Exchange Rate Exposure and Firm Dynamics

Juliana Salomao
University of Minnesota

Liliana Varela*
University of Warwick and
University of Houston

September 2017

This paper develops a firm-dynamics model with heterogenous firms and endogenous currency debt composition to jointly study financing and investment decisions in developing economies. In our model, foreign currency borrowing arises from a trade-off between aggregate deviations from the risk-free uncovered interest rate parity and firms' growth potential. Crucially, there is cross-sectional heterogeneity in foreign currency borrowing decisions in two dimensions. First, there is selection into foreign currency borrowing, as only productive firms find it optimal to be exposed to exchange rate shocks. Second, among productive firms, those with low capital employ this financing more intensively, as it allows them to reach faster their optimal scale of production. We test the model's implications using firm-level census data on firms' balance sheets and debt by currency denomination in Hungary. Our empirical results confirm that high productive firms have a higher probability and share of foreign currency loans, and see higher investment and growth after using this financing. Additionally, we show that higher deviations from the risk-free uncovered interest rare parity associate with increases in foreign currency borrowing and investment, particularly of productive firms with low capital. Our quantitative framework shows that foreign currency borrowing associates with a ten percent higher aggregate income, but at the expense of higher volatility.

JEL-Codes: F31, F34, F36 F46.
Keywords: firm dynamics, foreign currency debt, uncovered interest rate parity.

*We thank Cristina Arellano, Philippe Bacchetta, Vasco Carvalho, Andres Fernandez, Ana Maria Herrera, Stefan Lewellen, Loukas Karabarbounis, Xiaoji Lin, Brent Neiman, Juan Pablo Nicolini, Felipe Saffie, Kei-Mu Yi and Jing Zhang for helpful comments, as well as seminar and conference participants of Minnesota- Macro Asset Pricing Conference, Chicago Booth International Macro- Finance Conference, Brown University, IADB, HEC Laussane, HEC Montreal, Banque de France, SED 2016, North America Summer Meetings of the Econometric Society 2016, and London Business School- Financial Intermediation Junior Conference.

1 Introduction

Capital flows play a critical role on economic growth. The textbook neoclassical growth model predicts that capital flows into developing economies lead to higher capital accumulation and income per capita. Yet these flows have been associated with higher volatility and financial crises. One of the triggers of financial crises has been foreign currency borrowing in the corporate sector, as many firms employing this financing are not naturally hedged nor use hedging instruments. Hence, exchange rate depreciations can create a mismatch between the currency denomination of their assets and liabilities and prompt them into financial distress.[1] In this paper, we assess why firms in developing economies might choose to borrow in foreign currency and be exposed to exchange rate shocks, and quantify the aggregate implications of these choices.

This paper shows that firms' foreign currency borrowing choices arise from a dynamic trade-off between firms' optimal exposure to the currency risk and growth. We start by developing a firm-dynamics model, in which heterogenous firms choose the currency composition of their debt and their investment. In our model, firms might optimally choose to borrow in foreign currency to take advantage from deviations from the risk-free uncovered interest rate parity (UIP), as the relative lower foreign currency rate enables higher investment. Crucially, there is heterogeneity in firms' foreign currency borrowing choices in two dimensions. First, there is *selection* into foreign currency borrowing, as only productive firms find it optimal to be exposed to exchange rate shocks. Second, among productive firms those with lower capital employ this financing more intensively, as it allows them to reach faster their optimal scale of production. We next employ detailed firm-level census data on firms' balance sheets and debt by currency denomination in Hungary over 1996-2010 to assess these model's implications. In particular, we use the model to simulate firm-level data and conduct a parallel analysis between the simulated and the Hungarian data. Finally, we conduct several counterfactual exercises and quantify the aggregate impact of foreign currency borrowing.

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

We employ firm-level census data for Hungary between 1996 and 2010. We combine two differ-

[1] Foreign currency borrowing has been associated with several crises in emerging markets during the nineties and has recently surged in the aftermath of the Great Recession in many developing economies. In 2014, the share of foreign currency loans in the corporate sector exceeded 50% in many Eastern European countries, as for example Serbia, Bulgaria, Croatia, Romania and Hungary (see Figure A.1 in the Appendix). Other non-European countries also see high indebtedness in foreign currency, as for example Peru, Chile or Kazakhstan where the share of foreign currency loans was 55%, 33% and 40%, respectively. We discuss the related literature below.

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

ent datasets: APEH dataset, which provides information on firms' balance sheets reported to tax authorities for the entire population of firms, and the Credit Register dataset, which reports information on all firms' loans by currency denomination with financial institutions in Hungary. The coverage of our database is unique as it reports information for all firms in all economic activities over more than a decade. It allows to build comprehensive measures of leverage by currency denomination, and constitutes an advance regarding the previous literature focusing on manufacturing firms, listed companies or exporters.

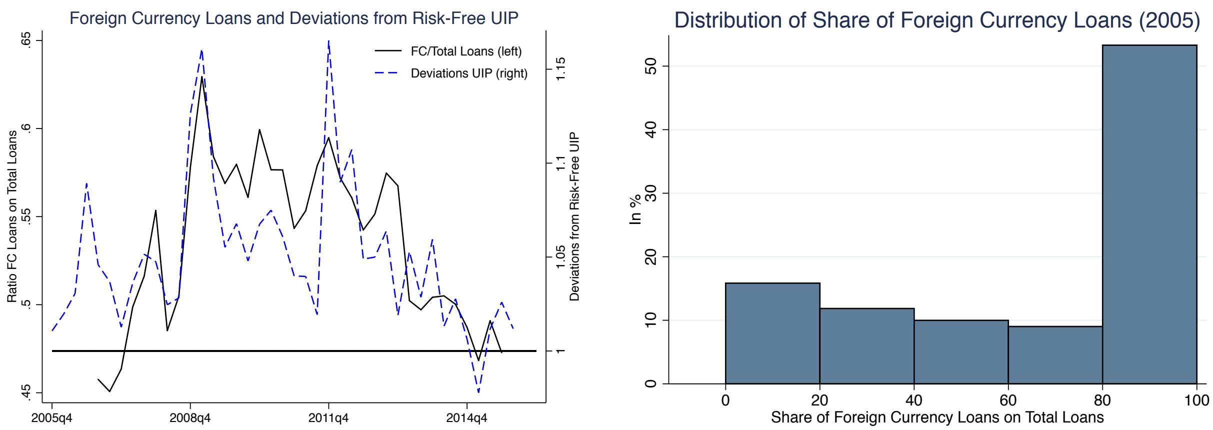
We start by documenting that foreign currency borrowing expanded rapidly in Hungary after the deregulation of international financial flows in 2001. By 2005, the share of foreign currency loans in the corporate sector exceeded 45%, and one-third of borrowing firms held foreign currency denominated loans. Firms using this financing made up for a non-negligible share of aggregate outcomes, as they accounted for 40% of aggregate value added and 34% of employment. Notably, two-thirds of foreign denominated loans were held by small and medium enterprises. Firms borrowing in foreign currency were highly exposed to exchange rate movements, as most of them were non-exporters (84% of firms) and did not use financial instruments to hedge the currency risk. Importantly, the use if foreign currency denominated loans associates with deviations from the risk-free UIP. Figure 1 (left graph) shows that, between 2006q4 and 2015q4, these deviations highly correlate with increases in the share of foreign currency loans in the corporate sector.[3][4] Yet firms borrowing in foreign currency did not use these loans to the same extent. Figure 1 (right graph) plots the distribution of the share of foreign currency loans on total loans for these firms, and shows that there is substantial heterogeneity in firms foreign currency borrowing decisions.

Next we develop a firm dynamics model with endogenous debt composition to jointly study firms' financing and investment decisions. In our model, firms are heterogenous in productivity, capital stock, level of foreign and local currency debt, and are subject to exchange rate and idiosyncratic productivity shocks. Firms' revenues are denominated in local currency and operations can be externally financed with loans denominated in local and/or foreign currency. These loans are not contingent and firms may choose to default. Hence, firms' cost of funds adds the idiosyncratic default risk to the respective risk-free rate. Firms' borrowing decisions are driven by a trade-off between aggregate deviations from the risk-free UIP and firms' idiosyncratic cost of funds. While deviations from risk-free UIP create a wedge between the domestic and foreign risk-free rates, for-

[3]The data on the share of foreign currency on total loans is provided by CHF Lending Monitor from the Swiss National Bank, which reports this information for 2006q4 and 2015q4. We compute the deviation from the risk-free 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 in $t+1$, respectively. We employ the one-year Hungarian government bond yield from Global Financial Data, the German one-year government bond yield, and the spot and expected exchange rate at one-year horizon with respect to the Euro coming from Foreign Exchange Consensus Forecast. We compute the deviation from the uncovered interest rate parity regarding the Euro, as in Hungary more than two-third of foreign currency borrowing was denominated in Euros (see Yesin 2013).

[4]Figures A.2 and A.3 in Appendix A show that this correlation remains true when considering different time horizons (3 months and 2 years), and using the Swiss Franc and the U.S. dollar as reference currencies. Figure A.4 illustrates that share of foreign loans highly correlates with the interest rate differential (r_t/r_t^*). Figures A.5 shows that the correlation between deviations from UIP and the share of foreign currency loans is also present in other Eastern European countries for which there is available data.

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



eign financing exposes firms to exchange rate shocks and increases their default probability. Firms borrow in foreign currency to the extent that the increase in the idiosyncratic cost of funds does not exceed the lower relative cost stemming from the deviation from the risk-free UIP. This trade-off drives the heterogeneity in firms' foreign currency borrowing decisions.

The model derives firm-level implications about the pattern of foreign currency borrowing and investment across firms. First, there is selection into foreign currency borrowing, as only high productive firms –for which the idiosyncratic risk does not rise significantly when using foreign funds– employ this financing. Second, higher deviations from the risk-free UIP increase the share of foreign currency borrowing, as they lower the relative risk-free rate in foreign currency. Notably, among productive firms, those with lower capital differentially exploit these deviations to increase their investment and reach faster their optimal scale of production.

We calibrate the model to the period following the financial liberalization in Hungary in 2001. To mimic the period following the liberalization, we simulate the model in two steps. We first simulate an economy without foreign currency debt to obtain the stationary distribution of firms prior to the liberalization. We then compute the policies from a model with foreign currency and fit the realized exchange rate shocks observed between 2001 and 2010. This allows us to obtain the moments for the transition years following the financial liberalization. The model successfully matches several non-targeted moments on investment and indebtedness of the distribution of Hungarian firms. In particular, it matches the share of firms borrowing in foreign currency, and their share of these loans on total loans. It also matches the investment rate of firms borrowing in either local, foreign currency or both. Additionally, it tracks closely the distribution of productivity and capital of these three groups of firms.

We turn next to assess, at the firm level, the model's predicted patterns of foreign currency borrowing and investment. With this end, we employ the model to simulate firm-level data and estimate in –in parallel– regressions using the simulated data and the Hungarian data.

To evaluate whether firms employing foreign currency loans are more productive and grow faster, we exploit the financial liberalization in Hungary as a source of time variation. In line with this first implication, we find that more productive firms prior to the reform have a higher probability of borrowing in foreign currency after it. The estimated coefficient using the Hungarian data tracks closely the firm-level response implied by the model. In particular, a one percent increase in a firm's productivity raises the probability of borrowing in foreign currency by 0.024 and 0.013 percentage points in the model and the data, respectively. Similarly, the share of foreign currency loans increases in firms' pre-reform productivity both in the model and the data, and implies an elasticity of 0.01 and 0.02 respectively. Our results also point that firms using this financing have higher investment rates and growth, as predicted by the model. Within the five years following the reform, Hungarian firms borrowing in foreign currency saw a differential expansion of 5% and 4% in their investment rate and sales, after including a full set of controls. Lately, after including a full set of controls, we show that firms borrowing in foreign currency pay a one percentage point lower interest rate, as predicted by the model.

Additionally, our results also point to the second implication of the model. First, the model implies that a one percent increase in the deviation from the risk-free UIP associates with a 0.07 and 0.06 percent higher probability of borrowing in foreign currency and share of foreign currency loans. The coefficients estimated using the Hungarian data track closely these model's responses. A one percent increase in the deviation correlates with a 0.14 and a 0.08 percent increase in the probability and share of foreign currency loans, after controlling for firm-fixed effects and four-digit industries and year fixed effects interacted. Second, both in the model and the data, the expansion in the use of foreign loans is heterogenous across firms and rises more for more productive firms. In line with the model's implication, among productive firms, those with lower capital stock expand their use of foreign currency loans relatively more. Third, we demonstrate that deviations from risk-free UIP also associate with higher investment and sales at the firm-level. In the model, a one percent increase in the deviation from the risk-free UIP associates with a 0.10 and 0.15 percent higher investment rate and sales. Similarly, the estimated coefficients using the Hungarian imply a 0.08 and 0.06 percent increase investment and sales. Just like the trends in foreign borrowing, this expansion is greater for high productive firms and, among them, firms with low capital stock. This result provides support to the mechanism proposed in this paper, namely firms employing foreign currency loans to increase their investment and reach faster their optimal scale of production.

We employ the model to conduct three numerical exercises. First, we show that economies allowing for foreign currency borrowing have 13% higher income and 15% more capital, and are significant more volatile than economies were these loans are not allowed. In these economies, firms are 11% bigger, have 20% higher invest rates, and see lower default probability. Second, our analysis indicates that selection of high productive firms into foreign currency borrowing is crucial to explain the higher income of economies allowing for this type of financing. More precisely, if all firms would borrow equally in foreign currency, the economy will see 30% lower aggregate income and capital. Firms' investment rate will one third lower and they will be three times more likely to default. Finally, we show that the exchange rate process substantially affect foreign currency borrowing decisions, since reducing by half the volatility of the exchange rate increases firms' share of foreign currency, investment rate and aggregate sales.

To explore the sensitivity of the numerical exercises, we conduct sensitivity analysis on main parameters of the model and show that the mechanism remains valid under different parametrizations. First, we relax the assumption of zero pass-through of exchange rate shocks into local price. We show that higher pass-through implies a higher share of foreign currency debt, investment and sales, as debt provides a better hedge. Second, we allow the risk-free rate in local and foreign currency to include a time-varying risk premium following exchange rate shocks. If both foreign and local currency investors charge a higher rate when the exchange rate is depreciated, the share of foreign currency debt drops. Importantly, foreign currency borrowing is still driven by high productive firms, which show higher rates of investment and growth. Lastly, we include aggregate shocks into the model, and let these shocks be negatively correlated with exchange rate shocks. Lower sales during depreciations increase the risk of borrowing in foreign currency, which decreases the optimal share of foreign currency loans.

