Currency Matching and Carry Trade by Non-Financial Corporations*

Péter Harasztosi[†] Gábor Kátay[‡]

Abstract

The paper investigates firms' willingness to match the currency composition of their assets and liabilities and their incentives to deviate from perfect matching. Using detailed information at the loan contract level for the Hungarian non-financial corporate sector, results show that the probability of borrowing in foreign currency decreases as soon as the firm's foreign currency debt reimbursement obligation exceeds its expected export revenues. This provides strong evidence to support the role of natural hedging. Matching motivation is even stronger in the aftermath of the crisis, however, it is still not firms' primary motivation for choosing foreign currency: it explains only about 10 percent of the overall corporate foreign currency debt during the pre-crisis and 20 percent during the post-crisis periods. Besides hedging, our results suggest that both carry trade and diversification strategies are relevant factors in firms' currency-of-denomination decisions.

Keywords: borrowing decisions; currency mismatch; carry trade; financial crisis
JEL classification: G01; G11; G32; F31; F34

1 Introduction

Matching debt payments to expected foreign currency (FX) revenues is a natural way to mitigate the adverse effects of foreign exchange risk exposure of exporting firms. Currency mismatch occurs when firms' assets and liabilities are denominated in different currencies. Financial stability concerns typically arise when firms' net FX denominated liabilities are greater than their net FX denominated cash flows, i.e. when firms borrow "too much" in FX compared to their export revenues.

*Job Market Paper. This version: 2015 Nov.
†Magyar Nemzeti Bank, harasztosip@mnb.hu
‡Corresponding author. Banque de France and Paris School of Economics, gabor.katay@banque-france.fr

As a result, if the domestic currency depreciates, firms with currency mismatch are likely to experience adverse balance sheet effects as the negative effect of the rise in FX denominated liabilities expressed in local currency usually outweighs the traditionally assumed positive competitiveness effect (Eichengreen et al. (2007)).

Currency mismatch is one of the main financial systemic risk factors that many emerging markets have been facing over the past decades. The debate about the importance of firms' currency mismatches and the adjustments following an unexpected exchange rate depreciation was particularly intense following the Latin American "Tequila" crisis. In these countries, the perceived security of the exchange rate peg encouraged liability dollarisation, while abandoning the peg resulted in a sharp depreciation of the respective home currencies. Due to the extensive dollarisation of firms' balance sheets and widespread currency mismatches, the weakening of the exchange rate and the implied increase in firms' debt burden in local currency terms forced firms to adjust their balance sheets, which translated into lower investment activities, declining production and, in many cases, liquidation proceedings. (see e.g. Krugman (1999) or Aghion et al. (2001)). Later, a similar process took place in Asia during the financial crisis of 1997-98 and in several Central and Eastern European countries following the outbreak of the current crisis.

This paper explores corporate borrowers' choice between the local currency and several possible foreign currencies in a situation where the market interest rates in one or several foreign currencies are lower than that of the local currency. In particular, we investigate firms' willingness to match the currency composition of their assets and liabilities and their incentives to deviate from perfect matching. To motivate our empirical analysis, we use a simple and transparent model to derive a closed form solution for optimal debt portfolio. Using detailed information at the loan contract level for the Hungarian non-financial corporate sector, we then construct a theory-consistent measure of a mismatch indicator and we test its influence on firms' choice of currency denomination of borrowings. In doing so, this paper is the first to provide direct evidence to support the role of matching incentives in firms' debt currency choice. The relative importance of matching motivation versus other factors such as the interest rate differential is also addressed. Finally, we explore the effects of the crisis on firms' preferences and risk assessments.

To test for the existence of matching motivations in firms' debt currency choice, existing empirical studies usually relate the share of FX debt to a proxy for the sensitivity of firms' profits to exchange rate fluctuations and other firm specific or macroeconomic variables. The earliest studies investigate the currency-of-denomination decision of large US firms (Allayannis and Ofek (2001), Kedia and Mozumdar (2003)) and Finnish firms (Keloharju and Niskanen (2001)) and find that firms with higher export shares (or a larger share of total assets held abroad) hold more FX denominated debt in order to hedge their increased foreign exposure. A considerable number of studies on emerging markets – many of which are published in a special issue of the *Emerging Market*

Review (vol. 4 no. 4) – point to the same conclusion.[1] These papers follow a similar reduced form estimation method in which the identification relies on the variable export share or on an indicator of tradability (dummy variable indicating whether the firm belongs to the tradable sector) to show that exporters or firms producing tradable goods are more likely to carry foreign debt. The coefficient of these variables being usually positive and – with the exception of the Argentinian and Brazilian results – significantly different from zero, the authors conclude that firms tend to match the currency composition of their liabilities with the ex-ante sensitivity of their revenues to the real exchange rate.

On the other hand, the role of the interest rate differential and thus carry trade behaviour is often put forward as an explanation for dollarisation in macro studies. Rosenberg and Tirpak (2009) examine the determinants of euroisation and swissfrancisation in the new EU Member States and find that the interest rate differential is a robust explanatory variable of cross-country differences. Basso et al. (2011) find that the interest rate differential is a significant driver for the dollarisation of both loans and deposits.

This paper highlights and addresses three important shortcomings of the existing empirical literature. First, the existing evidence that exporting firms tend to borrow more in FX does not provide direct proof for currency matching. Export revenues are only half of the story, the appropriate measure for testing matching considerations between assets and liabilities should include both export revenues denominated in FX and FX debt payments. For instance, a firm that increases its FX debt to a point that the expected export revenues do not fully cover its debt payments is exposed to a similar exchange rate risk as non-exporters with FX liabilities in their balance sheets. Similarly, it is safe for a firm with a relatively low export share to incur debt entirely in FX as long as its export revenues are higher than or equal to its debt payment obligations.

Second, unobserved firm heterogeneity is rarely taken into account. Comparing two distinct groups of firms, (larger) exporters and (smaller) non-exporters, which are probably different in many respects, and identifying firms' matching incentives from cross-sectional variation does not provide direct evidence for matching. If the choice of currency denomination of the debt is a result of an optimisation process, the same firm in different circumstances should make different choices. That is, the identification of matching incentives is only possible once firm fixed effects are controlled for.

[1] The special issue starts with a summary of Galindo et al. (2003) that collects results and findings from existing literature. Existing studies on emerging markets cover Argentina (Galiani et al. (2003)), Brazil (Bonomo et al. (2003), Janot et al. (2008)), Chile (Benavente et al. (2003), Cowan et al. (2005), Fuentes (2009)), Colombia (Echeverry et al. (2003)), Mexico (Pratap et al. (2003), Gelos (2003), Martinez and Werner (2002)) Peru (Carranza et al. (2003)), Lebanon (Mora et al. (2013)) and several East Asian (Allayannis et al. (2003)) and Latin-American (Kamil (2012)) economies.

Third, there is as yet no clear understanding of which effect dominates in a firm's decision to incur FX-denominated debt. Only a few studies concentrate on both natural hedging and carry trade incentives. Among a few exceptions are the contributions by Keloharju and Niskanen (2001) and Brown et al. (2010), who confirm that both matching and carry trade motives are present in firms' currency choice. By examining Finnish and Bulgarian firms, the authors find that exporters are more likely to request FX loans, while firms also tend to choose FX when the interest rate differential between FX and domestic currency is higher than average. A descriptive study by Endresz et al. (2012) also suggests that both matching and carry trade are relevant factors: FX debt is mostly concentrated among larger, exporting firms, but many small non-trading firms also take out FX loans in Hungary. The relative importance of the two factors is only addressed in Brown et al. (2011). The authors find that FX borrowing is much stronger related to firm-level FX revenues than it is to country-level interest rate differentials, which makes them conclude that speculation is not the key driver of firms' currency choice.

The recent Hungarian experience of FX indebtedness together with a newly available collection of matched administrative datasets – which includes financial reports of all Hungarian firms, monthly export revenues and import expenditures, information on all corporate loan contracts and on the credit provider – provide a valuable opportunity for reassessing the determinants of firms' borrowing decisions in a situation where they have access to FX loans.

Our identification strategy relies on the intuition that if currency matching is a relevant factor, the probability of incurring new FX-denominated debt must decrease as soon as the firm's FX debt reimbursement obligation during a given period of time exceeds its expected export revenues. This yields a binary dependent variable model in which the probability of choosing FX is related to a mismatch indicator which takes the value of 1 if the firm's debt payment obligations denominated in FX are higher than its export revenues and 0 otherwise. As a second step, a more accurate measure of mismatch indicator yields a mixed logit specification (Train (2003)) in which separate but correlated equations for two possible FX alternatives – corresponding essentially to euro (EUR) and Swiss francs (CHF) – are estimated simultaneously. We then use the estimated model to perform a counterfactual analysis. To isolate the effects of natural hedging motives on the aggregate corporate FX debt share, we "switch off" the effects of currency matching on firms' debt denomination choice by setting the mismatch indicator to 1 for all firms and for all choice occasions and we predict the counterfactual currency shares of newly contracted corporate loans in the absence of hedging motives.

The coefficient of the mismatch indicator being negative and highly significant across all specifications, our results provide strong evidence to support the role of natural hedging motivation in firms' currency choice. Matching motivation is even stronger in the aftermath of the crisis than during the pre-crisis period. However, our simulations indicate that natural hedging is not the primary motivation for firms to choose FX: it explains only about 10 percent of the overall corporate FX debt during the pre-crisis and 20 percent during the post-crisis periods.

In addition, our results indicate that firms with a higher probability of choosing EUR have also a higher probability of choosing CHF. The benefits of holding both EUR and CHF debt thus seems to outweigh the advantage of consistently choosing one (the preferred) FX relative to the other, which can be interpreted as firms placing higher value on diversification than on fully exploiting perceived arbitrage (carry trade) opportunities, if any, between foreign currencies. Since the outbreak of the crisis, the relative attractiveness of the two main foreign currencies has severely deteriorated. The CHF has lost its relative attractiveness vis-à-vis not only the local currency, but also vis-à-vis the EUR. As a result, a number of firms have switched from the CHF partly to the HUF, but also partly to the EUR.

