Explaining the Differences between Local Currency versus FX-denominated Loans and Deposits in the Central- Eastern European Economies

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Abstract

Foreign currency-based loans and deposits became very popular in Central-Eastern European countries (CEECs) over the 2000-2011 period. This paper employs a structural approach to simultaneously examine the demand-side (consumer-related) and supply-side (bank-related) determinants of the quick spread of FX-based banking. The econometric analysis uses a unique newly constructed dataset on FX and domestic currency loans, deposits and interest rates, covering 16 CEECs overtime. Results show that deregulation and cheap funding from parents abroad helped fuel FX lending. There is substantial heterogeneity across market segments, currencies and maturities. Corporate sector FX lending is fundamentally different from retail and mortgage markets.

Keywords: Bank lending, Interest rate choices, Discrete choice, Simultaneous equations, Cross-country analysis

JEL: E44, F31, G21, G28

1. Introduction

As the Central-Eastern European countries (CEECs) opened up their banking markets to foreign competition in the 1990s, Western European banks were quick to enter and capture market share through the acquisition of privatized domestic banks. By the time the large-scale transition of the banking sector concluded in the early 2000s, some states had seen the share of foreign banks rise to as high as two-thirds of total bank assets

(Bonin and Abel 2000). The new entrants engaged in aggressive competition, in a push to capture market share. In a competitive frenzy, foreign banks increasingly engaged in FX-denominated lending. Doing so was a profitable way of capturing market share. On the one hand, they could rely on cheap FX funding from their parents abroad, whereas attracting deposits as a source of lending promised to be a longer and more involved process. On the other hand, extending FX loans shielded foreign banks from the exchange rate risk of dealing with often volatile domestic currencies.

As a result of this process, bank lending denominated in foreign currencies became the standard in most Central-Eastern European economies by the end of the 2000s (Figure 1). This quick spread of FX-based banking created new concerns for policy-makers. In most countries, households and non-financial corporations (NFC) received income in the domestic currency but took out FX-denominated loans from the local subsidiaries of foreign banks. This practice exposed them to substantial unhedged exchange rate risk due to the significant currency mismatch on their balance sheets (Figure 2). Even though banks, unlike their clients, managed to fully hedge against the exchange rate risk of FX lending, the large-scale FX-indebtedness of the population threatened them with substantial default risk. As a quick devaluation of the domestic currency had the potential to push many FX-borrowers (and in turn, banks) into default, the FX-indebtedness of the population posed a threat to the stability of the financial system (Balas and Nagy 2010).

In light of the risks inherent in households' and non-financial corporations (NFCs) foreign exchange-based indebtedness, numerous empirical papers have examined the development and patterns of FX lending across the CEEC countries. FX-based banking became so popular among banking clients mainly because the interest rates banks charged on their FX loans were significantly lower than the local currency interest rates, as shown in Figures 3 and 4 (Basso et al. 2007; Rosenberg and Tirpak 2009; Csajbok et al. 2010; Brzoza-Brzezina et al. 2010).[1] As many CEECs were characterized by relative exchange rate stability but high price level volatility in the early 2000s (Pellenyi and Bilek 2009),

[1]These cross-currency rate differentials were large enough that standard adjustment techniques could not fully account for them (Temesvary 2011). An important implication of the persistent interest rate spread was that Uncovered Interest Parity failed in international banking markets. For a more general discussion on the failure of UIP, see Froot and Thaler (1990) and Engel (1996).

banks were particularly willing to offer FX loans at a discount (Ize and Levi-Yeyati 2003) and borrowers responded to the low FX rates elastically (Beer et al. 2010).[2]