Finally, we exploit the depreciation of the local currency during the Great Recession to study the performance of firms employing foreign currency borrowing upon the shock. After controlling for a full set of firm and sector characteristics, the empirical results confirm the theory proposed in this paper: firms borrowing in foreign currency see negative balance sheet effects, but they do not underperform their industry counterparts. In particular, the estimated coefficients indicate that one percent increase in the firm's initial foreign currency ratio decreases its leverage by 20%, share of foreign currency ratio by 18%, and investment by 48%. Importantly, firms borrowing in foreign currency experience lower reductions in sales and do not face a higher exit probability. These results are robust to various specifications, including after controlling by firms' export status and firm and industry time-varying and unvarying co-variates.

Related Literature. This paper is related to a long literature in international economics literature studying capital inflows into developing economies and their implications for economic growth and financial crisis (see Krugman 1999; Schneider and Tornell 2004; Céspedes, Chang, and Velasco 2004; Jeanne 2003; and Eichengreen and Hausmann 2005, among others). From a theoretical perspective, this paper is closest to Schneider and Tornell (2004), who develop a model of balance-of-payment crises in which firms endogenously choose the currency composition of their debt. Our paper contributes to this literature in two different ways. First, our firm dynamics theory micro-founds firms' foreign currency borrowing decisions, and accounts for the cross-sectional heterogeneity observed in the data. Second, our numerical exercise quantifies aggregate effects of foreign currency borrowing on economic growth based on firm-level decisions, for the first time.

There is a long strand of literature analyzing the consequences of currency depreciations on firms' balance sheets (see Aguiar 2005; Bleakley and Cowan 2008; Kim, Tesar, and Zhang 2015; Kalemli-Ozcan, Kamil, and Villegas-Sanchez 2010, for example), and the patterns of foreign currency borrowing across firms (see Baskaya, di Giovanni, Kalemi-Ozcan, and Ulu 2017; Ranciere, Tornell, and Vamvakidis 2010; and Brown, Ongena, and Yesin 2011). Our paper contributes to this literature by documenting the effects of foreign currency borrowing on the entire population of firms and over a long time, and by constructing detailed measures of foreign currency leverage and exposure to exchange rate movements at firm-level.

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 and derives the model's implications. Section 5 test the model's firm-level implications using the model simulated data and the Hungarian data. Section 6 conducts numerical exercises to quantify the impact of foreign currency borrowing on the aggregate. Section 7 carries sensitivity analysis on the main parameters of the model. Section 8 studies the impact of the currency depreciation during the Great Recession in Hungary. Section 9 concludes.

2 Data and Main Descriptive Statistics

We analyze firms' investment and debt 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 exports, sales, value added, investment, assets, employment and materials. Firm size varies significantly in the database, spanning from single-employee firms to large corporations. Since micro-enterprises are typically subject to measurement error problems, we retain firms that have at least three employees. We restrict our analysis to non-financial corporations on the agricultural, mining, manufacturing and service sectors.[5] Our panel of firms covers more than 86% of firms in the economy, and captures more than 89% of the value added, 92% in the employment and 99% of exports 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 debt over total debt) and revenue total factor productivity (RTFP).[6]

[5]We exclude firms in financial and real estate activities, public administration, education and health, as these activities are subject to especial regulations. See Appendix and Table A.7 for a detailed description of all the sectors under analysis.

[6]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

In Hungary, foreign currency borrowing expanded rapidly after the deregulation of international financial flows in 2001, which liberalized foreign denominated loans for Hungarian firms.[7] By 2005, one-third of firms employing bank credit held foreign-currency denominated loans. These firms made up for a non-negligible share of aggregate outcomes, and accounted for 40% of aggregate value added and 34% of total employment in the economy (Table A.8 in the Appendix).

Table 1 shows that firms borrowing in foreign currency use this type of financing intensively. In 2005, their share of foreign currency loans on total loans reached 64%. Remarkably, most of these firms were non-exporters (84% of firms) and, hence, were not naturally hedged. Furthermore, these firms did not usually employ derivative contracts to hedge the currency risk, as reported by Bodnár (2006).[8] The lack of foreign denominated income and hedging instruments shows that these firms were systematically exposed to exchange rate movements. Note that firms borrowing in foreign currency were typically larger –sales, capital and employment–, more productive and had a greater level of leverage (Table 1). In all these variables, the difference in means is statistically significant at one percentage point.[9]

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	95	84
Leverage	4	22
Sales	248	1,348
Capital	100	460
Log RTFP	6.5	6.7
Employment	17	45
Number of firms	147,166	13,493

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

In the next section, we develop a model showing that firms might optimally choose to borrow in foreign currency and be exposed to the exchange rate risk in order to grow faster. We next employ the APEH and Credit Register datasets to test the model's implications against the data.

using the methodology of Olley and Pakes (1996) and labor productivity. 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.

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

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

[9] Interesting, although firms borrowing in foreign currency were relatively larger, two-thirds of them were small and medium firms with less than 250 employees (Table A.8). Appendix A.3 presents additional descriptive statistics of firms borrowing in foreign currency.

3 Model

This section develops a firm-dynamic model with endogenous debt composition to jointly study firms' financing and investment decisions. The model has three main ingredients. First, there are heterogeneous firms that raise external funds to invest and choose the currency composition of their debt. Second, there are deviations from the risk-free uncovered interest rate parity that create a wedge between the domestic and foreign currency risk-free interest rates. Third, firms face productivity and exchange rate shocks that make external finance risky and firms susceptible to default. We employ the model to study firms' optimal currency debt composition and the distribution of foreign currency borrowing in the cross-section of firms. Sections 3.1-3.5 describe the model's setup, firms' optimization program and the stationary equilibrium.

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 $\alpha \in (0,1)$. Firms are subject to aggregate exchange rate and idiosyncratic productivity shocks shocks. The dynamics of these shocks are 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 to produce 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.[10] 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 (b and b^*) 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

[10]We restrict firms from equity financing to focus our analysis on the firms' currency debt composition. This assumption does not affect the mechanism proposed in this paper and allows us to illustrate the 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 in Hungary are not publicly traded.

external funds and an additional fixed cost c^* to borrow in foreign currency. In each period, there is a constant mass of potential entrants, which together with the endogenous exit make the distribution of firms endogenous and dependent of the exchange rate shock. Firms are heterogeneous in productivity, capital and level of local and foreign currency debts. Firms' problems are solved in partial equilibrium.

3.2 Incumbent Firms

In each period, incumbent firms choose whether to repay the 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 remains in the market, it chooses its investment in physical capital (k') and the levels of local and foreign currency debts (b', b'^*) to maximize its value (V^R):

$$V^R(s, z, k, b, b^*) = \max_{k', b', b'^*} [e + \beta\, E_{z', s'} V\,(s', z', k', b', b'^*)], \tag{4}$$

where e denotes equity payout, and is given by[11]

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

The first term in brackets denotes a firm's revenues net of investment ($i(k, k')$), the investment adjustment cost and the fixed operational cost. Let investment 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 represents the current period debt issuance net of the fixed credit and foreign currency credit costs.[12]

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 pos-

[11] Note that as we constrained firms from issuing equity, e is always non-negative.

[12] We set the local price as a function of the foreign price, i.e. $p = p^* s^\eta$, where the foreign price is normalized to one ($p^* = 1$) and η denotes the exchange rate pass-through to local prices. Under this specification, the law of one price holds whenever $\eta = 1$ and the local price moves one-to-one with the exchange rate, i.e. $p = s$. If there is zero pass-through, $\eta = 0$ and the local price is constant. For simplicity, in our benchmark specification, we assume zero pass-through on local firms' prices. In Section 7.1, we conduct several exercises for different levels of η and show that, as long as there is imperfect pass-through, this assumption does not affect the mechanism proposed in the paper. Note, finally, that the aggregate exchange rate pass-through η in Hungary is only 0.2 per year.

itive. Active firms receive revenues net of fixed and adjustment costs and debt repayments, and choose capital and debt for the next period.

Debt Contract and Debt Pricing

There is a mass of infinite risk-neutral 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. The price of firms' bonds adjusts such that investors earn zero profits in expectations.[13] In particular, define $\Delta(k, b, b^*)$ the set of exchange rate and productivity shocks for which a firm chooses to default: $\Delta(k, b, b^*) = \Big\{ (s, z) \, \text{s.t.} \; V^R(s, z, k, b, b^*) \leq 0 \Big\}$, and $P_{z,s}(\Delta(k, b, b^*))$ its default probability. The non-arbitrage condition implies that risk-neutral creditors invest in firms' bonds until their interest rate adjusted by the repayment probability is equal to the free-risk rate. That is,

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

where r^b and r^{b*} denote firms' domestic and foreign idiosyncratic interest rates. Using equation (6), we can define firms' bonds prices for domestic and foreign currency debt as

$$q \equiv \frac{1}{1 + r^b} \qquad \text{and} \qquad q^* \equiv \frac{1}{1 + r^{b*}}.$$

The relation between the foreign and local risk-free rates is defined by the risk-adjusted UIP:

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

where $\theta \in (0, \infty)$ denotes the deviation from the risk-free UIP. If $\theta = 1$, the risk-free UIP 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, a $\theta > 1$ implies a wedge on the domestic risk-free interest rate that makes the foreign risk-free interest rate relatively lower. As we discuss below, this wedge offers an incentive for firms to borrow in foreign currency. In this section, we assume that $\theta > 1$, and explain its calibration in Section 4.[14]

[13] 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.

[14] Note that $\theta > 1$ mimics the fact presented in the introduction showing that, in Hungary, there were systematic deviations from the risk-free UIP making foreign currency borrowing relatively cheaper. Between 2005 and 2015, the wedge θ between the risk-free rate in local and foreign currency adjusted by exchange rate fluctuations was systematically higher than one (1.05 on average). Deviations from the risk-free UIP creating a wedge between the local and foreign risk-free rate are not specific of Hungary. Ranciere, Tornell, and Vamvakidis (2010) document first evidence of these type of deviations for a group of ten emerging European economies (Bulgaria, Croatia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic and Ucrania) in the 2000s.

3.3 Entrant Firms

In each period, there is a constant mass M of potential entrants that receives a signal ν about their productivity in the next period. This signal follows a Pareto distribution, $\nu \sim \Upsilon(\nu)$ with parameter κ. This signal determines the probability 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

$$V_e(s,\nu) = \max_{k',b',b'^*} \left[-k' + \beta E_{z',s'} V(s',z',k',b',b'^*) \right].$$

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

3.4 Stationary Firm Distribution

Given an initial distribution, a recursive equilibrium is a set of functions for (i) firms' value function $V(s,z,k,b,b^*)$ and $V_e(s,\nu)$, capital holdings $k'(s,z,k,b,b^*)$, debt $b'(s,z,k,b,b^*)$, $b'^*(s,z,k,b,b^*)$ and default set $\Delta(k,b,b^*)$, and (ii) pricing functions $q(s,z,k,b,b^*)$ and $q^*(s,z,k,b,b^*)$ 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 ($q(s,z,k,b,b^*)$ and $q^*(s,z,k,b,b^*)$), the value function ($V(s,z,k,b,b^*)$), capital holdings ($k'(s,z,k,b,b^*)$), debt ($b'(s,z,k,b,b^*)$ and $b'^*(s,z,k,b,b^*)$), and the default set ($\Delta(k,b,b^*)$) satisfy the firm's optimization problem;

- the bond price functions ($q(s,z,k,b,b^*)$ and $q^*(s,z,k,b,b^*)$) 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 $Z \times K \subset \Re^+ \times B \times B^* \times \Re^+$ and $\forall t \geq 0$

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

where $B_e(K,B,B^*,s) = \{\nu \text{ s.t. } k'(s,\nu) \in K,\ b'(s,\nu) \in B,\ b'^*(s,\nu) \in B^* \text{ and } V_e(s,\nu) \geq c_e\}$;

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

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

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

3.5 Discussion of Model Components

The model has three main components that drive firms' decisions. First, firms invest in physical capital to reach their optimal scale of production, which is set by decreasing returns to scale and an idiosyncratic shock. This process is slow due to the investment adjustment costs. Second, firms can raise external funds to finance their investment. Importantly, debt is not enforceable and firms can default on their debt obligations. Idiosyncratic productivity shocks are a source of risk for firms, as they might induce them to default. In case of a low draw, firms might not be able to repay their debt and cover the fixed operation cost. Third, deviations from the uncovered interest rate parity affect the currency composition of firms' debt. These deviations create a wedge between the domestic and foreign risk-free rates that makes foreign currency borrowing relatively more attractive. However, foreign currency borrowing is risky, as it exposes firms to exchange rate shocks. In this way, firms face a trade-off between a relative lower foreign currency risk-free rate and an increase in the their idiosyncratic risk of default. This trade-off drives the currency composition of firms' debt. In the next section, we present the calibration and validation of the model, and describe the mechanism in detail.

4 Calibration and Validation of the Model

The thirteen parameters of the model are calibrated to Hungarian data on yearly basis. Eight parameters are externally calibrated, and five are internally calibrated to match moments in the data for Hungary in 2005-2006.

We calibrate the parameters governing the deviation from the UIP externally. Given our focus on a small open economy, we let the risk-free rate in foreign currency (r^*) be exogenous and set it to 1.75%, which was the average interest rate of the one year German government bond between 2001 and 2015.[15] We set the local currency risk-free rate (r) to 7.35%, which was the average interest rate of the one year government bond in Hungary in the same period. As such, the domestic risk-free interest rate is higher than the foreign interest rate.