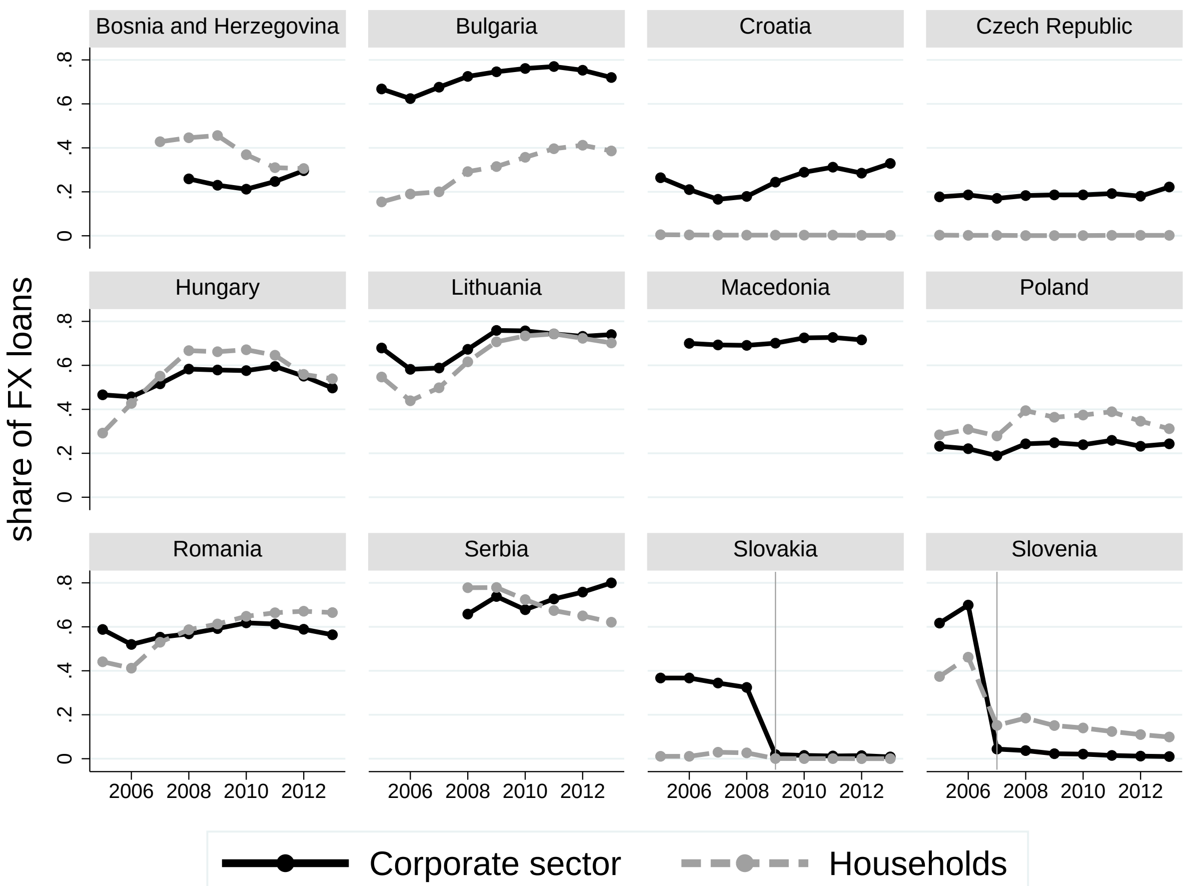
After briefly introducing the evolution of corporate FX denominated loans in CEE countries and in particular in Hungary (Section 2), we discuss the theoretical framework for understanding the trade-offs faced by firms in choosing the currency composition of their debt (Section 3). The estimation method is presented in Section 4. The dataset used for the estimations is described in Section 5, then the econometric analysis of firms' currency choice is presented in Section 6. Finally, Section 7 concludes.

2 Foreign currency debt in Hungary and other CEE countries

The post-socialist economic transition in emerging European countries was fuelled in part by heavy borrowing from Western banks and easy access to FX denominated loans. For about a decade before the crisis, FX denominated loans became widespread among the majority of Central and Eastern European (CEE) countries. In some of these countries, lending in foreign currencies to both households and firms has been the norm rather than the exception. As shown in Figure 1, FX-denominated bank loans accounted for at least 20 percent of total corporate debt in the twelve countries considered. Bulgaria, Macedonia and Slovenia recorded the highest pre-crisis shares, but FX was also dominant in Hungary, Lithuania and Romania. FX lending to the household sector displays a large heterogeneity across countries. It has been mostly prevalent in Hungary, Lithuania, Romania and Serbia, while the share of FX borrowing by households has been virtually zero in Croatia, in the Czech Republic and in Slovakia.

The financial crisis originated from the US subprime mortgage meltdown rapidly escalated to a global scale and brought to the fore the vulnerability of several CEE countries heavily indebted in FX. The high level of bank lending denominated in FX was less of a concern in Slovenia and Slovakia: by the time of the crisis broke out, Slovenia had already adopted the euro, while Slovakia had joined the eurozone at the beginning of 2009. Similarly, the currency board in Bulgaria and the fixed exchange rate regime in Lithuania (and, later, the introduction of the euro) insulated firms and households from adverse exchange rate shocks. In other countries, however, the weakening of the exchange rate first increased firms' debt burden expressed in terms of the local currency then, as a consequence, forced firms to adjust their balance sheets.

Figure 1: FX shares, 2005-2013



Notes: The figure displays the share of outstanding liabilities in the domestic financial sector (excl. central banks) denominated in foreign currency held by non-financial corporations and households. For Bosnia, Croatia, Macedonia, Slovakia and Slovenia, the data come from the Central Bank's Financial Stability report. For Bulgaria, the Czech Republic, Hungary, Poland and Romania, the data come from the ECB's Balance Sheet Items (BSI) statistics. Vertical lines show the dates of entry into the eurozone: 2007 for Slovenia and 2009 for Slovakia. Lithuania also joined the eurozone in 2015.

Hungary was one of the most affected economies in the region. The country entered the crisis with a combination of a high budget deficit, large current account imbalances and an over-leveraged private sector with a significant exchange rate risk exposure. Already by 2005, more than 45% of the outstanding corporate loans were denominated in FX.

Breaking down the composition of debt currencies by maturity and firm characteristics reveal that smaller bank loans – expressed as a percentage of firms' total assets, presumably for continuing operations or for financing replacement investment – were mainly denominated in local currency, while FX loans were primarily used for financing larger projects (Figure 2). We arrive at the same conclusion by comparing short-term (less than a year) and long-term contracts separately: comparing subfigures 2(a) and 2(b) shows that about two-thirds of the overall underwritten sums are in HUF for short-term contracts, but about half for long-term contracts. In line with previous empirical findings (Section 1), Figure 2 also shows that export-oriented firms are more likely to take out FX loans than other firms. Moreover, exporters tend to prefer euro-denominated loans. Given that the euro area accounts for an overwhelming share of Hungarian exports, these figures suggest that matching motives are likely to play a role in explaining firms' FX choices. At the same time, the FX debt exposure of non-exporting firms and the relatively large share of CHF loans in firms' debt portfolio also suggest that the share of unhedged loans was (and still is) substantial in Hungary.[2]

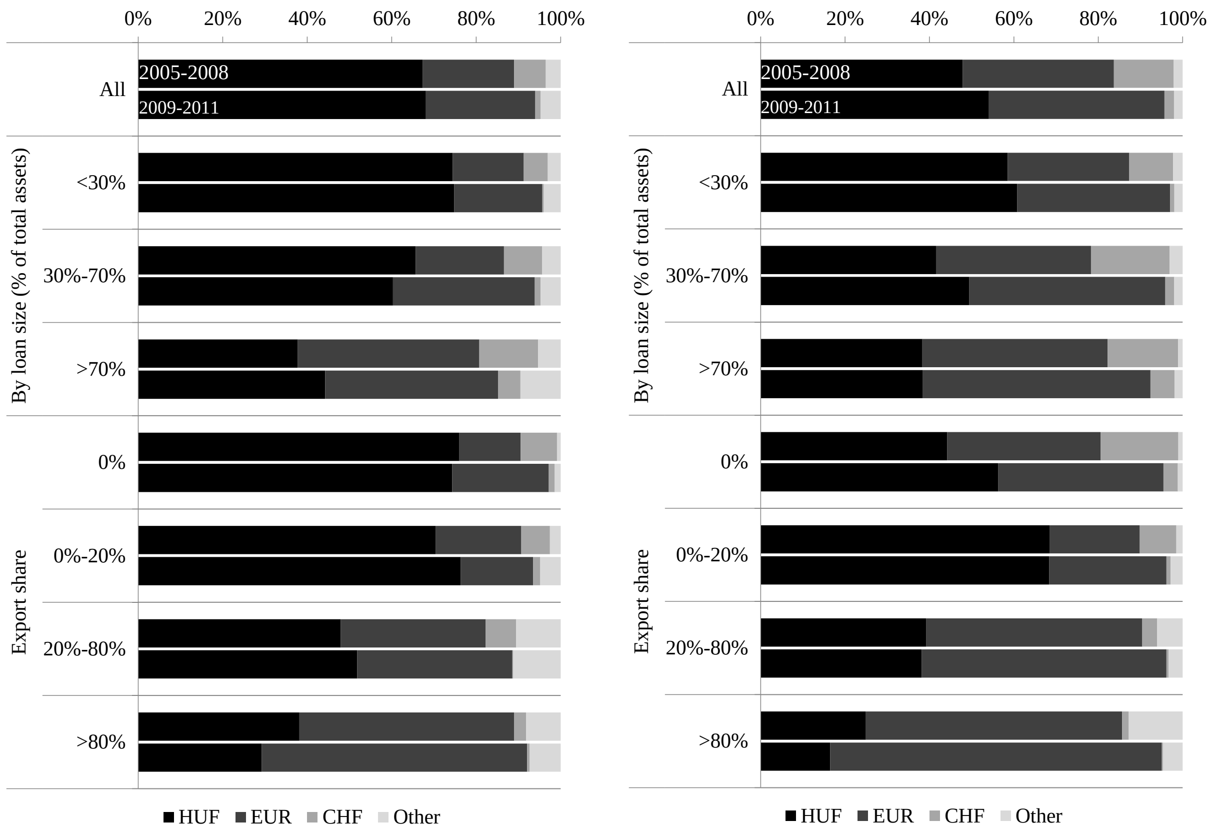
An ongoing research by Vonnak (2014) points to the same conclusion. By comparing CHF and EUR borrowers in the lending boom and during the crisis, the author finds that the latter are more likely to be bigger, foreign-owned and export-oriented firms, while the former are more probably non-exporting firms and firms with weaker balance sheets and a higher default probability already during the pre-crisis period. The descriptive study in Endresz et al. (2012) also reports that FX debt is mostly concentrated among larger and more productive and most likely multinational firms, but a significant share of domestic non-trading firms also took out FX loans. Moreover, a survey conducted by Bodnar (2009) on FX indebtedness of Hungarian companies suggests that financial hedging is practically non-existent. A significant share of the firms simply ignore exchange rate risks as either they are unaware of risk management techniques or such techniques are perceived as expensive, complicated and ineffective. Driven by the attractive foreign interest rates, these firms expose themselves, unwittingly or not, to risks associated with exchange rate depreciation.

Once the crisis broke out, the depreciation of the HUF quickly turned the FX debt previously considered as advantageous into a serious trouble for numerous firms and households heavily indebted in FX. The relative worse post crisis performance of FX borrowers is also confirmed by Endresz and Harasztosi (2014) who demonstrate that FX lending increased investment rates prior to the crisis, while balance sheet effects triggered by the depreciation decreased the investment of firms with FX loans. The authors also show that both effects are likely to be heterogeneous, more

[2]Note that the share of exports to Switzerland in total exports was only 1.3% in 2008 (source: Eurostat Comext database)

pronounced for firms with liquidity constraints. Likewise, Ranciere et al. (2010) show that before the crisis FX borrowing and lower interest rates benefited small domestic firms via a relaxing of credit constraints, while no effect was found for larger firms. The paper does not address firms' post-crisis performance.

