Currency Matching and Carry Trade by Non-Financial Firms*

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Abstract

The paper investigates firms' willingness to match the currency composition of assets and liabilities and incentives to deviate from perfect matching in a situation where they have access to foreign currency loans and the market interest rate in foreign currency is lower than that of the local currency. Using detailed information at the loan contract level for the Hungarian non-financial corporate sector, results show that the probability of issuing new debt 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 motivation in firms' currency choice. The specifications with several foreign currencies – essentially euro and Swiss francs – suggest that both diversification strategies and implicit carry-trade between the two foreign currencies are relevant factors in firms' 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, that is, when firms borrow "too much" in FX compared to their export revenues. As a result, if the domestic currency depreciates, firms with currency mismatch experience adverse balance sheet effects as the negative effect of the rise in FX denominated liabilities

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expressed in local currency 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 discussion 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 sharp depreciation of the respective home currencies. Due to 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-Eastern European countries following the outbreak of the current crisis.

To evaluate the risks associated with excessive FX indebtedness, it is therefore crucial to understand firms' FX borrowing decisions first. This paper aims at investigating firms' willingness to match the currency composition of assets and liabilities and incentives to deviate from perfect matching. To motivate our empirical analysis, we first derive a closed form the solution for optimal debt portfolio in a situation in which firms can issue debt in multiple currencies. Using detailed information at the loan contract level, we construct a theory-consistent measure of matching indicator and we test its influence on firms' choice of currency denomination of borrowing. 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 motives for firms to deviate from the perfect matching portfolio is also addressed. In particular, we investigate corporate borrowers' choice between several possible foreign currencies and we test whether diversification strategies or carry-trade incentives between foreign currencies drives firms' decisions. Finally, we explore the effects of the crisis on firms' preferences and risk assessments.

The existing empirical literature provides limited insight into these aforementioned specific issues. Most of the previous papers follow the methodology proposed by Bleakley and Cowan (2008), in which the determinants of firms' debt currency composition are analysed by relating the share of FX debt with a set of firm specific characteristics and other macroeconomic variables. Such studies cover Argentina (Galiani et al. (2003)), Brazil (Bonomo et al. (2003)), Chile (Benavente et al. (2003)), Colombia (Echeverry et al. (2003)), Mexico (Pratap et al. (2003)) and Peru (Carranza et al. (2003)).[1] In these papers, the identification of currency matching incentives rely solely on

[1] All these papers are published in a special issue of *Emerging Market Review* (vol. 4 no. 4). The issue starts with a summary of Galindo et al. (2003) collecting results and findings from previous literature to that date.

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 their ex-ante sensitivity of revenues to the real exchange rate. Many additional studies investigated Latin American countries since, e.g., Allayannis et al. (2003), Gelos (2003), Janot et al. (2008), Cowan et al. (2005), Fuentes (2009), Kamil (2012), Kalemli-Ozcan et al. (2011) and Martinez and Werner (2002). Studies on other countries include, e.g., Indonesia (Agustinus (2007)), Turkey (Kesriyeli et al. (2011)) and Korea (Gilchrist and Sim (2007)). Most of these more recent studies follow the same reduced form tradition and point to the same conclusions.

The existing evidence that exporting firms tend to borrow more in FX does not provide direct proof for currency matching even if firm-level fixed effects are controlled for. Export revenue is 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, a firm with relatively low export share is safe to get indebted entirely in FX as long as its export revenues are higher than or equal to its debt payment obligations.

It is not surprising that only indirect evidence exists and firms' currency matching behaviour has never been tested directly. The empirical literature on currency mismatch traditionally focuses on Latin American and Asian economies for which the available firm-level datasets are not detailed enough to go much beyond the existing specifications. Fortunately for economists and unfortunately for households and investors, the recent Hungarian experiment 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 and the credit register containing all corporate loan contracts – provide a rare if not unique opportunity to analyse firms' borrowing decisions in a situation where they have access to FX loans.

Our identification strategy to test for the existence of matching motivations in firms' debt currency choice relies on the intuition that if currency matching is a relevant factor in firms' decision, the probability of issuing new debt in FX 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 matching indicator taking the value of 1 if the firm's debt payment obligations denominated in FX is higher than its export revenue and 0 otherwise. In addition to other firm-level and bank-level controls, the unobserved firm-level heterogeneity is either treated as fixed effects (Chamberlain (1980)) or correlated random effects with Mundlak (1978) correction. As a second step, a more accurate – though still imperfect, as explained in the paper – measure of matching 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 simultaneously estimated.

Estimated on a sample before the outbreak of the crisis, all specifications yield similar results. In particular, the coefficient of the matching indicator being positive and highly significant, all estimates provide strong evidence to support the role of natural hedging motivation in firms' currency choice. In addition, the multinomial specification suggest that, as expected, matching is driven by EUR.

In the mixed logit specification, the estimated correlation structure between the probability of choosing EUR or CHF provides additional interesting insight into firms' debt currency choice. First, the estimated positive and significant within-firm correlation between alternatives indicate that firms with higher probability of choosing EUR have also a higher probability of choosing CHF. This result indicates that the benefits from holding both EUR and CHF debt outweighs the advantage of choosing one FX to the other one. As shown in the paper using a simple mean-variance approach adopted from modern portfolio theory (Markowitz (1952)), the positive correlation between alternatives can be interpreted as firms placing higher value on diversification than on exploiting perceived arbitrage (or carry trade) opportunities, if any, between foreign currencies.

At last, we explore potential changes in firms' matching behaviour, preferences and risk assessments between pre-crisis and post-crisis periods. Results indicate that, first, matching motivation plays a somewhat more important role in firms' currency choice decisions in the aftermath of the crisis than during the pre-crisis period. Second, the probability of choosing CHF has declined considerably since the outbreak of the crisis. On the other hand, the probability of taking out euro-denominated loan has increased. This seemingly confusing result is a reflection of the CHF loosing 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 adjusted their currency preferences and switched from CHF partly to HUF, but partly to EUR. This result also suggest that implicit carry-trade between the two foreign currencies has been part of firms' strategic decision-making.