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

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

[15] We consider the interest rate for the German Bund as the relevant foreign interest rate for Hungary, as 75% of foreign currency loans in Hungary were denominated in Euros in 2005. Similarly, we choose the Euro as our reference currency and estimate the risk-free uncovered interest rate parity with respect to it.

where μ_i and ϕ_{jt} denote firm-fixed and sector-year fixed effects. This specification follows Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2012) and Gopinath, Kalemli-Ozcan, Karabarbounis, and Villegas-Sanchez (2017) and controls for firm-time invariant characteristics and sector time-variant shocks, as demand specific shocks. Based on this regression, we set $\rho_z = 0.63$ and the cross-sectional standard deviation of the residuals $\sigma_z = 0.57$ in equation (2). Finally, we set the depreciation rate (δ) to 10% and the elasticity of capital (α) to 0.6, which is the value estimated for Hungarian firms.

To mimic the period following the liberalization, we simulate the model in two steps. We first simulate an economy without foreign currency debt to obtain the stationary distribution of firms prior to the liberalization. We then compute the policies from a model with foreign currency and fit the realized exchange rate shocks observed between 2001 and 2010. This allows us to obtain the moments for the transition years following the financial liberalization.

Next, 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 (i.e. the first year for which we observe foreign currency debt data for Hungary). 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%).[16] We set β to match the share of firms borrowing only in local currency (21%).[17]

This process 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. We construct this panel data to have similar number of simulated firms than in the Hungarian data, i.e. about 160,000 firms per year. Table 2 summarizes the parameters and targeted moments.

4.1 Validation of the Model

To assess whether the model matches firms' foreign currency borrowing decisions and their investment patterns, we break down firms with credit into three groups according to their exposure to exchange rate shocks : 1) firms borrowing only in local currency, 2) firms borrowing in both local and foreign currency, and 3) firms borrowing only foreign currency. We evaluate the following non-targeted moments: the share of firms in each group, their relative productivity and capital, their investment rate, and their share of foreign currency bonds on total bonds.

Table 3 shows that the model is able to replicate closely the shares of firms and the characteristics

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

[17] Two additional parameters were calibrated: the fixed entry cost and the mass of firms, (c_e, M). They were set such that average entry equals exit, so that over time the firm distribution is stable. Similarly, the entrants' productivity signal is estimated in the same support as the incumbents productivity.

Table 2: Parameter Values

	Parameter Values	
	Value	Target
Parameters selected independently		
Foreign currency risk-free rate	$r^* = 1.76\%$	German Bund, 1 year rate
Domestic currency risk-free rate	$r = 7.35\%$	Hungarian Government Bond, 1 year rate
Exchange rate shock	$\rho_s = 0.86$ $\sigma_s = 0.3$	Euro-HUF Forint rate
Firm productivity	$\rho_z = 0.63$ $\sigma_z = 0.57$	Hungarian firms
Return to scale	$\alpha = 0.6$	Hungarian firms
Depreciation rate	$\delta = 10\%$	
Jointly calibrated parameters		
Discount	$\beta = 0.85$	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.

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

Second, the model matches closely the distribution of productivity and capital of each group. Firms that borrow in foreign currency are more productive both in the model and the data. In particular, firms that employ local and foreign currency funds are 2% more productive than firms with credit in the model and the data; while firms that only borrow in foreign currency are 7% more productive in the model and 5% in the data. Firms that only borrow in local are less productive in the model and the data. As expected firms that only employ foreign loans are smaller both in the model and the data, which is consistent with these firms using intensively these loans to reach their optimal scale of production.

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

Finally, the model predicts that firms borrowing in both currency have a foreign currency share

Table 3: Non-Targeted Moments (2005)

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

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.

of 59%, while this share is 50% in the data.

4.1.1 Mechanism and Model Predictions

Results in Table 3 show that firms might optimally choose to borrow in foreign currency and be exposed to the currency risk. In this section, we describe the mechanism driving this decision and derive some qualitative implications to assess in data in Section 5.

Foreign currency borrowing decisions are driven by a trade-off between aggregate deviations from the risk-free UIP and firms' idiosyncratic cost of funds. Intuitively, deviations from the UIP create a wedge between the domestic and foreign risk-free rates that make the latter relatively cheaper. However, foreign financing is risky because it exposes firms to exchange rate shocks. This exposure increases their default probability and, as a result, their financing costs (in local and foreign currency). Hence, firms borrow in foreign currency to the extent that the increase in their idiosyncratic cost of funds does not exceed the lower relative cost stemming from the deviation from the risk-free UIP.

Importantly, this trade-off varies across firms, as the increase in the cost of funds is heterogenous among them. In what it follows, we exploit this heterogeneity to derive two firm-level implications about the pattern of foreign currency borrowing and investment across firms.

-Lemma 1. Only high firms productive borrow in foreign currency. Crucially, these firms have higher investment rates and grow faster.

To illustrate this, we plot in Figure 2 the local and foreign currency bond price schedule for a given (s, k, b) and for high and low productivity firms. For low levels of foreign currency debt (low sB'^*), the price of this debt is higher than the domestic currency debt ($q^* > q$), since firms' default probability is low and the deviation from the UIP makes the risk-free rate in foreign currency lower. However, as firms increase their foreign currency debt holdings, their risk of default rises, which decreases their bond prices. This decrease is slower for more productive firms as they are able to tolerate higher shares of foreign currency debt without increasing the probability of default enough to wipe the benefits of the lower risk-free rate in foreign currency. Therefore, only high productive firms choose to borrow in foreign currency. Figure 2 (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 and fixing the state (k, b, b^*) at the average firm. It shows that only above a certain productivity level firms will choose to issue foreign currency denominated bonds. Importantly, as these firms enjoy lower financing costs and have a lower required rate of return for capital, and can invest more and grow faster.

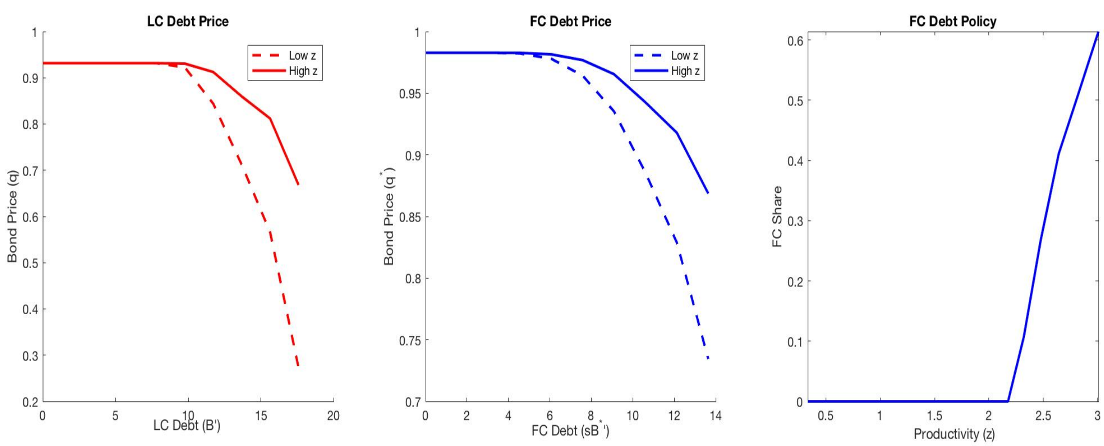


Figure 2: Domestic and Foreign Currency Bond Price

-Lemma 2. Higher deviations from the risk-free UIP increase foreign currency borrowing and decrease the productivity level to use this financing. Importantly, these deviations raise investment

and sales for firms issuing foreign bonds.

Higher deviations from the risk-free UIP increase the wedge between local and the foreign interest rate, which encourages firms to issue foreign currency denominated bonds. As the relative risk-free rate in foreign currency decreases, more firms are able to issue this financing and the productivity threshold decreases. To illustrate this, Figure 3 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 deviation from the risk-free UIP of 1.05 ($\theta = 1.05$). Note that only firms with productivity above 2.2 will choose to borrow in foreign currency and will hold less than 60% of their debt in that type of loan. The dashed line in Figure 3 depicts a higher the deviation from the risk-free UIP ($\theta = 1.07$). It shows that a higher deviation increases the benefit of foreign currency borrowing, which decreases the average productivity of firms borrowing in foreign currency and increases the average share of foreign currency loans.

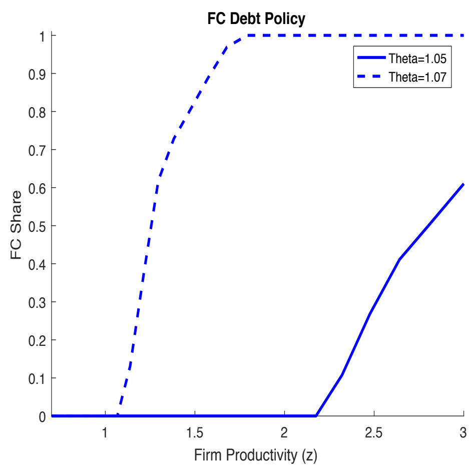


Figure 3: Deviation from the risk-free UIP and Share of Foreign Currency Loans

Note that, as the deviation increases, the relative borrowing costs decreases for foreign currency borrowing firms, which promotes their investment and future sales.

5 Model vs Data: Firm-Level Analysis

In this section, we assess the model's predicted patterns of foreign currency borrowing and investment at the firm level. We employ the model to simulate firm-level data and derive implications that we test empirically using the Hungarian data presented in Section 2. We conduct three empirical exercises estimating in parallel firm-level regressions using the model's and the Hungarian data. In Section 5.1, we assess selection into foreign currency borrowing and whether firms choosing this financing grow faster. In Section 5.2, we test whether deviations from the risk-free UIP correlate with increases in foreign currency borrowing and higher growth. In Section 5.3, we assess the model's mechanism by testing if firms borrowing in foreign currency face lower financing costs.

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

We start this section by studying the characteristics of firms borrowing in foreign currency and turn next to analyze whether they correlate with higher growth.

5.1.1 Firms' Characteristics

The model predicts that foreign currency borrowing correlates with firms' productivity. As shown in Section 4.1.1, more productive firms face lower idiosyncratic risk and borrowing costs, and can raise higher shares of foreign currency debt. Table 3 showed that, in 2005, firms borrowing in foreign currency were more productive and had higher shares of foreign currency debt, both in the model and the data. A potential issue of the Hungarian data presented in Table 3 is that firms borrowing in foreign currency could be using these loans to increase their productivity, which would question the causality of the empirical results. To address this reverse causality concern, in this section we exploit the deregulation of foreign currency loans in Hungary in 2001. This policy reform serves as an exogenous source of time variation to test whether firms starting to borrow in foreign currency after the deregulation were indeed more productive prior to it.

An important feature of capital controls in Hungary is that they were implemented asymmetrically between foreign-owned companies and domestic firms. While foreign firms were legally allowed to hold foreign denominated loans, domestic firms could only borrow locally in national currency.[18] The deregulation of international financial flows in 2001 removed capital controls on domestic firms and allowed them to borrow in foreign currency. In this section, we exploit the ban on domestic firms' foreign currency loans prior to 2001 to study the pre-reform characteristics of firms choosing to borrow in foreign currency, once these loans were legally allowed for them. In particular, we restrict our analysis to domestic firms and study whether foreign currency borrowing increases in domestic firms' pre-reform productivity.

With this end, we first employ the simulated data described in Section 4 to estimate the relationship between foreign currency borrowing and firms' productivity, and then test whether the correlations implied by the model are present in the Hungarian data. Hence, we estimate in parallel regressions using the model simulated data and Hungarian data. We focus on two indicators of

[18]Prior to the financial liberalization in 2001, regulations in the foreign exchange market were the main tool of capital controls in Hungary. These operations were regulated by the Act XCV of 1995, which –by imposing severe restrictions on the foreign exchange market– restricted domestic firms to borrow locally in national currency. Under this law, only foreign companies were allowed to hold foreign currency denominated loans. The deregulation of capital controls in 2001 removed these restrictions, enabling domestic firms to obtain foreign denominated loans. After the deregulation, foreign currency borrowing expanded substantially for domestic firms. See Varela (2017) and Appendix C for a detailed description of the financial liberalization.

firms' foreign borrowing decisions: whether firms borrow in foreign currency and their share of foreign currency loans on total loans.

We estimate the following linear probability regression using the model simulated data:

$$\text{FC Dummy}_i = \beta \log \mathrm{z}_i + \varepsilon_i, \tag{8}$$

where FC Dummy$_i$ is a dummy indicating whether a firm has a foreign currency loan in 2005, and z_i represents the firm's productivity in the year 2000 prior to the deregulation of foreign currency loans. We create the foreign currency loan dummy for 2005 because the Hungarian debt data that only dates from 2005 and this allow us to make a direct comparison with the Hungarian debt data.[19] The coefficient β captures whether firms that were more productive prior to deregulation of foreign currency borrowing have a higher probability of using this financing after the reform.

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

$$\text{FC Dummy}_i = \beta \log \mathrm{RTFP}_i + \mu_j + \varepsilon_{ij}, \tag{9}$$

where RTFP denotes firms' revenue TFP. μ_j represent four-digit NACE industries fixed effects that allow comparing firms within industries and control for sectoral time-invariant characteristics. We cluster standard errors at four-digit industries to account for cross-sectional serial correlation within sectors. To assess firms' currency debt composition, we replace in equations (8) and (9) the foreign currency dummy with firms' log share of foreign currency loans.

Results

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

Columns 5-8 report the results on the log of the share of foreign currency loans. The model implies that a one percent increase in firms' productivity raises the share of foreign currency loans by 0.01 percent (column 5). As above, the coefficient in column 6 remains stable when including firms' initial capital stock as a control. The regressions estimated using the Hungarian data confirm

[19] Unfortunately, the Credit Register data on foreign currency loans only starts in 2005, which limits our analysis to 2005 as initial year.

Table 4: Decision into Foreign Currency Borrowing

	Foreign Currency Loan Dummy				Log Share of Foreign Currency Loans			
	Model		Data		Model		Data	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log productivity	0.027***	0.024***	0.024***	0.013***	0.012***	0.011***	0.006***	0.002*
	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.001)
Log capital		0.007***		0.036***		0.002***		0.013***
		(0.001)		(0.002)		(0.000)		(0.001)
Sector FE			Yes	Yes			Yes	Yes
R^2	0.008	0.009	0.029	0.060	0.006	0.006	0.026	0.042
N	156,806	156,806	37,051	37,051	156,806	156,806	37,051	37,051

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

these results, as shown in columns 7 and 8. The coefficient on RTFP –presented in column 7– is statistically significant and close to the estimate using the model data. In particular, a one percent increase in Hungarian firms' productivity raises firms' share of foreign currency loans by 0.006 percent. The estimated coefficient is robust to controlling for firms' capital (column 8).