Most papers in the related empirical literature examined FX lending in a reduced form framework, generally regressing FX and domestic loan volumes on the corresponding interest rates and a set of macro variables. However, such an approach mixes together the demand (client)-side and supply (bank)-side of the market, missing to capture some important characteristics of FX-banking. First, banks and clients decisions are fundamentally different. On the supply side, commercial banks' strategic choice is their interest rates, not loan volumes.[3] On the demand side, banking clients have the option to choose among various loan and deposit currency denominations, resulting in the observed currency-specific market shares. Second, there are numerous important macro conditions (such as access to cheap FX funding from parent banks abroad, the prevalence of government regulations, fiscal discipline, etc.) that impact both banks' interest rate and clients' volume choices, but to differing degrees (Balas and Nagy 2010, Rosenberg and Tirpak 2009, Zettelmeyer et al. 2010). In order to gain a careful understanding of the drivers of FX-based banking, it is therefore important to look at the demand and supply sides separately while also accounting for the interaction of the two sides of the market.

That is what this paper attempts to do in a structural simultaneous equations setting. Looking at the supply-side decisions of banks, the study looks at the roles of a broad set of bank, market and client traits in determining the large interest rate differentials that banks set between the local currency and FX-denominated loans and deposits in the CEE region. On the demand-side, banking clients's choices of loan and deposit currency denominations are examined in a discrete choice setting.

The analysis relies on a unique, newly constructed dataset on 16 CEE economies for the 2000-2011 period, with stocks of new loans and deposits broken down by market segment (consumer, mortgage and corporate), currency denomination (EUR, USD and CHF), and maturity (short, medium and long-term) with monthly frequency. This newly

[2]There is ample anecdotal evidence of the high price elasticity of loan demand. For examples, see the article on Bloomberg (October 30, 2008).

[3]This is a particularly important feature in light of the fact that banks in the CEEC region enjoy significant market power (Molnar et al. 2007).

compiled dataset is more detailed than those used in previous papers. The analysis of data on deposit volumes and rates, beyond loans, adds to the literature [4].

Estimation results show significant heterogeneity across market segments, maturities and currencies. The market-specific estimations show striking similarity in the "behavior" of the consumer and mortgage markets, vis-a-vis the corporate market. Looking at currency denominations separately, there are strong similarities in how EUR and CHF denominations respond to market and client traits, while the USD is very different. In the maturity-specific regressions, short-term lending respond much stronger to market and client traits than medium or long-term lending. Highly significant across all the specifications is the result that the local - FX lending rate spread has widened, while the local - FX deposit rate and market share spreads have shrunk since the onset of the financial crisis.

The paper proceeds as follows. The next section describes the model, the estimable equations and the econometric methodology, and describes the data and variables. Section 3 discusses the results. The paper's findings are summarized in Section 4.

2. Model

2.1. The Supply Side (Banks)

The model below is guided by the characteristics of the CEEC banking market and data availability. Crucial facts for the following analysis are that (1) the available data is at the country level, and (2) banks enjoy significant market power in most CEEC countries. Therefore, the model is built such that each country c has one monopolistic bank which makes loans in all currencies j and market segments m. The optimal choices of this monopolistic representative bank are described.

Let the script $m = 1...M$ denote the market segment (household consumption, real estate and non-financial corporations), t is the time period (month), T is the period in which the loan or deposit matures, and j is the currency of business. Let $j = h$ denote the local (home) currency, while $j = e$, $j = c$ and $j = u$ denote the euro, the Swiss franc and the U.S. dollar, respectively. L and D denote the $1xM$ row vector of total market sizes, which

[4]While Rosenberg and Tirpak (2009) incorporated FX deposits into their analysis, only as an exogenously given proxy for banks' access to FX funds for lending.

the bank takes as given. In each market segment, the bank can do business in any of the J currencies. Let γ_l and γ_d denote the JxM matrices of market shares, such that γ_m^j stands for the share of currency j in market segment m.

Let $(r_l; r_d)$ denote the JxM matrices of loan and deposit interest rates chosen by the bank. ρ is the $Jx1$ column vector of interbank rates. The JxJ matrices $(F; S)$ denote the forward and spot exchange rate matrices. Elements $F^{j,k}$ and $S^{j,k}$ represent the exchange rates between currencies j and k, expressed as units of currency k per unit of currency j.[5] To characterize the FX swap market, let y denote the $Jx1$ column vector of implied yield differences between any currency j and the domestic currency, and κ is the $Jx1$ column vector of corresponding swap spreads. Banks' profits are evaluated in the local currency.

