduct a sensitivity analysis of main features of the model. In Section 7.1, we relax the assumption of zero pass-through of exchange rate shocks into local prices. Section 7.2 endogeneizes the risk-free rates by modeling investors' stochastic discount factors. Section 7.3 includes aggregate shocks into the model. Section 7.4 explores the role of the exchange rate volatility. Section 7.5 studies the role of investors' ability to observe firms' productivity and screen high productivity firms.[36]

7.1 Exchange Rate Pass-Through

In Section 4, we assumed zero exchange rate pass-through and let sales be set in local currency. In this section, we relax this assumption and assess how the exchange rate pass-through affects firms' financing and investment decisions. With this end, we re-write firms' equity in equation (5) as a function of the exchange rate pass-through η:

$$e = s^{\eta}[zk^{\alpha} - i(k,k') - \psi(k,k') - c_f] - [b + sb^*] + [qb' + q^*sb'^* - s^{\eta}c_{I_{(b'+b'^*>0)}} - s^{\eta}c^*_{I_{(b'^*>0)}}], \qquad (19)$$

where the foreign price is normalized to one ($p^* = 1$), and firms' revenue, investment, fixed costs and adjustment costs are affected by exchange rate pass-through η.

Equation (19) shows how exchange pass-through can create *balance sheet effects* on firms. These effects crucially depend on how exchange rate shocks affect firms' net revenues and debt repayment.[37] In particular, when the currency depreciates (an increase in s), foreign currency debt repayment rises one-to-one with the exchange rate (second term in equation (19)). However, the change in firms' net revenue depends on the exchange rate pass-through onto the local price (first term). When there is imperfect pass-through ($\eta < 1$), firms' net revenue increases by less than the foreign currency debt repayment. These asymmetric responses create a negative balance sheet effects on firms. Instead, when there is perfect pass-through ($\eta = 1$), net revenues increase at the same rate as the debt repayment, and foreign debt repayment is fully hedged. Hence, exchange rate pass-through affects firms' foreign currency borrowing decisions as it defines the extent to which firms are exposed to the currency risk.

To explore the role exchange rate pass-through, we follow a similar strategy as in Section 6 and estimate the counterfactuals for different levels of η. More precisely, we let η be 0.2, which is the value estimated for Hungary of regression of log consumer prices on the log exchange rate between 1992 and 2015, and be 1, which defines complete path-through.

Table 11 displays the results and compare them with our benchmark calibration in which $\eta = 0$. Column 2 shows that firms' share of foreign currency debt increases by two-fold when $\eta = 0.2$, from 12.1% to 27.3%. Lower currency risk decreases firms' idiosyncratic cost of funds, allowing them to in-

[36] In all these exercises, we follow a similar strategy as in Section 6 and simulate 160,000 firms from the stationary distribution of no foreign currency for each parametrization. We use the realized exchange rate shocks between 2001 and 2010 in Hungary, and the optimal policies of the model with foreign currency borrowing of each parametrization to obtain the moments for 2001-2010.

[37] We abstract in this explanation from next period debt, as negative balance sheet effects also undermine firms' ability to issue new debt, deepening the mechanism.

crease their investment rate by 1.4 percentage point per year. Furthermore, a better hedge against the currency risk decreases the productivity threshold to borrow in foreign currency allowing more firms to employ this financing. This generates a slight drop in firms' size. Finally, firms' default rate decreases, as they can accumulate more capital and foreign borrowing is less risky. Column 3 presents the results of complete pass-through. When $\eta = 1$, exchange rate pass-through offers a full hedge against exchange rate shocks, which leads firms to increase their foreign currency share, investment and size. Lower currency risk further decreases the productivity level to borrow in foreign currency and the default rate.

Table 11: Exchange Rate Pass-Through

	Benchmark ($\eta = 0$)	$\eta = 0.2$	$\eta = 1$
	(1)	(2)	(3)
		Firm-level results	
FC debt share	12.1	27.3	42.3
Investment rate	10.6	12.0	12.5
E(K)	20.0	19.5	21.5
Default rate	2.7	2.5	2.3
Productivity threshold	1.2	1.1	1.0

Notes: Rows 1, 3, and 4 are in percentage. Column 1 presents the results of the benchmark calibration with zero pass-through. Columns 2 and 3 report results with imperfect and perfect pass-through. In each experiment, we simulate approximately 160,000 firms from the stationary distribution without foreign currency loans, using the realized exchange rate shocks in Hungary and the policy functions of each experiment. Results reflect the average of the period between 2001 to 2010.

7.2 Endogenous Interest Rates

In our benchmark calibration, we let the domestic and foreign risk-free rates be constant, implying that investors valued all future states equally. In this section, we relax this assumption and let investors value payments differently for distinct realizations of the exchange rate. Therefore, we assess the impact of a time-varying premium on the exchange rate shock.

Investors have a stochastic discount factor that depends on the aggregate state of the world. In particular, they discount less (value more) payments in states where the exchange rate is depreciated. Since in a small open economy depreciations associate with lower consumption, investors require lower return for payments in those states. Similar to Lustig and Verdelhan (2006), we let investors discount payoffs using the following factor:

$$m = \frac{1}{(1+r)}\left(\frac{s'}{s}\right)^{\gamma} \qquad \text{and} \qquad m^* = \frac{1}{(1+r^*)}\left(\frac{s'}{s}\right)^{\gamma^*}, \tag{20}$$

where m and m^* are the discount factors of home and foreign investors, respectively. Discount factors are then defined by baseline rates (r and r^*) adjusted by the exchange rate shocks with sensitivity γ and γ^*. Thus, $\gamma, \gamma^* > 0$ imply that investors value more payments when the exchange rate depreciates. When $\gamma = \gamma^* = 0$ investors value all states equally, as in our benchmark calibration. Note that, if the exchange rate is a good predictor of consumption –as shown by Engel and West (2005)–, equation (20) is a version of the consumption C-CAPM discount factor.

We can define the risk-free rates for local and foreign currency loans as a function of the exchange rate shocks, $\tilde{r}(s)$ and $\tilde{r}^*(s)$,

$$1 + \tilde{r}(s) = \frac{1}{E(m|s)} \qquad \text{and} \qquad 1 + \tilde{r}^*(s) = \frac{1}{E(m^*|s)}. \tag{21}$$

Under this specification, the risk-free rates move with the exchange rate shocks, and they are lower during appreciations and higher during depreciations than the baseline rates. To see this, let investors expect a currency depreciation in the future (high s'). Since they value more payments in those states, they will be willing to discount less and charge a lower interest rate today. This results in lower interest rates during appreciations and higher during depreciations.

Using equations (20) and (21), we can re-write the UIP condition as:

$$\theta \frac{E(s'|s)}{s} = \frac{(1+r)}{(1+r^*)} \left(\frac{E(s'^{\gamma*-\gamma}|s)}{s^{\gamma*-\gamma}} \right). \tag{22}$$

Equation (22) shows that the deviation from the UIP depends on the exchange rate shocks as well as investors' sensitivity to these shocks. Note that this equation collapses to our earlier expression for the deviation from UIP in equation (8), whenever $\gamma = \gamma^* = 0$ and investors discount states equally.

Table 12 shows the results of different parameterizations of investors' sensitivity. In column 2, we let both local and foreign investors have the same sensibility to exchange rate shocks and $\gamma = \gamma* = 1$. Since the domestic and the foreign interest rate move at the same rate, deviations from the risk-free UIP remain at the same level as in the benchmark calibration (in column 1). However, firms' choose to hold a smaller share of foreign currency loans 11.4% (against 12.1% in the benchmark calibration), as the foreign interest rate charges a premium during depreciations. Importantly, foreign currency borrowing is still undertaken by more productive firms. Note that the default rate is higher than in the benchmark calibration, as increased interest rates during depreciations makes it harder for firms to finance their operations

In column 3, we only let the local currency rate change with the exchange rate shock, and set $\gamma = 1$ and $\gamma^* = 0$. In this case, the observed deviation from the UIP is lower than in the benchmark case, which leads to a decrease in the share of foreign currency debt. Since the currency was mainly appreciated during the period under analysis, the domestic interest rate is on average lower than in column 1. This lower rate promotes firms' investment, which raises from 10.6% to 11.4%, and a 25% increase in firms' size. As above, a higher interest rate during depreciation raises firms' default rate.

7.3 Aggregate Shock

Our model did not account for aggregate shocks common to all firms that could affect firms' financing and investment decisions differently across states of the world. To address this, we introduce an aggregate productivity shock and evaluate its impact on firms' decisions.

Table 12: Endogenous Interest Rates

	Benchmark ($\gamma = \gamma^* = 0$) (1)	$\gamma = \gamma^* = 1$ (2)	$\gamma = 1$ and $\gamma^* = 0$ (3)
	Firm-level results		
FC debt share	12.1	11.4	10.5
Investment rate	10.6	10.2	11.4
E(K)	20.0	23.8	25.0
Default rate	2.7	3.2	3.0
Productivity threshold	1.2	1.2	1.2
$\tilde{r}$	7.4	6.8	6.8
$\tilde{r}^*$	1.8	1.2	1.8
θ	1.05	1.05	1.04

Notes: Rows 1, 3, and 4 are in percentage. Column 1 presents the results of the benchmark calibration where $\gamma = \gamma^* = 0$. Columns 2 and 3 include a stochastic discount factor. In each experiment, we simulate approximately 160,000 firms from the stationary distribution without foreign currency loans, using the realized exchange rate shocks in Hungary and the policy functions of each experiment. Results reflect the average of the period between 2001 to 2010.

To keep the model tractable, we let the aggregate productivity shock be a function of the exchange rate. As shown by Engel and West (2005), the exchange rate is a good predictor of an economy's fundamentals. The reason is that the exchange rate is an asset price and its value incorporates expectations of future fundamentals. Following this approach, we model the aggregate productivity shock as a function of exchange rate shocks, as: $Z = s^{-\zeta}$, where $\zeta > 0$. This specification implies that as the currency depreciates, the aggregate shock is lower and the economy experiences a lower state. Firms' production is $F(s, z, k) = s^{-\zeta} z k^{\alpha}$. Note that if $\zeta = 0$ this collapses to our benchmark specification in Section 4.

To estimate ζ, we employ TFP data from the Penn World Table 8.0 for Hungary, and estimate a regression of TFP on exchange rate growth rates between 1992 and 2014. The estimated coefficient for Hungary is $\zeta = 0.05$.

Table 13 displays the results for different parameterizations $\zeta = [0.05, 0.1, 0.2]$ and compares them with our benchmark calibration (where ζ=0). Column 2 reports the results for $\zeta = 0.05$ and shows that firms choose lower levels of foreign currency debt share in presence of aggregate productivity shocks. Since when the exchange rate depreciates aggregate sales also drop, firms face an additional source of risk that undermines their incentives to employ this financing. As a result, firms' share of foreign currency debt drops from 12.1% to 11.5%. Aggregate productivity shocks also lower firms' investment rate and size. Note that firms' default rate increases because they accumulate less capital and face an additional source of risk. Nevertheless, foreign borrowing is still undertaken by highly productive firms. Columns 3 and 4 illustrate that the higher the correlation between the exchange rate shocks and aggregate productivity, the lower is firms' foreign currency share, investment rate and size, and higher is their default rate.

Table 13: Aggregate Shock

	Benchmark (1)	$\zeta = 0.05$ (2)	$\zeta = 0.1$ (3)	$\zeta = 0.2$ (4)
		Firm-level results		
FC debt share	12.1	11.5	9.5	0.1
Investment rate	10.6	10.5	10.3	9.8
E(K)	20.0	19.8	19.2	18.2
Default rate	2.7	3.0	3.1	3.4
Productivity threshold	1.2	1.2	1.2	1.3

Notes: Rows 1, 3, and 4 are in percentage. Column 1 presents the results of the benchmark calibration where $\zeta = 0$. Columns 2-4 include the aggregate productivity shock. In each experiment, we simulate approximately 160,000 firms from the stationary distribution without foreign currency loans, using the realized exchange rate shocks in Hungary and the policy functions of each experiment. Results reflect the average of the period between 2001 to 2010.

7.4 Exchange Rate Volatility

An important factor in firms' foreign currency borrowing decisions is the volatility of the exchange rate shock, as higher volatility raises the implied risk of this financing. In this section, we study how the volatility of the exchange rate shock affects firms' decisions.

Results are presented in Table 14. In the first exercise, we set the standard deviation of the exchange rate shock to be half of the value in the benchmark economy ($\sigma_s = 0.15$ vs $\sigma_s = 0.30$). Column 2 shows that less volatile exchange rate increases firms' optimal share of foreign currency debt. Since more firms borrow in foreign currency at a lower rate, the investment rate and average firm size are also higher than in the benchmark economy. Furthermore, lower exchange rate volatility allows less productive firms borrow in foreign currency and lowers the productivity threshold to employ this financing.

In the second exercise, we set the standard deviation to 50% higher than the value in the benchmark economy ($\sigma_s = 0.45$). Column 3 illustrates that the high exchange rate volatility makes borrowing in foreign currency a riskier option and, thus, firms prefer to borrow in local currency. As a result, the investment rate is lower than the benchmark model, firms are smaller and default more often.

7.5 Investors' Beliefs

One key assumption of the model is that creditors can perfectly observe firms' idiosyncratic productivity, which allows them to correctly price a firm's probability of default. In this section, we relax this hypothesis and evaluate the importance of the investor's ability to separate high productivity firms from low productivity ones when pricing the bond. To that end, we study the case where a creditor observe firms' choices (k', b', b'^*) and the exchange rate shock, but she does not observe firms' idiosyncratic productivity shock. In order to price the bond, the investor forms beliefs over the distribution of a firm's next period productivity. This implies that the investor offers a bond price that may not reflect the firm's true default probability.