Figure 2: Characterisation of long and short term contracts



(a) Short term contracts

(b) Long term contracts

Notes: The left-hand panel describes short-term loans and the right-hand panel describes for long-term loans. The Table shows the shares of new loans by denomination. A panel consists of three main blocks. The first describes all loans, with two separate bars for the periods 2005-2011 and 2009-2011, respectively. The second differentiates between loan sizes. We differentiate between three loan sizes: below 30%, between 30-70% and above 70% relative to total assets. The third block differentiates loans by firms' export shares.

After 2008, CHF lending bacame considerably less attractive. The share of newly contracted bank loans denominated in CHF dropped to one percent by 2010 as compared to ten percent before the outbreak of the crisis. Given the large depreciation of the HUF vis-à-vis the EUR and other hard currencies, it may seem surprising that the share of euro lending did not decrease or even increased among large exporters. There are at least two possible explanations for this observation. First, the composition of firms taking out new loans during the crisis may have changed and the best and most resilient, most probably highly export-oriented firms were more likely to choose euro-denominated loans. Second, firms that previously preferred CHF to EUR may have switched at least partly to euro-denominated loans. These hypotheses will be investigated in detail later in the paper.

Tables 1 and 2 depict whether the simultaneous presence of several currency denominations at the aggregate level results from the aggregation of distinct individual currency choices or from firms holding multiple currencies in their debt portfolio. The first row of Table 1 shows that about one fifth of firms took out both HUF and FX loans during the pre-crisis period. When only firms with more than one loan contract are taken into consideration, this share climbs to 38%. That is, a large share of firms do not stick to one single currency but choose – presumably strategically – the currency denomination of their loan at all choice occasion. These firms provide useful within-firm variation for our econometric analysis.

To see whether there is a clear pattern in the order of firms' currency choice, the second and third rows of Table 1 display the distribution of firms by their choice of currency denomination of their new loans subscribed after their first domestic or FX denominated loan contract. The third row is particularly interesting, as it disproves the idea that limited access to FX credit is the major source of within-firm variation. In this latter case, (risk neutral) firms previously indebted solely in HUF which get access to FX loans for the first time during our sample period would never switch back to the local currency. However, more than 69% of firms with an existing FX debt in their balance sheet will later sign at least one HUF-denominated loan contract. In the empirical part of this paper, we will examine whether firms' currency choice and, in particular, the timing of a specific choice, is purely arbitrary or whether it is governed by explicable rationality.

Table 1: Number of firms by the currency denomination of their contracts (2005-2008)

	one contract		more than one contract			Total
	HUF	FX	only HUF	only FX	both	
Total number of firms	38 971	11 032	33 406	2 481	22 434	108 324
	(36.0%)	(10.2%)	(30.8%)	(2.3%)	(20.7%)	
only contracts after the first HUF loan	15 064	3 339	20 480	948	13 100	52 931
	(28.5%)	(6.3%)	(38.7%)	(1.8%)	(24.7%)	
only contracts after the first FX loan	1 035	3 320	1 104	3 436	13 099	21 994
	(4.7%)	(15.1%)	(5.0%)	(15.6%)	(59.6%)	

Notes: The table shows the number of firms with at least one loan contract underwritten between 2005 and 2008, distributed according to the currency denomination of their loans. The table differentiates between single contract and multi-contract firms. The first row shows all contracts. The second and third rows show only contracts underwritten after the first HUF loan and first FX loan only, respectively. The last two rows thus show data for multi-contract firms only.

Table 2 focuses on firms with more than one FX denominated loan contract. When only firms with two FX denominated contracts are taken into consideration, about 14% of these firms contracted loans in two currencies, mainly EUR and CHF. The share of firms with several foreign currencies in their debt portfolio increases with the number of FX loans contracted: 24% of firms with three FX loans and almost 40% of firms with four or more FX loans prefer to diversify their FX liabilities rather than always choose the same FX.

Table 2: Number of firms with more than one FX loans (2005-2008)

	only EUR	only CHF	only other FX	EUR & CHF	EUR & other	CHF & other	EUR, CHF & other
two FX loans	1 107	3 978	42	771	28	18	
	(18.6%)	(66.9%)	(0.7%)	(13.0%)	(0.5%)	(0.3%)	
three FX loans	500	1 241	18	500	23	29	5
	(21.6%)	(53.6%)	(0.8%)	(21.6%)	(1.0%)	(1.3%)	(0.2%)
four or more FX loans	730	1 091	18	1 009	89	34	67
	(24.0%)	(35.9%)	(0.6%)	(33.2%)	(2.9%)	(1.1%)	(2.2%)

Notes: The table shows the number of firms with two (first row), three (second row) and four or more FX loans (third row) contracted between 2005 and 2008, distributed according to the currency denomination of their contracts.

3 The optimal debt currency portfolio

To illustrate the effect of exchange rate fluctuations on firms' borrowing decisions, firms' optimal debt currency composition is derived from a simple two-period model. We abstract from some realistic aspects of firms' investment strategies and concentrate only on the main features of their financing decisions that are relevant for our purposes.

The basic structure of our framework is similar to that of Bleakley and Cowan (2008) with two distinctions. First, firms may already hold an initial debt in period 0 when the decision takes place, in which case the amount of remaining debt at the end of period 0 and its interest are reimbursed at the end of period 1. Second, we allow firms to choose – in addition to the local currency – among several foreign currencies in which to borrow.[3] We start with the general case of any arbitrary number of funding currencies, then we look at the simple case with only two possible foreign currencies in more detail.[4]

[3]The model is general regarding the form of debt financing, it applies equally to corporate bonds, commercial papers and bank loans. However, in the empirical part, we will only concentrate on bank loans. The markets for corporate bonds and commercial papers do not exist in Hungary.

[4]As the number of relevant debt issuing currencies is generally limited, firms debt currency allocation problem usually does not require high-dimensional portfolio optimisation. In practice, at most only a few currencies are taken into

In period 0, the potential borrowing firm has an initial wealth $w_0 > 0$ that can be invested and an initial debt $B_0 \geq 0$ expressed in local currency. A fraction γ_c of the initial debt is denominated in foreign currency $c = \{1, ..., C\}$. Management decides on the investment strategy, contracts new loans ($B_1 > 0$) to finance the part of the investment that exceeds w_0 and chooses the currency composition of the new loans. The share of the newly contracted debt denominated in foreign currency c is denoted by β_c. In period 1, the project's cash outflow from the initial investment of amount $K_1 = B_1 + w_0$ is given by $F(K_1)$, where the function F is assumed strictly increasing and concave in K.[5] A fraction α_c of the total output from the project is exported and invoiced in currency c. Both the previous debt B_0 and the new debt B_1 are reimbursed with the accrued interest at the end of period 1. The firm's terminal net wealth w_1 is given by:

$$
\begin{aligned}
w_1 = \left(\sum_{c=1}^{C} \alpha_c e_{1c} + (1 - \sum_{c=1}^{C} \alpha_c)\right) F(K_1) - \left(\sum_{c=1}^{C} \gamma_c e_{1c}(1 + i_0^c) + (1 - \sum_{c=1}^{C} \gamma_c)(1 + i_0^d)\right) B_0 \\
- \left(\sum_{c=1}^{C} \beta_c e_{1c}(1 + i_1^c) + (1 - \sum_{c=1}^{C} \beta_c)(1 + i_1^d)\right) B_1
\end{aligned}
\tag{1}
$$

Today's exchange rates e_{0c} are normalised to one and we assume that $E\left[e_{1c}\right] = 1$ for all c. The domestic interest rates of the previous contract and the new contract in local currency are given by i_0^d and i_1^d, respectively. The total costs of borrowing in FX (i_0^c and i_1^c) equal the foreign interest rates plus the expected rate of depreciation of the home currency. We assume that the interest rates i_0^d and i_0^c are fixed by an already existing contract. For some reason, the UIP between the local currency and any of the foreign currencies may not hold, i.e. the market interest rate in a particular FX may be lower than that of the local currency ($i^d \geq i^c$).

Obviously, any risk-neutral firm would maximise its expected terminal wealth by choosing to incur the full amount of debt B_1 in the "cheapest" currency with the minimum interest rate. In reality, however, the optimal debt portfolio takes into account how investors are averse to risk. The firm's decision is modelled as a mean-variance optimisation problem of modern portfolio theory in which risk averse investors seek to maximise the expected utility of terminal wealth for a given level of risk captured by the variance of the expected cash flows.[6]

For simplicity, we assume that the future exchange rate is the only source of uncertainty, which influences both firms' export revenues and their FX debt reimbursement expressed in local currency.

consideration. One or two currencies generally dominate the FX loan market in all developing and transition countries. In non-European countries, the USD has been the predonimant debt issuance currency. Liabilities in emerging Europe have mainly been denominated in EUR and in CHF, the share of other currencies (mainly USD) has been limited.

[5]Function F also takes into account capital depreciation.

[6]The mean-variance utility was introduced in the seminal paper by Markowitz (1952), which is considered as the foundation of modern portfolio theory. The concept was later rationalised by Levy and Markowitz (1979), who showed that any twice differentiable von Neumann - Morgenstern utility function can be approximated by a mean-variance utility function. Even though the framework has been relentlessly criticized, the mean-variance technique has a strong intuitive appeal and still constitutes the cornerstone of portfolio theory (Dybvig and Ross (2003)).

From eq. (1), the expected variance of the portfolio is given by:

$$\begin{aligned} \mathrm{V}[w_1] = \sum_{c=1}^{C}\sum_{c'=1}^{C} \left[\alpha_c F(K_1) - \gamma_c(1+i_0^c)B_0 - \beta_c(1+i_1^c)B_1\right] \times \\ \left[\alpha_{c'} F(K_1) - \gamma_{c'}(1+i_0^{c'})B_0 - \beta_{c'}(1+i_1^{c'})B_1\right] \rho_{e_c,e_{c'}}\sigma_{e_c}\sigma_{e_{c'}} \end{aligned} \tag{2}$$

where $\sigma_{e_c} > 0$ is the standard deviation of the exchange rate of currency c vis-à-vis the local currency and $\rho_{e_c,e_{c'}}$ is the correlation coefficient between the exchange rates of c and c'. It is reasonable to assume that $0 \leq \rho_{e_c,e_{c'}} < 1$ for all $c' \neq c$.

