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Exchange Rate Exposure and Firm Dynamics

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Exchange Rate Exposure and Firm Dynamics

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This paper develops a heterogeneous firm-dynamics model with endogenous currency debt composition to jointly study financing and investment decisions in developing economies. In our model, firms' foreign currency borrowing arises from a trade-off between exposure to currency risk and 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. Our counterfactual exercises show that foreign currency borrowing can lead to higher growth and that the efficiency of the banking sector to screen productive and capital-scarce firms is essential to reap up the benefits of this financing.

JEL-Codes: F31, F34, F36 F46.

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 inflows into developing economies lead to higher capital accumulation and income per capita. Yet the international economic literature has associated these flows with deeper boom-and-bust cycles, and financial crisis. One of the sources of these financial crises has been foreign currency borrowing by the corporate sector, as many firms employing this financing do not export or use hedging instruments to shield their balance sheets from exchange rate shocks.[1] In this paper, we micro-found why firms in developing economies choose to borrow in foreign currency and be exposed to the currency risk and quantify the aggregate implications of these decisions.

This paper shows theoretically and empirically that firms' foreign currency borrowing choices arise from a trade-off between 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 borrow in foreign currency to take advantage of deviations from the risk-free uncovered interest rate parity (UIP) to increase their investment. However, this financing exposes them to balance sheet effects and can lead them to default. Crucially, foreign currency borrowing decisions are heterogenous across firms. At the extensive margin, only highly productive firms can tolerate the exchange rate risk and borrow in foreign currency. At the intensive margin, productive and capital-scarce firms –with high return to investment– employ this financing relatively more. This heterogeneity is key to understand the aggregate consequences of this financing.

Our model shows that, if foreign currency loans are allocated towards productive and capital-scarce firms, they lead to higher aggregate capital accumulation and reduce firms' default. Otherwise, our counterfactual exercises show that they lead to capital misallocation and balance sheet problems. Specifically, if the banking sector cannot allocate foreign loans as a function of firms' productivity, they produce capital misallocation. If the banking sector cannot allocate them as a function of the firms capital, they create balance sheet problems. Along these lines, we show that the ability of the banking sector to screen firms is essential to promote the higher investment and mitigate the negative balance sheet effects implied in this financing. Therefore, the aggregate impact of foreign currency loans depends ultimately on their allocation across firms and the local level of financial development.

We validate the model in three different ways. First, we use firm-level census data from the period covering the deregulation of foreign currency loans in Hungary –a policy reform that serves as an exogenous source of time variation– to identify the pre-reform characteristics and pattern of growth of firms borrowing in foreign currency and to confirm econometrically the model's implications. Second, we calibrate the model and show that it matches key moments of the firm distribution of foreign loans. 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 employ our model to quantify the aggregate impact of foreign currency loans and decompose the forces driving the higher growth and balance sheet effects. In our counterfactual exercises, we assess the role of firm heterogeneity into foreign loans, the financial sector, economic development and exchange rate policy.

[1] Foreign currency borrowing has been associated with several crises in emerging markets during the nineties (as the Tequila and Asian crises) and has recently surged in the aftermath of the Great Recession (Figure B.1 Appendix B).

Our paper contributes to the literature studying the impact of capital flows on growth and crises in developing economies. This literature assesses empirically the effects of currency depreciations on firms' balance sheets and uses a representative agent models to describe the emergence of foreign currency borrowing.[2] Yet there is so far little understanding about the trade-offs driving firms' decisions and their aggregate implications. Our paper fills in this gap in two dimensions. First, it formalizes and documents the micro-mechanism driving foreign currency debt decisions. Second, it quantifies the aggregate growth benefits and negative balance sheet effects of foreign currency borrowing and assesses their main determinants by conducting counterfactual exercises.

We start by building a firm-dynamics model with endogenous debt composition in which firms jointly make financing and investment decisions. Firms are heterogeneous in capital stock, level of foreign and local currency debts, and face idiosyncratic productivity shocks and aggregate exchange rate shocks. Firms operate domestically and can finance their investment using debt, which can be denominated in local or foreign currency. Debt is non-contingent, so firms can default. A currency depreciation can create balance sheet effects and make firms borrowing in foreign currency susceptible to default and exit the market. A firm's idiosyncratic risk of default endogenously determines its cost of funds. Firms' currency-debt composition is driven by a trade-off between aggregate UIP deviations and firms' default probability. While UIP deviations make the foreign risk-free rate relatively lower, foreign loans expose firms to exchange rate shocks, raising their default probability and, thus, costs of funds. A firm borrows in foreign currency to the extent in which the increase its default probability (and thus its financing costs) does not exceed the lower relative cost from the UIP deviation.

The model offers two firm-level implications about the pattern of foreign currency borrowing and investment. First, at the extensive margin, there is *selection* into foreign currency borrowing, as –for a given level of capital– only high productivity firms find it optimal to be exposed to the currency risk and 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 tolerate the currency risk without significantly increasing financing costs and borrow in foreign currency. Second, at the intensive margin, high productivity firms with low capital (high marginal product of capital -MPK) use foreign loans more intensively following UIP deviations. High MPK firms have higher returns and exploit the lower foreign rate to increase their investment and reach faster their optimal scale of production. This trade-off between exposure to currency risk and growth drives firms' foreign currency borrowing decisions.

We employ firm-level data from the period of the deregulation of foreign currency loans in Hungary in 2001 to test the model's predicted pattern of foreign currency borrowing at the firm-level. This policy reform serves as an arguably exogenous source of time variation to identify the pre-reform characteristics of firms that started to borrow in foreign currency once it was legally allowed. We complement this analysis by exploiting initial firm-level variations within four-digit industries to identify the differential use of foreign loans across firms over time.

Our 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

[2]We review the literature below.

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 (from agriculture to services) over more than a decade (1996-2010) and allows building comprehensive measures of leverage by currency denomination and controlling for firms' exports and imports. This coverage of non-exporters and service activities allows studying why firms choose to be exposed to balance sheet effects by borrowing in foreign currency –a well-documented fact in the balance of payment crisis literature– and constitutes an advance over previous studies that focused only on small samples of large, exporters and publicly listed firms.

We start by documenting that foreign currency borrowing expanded rapidly in Hungary after the deregulation of these loans. By 2005, the share of these loans on total banking loans exceeded 45% and one-third of the firms borrowing in Hungary held foreign currency loans. These firms made up for a non-negligible share of aggregate outcomes and accounted for 40% of aggregate value added and 34% of employment. Interestingly, these firms were highly exposed to exchange rate movements, as three quarters of them were non-exporters (73% of firms) and did not use financial instruments to hedge the currency risk. Furthermore, they were mainly domestically-owned and did not employ this financing with trade purposes. In line with the model's implications, firms borrowing in foreign currency had high MPK and their use of foreign currency loans inversely relates with their initial capital stock.

We employ the Hungarian data to validate the model in three different ways. First, we calibrate the model to the period following the deregulation of foreign currency loans in Hungary and show that it successfully matches several non-targeted moments of the distribution foreign currency 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 invest more–, 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 a one percent increase in a firm's pre-reform productivity raises the probability of borrowing in foreign currency by 0.012 percentage points. Similarly, the share of foreign currency loans increases in firms' initial productivity, and implies an elasticity of 0.03. Our results also point that firms using this financing had a differential expansion of 7% in their investment rate, after including a full set of controls. Confirming the model's mechanism, we show that firms borrowing in foreign currency pay –on average– a one percentage point lower interest rate.

Our empirical results also confirm the second implication of the model, that is, higher UIP deviations promote foreign currency borrowing, particularly of high MPK firms. First, the estimated coefficients imply that a one percent increase in the UIP deviation –making foreign currency loans relatively cheaper– associates with a 0.12 and 0.07 percent higher probability of borrowing in foreign currency and share of foreign currency loans. Second, the expansion in the use of foreign loans is heterogeneous across firms and increases more for high productivity firms with low initial capital stock. A one percent increase in the UIP deviation raises the probability of borrowing in foreign currency and share of foreign loans of high MPK firms by 0.17 and 0.074 percent. Third, we show that UIP deviations also associate with higher investment for firms borrowing in foreign currency, particularly for high MPK firms. These result provides support to the mechanism proposed in this paper, namely high MPK firms using in foreign currency loans to relax their financing constraints and increase their investment.

The empirical identification of the use of foreign loans is based on the initial characteristics of firms employing these loans. To test that the observed effects correspond to firms' initial productivity and capital and not something else, we contact a full set of robustness tests. First, in our baseline specification, we exclude exporters and foreign-owned firms, as they might use foreign loans for trade purposes and show, in robustness tests, that results hold true when including them into the analysis.[3] Secondly, we show that results are not driven by sector-specific trends or demand shocks, as they are robust to including year, sector and sector-year fixed effects. Finally, note that the general context around the deregulation of foreign currency loans and its timing minimizes reverse causality concerns, as it was part of a general program of fourteen transition economies to join the European Union (EU). Importantly, by 2001, the Hungarian economy was already deeply integrated with the EU, trade and foreign direct investment flows remained constant in the years of the reform, and there were no other reforms that could affect firms' currency borrowing decisions.

Third, to assess quantitatively the model's firm-level responses, we employ it to simulate firm-level panel data –that follows the transition period of Hungary after the deregulation of foreign currency loans– and use these data to estimate the same reduced-form regressions than we did in the empirics. The model's responses mimic identically the coefficients estimated with the Hungarian data, demonstrating that the model captures quantitatively well the firm-level responses observed in Hungary.

Having validated qualitative and quantitively the model's firm-level implications, we next use it as a laboratory to quantify the aggregate implications of foreign currency borrowing and conduct policy experiments.

In our first numerical exercise, we quantify the impact of foreign currency borrowing comparing two economies with and without this financing. We show that economies allowing for foreign currency borrowing have 12% higher sales and 19% more capital. Firms are 13% larger and have 27% higher investment rates and 20% lower default probability. Notably, the higher growth implied by foreign loans comes at the expense of higher aggregate volatility, as in these economies firms' balance sheets are exposed to exchange rate movements. In our second exercise, we assess how firm heterogeneity shapes the aggregate consequences of this financing. We show that accounting for productivity and capital is crucial to generate the higher growth and minimize the balance sheet effects of foreign loans. In particular, if all firms could borrow in foreign currency –regardless of their productivity or capital–, the economy would have 25% lower capital and sales, and firms would invest 18% less and be three-fold more likely to default. Both capital and productivity heterogeneity play a major role at explaining this lower growth and higher volatility. In two additional exercises, we show that if only high capital firms borrow in foreign currency independently of their productivity, the economy would see lower growth and capital misallocation, as foreign credit would be allocated towards large but unproductive firms. Inversely, if only highly productive firms employ foreign loans independently of their capital, the economy would be four-fold more volatile, as small firms cannot tolerate the currency risk and see balance sheet effects.

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

To assess how differences in a country's characteristics can affect the aggregate implications of foreign currency borrowing, we undertake three policy experiments on financial development, capital scarcity and exchange rate policy. In our first experiment, we show that, when the local level of financial development is low and creditors can not fully observe firms' productivity, costs of funds increase, the investment rate drops and the default increases. Hence, low financial development undermines the growth benefits of foreign currency loans and increases balance sheet effects. In our second exercise, we study the importance of the level of economic development and show that the more capital scarce is an economy, the higher are firms' investment rate and growth. Yet, since firms borrowing in foreign currency are smaller and less able to tolerate the currency risk, the economy sees more default and higher volatility. Thus, low economic development increases the growth benefits and risks of foreign currency loans. Our last exercise evaluates the exchange rate policy and indicates that low exchange rate volatility leads to higher investment but –as firms borrow intensively in foreign currency– they also make the economy susceptible to swings in the exchange rate. These results inform the current debate on macro-prudential policies, showing that the aggregate consequences of foreign loans depend crucially on their allocation across firms, the local level of financial development and the exchange rate policy.

Lastly, to explore the sensitivity of the numerical analysis, we conduct three counterfactual exercises. First, we include a stochastic discount factor that adds a premium during depreciations and show that it amplifies our model's mechanism. In particular, our results indicate that lower interest rates during appreciations encourage investment, but increase default during depreciations. Furthermore, since debt is riskier, firms' decrease their foreign currency debt holdings. Secondly, to account for aggregate demand shocks, we add –to our specification with the stochastic discount factor– an aggregate productivity shock that negatively correlates with the exchange rate and decreases firms' sales during depreciations. This shock raises firms' risk and, hence, idiosyncratic costs of funds, which lowers their investment and raises their default. Finally, we evaluate the sensitivity of the exchange rate pass-through and add it to our last specification. Higher pass-through offers a hedge against the currency risk, which promotes foreign currency borrowing and investment and lowers default.

Related Literature. This paper is related to a long literature in international economics studying capital inflows into developing economies and their implications for growth and crisis. 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. These early papers built macro models in which market failures generate interest rate differentials that lead a representative firm to be in a corner solution and to borrow in either local or foreign currency (Schneider and Tornell 2004; and Rappoport 2008, among others). Our paper focuses on firms' optimal currency debt composition and contributes to this literature in two different ways. First, our novel mechanism can explain the observed cross-sectional heterogeneity in firms' currency borrowing decisions and their foreign currency debt shares. Second, our firm-dynamics framework shows that this heterogeneity matters to explain the growth benefits and balance sheet effects of this financing, and allows us to quantify its aggregate implications and conduct policy experiments. These exercises relate to the literature quantifying the impact of capital flows and financial frictions in developing economies (as Arellano, Bai, and Zhang 2012; Heathcote and Perri 2016; Arellano and Heathcote 2010; Bianchi, Hatchondo, and Martinez 2018, among others).

There is also strand of literature showing empirically that currency depreciations can lead firms borrowing in foreign currency to experience negative balance sheets (see for example Kalemli-Ozcan, Kamil, and Villegas-Sanchez 2010; Kim, Tesar, and Zhang 2015; Rancière and Tornell 2016; and Alfaro, Asis, Chari, and Panizza 2017). Our paper contributes to this literature in that we exploit a policy reform to dissect empirically the mechanism driving firms' foreign currency choices and our extensive database allow us to study the effects of foreign currency loans on the entire population of firms across sectors and over a long period.