Define $\tilde{p}(z'|z)$ as an investor's belief about the probability distribution of a firm's next period pro-

Table 14: Exchange Rate Volatility

	Benchmark ($\sigma_s = 0.3$)	ER Volatility Low ($\sigma_s = 0.15$)	ER Volatility High ($\sigma_s = 0.45$)
	(1)	(2)	(3)
	Firm-level results		
FC debt share	12.1	42.9	0.0
Investment rate	10.6	11.9	9.5
E(K)	20.0	21.6	18.8
Default rate	2.7	2.5	3.1
Productivity threshold	1.2	1.0	1.3

Notes: Rows 1, 3, and 4 are in percentage. Column 1 presents the results of the benchmark calibration where $\sigma_s = 30$. Columns 2-3 report the results with low and high volatility of the exchange rate shock. In each experiment, we simulate approximately 160,000 firms from the stationary distribution without foreign currency loans, using the realized exchange rate shocks in Hungary and the policy functions of each experiment. Results reflect the average of the period between 2001 to 2010.

ductivity given the current shock. We model this probability using three different specifications, called *Belief 1-3*. For the first two specifications, we conjecture that the investor believes that the firm's probability distribution of next period shock is independent of the current productivity shock, that is $\tilde{p}(z'|z) = \tilde{p}(z)$. In Belief 1, we model this probability distribution to be equal to the unconditional average of the true distribution. More precisely, $\tilde{p}(z_i) = \frac{\sum_{j=1}^{N} p(z_i|z_j)}{\sum_{i=1}^{N}\sum_{j=1}^{N} p(z_i|z_j)}$. In Belief 2, we assume this probability distribution to be uniform, that is, $\tilde{p}(z') = \frac{1}{z_{max}-z_{min}}$. In Belief 3, investors observe the true conditional probability distribution - $p(z'|z)$ - but firms can pretend to have a higher productivity level (z^+) than their current realization. This implies that the investor's probability distribution of the firm's next period shock is biased towards higher productivity: $\tilde{p}(z'|z) = p(z'|z^+)$. For this specification, we show the results for $z^+ = 1.0875\ z$, which is equivalent to one grid point ahead productivity in our shock discretization.

To explore the importance of investors' beliefs over the productivity shock, we follow a similar strategy as in Section 6 and estimate the counterfactuals for the three belief specifications. Table 15 displays the results and compares them to our benchmark calibration in which investors observe the true probability distribution and the current productivity shock.

Under Belief 1 and 2, the investor perceives a firm's productivity to be i.i.d. This perception leads to the investor to infer a lower expected productivity and a higher probability of default for productive firms than under the true distribution. Therefore, high productivity firms are quoted a lower bond price than in the benchmark specification. Lower foreign currency bond prices induce firms to choose a lower share of foreign currency debt and lower investment rates. Note that, since all firms have the same bond prices, low productivity firms have incentives to borrow in foreign currency, which increases the default rate.

Under Belief 3, the productivity shock is persistent, but firms can pretend to be more productive. Consequently, bond prices are higher than in the benchmark, which leads to less productive firms to borrow in foreign currency. This results in higher share of foreign currency debt and lower productivity threshold. However, these firms are not able to tolerate the currency risk, which results in higher default.

Table 15: Investors' Beliefs

	Benchmark	Belief 1	Belief 2	Belief 3
	(1)	(2)	(3)	(4)
	Panel A. Firm-level results			
FC debt share	12.1	8.0	7.8	13.7
Investment rate	10.6	10.4	10.3	8.16
E(K)	20.0	19.4	19.4	29.8
Default rate	2.7	2.9	2.9	3.6
Productivity threshold	1.2	1.2	1.2	1.17

Notes: Rows 1, 2 and 3 are in percentage. Columns 2-4 show the moments for investor's Belief 1-3. In each experiment, we simulate approximately 160,000 firms from the stationary distribution without foreign currency loans, using the realized exchange rate shocks in Hungary and the policy functions of each experiment. Results reflect the average of the period between 2001 to 2010.

8 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.

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). From a policy perspective, this paper sheds lights on the importance of a well functioning financial sector in the process of international financial integration. We showed that the ability of banks to properly screen firms is crucial to reap benefit from international capital flows. Viewed through the lens of the paper, the sequence of reforms matters to profit from the financial globalization.

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Theorical and Empirical Appendices

(Not for publication)

Appendix A Theorical Appendix

Appendix A.1 Model: Additional Derivations

This Appendix derives the Euler equations, the mechanism of the model and lemmas 1 and 2.

Euler Equations

We use the envelop theorem to obtain:

$$\frac{\partial V^R(s,z,\upsilon)}{\partial k} = p\Big[z\alpha k^{\alpha-1} + (1-\delta) - \frac{\partial \psi(k,k')}{\partial k}\Big], \tag{23}$$

$$\frac{\partial V^R(s,z,\upsilon)}{\partial b} = -1, \tag{24}$$

$$\frac{\partial V^R(s,z,\upsilon)}{\partial b^*} = -s, \tag{25}$$

where $\upsilon = \{k, b, b^*\}$ is defined as the set of endogenous state variables. Taking first-order conditions with respect to k', b' and b'^*, we obtain:

$$k': \quad \underbrace{\underbrace{-p\left(1+\frac{\partial \psi(k,k')}{\partial k'}\right)}_{\text{direct effect}} + \underbrace{\frac{\partial q\,(\upsilon')}{\partial k'}b' + \frac{\partial q^*\,(\upsilon')}{\partial k'}sb'^*}_{\text{indirect bond price effect}}}_{\text{total cost}} = \beta\,\underbrace{\frac{\partial E_{z',s'}V\,(s',z',\upsilon')}{\partial k'}}_{\text{expected benefit}}, \tag{26}$$

$$b': \quad \underbrace{\underbrace{q\,(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'}b' + \frac{\partial q^*(\upsilon')}{\partial b'}sb'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \le -\beta\,\underbrace{\frac{\partial E_{z',s'}V\,(s',z',\upsilon')}{\partial b'}}_{\text{expected cost}}, \tag{27}$$

$$b'^*: \quad \underbrace{\underbrace{sq^*(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'^*}b' + \frac{\partial q^*(\upsilon')}{\partial b'^*}sb'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \le -\beta\,\underbrace{\frac{\partial E_{z',s'}V\,(s',z',\upsilon')}{\partial b'^*}}_{\text{expected cost}}, \tag{28}$$

where equations (27) and (28) hold with equality whenever $b' > 0$ and $b'^* > 0$, respectively. For expositional simplicity, in equations (27) and (28), we set the fixed credit costs to zero.[38]

[38]Note that these fixed costs only affect the decision of a firm to start issuing local or foreign currency debt, but they do not affect firms' marginal decisions once they issue bonds. The assumption that fixed credit costs are zero allows us to focus on the mechanism of the paper, and to show that the model's implications hold true independently of the fixed credit costs.

Equation (26) equates the total cost stemming from one extra unit of capital to the expected change in the value of the firm arising from this investment. Note that the total cost is given by the direct cost of investment and the indirect impact of this investment on a firm's current debt issuance. This indirect effect stems from the endogenous impact of current investment on a firm's bond prices. That is, as a firm's next-period capital affects its future repayment likelihood, current investment affects firms' current cost of funds and, as a result, the overall cost of this investment.

Equations (27) and (28) present the first-order conditions for local and foreign currency debt, respectively. These inequality conditions illustrate that if the total benefit of issuing debt is lower than the cost of this debt, firms choose not to issue it. Instead, a firm choosing to issue debt does so until the total benefit of an extra unit of debt equals its expected cost. Note that the benefit of one extra unit of debt depends directly on the current bond price of this debt, and indirectly on its endogenous effect on the firm's overall cost of funds. Since by issuing debt firms increase their default probability, current debt issuance affects bond prices and, hence, the total benefit of issuing debt. Importantly, since the default probability affects both local and foreign bond prices, higher debt issuance in one currency also affects the price of the bond of the other currency.

We can substitute equations (23)-(25) into the first order conditions (26)-(28) to obtain following Euler equations for capital, local currency debt and foreign currency debt:

$$k' : \underbrace{\underbrace{-p\left(1+\frac{\partial\psi(k,k')}{\partial k'}\right)}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial k'}b' + \frac{\partial q^*(\upsilon')}{\partial k'}sb'^*}_{\text{indirect bond price effect}}}_{\text{total cost}} = \beta \underbrace{E_{z',s'}[p(\alpha z' k'^{\alpha-1} + (1-\delta) - \frac{\partial\psi(k',k'')}{\partial k'})(1-\Delta(\upsilon'))]}_{\text{expected benefit}}, \tag{29}$$

$$b' : \quad \underbrace{\underbrace{q(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'}b' + \frac{\partial q^*(\upsilon')}{\partial b'}sb'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \leq \beta \underbrace{E_{z',s'}[1(1-\Delta(\upsilon'))]}_{\text{expected cost}}, \tag{30}$$

$$b'^* : \quad \underbrace{\underbrace{sq^*(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'^*}b' + \frac{\partial q^*(\upsilon')}{\partial b'^*}sb'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \leq \beta \underbrace{E_{z',s'}[s'(1-\Delta(\upsilon'))]}_{\text{expected cost}}, \tag{31}$$

where $\Delta(\upsilon')$ is the set of exchange rate and productivity shocks for which a firm chooses to default. Equation (29) shows that, at the optimum, the total cost of one extra unit of capital should be equal to its expected benefit, where this latter is given by the marginal product of capital plus its non-depreciated value net adjustment costs at states of repayment. Equations (30) and (31) illustrate that firms optimally choose to issue debt until the revenue of funds raised equals its expected cost. As above, if the future cost of debt is higher than its current benefit, firms do not issue bonds. Note that, at the optimum, the expected cost of local currency debt becomes its face value at states of repayment, whilst the expected cost of of foreign currency debt also depends on the future value of the exchange rate.

This illustrates that foreign currency borrowing adds an additional source of risk stemming from the exchange rate uncertainty.

Mechanism

In this section, we study the optimal choice of a firm issuing local currency bonds and deciding whether to issue foreign currency debt. With this end, we rewrite the Euler equations in (30)-(31), as a function of a firm's default probability. In particular,

$$b' : \; \frac{(1 - E_{z',s'}(\Delta(\upsilon')))}{(1+r)} - \frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'} \left(\frac{b'}{(1+r)} + \frac{sb'^*}{(1+r^*)} \right) \leq \beta E_{z',s'}[(1 - \Delta(\upsilon'))] \tag{32}$$

$$b'^* : \; \frac{s\,(1 - E_{z',s'}(\Delta(\upsilon')))}{(1+r^*)} - \frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'^*} \left(\frac{b'}{(1+r)} + \frac{sb'^*}{(1+r^*)} \right) \leq \beta E_{z',s'}[s'(1 - \Delta(\upsilon'))], \tag{33}$$

since

$$\frac{\partial q(\upsilon')}{\partial b'} = -\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'} \frac{1}{(1+r)} \qquad \text{and} \qquad \frac{\partial q^*(\upsilon')}{\partial b'} = -\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'} \frac{1}{(1+r^*)}$$

$$\frac{\partial q(\upsilon')}{\partial b'^*} = -\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'^*} \frac{1}{(1+r)} \qquad \text{and} \qquad \frac{\partial q^*(\upsilon')}{\partial b'^*} = -\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'^*} \frac{1}{(1+r^*)},$$

where $E_{z',s'}(\Delta(\upsilon'))$ denotes a firm's default probability, and $\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'}$ and $\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'^*}$ are changes in a firm's default probability stemming from increases in local and foreign currency debt.

To study a firm's foreign currency borrowing decisions, we focus on equation (33) and let equation (32) be binding such that the firm issues local currency bonds ($b' > 0$). Before turning to a firm's optimal foreign currency debt decision, note that the expected cost of borrowing in foreign currency (left hand side of equation (33)) can be expressed as:

$$E_{z',s'}[s'(1 - \Delta(\upsilon'))] = E(s'|s)E_{z',s'}[1 - \Delta(\upsilon')] + cov_{|z',s'}(s', 1 - \Delta(\upsilon')).$$

The first term represents the expected repayment of the foreign currency bond times its repayment probability, while the second term accounts for the covariance between the exchange rate shock and a firm's repayment probability. We next use equation (32) and the UIP condition to rewrite the Euler equation of foreign bonds relative to local bonds as follows:

$$\underbrace{(\theta - 1)\frac{\left[1 - E_{z',s'}(\Delta(\upsilon'))\right]}{(1+r)}}_{\text{relative benefit of FC debt}} - \underbrace{\left[\left(\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'^*} \frac{1}{E(s'|s)} - \frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'} \right) \left(\frac{b'}{(1+r)} + \frac{sb'^*}{(1+r^*)} \right) + \beta \frac{cov_{|z',s'}(s', 1 - \Delta(\upsilon'))]}{E(s'|s)} \right]}_{\text{relative cost of FC debt}} \leq 0. \tag{34}$$

Equation (34) shows the trade-off faced by firms choosing whether to issue foreign currency bonds. The first term arises from the deviation from the risk-free UIP and represents the relative benefit of financing at a lower risk-free rate when employing this financing. As expected, the higher this deviation (higher θ), the greater is the benefit of issuing foreign currency bonds.

The second term represents the relative cost of issuing foreign currency bonds. This cost depends on the relative change in the default probability when a firm chooses to employ this financing. Since foreign bonds expose firms' balance sheets to an additional risk, they affect firms' default probability relative more $(\frac{\partial E_{z',s'}(\Delta(v'))}{\partial b'^*}\frac{1}{E(s'|s)} \geq \frac{\partial E_{z',s'}(\Delta(v'))}{\partial b'})$. Importantly, the relative increase in the default probability has a large impact on firms' decisions, as it decreases bond prices of the *entire debt issuance.* As shown above, each marginal unit of foreign debt decreases both foreign and local bond prices because it affects a firm's overall default probability. As such, the cost of each foreign currency issuance differs from its benefit, as the latter only affects the marginal unit while the former affects the entire debt issuance. Note that, if the increase in the default probability is high enough, the cost of foreign currency borrowing could exceed its benefit, and the firm will choose not borrow in foreign currency. Firms issuing foreign currency debt choose levels such that the relative benefit equates the relative cost of this financing - i.e., equation (34) holds with equality.

In the next section, we show that the relative cost of foreign currency debt is lower for more productive firms, leading more productive firms to be more likely to issue foreign currency bonds and hold higher levels of this debt.