According to the mean-variance approach, the firm maximises its utility characterised by the weighted combination of expected terminal wealth and its expected variance:

$$\max_{K_1,\beta} U \left\{ \mathrm{E}[w_1] - \frac{\theta}{2}\mathrm{V}[w_1] \right\} \tag{3}$$

where $\theta > 0$ is the Arrow-Pratt measure of constant absolute risk aversion. The expected terminal wealth is given by eq. (1) by setting $e_{1c} = 1$ for all c and the expected variance is presented in eq. (2).[7]

It is immediately apparent from eq. (2) that the minimal variance portfolio is achieved with $\beta_c = \beta_c^M = (\alpha_c F(K_1) - \gamma_c(1+i_0^c)B_0) \,/\, ((1+i_1^c)B_1)$ for all c, i.e. when the currency matching is perfect. In this case, the expected variance of the portfolio is zero. The expected utility with the perfect matching portfolio is a straightforward benchmark that any firm with any degree of risk aversion can achieve. If the firm is not fully risk-averse ($\theta < \infty$) and at least one foreign interest rate i_1^c is lower than i_1^d, it is possible to achieve higher expected utility by moving along the efficiency frontier, i.e. choosing a risky (volatile) debt portfolio with higher expected terminal wealth that provides greater utility.

To see this, let us solve the maximisation problem (3) w.r.t. β_c for a given (optimal) K_1. The optimal currency shares are given by the following system of first order equations:

$$\frac{\partial}{\partial \beta_c} = B_1 G_c - \theta B_1^2 \left(\sum_{c'=1}^{C} (\beta_{c'} - \beta_{c'}^M)\rho_{e_c,e_{c'}}\sigma_c\sigma_{c'} \right) = 0, \forall c \tag{4}$$

with $G_c = \left((1+i_1^d) - (1+i_1^c)\right) \geq 0$ being the expected financial gain from contracting one unit of debt in currency c instead of the local currency, $\sigma_c = \sigma_{e_c}(1+i_1^c)$ is the corresponding standard deviation of the reimbursement obligation.

[7] For presentation convenience, positivity constraints – $\beta_c \geq 0$ for all c and $(1 - \sum_{c=1}^{C}\beta_c) \geq 0$ – are ignored. If any of the constraints are binding, a complementary slackness condition should be applied, which implies a corner solution for one or several currency shares.

Equation (4) can be solved using standard linear algebra techniques. Using matrix notations, the solution is given by:

$$\hat{\beta} = (1/(\theta B_1))V^{-1}G + \beta^M \tag{5}$$

where $\hat{\beta}$ and β^M are $C \times 1$ vectors with elements $\hat{\beta}_c$ and β^M_c, respectively, G is an $C \times 1$ vector of G_c's and V^{-1} is the $C \times C$ inverse of the variance-covariance matrix (a.k.a. concentration matrix or precision matrix) with elements $\rho_{e_c,e_{c'}}\sigma_c\sigma_{c'}$. The optimal portfolio is thus the sum of a standard Markowitz portfolio (the speculative component) and a hedge term represented by the perfect matching portfolio.

It is easy to see that – for a given K_1 – the expected excess financial gain over the perfect matching debt portfolio is $\mathrm{E}[\hat{w}_1] - \mathrm{E}[w_1 \,|\beta = \beta^M] = (1/\theta)\, G^T V^{-1} G \geq 0$ and the variance of the portfolio is $\mathrm{V}[\hat{w}_1] = (1/\theta^2) G^T V^{-1} G \geq 0$. That is, if the firm is not fully risk-averse ($\theta < \infty$) and if there is at least one "cheaper" FX in the set of possibilities ($i^c_1 < i^d_1$ for at least one c), the firm is willing to take some risk in exchange for higher expected future profits. Indeed, the firm will be taking on a carry trade position by exploiting perceived arbitrage opportunities between funding currencies.

Although the mathematical expressions for $\hat{\beta}_c$ shares become quite complex as the number of potential currencies increases, the properties of the Markowitz portfolio selection model are well-known from the financial literature. In a world with only one FX, the optimal allocation between the risky FX loan and the risk-free domestic loan is a simple trade-off between the additional gain (G) that the firm generates by increasing the FX share above the perfect matching level and the utility lost generated by the higher variance $(\theta\sigma^2)$.[8]

The possibility of contracting debt in more than one FX brings in two additional considerations: diversification and possible arbitrage opportunities between foreign currencies. According to equation (5), the relative "mismatch shares" $\tilde{\beta}_c/\tilde{\beta}_{c'} = (\hat{\beta}_c - \beta^M_c)/(\hat{\beta}_{c'} - \beta^M_{c'})$ for all c and c' are independent of the degree of risk aversion and the amount of borrowed funds. That is, firms set their diversification strategies and the relative allocation between foreign currencies according to their beliefs about relative gains and volatilities associated with the various alternatives and the correlation between the exchange rates, independently of their risk preferences.

To probe deeper into how firms choose the relative FX shares of their debt, let us consider the simple case with two available foreign currencies denoted, for example, by eur and chf. The

[8] According to eq. (5), the optimal $\hat{\beta}$ is also negatively correlated with the amount of borrowed fund B_1. In fact, in this framework, Markowitz's equations determine the optimal *level* of FX borrowing. It follows that a firm with constant absolute risk aversion (θ) contracts a fixed amount of risky FX debt, independently of the total amount of borrowing and the firm's initial wealth. This unrealistic implication of utility functions with constant absolute risk aversion is largely criticised in the financial literature. Nevertheless, this unpleasant property of the basic mean-variance framework does not alter the main messages of the paper. See e.g. Dybvig and Ross (2003) for alternative utility functions used in the literature.

optimal weights are given by:

$$\begin{cases} \hat{\beta}_{\text{eur}} - \beta^M_{\text{eur}} = \tilde{\beta}_{\text{eur}} = \frac{G_{\text{eur}}}{\theta\sigma^2_{\text{eur}}B_1}\frac{1-\rho_{e_{\text{eur}},e_{\text{chf}}}(1/\psi)}{1-\rho^2_{e_{\text{eur}},e_{\text{chf}}}} \\ \hat{\beta}_{\text{chf}} - \beta^M_{\text{chf}} = \tilde{\beta}_{\text{chf}} = \frac{G_{\text{chf}}}{\theta\sigma^2_{\text{chf}}B_1}\frac{1-\rho_{e_{\text{eur}},e_{\text{chf}}}\psi}{1-\rho^2_{e_{\text{eur}},e_{\text{chf}}}} \end{cases} \tag{6}$$

The firm's perception of arbitrage opportunities is captured by $\psi = (G_{\text{eur}}/\sigma_{\text{eur}})/(G_{\text{chf}}/\sigma_{\text{chf}})$, which is equal to one if the certainty equivalent foreign interest rates (or gains) are equal, and consequently, the firm has no arbitrage incentive between the two foreign currencies.[9] In the absence of arbitrage opportunities, the optimal currency shares simplify to $\tilde{\beta}_c = \left(G_c/(\theta\sigma^2_c B_1)\right)/(1+\rho_{e_{\text{eur}},e_{\text{chf}}})$, $c = \{\text{eur} ; \text{chf}\}$. Both FX shares are strictly decreasing in correlation between the two exchange rates. In fact, the additional FX share above β^M_c is twice as large in the case where the correlation is zero compared to that where $\rho_{e_{\text{eur}},e_{\text{chf}}} \to 1$. This result emerges from the principle of Markowitz diversification, which states that as the correlation between the returns on assets that are combined in a portfolio decreases, so does the variance of that portfolio. The same logic applies to optimal debt portfolio choices. The optimising firm can thus increase the share of risky portfolio and therefore increase expected wealth while maintaining risks within acceptable limits.

If $\psi \neq 1$, an additional trade-off arises between taking advantage of arbitrage opportunities and diversification. Without loss of generality (as the problem is symmetric), let us assume that $\psi < 1$, i.e. chf is preferred to eur. For low values of $\rho_{e_{\text{eur}},e_{\text{chf}}}$, the benefit from diversification is relatively high, while the carry-trade between the two foreign currencies is risky. As the correlation between the two exchange rates increases, diversification benefits become smaller and smaller and firms take increasingly advantage of the more attractive currency. Overall, $\hat{\beta}_{\text{eur}}$ is strictly decreasing with $\rho_{e_{\text{eur}},e_{\text{chf}}}$, while $\hat{\beta}_{\text{chf}}$ exhibits a U-shaped relationship with $\rho_{e_{\text{eur}},e_{\text{chf}}}$ with a minimum at $\rho_{e_{\text{eur}},e_{\text{chf}}} = \psi^{-1}\left(1 - \sqrt{1-\psi^2}\right)$.

Although the firm's management is supposed to have a clear preference for chf – either because the interest rate and/or the volatility of the exchange rate is lower –, the firm still maintains a higher debt share than required by matching even in the less attractive foreign currency (eur) as long as $\rho_{e_{\text{eur}},e_{\text{chf}}} < \psi$. Above this threshold, the relative attractiveness of chf outweighs the diversification benefits. If the positive constraint for β_{eur} is not binding (i.e. if $\beta^M_{\text{eur}} > 0$), the firm is even willing to sacrifice the security provided by perfect matching and to lower $\hat{\beta}_{\text{eur}}$ below β^M_{eur}.

[9] If $\psi = 1$, restricting $\beta_{\text{eur}} = \beta^M_{\text{eur}}$ or $\beta_{\text{chf}} = \beta^M_{\text{chf}}$ and solving the problem for the other FX share generates, in both cases, the same utility for the firm.

Finally, the full solution of the maximisation problem in eq. (3) requires solving for the optimal K_1. The F.O.C. w.r.t. K_1 yields:

$$\begin{aligned} F'(K_1) = &\left(\sum_{c=1}^{C}\beta_c(1+i_1^c) + (1-\sum_{c=1}^{C}\beta_c)(1+i_1^d)\right) \\ +\theta B_1 &\left(\sum_{c=1}^{C}\sum_{c'=1}^{C}\left(\beta_c - \frac{\alpha_c F'(K_1)}{1+i_1^c}\right)\left(\beta_{c'} - \beta_{c'}^M\right)\rho_{e_c,e_{c'}}\sigma_c\sigma_{c'}\right) \end{aligned} \tag{7}$$

The optimality condition for K_1 equates the expected marginal product of capital to the user cost (represented by the first term of the right hand side of eq. (7)) plus a marginal risk premium (second term). In line with the real option investment theory, the marginal product has to be greater than its marginal cost in the presence of uncertainty (Pindyck (1991)). Uncertainty increases the value of waiting (call option) and decreases the propensity to invest now relative to what would be suggested by a simple net present value rule. In this simple framework, combining equations (4) and (7) gives: $F'(K_1) = (1+i_1^d)/(1+\sum_{c=1}^{C}\alpha_c G_c/(1+i_1^c))$. Accordingly, the propensity to invest is unaffected by the possibility of borrowing in FX for non-exporting risk-averse investors.