2.1.1. Swap markets

In each country, the representative bank makes loans and takes deposits in all currencies listed (local, EUR, CHF, USD). The bank can raise funds in all currencies by taking deposits in that currency, or by borrowing in the interbank market. It can also raise FX funds by engaging in FX swaps.[6] In these swaps, the bank exchanges its excess local currency funds for FX funds in international financial markets. [7]

FX swaps consist of a spot leg and a forward leg. In the spot leg, the bank gives its counterparty local funds in exchange for equivalent FX funds. This transaction occurs at the spot exchange rate S^j. For the duration of the swap contract, the bank pays its counterparty the interbank rate ρ^j for the use of these funds. In return, the counterparty pays the bank the domestic interbank rate ρ^h for their use of the bank's domestic currency funds. The contract also specifies the future (forward) exchange rate F^j at which the transaction is unwound at the termination date.

FX swap markets serve two purposes. First, they provide banks with immediate access to FX liquidity (generally CHF and USD) in return for local currency through the spot leg of the transaction. Since the contracts specify a forward rate of exchange, a second

[5]For instance, $F^{e,h} = \frac{200HUF}{1EUR}$ indicates that 200 HUF are traded for 1 EUR at date T.

[6]It is assumed that the FX swaps are used only to finance lending. Swap contracts based on margin calls, and the liquidity risk due to the use of swap contracts are not considered.

[7]Banks' costs of FX transactions fundamentally depend on their ability to borrow in interbank markets, and to hedge exchange rate exposure through liquid FX swap markets.

advantage of FX swaps is that they allow banks to enter into forward ER contracts and hedge ER risk in the process (through the forward leg of the swap). Let δ denote the JxM matrix such that its element δ_m^j denotes the fraction of currency j non-deposit borrowing that is funded by FX swaps in market m.[8]

From the no-arbitrage (covered interest parity) condition, the elements of the implied yield vector Y are such that

$$y^j = \log F^j - \log S^j = \rho^h - \rho^j + \kappa^j \tag{2.1}$$

i.e. the difference in the exchange rates between today t and the maturity date T is approximately the interbank rate difference between the FX and local currencies, plus a "spread" κ. [9] Note that $y^j > 0$ is an implied excess appreciation of the FX currency against the local currency. Since the forward rate is predetermined, the bank can eliminate exchange rate risk through the use of FX swaps.

2.1.2. Risks

Banks fully hedge against all exchange rate risk through the use of FX swaps and forward markets. However, banks are exposed to the effects of exchange rate risk indirectly in that large ER fluctuations can push unhedged borrowers into default. Exchange rate fluctuations increase banks' default risk because borrowers have a currency mismatch on their balance sheet. During the period under examination, most CEEC retail borrowers had an income stream (on the asset side) in the local currency, and took out loans (on the liability side) in foreign currencies. As a result, a significant depreciation of the local currency relative to the foreign currency could easily push borrowers into default.

Default risk originating from exchange rate movements is modeled based on the debt-pricing work of Longstaff and Schwartz (1995) building on Merton (1974). Borrowers are exposed to exchange rate risk to the extent of their net FX debt. Let the JxM matrix ℓ

[8]For instance, $\delta_{HH}^c = 0.1$ would indicate that 10 percent of the bank's non-deposit CHF funds are funded through swapping local currency for CHF. While in theory banks could use any currency to fund FX swaps, due to the CEE's limited FX markets it is assumed that only the local currency is used to fund FX swaps.

[9]The spread κ represents the deviation from covered interest parity. $\kappa > 0$ leads to nominal lending and deposit rate differentials over short horizons (Mak and Pales 2009; Balas; Pales et al. 2011). Parent banks, however, are often able to intervene to reduce κ.

denote the currency and market-specific Loss Given Default (*LGD*) rates, such that ℓ_m^j is the fraction of the value of the loan that the bank loses, if the client defaults on his loan of currency j. When the client takes out an FX-denominated loan from the bank, the initial value of his debt (the principal) is given by $V_{0m}^j = [\gamma_{lm}^j L_m] > 0$.