Table A.1 (in Appendix A.2) presents additional tests and controls. Panels A and B report the results for the FC debt dummy and the share of foreign currency loans, respectively. Column 1 includes as a regressor firms' age to account for the finding that younger firms are usually more credit constrained (Cooley and Quadrini 2001, among others). The estimated coefficient indicates that age correlates negatively with firms' probability of borrowing in foreign currency and their foreign currency shares, suggesting that younger firms are more prone to take the currency risk and borrow in foreign currency. Column 2 shows that results are robust to estimating firms' RTFP using the methodology of Olley and Pakes (1996) to estimate the coefficients of the production function, and column 3 to using labor productivity (value added per worker) as a proxy for firms' productivity. Column 4 includes a dummy for export status and shows that results are robust to this control. Column 5 illustrates that results are robust to using averages between 1998 and 2000 as pre-reform firms' characteristics.

5.1.2 Firms' Growth

The model predicts that firms borrowing in foreign currency have a higher investment rate as they can borrow at cheaper financing terms. As a result, these firms also see higher level of sales. Section 4.1.1 discussed this result and Table 3 documented first evidence of it.

We turn now to assess this implication at the firm-level using the model simulated data and the Hungarian data. Similar to our previous exercise, we exploit the financial liberalization as a source of time variation and study whether firms borrowing in foreign currency grow faster within the five years before and after the financial liberalization. We consider the following model:

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

where $\log Y_{it}$ denotes log investment rate and sales between 1996-2005, FL_t is a dummy for the post-financial liberalization period ($\mathrm{FL}_t > 1$ if year$\geq$ 2001, and 0 otherwise), and ϕ_i are firm-fixed effects that allow capturing the evolution of firms over time. The coefficient of interest is β, which captures whether firms borrowing in foreign currency associate with higher investment and growth after the financial deregulation in 2001.

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 in our specification a time trend (T_t) and a time trend interacted with the foreign currency borrowing debt dummy ($T_t\,\mathrm{x}\,\mathrm{FC\,Dummy}_i$). The final model that we estimate is:

$$\log\, Y_{it} = \beta\,(\mathrm{FL}_t\,\mathrm{x}\,\mathrm{FC\,Dummy}_i) + FL_t + \phi_i + T_t + (T_t\,\mathrm{x}\,\mathrm{FC\,Dummy}_i) + \varepsilon_{it}. \qquad (10)$$

The coefficient β in equation (10) captures if firms borrowing in foreign currency see higher levels of investment rate and sales between 2001-2005, once pre-existing growth trends are taking into account. Standard errors are clustered at year and four-digit sector when employing the Hungarian data. Importantly, regression (10) does not aim to address causality, but to simply check whether foreign currency loans correlate with higher growth.

Results

Table 5 present the results for the investment rate and sales. Columns 1 and 2 report the coefficients for the model simulated data. As expected, the estimated coefficient in column 1 is positive, confirming that firms borrowing in foreign currency see higher investment rates. After the inclusion of pre-growth trends in column 2, the model implies that they have a 13.9 percent higher investment rate than non-foreign currency borrowing firms after the financial liberalization. Columns 3 and 4 report the results for the regressions estimated using the Hungarian data. The coefficient on the interaction term is statistically significant in both specifications. After the inclusion of the time trends in column 4, the estimated coefficient implies that Hungarian firms borrowing in foreign currency report 4.6 percent higher investment rates.

Columns 5-8 reports the results on firms' sales. Just like the trends in investment, firms borrowing in foreign currency enjoy higher levels of sales after the deregulation of foreign loans. The model implies that firms borrowing in foreign currency experience a 5.5 percent higher sales within the five years following the deregulation and once pre-growth trends are taken into account (column 6). The estimated coefficient using the Hungarian data is statistically significant and similar on magnitude. After the inclusion of all controls, the coefficient that having a foreign currency loan

Table 5: Foreign Currency Borrowing and Firms' Growth

	Log Investment Rate				Log Sales			
	Model		Data		Model		Data	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FL* FC dummy	0.319***	0.139**	0.214***	0.046*	0.639***	0.055***	0.280***	0.038***
	(0.032)	(0.061)	(0.018)	(0.025)	(0.005)	(0.010)	(0.013)	(0.014)
FL	0.002	0.117***	0.180***	0.207***	-0.190***	0.002	0.222***	0.013**
	(0.007)	(0.013)	(0.031)	(0.026)	(0.001)	(0.002)	(0.010)	(0.006)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time trend		Yes		Yes		Yes		Yes
FC d.* Time t.		Yes		Yes		Yes		Yes
R^2	0.218	0.218	0.651	0.489	0.571	0.570	0.834	0.836
N	1,568,060	1,568,060	432,864	432,864	1,568,060	1,568,060	436,062	436,062

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

correlates with 3.8 percent higher level of sales after the financial liberalization.

The model argues that firms borrowing in foreign currency are more productive and enjoy higher investment rates and sales. In this section, we tested these implications at the firm-level using the model simulated data and confirm them using the deregulation of foreign currency loans in Hungary in 2001. In the next section, we advance our analysis on firms' foreign currency borrowing decision by focusing on changes in the deviation from the UIP.

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

The model shows that deviations from the risk-free UIP create a wedge between the domestic and foreign risk-free rates that induces firms to borrow in foreign currency. Figure 1 presented first evidence that, in Hungary, these deviations correlate with increases in the aggregate share of foreign currency borrowing. In this section, we study this relationship at the firm level by assessing Lemma 2 using the model simulated data and the Hungarian data. We start by studying the relationship between deviations from the UIP and firms' foreign currency borrowing decisions, and turn next to study their impact on firms' growth. We finally analyze whether deviations from the UIP lowers the productivity level to employ this financing.

5.2.1 Foreign Currency Borrowing Decisions

We assess the relationship between deviations from the risk-free UIP and foreign currency borrowing in three steps. First, we check whether these deviations associate with higher foreign currency borrowing at the firm-level. Second, we evaluate whether these responses are heterogenous across firms and correlate with firms' productivity. As discussed above, more productive firms present lower idiosyncratic risk that should allow them to take greater advantage from increases in the deviations from the UIP to borrow and invest more. 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 firms to accumulate more capital and grow faster. Hence, we study whether –conditional on productivity– firms with lower capital stock exploit more the deviations from the UIP to reach faster their optimal scale of production. In this way, we exploit three sources of variations to identify firms' foreign currency borrowing decisions: deviations from the UIP across time and cross-sectional variations in terms of firms' productivity and capital stock.

We start studying these relationships employing the model simulated data. To check whether deviations from the uncovered risk-free interest rate parity correlate with increases in firms' foreign currency borrowing, we consider the following specification:

$$Y_{it} = \beta \log \mathrm{UIP}_t + \phi_i + \varepsilon_{it}, \tag{11}$$

where Y_{it} represents either a foreign currency debt dummy or the log share of foreign currency borrowing, FC Dummy_i or Log FC Share_i. Log UIP_t is the log deviation of the deviation from the risk-free UIP, i.e. the log of θ in the model. The coefficient β in equation (11) captures whether higher deviations from the UIP associate with increases firms' probability to borrow in foreign currency and with their share of foreign currency debt. We restrict our analysis to the years 2005-2010, which are the years for which we have credit data for Hungary.

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

$$Y_{it} = \beta \log(\mathrm{UIP}_t \text{ x } \mathrm{z}_i) + \iota_t + \phi_i + \varepsilon_{it}, \tag{12}$$

where z_i represents the firm's productivity and ι_t are year-fixed effects. The coefficient β in equation (12) captures whether more productive firms differentially increase their use of foreign currency loans following deviations from the UIP.

To evaluate whether firms with lower capital stock exploit the deviations from the UIP to reach faster their optimal scale, we break down firms by quartiles of productivity and capital in the initial year. In particular, we create four bins according with whether firms have "high" or "low" productivity and capital stock in 2005.[20] We create the following four bins: high productive firms with low capital ($Q_{HL} = 1$, if z^H and k^L), high productive firms with high capital ($Q_{HH} = 1$, if z^H and k^H), low productive firms with low capital ($Q_{LL} = 1$, if z^L and k^L), and low productive firms with high capital ($Q_{LH} = 1$, if z^L and k^H). These four dummies allow us to compare the

[20]We consider 2005 as our initial year because the Hungarian credit only reports from 2005. It is important to create the bins with respect to initial values to address reverse causality concerns. This is particularly important when employing the Hungarian data.

responses of firms with different levels of capital stock, but similar productivity level. We expect that high productive firms with low capital (Q_{HL}) present the highest response to deviations from the UIP, as these firms have low idiosyncratic risk and high growth potential. More precisely, we estimate the following regression:

$$Y_{it} = \beta_1 \log(\text{UIP}_t \text{ x } Q_{HLi}) + \beta_2 \log(\text{UIP}_t \text{ x } Q_{HHi}) + \tag{13}$$
$$\beta_3 \log(\text{UIP}_t \text{ x } Q_{LLi}) + \beta_4 \log(\text{UIP}_t \text{ x } Q_{LHi}) + \iota_t + \phi_i + \varepsilon_{it}.$$

The estimated coefficients $\beta_1, \beta_2, \beta_3$ and β_4 in regression (13) capture the differential response of each bin to changes in the deviation from the risk-free UIP.

We next turn to test regressions (11)-(13) employing the Hungarian data. We create the variable UIP_t by computing the one-year deviation from the risk-free 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.[21] 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 share of loans for each currency and year. We create the bins of RTFP and capital with respect to the median firm within the four-digit NACE industries in the initial year (2005). To control for demand specific shocks that can affect sectors differently across time, we include in regressions (12) and (13) four-digit NACE industry and year fixed effects interacted. We cluster the standard errors at year and four-digit NACE industries in the three specifications.

Results

Columns 1-3 in Table 6 present the results of regressions (11), (12) and (13) using the model simulated data. The coefficient in column 1 Panel A shows that the model implies that a one percent increase in the deviation from the risk-free UIP raises firms' probability of borrowing in foreign currency by 0.07 percent. To visualize the magnitude of this coefficient, note that in economy of 150,000 firms a ten percent increase in the deviation from the UIP leads 1,050 more firms to borrow in foreign currency. As expected, the model shows that more productive firms have higher probability of borrowing in foreign currency following deviations from the UIP (column 2). Column 3 presents the estimated coefficients for the four bins of firms. As expected, high productive firms with low initial capital stock (Q_{HL}) report the highest response to deviations from the UIP. 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 of regressions (11)-(13) estimated employing the Hungarian data. Column 4 presents the results of the regressions of the foreign currency dummy on the deviation from the UIP. The estimated coefficient implies that a one percent increase in the deviation from the UIP raises firms' probability to borrow in foreign currency by about 0.14 percent. This implies

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

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

	Panel A. FC Dummy					
	Model			Data		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.071**			0.139***		
	(0.028)			(0.018)		
Log (Dev. UIP x Productivity)		0.055***			0.035***	
		(0.014)			(0.008)	
Log (Dev. UIP x Q_{HL})			0.246***			0.189***
			(0.029)			(0.032)
Log (Dev. UIP x Q_{HH})			0.230***			0.080**
			(0.025)			(0.041)
Log (Dev. UIP x Q_{LL})			0.180***			0.050*
			(0.025)			(0.030)
Log (Dev. UIP x Q_{LH})			0.177***			0.089**
			(0.016)			(0.041)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes	Yes
Sector* Year FE					Yes	Yes
R^2	0.419	0.501	0.21	0.741	0.696	0.742
N	940,836	940,836	940,836	1,019,461	1,019,461	1,019,461
	Panel B. Log Share of Foreign Currency Loans					
	Model			Data		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.063***			0.076***		
	(0.015)			(0.010)		
Log (Dev. UIP x Productivity)		0.022***			0.022***	
		(0.008)			(0.004)	
Log (Dev. UIP x Q_{HL})			0.177***			0.085***
			(0.018)			(0.016)
Log (Dev. UIP x Q_{HH})			0.148***			0.059***
			(0.015)			(0.021)
Log (Dev. UIP x Q_{LL})			0.170***			-0.000
			(0.015)			(0.017)
Log (Dev. UIP x Q_{LH})			0.117***			0.053**
			(0.010)			(0.023)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes		Yes	Yes
Sector* Year FE					Yes	Yes
R^2	0.402	0.515	0.208	0.716	0.664	0.717
N	940,836	940,836	940,836	1,019,461	1,019,461	1,019,461

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

that a ten percent increase in the deviation leads to about 2,000 more firms borrowing in foreign currency. 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 model simulated data, high productive firms with low capital have the highest response to deviations from the uncovered interest rate (column 6). A one percent increase in this deviation raises the probability of borrowing in foreign by about 0.19 percent for this group of firms.

Panel B reports the results for the share of foreign currency debt. Columns 1-3 present the coefficients implied by the model. Column 1 shows that a one percent increase in the deviation from the UIP leads to a 0.06 percent increase in firms' foreign currency share. As expected this expansion increases in firms' productivity, as indicated in column 2. Results also point to high productive firms with low initial capital stock differentially increase their foreign currency shares. A one percent increase in the deviation from the UIP raises these firms' 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 increase in the deviation from the UIP 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). Column 6 shows that higher productive firms with low capital have the higher response to these deviations. In particular, a one percent increase in the deviation from the UIP leads these firms to expand their foreign currency share by 0.08 percent.

These results suggest that productive firms with low capital differentially exploit deviations from the risk-free UIP to borrow in foreign currency. As a robustness, we test whether these decisions correlate with firms' age. Since young firms usually face tighter credit constraints, one would expect that young and productive firms take greater advantage from these deviations to borrow more. With this end, we follow a similar procedure as above and create four bins: high productive and young firms (Q_{HY}), high productive and old firms (Q_{HO}), low productive and young firms (Q_{LY}), and low productive and old firms (Q_{LO}). We then interact these dummies with the variable reporting the deviations from the risk-free UIP and estimate equation (13). Table A.2 in Appendix A presents the results for the simulated and the Hungarian data. Columns 1-4 show that young and productive firms (Q_{HY}) have the highest response to these deviations among the four groups. Both in the model and the data, the estimated coefficients imply that these firms have a higher probability to borrow in foreign currency and increase their share of foreign currency loans following deviations from the risk-free UIP.