Our paper also relates to a more recent literature that studies the currency composition of capital flows. Baskaya, di Giovanni, Kalemi-Ozcan, and Ulu (2017) document that exogenous capital inflows to emerging markets substantially affect the credit supply of domestic banks and that Turkish firms can borrow at lower rates in foreign currency. 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. Relating to the international corporate finance literature studying foreign borrowing by multinational firms (Allayannis, Ihrig, and Weston 2001; Allayannis and Weston 2001), we show that domestic and non-exporting firms might also find it optimal to borrow in foreign currency. We are also close to the asset pricing literature studying carry trade (Backus, Gavazzoni, Telmer, and Zin 2010 and Ready, Roussanov, and Ward 2017) and show that firms might also borrow in foreign currency to invest and produce in local currency goods.[4]

There is a growing literature studying differences in currency returns across countries and persistent UIP deviations. This literature has proposed various macro channels driving interest rate differences, ranging from differences in country size, financial development, and consumption risk (see for example, Hassan 2013; Maggiori 2017; and Lustig and Verdelhan 2006). Similarly, in a recent paper, Bocola and Lorenzoni (2017) show that the risk of financial panic and precautionary motives of households can also lead to aggregate UIP deviations. Our paper shares with this literature the existence of persistent UIP deviations, although our aim is to micro-found firms' foreign currency debt composition. As such, in our model, firms make their currency debt and investment choices taking as given the macro origins driving aggregate UIP deviations. We also relate to Ranciere, Tornell, and Vamvakidis (2010), who document first evidence of these UIP deviations in emerging European economies during the 2000s.[5]

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 concludes.

[4] 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.

[5] 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.

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, 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.[6] 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).[7]

In Hungary, foreign currency borrowing expanded rapidly after the deregulation of international financial flows in 2001, which liberalized foreign currency denominated loans for domestically-owned firms.[8] By 2005, one-third of firms employing bank credit held foreign-currency loans. Firms borrowing in foreign currency were spread out across all economic activities, from agriculture and manufacturing to wholesale and entertainment activities, as shown in Table B.15 (Appendix B). Foreign currency borrowing firms made up for a non-negligible share of aggregate outcomes, accounting for 40% of value added and 34% of employment in the economy (Table B.16 in Appendix B). Importantly, the use of foreign currency loans was associated with aggregate deviations from the risk-free UIP, as shown by Figure 1 that displays this correlation between 2006Q4 and 2015Q4.[9]

Table 1 shows that firms borrowing in foreign currency used this 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. Furthermore, two-third of these

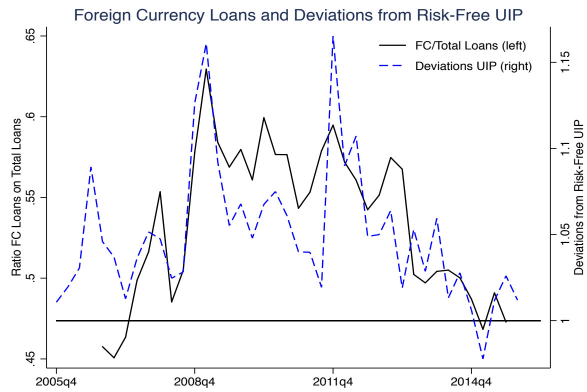
[6] We exclude firms in financial and real estate activities, public administration, education and health, as these activities are subject to especial regulations. Appendix B and Table B.15 describe the sectors under analysis in detail.

[7] 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.

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

[9] 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 of this correlation. In this appendix, we show that this correlation is robust to several controls, as for example countries' sovereign default risk (e.g. credit default swaps premiums).

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



Notes: Left axis: share of foreign currency loans on total loans in the corporate sector. Right axis: UIP deviations (1 year) with respect to the Euro. Source: CHF Lending Monitor, Consensus Forecast, and Credit Register.

firms were neither exporters or importers, and were domestically-owned firms (90% of firms) (Table B.17 in Appendix B). Notably, these firms did not employ derivative contracts to hedge the currency risk, as reported by Bodnár (2006).[10] This absence of natural or financial hedging shows that firms borrowing in foreign currency were substantially exposed to exchange rate movements.

Table 1: Characteristics of Firms Holding Foreign Currency Loans in 2005

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

Notes: Rows 1-3 are in %. The difference in means and correlation are statistically significant at one percentage point. Source: APEH, Credit Register data BEEPs (World Bank and EBRD).

Foreign currency loans were mainly held by small and medium firms with less than 250 employees, which accounted for two-thirds of these loans (Table B.16 in Appendix B). Firms borrowing in foreign currency were –on average– more productive and paid lower interest rates, as shown in Table 1.[11] Interestingly, their share of foreign currency loan inversely relates with their capital stock. These features suggest that capital-scarce and productive firms were taking advantage of lower financing terms

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

[11]Loans typically had a maturity over a year (90% of them). While the database only informs whether loans have a maturity of less or more than a year, anecdotal evidence from the NBH did not typically exceeded 5 years.

of foreign currency loans to invest more and reach faster their optimal scale.[12] In the next section, we develop an heterogenous firm-dynamic model that formalizes the trade-off between currency risk and growth and then employ the Hungarian data to test it econometrically and assess it quantitiatively.

3 Model

Our firm-dynamics model has three main ingredients. First, there are heterogeneous firms that can raise external funds to invest and choose the currency composition of their debt. Second, there are deviations from the UIP that affect the relative risk-free rates in local and foreign currency. Third, there are exchange rate shocks that make foreign currency borrowing risky and firms using these loans 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.

3.1 Environment

There is a continuum of heterogeneous incumbent firms that produce 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.

Firms can finance their investment using retained earnings and/or external loans.[13] 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.[14] In each period, there is a constant mass of potential entrants,

[12]Note that, in all these variables, the difference in means is statistically significant at one percentage point.

[13]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.

[14]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

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 Firms and Stationary Firm Distribution

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 capital (k') and the levels of local and foreign currency debts (b', b'^*) to maximize its value (V^R):

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

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

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

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 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.[15]

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.

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.

[15]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 6.4, we illustrate a sensitivity analysis for η.

Risk-Free Rates and UIP Condition

Investors can hold risk-free bonds that can be denominated in local or foreign currency. Investors discount payments in local currency by m and in foreign currency by m^*. The price of the risk-free bonds is defined as

$$q_{RF(s)} = \frac{1}{1+r(s)} = E_s(m) \qquad \text{and} \qquad q^*_{RF(s)} = \frac{1}{1+r^*(s)} = E_s(m^*), \tag{6}$$

where $r(s)$ and $r^*(s)$ represent the risk-free rate of local and foreign currency denominated bonds. The relationship between the risk-free rates is given by the adjusted UIP condition:

$$\theta\, E(s'|s)\,(1+r^*(s)) = s\,(1+r(s)). \tag{7}$$

where θ is the deviation from the risk-free UIP. Note that if $\theta = 1$, the UIP condition holds and the 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, if $\theta > 1$ the foreign risk-free rate is relatively lower, even after accounting for the expected fluctuation in the exchange rate.

Note that θ can be interpreted as a risk premium on the local currency, as argued by the risk-based literature that studies differences in currency returns. This premium can come from differential pricing of the exchange rate risk, where currencies with high interest rates pay higher returns because they tend to depreciate in bad times. Importantly, in our model, firms take the difference in the risk-free rate as given when making their currency debt decisions and, consequently, the mechanism driving these decisions holds regardless the channel originating the difference in the risk-free rates.[16]

In line with this idea, using equations (6) and (7), we can re-write the UIP deviation as a function of the expected depreciation and the difference in two discount rates:

$$\theta(s) = \frac{s}{E(s'|s)} E_s\left(\frac{m^*}{m}\right). \tag{8}$$

Debt Contract and Debt Pricing

Investors can also buy firms' risky bonds denominated in local or foreign currency. 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.[17] Firms' bonds prices are sold at a discount, $q(s,z,\upsilon)$ and $q^*(s,z,\upsilon)$, define as

$$q(s,z,\upsilon) = E_{s,z\notin\Delta(\upsilon)}(m) \qquad \text{and} \qquad q^*(s,z,\upsilon) = E_{s,z\notin\Delta(\upsilon)}(m^*) \tag{9}$$

To illustrate firms' trade-off between the difference in the risk-free rates in local and foreign currency and exposure to currency risk, consider that investors discount each future state of the world equally and, hence, m and m^* are non-stochastic. In the case, we can write the risky bond prices as:

[16] The literature has proposed various channels for this difference, ranging from differences in country size (Hassan 2013), financial development (Maggiori 2017), in disasters risk (Farhi and Gabaix 2016), consumption risk (Lustig and Verdelhan 2006). Note that the study of the origin of this difference is out of the scope of this paper.

[17] 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.

$$q(s,z,\upsilon) = \frac{1 - P_{z,s}(\Delta(\upsilon))}{1+r} \qquad \text{and} \qquad q^*(s,z,\upsilon) = \frac{1 - P_{z,s}(\Delta(\upsilon))}{1+r^*}. \tag{10}$$

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 and, hence, their cost of funds in local and foreign currency. 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.[18]

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: $V_e(s,\chi) \geq p\,c_e$.

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 and entrants such that: bond prices, the value function, capital holdings, debt, and the default set satisfy the firm's optimization problem, and 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.[19]

3.3 Firms' Optimal Decisions

To illustrate firms' choices, we present the Euler equations for capital, local and foreign currency debts:[20]

[18]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.

[19]Appendix A.1 describes this equilibrium formally.

[20]See Appendix A.1 for the analytical derivations. For expositional simplicity, in equations (11) to (14), 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,

$$k': \underbrace{\underbrace{-p\left(1+\frac{\partial\psi(k,k')}{\partial k'}\right)}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial k'}b' + \frac{\partial q^*(\upsilon')}{\partial k'}sb'^*}_{\text{indirect bond price effect}}}_{\text{total cost}} = \beta \underbrace{E_{z',s'}[p(\alpha z' k'^{\alpha-1} + (1-\delta) - \frac{\partial\psi(k',k'')}{\partial k'})(1-\Delta(\upsilon'))]}_{\text{expected benefit}}, \quad (11)$$

$$b': \quad \underbrace{\underbrace{q(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'}b' + \frac{\partial q^*(\upsilon')}{\partial b'}sb'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \leq \beta \underbrace{E_{z',s'}[1(1-\Delta(\upsilon'))]}_{\text{expected cost}}, \quad (12)$$

$$b'^*: \quad \underbrace{\underbrace{sq^*(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'^*}b' + \frac{\partial q^*(\upsilon')}{\partial b'^*}sb'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \leq \beta \underbrace{E_{z',s'}[s'(1-\Delta(\upsilon'))]}_{\text{expected cost}}. \quad (13)$$

Equation (11) 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 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, as next-period capital affects future repayment likelihood.

Equations (12) and (13) 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. Importantly, 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 (equation (10)). 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 (11)-(13) 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.

and to show that the model's implications hold true independently of the fixed credit costs.

Mechanism: Foreign Currency Borrowing Decisions
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 (7) and equations (12)-(13) to rewrite the Euler equation of foreign bonds relative to local bonds as follows (see analytical derivation in Appendix A.1):

$$\underbrace{(\theta-1)\frac{\left[1-E_{z',s'}(\Delta(\upsilon'))\right]}{(1+r)}}_{\text{relative benefit of FC debt}}-\underbrace{\left[\left(\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'^{*}}\frac{1}{E(s'|s)}-\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'}\right)\left(\frac{b'}{(1+r)}+\frac{sb'^{*}}{(1+r^{*})}\right)+\beta\frac{cov_{|z',s'}(s',1-\Delta(\upsilon'))]}{E(s'|s)}\right]}_{\text{relative cost of FC debt}}\leq 0. \tag{14}$$

Note that, to illustrate analytically the intuition, we kept in equation (14) m and m^{*} constant.[21] The first term in equation (14) arises from the UIP deviation and shows 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 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 (14) holds with equality. We present below two lemmas that summarize firms' foreign currency borrowing decisions. The analytical derivations of these lemmas are presented in Appendix A.1.

-Lemma 1. Selection into foreign currency borrowing: Only highly productive firms borrow in foreign currency. Given the state υ, the share of foreign currency borrowing increases in firms' productivity.

To see the intuition behind this lemma, note that equations (4) and (5) define a productivity level below which a firm –with state υ' and the exchange rate realization s'– has negative equity and defaults. Given the persistence of the productivity shock, highly productive firms today are more likely to be above this productivity level next period. Therefore, the higher a firm's productivity, the easier is to tolerate the currency risk and the less increases its default probability when issuing foreign bonds, for a given υ' and s'. Importantly, there is a productivity threshold below which the increase in default

[21] As we show in Section 6.4 keeping m and m^{*} constant does not affect the mechanism of the paper, but allow us to show the mechanism analytically in a simple manner.

probability is sufficiently high that the optimal decision is not to issue foreign currency debt.

-Corollary 1: Firms borrowing in foreign currency have higher investment rates.
Firms borrowing in foreign currency enjoy lower financing costs that allow them to rise 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, for a given state υ.
As shown in equation (14), higher UIP deviations increase the relative benefit of issuing foreign bonds, allowing firms 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 (14) 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, encouraging higher investment.

4 Calibration and Non-Targeted Moments

We calibrate the model to match data moments in Hungary in 2005 –i.e. the first year for which the dataset reports information on foreign currency loans. 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).

We conduct the simulation in three steps. First, we simulate an economy without foreign currency debt and find the stationary distribution of firms. This first step gives an initial condition for the economy prior to the deregulation of foreign currency loans. Second, we solve an economy with foreign currency borrowing and obtain firms' optimal capital, and local and foreign currency debt policies. Finally, we simulate approximately 160,000 firms starting from the distribution without foreign currency debt (which is the number of firms we observe in Hungary), using the realized 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. We fix the discount factor of both local and foreign investors to be constant such that $m = \frac{1}{1+r}$ and $m^* = \frac{1}{1+r^*}$. We set the risk-free rate in foreign currency (r^*) to 1.73%, 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. Note that although in this specification the risk-free interest rates do not move with the aggregate shock, the deviation from the UIP (θ) is still a function of the exchange rate. In particular, for the period analyzed, the model generates -on average-a deviation of 1.052, closed to the deviation observed in the data of 1.054. In Section 6.4, we model the discount factor as a stochastic function of the aggregate shock –i.e. the exchange rate– and show that this assumption does not affect the mechanism proposed in the paper.