Let ω_0^j denote the FX value of the banking client's initial wealth (at the time the loan is issued). The representative client holds his wealth in the local currency. Since the local currency- FX exchange rate fluctuates, the value of ω_0^j evolves over time stochastically. Importantly, a devaluation of the local currency relative to the FX causes the FX value of the client's wealth to collapse, i.e. ω_0^j falls. Each period, the banking client uses his wealth to repay fraction $\frac{1}{T-t}$ of the debt. [10]. At any given period s (such that $t \leq s \leq T$), the client therefore still has fraction $\frac{T-s}{T-t}$ of his debt to repay. At time s, the repayable amount of debt is:

$$V_{sm}^j = \frac{T-s}{T-t} \cdot V_{0m}^j \tag{2.2}$$

The client's ability to repay will depend on how the FX value of his wealth ω^j fares relative to his outstanding debt V_{sm}^j. If his wealth is not sufficient to cover his outstanding debt (perhaps because devaluation destroys the FX value of his wealth), he defaults on the loan. Let $\bar{V}_{sm}^j = \frac{T-s}{T-t} \cdot \bar{V}_{0m}^j$ denote the threshold value of debt such that the loan defaults the first time the client's wealth falls below this threshold level, i.e. if $\omega^j \leq \bar{V}_{sm}^j$. If default occurs, the bank recovers a cumulative total of $\bar{V}_{0m}^j$ of the loan.Using the concept of *LGD*, this is equal to fraction $(1 - \ell_m^j)$ of the original loan $\bar{V}_{0m}^j$.

Based on Longstaff and Schwartz (1995), the JxM matrix of cumulative default probabilities on currency j net borrowing at time T in market m has elements:[11]:

[10]It is assumed that wealth is regenerated through income, such that the local currency value of client wealth is constant over time

[11]This CDF corresponds to the first time passage probability distribution function $f(t, x, \mu, \sigma) = (\frac{x}{\sigma\sqrt{2t^3\Pi}}) \exp^{-(x+(\mu-.5\sigma^2)t)/(2\sigma^2 t)}$ of a variable x with mean and standard deviation of returns (μ, σ).

$$\psi(\nu_m^j, T, \mu^j, \sigma^j) = N[-\nu_m^j(\sigma^j\sqrt{T-t})^{-1} - \Omega^j\sqrt{T-t}] + N[-\nu_m^j(\sigma^j\sqrt{T-t})^{-1} + \Omega^j\sqrt{T-t}]\exp^{-2\nu_m^j\Omega^j(\sigma^j)^{-1}} \tag{2.3}$$

where

$$\nu_m^j = \log\frac{V_{0m}^j}{V_{Bm}^j} = -\log\left[1-\ell_m^j\right]$$
$$\Omega^j = \frac{\mu^j - .5(\sigma^j)^2}{\sigma^j} \tag{2.4}$$

$N(\cdot)$ is the cumulative density function of the normal distribution. The expected change in the FX value of the client's wealth ω^j from one period to the next is $\mu^j = y_{t,t+1}^j$. Recall from Equation 2.1 that this is the implied appreciation of the foreign currency relative to the domestic currency. Similarly, σ is the variance-covariance matrix of $y_{t,t+1}$, i.e. the implied volatility of the exchange rate from one period to the next. Since it is assumed that each banking client holds only one foreign currency, the co-movement of FX currencies does not affect the default probability. Therefore, the covariances (off-diagonal elements) in the matrix σ are zeros.