5.2.2 Firms' Growth

We showed in the previous section that deviations from the UIP associate with increases in foreign currency borrowing. We turn now to assess whether firms employ these funds to expand their investment. With this end, we follow a similar exercise than in the previous section and regress (11)-(13) using the log of the investment rate and sales as dependent variables.

Table 7: Deviations from the Risk-Free UIP: Firms' Growth

	Panel A. Log Investment Rate					
	Model			Data		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.099***			0.079*		
	(0.027)			(0.042)		
Log (Dev. UIP x Productivity)		0.190***			0.328***	
		(0.031)			(0.017)	
Log (Dev. UIP x Q_{HL})			4.708***			0.235***
			(0.026)			(0.071)
Log (Dev. UIP x Q_{HH})			1.032***			0.188**
			(0.027)			(0.082)
Log (Dev. UIP x Q_{LL})			0.079***			0.129**
			(0.025)			(0.060)
Log (Dev. UIP x Q_{LH})			-5.598***			-0.019
			(0.027)			(0.071)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector* Year FE					Yes	Yes
R^2	0.42	0.412	0.706	0.033	0.042	0.700
N	940,836	940,836	940,836	513,116	513,116	513,116
	Panel B. Log Sales					
	Model			Data		
	(1)	(2)	(3)	(4)	(5)	(6)
Log Dev. UIP	0.152**			0.059*		
	(0.072)			(0.031)		
Log (Dev. UIP x Productivity)		0.210**			0.145***	
		(0.087)			(0.041)	
Log (Dev. UIP x Q_{HL})			9.963***			0.250*
			(0.079)			(0.146)
Log (Dev. UIP x Q_{HH})			6.218***			0.248*
			(0.077)			(0.145)
Log (Dev. UIP x Q_{LL})			-4.649***			0.193
			(0.077)			(0.176)
Log (Dev. UIP x Q_{LH})			-6.584***			0.297
			(0.078)			(0.191)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector* Year FE					Yes	Yes
R^2	0.722	0.722	0.873	0.877	0.852	0.905
N	940,836	940,836	940,836	765,611	765,611	765,611

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

Results

Panel A in Table 7 presents the results on firms' investment. Column 1 reports the estimated coefficient of equation (11) employing the model simulated data. The model implies that a one percent increase in the deviation from the UIP leads to an expansion of 0.1 percent in firms' investment rate. As expected, this expansion is higher for more productive firms (column 2). Just like the previous trends, column 3 shows that high productive firms with low levels of capital have the highest response to deviations from the UIP. This result confirms that firms take advantage from the relatively lower risk-free cost of foreign currency debt to expand their investment and reach their optimal scale of production.

Columns 4-6 report the results for Hungarian firms. The estimated coefficient on the investment rate is statistically significance and similar in size to the elasticity implied by the model in column 1. In particular, column 4 shows that a one percent increase in the deviation from the UIP leads to 0.08 percent increase in firms' investment rate. Column 5 shows that the expansion is higher for more productive firms and column 6 that –among them– firms with low level of capital report the highest response. The estimated coefficient implies that a one percent increase in the deviation from the UIP leads to an expansion of 0.23 percent in the investment rate of these firms.

Columns 1-3 in Panel B show the results for sales employing the model simulated data. The model implied elasticity of deviation from the UIP to firms' sales is 0.15 percent (column 1). As expected, this elasticity is higher for more productive firms (column 2). Column 3 confirms that high productive firms with low capital present the highest response to deviations from the UIP.

Columns 4-6 report the results for Hungarian firms. Column 4 confirms that deviations from the UIP correlate with increases in firms' sales. A one percent increase in these deviations leads to a 0.06 percent expansion in firms' sales. This expansion is higher for productive and, among them, firms with low capital stock (columns 5 an 6).

We now turn to check whether young and productive firms expand more their investment rate and sales following deviations from the risk-free UIP, as in the previous section. We estimate equation (13) using the four dummies for age and productivity interacted. Results are presented in Table A.2, Appendix A. Columns 5-8 show that, both in the model and the data, young and productive firms have the highest response to deviations from the risk-free UIP. Following these deviations, they expand their investment rate and sales relatively more than the other groups of firms.

Results above show that deviations from the UIP correlate with a higher probability of borrowing in foreign currency, share of foreign currency loans, investment rate and higher level of sales. Importantly, there is heterogeneity in firms' responses to deviations from the UIP. In particular, more productive firms and, among them, firms with lower capital take greater advantage of these deviations to further increase their investment and growth faster. In the next section, we have a closer look at the implied mechanism driving these decisions.

5.2.3 Productivity Level to Borrow in Foreign Currency

Lemma 2 states that deviations from the risk-free UIP decrease the productivity level to employ foreign currency loans, as they reduce the relative risk-free rate of this financing. We turn now to assess this implication using the simulated and the Hungarian data.

To evaluate this, we estimate the following regression for firms borrowing in foreign currency

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

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

Results

Columns 1 and 2 in Table 8 report the results for the simulated and the Hungarian data, respectively. The estimated coefficients are negative in both specifications arguing for a reduction in the average productivity of firms borrowing in foreign currency. This result confirms that deviations from the UIP reduce the productivity threshold to start borrowing in foreign currency and induce less productive firms to employ this financing.

Table 8: 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 a regression of log productivity on the log deviation from the risk-free UIP for firms borrowing in foreign currency between 2005-2010. Source: APEH and Credit register.

5.3 Mechanism: Costs of Funds

A key feature of the model is that firms borrowing in foreign currency enjoy lower costs of funds, as discussed in Section 4.1.1. We turn to assess this implication using the following regression estimated on the simulated and the Hungarian data

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

where Y_{it} denotes the local bond price or the foreign bond price in the model (q and q^*), and the interest rate for Hungarian firms. The data on Hungarian firms' interest rate comes from the Business Environment and Enterprise Performance Surveys (BEEPS) of the World Bank and the European Bank for Reconstruction and Development on Hungary.[22] Since the Hungarian data on interest rates is only available for 2005, we estimate the regression on the simulated data for the same year.

Results

Columns 1 and 2 in Table 9 presents the results using the model simulated data. As expected, firms borrowing in foreign currency can issue bonds at higher prices. Columns 3-5 report the estimated coefficients for Hungarian firms. Column 3 shows that firms borrowing in foreign currency paid on average lower interest rates. After controlling for firm characteristics and sector-fixed effects in column 5, the estimated coefficient implies that foreign currency borrowing firms pay on average one percentage point lower interest rate.[23]

Table 9: Bond Prices and Interest Rate

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

Notes: *, **, *** significant at 10, 5, and 1 percent. Standard errors in parentheses. The 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. Firm-level controls 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.

[22] 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.

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

6 Aggregate Implications

We use our firm-dynamics model to quantify the aggregate impact of foreign currency borrowing. To understand the impact of foreign currency debt, we compare the results of the benchmark model to three experiments: without foreign currency borrowing, without selection into foreign borrowing, and with different exchange rate volatility. In all experiments, we start from the stationary distribution of the model without foreign currency, and simulate firms using the policies of each of the three experiments and the realized exchange rate shocks in Hungary during 2001 to 2010.

6.1 FC vs non FC borrowing

In the first counterfactual exercise, we ban firms' ability to borrow in foreign currency and restrict them to use local bonds. This exercise is equivalent to what would have happened to the Hungarian economy if they had not liberalized foreign currency loans in 2001.

Column 2 in Table 10 displays the results for the benchmark model from Sections 3 and 4. The moments correspond to the average for the period 2001-2010. Column 3 of Table 10 presents the results of the economy without foreign currency. In line with the mechanism proposed in this paper, in the benchmark economy firms have higher investment rates (22%) and are larger in size (12%) compared to the economy where foreign currency is not an option. Furthermore, firms see lower exit probability (22%) in the economy with foreign currency borrowing. Therefore, even though in the benchmark economy firms are expose to an additional risk –the exchange rate shock– their higher investment allows them to grow and to become more resilient to shocks.

On the aggregate, column 3 shows that during that period the economy without foreign currency borrowing would see 13% lower sales and 18% fewer capital. This economy has no volatility, as it is not affected by exchange rate shocks and firm-idiosyncratic shocks average out on the aggregate. This exercise indicates that foreign currency borrowing in this period would trade higher growth for higher volatility.

6.2 Selection into FC Borrowing

One key feature of the model is that firms self-select into foreign currency borrowing and choose their optimal level of exposure to it. Therefore, only firms sufficiently productive choose to take advantage of the lower financing costs. To understand the quantitive importance of this selection, we conduct an exercise in which all firms have a fixed share of foreign currency debt. We choose this share to be equal to the equilibrium value in the benchmark model. This exercise can be interpreted as firms not being able to evaluate their resilience to exchange rate shocks. Column 4 displays the results of the model where all firms hold the same level of foreign currency debt. In an economy with no selection firms have lower investment rates (29%) and are larger in size

Table 10: Numerical Exercises

	Benchmark	No FC Borrowing	No Selection	ER Volatility	
				Low ($\sigma_s = 0.15$)	High ($\sigma_s = 0.45$)
	(1)	(2)	(3)	(4)	(5)
			Panel A. Firm-level results		
FC debt share	12.1	-	12.1	42.9	0.0
Investment rate	10.6	8.3	7.6	11.9	9.5
E(K)	20.0	17.8	23.1	21.6	18.8
Default rate	2.7	3.3	7.7	2.5	3.1
Productivity threshold	1.2	-	0.0	1.0	1.3
			Panel B. Aggregate results		
Sales growth rate	1.2	-1.4	-3.9	1.9	-0.6
Capital growth rate	2.3	-1.4	-3.0	3.5	-0.2
Sales (level)	100.0	87.8	79.6	111.9	98.9
Capital (level)	100.0	82.8	78.6	115.3	95.2
Std. dev. sales	100.0	0.0	84.2	68.1	22.6
Std. dev. capital	100.0	0.0	39.7	93.3	7.5

Notes: Rows 1, 3, 4, 6 and 7 are in percentage, rows 8-11 are with respect to column 1. This table shows moments for the benchmark model, the model with no foreign currency debt and the model where all firms hold the same share of foreign debt (no selection). For those results, we simulate approximately 160,000 firms from the stationary distribution of no foreign currency using the realized exchange rate shocks between 2000 to 2010 and the policy functions of each model. Table shows the average for the period.

(9%) relative to the benchmark model. This lower investment stems from the increase in the cost of funds of less productive firms. The larger size is due to the higher default probability which generates the survival of only the larger firms. Foreign currency borrowing increases their exposure to the exchange rate risk and, hence, their default probability. This higher risk raises their costs of funds, undermining their investment. The greater exposure to the currency risk also reflects in a higher average exit probability, which is significantly higher (185%) in an economy where firms are unable to select into borrowing in foreign currency.

On the aggregate, the economy with no selection would have 20% lower sales and is 21% smaller in the size when compared to the benchmark. This exercise indicates that no selection into foreign currency borrowing would actually be detrimental in a small open economy.

6.3 Exchange Rate Volatility

We turn now to analyze the effect of the volatility of the exchange rate shock. First, we set the standard deviation of the exchange rate shock to be half of the value in the benchmark economy ($\sigma_s = 0.15$). Results for this exercise are presented in column (4). Less volatile exchange rate increases firms' optimal share of foreign currency debt. Since more firms can borrow at a lower rate, investment rate and average firm size are also higher than in the benchmark economy (12% and 7%, respectively). Furthermore, lower exchange rate volatility allows less productive firms to select into borrowing in foreign currency. Aggregate sales and capital are higher than in the benchmark (11% and 15%), and their volatility is lower. Intuitively, if the exchange rate is less volatile the risk from its exposure is lower, making the net benefit of foreign currency borrowing higher.

Next, we set the standard deviation to 50% higher than the value in the benchmark economy ($\sigma_s = 0.45$). Results for this exercise are presented in column (5). The high volatility makes borrowing in foreign currency a very risky option and, thus, firms prefer to borrow only in local currency. If firms do not have access to the lower financing of foreign currency loans, investment is lower than the benchmark model (11%), firms are smaller (7%) and default more often (15%). On the aggregate, the economy with higher volatility have 5% lower capital and 1% lower sales but, since they do not borrow in foreign currency, have lower volatility.

7 Model: Sensitivity Analysis

In this section, we conduct a sensitivity analysis of main parameters of our model. In particular, we follow similar exercises than in Section 6 and estimate counterfactuals at firm and aggregate level for each extension. In Section 7.1, we relax the assumption of zero pass-through of exchange rate shocks into local prices. Section 7.2 endogeneizes the risk-free rates by modeling investors' stochastic discount factors. Section 7.3 includes aggregate shocks into the model, and let these shocks be negatively correlated with exchange rate shocks.

In all these exercises, we follow a similar strategy as in Section 6 and simulate approximately 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, and the optimal policies of the model with foreign currency borrowing of each parametrization to obtain the moments for 2001-2010.

7.1 Exchange Rate Pass-Through

In our benchmark calibration, we let sales to be denominated in local currency, and allowed no pass through of the exchange rate into local currency prices. In this section, we assets how the exchange rate pass through affects firms' decisions. In particular, we follow similar exercises than in Section 6 and estimate counterfactuals at firm and aggregate level.

To analyze the impact of exchange rate pass-through in firms' financing and investment decisions, we model local prices as $p = p^* s^\eta$, and normalize the foreign price p^* to one. We can rewrite firms' equity as

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

where firms' revenue, investment and costs receive a pass-through η from the exchange rate.

Table 11 displays the results different parameterizations of η and our benchmark calibration (where $\eta = 0$). We let $\eta = [0.2, 0.5, 1]$, which are the exchange rate pass-through observed in Hungary between 1992 and 2015, half pass-through into local prices and complete pass-through.