After briefly introducing the evolution of corporate FX denominated loans in CEE countries and in particular in Hungary (Section 2), we discuss in Section 3 the theoretical framework for understanding the trade-offs faced by firms in choosing the currency composition of their debt. 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

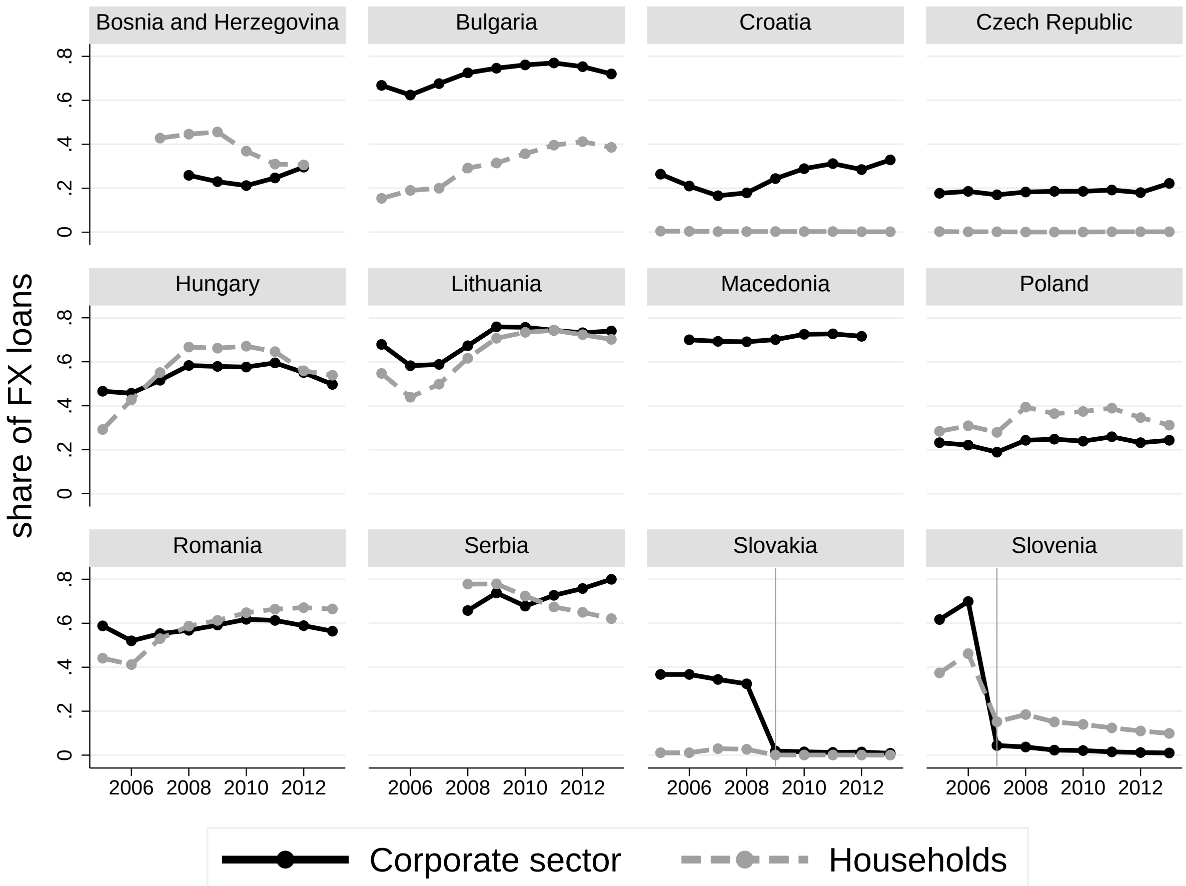
The post-socialist economic transition in emerging European countries was fuelled in part by heavy borrowing from Western banks and easy access to FX denominated loans. For about a decade before the crisis, FX denominated loans became widespread among the majority of Central and Eastern European (CEE)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

Not surprisingly, EUR is the predominant FX in emerging European countries. This single currency constitutes more than 95 percent of the outstanding FX loans, while other hard currencies like US dollar (USD) or CHF play an almost negligible role in most CEE countries. There are some exceptions, though. In Hungary, Bosnia and Romania, the CHF has become a rather important alternative to EUR (Figure 2). In these countries, the currency composition of FX debt does not reflect the trade structure of the country. Indeed, the export share to Switzerland in overall exports is generally relatively low: out of the three countries, the highest share in 2008 was recorded in Bosnia (2.6%), followed by Hungary (1.3%) and Romania (0.9%).[2] The sharp discrepancy in the importance of trade with Switzerland and the share of CHF in borrowings provides a strong indication of currency mismatch in the corporate sector.

The financial crisis originated from the US subprime mortgage meltdown rapidly escalated to a global scale and brought to the surface 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 outbreak of the crisis, Slovenia has already adopted the euro, while Slovakia 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 local currency then, as a consequence, forced firms to adjust their balance sheets.