We employ equation (1) to estimate the exchange rate process between 1992 to 2015. The estimated value for ρ_s is 0.86 and for 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 follow Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2012) and Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017) and 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. Based on this regression, we set $\rho_z = 0.63$ and $\sigma_z = 0.57$. We let the depreciation rate (δ) be 10% and the elasticity of capital (α) be 0.6, which is the value estimated for Hungarian firms. We set the exchange rate pass-through onto local firms' prices to zero (η), 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. In Section 6.4, we calibrate η and show that the models' mechanism remains valid.[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.

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.

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 (6% in the model vs in the data), and only borrowing in foreign currency (2% in the model vs 3% in the data).

[22]There is a long literature on 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), among others.

[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 discount rate $\left(m^* = \frac{1}{1+r^*}\right)$	$r^* = 1.76\%$	German Bund, 1 year rate
Domestic currency discount rate $\left(m = \frac{1}{1+r}\right)$	$r = 7.35\%$	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.

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. Notably, firms that only borrow in foreign currency are 7% more productive in the model and 5% in the data. Interestingly, these have lower level of capital both in the model and the data. Their high productivity and low capital indicates that these firms have high MPK, which is consistent with an intensive use of cheap foreign loans to expand their investment.

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 employing both types of financing see investment rates of 18% both in the model and the data; whilst 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]

[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.

Table 3: Non-Targeted Moments

Moment	Group	Model (1)	Data (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 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.

Mechanism: Foreign Currency Borrowing Decisions

To illustrate firms' trade-off between aggregate deviations from the risk-free UIP and idiosyncratic cost of funds, 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. Note, first, that 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.

-Lemma 1. Selection into foreign currency borrowing: Only highly productive firms borrow in foreign currency. Given the state υ, the share of foreign currency borrowing increases in firms' productivity.

Figure 3 (left panel) plots bonds' price schedule for high and low productivity firms and shows that the drop in prices is slower for more productive firms. These firms 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. 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. It shows that only above a certain productivity

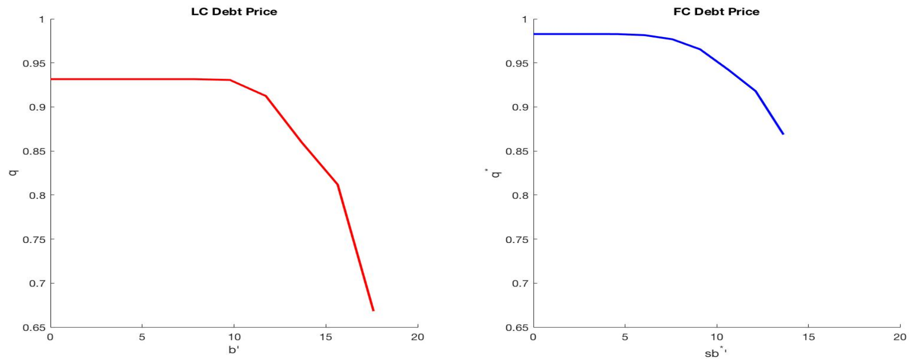


Figure 2: Domestic and Foreign Currency Bond Price

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.

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.

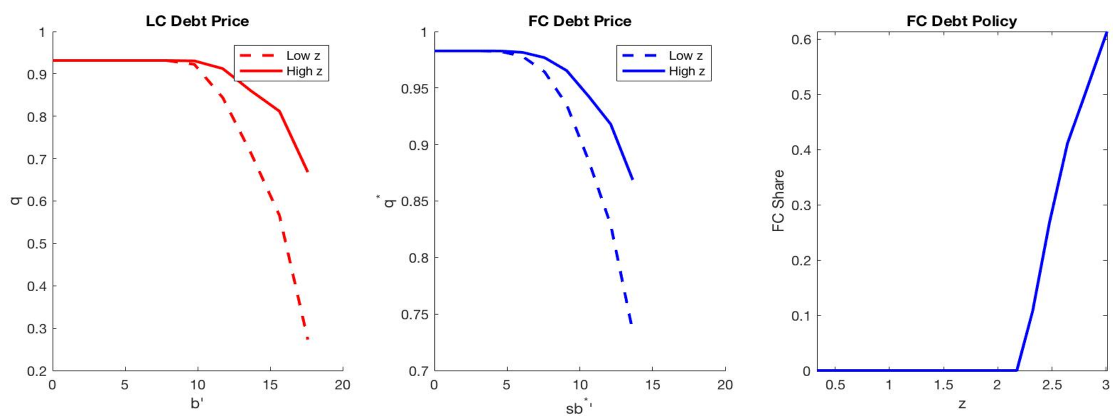


Figure 3: Domestic and Foreign Currency Bond Price

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, for a given state υ.

To illustrate this lemma, 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.

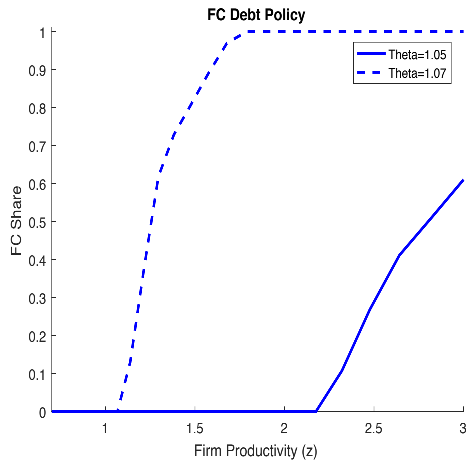


Figure 4: Deviation from the risk-free UIP and Share of Foreign Currency Loans

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 describe the deregulation of foreign currency loans in Hungary, assess selection 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 Investment

5.1.1 Deregulation of Foreign Currency Loans in Hungary

Lemma 1 states that foreign currency borrowing decisions correlate with firms' productivity and that firms employ this financing to expand their investment. To assess this lemma, we exploit the deregulation of foreign currency loans in Hungary in 2001, as an arguably exogenous source of time variation.

Prior to 2001, foreign currency loans were regulated by the Act XCV of 1995. As Varela (2018) shows, this law treated foreign and domestically-owned firms asymmetrically. Whilst foreign firms were legally allowed to hold foreign denominated loans, home firms were restricted to borrow locally in national currency. In 2001, the ban on home firms' foreign currency loans was removed and home firms were thereafter allow to borrow in foreign currency. Our empirical strategy to identify the pre-reform characteristics and investment behavior of firms borrowing in foreign currency focuses on those firms that gain access to foreign currency loans upon the reform, i.e., home firms. This allows us to address reverse causality concerns that could arise from firms using foreign currency loans to increase their productivity. To address this concern, we restrict our analysis to home firms.

The general context around the deregulation of foreign currency loans and its timing makes it likely to be exogenous with respect to the main outcome analyzed, i.e. home firms' decisions to borrow in foreign currency. The reform was driven by the accession of transition economies to the EU. The requirements to join the EU were predetermined by the Copenhagen Criteria in 1993 and have been equal for all accessing countries since then. In this sense, the content of the reform was exogenous to the country's political choice. As the agenda was jointly determined by the European Council and the candidate countries, it is unlikely to have been driven by political pressure from Hungarian firms. Furthermore, given the speed of the reform, it is unlikely that firms anticipated it and increased their productivity in advance.[26] Importantly, Hungary did not join the Euro zone and, hence, did not have to fulfill any monetary or fiscal criteria. Furthermore, the EU did not require any additional reform that could affect Hungarian firms' foreign currency borrowing decisions (see Varela 2018). Note as well that the Hungarian economy was already deeply integrated with the EU, as exports to the EU already accounted for 80% of total exports in 2001, and trade with the EU did not increase upon the reform (Figure B.9). Finally, FDI and trade remained constant during this period (Figures B.8 and B.10).[27]

5.1.2 Firms' Characteristics

We assess Lemma 1 by studying whether home firms' pre-reform productivity correlates with the probability of borrowing in foreign currency and share of foreign currency loans after the reform. We estimate the following linear probability regression:

$$\text{FC Dummy}_i = \beta \log \text{Productivity}_i + \varepsilon_i, \tag{15}$$

where FC Dummy_i is a dummy indicating whether a firm had a foreign currency loan in 2005, and Productivity_i represents the firm's productivity in the year 2000 prior to the deregulation of foreign currency loans. It represents z_i of the model's simulated data, and firm's RTFP in the Hungarian data.[28] We create the foreign currency loan dummy for 2005 because the Hungarian debt data only

[26]In December 2000, the European Council defined the timing for the accession vote and the last requirements to be met by each candidate. The reform had to take place before the accession vote in December 2002. Soon after the European Council meeting, in March 2001, Hungary deregulated foreign currency loans. Note that from the fourteen candidates only ten countries joined the EU in 2004 (Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia).

[27]Varela (2018) shows that domestics exporters and non-exporters do not expand differentially during this period, and that there are no significant changes in firms ownership structure after 1996. Finally, foreign firms entering the market represented less than one percent of firms and this share remained constant over the period under analysis.

[28]Note that the difference between physical and revenue TFP is –to a certain degree– second order in our analysis since –as shown by Foster, Haltiwanger, and Syverson (2008)– these measures are highly correlated in the cross-section.

starts in 2005 and this allow us to make a direct comparison with the Hungarian debt data.[29] The regressions estimated for Hungary consider three additional features. First, we include four-digit NACE industries fixed effects that allow comparing firms within narrow industries and control for sectoral time-invariant characteristics. Second, in our baseline specification, we exclude exporters (as they could be naturally hedged) and include them later in a robustness test. Finally, we cluster standard errors at four-digit industries to account for cross-sectional serial correlation within sectors. To assess whether more productive firms employ foreign currency loans more intensively, we additionally estimate equation (15) using firms' log share of foreign currency loans in 2005. The coefficient of interest is β and captures whether firms that were more productive prior to deregulation of foreign currency borrowing have a higher probability of using this financing and share of foreign currency loans after it.

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 0.02 percentage points. 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***	0.020***	0.012***	0.012***	0.011***	0.005***	0.003**
	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)	(0.002)	(0.001)
Log capital		0.007***		0.032***		0.002***		0.009***
		(0.001)		(0.002)		(0.000)		(0.001)
Sector FE			Yes	Yes			Yes	Yes
R^2	0.008	0.009	0.028	0.053	0.006	0.006	0.028	0.035
N	156,806	156,806	33,327	33,327	156,806	156,806	33,327	33,327

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 and confirm the relationship between productivity and foreign currency borrowing. The model implies that a one percent increase in firms' productivity raises the share of foreign currency loans by 0.01 percent (column 5). As above, the coefficient in column 6 remains stable when including the initial capital stock as a control.

Furthermore, in all our empirical exercises, we employ RTFP in a given year as a proxy for firms' initial productivity (i.e. we do not study changes in QTFP or RTFP across time).

[29] Given that the Hungarian credit data only starts in 2005, in this exercise, we are limited to estimate a cross-sectional regression. In section 5.2, we exploit the panel dimension of the data between 2005 and 2010 to study firms' foreign currency borrowing decisions over time.

The regressions estimated using the Hungarian data confirm these results, as shown in columns 7 and 8. The coefficient on RTFP 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 0.005 percent, and is robust to controlling for firms' capital.[30]

Table B.2 (in Appendix B.2) presents a full set of robustness tests. Column 1 includes exporters and shows that the estimated coefficients remain stable and highly statistically significant when including them into the analysis. Column 2 controls for firms' local currency leverage prior to the deregulation, as firms with better initial access to bank credit might find it easier to access to foreign loans. The coefficients remain highly significant and similar in size than those in the baseline specifications. Column 3 shows that results are robust to controlling for firms' age. Column 4 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 5 to using labor productivity as a proxy for firms' productivity. Column 6 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 break down loans by their currency denomination and show that all the model's implications hold true.

5.1.3 Firms' Investment

Corollary 1 predicts that firms borrowing in foreign currency have a higher investment rate as they can borrow at lower financing terms. To assess this corollary, we exploit the deregulation of foreign currency loans and study whether domestic firms borrowing in foreign currency have higher investment rates within the five years before and after the reform. We consider the following regression:

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

where $\log Y_{it}$ denotes log investment rate between 1996-2005, R_t is a dummy for the post-reform period ($\mathrm{R}_t > 1$ if year$\geq$ 2001, and 0 otherwise), ι_t are year-fixed effects that capture year-specific shocks 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 interacted with the foreign currency debt dummy ($T_t\,\mathrm{x}\,\mathrm{FC\,Dummy}_i$). The final regression that we estimate is:

$$\log\, Y_{it} = \beta\,(\mathrm{R}_t\,\mathrm{x}\,\mathrm{FC\,Dummy}_i) + \iota_t + \phi_i + (T_t\,\mathrm{x}\,\mathrm{FC\,Dummy}_i) + \varepsilon_{it}. \tag{16}$$

[30]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.

The coefficient of interest is β and captures whether firms borrowing in foreign currency have higher a investment rate 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.

Table 5 presents the results. 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 enjoy higher investment rates. After the inclusion of pre-growth trends in column 2, the model implies that these firms had a 13.8 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 7.1 percent higher investment rate (column 4). Table B.3 shows that results are robust to including exporters and to considering sales as dependent variable. In particular, firms borrowing in foreign currency experienced a 6 and 5 percent differential increase in sales after the reform, in the model and the Hungarian data.

Table 5: Foreign Currency Borrowing and Investment

	Log Investment Rate			
	Model		Data	
	(1)	(2)	(3)	(4)
R*FC dummy	0.321***	0.138**	0.207***	0.071***
	(0.032)	(0.061)	(0.020)	(0.027)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
FC d.*time trend		Yes		Yes
R^2	0.218	0.218	0.511	0.512
N	1,568,060	1,568,060	393,149	393,149

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

Results presented in this section show that the model reproduces quantitatively well the responses of Hungarian firms. In the next section, we advance our analysis 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.