Lemmas 1 and 2: Sketch of a Proof

A firm's probability of default can be defined as:

$$E_{z',s'}(\Delta(v')) = P_{z',s'}(e' < 0) = P_{z',s'}(p[z'k'^{\alpha} - i(k',k'') - \psi(k',k'') - c_f] - [b' + s'b'^*] + [q'b'' + s'q'^*b'^*] < 0).$$

Given a value of the exchange rate s', we can define $\tilde{z}'$ as the productivity threshold below which a firm with states $v' = \{k', b', b'^*\}$ defaults and exits the market. In particular, $\tilde{z}'$ is given by:

$$p[\tilde{z}'\, k'^{\alpha} - i(k',k'') - \psi(k',k'') - c_f] - [b' + s'b'^*] + [q'b'' + s'q'^*b^{*\prime\prime}] = 0 \qquad \Leftrightarrow$$

$$\tilde{z}' = \frac{p[i(k',k'') + \psi(k',k'') + c_f] + [b' + s'b^{*\prime}] - [q'b'' + s'q^{*\prime}b^{*\prime\prime}]}{pk'^{\alpha}}. \tag{35}$$

To a first-order approximation, equation (35) shows that a firm's productivity threshold and, hence, its default probability increase with the level of debt (both foreign and local currency debts).[39] The higher the level of debt, the higher is the productivity level required to earn non-negative equity and remain in

[39]Remark that q' and $q^{*\prime}$ also depend on the level of foreign currency debt $b^{*\prime}$, as the latter affects future equity value (e'') and the default probability ($P_{z'',s''}(e'' < 0)$). These second order effects are, however, very small. Given the persistence of shocks and the adjustment cost of capital, bond prices of firms close to default are significantly low, making external borrowing difficult for these firms.

the market. Note that, since $\frac{\partial \tilde{z}'}{\partial b'^*} = \frac{s'}{pk'^\alpha}$ and $\frac{\partial \tilde{z}'}{\partial b'} = \frac{1}{pk'^\alpha}$ for a given k', the default probability increases relatively more in foreign currency debt than local currency debt when the exchange rate depreciates.

Considering the idiosyncratic productivity shock in equation (2), we can express a firm's probability of default as

$$E_{z',s'}(\Delta(v')) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\frac{\log \tilde{z}' - \rho_z \log z}{\sigma_z}} e^{-t^2/2}\, dt. \tag{36}$$

Lemma 1. Selection: Only highly productive firms borrow in foreign currency.

We show this lemma in three steps. First, note that, given the persistence of the idiosyncratic productivity shock ($\rho_z > 0$), highly productive firms today expect a high productivity in the next period. As a result, more productive firms have a lower sensitivity of next period default probability for a given choice of (k', b', b'^*) and a shock s'. Formally,

$$\frac{\partial E_{z',s'}(\Delta(v'))}{\partial z} = -\frac{\rho_z}{\sigma_z z \ln(10)} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\log \tilde{z}' - \rho_z \log z}{\sigma_z}\right)^2} < 0.$$

This expression shows that, given the exchange rate shock, the set of productivity shocks that makes a firm default in the next period decreases with a firm's current productivity level.

Second, we show that foreign currency borrowing increases a firm's default probability relatively more when the exchange rate depreciates for a given level of k'. In particular, we can use equations (35) and (36) to derive changes in a firm's default probability as a function of changes in foreign and local currency debts, b'^* and b'. That is,

$$\frac{\partial E_{z',s'}(\Delta(v'))}{\partial b'^*} = \frac{s'}{p\tilde{z}'k'^\alpha} \frac{1}{\sigma_z \ln(10)} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\log \tilde{z}' - \rho_z \log z}{\sigma_z}\right)^2} > 0$$

$$\frac{\partial E_{z',s'}(\Delta(v'))}{\partial b'} = \frac{1}{p\tilde{z}'k'^\alpha} \frac{1}{\sigma_z \ln(10)} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{\log \tilde{z}' - \rho_z \log z}{\sigma_z}\right)^2} > 0.$$

Finally, we illustrate that the relative cost of foreign currency borrowing decreases in a firm's productivity. To see this, we replace $\frac{\partial E_{z',s'}(\Delta(v'))}{\partial b'^*}$ and $\frac{\partial E_{z',s'}(\Delta(v'))}{\partial b'}$ into equation (34) and rewrite the Euler equation of foreign bonds relative to local bonds (equation (34)) as:

$$(\theta - 1)\frac{(1 - E_{z',s'}(\Delta(v')))}{(1+r)} -$$

$$\left[\frac{e^{-\frac{1}{2}\left(\frac{\log \tilde{z}' - \rho_z \log z}{\sigma_z}\right)^2}}{p\tilde{z}'k'^\alpha \sigma_z \ln(10)\sqrt{2\pi}} \left(\frac{s' - E(s'|s)}{E(s'|s)}\right)\left(\frac{b'}{(1+r)} + \frac{sb'^*}{(1+r^*)}\right) + \beta\frac{cov_{|z',s'}(s', 1 - \Delta(v'))]}{E(s'|s)}\right] \leq 0. \tag{37}$$

Equation (37) shows that the higher a firms' current productivity level (z), the lower is the productive threshold to operate next period ($\tilde{z}'$) and smaller is $\frac{e^{-\frac{1}{2}\left(\frac{\log \tilde{z}' - \rho_z \log z}{\sigma_z}\right)^2}}{\sigma_z \tilde{z}' \ln(10)\sqrt{2\pi}}$ for a given choice of k'.

As such, the relative cost of borrowing in foreign currency decreases in a firm's productivity. Since the relative cost of foreign currency debt to local currency debt drops at a lower rate for more productive firms, there is a productivity level such that equation (37) holds with equality. This demonstrates that only firms above a certain productivity level choose to issue foreign denominated bonds.

Lemma 2. Deviations from the risk-free UIP: Higher UIP deviations promote foreign currency borrowing and decrease the productivity level to employ this financing.

From equation (37), it is straightforward to see that higher deviations from UIP (higher θ) require lower productivity levels to issue foreign bonds, as this equation holds with equality at lower levels of z.

Appendix A.2 Two-Period Model

In this section, we introduce a two-period model to illustrate the mechanism proposed in this paper, namely trade-off between exposure to the currency risk and growth. This two-period model has three main ingredients. First, firms jointly choose their investment and the currency composition of their debt. Second, the exchange rate is stochastic, which makes foreign currency loans risky. Third, there are deviations from the risk-free UIP that make foreign currency borrowing relatively more attractive.

Environment

Firms produce employing a decreasing returns to scale technology, i.e. $y = zk^{\alpha}$, where $\alpha \in (0,1)$ and z denotes a firm's productivity, which is exogenously determined and fixed. Firms invest in capital k, which fully depreciates after production. Firms are born with zero capital stock, and incur in a fixed operational cost to produce (c_f). The exchange rate s is stochastic, and is defined in units of local currency per foreign currency.

Firms finance their investment employing retained earnings and/or external loans. These bonds take the form of one-period bonds, which we denote with b_t. To better illustrate the mechanism, we let firms choose the currency composition of their bonds and leverage be fixed. In particular, we denote d_t the fraction bonds denominated in local currency and $(1-d_t)$ the fraction in foreign currency. A firm's total debt is given by: $[d_t q_t + (1-d_t)q_t^*]\, b_t$, where q_t and q_t^* are the discounted price of local and foreign bonds.[40]

The timeline is as follows. In the first period, firms choose their investment in physical capital and the currency composition of their liabilities. In the second period, the exchange rate is realized, and firms decide whether to repay their debt and produce, or default and exit the market.

Firms' Optimal Behavior

A firm's problem can be expressed as a function of its investment, debt issuance, and the discounted expected value of the firm in the second period. Formally,

$$\max_{k_t, d_t} \; -pk_t + [d_t q_t + (1-d_t)q_t^*]\, b_t + \beta E_t V(s_t, s_{t+1}, z, k_t, d_t),$$

The value of the firm in the second period is given by:

$$V(s_t, s_{t+1}, z, k_t, d_t) = \max\left\{0, p\, z k_t^{\alpha} - \left[d_t + (1-d_t)\frac{s_{t+1}}{s_t}\right] b_t - p\, c_f\right\}, \tag{38}$$

where the local price (p) is defined as a function of the foreign prices: $p = p^* s^{\eta}$, the foreign price is normalized to one ($p^* = 1$), and for simplicity we assume zero exchange rate pass-through ($\eta = 0$). Equation (38) shows that the value of the firm in the second period is the maximum between the value of default –normalized to zero–, and its net income (sales minus debt repayment and fixed operational costs).

[40] For simplicity, we assume that the firm can not issue equity and, hence, cannot see negative income in the first period.

From equation (38), we can define the exchange rate threshold that makes a firm's second-period profit equal to zero and the firm indifferent between repaying or defaulting. In particular, define $\tilde{s}$ as the exchange rate threshold that makes $V(z, s_t, d_t, k_t, s_{t+1}) = 0$. If the second-period exchange rate is higher than the threshold - $s_{t+1} > \tilde{s}$ -, the value of debt repayment exceeds the net income, and the firm defaults and exits the market. Instead, if $s_{t+1} \leq \tilde{s}$, the firm repays its debt obligation and produces. More precisely, the exchange rate threshold is given by

$$\widetilde{s} \equiv \frac{(zk_t^{\alpha} - d_t b_t - c_f)s_t}{(1-d_t)b_t}. \tag{39}$$

Equation (39) shows that the higher the share of foreign currency debt $(1 - d_t)$, the lower is the exchange rate threshold ($\frac{\partial \tilde{s}}{\partial(1-d)} < 0$) and, hence, higher is the firm's default probability. Inversely, the higher the firm's productivity, the higher its income and exchange rate threshold ($\frac{\partial \tilde{s}}{\partial z} > 0$), and lower its default probability.

-Debt Contract and Debt Pricing

There is a mass of infinite creditors that can invest in risk-free bonds or in firms' risky bonds. Risk-free bonds can be denominated in local or foreign currency, and pay interest rates r and r^*, respectively. Firms' bonds are not enforceable and firms can default on their debt obligations. The default probability is endogenously determined and depends on the value of the firm in the second period, once the exchange rate and the value of debt repayment are realized. The firm repays whenever its net second-period income is positive, and defaults otherwise. Firm's bond price takes into account repayment probability such that investors break even in expectations. The discounted price of bonds in local and foreign currency -q_t and q_t^*- are given by:

$$q_t = \frac{P_t(V(s_t, s_{t+1}, z, k_t, d_t) > 0)}{1+r} \qquad \text{and} \qquad q_t^* = \frac{P_t(V(s_t, s_{t+1}, z, k_t, d_t) > 0)}{1+r^*}. \tag{40}$$

We write the adjusted UIP as follows:

$$\theta \, E(s_{t+1})(1+r^*) = s_t \, (1+r), \tag{41}$$

where θ denotes the deviation from the risk-free UIP. Note that if $\theta = 1$, the UIP holds and the expected cost of lending the risk-free asset in local or foreign currency is equal. Instead, if $\theta \neq 1$ there are deviations from the risk-free uncovered interest condition. In particular, a $\theta > 1$ implies a wedge on the domestic currency that makes the risk-free foreign rate cheaper. This wedge offers an incentive to borrow in foreign currency.

The Model's Qualitative Implications

This section presents the model's qualitative implications using a numerical illustration that employs the parametrization of Section 4.[41]

-Lemma 1. Selection: Only higly productive firms borrow in foreign currency.

Lemma 1 implies that firms might optimally choose to borrow in foreign currency and be exposed to exchange rate fluctuations. This choice arises from deviations from the risk-free UIP creating a wedge between the domestic and the foreign interest rare making the latter relatively lower ($\theta > 1$). However, there is heterogeneity in firms' foreign borrowing decisions, since not all firms choose to borrow in foreign currency. As this financing exposes firms to the currency risk, only firms above a certain productivity threshold can bear this risk and choose foreign bonds.

The productivity threshold stems from the firm's equilibrium borrowing costs. Foreign currency borrowing raises the firm's default probability because it decreases the exchange rate threshold $\tilde{s}$ above which the firm defaults -equation (39)-. In turn, this increase in the default probability reduces the price of the domestic and foreign bonds issued by the firm -q_t and q_t^* in equation (40)- as it becomes riskier. Hence, by increasing the overall cost of funds, foreign currency issuance becomes costly for the firm. This creates a trade-off between the increase in the idiosyncratic cost of funds and the relatively lower risk-free rate of foreign currency bonds. It is this trade-off between the deviation from the UIP, and the increase in the idiosyncratic risk of default what determines the currency composition of the firm's liabilities and the productivity threshold to borrow in foreign currency. Importantly, the increase in the borrowing cost decreases in firm's productivity. That is, the more productive is the firm, higher is its income, and lower is the increase in the default probability and borrowing cost.

To illustrate this trade-off, Figure A1 plots the price of local and foreign bonds (q_t and q_t^*) on the share of foreign currency debt $(1 - d_t)$. It shows that the price of domestic and foreign denominated bonds decreases with the share of foreign currency debt. Importantly, this decrease is faster for low productive firms. The reason is that, as these firms earn less income, a smaller share of foreign bond is necessary to make them likely to default. For this reason, only firms for which the price of the bonds does not decrease significantly -more productive firms- issue foreign debt.

Figure A1 plots the policy of the share of foreign currency borrowing $(1 - d)$ as a function of the firm's productivity (z). It shows that only firms above a certain productivity threshold choose to issue foreign currency denominated debt. Above this threshold, the share of foreign bonds increases in firm's productivity. Note that, since UIP deviations make the risk-free foreign bonds relatively cheaper, firms issuing foreign debt enjoy lower borrowing costs that allows them to expand their investment.

-Lemma 2. Deviations from the risk-free UIP: Higher UIP deviations promote foreign currency borrowing and decrease the productivity level to employ this financing.

Increases in the deviation from the risk-free UIP make foreign currency borrowing relatively more

[41] In particular, we set $\alpha = 0.6$, $r^* = 1.75\%$, $r = 7.35$, and $\beta = 0.85$, and let leverage be 25%, which is the average value observed for Hungarian firms. We normalize the initial exchange rate to one and assume that it follows a truncated log normal distribution between $(0, \bar{s}]$, where $\bar{s}$ is set equal to 2.