4 Identification strategy

Using monthly panel data at the contract level, firms' currency choice is studied using discrete choice models. If currency matching is a relevant factor that firms consider in their choice of currency denomination of their bank loans, the probability of contracting new debt in a particular FX must decrease as soon as the firm's debt reimbursement obligation in this currency during a given period of time exceeds its expected export revenues invoiced in the same currency during the same period (see Section 3). To test natural matching considerations, we rely on a "mismatch indicator" variable that takes a value of 1 if the firm's debt payment obligations denominated in foreign currency c (without considering the actual loan contract) is higher than its export revenues in the same foreign currency and 0 otherwise. More precisely:

$$\begin{cases} M_{ijct} & = 1 \text{ if } \bar{X}_{ict} - \bar{L}_{ij'c,t+1} < 0 \\ & = 0 \text{ otherwise} \end{cases} \tag{8}$$

where M_{ijct} is the mismatch indicator for firm i and contract j in currency c subscribed in time t, $\bar{X}_{ict}$ denote the firm's past 12-months average export revenues invoiced in currency c and $\bar{L}_{ij'c,t+1}$ is the firm's monthly average debt payment obligation over the next 12 months in the same currency c stemming from all existing contracts j' other than the actual loan contract j. We only use past values for $\bar{X}_{ict}$ – just as for all other explanatory variables explained later – to avoid simultaneity.

The mismatch indicator is thus equal to 1 if the firm is already in mismatch without considering the actual loan contract.

In our empirical specifications, firms' decisions are modelled as a probabilistic choice problem. In line with the theoretical predictions of optimal currency shares presented in Section 3, the extent of deviation from the perfect matching portfolio is influenced by firms' risk perceptions, risk attitudes and expectations about the future paths of interest rates and exchange rates, all of which are subjective assessments that investors believe in and that differ from firm to firm. These measures are captured by a set of observed time varying firm-level and bank-level characteristics (Z_{it-1}^T), a currency-specific firm-level unobserved parameter (a_{ic}) that represents the effects of firms' unobserved attributes and a random component ε_{ijct} assumed to follow an i.i.d. logistic distribution. Under these assumptions, the conditional probability that currency c is chosen is given by (see McFadden (1974)):

$$P(y_{ijt} = c \,\big|\, Z_{it-1}^T, M_{ijct}, a_{ic}, \forall c) = \frac{\exp(a_{ic} + Z_{it-1}^T \Omega_c + \phi_c M_{ijct})}{1 + \sum_{c'=1}^{C} \exp(a_{ic'} + Z_{it-1}^T \Omega_{c'} + \phi_{c'} M_{ijc't})} \tag{9}$$

where y_{ijt} is the observed outcome.[10] Parameters ϕ_c capture firms' willingness to match the currency composition of their incomes and liabilities to avoid exposure to exchange rate risk. If matching incentives matter, we expect that a firm is less likely to take out a FX loan in a situation of currency mismatch, so ϕ_c is expected to be negative. The baseline category is the local currency (HUF) with the probability of being chosen given by $P(y_{ijt} = \text{HUF} \,\big|\, Z_{it-1}^T, M_{ijct}, a_{ic} \forall c) = 1/(1 + \sum_{c'=1}^{C} \exp(a_{ic'} + Z_{it-1}^T \Omega_{c'} + \phi_{c'} M_{ijc't}))$.

4.1 The binomial case

In our first specification, we estimate the impact of the mismatch indicator on the probability of signing a FX loan contract rather than one in local currency. For each month, all foreign currencies are collapsed together. The set of possible alternative choices is thus limited to $c = \{\text{fx}\}$ and HUF as the baseline category. The matching indicator is constructed using total export revenues and total

[10]McFadden derives the analytical expression for the selection probabilities in eq. (9) using the axiom of independence of irrelevant alternatives (IIA) introduced by Luce (1959), which states that the relative odds of one alternative being chosen over a second one is independent of the presence or absence of any other alternatives. Under this assumption, the relative odds of choosing a specific foreign currency rather than the local currency can be determined as if no other foreign currency alternative were available. Accordingly, the probability of choosing foreign currency c is given by $P[(U\,|\beta_c = 1\,) > (U\,|\beta_c = 0\,)] = P[G_c/(\theta\sigma_c^2 B_1) + \beta_c^M > 1/2]$ or, equivalently: $P[a_{ic} + Z_{it}^T \Omega_c + \phi_c M_{ijct} > \varepsilon_{ijct}]$. With multiple foreign currencies, the system of independent logit equations leads to the expression for the probability that firm i chooses currency c given by eq. (9). As explained later, the strong assumption of IIA can be relaxed by specifying, for example, a mixed logit model.

debt payment obligations all foreign currencies combined. In this case, equation (9) reduces to the binomial logistic function (and subscripts c can be dropped).

The main econometric difficulty is dealing with unobserved heterogeneity (a_i), in particular its relationship with the covariates. Explicitly including dummies for the fixed effects and estimating the equation using standard logit yields consistent estimates only if the time dimension tends to infinity. For fixed time dimension (Γ), the unconditional maximum-likelihood estimator of the incidental parameters is inconsistent, which in turn contaminates the rest of the coefficients. The inconsistency arises because the number of incidental parameters increases without bound, while the amount of information about each incidental parameter remains fixed (Neyman and Scott (1948)). To resolve the endogeneity issue due to the presence of incidental parameters, Andersen (1970) and Chamberlain (1980) propose an estimator of the structural parameters by conditioning the likelihood function on minimal sufficient statistics for the incidental parameters and then maximizing the conditional likelihood function. In the logit case, such statistics can be $\sum_{t=1}^{\Gamma} y_{ijt}$. Intuitively, the minimal sufficient statistics capture all possible information about time-invariant firm-level parameters which influence how many times an alternative has been chosen by the firm. Conditional on this, the parameters of interest are identified by using information on when a specific alternative is chosen.

The principal advantage of Chamberlain's conditional (fixed effects) logit is that it requires no assumption on a_i, hence it allows for any form of correlation between the fixed effects and the regressors. However, the estimation method has several drawbacks. First, since the parameters are identified using within-firm variation, only firms which change state (i.e. those indebted in more than one currency) are considered. Although the sample of firms with bank loans denominated in more than one currency is large enough for asymptotic results to be valid (see Table 1), the incomplete coverage of firms might be a problem if one wants to draw inferences for the whole population or the excluded sub-population. Second, the incidental parameters are not identified and their distributions are unrestricted, which are necessary to calculate quantities of interest such as marginal effects and probability projections. Finally, the conditional logit exhibits the unpleasant property of independence of irrelevant alternatives (IIA): adding another alternative (another foreign currency, in our case) does not affect the relative odds between the two alternatives previously considered.[11]

An alternative approach is to treat the unobserved heterogeneity as random effects. Obviously, the extreme assumption of no-correlation between a_i and the covariates is necessarily violated. Indeed, a more risk-averse firm is, *ceteris paribus*, less likely to carry FX debt and its export revenues are thus more likely to exceed its FX debt payment obligations. Mundlak (1978) and Chamberlain (1982) relax this crucial random effects assumption by allowing the unobserved effects to be correl-

[11] See e.g. Wooldridge (2010). This property is irrelevant if only two options are taken into consideration: foreign currency and local currency. However, in the multinomial case, the model generates implausible substitution patters.

ated with the covariates following a linear specification. In Mundlak's specification, $a_i = \bar{X}_i^T \xi + \omega_i$, with $\bar{X}_i^T$ being a row vector of the time-average of all exogenous covariates (Z_{it-1}^T and M_{ijt}) and ω_i being a normally distributed error term. Chamberlain proposes a more general form by including the vector of all explanatory variables across all time periods: $a_i = \sum_{t=1}^{\Gamma} X_{it}^T \xi_t + \omega_i$. In both cases, the additional explanatory variables included in the model allow us to control for the correlation between a_i and the covariates while using a standard random effects estimator. The intuition behind the identification is in fact similar to that of the conditional logit estimator. In this paper, we employ both the conditional logit model and the correlated random effects logit model with Mundlak's correction to estimate the determinants of foreign currency choice.

4.2 The multinomial case

To estimate the discrete choice model with all available alternatives, a separate mismatch indicator has to be constructed for all foreign currencies. Unfortunately, export destinations (or, which would be even better, export invoicing currencies) are not specified in the database that we use. Based on the relative importance of the different currencies in the Hungarian external trade and the aggregate currency composition of the loans, it is reasonable to assume that the main "matching currency" that firms may consider to hedge exchange rate risks on exports is EUR, while CHF is the principal "speculative currency" irrelevant for hedging purposes. Indeed, the euro area is Hungary's major trading partner: it accounts for more than 57% (in 2008) of the country's total exports, compared to less than 2% for Switzerland. We therefore rely on the simplifying assumption that all export revenues are invoiced in EUR for all firms. The other foreign currencies are collapsed together and we estimate a three-alternative choice model with $c = \{$eur ; other foreign currencies$\}$ and HUF as the baseline category. The mismatch indicator is constructed for the EUR only. As an alternative, we also test the model which places emphasis on the CHF as a speculative currency. The choice set becomes: $c = \{$chf ; other foreign currencies$\}$ and HUF. Since the share of foreign currencies other than the EUR and the CHF has been limited in Hungary, we expect that the two specifications yield similar results. For presentation convenience, in what follows, we simply denote the set of choices by $c = \{$eur ; chf$\}$.

The multinomial discrete choice models are estimated using the mixed logit procedure described in detail in Train (2003). The approach allows very flexible substitution patterns through the estimation of random rather than fixed parameters. Within each firm, the random terms are allowed to be correlated across alternatives, however, they are uncorrelated across firms: corr$(\omega_{ic}, \omega_{i'c'}) = \rho_{\omega_c,\omega_{c'}}$ for all c and c' if $i = i'$ and 0 otherwise.

Conditional on knowing the parameters of the model, the probability that firm i chooses currency c on a given choice occasion is given by McFadden's logit formula (eq. 9). The unconditional mixed logit probability is the integral of the conditional probability over all the possible parameter values, which depends on the density function of each of the random parameters. The estimation is carried out using maximum simulated likelihood technique (see Train (2003)).

Like in the binomial case, we apply Mundlak's correction to both alternatives by including firm level averages in the equations. Theoretically, it is possible to use a very general random coefficient specification by assuming all coefficients (Ω_c, ϕ_c, ξ_c and the intercepts for all c) to vary randomly. However, depending on the number of coefficients the estimation procedure becomes very complex as multiple integrals have to be solved (Train (2003)). In this paper, we only assume the intercepts to be random.[12]

5 The dataset

Estimations were carried out using four matched administrative datasets. We principally rely on the credit register (*KHR*) database containing the universe of all new and already existing corporate loan contracts from Hungarian financial institutions between 2005 and 2011. The dataset provides information on contracts starting date, duration, value, denomination, loan types and type of providers. Four types of contracts are distinguished: loans, credit lines, factoring and leasing. Providers are banks, saving banks and other financial companies. Between 2005 to 2011, the average annual number of new contracts stands at 65,000. It rises from about 77,000 to a little over 82,000 until the outbreak of the crisis. After 2008, it drops to below 50,000. Overall, there are 129,066 firms in the dataset and, on average, about 42,700 firms take out loans each year.