There are several noteworthy aspects of this Longstaff and Schwartz-type 'exogenous default boundary' model. First, the mechanism of default: according to this model, a depreciation of the local currency lowers the FX value of the client's wealth and thereby increases the probability of default *PD* directly. [12] Second, the default boundary is constant over time, that is, it does not vary with the outstanding value of the loan principal. However, it is important to note that the default probability does vary over time. Since the local currency value of client wealth is steady over time, the more of the loan principal the client repays, the less likely it is that his wealth will fall below the outstanding value of the loan. Therefore, the probability of default decreases monotonically over time as more and more of the loan principal is repaid. An alternative (and more realistic) for-

[12] In reality, currency mismatch affects *PD* through a secondary channel as well. The depreciation of the local currency increases the local currency value of the loan relative to the value of the collateral offered by the client, raising the loan-to-value ratio. Since now the bank can recover a smaller fraction of the loan's value in case of default, the Loss Given Default ℓ rises as well (Balas and Nagy 2010).

mulation would assume an endogenous default threshold where default threshold varies depending on the amount of outstanding debt still unpaid. However, those models are mathematically very complex, and do not allow for the derivation of reduced-form default probabilities.

The next step is to describe the bank's optimization problem. When making decisions, the bank considers its profit function (revenue minus variable costs) rather than its revenue function. Therefore, it is important to consider the bank's costs as well as its revenue items. The type of cost considered below is the carrying cost of non-performing loans, which is the bank's loss of interest revenue on the loans that default. In other words, Expected Revenue Loss is the lost interest that the bank could have earned on the volume of defaulted loans, if the default had not occurred. This is given by

$$ERL(s) = \psi^j_{ms} \cdot \tfrac{T-s}{T-t} \cdot S^j_s \cdot \gamma^j_{lm} L_m \cdot \left[\ell_m \cdot r^j_{lis} + (1-\ell_m)(r^j_{lms} - \rho^j)\right] \tag{2.5}$$

The above expression states that the bank loses interest revenue on all of the fraction ψ of loans that default. However, the bank is able to recover fraction $(1-\ell_m)$ of the defaulted loans, on which it can then earn the interbank rate ρ^j.

2.1.3. Revenues and Costs

The bank's sources of revenue are the interest payments from borrowing clients, and the appreciation gains on its foreign-currency denominated loans. The bank's costs of doing business are of various types. Of primary importance to the bank is the cost of raising funds. Loans can be financed from three sources. First, the bank can raise funds through taking deposits. The costs of doing so are the interest payments on deposits, plus (in the case of FX funds) the appreciation losses the bank might incur on its FX liabilities.[13] Second, the bank can use FX swap markets to exchange excess holdings of the local currency into FX funds. The cost of using the swap markets to raise FX funds is the cost of raising local currency funds (deposit or interbank rates), plus any additional costs arising from exchange rate movements. Third, the bank can use the interbank market to

[13]Since deposits are liabilities, appreciation of the currency of the deposit is a loss to the bank.

borrow FX funds directly. The cost of doing so is the interbank rate of the currency in question, plus the costs of ER movements. Recall from above that the bank raises fraction δ of its non-deposit funds from the swap market, and $(1-\delta)$ from the interbank market. The Expected Losses from default, as described above, are also costs to the bank. In addition, the bank must incur costs resulting from regulations that put limits on lending volumes. Let Δ denote the JxM vector of these regulatory costs. Finally, the inflation rate π^j is a cost to the bank as it lowers the nominal value of the repaid loan.

Using the notation introduced above, the bank's profit between time t and T is:

$$\Sigma_{s=t}^{T}\Sigma_i\Sigma_j\Pi_{m,s}^{j} =$$

$$\Sigma_i\Sigma_j\frac{T-s}{T-t}\cdot S^{j,h}\cdot\left[\begin{array}{c}\gamma_{lm}^{j}L_m\cdot(r_{lm,s}^{j}+y_s^{j,h}-\pi_s-\Delta_m^{j})-\gamma_{dm}^{j}D_m\cdot(r_{dm,s}^{j}+y_s^{j,h}-\pi_s-\Delta_m^{j})\\ +\psi_{ms}^{j}\cdot\gamma_{lm}^{j}L_m\cdot(1-\ell_m)\cdot\rho^j-\psi_{ms}^{j}\cdot\gamma_{lm}^{j}L_m\cdot(r_{lm,s}^{j}+y_s^{j,h})\\ -(\gamma_{lm}^{j}L-\gamma_{dm}^{j}D)\cdot[\delta_m^{j}\cdot(\rho^j-\rho^h+y^{j,h})+(1-\delta_m^{j})\cdot(\rho^j+y^{j,h})]\end{array}\right] \tag{2.6}$$