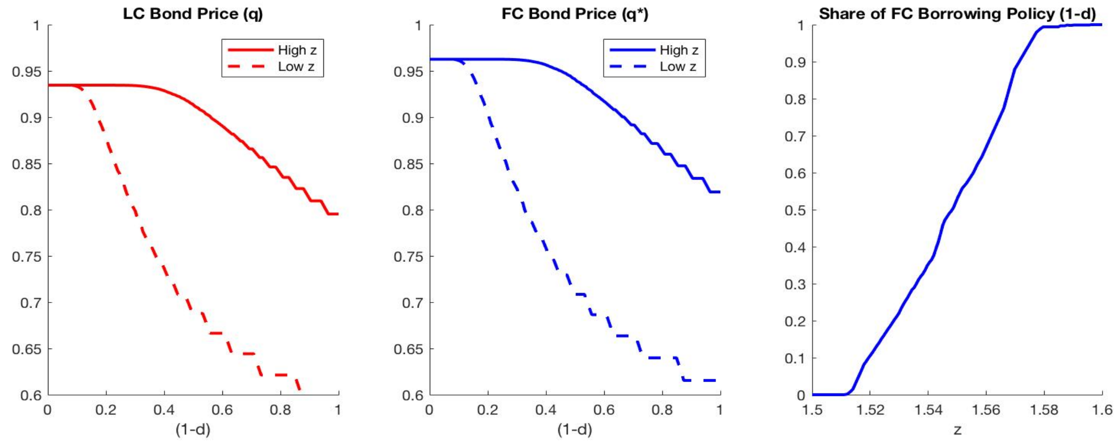


Figure A1: Bond Prices

attractive, as they raise the relative cost of local currency bonds. As a result, firms increase the share of foreign bonds. Furthermore, as the relative cost of foreign financing drops, a larger pool of firms chooses to undertake these funds, decreasing in the productivity cut-off to start issuing foreign bonds. Figure A2 plots the decrease in the productivity threshold and the increase in the share of foreign currency borrowing following an increase in θ. This decrease in the relative cost of funds in foreign currency encourage the firm to expand its investment.

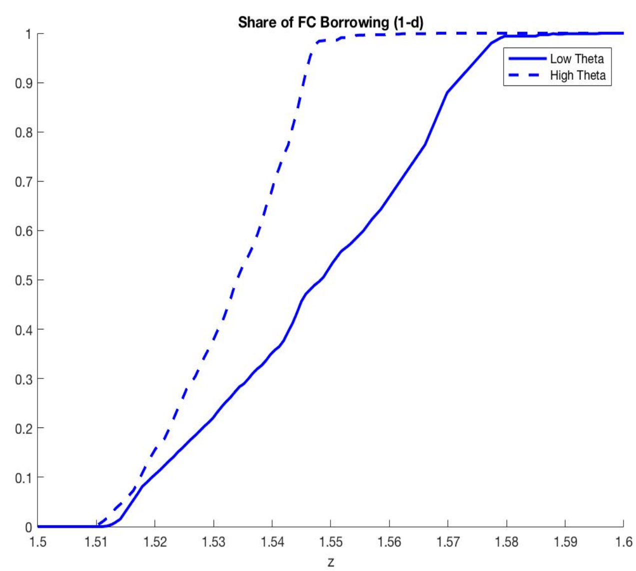


Figure A2: Deviations in the Risk-Free UIP and the Share of Foreign Currency Borrowing

This two-period model shows that UIP deviations encourage firms to employ foreign currency debt. Critically, there is heterogeneity in foreign currency borrowing decisions, as not all firms find it optimal to issue these bonds. Only highly productive firms can bear the exposure to the currency risk and borrow in foreign currency. Lower financing terms allow these firms to reach higher investment.

Appendix A.3 Model: No-Fixed Credit Cost

This Appendix shows that the mechanism proposed in this paper holds true when the foreign currency credit cost is set to zero. In particular, we show that there is selection into foreign currency borrowing, as only sufficiently productive firms find it optimally to employ this financing, and that higher deviations from the risk-free UIP decrease the productivity threshold to employ this financing (Lemmas 1 and 2).

To illustrate this, we re-estimate the non-targeted moments for a calibration in which the foreign currency credit cost is set to zero ($c^* = 0$), using a same simulation strategy as in Section 4. Column 1 in Table A1 shows the non-targeted moments of the benchmark calibration, column 2 reports those of the calibration without foreign currency credit costs and column 3 report the moments for the Hungarian data. Column 2 shows that there is still selection into foreign currency borrowing when $c^* = 0$, as not all firms borrow in foreign currency. In particular, 9% of the firms borrow only in local currency, 31% of firms borrow in both local and foreign currency, and 9% of firms issue only foreign currency debt. Importantly, firms that borrow in foreign currency are more productive and enjoy higher investment rates, as in the benchmark calibration.

Additionally, we illustrate the validity of Lemmas 1 and 2 when the foreign currency credit costs is set to zero. Figure A3 plots firms' bond price schedule for the average productivity shock fixing the exchange rate and the states (k, b, b^*) at the average firm. This figure shows that firms' bond prices decrease when firms increase their debt holdings and their default risk rises. As above, this drop is slower for more productive firms. Crucially, we still observe selection in to foreign currency borrowing (Lemma 1), since only highly productive firms borrow in foreign currency. The right hand side figure illustrates this mechanism by plotting the policy of the share of foreign currency debt on total debt at the average firm. Figure A4 shows that higher deviations from the risk-free UIP decrease the productivity threshold to borrow in foreign currency (Lemma 2). This figure displays the policy of the share of foreign currency debt for different productivity shocks for a deviation from the UIP of 1.05 and 1.07.

Figure A3: Robustness of Lemma 1: No foreign currency credit cost

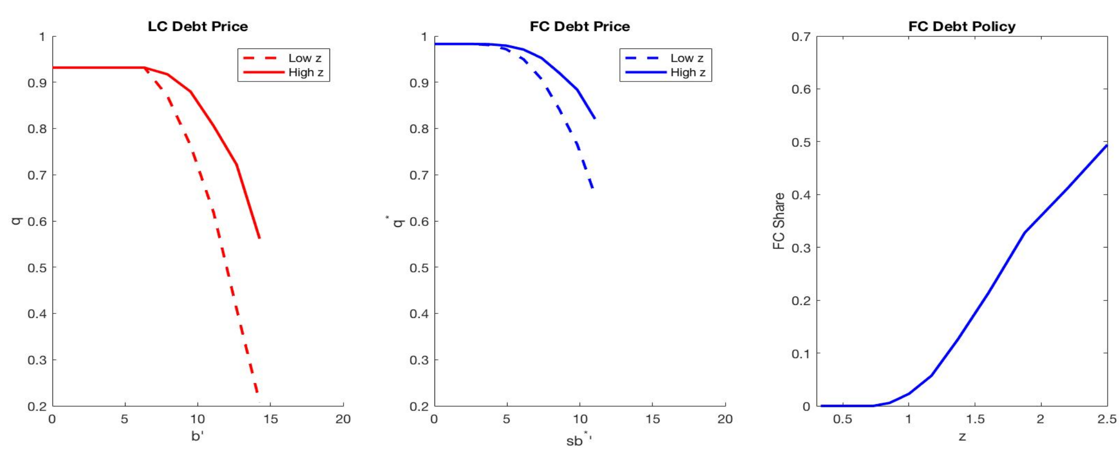
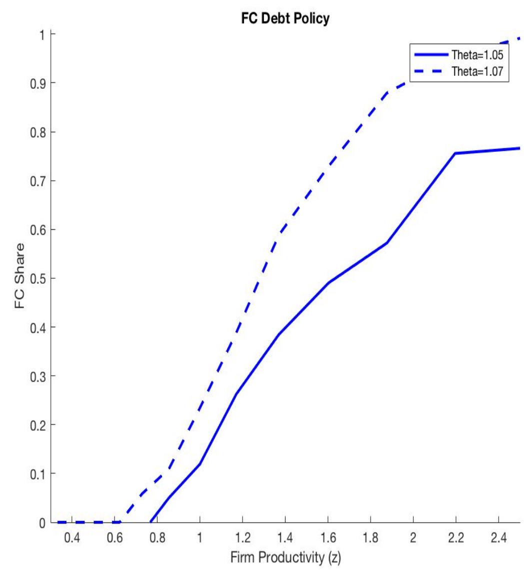


Table A1: Non-Targeted Moments (2005)

Moment	Group	Benchmark Model (1)	No FC Credit Cost ($c^* = 0$) (2)	Data (3)
Firm share (%)	LC debt only	-	9	21
	LC & FC debt	6	31	6
	FC debt only	2	9	3
Relative productivity*	LC debt only	0.97	0.97	0.99
	LC & FC debt	1.02	0.99	1.02
	FC debt only	1.07	1.04	1.05
Relative capital*	LC debt only	1.00	1.00	0.97
	LC & FC debt	1.02	1.02	1.06
	FC debt only	0.91	0.93	0.99
Investment rate (%)	LC debt only	9	7	9
	LC & FC debt	18	13	18
	FC debt only	22	25	19
FC Share (%)	LC & FC debt	59	46	50
	FC debt only	100	100	100
Leverage (%)	LC debt only	52	52	17
	LC & FC debt	45	44	25
	FC debt only	25	26	18

Notes: This table shows data and model moments for different groups of firms. The data moments refer to the average 2005 and 2006. We simulate approximately 160,000 firms from the stationary distribution of no foreign currency. In this simulation, we use the realized exchange rate shocks between 2001 and 2010 and the optimal policies of the model with foreign currency borrowing to obtain the moments for 2001-2010. The model moments refer to the average over 2005 and 2006. * Relative productivity and capital are considered with respect to firms with credit, which are normalized to one.

Figure A4: Robustness of Lemma 2: No foreign currency credit cost



Appendix A.4 Model: Stationary Equilibrium with FC Borrowing

This appendix shows that the model's aggregate implications hold true when computing the stationary equilibrium with foreign currency borrowing. In particular, we simulate the model for 500 years, drop the first 300 observations and calculate averages using the remaining observations. We remove any shock dependency by simulating the model several times and averaging across simulations. We then compare the stationary moments of the counterfactual exercises.

Table A2: Numerical Exercises

	Benchmark	No FC Borrowing	No Selection
	(1)	(2)	(3)
	Panel A. Firm-level results		
	Benchmark	No FC	No Selection
FC debt share	55.6	-	10.5
Investment rate	9.7	8.3	4.0
E(K)	32.1	17.8	26.1
Default rate	2.7	3.7	6.7
Productivity threshold	1.1	-	0.0
	Panel B. Aggregate results (wrt column 1)		
Sales	100.0	35.5	16.1
Capital	100.0	27.0	13.4
Std. dev. aggregate sales	100.0	0.0	0.3
Std. dev. aggregate capital	100.0	0.0	0.2

Notes: Rows 1, 2 and 3 are in percentage, rows 6-9 are with respect to column 1. Columns 1-3 show the moments for an economy with and without foreign currency borrowing, and with no selection. Results reflect the average over 200 years.

Similarly to Section 6, Table A2 shows that, in the stationary equilibrium with foreign currency borrowing, firms are larger in size, enjoy higher investment rates and have a lower default probability than an economy with no foreign currency borrowing (columns 1 and 2). Selection of productive firms into foreign currency borrowing plays an important role in generating gains from this financing in the stationary equilibrium. Column 3 illustrates that, in an economy without selection, firms are smaller in size, have lower investment rates and are more likely to exit. As a result, the economy has lower levels of aggregate sales and capital than an economy with selection.

Appendix B Empirical Appendix

Appendix B.1 Additional Figures

Deviations from Risk-Free UIP and Foreign Currency Loans.

The data on the share of foreign currency on total loans is provided by CHF Lending Monitor from the Swiss National Bank. We compute the deviation from the UIP, as $\text{Dev}_t \equiv \frac{s_t}{E(s_{t+1})}\frac{(1+r_t)}{(1+r_t^*)}$ where r_t, r_t^*, s_t and $E(s_{t+1})$ denote the domestic and foreign risk-free interest rates, the nominal exchange rate and the expected exchange rate. We employ the one-year Hungarian and German government bond yields from Global Financial Data, and the spot and expected exchange rate with respect to the Euro from Foreign Exchange Consensus Forecast. We compute the deviation from the UIP regarding the Euro, as more than two-third of foreign currency borrowing was denominated in Euros (see Yesin 2013).

Figure B.1 plots the share of foreign currency loans in the corporate sector of European countries for which there is available data. Figures B.2-B.5 show that the correlation between deviations from the risk-free UIP and foreign currency loans remains true when considering: 1) different time horizons (3 months and 2 years), 2) the Swiss Franc and the U.S. dollar as reference currencies, 3) only the interest rate differential (r_t/r_t^*), and 4) credit defaults swap to control for governments' default risk. Table B.1 reports the correlation estimated separately for each component. Figure B.6 shows that this correlation is also present in other Eastern European countries for which there is available data.