For the detailed description of the *KHR* dataset, see Endresz et al. (2012). We deviate from the construction of the dataset described in Endresz et al. (2012) on one important aspect. To focus on currency choices, we collapse the loan contacts denominated in the same currency and signed by the same company in the same month. That is, if a firm takes out two loans in the same currency in the same month, we combine the corresponding contracts to form a single contract with the sum of the two loans and a duration defined as the weighted mean of the duration of the two original loans. As a result, the average annual number of new contracts falls to about 70% of the original, while the total amount of outstanding debt in each month and the aggregate monthly flow of debt service expenses remain unchanged.

The credit register is then merged with the yearly panel database of corporate tax returns. The database is provided by the Hungarian tax authorities (*NAV*) and contains balance-sheet and in-

[12]The mixed logit procedure with an arbitrary combination of random and fixed parameters can aslo be applied to the binomial case. Assuming only the intercept to be random is equivalent to the random effects logit model described earlier. Although the estimation strategy of mixed logit models differs from that of the standard random effects model, the mixed logit procedure with random intercepts and the random effects logit model yield similar results.

come statement information for all double entry book-keeping firms operating in Hungary. We use variables that are likely to affect firms' demand for credit and its choice of currency denomination such as employment, foreign ownership, capital, liquidity, total assets and profitability measures.

Although the *NAV* dataset contains the export share of sales, we collect additional trade information from the Hungarian Central Statistical Office on trade behaviour. We merge the statistics on exports and imports calculated from the monthly reports on commodity trade to Extra- and Intrastat for the universe of direct trading firms in Hungary. The monthly frequencies enable us to calculate, for example, the export revenues during the 12 months preceding the signature of the loan contract.

Finally, we extend the dataset by including information on the credit provider. Following the methodology proposed by Ongena et al. (2014), we match a list of bank characteristics – such as foreign ownership, total assets, capital ratio, liquidity ratio, return on assets and doubtful loan ratio – to the contract-firm level dataset.[13]

6 Estimation results

6.1 Pre-crisis period

Table 3 summarises the main empirical findings for the pre-crisis period (2005-2008). The first two columns report the results for the binomial specification estimating the probability of choosing a foreign currency over the domestic currency using conditional (fixed effects) logit (column (1)) and Mundlak's correlated random effects logit (column (2)) regression techniques. In both cases, the coefficients of the mismatch indicator are negative and highly significant. The probability of taking out an FX loan is thus higher as long as the firm's expected export revenues fully cover its foreign currency debt service expenses, which provides strong evidence to support the role of natural hedging incentives in firms' debt currency choice.

The mixed logit models with three possible alternatives provides a more accurate, albeit still imperfect, measure of currency matching. As explained in Section 4, two specifications are considered. First, the results presented in column (3) of Table 3 correspond to the case where exports are all assumed to be invoiced in euro and consequently, only the euro-denominated debt is used for hedging purposes. Debt incurred in other foreign currencies (that are collapsed together) is the result of pure speculation. Second, column (4) reports the results for the case in which CHF is the only purely speculative currency and debt incurred in any other foreign currency may potentially be used for hedging purposes. The mismatch indicators are constructed accordingly.

[13]We thank Adam Szeidl for giving us access to the structured dataset and Dzsamila Vonnák for the excellent work of matching the databases.

The two specifications yield similar results. In particular, both estimates reinforce the role of matching incentives in firms' currency choice and suggest that, as expected, results previously presented for the binomial case are mainly driven by matching in euro.

The positive and significant estimated covariance between the two foreign currency alternatives implies that firms that are more likely to choose one of the two foreign currencies are also more likely to choose the other. Theory (Section 3) suggests that the substitution pattern between foreign currencies – i.e. the within-firm correlation between the random effects – is affected by two distinct yet interacting factors: arbitrage and diversification. While our model does not allow us to disentangle the two factors, results suggest that the benefits from diversification – i.e. holding both EUR and CHF debt – outweighs the advantage of consistently choosing one (the preferred) FX to the other. In other words, the average (or representative) firm seeks diversification. However, the correlation coefficient of about 0.2 implied by the estimated parameters is rather low. As the average number of contracted FX loans is relatively low in our sample (1.8 among the firms that subscribed at least one FX contract; see also Table 2), the model fails to detect a strong interdependence between the alternative choices.

We also check the robustness of our results to various sample selection alternatives. The estimation sample for the conditional fixed effects model is by construction restricted to firms indebted in more than one currency. In principle, however, all observations can be used to estimate the correlated random effects and the mixed effects models, even though the firms that exhibit no variation in the explanatory variables or the dependent variable do not contribute to the identification of the structural parameters. Along with our baseline specification on the whole sample of firms, we re-estimate our models presented in columns (2) to (4) of Table 3 for the sample of firms exhibiting a variation in the left-hand side variable (same sample as for the fixed effects logit) and for the sample of firms with variation in the matching indicator. In addition, we test whether using net exports instead of export sales or considering only long-term contracts changes the results of the fixed effects, random effects or mixed logit models. Finally, we re-estimate all our models separately for foreign firms (foreign ownership over 50%) and domestic firms (we have run the regressions both on the sample of firms with foreign ownership less than 50% and on the sample of entirely domestic firms). For all estimation methods, results based on these alternative sample selection choices are very close to our baseline findings.[14]

[14]These results are not presented in this paper for reasons of brevity, but are available from the authors upon request.

Table 3: Estimation results for the pre-crisis period (2005-2008)

			Mixed logit with three alternatives	
	Fixed-effects logit	Random-effects logit	EUR, other foreign currencies ($\sim$CHF) and HUF	CHF, other foreign currencies ($\sim$EUR) and HUF
	(1)	(2)	(3)	(4)
Mismatch indicator	-1.058*** [0.025]	-1.244*** [0.027]	-0.987*** [0.055]	-0.886*** [0.052]
$\text{var}(\omega_{\text{eur}})$			3.087*** [0.112]	3.135*** [0.112]
$\text{cov}(\omega_{\text{eur}}, \omega_{\text{chf}})$			0.553*** [0.090]	0.513*** [0.064]
$\text{var}(\omega_{\text{chf}})$			2.443*** [0.055]	2.395*** [0.054]
$\text{corr}(\omega_{\text{eur}}, \omega_{\text{chf}})$			0.201*** [0.032]	0.187*** [0.022]
Nb. of obs.	83 147	173 673	521 019	521 019
Nb. of firms	12 869	51 706	51 706	51 706

*Notes: Each column of Table 3 collects results from a separate regression. The first specification is a firm fixed effects logit. It includes all firm- and bank-level controls (both lagged) described in the Appendix, year dummies and a constant. The next column shows the results for the correlated random effects logit regression. In addition to the aforementioned controls, the regression also controls for the time-averages of the variables for each firm to implement Mundlak's correction. The last two columns collect results from mixed logit regressions with three alternatives. Here, we allow the constants in both choice equations to be randomly distributed across firms. The elements of the covariance matrix and the correlation between alternatives (i.e. between the random terms ω_{eur} and ω_{chf}) are calculated from the estimated lower-triangular matrix L, where the matrix L is the Cholesky factorization of the covariance matrix. The corresponding standard errors are computed using the delta method. *** significant at 1%, ** significant at 5%, * significant at 10%.*

6.2 The effects of the crisis on firms' currency choice

Our final specification estimates the mixed logit model in column (3) of Table 3 for the whole period covered by our database (2005-2011). To explore potential changes in firms' matching behaviour, in particular after the outbreak of the crisis, we let the parameter of the matching indicator take different values for the pre- and post-crisis periods. As explained in Section 4, different random parameters (ω_{ic}) are estimated for the pre- and post-crisis periods that can be correlated both in time and between alternatives. The estimation sample covers only firms contracting new debt in both periods. Figure 3 plots the evolution of the estimated average alternative-specific effects calculated from the year dummies and the mean estimates of the random parameters.[15]

The significantly negative interaction term between the mismatch indicator and the post-crisis dummy suggests that matching incentives played a somewhat more important role in firms' currency choice decisions in the aftermath of the crisis than before 2008.[16] At the same time, the estimated average year effects (Figure 3) reveal that the attractiveness of the two foreign currencies remained stable prior to the crisis but has severely deteriorated since 2009. While the relative odds of taking out euro-denominated corporate loans compared to local currency loans did not change significantly in the aftermath of the financial crisis, either the expected financial gain from taking out CHF loans declined or the perceived risks associated with bank loans denominated in CHF increased considerably.[17]

The estimated covariance matrix of the random coefficients is also consistent with the deterioration in firms' relative preference for the EUR over the CHF. The relatively high correlations between pre- and post-crisis random terms for both currencies – over 0.7 for both the EUR and the CHF, see Table 4 – indicate that firms that placed a higher value on a particular currency before the crisis still have a stronger preference for this currency than the average firm. However, cov$(\omega_{\text{chf, pre-crisis}}, \omega_{\text{eur, post-crisis}})$ largely exceeds cov$(\omega_{\text{eur, pre-crisis}}, \omega_{\text{chf, post-crisis}})$, which suggests that the probability of firms with a stronger preference for the CHF before the outbreak of the crisis switching to the EUR is greater than the probability of firms with a stronger preference for the EUR before the crisis of later switching to the CHF. In other words, a number of firms seem to have adjusted their optimal relative shares of the two FX-denominated debts and have switched from the CHF partly to the HUF, but also partly to the EUR.

[15] More precisely, the figure plots the year dummy parameters $(\hat{d}_y)$ for the years 2006 to 2008. For 2009, it is calculated as the difference between the mean of the random parameters: $\hat{d}_{2009} = \hat{\omega}_{c,\text{post}} - \hat{\omega}_{c,\text{pre}}$. For the years 2010 and 2011, we subtract $\hat{d}_{2009}$ from the estimated year dummies.

[16] The point estimate for the parameter of the mismatch indicator for the pre-crisis period is lower in absolute value than the parameter values presented in Table 3. These estimates are, however, not directly comparable. As is the case with any nonlinear probability model, the coefficients are identified only up to scale and therefore estimated parameters across various estimation methods and different sample of firms and periods cannot be naively compared.