Table 11: Exchange Rate Pass-Through

	Benchmark (1)	$\eta = 0.2$ (2)	$\eta = 0.5$ (3)	$\eta = 1$ (4)
	Panel A. Firm-level results			
FC debt share	12.1	27.3	38.6	42.3
Investment rate	10.6	12.0	13.6	12.5
E(K)	20.0	19.5	20.1	21.5
Default rate	2.7	2.5	2.6	2.3
Productivity threshold	1.2	1.1	1.1	1.0
	Panel B. Aggregate results			
Sales growth	1.2	2.8	5.4	6.3
Capital growth	2.3	4.1	6.7	5.6
Aggregate sales	100.0	89.6	101.7	82.5
Aggregate capital	100.0	83.5	88.6	64.2
Std. dev. aggregate sales	100.0	87.1	181.7	166.7
Std. dev. aggregate capital	100.0	81.5	135.7	84.6

Notes: Rows 1, 3, 4, 6 and 7 are in percentage, rows 8-11 are with respect to column 1. This table shows moments for the benchmark model and for different levels of exchange rate pass-through into local prices (η). 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. Table shows the average for the period.

In the case that sales move with the exchange rate ($\eta > 0$), foreign currency debt provides a hedge against exchange rate movements. Therefore, the higher η, the higher is the share of foreign currency debt and the lower the average productivity of firms using this type of financing. However, the mechanism we focus on this paper, lower cost of risk free foreign currency debt, is still present so higher η also implies higher investment rate. Note that when $\eta = 1$, more and less productive firms borrow. This generates a slight drop in average investment relative to $\eta = 0.5$. In aggregate, sales and capital are generally lower and more volatile, this is due to the fact that prices are moving adding an additional source of risk.

7.2 Endogenous Interest Rates

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

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

$$m' = \frac{1}{(1+r)}\left(\frac{s'}{s}\right)^{\gamma} \qquad \text{and} \qquad m'^{*} = \frac{1}{(1+r^{*})}\left(\frac{s'}{s}\right)^{\gamma^{*}}, \tag{14}$$

where m' and m'^{*} are the discount factors of home and foreign investors, respectively. Discount factors are then defined by baseline rates (r and r^{*}) adjusted by the exchange rate shocks with sensitivity γ and γ^{*}. Thus, $\gamma, \gamma^{*} > 0$ imply that investors value more payments when the exchange rate depreciates (i.e. lower states). Note that, if the exchange rate is a good predictor of consumption –as shown by Engel and West (2005)–, equation (14) is a version of the consumption C-CAPM discount factor.

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

$$1+\tilde{r}(s) = \frac{1}{E(m'|s)} \qquad \text{and} \qquad 1+\tilde{r}^{*}(s) = \frac{1}{E(m'^{*}|s)}. \tag{15}$$

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

Using equations (14) and (15), we can re-write the UIP condition as:

$$\theta\frac{E(s'|s)}{s} = \frac{(1+r)}{(1+r^{*})}\left(\frac{E(s'^{\gamma*-\gamma}|s)}{s^{\gamma*-\gamma}}\right). \tag{16}$$

Equation (16) shows that the deviation from the UIP depends on the exchange rate shocks as well as investors' sensitivity to these shocks. Note that our benchmark calibration of Section 4 is equivalent to setting $\gamma = \gamma^{*} = 0$.

Table 12 shows the results of different parameterizations of investors' sensitivity. In column (2), we let both local and foreign investors have the same sensibility to exchange rate shocks and $\gamma = \gamma* = 1$. Compare to the benchmark model in column 1, if $\gamma^{*} = 1$, foreign investors charge a premium during depreciations. As the foreign interest rate becomes higher, a smaller share of firms finds it optimal to borrow in foreign currency. Since the domestic interest rate also increases during depreciations, the deviations from the risk-free UIP remains at the same levels as in the benchmark calibration. As a result, we still observe that foreign currency borrowing is driven by more productive firms –those that do not default during depreciations–, and that these firms choose higher investment rates (their average investment for this period is 11.7%). In this specification, the default rate is higher, as increased interest rates during depreciations makes harder it for firms to finance their operations. On aggregate, since for this period rates are on average lower than in the benchmark calibration, we see higher levels of aggregate sales and capital. Interestingly, the growth rates are on average lower, since during the depreciation the risk-free and risk-adjusted rates are higher.

Table 12: Endogenous Interest Rates

	Benchmark	$\gamma = \gamma^* = 1$	$\gamma = 1$ and $\gamma^* = 0$
	(1)	(2)	(3)
	Panel A. Firm-level results		
FC debt share	12.1	11.4	10.5
Investment rate	10.6	10.2	11.4
E(K)	20.0	23.8	25.0
Default rate	2.7	3.2	3.0
Productivity threshold	1.2	1.2	1.2
$\tilde{r}$	7.4	6.8	6.8
$\tilde{r}^*$	1.8	1.2	1.8
θ	1.05	1.05	1.04
	Panel B. Aggregate results		
Sales growth rate	1.2	-0.2	1.1
Capital growth rate	2.3	0.3	2.2
Sales (level)	100.0	204.0	215.8
Capital (level)	100.0	219.0	238.2
Std. dev. sales	100.0	77.2	88.1
Std. dev. capital	100.0	86.9	133.9

Notes: Rows 1, 3, 4, 6 and 7 are in percentage, rows 8-11 are with respect to column 1. This table shows moments for the benchmark calibration with different levels of risk aversion. 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. Table shows the average for the period.

In column (3), we assume that only the local currency rate changes with the exchange rate shock, that is, $\gamma^* = 0$ and $\gamma = 1$. In this case, the observed deviation from the UIP is lower than in the benchmark case. As a result, the share of foreign currency debt decreases. The lower local interest rate promotes investment, aggregate sales and capital. Nevertheless, since the local rate increases during depreciations, aggregate growth rates are lower than in than in the benchmark calibration. Note, that since the foreign currency rate does not raise in the depreciation, the drop is not as large as in column (2).

7.3 Aggregate Shock

In our benchmark calibration we assumed that there was no aggregate shock common to all firms that could affect their borrowing and investment decisions. In this section, we assess the impact of these shocks by including an aggregate productivity shock and evaluating its impact on firms' decisions. In particular, we follow similar exercise than in Section 6 and estimate counterfactuals at firm and aggregate level. To keep the model tractable, we assume that the aggregate shock is a function of the exchange rate shock. Exchange rate was shown to be a good predictor of fundamentals by Engel and West (2005). The rational is that exchange rate is an asset price, so its value incorporates expectations of future fundamentals. We model the aggregate shock as $Z = s^{-\nu}$, where $\nu > 0$. This assumption captures the pattern that as exchange rate depreciates, the aggregate shock is lower. The aggregate shock affects the production of all firms $F(s, z, k) = s^{-\nu} z k^{\alpha}$.

Table 13: Aggregate Shock

	Benchmark	$\nu = 0.05$	$\nu = 0.1$	$\nu = 0.2$
	(1)	(2)	(3)	(4)
	Panel A. Firm-level results			
FC debt share	12.1	11.5	9.5	0.1
Investment rate	10.6	10.5	10.3	9.8
E(K)	20.0	19.8	19.2	18.2
Default rate	2.7	3.0	3.1	3.4
Productivity threshold	1.2	1.2	1.2	1.3
	Panel B. Aggregate results			
Aggregate sales growth	1.2	1.0	0.8	0.4
Aggregate capital growth	2.3	2.2	2.1	2.0
Aggregate sales (level)	100.0	76.0	70.0	59.0
Aggregate capital (level)	100.0	75.6	70.1	59.0
Std. dev. aggregate sales	100.0	32.7	25.5	7.8
Std. dev. aggregate capital	100.0	52.3	49.1	47.1

Notes: Rows 1, 3, 4, 6 and 7 are in percentage, rows 8-11 are with respect to column 1. This table shows moments for the benchmark model with aggregate shock with increasing levels of sensibility [-0.05,-0.1,-0.2] . 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. Table shows the average for the period.

Table 13 displays the results for $\nu = [0.05, 0.1, 0.2]$ in comparison to the benchmark model (equivalent to ν=0). Using data from 1992 to 2015 on exchange rate and output we estimate

ν=0.05. In all parameterizations, we simulate 160,000 firms from the stationary distribution of no foreign currency using the realized exchange rate shocks between 2001 and 2010. Given that the aggregate shock implies that when the exchange rate depreciates the output also drops, it generates an additional source of risk steaming from the exchange rate. However, the mechanism we focus on in this paper, lower cost of risk free foreign currency debt, is still present. Because the output drops when the exchange rate depreciates, the higher the ν, the less firms will borrow in foreign currency and the higher is the average probability of firms with foreign currency (tougher selection), because the probability of default is higher. Since firms borrow less in foreign currency, the cost of funds is higher, so firms will invest less and size of firms is smaller. In aggregate, sales and capital are lower but also less volatile, since firms choose to be less exposed to foreign currency borrowing.

8 Empirical Exercise: Currency Depreciation during the Great Recession

In this section, we exploit the depreciation of the local currency during the Great Recession to study the performance of firms holding foreign currency debt after the 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:

$$\log Y_{it} = \beta(D_t \,\mathrm{x}\, \mathrm{FC\ Ratio}_i) + \phi_i + (T_t \,\mathrm{x}\, \mathrm{FC\,Dummy}_i) + (\mu_i \,\mathrm{x}\, D_t) + X_{jt} + \varepsilon_{ijt} \tag{17}$$

where i, j, t index firm, two-digit NACE industries and time, respectively. Y_{ijt} is a vector of $\{\log \mathrm{Leverage}_{it}, \log \mathrm{FC\ Share}_{it}, \log \mathrm{Investment\ Rate}_{it}, \log \mathrm{Sales}_{it}, \mathrm{Exit}_{it}\}$. 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 ($T_t \,\mathrm{x}\, \mathrm{FC\,Dummy}_i$); 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 ($\mu_i \,\mathrm{x}\, D_t$). The coefficient of interest is β in equation (17) and captures the differential impact of the depreciation on firms holding foreign currency. We cluster the OLS standard errors at four-digit sector-year level.

Results

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

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 15). 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-

Table 14: 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.

significant. This result is consistent with our previous finding on firms' sales and suggests that, while the currency shock, negatively affected the balance sheet of firms holding foreign currency debt, these firms did not underperform in terms of sales or exit their industry counterparts. While this effect might appear counter-intuitive at a first view, it is not surprising in light with the model and the figures presented in Table 10. As the model shows, when the risk-free uncovered interest parity does not hold, firms have incentives to take foreign currency borrowing in order to expand their investment and scale of operation. As these firms grow faster during good times, it is not surprising that they become more resilient to shocks. In other terms, these results suggest that despite the negative balance sheet effects, previous investments allow foreign currency borrowing firms to survive the shock.

Tables A.3 and A.4 in Appendix A report the estimated coefficients of regression (17) for non-exporter firms. In all regressions, the coefficients are of the same sign and similar in magnitude to

Table 15: 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.

those estimated in Tables 14 and 15. 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.[24] Tables A.5 and A.6 in Appendix A 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).

[24]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.

9 Conclusion

This paper shows that firms' foreign currency borrowing choices arise from a dynamic trade-off between firms' optimal exposure to the currency risk and growth. We develop a firm dynamics model with endogenous debt composition to study firms' financing and investment decisions. In our model, firms might optimally choose to borrow in foreign currency to take advantage of the lower foreign currency risk free rate that arises due to deviations of the UIP. Importantly, the model shows that there is heterogeneity in firms' foreign currency borrowing choices in two dimensions. First, there is selection into foreign currency borrowing, as only productive firms find it optimal to be exposed to exchange rate shocks. Second, among productive firms those with lower capital employ this financing more intensively, as it allows them to reach faster their optimal scale of production.

The model delivers firm-level implications that we test using a unique data set reporting information on firms' balance sheets and debt by currency denomination in Hungary over 1996-2010. Using model simulated firm-level data and the Hungarian data, we confirm the model's implication and mechanism proposed in this paper.

Finally, we use our model to conduct numerical exercises and understand the aggregate implications of foreign currency borrowing. We show that the firm's self-selection into foreign currency borrowing is crucial to mitigate the negative aggregate impact of foreign currency debt during a depreciation. In line with this mechanism, we show that in Hungary, after the 2010 depreciation of the Forint, firms borrowing in foreign currency did not perform worst relative to sales and default than their local currency only peers.

References

Aguiar, M. (2005): "Investment, devaluation, and foreign currency exposure: The case of Mexico," *Journal of Development Economics*, 78(1), 95–113.

Baskaya, S., J. di Giovanni, S. Kalemi-Ozcan, and M. Ulu (2017): "International Spillovers and Local Credit Cycles," *Mimeo.*

Bauer, P., and M. Endresz (2016): "Modelling Bankruptcy using Hungarian Firm-Level Data," *MNB Occasional Papers 122.*

Bleakley, H., and K. Cowan (2008): "Corporate Dollar Debt and Depreciations: Much Ado About Nothing?," *The Review of Economics and Statistics*, 90(4), 612–626.

Bloom, N., M. Floetotto, N. Jaimovich, I. Saporta-Eksten, and S. J. Terry (2012): "Really Uncertain Business Cycles," NBER Working Papers 18245, National Bureau of Economic Research, Inc.

Bodnár, K. (2006): "Survey evidence on the exchange rate exposure of Hungarian SMEs," *MNB Bulletin (discontinued)*, 1(1), 6–12.

Brown, M., S. Ongena, and P. Yesin (2011): "Foreign currency borrowing by small firms in the transition economies," *Journal of Financial Intermediation*, 20(3), 285 – 302.

Chinn, A. (2005): "Long Run Labor Market Effects of Japanese American Internment during World War II on Working Age Male Internees," *Journal of Labor Economics*, 23 (3), 491–525.

Cooley, T. F., and V. Quadrini (2001): "Financial Markets and Firm Dynamics," *American Economic Review*, 91(5), 1286–1310.

Céspedes, L. F., R. Chang, and A. Velasco (2004): "Balance Sheets and Exchange Rate Policy," *The American Economic Review*, 94(4), 1183–1193.

Eichengreen, B., and R. Hausmann (eds.) (2005): *Other People's Money*, no. 9780226194554 in University of Chicago Press Economics Books. University of Chicago Press.

Engel, C., and K. West (2005): "Exchange Rates and Fundamentals," *Journal of Political Economy*, 113(3), 485–517.

Foster, L., J. Haltiwanger, and C. Syverson (2008): "Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?," *American Economic Review*, 98(1), 394–425.

Gopinath, G., S. Kalemli-Ozcan, L. Karabarbounis, and C. Villegas-Sanchez (2017): "Capital Allocation and Productivity in South Europe," *The Quarterly Journal of Economics*, (21453).