Figure B.1: European Countries: Share of Foreign Currency Loans on Total Loans in the Corporate Sector (2014)

Figure B.2: Hungary: Deviations from the Risk-Free UIP and Foreign Currency Loans (Different Horizons)

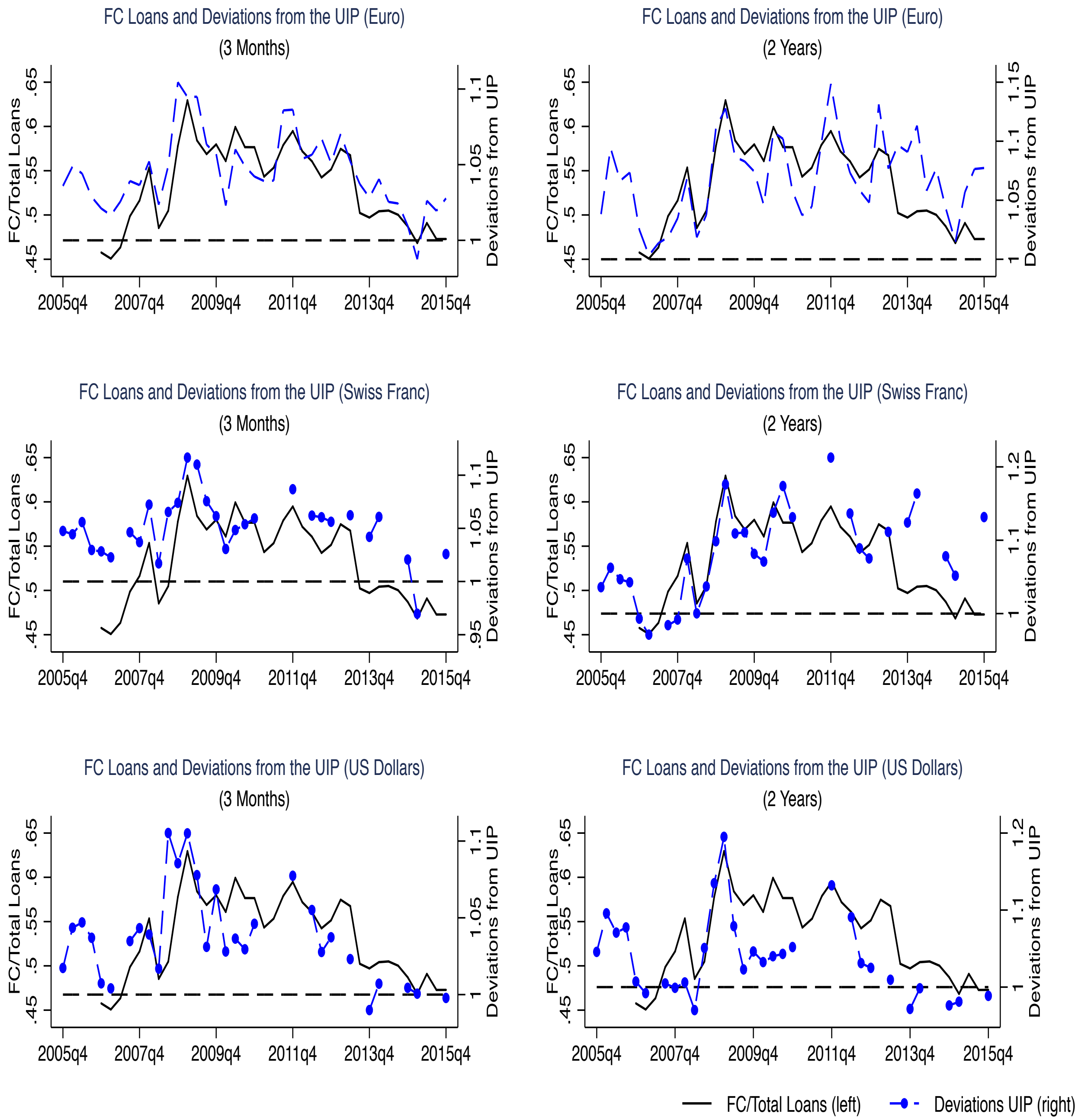
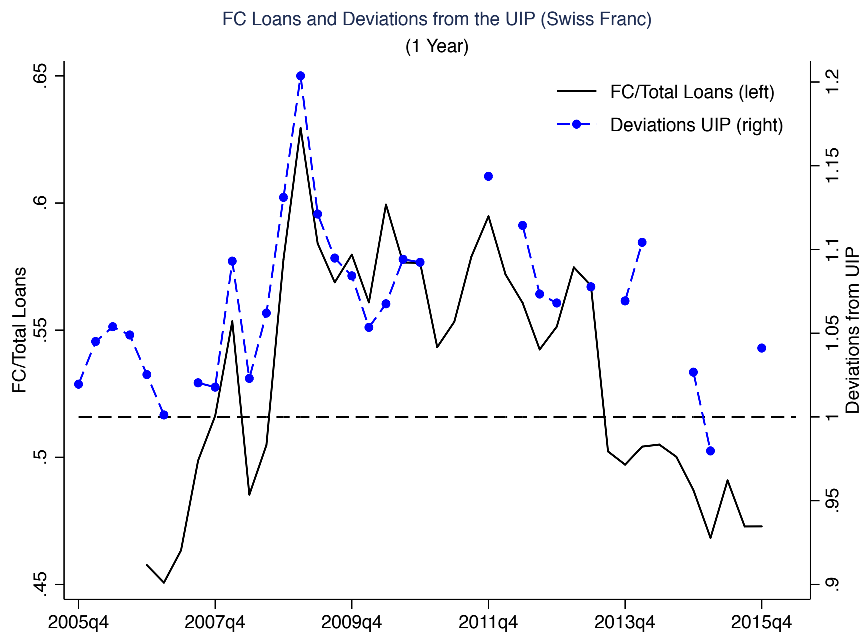


Figure B.3: Hungary: Deviations from the Risk-Free UIP with Swiss Franc and U.S. Dollars and Foreign Currency Loans



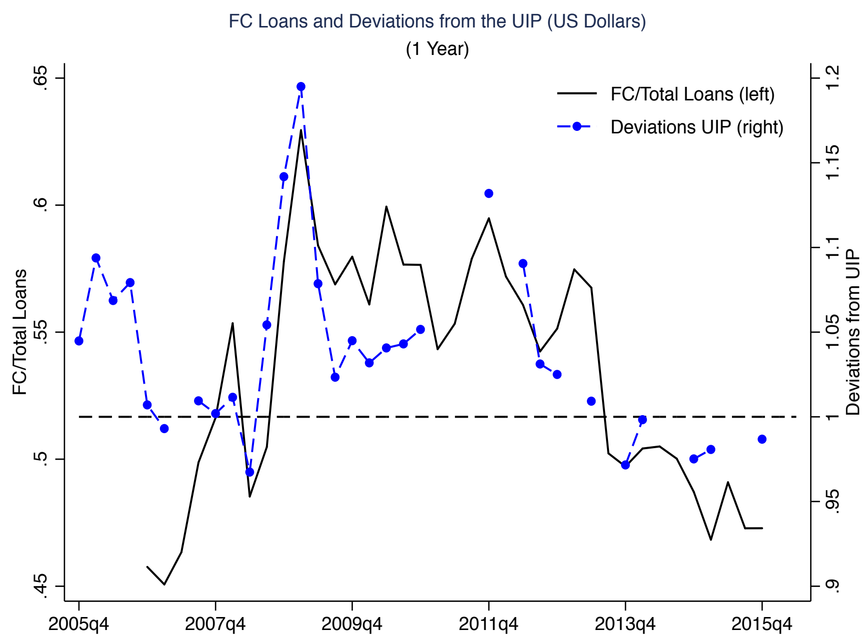


Figure B.4: Hungary: Foreign Currency Loans and Interest Rate Differential

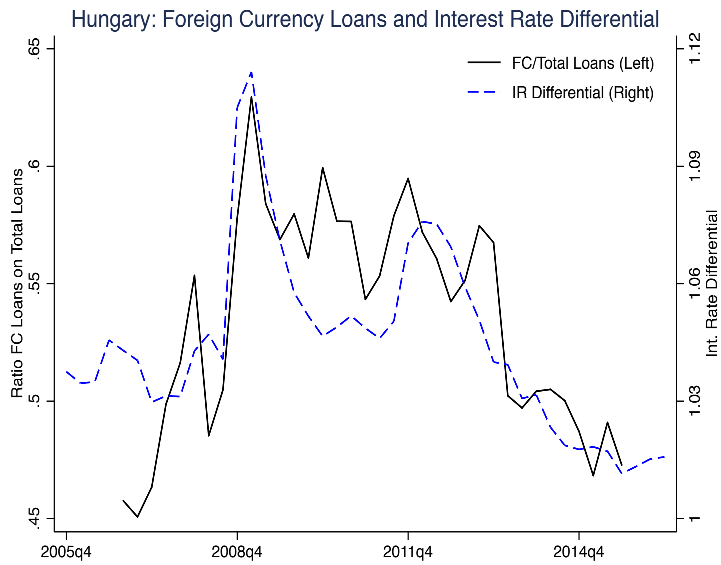


Figure B.5: Hungary: Deviations from the Risk-Free UIP and Foreign Currency Loans (controlling for CDS)

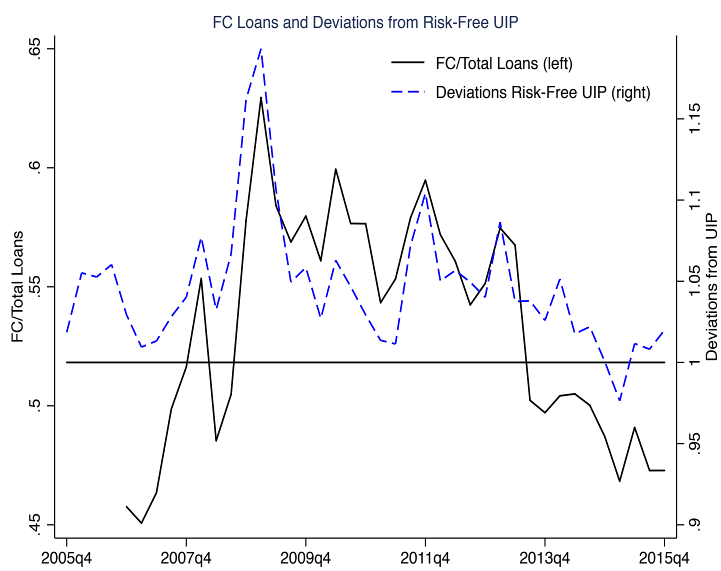


Figure B.6: Eastern European Countries: Foreign Currency Loans, Deviations from Risk-Free UIP and Interest Rate Differential

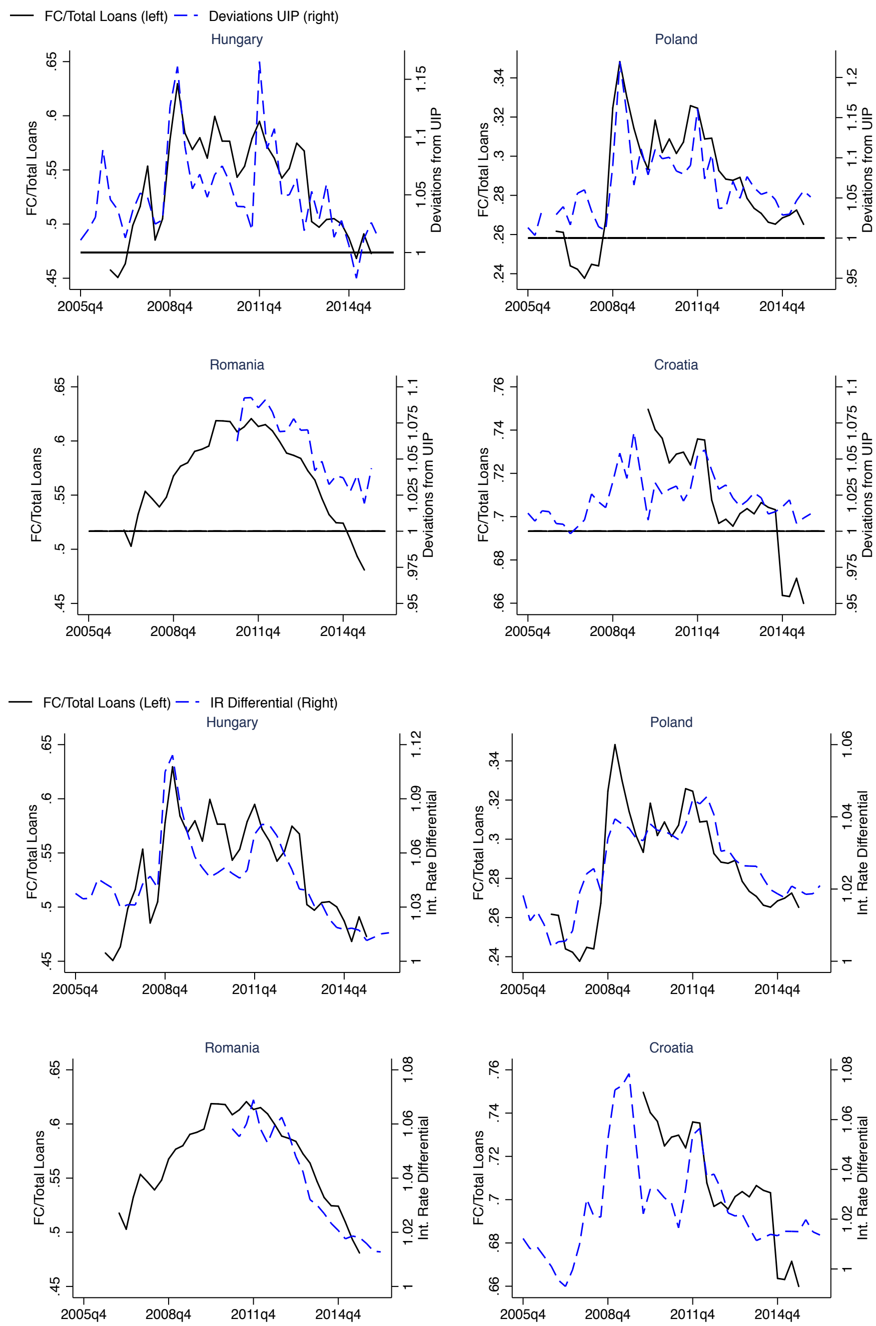
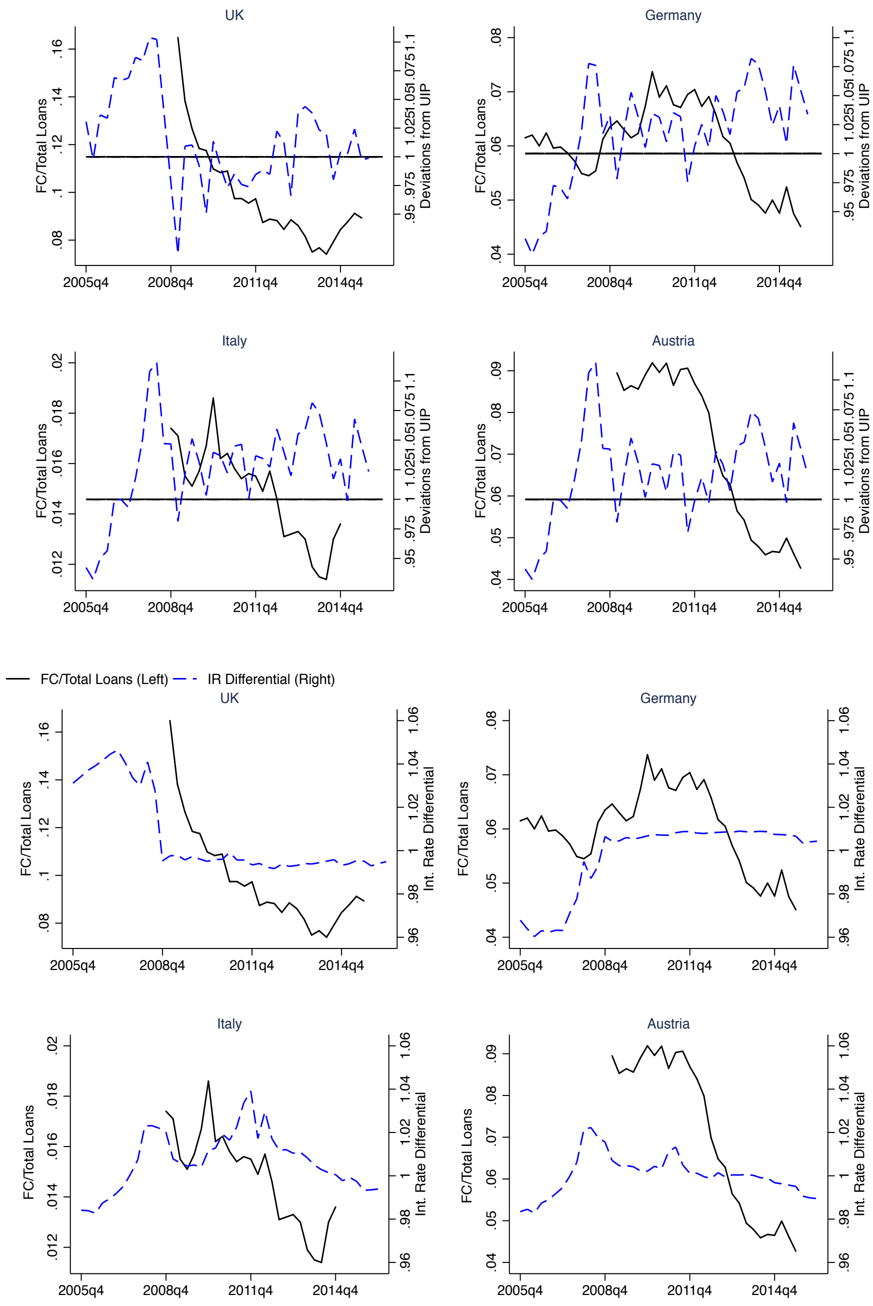