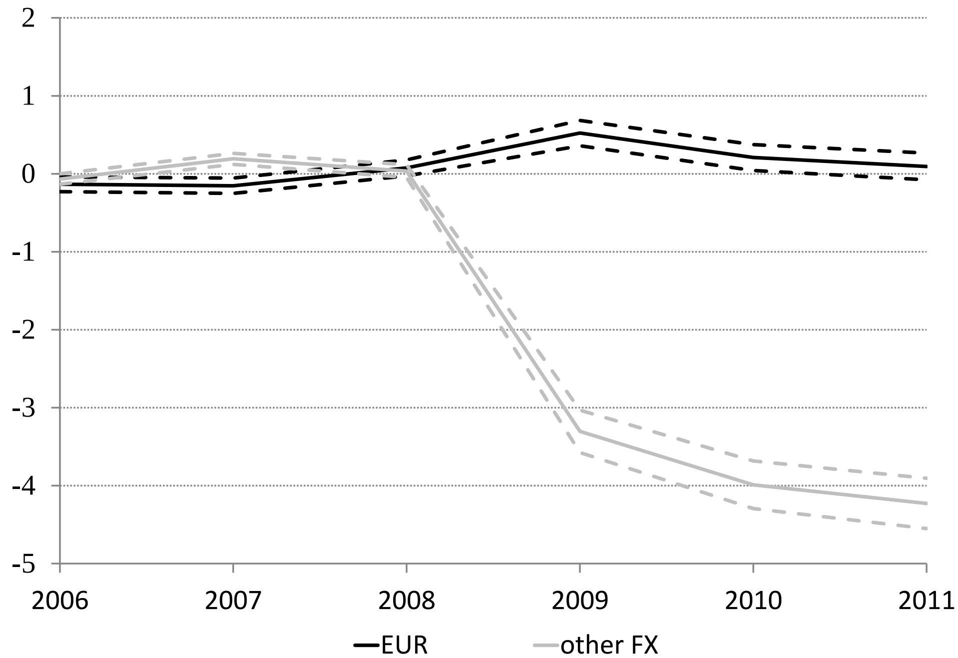
[17] We interpret estimates for "other foreign currencies" as results for CHF for two reasons. First, as explained earlier in the paper, the share of foreign currency loans other than EUR and CHF has been limited in Hungary and consequently, contracts denominated in CHF may drive the results. Second, our alternative mixed logit specification presented in column (4) of Table 3 re-estimated for the whole period 2005-2011 with time-varying matching indicator parameters yield similar results to the specification discussed in the paper.

Table 4: Estimation results for the whole period (2005-2011)

	Mismatch indicator	-0.632*** [0.055]
	Mismatch indicator × post-crisis dummy	-0.268*** [0.068]
	covariances	correlations
var($\omega_{\text{eur, pre-crisis}}$)	2.351*** [0.085]	
var($\omega_{\text{chf, pre-crisis}}$)	2.284*** [0.062]	
var($\omega_{\text{eur, post-crisis}}$)	4.121*** [0.154]	
var($\omega_{\text{chf, post-crisis}}$)	5.959*** [0.416]	
cov/corr($\omega_{\text{eur, pre-crisis}}, \omega_{\text{chf, pre-crisis}}$)	0.429*** [0.046]	0.185*** [0.019]
cov/corr($\omega_{\text{eur, post-crisis}}, \omega_{\text{chf, post-crisis}}$)	0.533*** [0.171]	0.108*** [0.034]
cov/corr($\omega_{\text{eur, pre-crisis}}, \omega_{\text{eur, post-crisis}}$)	2.176*** [0.080]	0.699*** [0.017]
cov/corr($\omega_{\text{chf, pre-crisis}}, \omega_{\text{chf, post-crisis}}$)	2.587*** [0.118]	0.701*** [0.020]
cov/corr($\omega_{\text{eur, pre-crisis}}, \omega_{\text{chf, post-crisis}}$)	0.906*** [0.122]	0.242*** [0.031]
cov/corr($\omega_{\text{chf, pre-crisis}}, \omega_{\text{eur, post-crisis}}$)	1.681*** [0.0623]	0.548*** [0.016]
	Nb. of obs.	544 785
	Nb. of firms	26 124

*Notes: The table displays the parameter estimates for the mismatch indicator and its interaction term with a post-crisis dummy from the mixed logit regression on the whole sample 2005-2011. The sample covers firms contracting new debt in both periods. The regressions include all firm and bank level controls (both lagged) described in the Appendix, year dummies and constant terms. The elements of the covariance matrix (i.e. the correlation between the random terms $\omega_{c,t}$ with $c = \{eur\ ;\ chf\}$ and $t = \{pre\text{-}crisis\ ;\ post\text{-}crisis\}$) are calculated from the estimated lower-triangular matrix L, where the matrix L is the Cholesky factorization of the covariance matrix. The corresponding standard errors are computed using the delta method. *** significant at 1%, ** significant at 5%, * significant at 10%*

Figure 3: Average currency-specific effects



Notes: The Figures plots the evolution of the estimated average alternative-specific effects issued from the mixed logit regression on the whole sample 2005-2011. More precisely, the values plotted on the graph are: year dummy parameters ($\hat{d}_y$) for the years 2006-2008; for 2009, it is calculated as the difference between the mean of the random parameters $\hat{d}_{2009} = \hat{\omega}_{c,post} - \hat{\omega}_{c,pre}$; and form the years 2010 and 2011, $\hat{d}_{2009}$ is subtracted from the estimated year dummies $\hat{d}_{2010}$ and $\hat{d}_{2011}$, respectively. The standard errors corresponding to the calculated parameters are computed using the delta method.

6.3 Matching or speculation?

An important advantage of our modelling approach compared to those previously used in the literature is that our model allows us to perform a counterfactual analysis to isolate the effects of currency matching motives on the aggregate corporate FX debt share. To do so, we first predict for all firms and for all choice occasions the probability of choosing the EUR, the CHF or the HUF using the estimated model of Table 4. The weighted – by the size of the loan – yearly averages of these probabilities give the estimated aggregate currency shares of newly contracted bank loans. If the fit of our model is good, the estimated shares should be close to the observed shares. We then "switch off" the effects of currency matching on firms' debt denomination choice by setting the mismatch indicator to 1 for all observations and we predict the counterfactual currency shares of newly contracted corporate loans in the absence of matching motives. The weighted averages of these counterfactual probabilities correspond to the currency shares of new loans that would have resulted from "speculation", i.e. if all firms were constantly in a mismatch situation and hedging strategy was irrelevant. The difference between the baseline predictions and the counterfactual currency shares represents the effect of matching on the aggregate shares.

Table 5 presents the results. The first block of the table displays the observed currency shares of newly contracted loans in the database between 2005 and 2011, while the second block shows the baseline predicted currency shares using the estimated mixed logit model of Table 4. Although the model appears to moderately underestimate the share of "other FX" ($\sim$CHF), overall the predicted currency shares are close to the observed ones.

Table 5: Decomposition of currency choice

	Data (1)			Prediction: Baseline (2)			Prediction: "Speculative" part (3)			Prediction: Matching effect (4) = (2) - (3)		
	HUF	EUR	other	HUF	EUR	other	HUF	EUR	other	HUF	EUR	other
2005	55.0	31.7	13.3	57.1	32.3	10.6	61.8	26.8	11.5	-4.7	5.5	-0.9
2006	53.7	32.0	14.2	57.5	32.4	10.1	62.9	26.1	11.0	-5.4	6.3	-0.9
2007	54.2	29.7	16.0	59.0	28.0	13.1	63.5	22.5	14.0	-4.5	5.5	-0.9
2008	60.8	26.4	12.7	61.7	27.0	11.3	66.3	22.7	12.1	-4.6	5.3	-0.8
2009	62.8	32.1	5.1	60.0	38.3	1.7	68.5	29.6	2.0	-8.3	8.7	-0.3
2010	62.0	33.7	4.3	61.6	37.2	1.1	69.2	29.6	1.3	-7.6	7.6	-0.2
2011	62.4	30.9	6.7	62.2	36.9	0.9	70.0	29.0	1.0	-7.7	7.9	-0.1

Notes: The first block displays the currency shares of newly contracted loans in the database between 2005 and 2011. The second block shows the weighted averages of the predicted currency shares using the estimated mixed logit model of Table 4. The "speculative part" in column (3) is obtained by "switching off" the matching motive in firm's decision, i.e. by setting the mismatch indicator to one for all firms and all choice occasion and predicting the currency shares the same way as before. The effects of the matching, presented in the last block of the Table, is the difference between the baseline predictions and the predicted speculative part.

If currency matching had not been part of firms' strategies, the share of the newly contracted FX debt would have been lower by 4.8 percentage points before the crisis and by about 7.9 percentage points after the outbreak of the current crisis (see blocks (3) and (4) of Table 5). Given that the share of the new FX loans is on average approximately 44 percent between 2005 and 2008 and 38 percent between 2009 and 2011, roughly 10 percent of the overall corporate FX debt during the pre-crisis and 20 percent during the post-crisis periods can be explained by matching motivation. The largest share of FX debt is thus not related to natural hedging.

7 Conclusion

Households indebted in FX naturally expose themselves to exchange rate risks. Conversely, firms with export revenues can also use FX debt to reduce or eliminate their exposure to exchange rate variations. While a large body of empirical research documents a significant positive correlation between the share of FX debt in firms' balance sheets and a proxy for the sensitivity of firms' revenues to exchange rate fluctuations, such as export shares or an indicator of tradability, there is little rigorous empirical evidence on the importance of matching motives in firms' currency-of-denomination decisions. Furthermore, there has been no clear understanding whether natural hedging motivation or other factors such as the interest rate differential is the key driver of firms' currency choices.

This paper investigates firms' willingness to match the currency composition of their assets and liabilities and their incentives to deviate from perfect matching in the presence of multiple available foreign currency loans. By adopting a simple mean-variance approach from modern portfolio theory, we first derive a closed form solution for optimal debt portfolio. In line with the proposed theory, we then rely on Hungarian corporate loan data and estimate discrete choice models in which firms choose the currency denomination of their loans.

Results show that the probability of borrowing in FX decreases as soon as the firm's foreign currency debt reimbursement obligation exceeds its expected export revenues. This finding is robust across various model specifications and sample choices, which provides strong evidence to support the role of currency matching incentives in firms' currency choice. In addition, our results suggest that the benefits from diversification outweigh the perceived carry trade opportunities between EUR and CHF, the two major foreign currencies in Hungary.

Matching motivation is even stronger after the outbreak of the current financial crisis than during the pre-crisis period. However, our counterfactual simulations suggest that natural hedging is not the main cause of firms' FX indebtedness: only about 10 percent of overall corporate FX debt is attributable to natural hedging during the pre-crisis and 20 percent during the post-crisis periods.

While our model allows us to isolate the effects of matching motives on firms' currency choice, we do not directly explain the underlying reasons why firms deviate from the pure natural hedging strategy. One obvious candidate is the interest rate differential and thus firms' carry trade strategies, yet other explanations may also exist. The existing literature proposes a few other explanations for firms' FX choice. However, none of these alternative explanations seem relevant for Hungary. For instance, Shapiro (1984) shows that in some countries, such as Sweden, the tax law encourages firms to incur FX debt by making foreign exchange losses on FX debt immediately tax deductible, while taxes on foreign exchange gains are deferred until realised. On the other hand, if the exchange losses (gains) on the principal of the FX debt are tax deductible (taxable) at the same rate as the local corporate income tax, such as is the case in Hungary, the firm is indifferent between borrowing in FX or local currency. Other papers concentrate on the financing decisions of multinational firms. Multinationals may have incentives to locate their debt in the highest-tax country (see e.g. Hodder and Senbet (1990)) or may choose the country and the currency in which the debt is incurred depending on legal barriers (Jorion and Schwartz (1986)) or the costs of gathering information (Hietala (1989)). These theories can hardly explain the FX borrowing of many domestic firms from local commercial banks.