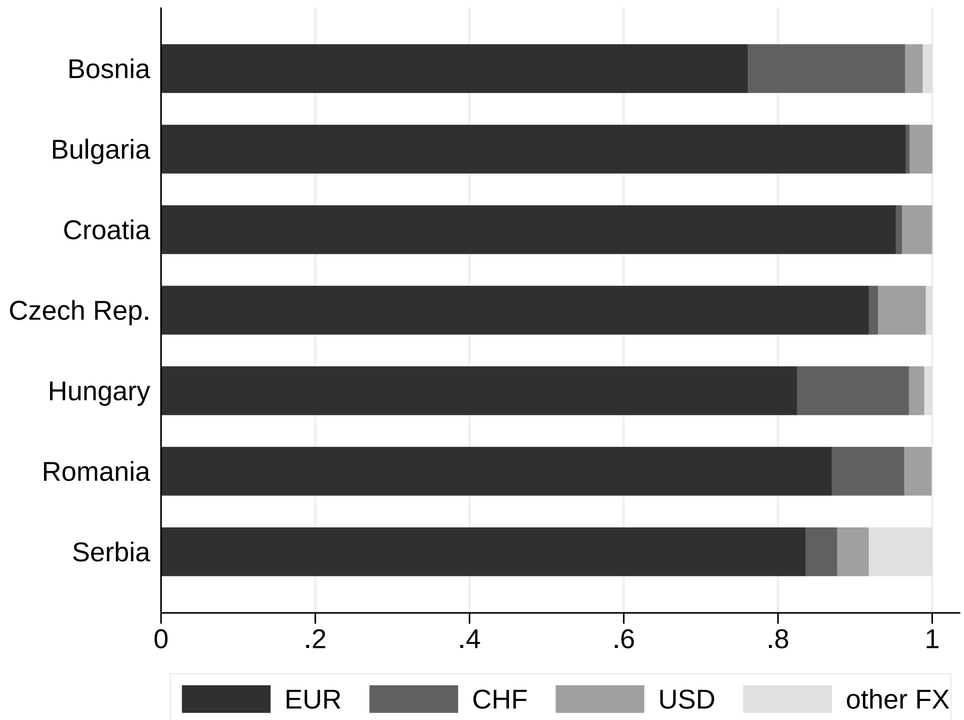
[2]Source: Eurostat Comext database

Figure 1: FX shares, 2005-2013



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

Figure 2: Currency composition of FX debt



** Notes: The figure displays the currency composition of foreign currency debt of the household and corporate sector combined (Bulgaria, Croatia, Czech Republic and Romania) or the corporate sector only (Hungary, Serbia and Bosnia). The shares are averages over 2006-2012, except for Romania (2007-2012), Croatia (2012-2013) and Bosnia (2008-2012).*

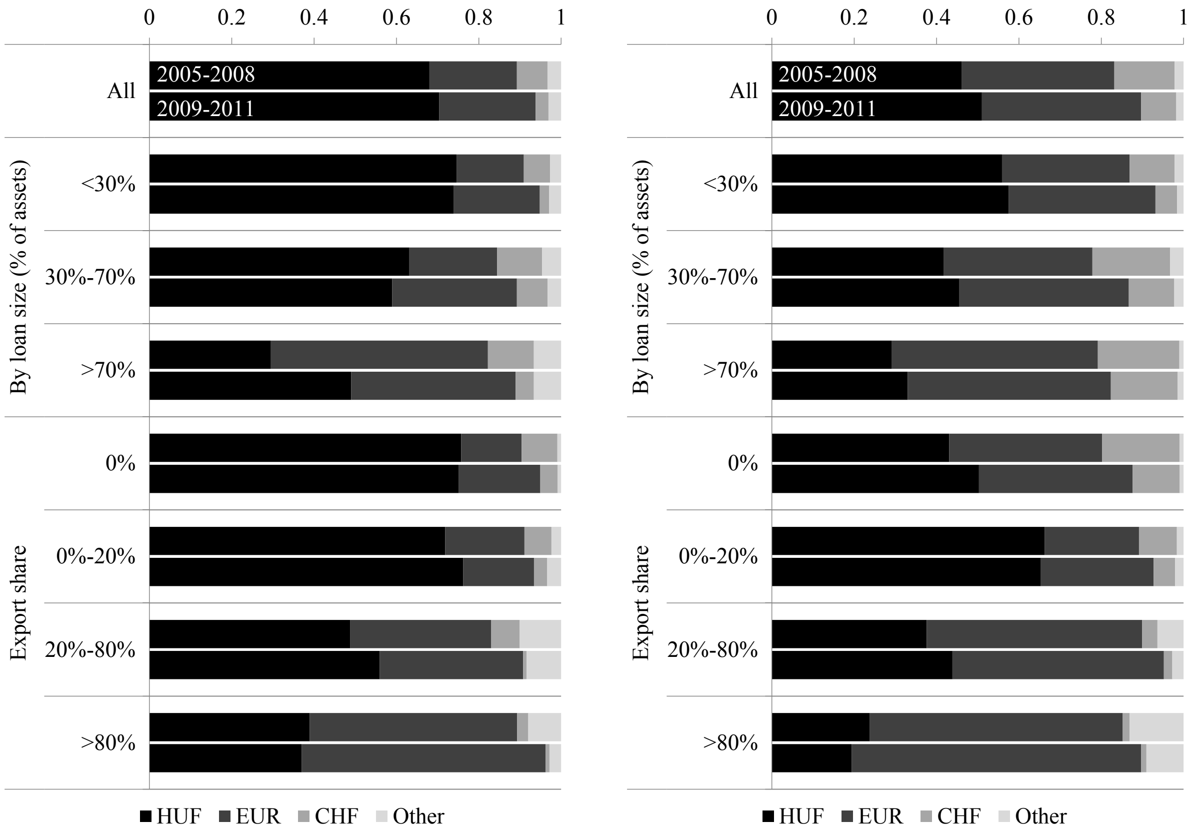
Hungary was one of the most affected economies in the region. The country entered the crisis with a combination of high budget deficits, large current account imbalances and an over-leveraged private sector with significant exchange rate risk exposure. Already by 2005, more than 45 percent of the outstanding corporate loans were denominated in FX. Foreign loans were primarily denominated in EUR (around 68%), while CHF lending accounted for about one-fourth of the FX denominated debt.

Breaking down the composition of debt currencies by duration and firms' characteristics reveal that smaller bank loans – as 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 3). We arrive to the same conclusion by comparing short term (less than a year) and long term contracts separately: comparing the subfigures 3(a) and 3(b) reveals that while about two-thirds of the overall underwritten sums in the case of short term contracts is in HUF, the corresponding figure in the case of long term contracts is about one-half. Consistently with previous empirical findings (Section 1), Figure 3 also reveals 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 overwhelming part of Hungarian exports going to the eurozone, these figures suggest that matching motives are likely to play a role in explaining firms' FX choices. At the same time, FX debt exposure of non-exporter firms and the relatively large share of CHF loans in firm's debt portfolio also suggest that the share of unhedged loans was (and still is) important in Hungary.

An ongoing research by Vonnak (2014) points towards the same conclusion. By comparing CHF and euro borrowers in the lending boom and during the crisis, the author finds that the latter ones are more likely to be bigger, foreign owned and export-oriented firms, while the former group of firms are more probably non-exporters and firms with weaker balance sheets and 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. A survey conducted by Bodnar (2009) on FX indebtedness of Hungarian companies differentiate even more radically between large exporting enterprises and small and medium domestic firms. Survey results suggest that natural hedging is a privilege of the former group, while the majority of the firms simply ignored exchange rate risks as either they were unaware of risk management techniques or such techniques were perceived as expensive, complicated and ineffective. Driven by the attractive foreign interest rates, these firms exposed 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 deteriorated investments of firms with FX loans. The authors also show that both effects are likely to be heterogeneous, more pronounced for firms with liquidity constraints. Likewise, Ranciere et al. (2010) reported that FX borrowing and lower interest rates have been beneficial before the crisis for small domestic firms via relaxing credit constraints, while no effect is found for larger firms. The paper is silent about firms' post-crisis performance.