5.2.1 Foreign Currency Borrowing Decision

We assess the relationship between UIP deviations and foreign currency borrowing in three steps. First, we check whether these deviations associate with increases in foreign currency borrowing at the firm-level. Second, we evaluate whether these responses are 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. 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:

$$Y_{it} = \beta \log \text{UIP}_t + \phi_i + \varepsilon_{it}, \tag{17}$$

where Y_{it} is either the foreign currency debt dummy or the log share of foreign currency borrowing between 2005 and 2010, i.e. FC Dummy_{it} or Log FC Share_{it}. To control for valuation effects that could arise from the foreign currency share moving contemporaneously with the exchange rate, we construct the share of foreign currency loans in each year by employing the exchange rate of the previous year. Below we add robustness without this control. Log UIP_t is the log of the deviation from the risk-free UIP during this period (the log of θ in the model). When using 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.[31] 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. Since foreign currency borrowing of exporters and foreign firms might be driving by other considerations, we exclude them in our baseline regressions and add robustness tests with them. The coefficient β in equation (17) captures whether higher UIP deviations associate with increases firms' probability of borrowing in foreign currency and share of foreign currency debt.

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

$$Y_{it} = \beta \log(\text{UIP}_t \text{ x } \text{Productivity}_i) + \phi_i + \iota_t + \varepsilon_{it}, \tag{18}$$

where Productivity_i is firm's initial productivity (z_i or RTFP_i) in 2005 and ϕ_i are firm-fixed effects that capture all time invariant firm and sector characteristics. To control for demand specific shocks that can affect sectors differently over time, we include four-digit NACE industry and year fixed effects interacted when using the Hungarian data. We cluster the standard errors at year and four-digit NACE industries. The coefficient β in equation (18) captures whether more productive firms differentially increase their use of foreign currency loans following 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

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

in 2005.[32] We create the following four bins: high productivity firms with low capital (Q_{HL}), high productivity firms with high capital (Q_{HH}), low productivity firms with low capital (Q_{LL}), and low productivity firms with high capital (Q_{LH}). 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 idiosyncratic risk and high growth potential. When using the Hungarian data, 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). More precisely. we estimate the following regression:

$$Y_{it} = \beta_1 \log(\text{UIP}_t \text{ x } Q_{HLi}) + \beta_2 \log(\text{UIP}_t \text{ x } Q_{HHi}) + \tag{19}$$
$$\beta_3 \log(\text{UIP}_t \text{ x } Q_{LLi}) + \beta_4 \log(\text{UIP}_t \text{ x } Q_{LHi}) + \phi_i + \iota_t + \varepsilon_{it}.$$

The estimated coefficients $\beta_1, \beta_2, \beta_3$ and β_4 in regression (19) capture the differential response of each bin to changes in the UIP deviation.[33]

Columns 1-3 in Table 6 present the results of regressions (17)-(19) 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 0.119 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 0.17 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.

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

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

[33]Note that, since all these variables are dummies interacted with the UIP deviation (common to all of them), it is not necessary to standardized the beta coefficients.

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

	Model			Data		
	Panel A. FC Dummy					
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.071**			0.119***		
	(0.028)			(0.019)		
Log (Dev. UIP x Productivity)		0.055***			0.039***	
		(0.014)			(0.009)	
Log (Dev. UIP x Q_{HL})			0.246***			0.170***
			(0.029)			(0.034)
Log (Dev. UIP x Q_{HH})			0.230***			0.047
			(0.025)			(0.046)
Log (Dev. UIP x Q_{LL})			0.180***			0.053*
			(0.025)			(0.031)
Log (Dev. UIP x Q_{LH})			0.177***			0.078*
			(0.016)			(0.044)
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	0.21	0.742	0.688	0.743
N	1,005,783	1,005,783	1,005,783	892,584	892,584	892,584
	Panel B. Log Share of Foreign Currency Loans					
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.063***			0.071***		
	(0.015)			(0.011)		
Log (Dev. UIP x Productivity)		0.022***			0.023***	
		(0.008)			(0.005)	
Log (Dev. UIP x Q_{HL})			0.177***			0.074***
			(0.018)			(0.017)
Log (Dev. UIP x Q_{HH})			0.148***			0.047**
			(0.015)			(0.024)
Log (Dev. UIP x Q_{LL})			0.170***			0.009
			(0.015)			(0.018)
Log (Dev. UIP x Q_{LH})			0.117***			0.062**
			(0.010)			(0.025)
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	0.208	0.716	0.655	0.718
N	1,005,783	1,005,783	1,005,783	892,584	892,584	892,584
	Panel C. Log Investment Rate					
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.099***			0.080***		
	(0.027)			(0.029)		
Log (Dev. UIP x Productivity)		0.190***			0.330***	
		(0.031)			(0.020)	
Log (Dev. UIP x Q_{HL})			4.708***			0.213***
			(0.026)			(0.076)
Log (Dev. UIP x Q_{HH})			1.032***			0.169*
			(0.027)			(0.087)
Log (Dev. UIP x Q_{LL})			0.079***			0.108*
			(0.025)			(0.065)
Log (Dev. UIP x Q_{LH})			-5.598***			-0.020
			(0.027)			(0.079)
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	0.027	0.041	0.709
N	1,005,783	1,005,783	1,005,783	436,455	436,455	436,455

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

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 0.074 percent.

We conduct five robustness tests. First, we show that these results are robust to include exporters and foreign firms (Table B.4 in Appendix B). Second, results on the foreign currency share are robust to not controlling for valuations effects, and to computing this share with the current exchange rate (Table B.5). Third, we construct a measure of firms' MPK and regress equation (18) using this measure (Table B.6). Fourth, we control for differential exchange rare pass-through across sectors (Table B.7). Finally, we test whether these decisions correlate with firms' age. Since young firms are farer away from their optimal scale of production, one would expect that young and productive firms take greater advantage of UIP deviations. We follow a similar procedure as above and create four bins between productivity and age. Table B.8 in Appendix B shows that young and productive firms have the largest response to these deviations.[34]

5.2.2 Firms' Investment

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 (17)-(19) using the log of the investment rate and sales as dependent variables.

Panel C in Table 6 presents the results on firms' investment. Column 1 reports the estimated coefficient of equation (17) employing the simulated data. The model implies that a one percent increase in the UIP deviation leads to an expansion of 0.099 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 and show that the coefficients are statistically significant and similar in size to the model's estimates. Column 4 shows that a one percent increase in the UIP deviation leads to 0.08 percent increase in firms' investment rate. This expansion is higher for high MPK firms, which see a differential increase of 0.213 percent following a one percent increase in the UIP deviation (column 6). Appendix B report four robustness tests. First, Table B.4 shows that results are robust to including exporters and foreign firms. Second, Table B.6 confirms these results using the continuos measure of MPK. Third, we show that young and productive firms expand their investment rate relatively more (Table B.8). Finally, we show that results are consistent with expansions in firms' sales (Table B.10).

Results in this section confirm the model's mechanism by showing that UIP deviations correlate with a higher probability of borrowing in foreign currency, share of foreign currency loans and investment rate, especially for high MPK firms.

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. We assess this implication using the following regression

[34] Additionally, to test whether the productivity threshold to borrow in foreign currency drops following UIP deviations (as stated in Lemma 2), we estimate a regression of the productivity of firms borrowing in foreign currency on UIP deviations. Results presented in Table B.9 in Appendix B confirm that the average productivity of firms borrowing in foreign currency decreases following these deviations.

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

where Y_{it} denotes the model-implied interest rates ($1/q - 1$ and $1/q^* - 1$), 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.[35] Since the Hungarian data on interest rates is only available in 2005, we estimate the regression on the simulated data for that year.

Columns 1 and 2 in Table 7 present the results using the simulated data and shows that firms borrowing in foreign currency pay approximately one percentage point lower interest rates. Columns 3-5 report the estimated coefficients for Hungarian firms. Similar to the model's estimates, 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.[36]

Table 7: Interest Rate

	LC Interest Rate	FC Interest Rate	Interest Rate		
	Model		Data		
	(1)	(2)	(3)	(4)	(5)
FC Dummy	-0.016***	-0.013***	-0.011**	-0.009*	-0.009*
	(0.001)	(0.001)	(0.005)	(0.004)	(0.006)
Firm Level Controls					Yes
Sector FE				Yes	Yes
R^2	0.002	0.003	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. Column 1 and 2 derive firms' implicit interest rate from the price of their LC and FC bonds. 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.

6 Aggregate Implications

In this section, we build on from firm-level decisions to quantify the aggregate impact of foreign currency borrowing and to conduct policy experiments and sensitivity analysis. We start by showing that firm heterogeneity is key to understand the aggregate consequences of this financing in two steps. First, we quantify the effect of foreign currency borrowing by comparing an economy with and without this financing (Section 6.1). Second, we explore the role of productivity and capital heterogeneity in firms' choices by comparing economies where firms use foreign currency debt independently of their levels of productivity and/or capital (Section 6.2). We turn next to asses how differences in country's characteristics can affect the aggregate implications of foreign currency loans by conducting policy experiments on the role of the financial sector, economic development and exchange rate policy (Section 6.3). Finally,

[35]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.

[36]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.

in Section 6.4, we present the sensitivity analysis of the numerical exercises by considering a stochastic discount factor, an aggregate shock and the exchange rate pass-through.[37]

6.1 Impact of 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 8 display the results for the economy with and without foreign currency borrowing, respectively. Panel A presents firm-level results and shows that foreign currency borrowing relaxes firms' financing constraint, which allows firms to have 22% higher investment rates and be -on average- larger than in an economy without foreign loans. In particular, the investment rate is 10.8% with foreign borrowing, whilst it is only 8.5% when firms can only borrow in local currency. Additionally, our results show that, in the economy with foreign borrowing, firms see a 20% lower default rate. This higher resilience stems from the dynamic nature of our model. Whilst foreign borrowing increases a firm's current risk, it also allows the firm to accumulate more capital and better tolerate both productivity and exchange rate shocks.[38]

Panel B reports the aggregate results and illustrates that an economy with foreign currency borrowing has 11% higher sales and 16% more capital. Yet this higher level of sales and capital comes to the expense of volatility arising from the exposure to the exchange rate shock.[39]

While the previous literature has focused on the balance sheet effects of foreign currency borrowing, our joint treatment of firms' currency debt choice and investment behavior allows us to quantify ?for the first time- the dynamic the trade off between currency-risk taking and growth. As shown above, in Hungary foreign currency borrowing led to higher volatility, but it also increased investment and the aggregate level of sales and capital. Moreover, our heterogeneous firm dynamic model enables us to decompose the importance of productivity and capital in generating these aggregate effects. In the next section, we present this decomposition exercise.

[37]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. 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.

[38]Interestingly, this lower exit rate is consistent with the empirical evidence of Hungarian firms showing that, following the depreciation of the local 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. 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.

[39]Note that an economy without foreign currency borrowing does not experience aggregate volatility, as it is not affected by exchange rate shocks and firm-idiosyncratic shocks average out on the aggregate.

Table 8: NUMERICAL EXERCISES

	Benchmark	No FC Borrowing	No Heterogeneity in Prod. and Capital	No Heterogeneity in Productivity	No Heterogeneity in Capital
	(1)	(2)	(3)	(4)	(5)
			Panel A. Firm-level results		
FC debt share	12.1	-	40.8	7.8	40.8
Investment rate	10.8	8.5	8.9	9.8	15.4
E(K)	19.9	17.6	23.2	17.8	31.2
Default rate	2.8	3.5	8.3	3.7	6.8
Productivity threshold	1.2	-	-	-	-
			Panel B. Aggregate results (wrt column 1)		
Sales	100.0	89.2	74.7	87.7	100.8
Capital	100.0	84.3	73.6	83.4	114.9
Coef. of var. sales	100.0	-	425.3	19.3	121.4
Coef. of var. capital	100.0	-	255.6	72.2	419.1

Notes: Rows 1, 2 and 3 are in percentage. Rows 6-9 are with respect to column 1. Rows 6 and 7 are in levels, rows 8 and 9 present the coefficient of variation. Columns 1-5 show the moments for an economy with and without foreign currency borrowing, and with no heterogeneity in productivity and capital. 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 *The Role of Productivity and Capital Heterogeneity in FC Borrowing*

To understand the importance of productivity and capital heterogeneity on the aggregate impact of foreign currency borrowing, we perform three counterfactual exercises. In these exercises, we make firms' decision to borrow in foreign currency to be independent of their level of productivity and/or capital. In the first exercise, we restrict the heterogeneity in both productivity and capital, and force all firms to hold the same of leverage in foreign currency. In the second exercise, we assess the importance of heterogeneity in productivity and let only high capital firms to borrow in foreign currency. In the third exercise, we study the role of capital heterogeneity and let only high productivity firms use foreign loans. For comparison, in all exercises, we set firms' foreign currency leverage to imply the same aggregate share of foreign currency debt than in the benchmark economy.

Column 3 in Table 8 presents the results of our first exercise, where firms can not choose their exchange rate exposure as a function of their productivity and capital. Panel A shows that firms' investment rate is 20% lower than in the benchmark calibration (8.9% vs 10.8%), and the default rate is three-times larger (8.3% and 2.8%). When firms can not choose their exposure to the currency risk and all borrow in foreign currency, less productive and/or smaller firms cannot tolerate exchange rate shocks and default. Since surviving firms are larger and closer to their optimal scale, they invest less. Panel B shows that, on the aggregate, this economy has 25% lower sales and capital and is significantly more volatile than in an economy where firms can choose their exposure to the currency risk according to their productivity and capital levels. This exercise highlights two consequences of ignoring firm heterogeneity: balance sheet effects causing higher default and capital misallocation lowering investment. Next, we turn off productivity and capital separately to assess the importance of each dimension of heterogeneity in generating these effects.