Other explanations may exist, but apart from exploiting interest rate differentials, we are not aware of any convincing evidence or theory that could explain the large share of FX debt in Hungary or in other similar countries. Most likely, the largest share of corporate FX debt, at least in Hungary, corresponds to open carry trade positions held by non-financial corporations.

References

Aghion, P., Bacchetta, P., and Banerjee, A. (2001). Currency crises and monetary policy in an economy with credit constraints. *European Economic Review*, 45(7):1121–1150.

Allayannis, G., Brown, G. W., and Klapper, L. F. (2003). Capital structure and financial risk: Evidence from foreign debt use in East Asia. *Journal of Finance*, 58(6):2667–2710.

Allayannis, G. and Ofek, E. (2001). Exchange rate exposure, hedging, and the use of foreign currency derivatives. *Journal of International Money and Finance*, 20(2):273–296.

Andersen, E. B. (1970). Asymptotic properties of conditional maximum-likelihood estimators. *Journal of the Royal Statistical Society. Series B (Methodological)*, 32(2):283–301.

Basso, H. S., Calvo-Gonzalez, O., and Jurgilas, M. (2011). Financial dollarization: The role of foreign-owned banks and interest rates. *Journal of Banking & Finance*, 35(4):794–806.

Benavente, J. M., Johnson, C. A., and Morande, F. G. (2003). Debt composition and balance sheet effects of exchange rate depreciations: a firm-level analysis for Chile. *Emerging Markets Review*, 4(4):397–416.

Bleakley, H. and Cowan, K. (2008). Corporate dollar debt and depreciations: Much ado about nothing? *The Review of Economics and Statistics*, 90(4):612–626.

Bodnar, K. (2009). Exchange rate exposure of hungarian enterprises: results of a survey. Occasional Papers 80, Magyar Nemzeti Bank.

Bonomo, M., Martins, B., and Pinto, R. (2003). Debt composition and exchange rate balance sheet effect in Brazil: a firm level analysis. *Emerging Markets Review*, 4(4):368–396.

Brown, M., Kirschenmann, K., and Ongena, S. (2010). Foreign Currency Loans - Demand or Supply Driven? CEPR Discussion Papers 7952, C.E.P.R. Discussion Papers.

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

Carranza, L. J., Cayo, J. M., and Galdon-Sanchez, J. E. (2003). Exchange rate volatility and economic performance in Peru: a firm level analysis. *Emerging Markets Review*, 4(4):472–496.

Chamberlain, G. (1980). Analysis of covariance with qualitative data. *Review of Economic Studies*, 47:225–238.

Chamberlain, G. (1982). Multivariate regression models for panel data. *Journal of Econometrics*, 18(1):5–46.

Cowan, K., Hansen, E., and Herrera, L. O. (2005). Currency Mismatches, Balance Sheet Effects and Hedging in Chilean non-Financial Corporations. Working Papers Central Bank of Chile 346, Central Bank of Chile.

Dybvig, P. H. and Ross, S. A. (2003). Arbitrage, state prices and portfolio theory. In Constantinides, G., Harris, M., and Stulz, R. M., editors, *Handbook of the Economics of Finance*, volume 1 of *Handbook of the Economics of Finance*, chapter 10, pages 605–637. Elsevier.

Echeverry, J. C., Fergusson, L., Steiner, R., and Aguilar, C. (2003). 'Dollar' debt in Colombian firms: are sinners punished during devaluations? *Emerging Markets Review*, 4(4):417–449.

Eichengreen, B., Hausmann, R., and Panizza, U. (2007). Currency mismatches, debt intolerance, and the original sin: Why they are not the same and why it matters. In *Capital Controls and Capital Flows in Emerging Economies: Policies, Practices and Consequences*, NBER Chapters, pages 121–170. National Bureau of Economic Research, Inc.

Endresz, M., Gyongyosi, G., and Harasztosi, P. (2012). Currency mismatch and the sub-prime crisis: firm-level stylised facts from Hungary. MNB Working Papers 2012/8, Magyar Nemzeti Bank (the central bank of Hungary).

Endresz, M. and Harasztosi, P. (2014). Corporate foreign currency borrowing and investment: The case of Hungary. *Emerging Markets Review*, 21(C):265–287.

Fuentes, M. (2009). Dollarization of debt contracts: Evidence from chilean firms. *The Developing Economies*, 47(4):458–487.

Galiani, S., Levy Yeyati, E., and Schargrodsky, E. (2003). Financial dollarization and debt deflation under a currency board. *Emerging Markets Review*, 4(4):340–367.

Galindo, A., Panizza, U., and Schiantarelli, F. (2003). Debt composition and balance sheet effects of currency depreciation: A summary of the micro evidence. *Emerging Markets Review*, 4(4):330–339.

Gelos, G. (2003). Foreign currency debt in emerging markets: firm-level evidence from Mexico. *Economics Letters*, 78(3):323–327.

Hietala, P. T. (1989). Asset Pricing in Partially Segmented Markets: Evidence from the Finnish Market. *Journal of Finance*, 44(3):697–718.

Hodder, J. E. and Senbet, L. W. (1990). International Capital Structure Equilibrium. *Journal of Finance*, 45(5):1495–1516.

Janot, M. M., Garcia, M. G. P., and Novaes, W. (2008). Balance Sheet Effects in Currency Crises: Evidence from Brazil. Working Papers Series 162, Central Bank of Brazil, Research Department.

Jorion, P. and Schwartz, E. (1986). Integration vs. Segmentation in the Canadian Stock Market. *Journal of Finance*, 41(3):603–14.

Kamil, H. (2012). How do exchange rate regimes affect firms' incentives to hedge currency risk? micro evidence for Latin America. IMF Working Papers 12/69, International Monetary Fund.

Kedia, S. and Mozumdar, A. (2003). Foreign Currency Denominated Debt: An Empirical Examination. *The Journal of Business*, 76(4):521–546.

Keloharju, M. and Niskanen, M. (2001). Why Do Firms Raise Foreign Currency Denominated Debt? Evidence from Finland. *European Financial Management*, 7(4):481–496.

Krugman, P. (1999). Balance sheets, the transfer problem, and financial crises. *International Tax and Public Finance*, 6(4):459–472.

Levy, H. and Markowitz, H. M. (1979). Approximating expected utility by a function of mean and variance. *American Economic Review*, 6(3):308–317.

Luce, R. D. (1959). *Individual Choice Behavior: A Theoretical Analysis*. New York: Wiley.

Markowitz, H. M. (1952). Portfolio selection. *Journal of Finance*, 7(1):77–91.

Martinez, L. and Werner, A. (2002). The exchange rate regime and the currency composition of corporate debt: the Mexican experience. *Journal of Development Economics*, 69(2):315–334.

McFadden, D. (1974). Conditional logit analysis of qualitative choice behavior. In Zarembka, P., editor, *Frontiers in Econometrics*, pages 105–142. Econometrics, New York: Academic Press.

Mora, N., Neaime, S., and Aintablian, S. (2013). Foreign currency borrowing by small firms in emerging markets: When domestic banks intermediate dollars. *Journal of Banking & Finance*, 37(3):1093–1107.

Mundlak, Y. (1978). On the pooling of time series and cross section data. *Econometrica*, 46(1):69–85.

Neyman, J. and Scott, E. L. (1948). Consistent estimates based on partially consistent observations. *Econometrica*, 16(1):1–32.

Ongena, S., Schindele, I., and Vonnak, D. (2014). In lands of foreign currency credit, bank lending channels run through? the effects of monetary policy at home and abroad on the currency denomination of the supply of credit. CFS Working Paper Series 474, Center for Financial Studies (CFS).

Pindyck, R. S. (1991). Irreversibility, uncertainty, and investment. *Journal of Economic Literature*, 29(3):1110–48.

Pratap, S., Lobato, I., and Somuano, A. (2003). Debt composition and balance sheet effects of exchange rate volatility in mexico: a firm level analysis. *Emerging Markets Review*, 4(4):450–471.

Ranciere, R., Tornell, A., and Vamvakidis, A. (2010). Currency mismatch, systemic risk and growth in emerging Europe. *Economic Policy*, 25(64):597–658.

Rosenberg, C. and Tirpak, M. (2009). Determinants of Foreign Currency Borrowing in the New Member States of the EU. *Czech Journal of Economics and Finance*, 59(3):216–228.

Shapiro, A. C. (1984). The Impact of Taxation on the Currency-of-Denomination Decision for Long-Term Foreign Borrowing and Lending. *Journal of International Business Studies*, 15(1):15–25.

Train, K. (2003). *Discrete Choice Methods with Simulation*. Cambridge University Press.

Vonnak, D. (2014). Determinants and riskiness of corporate foreign currency lending: the case of Hungary. Unpublished manuscript, Central European University.

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*, volume 1 of *MIT Press Books*. The MIT Press.

Appendix

Table 6: Descriptive statistics of the variables

	2005-2008			2009-2011		
Definition of the variable	N	mean	std.	N	mean	std.
short contract dummy (duration is one year or less)	309 077	0.26	0.44	186018	0.29	0.46
loan size / total assets (in logs)	206 095	4.77	1.70	125 648	4.86	1.62
firm level variables						
employment (in logs)	287 161	2.31	1.35	172 872	2.30	1.35
foreign ownership dummy (over 50%)	287 138	0.06	0.24	172 864	0.06	0.23
importer dummy	309 077	0.21	0.41	186 018	0.19	0.39
exports share in sales	201 884	0.07	0.20	122 974	0.07	0.20
firms' real capital (in logs)	206 180	0.36	0.25	125 661	0.36	0.25
current assets / total assets	206 180	0.62	0.26	125 661	0.62	0.27
total assets (in logs)	206 180	11.34	1.88	125 661	11.46	1.89
profits / total assets	206 180	0.02	0.36	125 661	0.02	0.32
bank level variables						
foreign ownership dummy (over 50%)	250 217	0.95	0.21	152 320	0.94	0.23
total assets (in logs)	250 217	14.15	0.96	152 320	14.49	1.01
bank capital ratio	250 217	0.09	0.04	152 320	0.09	0.04
bank liquidity ratio	250 217	0.13	0.06	152 320	0.17	0.09
profits / total assets	250 217	0.01	0.02	152 320	0.00	0.01
doubtful loan ratio	250 014	0.57	0.04	152 202	0.61	0.04

Notes: The Table provides descriptive statistics on the variables of the dataset used in the estimations. The statistics, – number of observations, mean and standard deviation – are given for two periods, 2005-2008 and 2009-2011. The table separates the variables related to the firms and those related to the banks providing the loans.