Figure 3: Characterisation of long and short term contracts



(a) Short term contracts

(b) Long term contracts

** Notes: The figure contains a left panel for short-term loans and a right panel describing long term loans. Each panel divides the stock of loans underwritten by denomination. That is, it depicts sums rather than number of contracts. 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 loans size relative to the total of the firms securing the loan. We differentiate between three degrees of loan size: below 30%, between 30-70% and above 70% relative to the total assests. The third block differentiates loans by the export share of the firm securing the loan.*

After 2008, CHF lending has lost its attractiveness considerably. The share of newly contracted bank loan 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 explanation for this observation. First, the composition of firms taking out new loan during the crisis may have changes and the best and most resilient, most probably highly export-oriented firms are more likely to choose euro-denominated loans. Second, firms that previously preferred CHF to EUR may have switched back at least partly to euro-denominated loans. These hypotheses will be investigated in detail later in the paper.

Overall, there are both signs of matching motives behind firms' currency choices and indications of severe currency mismatches in the Hungarian corporate sector. Previous empirical findings generally argue that firms tend to at least partly match the currency denomination of their assets and liabilities (see Section 1). At the same time, previous survey results and descriptive analysis suggest that there is a large difference between the behaviour of a few large exporting firm that probably – but not surely – take into account matching motives in their debt currency choice and that of other, mostly small and medium non-exporting firms simply ignored exchange rate risks. Aggregate statistics however may mask the underlying motives of firms' currency choice. Comparing two distinct groups of firms, large exporters and small non-exporters, that are probably different in many respect and identifying firms' matching incentives from cross-sectional variation is not a satisfying solution either. If the choice of currency denomination of the debt is a result of an optimisation, 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 and there is enough within-firm variation in the data.

The first row of Table 1 shows that about half of the firms took out both HUF and FX loans during the pre-crisis period. When only firms with more than one loan contract are considered, this share becomes 71%. That is, the majority 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 displays the distribution of firms by their choice of the currency denomination of their new loans subscribed after their first local 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 that get access to FX loan for the first time during our sample period would never switch back to local currency. However, more than 97% of the firms with existing FX debt in their balance sheets will sign later on at least one HUF-denominated loan contract. In the empirical part of this paper, we will see if firms' currency choice and, in particular, the timing of a specific choice is purely arbitrary or it is governed by explicable rationality.

Table 1: Number of firms by the distribution of contract type over time (2005-2008)

	one contract		more than one contract			Total
	HUF	FX	only HUF	only FX	both	
Total number of firms	35 694	9 401	27 862	1 974	74 244	149 175
	(23.9%)	(6.3%)	(18.7%)	(1.3%)	(49.8%)	
only contracts after the first HUF loan	12 937	13 735	14 925	1 084	10 673	53 354
	(24.2%)	(25.7%)	(28.0%)	(2.0%)	(20.0%)	
only contracts after the first FX loan	40 028	1 288	34 216	686	5 924	82 142
	(48.7%)	(1.6%)	(41.7%)	(0.8%)	(7.2%)	

** Notes:The table shows the number of firms distributed according to the number of contracts underwritten in 2005-2008 period and the denomination of the loans. Additionally, it differentiates between single contract and multi-contract firms. The first row shows all contracts. The second and third rows classifies only contracts underwritten after the first HUF and first FX loan only, respectively. The last two rows thus show data for multi-contract firms only.*

3 The optimal debt currency portfolio

To illustrate the effect of exchange rate fluctuations on firms' borrowing decisions, the 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 the period 0 and its interests 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 issue their debt. We start with the general case of any arbitrary number of funding currencies, than we explore the simple case with only two possible foreign currencies in more detail.[3]

In period 0, the potential borrower 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 $c = \{1, ..., C\}$. The management decides on the investment strategy, contracts

[3]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 considered. One or two currencies generally dominate the foreign currency loan market in all developing and transition countries. In non-European countries, the USD has been the pre-eminent debt issuance currency. Liabilities in emerging Europe have been predominantly denominated in EUR and in CHF, the share of other currencies (mainly USD) has been limited (see Section 2).

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 fraction 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 the amount $K_1 = B_1 + w_0$ is given by $F(K_1)$, where the function F is assumed increasing strictly concave in K.[4] 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 interests 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 ($i^d \geq i^c$).[5]

Obviously, any risk-neutral firm would maximise its expected terminal wealth by choosing to issue 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. 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 future exchange rate is the only source of uncertainty, which influences both firms' export revenues and FX debt reimbursement expressed in local currency.

[4] The function F takes also account the depreciation of the capital

[5] Although not exhaustive, the "original sin" is a commonly used explanation for this phenomenon. See e.g Eichengreen et al. (2005) for details.

[6] The mean-variance utility was introduced in the seminal paper by Markowitz (1952), which is considered as the foundation of the 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 $0 \le \rho_{e_c,e_{c'}} < 1$ for all $c' \neq c$.

According 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, that is, 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 higher utility.

To see this, let's 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 $G_c = \left((1+i_1^d) - (1+i_1^c)\right) \ge 0$ being the expected financial gain from issuing 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 reimbursement obligation.

Equation (4) can be solved using standard linear algebra techniques. Using matrix notations,

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

the solution is given by:

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

where $\hat{\beta}$ and β^M are $C \times 1$ vectors with elements $\hat{\beta}_c$ and β_c^M, 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 ($i_1^c < i_1^d$ for at least one c), the firm is willing to take some risk in exchange for higher expected future profits. In effect, 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 higher variance ($\theta\sigma^2$).[8]

The possibility of issuing 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" $\tilde{\beta}_c/\tilde{\beta}_{c'} = (\hat{\beta}_c - \beta_c^M)/(\hat{\beta}_{c'} - \beta_{c'}^M)$ for all c and c' are independent of the degree of risk aversion and the amount of borrowed founds. 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 among the exchange rates, independently of their risk preferences.