Figure B.7: Developed European Countries: Foreign Currency Loans, Deviations from Risk-Free UIP and Interest Rate Differential



Appendix B.2 Additional Tables

Table B.1: Hungary: Share of Foreign Currency Loans and Deviations from Risk-Free UIP

	Log Share of Foreign Currency Loans				
	(1)	(2)	(3)	(4)	(5)
Log Dev. UIP (3M)	3.001***				
	(0.362)				
Log Dev. UIP (1Y)		2.007***			
		(0.250)			
Log Dev. UIP (2Y)			1.782***		
			(0.332)		
Log Exchange Rate				0.163	
				(0.169)	
Log Interest Rate Differential					0.121***
					(0.019)
R^2	0.656	0.641	0.445	0.025	0.538
N	38	38	38	38	38

Note: *, **, *** significant at the 10, 5, and 1 percent level. Standard errors in parentheses. Columns 1-3 report the correlation of the log share of foreign currency loans with the deviation from the risk-free UIP (Euro) at 3, 12 and 24 months, column 4 presents the correlation with the exchange rate HUF-EUR, and column 5 plots the correlation with the interest rate differential.

Table B.2: Robustness Tests: Decision into Foreign Currency Borrowing

	(1)	(2)	(3)	(4)	(5)
	Panel A. Foreign Currency Loan Dummy				
Log productivity	0.014***	0.010***	0.009***	0.012***	0.017***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
Log capital	0.037***	0.036***	0.036***	0.030***	0.034***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log age	-0.019***	-0.015***	-0.018***	-0.020***	-0.020***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Sector FE	Yes	Yes	Yes	Yes	Yes
R^2	0.061	0.060	0.063	0.048	0.055
N	37,051	37,051	38,237	29,802	39,740
	Panel B. Log Share of FC Loans				
Log productivity	0.003**	0.006***	0.003***	0.004**	0.004***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Log capital	0.014***	0.015***	0.013***	0.010***	0.014***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log age	-0.010***	-0.011***	-0.010***	-0.011***	-0.010***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Sector FE	Yes	Yes	Yes	Yes	Yes
R^2	0.043	0.039	0.048	0.038	0.044
N	37,051	37,051	38,237	29,802	39,740

Note: *, **, *** significant at the 10, 5, and 1 percent level. Standard errors in parentheses. Column 1 includes age as a regressor. Column 2 uses RTFP measured with the Olley and Pakes (1996) methodology. Column 3 employs labor productivity as a proxy for firms' RTFP. Column 4 excludes exporter firms. Column 5 employs the average for 1998-2000 as initial conditions. Source: APEH and Credit Register.

Table B.3: Robustness Tests: Firms' Growth (Non-Exporters)

	Log Investment Rate	Log Sales
	(1)	(2)
R* FC dummy	0.078***	0.028*
	(0.024)	(0.016)
R	0.244***	0.005
	(0.009)	(0.006)
Firm FE	Yes	Yes
Time trend	Yes	Yes
FC d.* Time t.	Yes	Yes
R^2	0.494	0.805
N	361,992	372,635

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. This table excludes exporter firms. Source: APEH and Credit Register.

Table B.4: Robustness Tests: Deviations from the Risk-Free UIP (Non-Exporters)

	FC Dummy			Log Share of FC Loans		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.108***			0.057***		
	(0.018)			(0.009)		
Log (Dev. UIP x Productivity)		0.030***			0.016***	
		(0.008)			(0.004)	
Log (Dev. UIP x Q_{HL})			0.157***			0.065***
			(0.034)			(0.017)
Log (Dev. UIP x Q_{HH})			0.033			0.025
			(0.045)			(0.022)
Log (Dev. UIP x Q_{LL})			0.054*			0.009
			(0.032)			(0.018)
Log (Dev. UIP x Q_{LH})			0.082*			0.048*
			(0.044)			(0.025)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes	Yes
Sector* Year FE	Yes	Yes			Yes	Yes
R^2	0.746	0.723	0.747	0.723	0.695	0.724
N	907,031	907,031	907,031	907,031	907,031	907,031
	Log Investment Rate			Log Sales		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.127***			0.156***		
	(0.047)			(0.034)		
Log (Dev. UIP x Productivity)		0.340***			0.124***	
		(0.020)			(0.043)	
Log (Dev. UIP x Q_{HL})			0.218***			0.255*
			(0.073)			(0.150)
Log (Dev. UIP x Q_{HH})			0.186**			0.229
			(0.085)			(0.145)
Log (Dev. UIP x Q_{LL})			0.111*			0.167
			(0.062)			(0.173)
Log (Dev. UIP x Q_{LH})			-0.013			0.237
			(0.077)			(0.174)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes	Yes
Sector* Year FE	Yes	Yes			Yes	Yes
R^2	0.034	0.041	0.641	0.873	0.840	0.910
N	427,027	427,027	427,027	653,259	653,259	653,259

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

Table B.5: Robustness Tests: Deviations from the Risk-Free UIP (Valuation Effects)

	Log Share of FC Loans		
	(1)	(2)	(3)
Log Dev. UIP	0.083***		
	(0.011)		
Log (Dev. UIP x Productivity)		0.022***	
		(0.004)	
Log (Dev. UIP x Q_{HL})			0.085***
			(0.016)
Log (Dev. UIP x Q_{HH})			0.064***
			(0.022)
Log (Dev. UIP x Q_{LL})			0.003
			(0.017)
Log (Dev. UIP x Q_{LH})			0.063***
			(0.024)
R^2	0.714	0.663	0.716
N	940,836	940,836	940,836

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

Table B.6: Robustness Tests: Deviations from the Risk-free UIP (Age)

	FC Dummy		Log FC Share		Log Investment Rate		Log Sales	
	Model	Data	Model	Data	Model	Data	Model	Data
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log (Dev. UIP x Q_{HY})	0.435***	0.315***	0.258***	0.096***	4.054***	0.209***	6.186***	0.700***
	(0.040)	(0.047)	(0.021)	(0.025)	(0.033)	(0.062)	(0.091)	(0.165)
Log (Dev. UIP x Q_{HO})	0.177***	0.032	0.119***	0.054***	3.463***	0.183**	5.979***	0.047
	(0.040)	(0.034)	(0.021)	(0.017)	(0.033)	(0.073)	(0.088)	(0.169)
Log (Dev. UIP x Q_{LY})	0.137***	0.172***	0.108***	0.056***	-1.649***	0.008	-5.142***	0.567***
	(0.040)	(0.039)	(0.021)	(0.021)	(0.032)	(0.065)	(0.082)	(0.163)
Log (Dev. UIP x Q_{LO})	-0.231***	-0.024	-0.081***	-0.003	-2.156***	0.161***	-5.370***	-0.125
	(0.039)	(0.034)	(0.020)	(0.019)	(0.032)	(0.054)	(0.079)	(0.185)
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	0.42	0.742	0.403	0.717	0.623	0.700	0.748	0.919
N	940,836	1,019,461	940,836	1,019,461	940,836	513,116	940,836	765,611

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

Table B.7: Currency Depreciation during the Great Recession: Non-Exporters

	Panel A					
	Log FC Share			Log Leverage		
	(1)	(2)	(3)	(4)	(5)	(6)
D*FC Ratio	-0.333***	-0.252***	-0.255***	-0.118***	-0.138***	-0.137***
	(0.019)	(0.017)	(0.017)	(0.016)	(0.017)	(0.017)
D	0.008***			0.009***		
	(0.001)			(0.001)		
Firm FE	yes	yes	yes	yes	yes	yes
Firm-Time controls		yes	yes		yes	yes
Year FE		yes	yes		yes	yes
Sector*Year FE			yes			yes
R^2	0.693	0.695	0.696	0.577	0.578	0.578
N	771,756	771,756	771,756	771,756	771,756	771,756

	Panel B					
	Log Investment Ratio			Log Sales		
	(1)	(2)	(3)	(4)	(5)	(6)
D*FC Ratio	-0.777***	-0.454***	-0.541***	0.075***	0.104***	0.070**
	(0.157)	(0.106)	(0.144)	(0.028)	(0.029)	(0.029)
D	-0.587***			-0.115***		
	(0.025)			(0.002)		
Firm FE	yes	yes	yes	yes	yes	yes
Firm-time controls		yes	yes		yes	yes
Year FE		yes	yes		yes	yes
Sector*Year FE			yes			yes
R^2	0.788	0.815	0.791	0.931	0.931	0.932
N	324,963	324,963	324,963	587,140	587,140	587,140

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Standard errors are cluster at year and four-digit NACE industries. FC ratio is the firm's foreign currency debt over total assets in the initial year (2005). Firm-time varying controls include the interaction of foreign currency borrowing with a time trend, and the interaction of firms' initial productivity and import share with the depreciation dummy. Sector-year fixed effects are estimated at two-digit NACE industries.

Table B.8: Currency Depreciation during the Great Recession: Non-Exporters

	Exit		
	(1)	(2)	(3)
D*FC Ratio	-0.046***	0.017	-0.011
	(0.010)	(0.012)	(0.013)
D	0.084***		
	(0.002)		
Firm FE	yes	yes	yes
Firm-time controls		yes	yes
Year FE		yes	yes
Sector*Year FE			yes
R^2	0.591	0.607	0.619
N	664,290	664,290	664,290

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Standard errors are cluster at year and four-digit NACE industries. FC ratio is the firm's foreign currency debt over total assets in the initial year (2005). Firm-time varying controls include the interaction of foreign currency borrowing with a time trend, and the interaction of firms' initial productivity and import share with the depreciation dummy. Sector-year fixed effects are estimated at two-digit NACE industries.

Table B.9: Currency Depreciation during the Great Recession: Short vs Long Term Loans

	Panel A					
	Log FC Share			Log Leverage		
	(1)	(2)	(3)	(4)	(5)	(6)
D*ST Ratio	-0.343***	-0.231***	-0.250***	-0.071*	-0.081**	-0.199***
	(0.057)	(0.060)	(0.060)	(0.037)	(0.038)	(0.068)
D* LT Ratio	-0.421***	-0.354***	-0.355***	-0.138***	-0.143***	-0.195***
	(0.020)	(0.020)	(0.020)	(0.018)	(0.020)	(0.016)
D* ST &LT Ratio	-0.267***	-0.196***	-0.206***	-0.130***	-0.137***	-0.141***
	(0.024)	(0.024)	(0.024)	(0.023)	(0.025)	(0.027)
D	0.009***			0.008***		
	(0.001)			(0.001)		
Firm FE	yes	yes	yes	yes	yes	yes
Firm-Time controls		yes	yes		yes	yes
Year FE		yes	yes		yes	yes
Sector*Year FE			yes			yes
R^2	0.716	0.719	0.719	0.600	0.600	0.510
N	843,545	843,545	843,545	843,545	843,545	843,545
	Panel B					
	Log Investment Ratio			Log Sales		
	(1)	(2)	(3)	(4)	(5)	(6)
D*ST Ratio	0.022	0.064	-0.062	0.078	0.095	0.003
	(0.034)	(0.149)	(0.166)	(0.132)	(0.071)	(0.071)
D* LT Ratio	-0.122***	-0.091**	-0.084***	0.077***	0.088***	0.044**
	(0.029)	(0.036)	(0.030)	(0.029)	(0.023)	(0.023)
D* ST &LT Ratio	0.049	0.104	0.107	0.077	0.092*	0.046
	(0.094)	(0.092)	(0.093)	(0.058)	(0.051)	(0.051)
D	-0.579***			-0.122***		
	(0.007)			(0.010)		
Firm FE	yes	yes	yes	yes	yes	yes
Firm-Time controls		yes	yes		yes	yes
Year FE		yes	yes		yes	yes
Sector*Year FE			yes			yes
R^2	0.805	0.808	0.829	0.936	0.936	0.937
N	441,685	441,685	441,685	655,996	655,996	655,996

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Standard errors are cluster at year and four-digit NACE industries. FC ratio is the firm's foreign currency debt over total assets in the initial year (2005). Firm-time varying controls include the interaction of foreign currency borrowing with a time trend, and the interaction of firms' initial productivity and import share with the depreciation dummy. Sector-year fixed effects are estimated at two-digit NACE industries.

Table B.10: Currency Depreciation during the Great Recession: Short vs Long Term Loans

	Exit		
	(1)	(2)	(3)
D*ST Ratio	-0.069	0.019	0.024
	(0.045)	(0.027)	(0.045)
D* LT Ratio	-0.048***	-0.001	-0.012
	(0.009)	(0.007)	(0.012)
D* ST &LT Ratio	-0.044*	0.011	0.015
	(0.023)	(0.013)	(0.023)
D	0.086***		
	(0.002)		
Firm FE	yes	yes	yes
Firm-time controls		yes	yes
Year FE		yes	yes
Sector*Year FE			yes
R^2	0.639	0.602	0.661
N	725,501	725,501	725,501

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Standard errors are cluster at year and four-digit NACE industries. FC ratio is the firm's foreign currency debt over total assets in the initial year (2005). Firm-time varying controls include the interaction of foreign currency borrowing with a time trend, and the interaction of firms' initial productivity and import share with the depreciation dummy. Sector-year fixed effects are estimated at two-digit NACE industries.