In our second exercise, we assess the role of productivity by letting only high capital firms (those in the top decile of the capital distribution in the benchmark calibration) to borrow in foreign currency, regardless of their productivity. Column 4 in Table 8 displays the results. Since firms with high capital but low productivity also borrow in foreign currency, investment is 10% lower and default is 50% higher. On the aggregate, the economy has lower 13% lower sales and 17% lower capital. This exercise shows that not accounting for productivity heterogeneity and allocating foreign loans to high capital firms leads to significant capital misallocation, as it would allocate credit to large but unproductive firms.

Finally, in our third exercise, we study the importance of capital by assigning foreign currency debt only to high productivity firms (those in the top decile of the productivity distribution in the benchmark economy), independently of their capital. Since foreign currency borrowing is now also held by productive but small capital firms, which are riskier and have higher needs of capital, investment increases 50% while defaults surges 140% (column 5 in Table 8). On the aggregate, the economy has higher level of capital, but at the expense of a four-fold increase in volatility. This exercise shows that allocating foreign currency debt to high productivity firms, regardless of their capital, leads to significant balance sheet problems, as small firms might not be able to tolerate the currency risk implied by foreign borrowing.

These exercises demonstrate that accounting for heterogeneity in capital and productivity is essential to understand the trade-off between currency risk and growth implied in firms' foreign currency borrowing decisions. A model abstracting from heterogenous productivity would understate growth potential, as foreign currency borrowing could create misallocation towards large and unproductive firms. A model abstracting from heterogenous capital would amplify balance sheet effects, as small firms might find it difficult to tolerate the currency risk.

6.3 Policy Experiments

So far, we assessed firms' foreign currency borrowing decisions for a given country. We turn now to evaluate how differences in individual country's characteristic can affect firms' choices. In particular, we study how firms' currency debt decisions depend on the local level of financial development, the level of economic development of the country and its exchange rate volatility.

-Financial Development. To study how the local level of financial development affects foreign currency borrowing decisions, we consider two counterfactual exercises. First, we analyze an economy where creditors can not observe firms' productivity and, hence, are uncertain about firms' implicit risk. In particular, the creditor observes the aggregate exchange rate shock and a firm's choice (k', b', b'^{*}), but she can not observe a firm's idiosyncratic productivity shock. In order to price bonds, the creditor forms a belief over the distribution of a firm's next period productivity. We let creditors believe that a firm's probability distribution of the next period shock is independent of the current productivity shock

and is equal to the unconditional average of the true distribution.[40] Column 2 in Table 9 shows that the investment rate drops, firms are smaller and borrow less in foreign currency. Since creditors infer a lower expected productivity and a higher probability of default for productive firms than under the true distribution, they quote them a lower bond price than in the benchmark specification. This higher financing cost undermines investment and foreign indebtedness.

Secondly, we let creditors observe the true conditional probability distribution of a firm's productivity, but firms misreport a higher productivity level than their current realization (one grid point ahead in the discretization of the productivity shock). This implies that the investor's probability distribution of the firm's next period shock is biased towards higher productivity. In Table 9 column 3, we show that, since firms less productive firms start to borrow in foreign currency, the share of foreign currency loans increases and the productivity threshold drops. However, since many firms are not able to tolerate the currency risk, the default significantly increases and investment substantially drops.

These exercises show that lower level of financial development lowers investment and increases balance sheet problems, which undermines the benefit of foreign currency borrowing and raises its costs.

-*Economic Development.* To study the importance of capital scarcity, we simulate an economy with the same optimization as in the benchmark, but we change the initial firm size distribution towards larger firms. In particular, we truncate the initial distribution to have only the top 50% in size firms and re-scale it such that the number of firms is the same as benchmark. Column 3 in Table 9 displays the results for this economy. Since firms are less capital scarce than the benchmark economy we observe 25% lower investment. Furthermore, as firms are larger and more resilient to shocks, the default rate drops 22%. This exercise shows that the higher volatility implied in foreign currency borrowing depends on the economic development of the economy. The more capital-scarce is the economy, the higher growth and balance sheet effects it observes when allowing firms to employ this financing.

-*Exchange Rate Policy.* 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. We turn now to study how this volatility affects firms' decisions and present the results in Table 9. We first lower the standard deviation of the exchange rate shock to be half of the value in the benchmark economy ($\sigma_s = 0.15$ vs $\sigma_s = 0.30$) and show that lower volatility increases by more than three-fold firms' optimal share of foreign currency debt (column 4). 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. We then set the standard deviation to 50% higher than the value in the benchmark economy ($\sigma_s = 0.45$) higher volatility led 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. This exercise illustrates the exchange

[40]Formally, define $\tilde{p}(z'|z)$ as an creditor's belief about the probability distribution of a firm's next period productivity given the current shock. Since the creditor believes that this distribution is independent of the current productivity shock $\tilde{p}(z'|z) = \tilde{p}(z)$. The unconditional average of the true distribution becomes $\tilde{p}(z_i) = \frac{\sum_{j=1}^{N} p(z_i|z_j)}{\sum_{i=1}^{N}\sum_{j=1}^{N} p(z_i|z_j)}$, where i and j are the idiosyncratic productivity state.

rate policy plays a big role in firms' foreign currency borrowing decisions. The less the exchange rate fluctuates, the more intensively firms borrow in foreign currency and the more susceptible the economy becomes to large swings in the exchange rate.

Table 9: Policy Experiments

	Benchmark	Financial Development		Economic	ER Policy	
	($\sigma_s = 0.3$)	Unobserved z	Misreported z	Development	Low ($\sigma_s = 0.15$)	High ($\sigma_s = 0.45$)
	(1)	(2)	(3)	(4)	(5)	(6)
	Firm-level results					
FC debt share	12.1	8.0	13.7	12.8	42.9	0.0
Investment rate	10.8	10.4	8.16	8.2	11.9	9.5
E(K)	19.9	19.4	29.8	23	21.6	18.8
Default rate	2.8	2.9	3.6	2.2	2.5	3.1
Productivity threshold	1.2	1.2	1.17	1.2	1.0	1.3

Notes: Notes: Rows 1, 2 and 3 are in percentage. Columns 1 shows the moments for the benchmark calibration. Column 2 shows an economy with a low level of financial development. Column 3 present the results of an economy with larger firms. Column 4 and 5 report the results for low and high volatility of the exchange rate. 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.

6.4 Sensitivity Analysis

In this section, we conduct three sensitivity analysis. First, we allow investors to have a stochastic discount factor that depends on the aggregate state of the economy. Second, we add to this setting an aggregate productivity shock. Finally, we also relax the assumption of zero pass-through of exchange rate shocks into local prices.[41]

-Stochastic Discount Factor: Previous studies modeled deviations from the UIP as originating from foreign and local investors distinct aversion to the exchange rate risk (see Lustig and Verdelhan 2006). To incorporate this difference in risk aversion in our setting, we follow Engel and West (2005) and use exchange rate as a predictor of consumption. This makes our discount a simplified version of the consumption C-CAPM.[42] More precisely, we set $m = \beta_i \left(\frac{s'}{s}\right)^\gamma$, where β_i is the level of the discount and $\gamma > 0$ implies that investors value more payments when the exchange rate depreciates (i.e. a premium for firms that default on those states). Under this specification, investors' domestic discount rates m depend stochastically on the exchange rate, which makes the domestic interest rate move with it as well. Since Hungary is a small open economy, we do not let r^* move with the exchange rate, therefore

[41] 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.

[42] Lustig and Verdelhan (2006) build an aggregate model where the stochastic discount factor depends on the country's growth rate of non-durable consumption. While our model focuses on firm-level decisions and does not analyze the difference between durable and non-durable goods, our focus on non-tradable goods (which are non-durable) make our specification close to Lustig and Verdelhan (2006).

we set $m^* = 1/1+r^*$ as in the benchmark specification. We calibrate (β^i, γ)=(0.936, 1.02) to match the average and the variance of the local currency risk-free interest rate and the average deviation of the UIP observed in Hungary. Results are presented in Column 2 of Table 10 and show that the stochastic discount factor amplifies the mechanism implied by the model. In particular, the investment rate increases from 10.8% in the benchmark specification to 12.5%, as for half of our sample period the exchange rate was appreciated and the interest rate was lower than in the benchmark calibration. Since now investors charge a premium if the firm defaults during a depreciation, firms borrow less in foreign currency and the share of foreign currency loans decreases to 10.4%. This lower exposure allows the probability of default to not change significantly relative to the benchmark specification, even though investors are risk averse.

-Aggregate Productivity Shock: In our model, firms' sales are only affected by the firm's idiosyncratic productivity, so aggregate shocks do not directly affect a firm's revenue. To account for aggregate shocks, we add an aggregate productivity shock and evaluate its impact on firms' financing and investment decisions, in presence of investors having a stochastic discount factor. To keep the model tractable, we let the shock be a function of the exchange rate and define the aggregate productivity level as $Z = s^{-\zeta}$, where $\zeta > 0$. Firms' production function becomes $F(s, z, k) = s^{-\zeta} z k^{\alpha}$, which implies that, as the currency depreciates, income is lower and the firm experiences a lower state.[43] 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 $\zeta = 0.05$. Column 3 in Table 10 shows that aggregate shocks increase firms' risk and idiosyncratic costs of funds, which lowers their investment and increases default relative to column 2.

-Exchange Rate Pass-Through: We now relax the assumption of zero exchange rate pass-through into local prices, and assess pass-through in a setting with aggregate shocks and depreciation premium. To conduct this exercise, we set the exchange rate pass-through, η ($p = s^{\eta}$), to 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. Column 4 in Table 10 presents the results and shows that firms increase by more than two-fold their foreign currency share.[44] Since now firms revenue moves with the exchange rate, foreign currency debt is less risky, lowering the default rate and the productivity threshold to borrow in foreign currency relative to column 3.

[43] As shown by Engel and West (2005), the exchange rate is a good predictor of an economy's fundamentals, as this asset price incorporates expectations of future fundamentals. Note that if $\zeta = 0$ this collapses to our benchmark specification in Section 4.

[44] Note that balance sheet effects crucially depend on how exchange rate shocks affect firms' net revenues and debt repayment. While foreign currency debt repayment moves one-to-one with the exchange rate, the change in firms' net revenue depends on the pass-through. When $\eta < 1$ and there is imperfect pass-through firms' net revenue moves less than the foreign currency debt repayment and the firm sees balance sheet effects.

Table 10: Sensitivity Analysis: SDF, Aggregate Productivity Shock and ER Pass-through

	Benchmark	SDF	SDF + Aggregate Shock	SDF+ Aggregate Shock + Pass-Through
	(1)	(2)	(3)	(4)
	Panel A. Firm-level results			
FC debt share	12.1	10.4	10.4	24.3
Investment	10.8	12.5	12.0	12.0
E(K)	19.9	25.9	25.8	25.3
Default rate	2.8	2.8	3.0	2.5
Productivity threshold	1.2	1.2	1.2	1.1

Notes: Rows 1, 2 and 3 are in percentage. Columns 1 shows the moments for the benchmark calibration. Column 2 includes the investor's stochastic discount factor. Column 3 adds the SDF and an aggregate productivity shock. Column 4 includes the SDF, the aggregate productivity shock and the exchange rate 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 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:

$$\frac{\partial V^R(s,z,\upsilon)}{\partial k} = p\left[z\alpha k^{\alpha-1} + (1-\delta) - \frac{\partial \psi(k,k')}{\partial k}\right], \tag{20}$$

$$\frac{\partial V^R(s,z,\upsilon)}{\partial b} = -1, \tag{21}$$

$$\frac{\partial V^R(s,z,\upsilon)}{\partial b^*} = -s, \tag{22}$$

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:

$$k': \quad \underbrace{\underbrace{-p\left(1+\frac{\partial\psi(k,k')}{\partial k'}\right)}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial k'}b' + \frac{\partial q^*(\upsilon')}{\partial k'}sb'^*}_{\text{indirect bond price effect}}}_{\text{total cost}} = \beta \underbrace{\frac{\partial E_{z',s'}V(s',z',\upsilon')}{\partial k'}}_{\text{expected benefit}}, \tag{23}$$

$$b': \quad \underbrace{\underbrace{q(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'}b' + \frac{\partial q^*(\upsilon')}{\partial b'}sb'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \leq -\beta \underbrace{\frac{\partial E_{z',s'}V(s',z',\upsilon')}{\partial b'}}_{\text{expected cost}}, \tag{24}$$

$$b'^*: \quad \underbrace{\underbrace{sq^*(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'^*}b' + \frac{\partial q^*(\upsilon')}{\partial b'^*}sb'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \leq -\beta \underbrace{\frac{\partial E_{z',s'}V(s',z',\upsilon')}{\partial b'^*}}_{\text{expected cost}}, \tag{25}$$

where equations (24) and (25) hold with equality whenever $b' > 0$ and $b'^* > 0$, respectively. For expositional simplicity, in equations (24) and (25), we set the fixed credit costs to zero.[45]

[45]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 (23) 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 (24) and (25) 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 (20)-(22) into the first order conditions (23)-(25) to obtain following Euler equations for capital, local currency debt and foreign currency debt:

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

$$b' : \quad \underbrace{\underbrace{q(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'}b' + \frac{\partial q^*(\upsilon')}{\partial b'}sb'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \leq \beta\, \underbrace{E_{z',s'}[1(1-\Delta(\upsilon'))]}_{\text{expected cost}}, \tag{27}$$

$$b'^* : \quad \underbrace{\underbrace{sq^*(\upsilon')}_{\text{direct effect}} + \underbrace{\frac{\partial q(\upsilon')}{\partial b'^*}b' + \frac{\partial q^*(\upsilon')}{\partial b'^*}sb'^*}_{\text{indirect bond price effect}}}_{\text{total benefit}} \leq \beta\, \underbrace{E_{z',s'}[s'(1-\Delta(\upsilon'))]}_{\text{expected cost}}, \tag{28}$$

where $\Delta(\upsilon')$ is the set of exchange rate and productivity shocks for which a firm chooses to default. Equation (26) 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 (27) and (28) 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 (27)-(28), as a function of a firm's default probability. In particular,

$$b' : \; E_{s',z'\notin\Delta(\upsilon')}(m) + \frac{\partial E_{s',z'\notin\Delta(\upsilon')}(m)}{\partial b'}b' + \frac{\partial E_{s',z'\notin\Delta(\upsilon')}(m^*)}{\partial b'}sb'^* \leq \beta E_{z',s'}[(1-\Delta(\upsilon'))] \tag{29}$$

$$b'^* : \; sE_{s',z'\notin\Delta(\upsilon')}(m^*) + \frac{\partial E_{s',z'\notin\Delta(\upsilon')}(m)}{\partial b'^*}b' + \frac{\partial E_{s',z'\notin\Delta(\upsilon')}(m^*)}{\partial b'^*}sb'^* \leq \beta E_{z',s'}[s'(1-\Delta(\upsilon'))], \tag{30}$$

since

$$\frac{\partial q(\upsilon')}{\partial b'} = \frac{\partial E_{s',z'\notin\Delta(\upsilon')}(m)}{\partial b'} \qquad \text{and} \qquad \frac{\partial q^*(\upsilon')}{\partial b'} = \frac{\partial E_{s',z'\notin\Delta(\upsilon')}(m^*)}{\partial b'}$$

$$\frac{\partial q(\upsilon')}{\partial b'^*} = \frac{\partial E_{s',z'\notin\Delta(\upsilon')}(m)}{\partial b'^*} \qquad \text{and} \qquad \frac{\partial q^*(\upsilon')}{\partial b'^*} = \frac{\partial E_{s',z'\notin\Delta(\upsilon')}(m^*)}{\partial b'^*}$$

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 (30) and let equation (29) 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 (30)) 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 (29) and the UIP condition to rewrite the Euler equation of foreign bonds relative to local bonds as follows:

$$(\theta-1)E(m) - s\frac{\overline{E}(m^*)}{E(s'|s)} + \overline{E}(m) + \frac{\partial \overline{E}}{\partial b'^*}\frac{b'}{E(s'|s)} + \frac{\partial \overline{E}(m^*)}{\partial b'^*}\frac{sb}{E(s'|s)}{}'^* - \frac{\partial \overline{E}(m)}{\partial b'}b' - \frac{\partial \overline{E}(m^*)}{\partial b'}sb'^* - \frac{\beta cov_{|z',s'}(s', 1-\Delta(\upsilon'))}{E(s'|s)} \leq 0.$$

where $\overline{E} = E_{s',z'\notin\Delta(\upsilon')}$. In the case that m and $m^*$are constant and not dependent on the exchange rate shock this equation boils down to:

$$\underbrace{(\theta-1)\frac{\left[1-E_{z',s'}(\Delta(v'))\right]}{(1+r)}}_{\text{relative benefit of FC debt}}-\underbrace{\left[\left(\frac{\partial E_{z',s'}(\Delta(v'))}{\partial b'^*}\frac{1}{E(s'|s)}-\frac{\partial E_{z',s'}(\Delta(v'))}{\partial b'}\right)\left(\frac{b'}{(1+r)}+\frac{sb'^*}{(1+r^*)}\right)+\beta\frac{cov_{|z',s'}(s',1-\Delta(v'))]}{E(s'|s)}\right]}_{\text{relative cost of FC debt}}\leq 0. \tag{31}$$

Equation (31) 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 (31) 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. For exposure simplicity we will assume that m and m^* are constant and not dependent on the exchange rate shock.

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:

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

$$\tilde{z}'=\frac{p[i(k',k'')+\psi(k',k'')+c_f]+[b'+s'b'^*]-[q'b''+s'q'^*b''^*]}{pk'^{\alpha}}. \tag{32}$$

To a first-order approximation, equation (32) shows that a firm's productivity threshold and, hence, its default probability increase with the level of debt (both foreign and local currency debts).[46] The higher the level of debt, the higher is the productivity level required to earn non-negative equity and remain in 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

$$E_{z',s'}(\Delta(\upsilon')) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\frac{\log \tilde{z}' - \rho_z \log z}{\sigma_z}} e^{-t^2/2}\, dt. \tag{33}$$

-Lemma 1. Selection into foreign currency borrowing: Only highly productive firms borrow in foreign currency. Given the state υ, the share of foreign currency borrowing increases in firms' productivity.

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,

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

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 (32) and (33) 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,

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

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

Finally, we illustrate that the relative cost of foreign currency borrowing decreases in a firm's productivity. To see this, we replace $\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'^*}$ and $\frac{\partial E_{z',s'}(\Delta(\upsilon'))}{\partial b'}$ into equation (31) and rewrite the Euler equation of foreign bonds relative to local bonds (equation (31)) as:

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

[46]Remark that q' and q'^* also depend on the level of foreign currency debt b'^*, 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.

$$\left[\frac{e^{-\frac{1}{2}\left(\frac{\log \tilde{z}'-\rho_z \log z}{\sigma_z}\right)^2}}{p\tilde{z}'k'^{\alpha}\sigma_z \ln(10)\sqrt{2\pi}}\left(\frac{s'-E(s'|s)}{E(s'|s)}\right)\left(\frac{b'}{(1+r)}+\frac{sb'^{*}}{(1+r^{*})}\right)+\beta\frac{cov_{|z',s'}(s',1-\Delta(\upsilon'))]}{E(s'|s)}\right]\leq 0. \tag{34}$$

Equation (34) 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 (34) 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, for a given state υ.

From equation (34), 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.

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

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.[47]

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:

$$V(s_t, s_{t+1}, z, k_t, d_t) = \max\left\{0, p\, z k_t^{\alpha} - \left[d_t + (1-d_t)\frac{s_{t+1}}{s_t}\right] b_t - p\, c_f\right\}, \tag{35}$$

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 (35) 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).

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

From equation (35), 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

$$\widetilde{s} \equiv \frac{(zk_t^{\alpha} - d_t b_t - c_f)s_t}{(1-d_t)b_t}. \tag{36}$$

Equation (36) 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:

$$q_t = \frac{P_t(V(s_t, s_{t+1}, z, k_t, d_t) > 0)}{1+r} \qquad \text{and} \qquad q_t^* = \frac{P_t(V(s_t, s_{t+1}, z, k_t, d_t) > 0)}{1+r^*}. \tag{37}$$

We write the adjusted UIP as follows:

$$\theta\, E(s_{t+1})(1 + r^*) = s_t\,(1 + r), \tag{38}$$

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.[48]

-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 (36)-. 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 (37)- 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

[48]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.

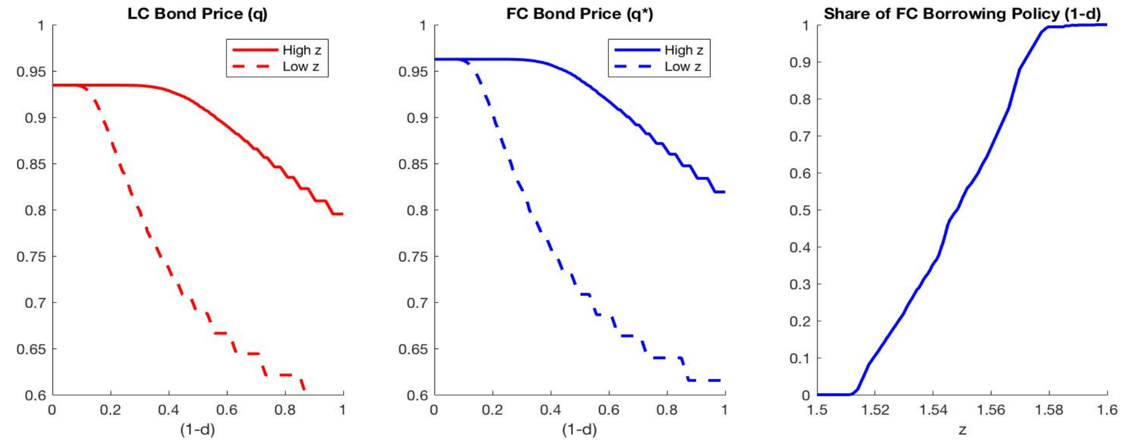


Figure A1: Bond Prices

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.

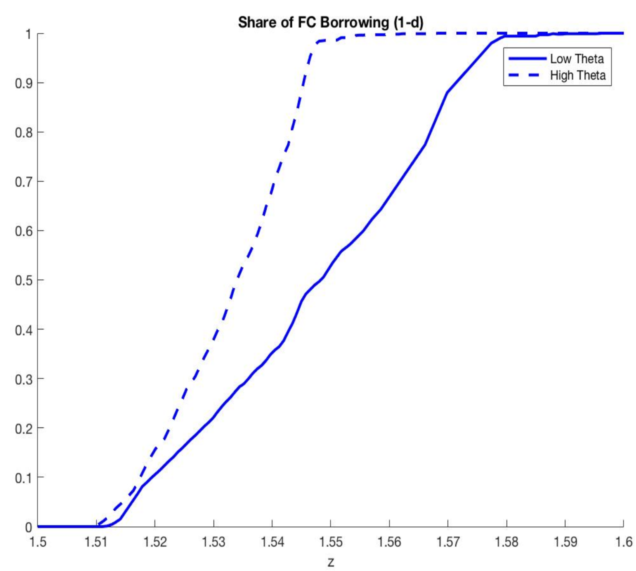


Figure A2: Deviations in the Risk-Free UIP and the Share of Foreign Currency Borrowing

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

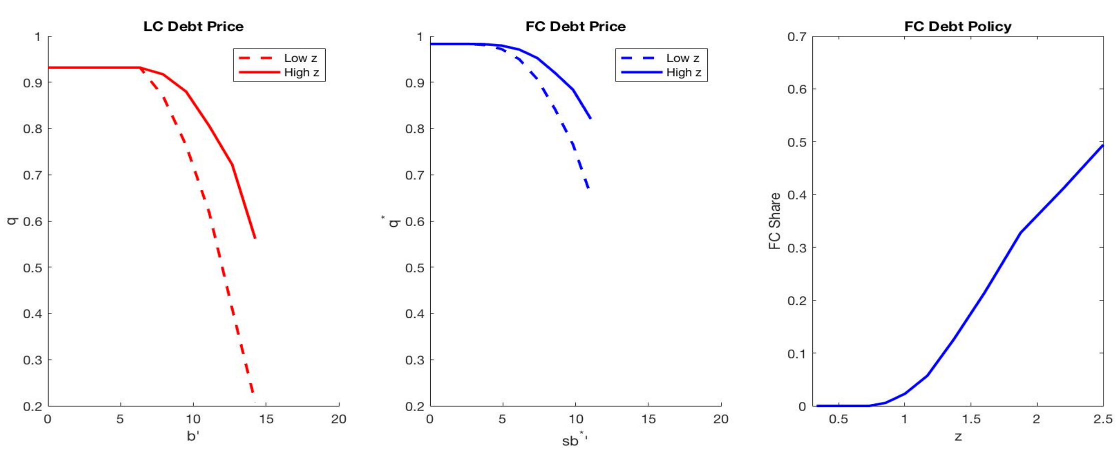
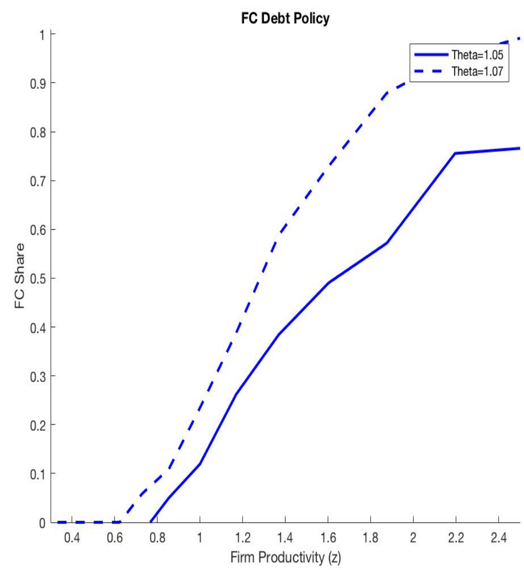


Table A1: Non-Targeted Moments (2005)

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)