To probe deeper into how firms choose the relative FX shares of their debt, let's 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 (that is, no incentive for carry trade) between the two foreign currencies.[9] In the absence of arbitrage opportunities, the optimal currency shares simplify to $\tilde{\beta}_c = (G_c/(\theta\sigma^2_c B_1))/(1+\rho_{e_{\text{eur}},e_{\text{chf}}}),\ c = \{\text{eur} ; \text{chf}\}$. 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 the size if the correlation is zero as compared to the case if $\rho_{e_{\text{eur}},e_{\text{chf}}} \to 1$. This result emerges from the principle of Markowitz diversification of assets, which states that as the correlation between the returns for assets that are combined in a portfolio decreases, so does the variance of that portfolio. The same logic applies for optimal debt portfolio choice. The optimising firm can thus increase the share of risky portfolio and therefore increase the expected wealth while maintaining risks within acceptable levels.

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's assume that $\psi < 1$, i.e. currency 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 $\rho_{e_{\text{eur}},e_{\text{chf}}} = \psi^{-1}\left(1 - \sqrt{1-\psi^2}\right)$.

Albeit the management of the firm 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 higher debt share than matching requires 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 (that is, 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}.

Finally, the full solution of the maximisation problem in eq. (3) requires solving for the optimal

[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 the two cases, the same utility for the firm.

K_1. The F.O.C. w.r.t. K_1 yields:

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

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 for investment is unaffected by the possibility of borrowing in FX for non-exporter 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 issuing 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 "matching indicator" variable taking 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 revenue 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 matching 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 revenue invoiced in currency c and $\bar{L}_{ij'c,t+1}$ is the firm's monthly average debt payment obligation during the next 12 months in the same currency c resulted from all existing contracts j' other than the actual loan contract j. We only used past values for $\bar{X}_{ict}$ – just as for all other explanatory variables explained later – to avoid simultaneity.

In our empirical specifications, firms' decisions are modelled as a probabilistic choice problem. Consistently 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 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)):

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

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 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 $P(y_{ijt} = \text{HUF} \,\middle|\, Z_{it-1}^T, M_{ijct}, a_{ic} \forall c) = 1/(1 + \sum_{c'=1}^{C} \exp(a_{ic'} + Z_{it-1}^T \Omega_{c'} + \phi_{c'} M_{ijc't}))$.

4.1 The binomial case

In our first specification, we estimate the impact of the matching indicator on the probability of signing a loan contract denominated in foreign currency in general versus choosing the local currency instead. 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 debt payment obligations all foreign currencies combined. In this case, equation (9) reduces to the binomial logistic function (and subscripts c can be dropped).

[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 would be available. Accordingly, the probability of choosing the 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 the firm i chooses the 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.

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 (T), 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 $\sum_{t=1}^{T} y_{ijt}$. 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. The estimation method has several drawbacks, however. First, since 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 would be 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 be indebted in foreign currency and hence the firm has a higher probability that its export revenues exceed its foreign currency debt payment obligations. Mundlak (1978) and Chamberlain (1982) relax this crucial random effects assumption by allowing the unobserved effects to be correlated 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

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

distributed error term. Chamberlain proposes a more general form by including the vector of all explanatory variables across all time periods: $a_i = \sum_{t=1}^{T} X_{it}^T \xi_t + \omega_i$. 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 effect 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. Results are presented in the next section.

4.2 The multinomial case

To estimate the discrete choice model with all available alternatives, a separate matching 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 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 the major trading partner for Hungary with statistics showing more than 57 percent (in 2008) of total exports, whereas the share of exports to Switzerland is below 2 percent (see Section 2). 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 $c = \{\text{eur} ; \text{other foreign currencies}\}$ and HUF as the baseline category. The matching indicator is constructed for the euro only. As an alternative, we also test the model which puts emphasis on the CHF as a speculative currency. The choice set becomes: $c = \{\text{chf} ; \text{other foreign currencies}\}$ and HUF. Since the share of foreign currencies other than EUR and 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 choice by $c = \{\text{eur} ; \text{chf}\}$.

The multinomial discrete choice models are estimated using the mixed logit procedure described in details in Train (2003). The approach allows very flexible substitution patterns through the estimation of random rather than fixed parameters. 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)).

Similarly to the binomial case, we apply Mundlak's correction for 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 assume only the intercepts to be random.[12]

Within each firm, the random terms are allowed to be correlated over alternatives, however, they are uncorrelated across firms: $\text{corr}(\omega_{ic}, \omega_{i'c'}) = \rho_{\omega_c,\omega_{c'}}$ for all c and c' if $i = i'$ and 0 otherwise. Theory (Section 3) suggests that the substitution pattern between foreign currencies is affected by two distinct yet interacting factors: arbitrage and diversification. For instance, a positive and significant correlation implies that firms that are likely to choose one of the two foreign currencies are also likely to choose the other one. To put it differently, 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 one.

To see how the arbitrage-diversification trade-off is related to the estimated covariance between alternatives, let's assume that both random terms ω_{ic} can be decomposed into the sum of a "rational" part that results from optimal allocation decisions (Γ_{ic}) and an error component (ζ_{ic}) indicating that firms have some inherent propensity to choose one currency over another for reasons that are not captured in the model. Only the two Γ_{ic} are allowed to be correlated across alternatives. Assuming that the mean-variance optimisation presented in Section 3 represents the underlying theory for our empirical model, it can be seen from eq. (6) that the ratio $\Gamma_{i,\text{eur}}/\Gamma_{i,\text{chf}}$ – equivalently to $\tilde{\beta}_{\text{eur}}/\tilde{\beta}_{\text{chf}}$ – can be expressed as $(\sigma_{\text{chf}}/\sigma_{\text{eur}}) \times (\psi - \rho_{e_{\text{eur}},e_{\text{chf}}})/(1 - \rho_{e_{\text{eur}},e_{\text{chf}}}\psi)$.[13] Let Γ be a coefficient to estimate corresponding to the average or the "representative firm's" perception of the aforementioned expression. The within-firm covariance between foreign currency choices is thus given by:

$$\text{cov}(\omega_{i,\text{eur}}, \omega_{i,\text{chf}}) = \text{cov}(\Gamma_{i,\text{eur}}, \Gamma_{i,\text{chf}}) = \Gamma\text{var}(\Gamma_{i,\text{chf}}) = \Gamma[\text{var}(\omega_{i,\text{chf}}) - \text{var}(\zeta_{i,\text{chf}})] \qquad (10)$$

Since $\text{var}(\omega_{i,\text{chf}}) \geq \text{var}(\zeta_{i,\text{chf}})$, a significantly positive covariance between alternatives indicate that $\Gamma > 0$. That is, the correlation between foreign exchange rates is low enough ($\min(\psi, \psi^{-1}) > \rho_{e_{\text{eur}},e_{\text{chf}}}$) for firms to benefit from diversification even if one foreign currency is preferred to the other one. Conversely, if the estimated covariance is negative, carry trade incentives between foreign currencies outweigh the benefits from diversification.