Appendix B.3 Descriptive Statistics

Table B.11 reports the sectors under analysis and the number of firms in 2005. We consider all sectors in the economy, except for the financial sector and activities subject to special regulations as education and health. In particular, we exclude from the analysis: financial and insurance activities (K); real estate activities (L); public administration, defense and compulsory social security (O); education (P); and human health and social work activities (Q).

In 2005, there were 160,659 firms with three or more employees in the sectors under analysis (column 1). Firms borrowing in foreign currency reached 13,493 companies (column 2) and where spread out across all economic activities. The sectors showing more firms borrowing in foreign currency are wholesale, manufacturing and construction, which also have the higher number of firms in the economy.

Table B.11: Sample of Firms (2005)

Sector		Number of firms	
		Total	Borrowing in FC
		(1)	(2)
A	Agriculture, forestry and fishing	7,511	748
B	Mining and quarrying	351	30
C	Manufacturing	22,656	3,083
D	Electricity, gas steam and air conditioning supply	357	50
E	Water supply, sewerage, waste management and remediation activities	1,099	119
F	Construction	19,334	1,738
G	Wholesale and retail trade, repair or motor vehicles and motorcycles	48,198	4,485
H	Transportation and storage	6,291	631
I	Accommodation and food service activities	9,305	611
J	Information and communication	8,153	351
M	Professional, scientific and technical activities	18,522	814
N	Administrative and support service activities	10,014	525
R	Arts, entertainment and recreation	3,933	97
S	Other service activities	4,935	211
Total		160,659	13,493

Notes: Nace Rev.2 Industry Classification. Source: APEH.

Tables B.12 presents the size of firms holding foreign currency loans and the share on aggregate employment and value added in 2005. Interesting, note that only 10% of firms borrowing in foreign currency were foreign-owned in 2005. Finally, we break down firms by export and import status and create four bin of firms: exporters, importers, exporters and importers, and non-exporters or importers. Tables B.13-B.14 report the share of firms borrowing in foreign currency by group and their foreign currency share.

Table B.12: Firms Holding Foreign Currency Loans by Size (2005)

	Share on Aggregate		Share on
	Value Added	Employment	Foreign Loans
In %	(1)	(2)	(3)
Small & Medium Firms (<250 empl.)	14	18	63
Large Firms (>250 empl.)	26	16	37
Total	40	34	100

Source: APEH and Credit Register data.

Table B.13: Share of Firms Borrowing in Foreign Currency by Group

In %	Only Exporter	Only Importer	Exporters and Importers	Non-Exporter and Non-Importer
2005	9.9	7.4	17.3	65.3
2006	11.3	6.6	16.1	66.0
2007	12.7	5.7	15.9	65.6
2008	14.5	5.3	15.1	65.2
2009	15.8	5.1	16.3	62.9
2010	16.7	4.6	17.7	61.0

Note: columns 1-4 report the share of firms borrowing in foreign currency by group on total firms borrowing in foreign currency. Source: APEH and Credit Register.

Table B.14: Foreign Currency Debt Share by Group of Firm

In %	Only Exporter	Only Importer	Exporters and Importers	Non-Exporter and Non-Importer
2005	60.6	58.7	62.4	65.5
2006	59.1	57.4	61.3	65.8
2007	59.1	60.0	62.5	66.2
2008	60.3	60.7	64.3	67.7
2009	61.2	64.3	65.7	67.5
2010	62.9	63.4	67.4	69.1

Note: Foreign Currency debt share by group of firm. Source: APEH and Credit Register.

Appendix B.4 Currency Depreciation during the Great Recession

To study how firms borrowing in foreign currency perform following exchange rate depreciations, in this section, we exploit the depreciation of the Hungarian Forint during the Great Recession (2008-10) and assess empirically the impact of this shock.

Following the bankruptcy of Lehman Brothers in 2008, the external conditions substantially changed for the Hungarian economy. Capital inflows turned into outflows, and the local currency substantially depreciated against main trading currencies. By 2010, the depreciation of the Hungarian Forint against the Euro had reached 10% and more than 30% against the Swiss Franc. This section uses this shock as an exogenous source of time variation and studies whether firms borrowing in foreign currency underperformed during the depreciation years. With this end, we estimate the following OLS regression:

$$\log Y_{it} = \beta(D_t \,\text{x}\, \text{FC Ratio}_i) + \phi_i + (T_t \,\text{x}\, \text{FC Dummy}_i) + (\mu_i \,\text{x}\, D_t) + X_{jt} + \varepsilon_{ijt} \tag{42}$$

where i, j, t index firm, two-digit NACE industries and time, respectively. Y_{ijt} is a vector of $\{\log \text{Leverage}_{it}, \log \text{FC Share}_{it}, \log \text{Investment Rate}_{it}, \log \text{Sales}_{it}, \text{Exit}_{it}\}$. D_t is a dummy equal to one for the currency depreciation years ($D_t = 0$ if t $<$ 2008, and $D_t = 1$ if $t \geq$ 2008). FC_i is the firm's foreign currency debt-to-assets ratio in the initial year (2005). ϕ_i are firm fixed-effects that capture all time-invariant firm and sector characteristics. Additionally, we include a full set of time-varying controls that capture sector and firm differential trends. In particular, we include: (*i*) two-digit sector-year fixed effects (X_{jt}) to absorb any year-sectoral shock that could affect firms differently across activities (as for example demand-industry specific shocks); (*ii*) a time trend interacted with the foreign currency dummy to control for firms' differential pre-growth trends ($T_t \,\text{x}\, \text{FC Dummy}_i$); and (*iii*) interaction terms for the firm's initial productivity and import share with the depreciation dummy to take into account that the depreciation could affect firms differentially according these characteristics ($\mu_i \,\text{x}\, D_t$). The coefficient of interest is β in equation (42) and captures the differential impact of the depreciation on firms holding foreign currency. We cluster the OLS standard errors at four-digit sector-year level.

Results

Table 8 presents the result. Panel A reports the estimated coefficients for foreign currency share and leverage. In column 1, the estimated coefficient on the interaction term is negative and highly statistically significant, implying that firms holding foreign currency debt deleveraged in foreign currency and switched to local currency financing in the years after the currency shock. In particular, one percent increase in the firm's initial foreign debt-to-asset ratio associates with a 0.33 percent decrease in its foreign currency debt share during the Great Recession. The estimated coefficient remains negative and highly statistically significant after the inclusion of firm-time varying controls and yearly dummies in column 2, and of sector-year fixed effects in column 3. After the inclusion of all controls, the coefficient implies that one percent increase in the initial foreign leverage reduces a firm's share of foreign currency loans by 0.20 percent. Columns 4-6 report the results on the firms' leverage. All along estimations the coefficient is negative and highly statistically significant, indicating that firms holding foreign currency loans reduced their leverage. After the inclusion of all controls in column 6, the coefficient implies that one percent increase in the initial foreign currency leverage associates with a reduction of 0.18 percent in their leverage.

Table B.15: Currency Depreciation during the Great Recession

	Panel A					
	Log FC Share			Log Leverage		
	(1)	(2)	(3)	(4)	(5)	(6)
D*FC Ratio	-0.330***	-0.253***	-0.204***	-0.129***	-0.146***	-0.179***
	(0.017)	(0.016)	(0.013)	(0.015)	(0.015)	(0.013)
D	0.009***			0.009***		
	(0.001)			(0.001)		
Firm FE	yes	yes	yes	yes	yes	yes
Firm-Time controls		yes	yes		yes	yes
Year FE		yes	yes		yes	yes
Sector*Year FE			yes			yes
R^2	0.701	0.704	0.705	0.572	0.572	0.478
N	843,545	843,545	843,545	843,545	843,545	843,545
	Panel B					
	Log Investment Ratio			Log Sales		
	(1)	(2)	(3)	(4)	(5)	(6)
D*FC Ratio	-0.673***	-0.455***	-0.478***	0.079**	0.100***	0.073***
	(0.135)	(0.094)	(0.094)	(0.034)	(0.027)	(0.027)
D	-0.568***			-0.122***		
	(0.024)			(0.010)		
Firm FE	yes	yes	yes	yes	yes	yes
Firm-time controls		yes	yes		yes	yes
Year FE		yes	yes		yes	yes
Sector*Year FE			yes			yes
R^2	0.800	0.826	0.827	0.936	0.936	0.937
N	441,685	441,685	441,685	655,996	655,996	655,996

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Standard errors are cluster at year and four-digit NACE industries. FC ratio is the firm's foreign currency debt over total assets in the initial year (2005). Firm-time varying controls include the interaction of foreign currency borrowing with a time trend, and the interaction of firms' initial productivity and import share with the depreciation dummy. Sector-year fixed effects are estimated at two-digit NACE industries.

These results suggest that firms holding foreign currency debt saw their balance sheets affected after the depreciation. We turn next to test whether this correlates with lower level of investment rates and sales. Columns 1-3 in Panel B show that these firms differentially reduced their investment and, as expected, this drop is higher for firms with larger initial foreign currency borrowing leverage. After the inclusion of all controls, the estimated coefficient in column 3 implies that one percent increase in the initial foreign leverage reduces firms' investment rate by an additional 0.48 percent. Columns 4-6 report the results for firms' sales. The coefficient on the depreciation dummy (D_t) in column 4 is negative and statistically significant, reflecting the negative impact of the recession. Interesting, the coefficient on the interaction term with the foreign currency leverage is positive and statistically significant, implying that firms holding foreign currency borrowing experienced a 0.8 percent lower decline in their sales than firms borrowing only in local currency. This interaction term is positive and robust all across specifications. This result indicates that while firms choosing foreign currency borrowing experienced negative balance sheet effects following the currency shock, they outperform their industry counterparts that only borrowed in local currency.

We test next whether the currency shock affected firms' exit likelihood (Table B.16). Column 1 shows that after the currency depreciation firms experience higher exit probability. It is worth remarking on the coefficient of the depreciation dummy, absorbing the impact of the depreciation on firms borrowing solely in local currency. The estimated coefficient is positive and implies that these firms saw a 8.2% higher probability of exiting after the shock. Interesting, the coefficient on the interaction term for foreign currency borrowing firms is negative and statistically significant. After the inclusion of all controls, the coefficient remains negative but becomes statistically non-significant. This result is consistent with our previous finding on firms' sales and suggests that, while the currency shock, negatively affected the balance sheet of firms holding foreign currency debt, these firms did not underperform in terms of sales or exit their industry counterparts. While this effect might appear counter-intuitive at a first view, it is not surprising in light with the model and the figures presented in Table 10. As the model shows, when the risk-free uncovered interest parity does not hold, firms have incentives to take foreign currency borrowing in order to expand their investment and scale of operation. As these firms grow faster during good times, it is not surprising that they become more resilient to shocks. In other terms, these results suggest that despite the negative balance sheet effects, previous investments allow foreign currency borrowing firms to survive the shock.

Table B.16: Currency Depreciation during the Great Recession

	Exit		
	(1)	(2)	(3)
D*FC Ratio	-0.036*** (0.009)	0.018* (0.006)	-0.001 (0.009)
D	0.082*** (0.002)		
Firm FE	yes	yes	yes
Firm-time controls		yes	yes
Year FE		yes	yes
Sector*Year FE			yes
R^2	0.586	0.602	0.614
N	725,501	725,501	725,501

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Standard errors are cluster at year and four-digit NACE industries. FC ratio is the firm's foreign currency debt over total assets in the initial year (2005). Firm-time varying controls include the interaction of foreign currency borrowing with a time trend, and the interaction of firms' initial productivity and import share with the depreciation dummy. Sector-year fixed effects are estimated at two-digit NACE industries.

Tables B.7 and B.8 in Appendix B report the estimated coefficients of regression (42) for non-exporter firms. In all regressions, the coefficients are of the same sign and similar in magnitude to those estimated in Tables B.15 and B.16. This confirms that the currency depreciation had a negative impact on the balance sheet of firms borrowing in foreign currency, as upon the shock they reduced their leverage, investment and share of foreign denominated currency debt. Importantly, these firms experienced lower decreased in their sales and similar increase in their exit than their industry counterparts borrowing only in local currency denominated debt.

Finally, we study whether firms were differently affected accordingly with the maturity of their foreign currency loans. We distinguish three groups of firms: holding only short-term loans (maturity less of one year), holding only long-term loans (maturity more than one year), and holding both types of loans.[42] Tables B.9 and B.10 in Appendix B present the results. Column 1-6 confirm that, following the depreciation, all firms holding foreign currency debt switched to local currency borrowing and decrease their leverage. Notably, the drop in the share of foreign debt was significantly larger for firms using long-term contracts. These firms also saw larger reductions in their investment, as shown in columns 7-9. Remarkably, despite this negative balance sheet effects, firms holding long-term debt experienced a lower reduction in their sales and do not see a higher exit probability (columns 10-15).

[42]Note that firms using only long-term loans constituted 80% of firms indebted in foreign currency, where the rest was equally divided between firms only borrowing short-term and using both types of debt.

Appendix B.5 Euro vs Swiss Franc Loans

The previous sections averaged the effect of foreign denominated loans across different currencies. In this section, we break down the currency denomination of credits and study the patterns of firms' borrowing across currencies. That is, we study why firms choose to borrow in one foreign currency or another, and whether these choices are in line with the mechanism proposed in this paper, i.e. namely deviations from the risk-free UIP making foreign borrowing more attractive, particularly for firms with higher needs of funds. We next exploit this cross-sectional variation to test whether the effects of the depreciation in 2008 on firms' performance differ across currencies.

-Selection and Firm's Growth

A key feature of foreign currency borrowing in Hungary is that the majority of firms borrowed in one foreign currency or another.[43] In 2005, 95% of firms employing foreign denominated loans were indebted in one particular currency, and only 5% of the firms hold debt in more than one currency. In this section, we exploit this selection to test the mechanism proposed in this paper. In particular, the second prediction of the model stated that higher deviations from the UIP decrease the productivity threshold to start borrowing in foreign currency and encourage smaller firms to invest and expand more. Hence, we can check whether variations in the deviation from the risk-free UIP across currencies associate with certain firms' initial characteristics and pattern of growth. That is, we would expect that firms borrowing in the currency that shows the highest deviation from the UIP are on average less productive and see higher growth.