Gruber, J. (1994): "The Incidence of Mandated Maternity Benefits," *American Economic Review*, 84(3), 622–41.

Jeanne, O. D. (2003): "Why Do Emerging Economies Borrow in Foreign Currency?," (03/177).

Kalemli-Ozcan, S., H. Kamil, and C. Villegas-Sanchez (2010): "What Hinders Investment in the Aftermath of Financial Crises: Insolvent Firms or Illiquid Banks?," Working Paper 16528, National Bureau of Economic Research.

Kim, Y. J., L. L. Tesar, and J. Zhang (2015): "The impact of foreign liabilities on small firms: Firm-level evidence from the Korean crisis," *Journal of International Economics*, 97(2), 209–230.

Krugman, P. (1999): "Balance Sheets, the Transfer Problem, and Financial Crises," *International Tax and Public Finance*, 6(4), 459–472.

Lustig, H., and A. Verdelhan (2006): "INVESTING IN FOREIGN CURRENCY IS LIKE BETTING ON YOUR INTERTEMPORAL MARGINAL RATE OF SUBSTITUTION," *Journal of the European Economic Association*, 4(2-3), 644–655.

Olley, G. S., and A. Pakes (1996): "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, 64(6), 1263–97.

Petrin, A., and J. Levinsohn (2011): "Measuring Aggregate Productivity Growth Using Plant-Level Data," NBER Working Papers 11887, RAND Journal of Economics.

Ranciere, R., A. Tornell, and A. Vamvakidis (2010): "Currency mismatch, systemic risk and growth in emerging Europe," *Economic Policy*, 25, 597–658.

Schneider, M., and A. Tornell (2004): "Balance Sheet Effects, Bailout Guarantees and Financial Crises," *The Review of Economic Studies*, 71(3), 883–913.

Tauchen, G., and R. Hussey (1991): "Quadrature-Based Methods for Obtaining Approximate Solutions to Nonlinear Asset Pricing Models," *Econometrica*, 59(2), 371–396.

Varela, L. (2017): "Reallocation, Competition and Productivity: Evidence from a Financial Liberalization Episode," *The Review of Economic Studies*, (225).

Wooldridge, J. M. (2009): "On estimating firm-level production functions using proxy variables to control for unobservables," *Economics Letters*, 104(3), 112–114.

Yesin, P. (2013): "Foreign Currency Loans and Systemic Risk in Europe," *Federal Reserve Bank of St Louis Review*.

Appendix A Additional Figures, Tables and Robustness Tests

Appendix A.1 Additional Figures

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

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

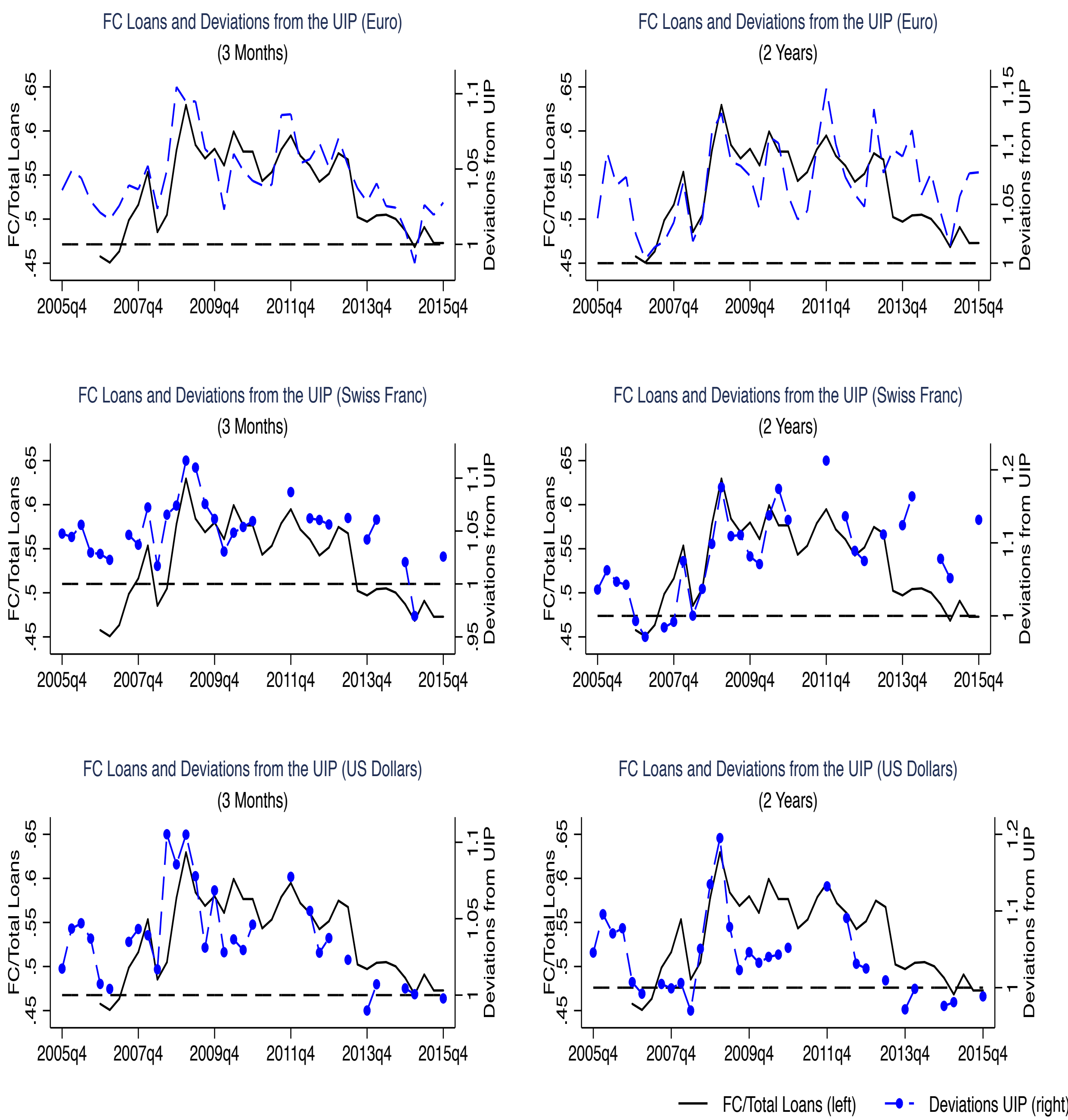
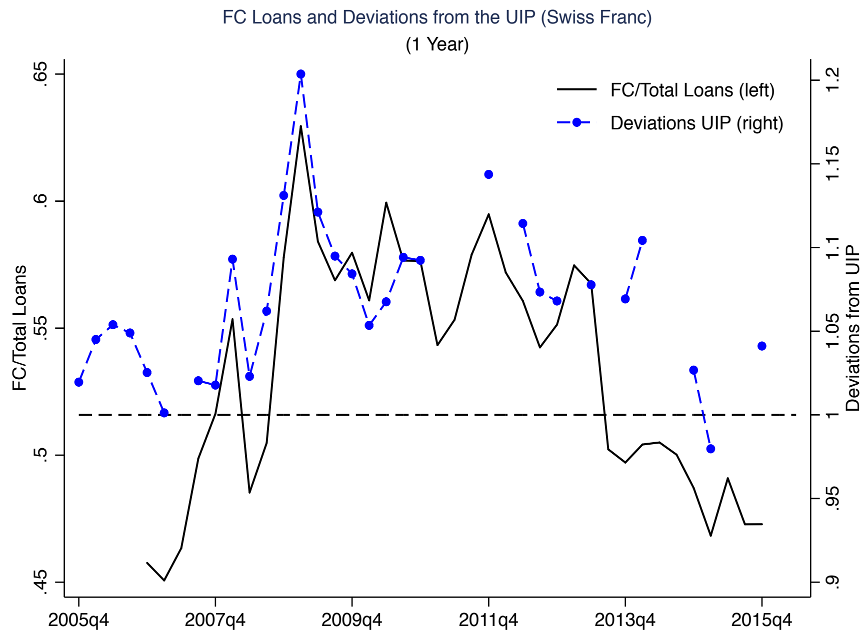


Figure A.3: Hungary: Deviations from the Risk-Free UIP with Swiss Franc and U.S. Dollars and Foreign Currency Loans



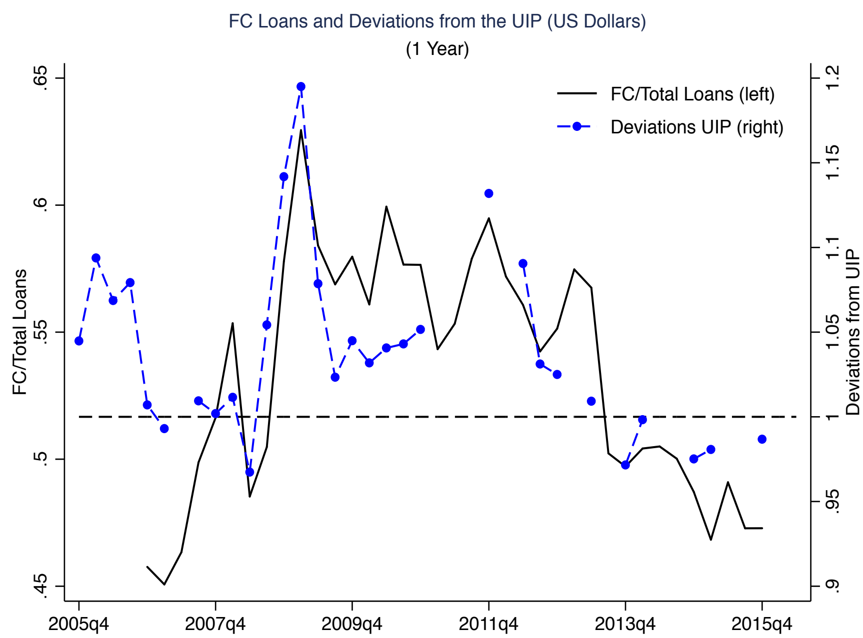


Figure A.4: Hungary: Foreign Currency Loans and Interest Rate Differential

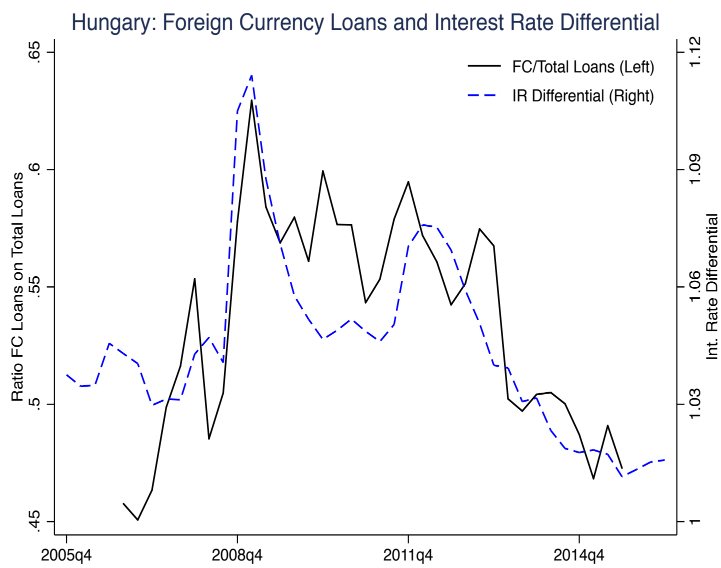


Figure A.5: Eastern European Countries: Foreign Currency Loans, Deviations from Risk-Free UIP and Interest Rate Differential