The level of Γ is nonetheless not identified, principally because the variance of Γ_{ic} and ζ_{ic} cannot

[12]The mixed logit procedure with arbitrary combination of random and fixed parameters can be applied to the binomial case as well. Specifying only the intercept as random is equivalent to the random effect logit model described earlier. Although the estimation strategy of mixed logit models differ from the standard random effects model, the mixed logit procedure with random intercept and the random effects logit yield similar results.

[13]More precisely, $\Gamma_{i,\text{eur}}/\Gamma_{i,\text{chf}}$ indicates the deviation of the aforementioned expression from the population mean.

be naively disentangled. The evolution of Γ can, however, be identified if the random terms ω_{ic} are allowed to change over time. Suppose that the model is estimated on a sample including pre-crisis and post-crisis periods. It is reasonable to assume that firms have changed their preferences and risk assessments following an unexpectedly large negative shock. We therefore specify different random coefficients for the pre- and post-crisis period. The four random terms – ω_{icd}, $c = \{\text{eur} ; \text{chf}\}$ and $d = \{\text{pre-crisis} ; \text{post-crisis}\}$ – are allowed to be correlated. The identification of $\Gamma_{\text{post}}/\Gamma_{\text{pre}}$ relies on the assumption that the error components ζ_{ict} are strictly uncorrelated across alternatives. In the same vein as before, the cross-correlations between pre- and post-crisis alternatives can be expressed as:

$$\begin{cases} \text{cov}(\omega_{i,\text{eur, post}}, \omega_{i,\text{chf, pre}}) = \text{cov}(\Gamma_{i,\text{eur, post}}, \Gamma_{i,\text{chf, pre}}) = \Gamma_{\text{post}} \times \text{cov}(\Gamma_{i,\text{chf, post}}, \Gamma_{i,\text{chf, pre}}) \\ \text{cov}(\omega_{i,\text{chf, post}}, \omega_{i,\text{eur, pre}}) = \text{cov}(\Gamma_{i,\text{chf, post}}, \Gamma_{i,\text{eur, pre}}) = \Gamma_{\text{pre}} \times \text{cov}(\Gamma_{i,\text{chf, post}}, \Gamma_{i,\text{chf, pre}}) \end{cases} \tag{11}$$

The ratio $\text{cov}(\omega_{i,\text{eur, post}}, \omega_{i,\text{chf, pre}})/\text{cov}(\omega_{i,\text{chf, post}}, \omega_{i,\text{eur, pre}})$ thus identifies $\Gamma_{\text{post}}/\Gamma_{\text{pre}}$. For example, if firms placing high value on chf before the outbreak of the crisis have a higher probability of switching to eur than the probability that firms placing high value on eur before the crisis to switch later to chf, the aforementioned relative covariance term is higher than one, indicating that, on average, the currency chf has lost its relative attractiveness vis-à-vis eur. The estimated covariance structure of the random terms and the implied estimate for $\Gamma_{\text{post}}/\Gamma_{\text{pre}}$ are presented in Section 6.

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 the starting date of the contract, duration, value, denomination, type of loans and type of provider. Four types of contracts are distinguished: loans, credit lines, factoring and leasing. Providers are banks, saving banks or other financial companies. The dataset contains on average 65 thousand new contracts each year between 2005 to 2011. The number of contracts rose from about 77 thousand to a little over 82 thousand until the outbreak of the crisis. After 2008 the average annual number of contracts drops to below 50 thousand. Overall, there are 129 066 firms in the dataset and on average, about 42 700 firms take out loans per 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) in 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 up 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 consequence, 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 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 income 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 denomination choice such as employment, foreign ownership, firms' capital, liquidity, total assets and profitability measures.

Although the *NAV* dataset contains the export share of sales, we collected additional trade information from the Central Statistical Office on trade behaviour. We merge statistics on exports and imports calculated from monthly reports on commodity trade to Extra- and Intrastat for the universe of direct trading firms in Hungary. Monthly frequency allows us to calculate, e.g., the export revenue 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.[14]

6 Estimation results

6.1 Pre-crisis period

Table 2 summarises the main empirical findings for the pre-crisis period (2005-2008). We start by discussing the results for the binomial specification estimating the probability of choosing foreign versus domestic currency, then we turn our attention to mixed logit models with two foreign currency alternatives.

The first column reports the results for the conditional (fixed effects) regression, while the second to fifth columns present Mundlak's correlated random effects logit estimates for various sample choices. The estimation sample for the conditional fixed effects model is restricted to firms indebted in more than one currency. In principle, all observations can be used to estimate the cor-

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

related random effects model. However, firms that exhibit no variation in the explanatory variables or the dependent variable do not contribute to the identification of the structural parameters of the model. Along with the baseline results on the whole sample of firms (column (2)), Table 2 also reports regression results for the sample of firms exhibiting variation in the left-hand side variable (same sample as for the fixed effects logit, column (3)), the estimation results on the sample of firms with variation in the matching indicator (column (4)) and when only long-term contracts are considered (column (5)).[15]

In all cases, the coefficient of the matching indicator is positive and highly significant. Results indicate that the probability of taking out FX loan is higher as long as the firm's expected export revenues fully cover its foreign currency debt service expenses, which provide 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, though still imperfect measure of currency matching. As explained in Section 4, two specifications are considered. First, results presented in column (6) of Table 2 correspond to the case where exports are all assumed to be invoiced in euro and consequently, only euro-denominated debt is used for hedging purposes. Debt issued in other foreign currencies (that are collapsed together) is a result of pure speculation. Second, column (7) reports the results for the case in which CHF is the only purely speculative currency and debt issued in any other foreign currency may potentially serve for hedging. The matching indicators are constructed accordingly.