Since the majority of firms employing foreign currency debt choose Euros or Swiss Francs (99% of firms), we focus our analysis in both currencies. Deviations from the risk-free UIP were higher with respect to the Swiss Franc than with respect to the Euro (Figures 1 and B.3). In particular, the average deviation from the risk-free UIP at one year was 1.06 against the Swiss Franc and 1.04 against the Euro, between 2001 and 2005. This implies a two percentage point expected risk-free interest differential in favor of the Swiss Franc. This difference in favor of the Swiss Franc was still present at 3 months (1.5 pp) and 2 years horizons (1.7pp), and during all the period 2001 to 2015 (1.5pp) (Figure B.2). This implies that the risk-free rate of Swiss Franc was relatively lower than that of the Euro, once expected changes in the exchange rate were taken into account. Hence, one would expect that firms opting for loans denominated in Swiss Franc would be on average less productive.

To test this, we restrict our analysis to the 95% of firms that borrow in either Swiss Francs or Euros, and study whether there are differences in firms' initial productivity and pattern of growth among these firms. We start by estimating a similar regression to equation (14), and regress a dummy variable indicating whether the firm held a loan denominated in Swiss Francs in 2005 on firms' productivity prior to the deregulation of foreign loans in 2001. Next, we estimate a similar equation using the log share of Swiss Franc loans on total foreign currency loans as dependent variable. These estimations capture whether firms that opted for Swiss Franc loans and held higher shares of these loans were initial

[43]Foreign loans to the corporate sector were mainly denominated in Euros, Swiss Francs, and a small proportion in U.S. Dollars. In 2005, 74% of total loans were denominated in Euros, 19% in Swiss Francs and 6% in U.S. dollars. Interesting, while most of credits were denominated in Euros, the majority of firms borrowed in Swiss Francs (73%), less than one-third in Euros (31%), and only 250 firms in U.S. dollars (about 1%).

less productive than those selecting Euro loans.

Table B.17 presents the results. Column 1 confirms that firms choosing to borrow in Swiss Francs were initially less productive than firms opting for Euro denominated loans. In particular, the estimated coefficient implies that a one percent increase in firms' productivity decreases the probability to choose Swiss Franc loans by 0.045 percentage points. The coefficient remains statistically significant after controlling for firms' initial capital stock (column 2). As expected, column 3 shows that less productive firms had higher shares of Swiss Franc loans. The estimated coefficient implies that a one percent increase in firms' productivity decreases the share of Swiss Franc loans by 0.03 percent. This result remains true after controlling for firms' initial capital stock, as reported in column 4.

Table B.17: Decision into Foreign Currency Borrowing: Euro vs Swiss Franc Loans

	Swiss Franc Dummy		Log Share of Swiss Franc Loans	
	(1)	(2)	(3)	(4)
Log productivity	-0.045***	-0.025***	-0.031***	-0.018***
	(0.008)	(0.009)	(0.006)	(0.006)
Log capital		-0.041***		-0.029***
		(0.006)		(0.004)
Sector FE	Yes	Yes	Yes	Yes
R^2	0.134	0.153	0.134	0.153
N	4,367	4,367	4,367	4,367

Notes: *, **, *** significant at the 10, 5, and 1 percent level. Standard errors in parentheses. This regression only includes firms that have either Swiss Franc or Euro Loans. All regressions include four-digit NACE industry fixed effects. Source: APEH and Credit Register.

We turn next to check whether Swiss Franc loans correlated with higher investment rate and sales after the deregulation of foreign denominated loans. Importantly, this exercise does not aim to address causality, but to attest whether firms using these loans see higher growth once foreign denominated borrowing was allowed. With this end, we conduct an analog exercise to that of equation (15) and regress investment rate and sales on the reform dummy and its interaction term with the Swiss Franc debt dummy. Our coefficient of interest is that of the interaction between the reform variable and the Swiss Franc dummy that reflects whether firms employing these loans see higher investment rate and sales than firms borrowing in Euros within the five years prior and following the reform.

Table B.18 presents the results. Column 1 and 3 show that firms using Swiss Franc loans saw higher level of investment rate and sales than firms only employing Euro denominated loans after the reform. Columns 2 and 4 report that these results are robust after the inclusion pre-reform growth trends, as the time trend and the interaction of the time trend with the Swiss dummy.

We turn now to study the effect of the exchange rate depreciation during the Great Recession for firms indebted in Euros and Swiss Francs. Following 2008 the Hungarian currency depreciated three-times more against the Swiss Franc (30%) than the Euro (10%). We exploit this differential depreciation to analyze whether firms indebted in Swiss Francs were differentially affected. Table B.19 presents the results of equation (42) estimating separately the effects on the Euro and Swiss Franc debt. Columns 1-3 in Panel A report the estimated coefficients for the change in the share of foreign currency debt after

Table B.18: Foreign Currency Borrowing and Firms' Growth

	Log Investment Rate		Log Sales	
	(1)	(2)	(3)	(4)
R*Swiss Dummy	0.066**	0.068**	0.065***	0.061***
	(0.033)	(0.033)	(0.022)	(0.014)
R	0.266***	0.078**	0.459***	0.024
	(0.027)	(0.036)	(0.021)	(0.016)
Firm FE	yes	yes	yes	yes
Time Trend		yes		yes
Swiss Dummy*Time Trend		yes		yes
R^2	0.622	0.623	0.816	0.841
N	49,964	49,964	53,538	53,538

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. This regression only includes firms that have either Swiss Franc or Euro Loans. Swiss dummy is a binary variable of whether the firm hold a Swiss Franc loan in 2005. R is a dummy for the period 2001-05. Sample period 1996-2005.

2008. In line with the higher depreciation against the Swiss Franc, column 1 shows that firms initially indebted in this currency reduced their share of foreign currency debt relatively more following 2008. In particular, one percentage point increase in the Swiss Franc debt-to-assets ratio leads to a decrease of 0.36 percent in the share of foreign currency debt following 2008, whilst the estimated coefficient is 0.28 percent for firms originally indebted in Euros. After the inclusion of firm-level and sectoral time-varying controls, this differential reduction holds true and is statistically significant, as reported by the F-test on equality of coefficients in Panel B. Columns 4-6 present the results for firms' leverage. As in the previous section, firms indebted in foreign currency decreased their leverage relatively more following the depreciation. Column 6 shows that the decrease in leverage is slightly higher for firms initially indebted in Euros, as one percentage increase in the ratio of Euro debt- to-assets ratio reduces the leverage by 0.20 percent, whilst this reduction reaches 0.17 percent for firms indebted Swiss Francs.

Columns 1-3 in in Panel B show that the depreciation of the Hungarian currency associates with a decrease in the investment rate of firms borrowing in Euros and Swiss Francs. In particular, column 1 shows that one percent increase in the share of Euro denominated debt decreases investment by 0.28 percent. Consistent with the greater depreciation of the Swiss Franc, firms employing this financing saw a higher decrease in their investment for which the estimated coefficient is 0.94 percent. After the inclusion of all firm and sector time-varying controls, the estimated coefficient implies that one percent increase in the share of Swiss Franc debt-to-asset ratio reduces firms' investment by 0.50 percent. The estimated coefficients for Euro and Swiss Franc debt remain statistically different after the inclusion of all controls. Despite this negative balance sheet effects, column 4 shows that firms indebted in Swiss Francs see a lower decrease in their sales than firms only employing local currency debt. Importantly, this lower reduction remains statistically significant after the inclusion of all controls (column 6).

The results on exit are presented in columns 1-3 of Table B.20. In line with the results reported in Section Appendix B.4, firms employing either Euro or Swiss Franc debt have lower unconditional probability of exiting after 2008 (column 1). However, once firm and sector time-varying controls are included in the regression, the estimated coefficient are not statistically different than those of firms only employing local currency borrowing. Importantly, there is no statistical difference between firms borrowing in Swiss Francs or Euros, despite the larger depreciation against the former currency.

The results presented in this section suggest that the higher deviation from the risk-free UIP led smaller and less productive firms to select into Swiss Francs borrowing. Following the deregulation of foreign currency borrowing, this type of borrowing correlates with higher investment rate and sales at firm-level. Furthermore, in line with the higher depreciation against the Swiss Franc, firms employing these loans experienced substantial negative balance sheet effects after 2008, but they do not perform worst in terms of sales or see a higher exit probability than firms choosing Euros or local currency borrowing. These results are in line with the model predictions, arguing that firms take advantage of deviations from the risk-free UIP to invest more.

Table B.19: Currency Depreciation during the Great Recession: Euro vs Swiss Franc Loans

	Panel A					
	Log FC Share			Log Leverage		
	(1)	(2)	(3)	(4)	(5)	(6)
D*Euro Ratio	-0.281***	-0.218***	-0.178***	-0.160***	-0.176***	-0.200***
	(0.016)	(0.017)	(0.015)	(0.022)	(0.023)	(0.021)
D*SF Ratio	-0.362***	-0.288***	-0.232***	-0.103***	-0.120***	-0.168***
	(0.025)	(0.022)	(0.018)	(0.019)	(0.020)	(0.015)
D	0.010***			0.009***		
	(0.001)			(0.001)		
Firm FE	yes	yes	yes	yes	yes	yes
Firm-Time controls		yes	yes		yes	yes
Year FE		yes	yes		yes	yes
Sector*Year FE			yes			yes
R^2	0.698	0.701	0.702	0.574	0.575	0.480
N	843,545	843,545	843,545	843,545	843,545	843,545
	F-Test on Equality of Coefficients					
F-stat			128.76			88.88
P-value			0.0000			0.0000

	Panel B					
	Log Investment Rate			Log Sales		
	(1)	(2)	(3)	(4)	(5)	(6)
D*Euro Ratio	-0.278**	-0.282**	-0.301***	0.098*	0.071***	0.057**
	(0.140)	(0.119)	(0.100)	(0.051)	(0.013)	(0.023)
D*SF Ratio	-0.938***	-0.504***	-0.503***	0.113***	0.102***	0.080***
	(0.113)	(0.095)	(0.090)	(0.036)	(0.012)	(0.015)
D	-0.568***			-0.122***		
	(0.007)			(0.010)		
Firm FE	yes	yes	yes	yes	yes	yes
Firm-time controls		yes	yes		yes	yes
Year FE		yes	yes		yes	yes
Sector*Year FE			yes			yes
R^2	0.799	0.802	0.824	0.935	0.936	0.936
N	441,685	441,685	441,685	655,996	655,996	655,996
	F-Test on Equality of Coefficients					
F-stat			16.99			14.92
P-value			0.0000			0.0000

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Standard errors are cluster at year and four-digit NACE industries. FC ratio is the firm's foreign currency debt over total assets in the initial year (2005). Firm-time varying controls include the interaction of foreign currency borrowing with a time trend, and the interaction of firms' initial productivity and import share with the depreciation dummy. Sector-year fixed effects are estimated at two-digit NACE industries.

Table B.20: Currency Depreciation during the Great Recession: Euro vs Swiss Franc Loans

	Exit		
	(1)	(2)	(3)
D*Euro Ratio	-0.029***	0.022**	0.008
	(0.011)	(0.010)	(0.015)
D*SF Ratio	-0.030***	0.014*	0.006
	(0.009)	(0.008)	(0.014)
D	0.082***		
	(0.002)		
Firm FE	yes	yes	yes
Firm-time controls		yes	yes
Year FE		yes	yes
Sector*Year FE			yes
R^2	0.587	0.603	0.614
N	725,501	725,501	725,501
	F-Test on Equality of Coefficients		
F-stat			0.18
P-value			0.8362

Notes: *, **, *** significant at 10, 5, and 1 percent. Std. errors in parenthesis. Standard errors are cluster at year and four-digit NACE industries. FC ratio Euro and SF are the firm's foreign currency debt in Euros or Swiss Francs over total assets in the initial year (2005). Firm-time varying controls include the interaction of foreign currency borrowing with a time trend, and the interaction of firms' initial productivity and import share with the depreciation dummy. Sector-year fixed effects are estimated at two-digit NACE industries. These regressions exclude firms that had U.S. denominated loans and both Euro and Swiss Franc loans in 2005.

Appendix C The Hungarian Economy in the 2000s

In Hungary, international financial flows were highly restricted prior to the deregulation of the financial account in 2001. During the 1990s, there were capital controls on foreign exchange transactions that severely limited banks' ability to intermediate foreign funds and restricted Hungarian firms from borrowing in foreign currency. In 2001, these capital controls were lifted and all restrictions in the foreign exchange market eliminated (see Varela 2017 for a detailed description of this reform).

The deregulation of international financial flows in Hungary in 2001 had two main components: the lift of the restrictions on foreign exchange transactions that limited banks' ability to intermediate foreign funds, and the removal of the ban on domestic firms' foreign currency borrowing. In particular, the liberalization allowed banks to raise funds from abroad at low interest rates, and to use them to expand their local credit supply towards domestic firms that -thereafter- were allowed to borrow in foreign currency. This reform had a large impact on the banking sector and foreign currency lending. According with data from the NBH, three years after the reform -in 2004- net capital inflows to financial institutions had grown more than five-fold (from 0.6 to 3.3 billion U.S. dollars per year) and their external debt had more than tripled (exceeding the 20 billions of U.S. dollars). The expansion in the use foreign funds was parallel to an increase in the supply of foreign-currency denominated loans, specially towards domestic firms. By 2004, foreign currency loans to small and medium enterprises had already reached more than one third (Varela 2017). By 2005, the share of foreign currency loans in the corporate sector reached 44% and exceeded half of total loans by 2007. On the external front, capital inflows reached almost 10% of GDP per year. These large capital inflows associated with an expansion of the Hungarian economy, which grew at more than 4% per year within the four years following the reform.

In 2008, the change in the international conditions substantially hit the Hungarian economy. At the end of year, GDP and exports dramatically slowed down, and dropped 7% and 10% respectively in 2009. Net capital outflows turned the financial account into deficit and the Hungarian currency significantly depreciated. By 2010, the depreciation against the Euro had reached 10%, and more than 40% against the Swiss Franc.