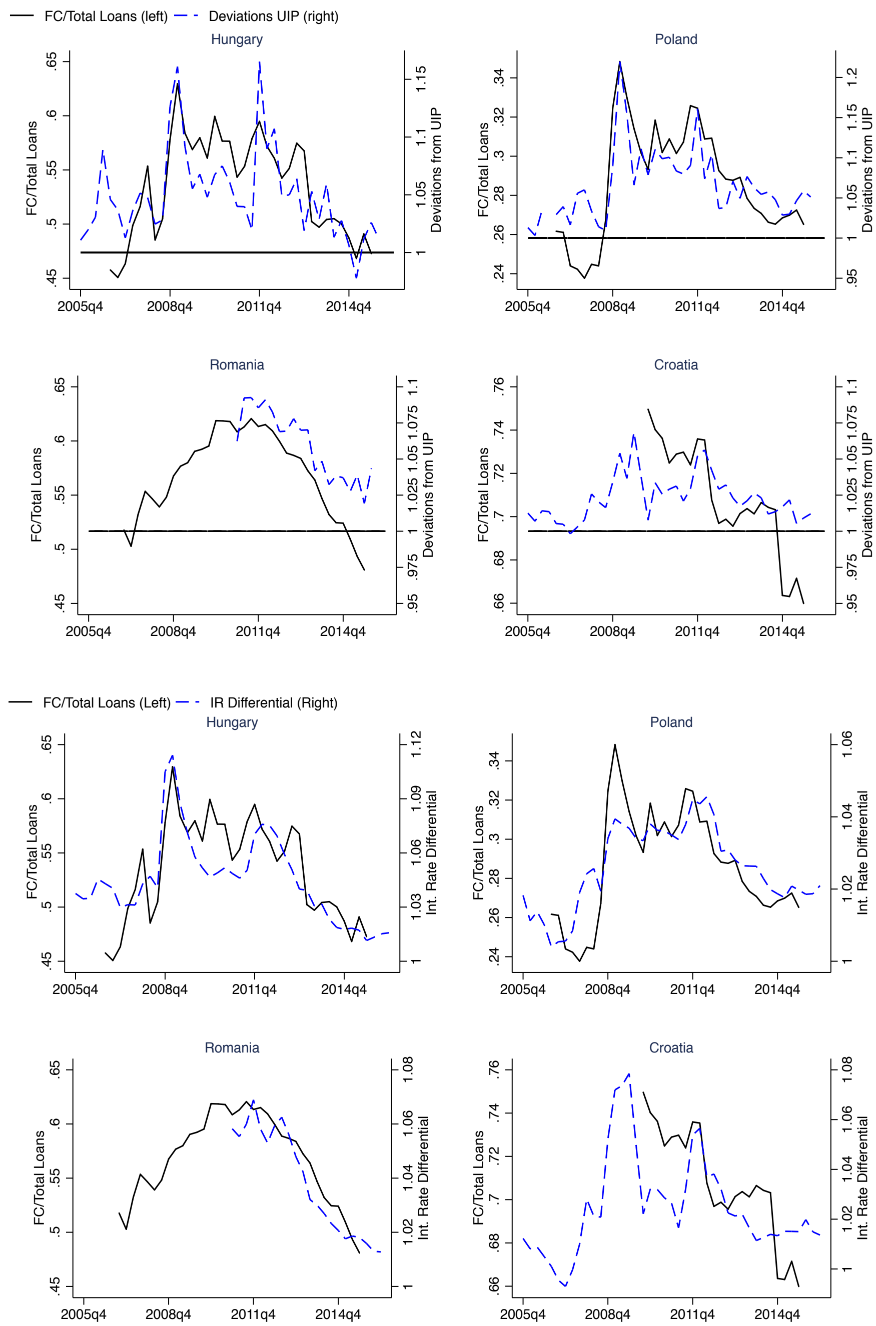
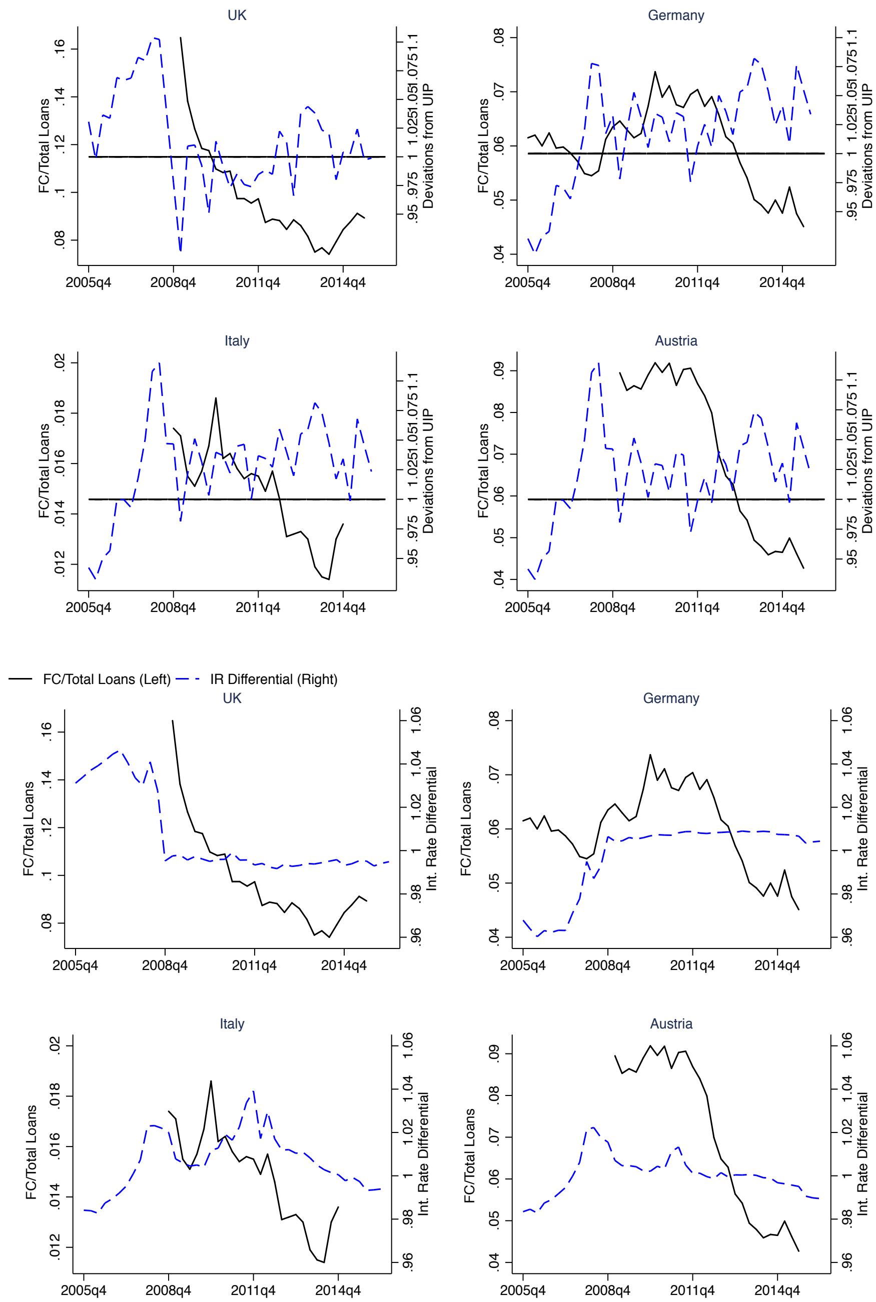


Figure A.6: Developed European Countries: Foreign Currency Loans, Deviations from Risk-Free UIP and Interest Rate Differential



Appendix A.2 Additional Tables

Table A.1: Robustness Tests: Decision into Foreign Currency Borrowing

	(1)	(2)	(3)	(4)	(5)
	Panel A. Foreign Currency Loan Dummy				
Log productivity	0.014***	0.010***	0.009***	0.012***	0.017***
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
Log capital	0.037***	0.036***	0.036***	0.035***	0.034***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Log age	-0.019***	-0.015***	-0.018***	-0.020***	-0.020***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Exporter				0.048***	
				(0.007)	
Sector FE	Yes	Yes	Yes	Yes	Yes
R^2	0.061	0.060	0.063	0.063	0.055
N	37,051	37,051	38,237	37,051	39,740
	Panel B. Log Share of FC Loans				
Log productivity	0.003**	0.006***	0.003***	0.004***	0.004***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)
Log capital	0.014***	0.015***	0.013***	0.012***	0.014***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log age	-0.010***	-0.011***	-0.010***	-0.011***	-0.010***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Exporter				0.025***	
				(0.004)	
Sector FE	Yes	Yes	Yes	Yes	Yes
R^2	0.043	0.039	0.048	0.050	0.044
N	37,051	37,051	38,237	37,051	39,740

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

Table A.2: ROBUSTNESS TESTS: DEVIATIONS FROM THE RISK-FREE UIP

	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
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 A.3: 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 A.4: 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 A.5: 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 A.6: 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 A.3 Descriptive Statistics

Table A.7 reports the sectors under analysis and the number of firms in 2005. We consider all sectors in the economy, except for the financial sector and activities subject to special regulations as education and health. In particular, we exclude from the analysis: financial and insurance activities (K); real estate activities (L); public administration, defense and compulsory social security (O); education (P); and human health and social work activities (Q).

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

Table A.7: 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 A.8: 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.

Appendix B 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 vast majority of firms self-selected to borrow in one foreign currency or another.[25] 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 self-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 experiences higher deviations from the uncovered interested parity are on average less productive and see higher growth.

Since the vast majority of firms employing foreign currency debt choose Euros or Swiss Francs (99% of firms), we center our analysis in both currencies. As described in Section **??**, deviations from the risk-free UIP were higher with respect to the Swiss Franc than with respect to the Euro. In particular, the average deviation from the risk-free uncovered interest parity 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). This implies that the risk-free rate of Swiss Franc was relatively lower than that of the Euro once the expected depreciation was 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 one currency or another, and study whether there are differences in observable characteristics and pattern of growth among firms borrowing either in Euros or Swiss Francs. We start by estimating a similar regression to

[25] As discussed in Section 2, 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%).

equation (8) for firms that hold one of these types of loans, and regress a dummy variable if the firm hold a loan denominated in Swiss Francs in 2005 on firms' covariates prior to the financial liberalization in 2000. This estimation captures whether firms that opted for Swiss Franc loans differed initial characteristic with those that selected Euro loans.

Table B.1 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, firms choosing Swiss Franc loans were 3.3% less productive, smaller, older and less likely to be exporters. Column 2 confirms these results when using the five-years average of firms' initial characteristics (1996-2000), instead of focusing only on the pre-reform year.

Table B.1: Decision into Foreign Currency Borrowing: Euro vs Swiss Franc Loans

	Swiss Franc Loan Dummy	
	(1)	(2)
RTFP	-0.033***	-0.008*
	(0.008)	(0.004)
Employment	-0.041***	-0.044***
	(0.009)	(0.004)
Age	0.022*	0.023***
	(0.013)	(0.008)
Exporters	-0.151***	-0.155***
	(0.022)	(0.009)
Sector FE	yes	yes
R^2	0.171	0.209
N	4,409	11,938

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. The dependent variable is a dummy of whether the firm hold a Swiss Franc loan in 2005. Firm-level controls include size, age and export status. All regressions include four-digit NACE industry fixed effects. Column 1 is estimated for the year 2000, and Column 2 estimates the average over 1996 and 2000. Firm-level controls in Column 2 are considered in the initial year (1996).

We turn next to check whether Swiss Franc loans correlated with higher investment and sales growth 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 (10) and regress the sales and investment on the financial liberalization dummy and its interaction term with the Swiss Franc debt dummy. Our coefficient of interest is that of the interaction between the financial liberalization variable and the Swiss Franc dummy that reflects whether firms employ these loans see larger investment and sales growth than firms borrowing in Euros within the five years prior and following the financial liberalization.

Table **??** presents the results. Column 1 and 3 show that firms using Swiss Franc loans saw higher level of investments and growth than firms only employing Euro denominated loans after

Table B.2: Foreign Currency Borrowing and Firms' Growth

	Log Sales		Log Investment	
	(1)	(2)	(3)	(4)
FL*Swiss Dummy	0.073**	0.090***	0.077***	0.053**
	(0.037)	(0.033)	(0.021)	(0.026)
FL	0.257***	0.063*	0.451***	0.039*
	(0.032)	(0.036)	(0.021)	(0.021)
Firm FE	yes	yes	yes	yes
Time Trend		yes		yes
Swiss Dummy*Time Trend		yes		yes
R^2	0.620	0.622	0.817	0.842
N	49,249	49,249	49,472	49,472

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. FL is a dummy for the period 2001-05. Sample period 1996-2005.

the financial liberalization. Columns 2 and 4 show 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 **??** presents the results of equation (17) estimating separately the effects on the Euro and Swiss Franc debt. Columns 1-3 report the estimated coefficients for the change in the share of foreign currency debt after 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 36% in the share of foreign currency debt following 2008, whilst the estimated coefficient is 28% 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 20%, whilst this reduction reaches 17% for firms indebted Swiss Francs.

Column 7-9 show that the depreciation of the Hungarian currency associates with a decrease in investment of firms borrowing in Euros and Swiss Francs. In particular, column 7 shows that one percent increase in the share of Euro denominated debt decreases investment by %. 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 %. 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 71.2%. As reported in Panel B, 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 10 shows that firms indebted in Swiss Francs see a lower decrease in their sales than firms only employing local currency borrowing. Importantly, this lower reduction in sales remains statistically significant after the inclusion of all controls in column 12.

The results on exit are presented in columns 13-15. In line with the results reported in Section 8, firms employing either Euro or Swiss Franc debt have lower unconditional probability of exiting after 2008 (column 13). 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 self-selecting into Swiss Francs borrowing. Following the financial liberalization, this type of borrowing correlates with higher investment 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 UIP to invest more.

Table B.3: Currency Depreciation during the Great Recession: Euro vs Swiss Franc Loans

	Log FC Share			Log Leverage			Log Investment			Log Sales			Exit		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Panel A : All Firms															
D*Euro Ratio	-0.281***	-0.218***	-0.178***	-0.160***	-0.176***	-0.200***	-0.278**	-0.282**	-0.301***	0.098*	0.071***	0.057**	-0.029***	0.022**	0.008
	(0.016)	(0.017)	(0.015)	(0.022)	(0.023)	(0.021)	(0.140)	(0.119)	(0.100)	(0.051)	(0.013)	(0.023)	(0.011)	(0.010)	(0.015)
D*SF Ratio	-0.362***	-0.288***	-0.232***	-0.103***	-0.120***	-0.168***	-0.938***	-0.504***	-0.503***	0.113***	0.102***	0.080***	-0.030***	0.014*	0.006
	(0.025)	(0.022)	(0.018)	(0.019)	(0.020)	(0.015)	(0.113)	(0.095)	(0.090)	(0.036)	(0.012)	(0.015)	(0.009)	(0.008)	(0.014)
D	0.010***			0.009***			-0.568***			-0.122***			0.082***		
	(0.001)			(0.001)			(0.007)			(0.010)			(0.002)		
Firm FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm-Time controls		yes	yes		yes	yes		yes	yes		yes	yes		yes	yes
Year FE		yes	yes		yes	yes		yes	yes		yes	yes		yes	yes
Sector*Year FE			yes			yes			yes			yes			yes
R^2	0.698	0.701	0.702	0.574	0.575	0.480	0.799	0.802	0.824	0.935	0.936	0.936	0.587	0.603	0.614
N	840,196	840,196	840,196	840,196	840,196	840,196	439,937	439,937	439,937	652,658	652,658	652,658	722,152	722,152	722,152
Panel B: F-Test on Equality of Coefficients															
F-stat			128.76			88.88			16.99			14.92			0.18
P-value			0.0000			0.0000			0.0000			0.0000			0.8362

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

Appendix C The Hungarian Economy in the 2000s

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

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 use them to expand their local credit supply towards domestic firms that -thereafter- were allowed to borrow in foreign currency (see Varela 2017 for a detailed description of this reform). 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, according with the NBH.

The financial liberalization had a large impact on the economy, particularly on the local banking system. After the deregulation, banks started raising funds from abroad at lower interest rates and used these funds to expand their local activities. Three years after the reform, in 2004, net capital inflows to financial institutions had grown more than five-fold and the external debt of banks more than tripled. The increase in banks' liquidity yielded an expansion of the credit supply, specially of credits in foreign currency towards domestic firms. According to the National Bank of Hungary, by 2004, credits in foreign currency to small and medium enterprises had already reached more than one third. In 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 and exports grew at 15% 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 (HUF) significantly depreciated. By 2010, the HUF depreciation against the Euro had reached 10%, and more than 40% against the Swiss Franc. The depreciation of the Hungarian Forint entailed non-trivial consequences on the economy, as it worsen the balance sheets of firms indebted in foreign currency.