The two specification 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 estimated covariance between the two foreign currency alternatives is significantly positive, suggesting that on average, firms seek diversification. The correlation coefficient of about 0.2 implied by the estimated parameters is however rather low. A simple linear dependence structure between the random effects ω_{ic} arguably fails to detect strong interdependence of the alternative choices.

6.2 The effects of the crisis on firms' currency choice

Our final specification estimates the mixed logit model in column (6) of Table 2 for the whole period covered by our database (2005-2011). To explore potential changes in firms' matching behaviour,

[15] As additional robustness checks, all other specifications presented in this paper – including fixed effects logit and mixed logit specifications for both the pre-crisis period and for the whole period 2005-2011 – were also re-estimated for the sample of firms in columns (3) to (5). For all estimation methods, results based on these alternative sample selection choices are very close to our baseline findings. These estimation results are not presented in this paper for reasons of brevity, but are available from the author upon request.

Table 2: Estimation results for the pre-crisis period (2005-2008)

		Random-effects logit				Mixed logit with three alternatives	
	Fixed-effects logit	Baseline	Firms with both HUF and FX debt	Firms with variation in mismatch indicator	Only long-term contracts	EUR, other foreign currencies ($\sim$CHF) and HUF	CHF, other foreign currencies ($\sim$EUR) and HUF
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Matching indicator	1.006*** [0.0237]	1.171*** [0.0250]	1.073*** [0.0242]	0.990*** [0.0236]	1.558*** [0.0297]	0.823*** [0.0465]	0.791*** [0.0461]
$\text{var}(\omega_{\text{eur}})$						2.976*** [0.1053]	3.045*** [0.1067]
$\text{cov}(\omega_{\text{eur}}, \omega_{\text{chf}})$						0.546*** [0.0707]	0.480*** [0.0584]
$\text{var}(\omega_{\text{chf}})$						2.477*** [0.0543]	2.487*** [0.0545]
$\text{corr}(\omega_{\text{eur}}, \omega_{\text{chf}})$						0.201*** [0.0252]	0.174*** [0.0205]
Nb. of obs.	83 179	173 739	83 179	67 033	122 167	521 217	521 217
Nb. of firms	12 871	51 714	12 871	10 734	48 174	51 714	51 714

** Notes: Each column of Table 2 collects results from a separate regression. The first specifications 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 4 columns show correlated random effects logit regression on various subsamples. In addition to the aforementioned controls, the regressions also control 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, besides the controls and Mundlak's correction terms 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 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.*

in particular after the outbreak of the crisis, we let the parameter of the matching indicator to 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 period that can be correlated both in time and between alternatives. Results are presented in Table 3 and Figure 4. The figure plots the evolution of the estimated average alternative-specific effects calculated from the year dummies and the mean estimates of the random parameters.[16]

Results indicate that the parameter of the matching indicator increased during the crisis, suggesting that matching incentives play a somewhat more important role in firms' currency choice decisions in the aftermath of the crisis than before 2008.[17] The estimated average year effects (Figure 4) reveal that the attractiveness of the two foreign currencies remained stable prior to the crisis and has severely deteriorated since 2009. Either the expected financial gain from taking out CHF loan has declined or (most probably) the perceived risks associated with bank loans denominated in CHF have increased considerably.[18]

On the other hand, interestingly, the relative odds of taking out euro-denominated corporate loan as compared to the local currency did not decrease but increased during the crisis. In light of previous empirical findings showing that firms rather tend to reduce currency imbalances in their balance sheets following an unexpectedly large exchange rate depreciation (see e.g. papers listed in Section 1), this result may seem surprising. In fact, this result is a reflection of deterioration in firms' relative preferences for EUR over CHF, which makes it optimal for firms to adjust the relative shares of the two FX denominated debts. To put it simple, a number of firms seem to have switched from CHF to EUR after 2008.

The estimated covariance matrix of the random coefficients and the implied $\Gamma_{\text{post}}/\Gamma_{\text{pre}}$ provides evidence for the change in relative preferences between EUR and CHF in favour of the former currency. On the one hand, the relatively high correlations between pre- and post-crisis random terms for both currencies – over 0.7 for both EUR and CHF, see Panel (C) of Table 3 – suggest that firms which placed a higher value on a particular currency before the crisis still prefers more this currency than the average firm. On the other hand, the change in the relative attractiveness of the

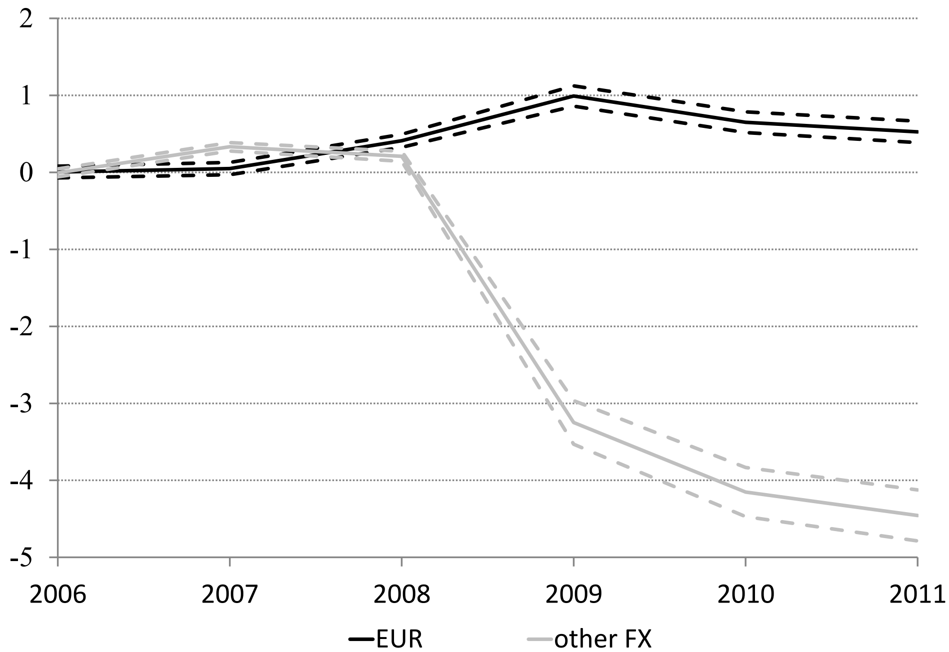
[16]More precisely, the figure plots the year dummy parameters $(\hat{d}_y)$ for the years 2006 to 2008. For 2009, it is calculated as the difference between the mean of the random parameters: $\hat{d}_{2009} = \hat{\omega}_{c,\text{post}} - \hat{\omega}_{c,\text{pre}}$. For the years 2010 and 2011,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

[17]The point estimate for the parameter of the matching indicator for the pre-crisis period is lower than the parameter values presented in Table 2. 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 between various estimation methods and different sample of firms and periods cannot be naively compared.