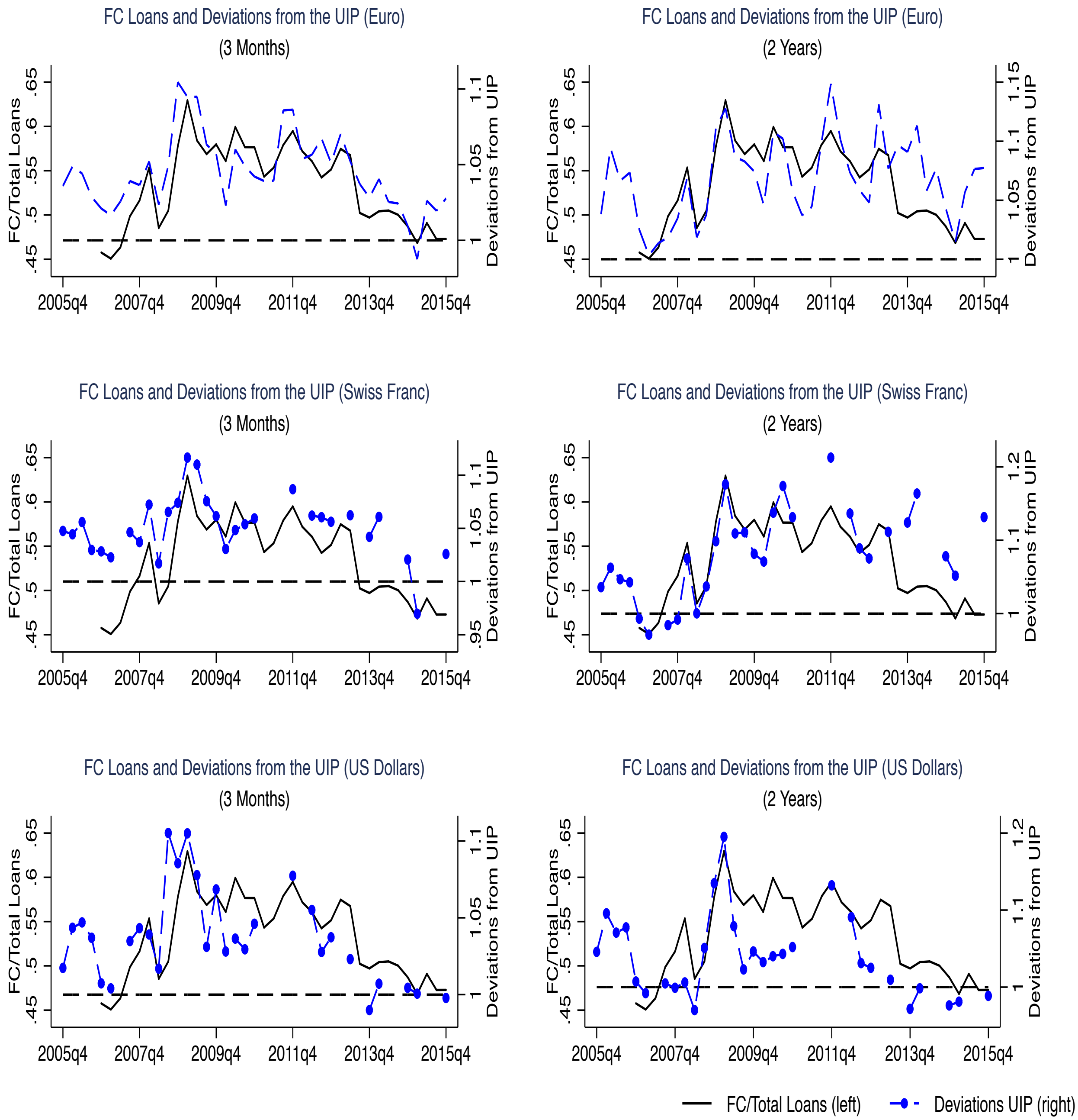
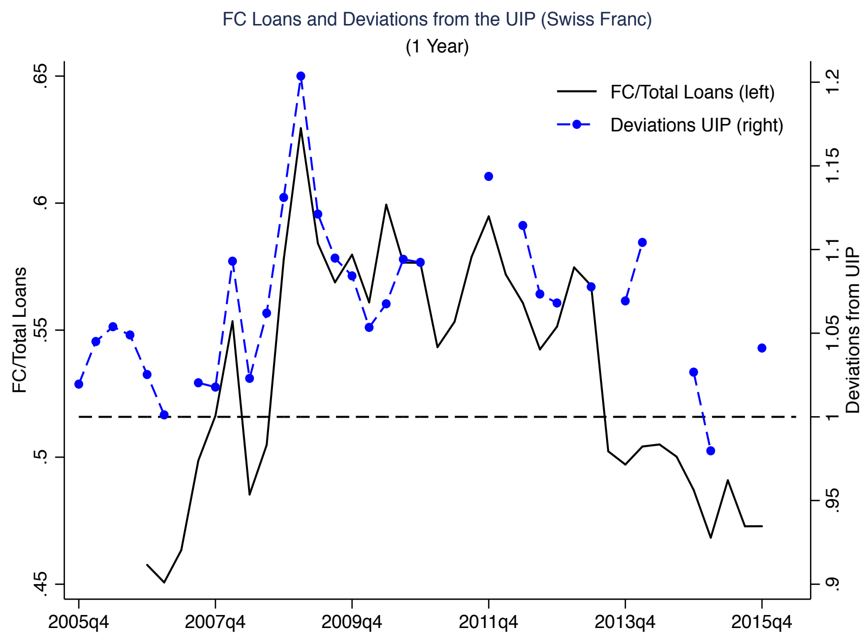


Figure B.3: Hungary: Deviations from the Risk-Free UIP with Swiss Franc and U.S. Dollars and Foreign Currency Loans



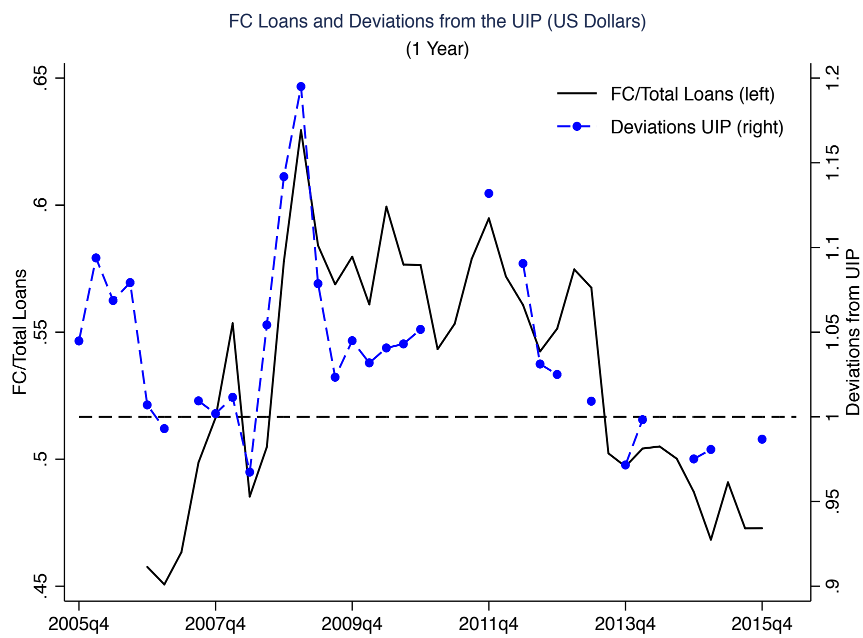


Figure B.4: Hungary: Foreign Currency Loans and Interest Rate Differential

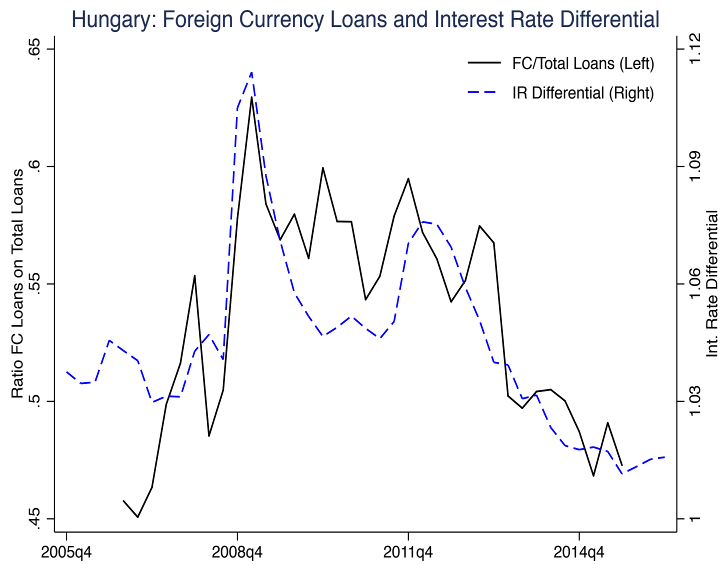


Figure B.5: Hungary: Deviations from the Risk-Free UIP and Foreign Currency Loans (controlling for CDS)

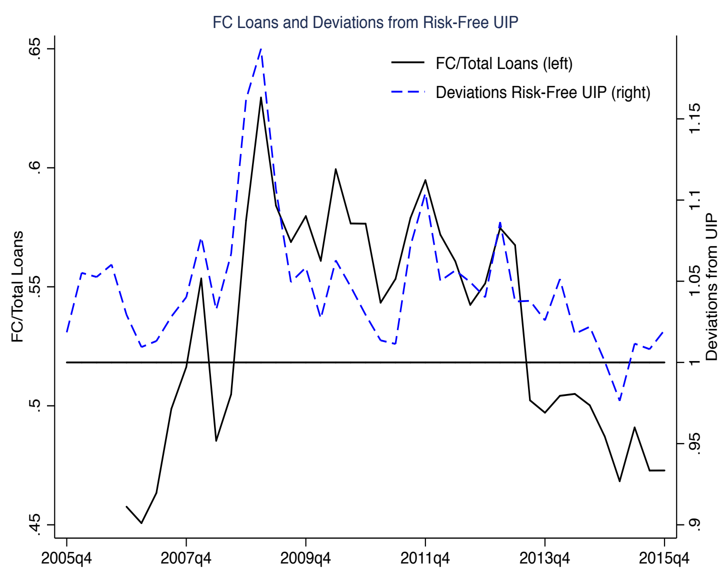


Figure B.6: Eastern European Countries: Foreign Currency Loans, Deviations from Risk-Free UIP and Interest Rate Differential

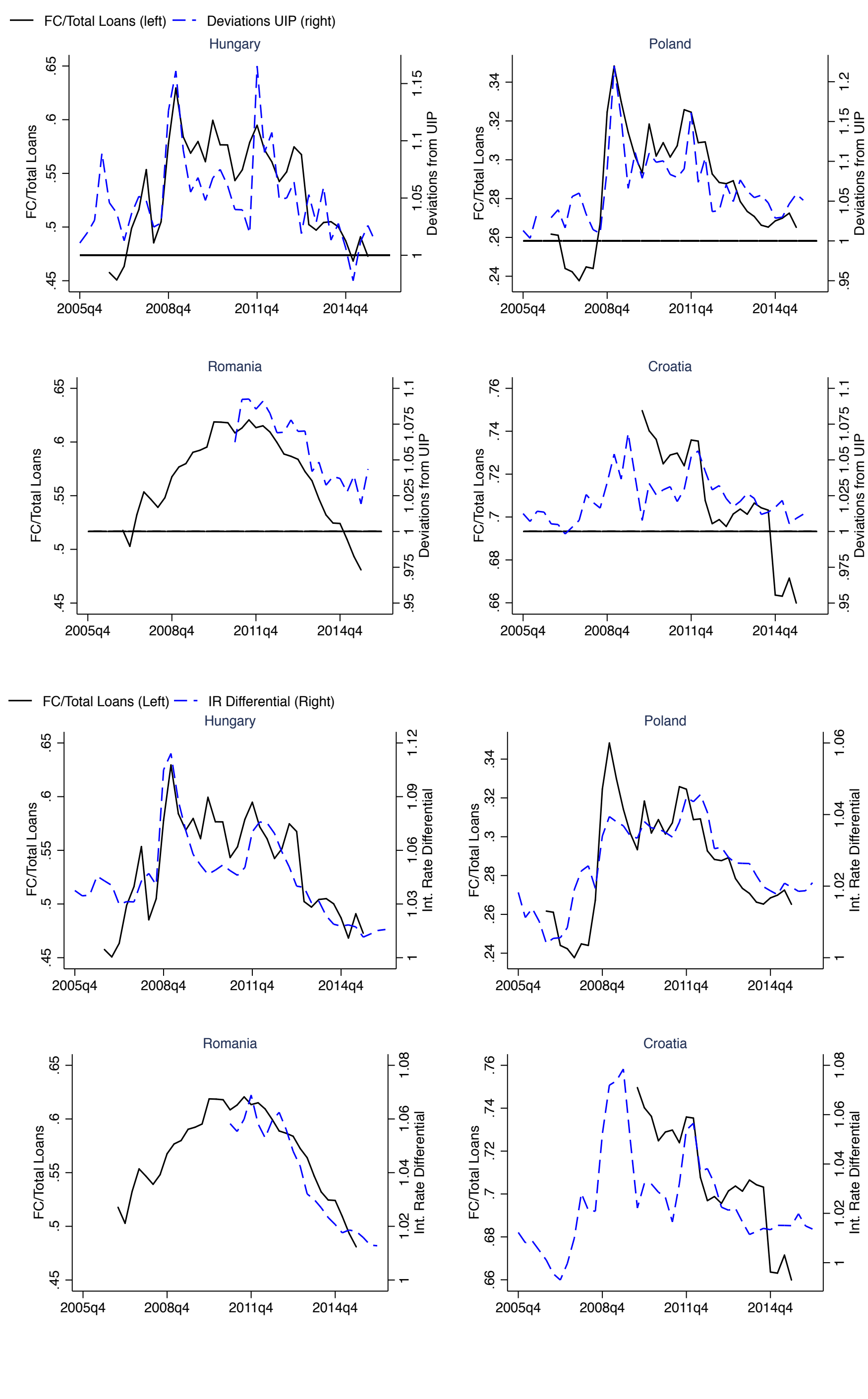
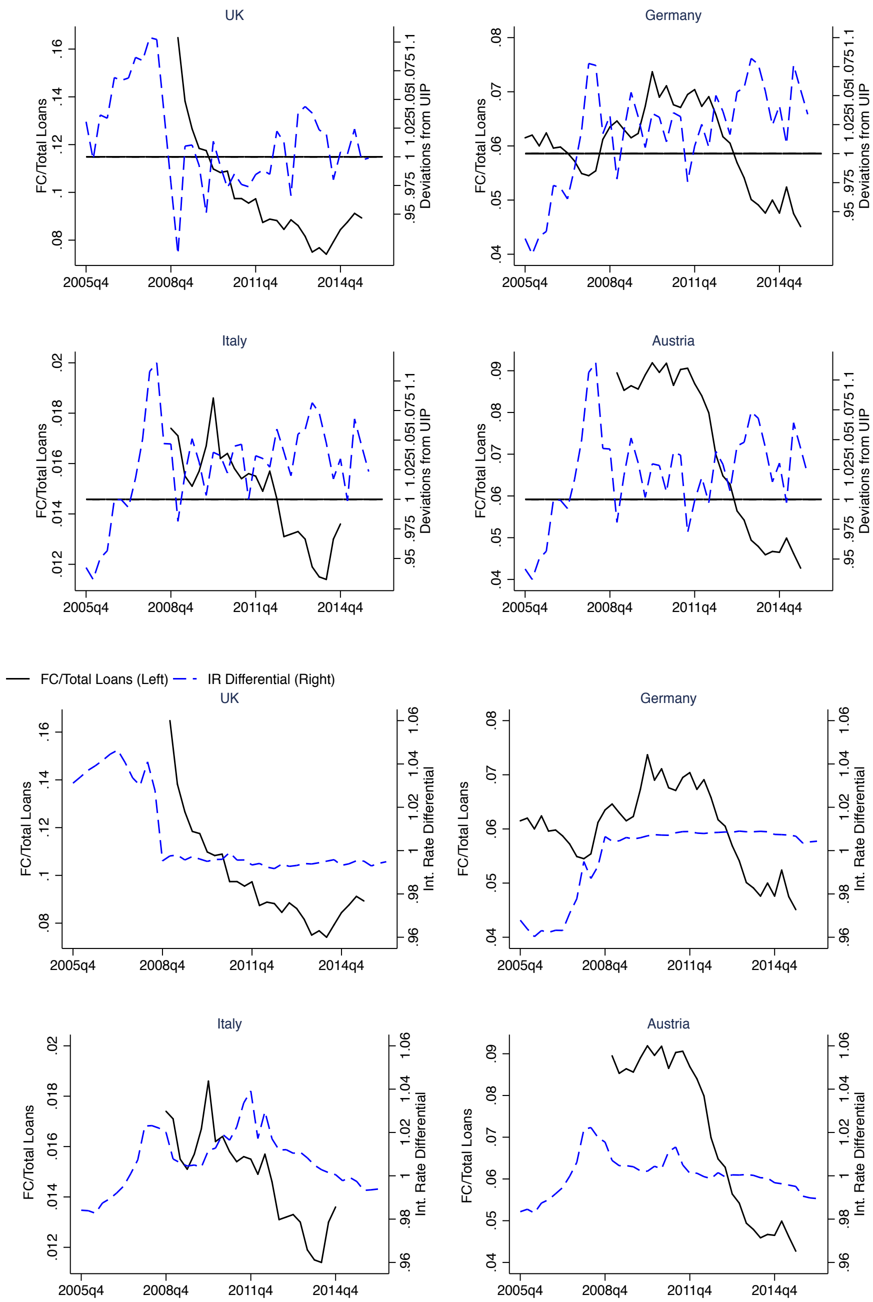