[18]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 euro 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 (7) of Table 2 re-estimated for the whole period 2005-2011 with time-varying matching indicator parameters yield similar results to the specification discussed in the paper.

EUR vis-à-vis the CHF, represented by $\Gamma_{\text{post}}/\Gamma_{\text{pre}}$, suggest that on average, firms indeed gave up their preference for CHF and switched partly to HUF, but partly to EUR. Either the relative risks associated with choosing EUR or CHF $(\sigma_{\text{eur}}/\sigma_{\text{chf}})$ and/or the relative Sharpe ratios (ψ) seem to have changed in favour of the EUR. This result also suggest that implicit carry-trade between the two foreign currencies could have been part of firms' strategic decision-making. The overall probability of choosing foreign currency denominated loan has declined, as illustrated by the declining sum of the two alternative-specific year dummies in Figure 4.

Figure 4: Average currency-specific effects



** Notes: The Figure 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 $(\hat{d}_y)$ form 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 calculated parameters are computed using the delta method.*

Table 3: Estimation results for the whole period (2005-2011)

(A) Parameters				
Matching indicator	0.676*** [0.0420]			
Matching indicator×post-crisis dummy	0.127*** [0.0561]			
$\Gamma_{\text{post-crisis}}/\Gamma_{\text{pre-crisis}}$	1.248*** [0.1256]			
Nb. of obs.	777 414			
Nb. of firms	63 404			
(B) Covariance matrix				
	$\omega_{\text{eur, pre-crisis}}$	$\omega_{\text{eur, post-crisis}}$	$\omega_{\text{chf, pre-crisis}}$	$\omega_{\text{chf, post-crisis}}$
$\omega_{\text{eur, pre-crisis}}$	2.463*** [0.0794]			
$\omega_{\text{eur, post-crisis}}$	2.278*** [0.0734]	3.756*** [0.1230]		
$\omega_{\text{chf, pre-crisis}}$	0.557*** [0.0719]	1.759*** [0.0585]	2.449*** [0.0545]	
$\omega_{\text{chf, post-crisis}}$	1.409*** [0.1407]	1.009*** [0.1389]	2.894*** [0.1288]	6.658*** [0.4927]
(C) Correlation matrix				
	$\omega_{\text{eur, pre-crisis}}$	$\omega_{\text{eur, post-crisis}}$	$\omega_{\text{chf, pre-crisis}}$	$\omega_{\text{chf, post-crisis}}$
$\omega_{\text{eur, pre-crisis}}$	1			
$\omega_{\text{eur, post-crisis}}$	0.749*** [0.0149]	1		
$\omega_{\text{chf, pre-crisis}}$	0.227*** [0.0277]	0.580*** [0.0148]	1	
$\omega_{\text{chf, post-crisis}}$	0.348*** [0.0337]	0.202*** [0.0271]	0.717*** [0.0206]	1

** Notes: Panel (A) displays the parameter estimates for the matching indicator and its product with a post-crisis dummy from the mixed logit regression on the whole sample 2005-2011. The estimate for $\Gamma_{post}/\Gamma_{pre} = cov(\omega_{eur,\,post}, \omega_{chf,\,pre})/cov(\omega_{chf,\,post}, \omega_{eur,\,pre})$ is computed from the elements of the covariance matrix between random terms presented in Panel (B). Finally, the correlation matrix corresponding to the covariance matrix is displayed in Panel (C). The elements of the covariance matrix and the correlation matrix 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.*

7 Conclusion

The 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 in closed form the solution for optimal debt portfolio. Consistently 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 loan.

Results show that the probability of issuing new debt in foreign currency 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.

The specifications with several foreign currencies – essentially euro and Swiss francs – also test whether diversification strategies and/or carry-trade incentives between foreign currencies are relevant factors in firms' decision. Estimation results suggests that the benefits from diversification outweighs the perceived carry trade opportunities, if any, between EUR and CHF. At the same time, we show that since the outbreak of the current crisis, the relative attractiveness of CHF has considerably deteriorated not only vis-à-vis the local currency, but also vis-à-vis the EUR. The changing relative preference between foreign currencies suggest that implicit carry-trade between the two foreign currencies could have been part of firms' strategic decision-making.

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.

Agustinus, P. (2007). Corporate responses to currency depreciations: Evidence from indonesia. MPRA Paper 6502, University Library of Munich, Germany.

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.

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

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.

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. (2005). The pain of original sin. In Eichengreen, B. and Hausmann, R., editors, *Other People's Money*. Chicago University Press.

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.

Gilchrist, S. and Sim, J. W. (2007). Investment during the korean financial crisis: A structural econometric analysis. NBER Working Papers 13315, National Bureau of Economic Research, Inc.

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.

Kalemli-Ozcan, S., Kamil, H., and Villegas-Sanchez, C. (2011). What hinders investment in the aftermath of financial crises: Insolvent firms or illiquid banks? CEPR Discussion Papers 8543, C.E.P.R. Discussion Papers.

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.

Kesriyeli, M., Ozmen, E., and Yigit, S. (2011). Corporate sector liability dollarization and exchange rate balance sheet effect in turkey. *Applied Economics*, 43(30):4741–4747.

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.

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*.

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".

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

Appendix

Table 4: Descriptive statistics of the variables

	2005-2008			2009-2011		
Definition of the variable	N	mean	std.	N	mean	std.
short cotract dummy (duration is one year or less)	309 077	0.26	0.44	186018	0.29	0.46
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 groups variables related to the firms and related to the banks issuing the loans separately.*