Figure B.7: Developed European Countries: Foreign Currency Loans, Deviations from Risk-Free UIP and Interest Rate Differential



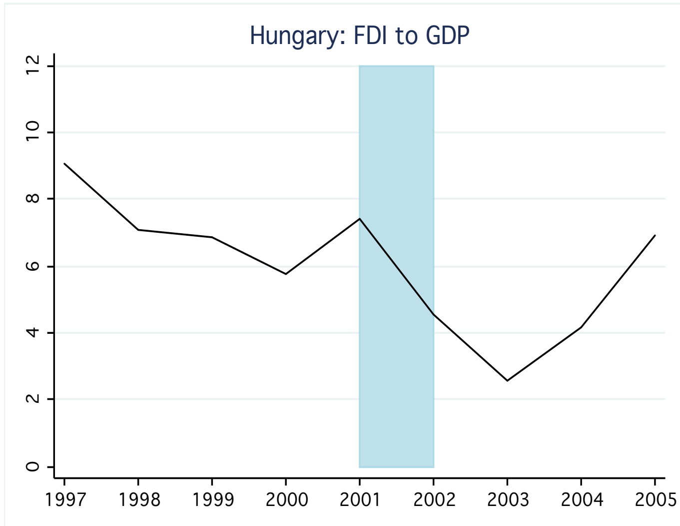


Figure B.8: Evolution of Foreign Direct Investment in Hungary

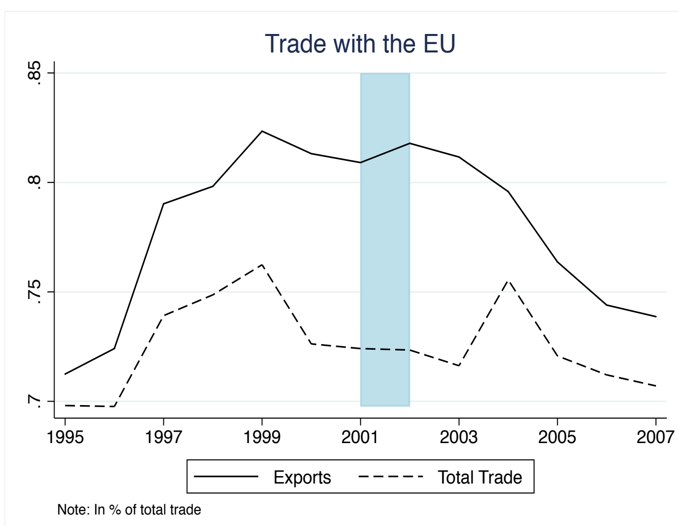


Figure B.9: Hungary: trade and exports with the European Union

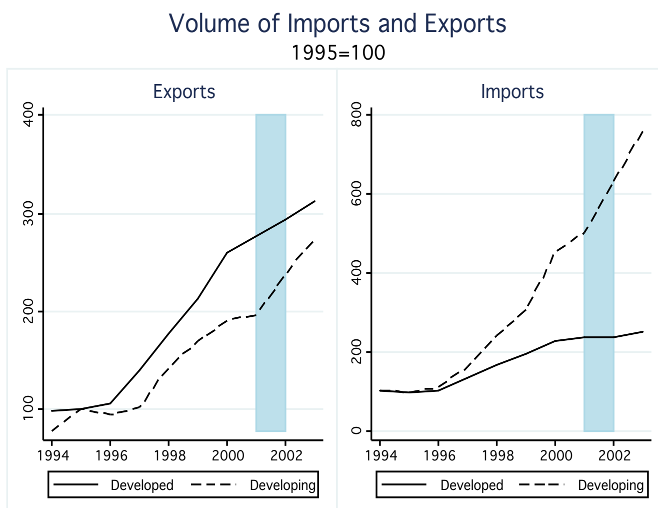


Figure B.10: Evolution of Trade in Hungary

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

	Panel A. Foreign Currency Loan Dummy					
	(1)	(2)	(3)	(4)	(5)	(6)
Log productivity	0.014***	0.015***	0.016***	0.013***	0.011***	0.020***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
Log capital	0.036***	0.030***	0.031***	0.031***	0.030***	0.030***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log LC leverage		0.008***	0.008***	0.007***	0.008***	0.012***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log age			-0.020***	-0.016***	-0.018***	-0.017***
			(0.003)	(0.003)	(0.003)	(0.003)
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.060	0.060	0.061	0.060	0.064	0.056
N	37,051	33,327	33,327	33,327	34,478	35,783
	Panel B. Log Share of FC Loans					
Log productivity	0.005***	0.003**	0.004***	0.004**	0.004**	0.004***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Log capital	0.013***	0.009***	0.010***	0.012***	0.010***	0.010***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log LC leverage		0.002***	0.002***	0.002***	0.002***	0.004***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log age			-0.012***	-0.011***	-0.011***	-0.008***
			(0.002)	(0.002)	(0.002)	(0.002)
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.048	0.039	0.041	0.036	0.043	0.038
N	37,051	33,327	33,327	33,327	34,478	35,783

Note: *, **, *** significant at the 10, 5, and 1 percent level. Standard errors in parentheses. Column 1 includes exporters. Column 2 includes controls for local currency leverage prior to the deregulation. Column 3 controls for age. Column 4 uses RTFP measured with the Olley and Pakes (1996) methodology. Column 5 employs labor productivity as a proxy for firms' RTFP. Column 6 employs the average for 1998-2000 as initial conditions. Source: APEH and Credit Register.

Table B.3: Robustness Tests: Firms' Investment and Sales

	Log Investment Rate	Log Sales		
	Data	Model	Data	
	(1)	(2)	(3)	(4)
R*FC dummy	0.056**	0.063***	0.048***	0.055***
	(0.025)	(0.010)	(0.017)	(0.015)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
FC d.*time trend	Yes	Yes	Yes	Yes
R^2	0.475	0.570	0.866	0.870
N	432,864	1,568,060	458,883	500,343

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. Column 1 includes exporters. Column 2 presents the estimated results for sales using the simulated data. Column 3 and 4 present the results for sales for non-exporting and exporting firms respectively. Source: APEH and Credit Register.

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

	FC Dummy			Log Share of FC Loans			Log Investment Rate		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log Dev. UIP	0.139***			0.083***			0.079*		
	(0.018)			(0.011)			(0.042)		
Log (Dev. UIP x Productivity)		0.035***			0.022***			0.328***	
		(0.008)			(0.004)			(0.017)	
Log (Dev. UIP x Q_{HL})			0.189***			0.085***			0.235***
			(0.032)			(0.016)			(0.071)
Log (Dev. UIP x Q_{HH})			0.080**			0.064***			0.188**
			(0.041)			(0.022)			(0.082)
Log (Dev. UIP x Q_{LL})			0.050*			0.003			0.129**
			(0.030)			(0.017)			(0.060)
Log (Dev. UIP x Q_{LH})			0.089**			0.063***			-0.019
			(0.041)			(0.024)			(0.071)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes	Yes		Yes	Yes
Sector* Year FE		Yes	Yes		Yes	Yes		Yes	Yes
R^2	0.741	0.696	0.742	0.714	0.663	0.716	0.033	0.042	0.700
N	1,019,461	1,019,461	1,019,461	1,019,461	1,019,461	1,019,461	513,116	513,116	513,116

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

Table B.5: Robustness Tests: Deviations from the Risk-Free UIP (No Valuation Effects)

	Log Share of FC Loans		
	(1)	(2)	(3)
Log Dev. UIP	0.062***		
	(0.010)		
Log (Dev. UIP x Productivity)		0.020***	
		(0.004)	
Log (Dev. UIP x Q_{HL})			0.074***
			(0.017)
Log (Dev. UIP x Q_{HH})			0.037*
			(0.022)
Log (Dev. UIP x Q_{LL})			0.007
			(0.018)
Log (Dev. UIP x Q_{LH})			0.051**
			(0.024)
Firm FE	Yes	Yes	Yes
Year FE		Yes	Yes
Sector* Year FE		Yes	Yes
R^2	0.717	0.663	0.718
N	892,584	892,584	892,584

Notes: *, **, *** significant at the 10, 5, and 1 percent level. Standard errors in parentheses. Period 2005-2010. Columns 1-3 employ year current exchange rate to compute the share of foreign currency loans on total loans. Source: APEH and Credit Register.

Table B.6: Robustness Tests: Deviations from the Risk-Free UIP (MPK)

	FC Dummy	Log Share of FC Loans	Log Investment Rate
	(1)	(2)	(3)
Log (Dev. UIP x MPK)	0.021***	0.014***	0.054**
	(0.005)	(0.003)	(0.023)
Firm FE	Yes	Yes	Yes
Year FE		Yes	Yes
Sector* Year FE		Yes	Yes
R^2	0.695	0.649	0.513
N	892,584	892,584	436,455

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: Robustness Tests: Deviations from the Risk-Free UIP (Exchange Rate Pass-Through)

	FC Dummy			Log Share of FC Loans		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.109***			0.050***		
	(0.024)			(0.012)		
Log (Dev. UIP x Productivity)		0.017***			0.008***	
		(0.004)			(0.002)	
Log (Dev. UIP x Q_{HL})			0.234***			0.103***
			(0.040)			(0.020)
Log (Dev. UIP x Q_{HH})			0.106**			0.072***
			(0.053)			(0.027)
Log (Dev. UIP x Q_{LL})			0.118***			0.038*
			(0.037)			(0.021)
Log (Dev. UIP x Q_{LH})			0.142***			0.090***
			(0.048)			(0.028)
Log Producer Price Index	0.007	-0.001	0.011	0.014***	0.008*	0.016***
	(0.008)	(0.008)	(0.008)	(0.004)	(0.004)	(0.004)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.742	0.686	0.742	0.716	0.653	0.716
N	892,584	892,584	892,584	892,584	892,584	892,584

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

Table B.8: 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.9: Productivity Level to Borrow in Foreign Currency

	Log Productivity	
	Model	Data
	(1)	(2)
Log Dev. UIP	-5.435***	-0.655***
	(0.482)	(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 $\log Y_{it} = \beta \log \text{UIP}_t + \phi_i + \varepsilon_{it}$, where Y_{it} is either productivity z_{it} in the model's simulated data or RTFP_{it} in the Hungarian data. Period 2005-2010. A negative β implies that the productive level of the pool of firms borrowing in foreign currency decreases following higher UIP deviations. Source: APEH and Credit register.

Table B.10: Robustness Tests: Deviations from the Risk-Free UIP (Sales)

	Log Sales					
	Model			Data		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.152** (0.072)			0.149*** (0.033)		
Log (Dev. UIP x Productivity)		0.210** (0.087)			0.115*** (0.042)	
Log (Dev. UIP x Q_{HL})			9.963*** (0.079)			0.366** (0.154)
Log (Dev. UIP x Q_{HH})			6.218*** (0.077)			0.314** (0.150)
Log (Dev. UIP x Q_{LL})			-4.649*** (0.077)			0.227 (0.178)
Log (Dev. UIP x Q_{LH})			-6.584*** (0.078)			0.310* (0.179)
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	0.876	0.846	0.911
N	940,836	940,836	940,836	667,726	667,726	667,726

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

Table B.11: 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.12: 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.13: 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.14: 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.15 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 were 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.15: 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.

Table B.16 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.17-B.18 report the share of firms borrowing in foreign currency by group and their foreign currency share.

Table B.16: 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.17: 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.18: 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:

$$\log Y_{it} = \beta(D_t \,\text{x}\, \text{FC Ratio}_i) + \phi_i + (T_t \,\text{x}\, \text{FC Dummy}_i) + (\mu_i \,\text{x}\, D_t) + X_{jt} + \varepsilon_{ijt} \tag{39}$$

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 (39) 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 B.9 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.19: 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.20). 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 8. 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.20: Currency Depreciation during the Great Recession

	Exit		
	(1)	(2)	(3)
D*FC Ratio	-0.036***	0.018*	-0.001
	(0.009)	(0.006)	(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.11 and B.12 in Appendix B report the estimated coefficients of regression (39) for non-exporter firms. In all regressions, the coefficients are of the same sign and similar in magnitude to those estimated in Tables B.19 and B.20. 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.[49] Tables B.13 and B.14 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).

[49]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.[50] 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 (**??**), 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

[50] 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.21 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.21: 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 (16) 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.22 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.23 presents the results of equation (39) 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.22: 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.24. 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.23: 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.24: 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 2018 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 2018). 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.