In this expression, the first term in the square brackets is the interest and appreciation revenue from loans, net of inflation π and distortionary regulatory costs Δ. The second term is the net deposit expense, while the expression in the bottom two rows is the expected local currency value of the defaulted loans. Accordingly, the third term shows the return on the fraction of the defaulted loan that the bank is able to recover, after re-lending it at the interbank rate. The fourth term is the interest loss on the defaulted amount. Finally, the fifth term (last row) shows the net costs of FX swap and interbank funding, respectively.

This expression can be further simplified by assuming that the Expectation Hypothesis of the Term Structure (EHT) holds (Corte et al. 2007). Accordingly, the relationship between the $(T-t)$ period interest rate $r_{t,T}$ and the one-period interest rate $r_{t,t+1}$ can be approximated with the following equation.

$$r_{t,T} = \frac{1}{T-t}\Sigma_{s=t}^{T} r_s \tag{2.7}$$

The EHT is assumed to hold for the other time-dependent variables ($\kappa;\rho;\psi$) as well. Using the EHT and Equation (2.1), the expression in (2.6) simplifies to express the bank's optimization problem of choosing loan and deposit interest rates ($r^j_{dm}; r^j_{lm}$) as follows.

$$\max_{r^j_{dm};r^j_{lm}} \quad \Sigma_m \Sigma_j E_t\left[\Pi_{t,T}\right] =$$

$$\Sigma_m \Sigma_j S^j \Big[\begin{array}{c} \gamma^j_{lm} L_m \cdot [r^j_{lm} \cdot (1-\psi^j_{Tm}) - \rho^j \cdot (1-\psi^j_{Tm} - \psi^j_{Tm}(1-\ell^j_m)) - \rho^h \cdot (\delta^j_m + \psi^j_{Tm}) - \psi^j_{Tm}\kappa^j - \pi^j - \Delta^j_m] \\ -\gamma^j_{dm} D_m \cdot [r^j_{dm} - \rho^j + \delta^j_m \rho^h - \pi^j - \Delta^j_m] \end{array} \Big]_{t,T} \tag{2.8}$$

In reality, the shares of lending financed by swaps, i.e. the δ's, are also chosen by the bank. In fact, the bank would choose $\delta^j_m = 1$ if $\kappa^j > 0$. This means that the bank would choose to finance all its non-deposit FX borrowing via FX swaps if in the forward markets the FX is expected to appreciate against the local currency. However, CEE FX swap markets suffer from severely limited liquidity. Therefore, the bank is assumed to take the set of δ's as given, i.e. the highest degree of FX swap financing that is allowed by market liquidity conditions.

2.1.4. Optimal interest rate choices

It is assumed that loan rates have no impact on deposit quantities, and vice versa. Furthermore, banking clients do not substitute between the various market segments *m*. However, clients do treat the various currency denominations as substitutes within each market *m*.[14] The first-order optimality condition for the choice of loan rate r^j_{lm} is given by

[14]These assumptions imply that: (1) there is no role for relationship banking in the analysis, (2) borrowers would not substitute a mortgage loans for a consumption loan just because the mortgage rates are better, but (3) they would be happy to substitute CHF loans for EUR loans for a house purchase, for better rates.

$$S^j \cdot \left[\frac{\partial \gamma^j_{lm}}{\partial r^j_{lm}} \cdot L_m \cdot H^j + \gamma^j_{lm} L_m \cdot (1 - \psi^j_{Tm})\right] + \Sigma_{k \neq j} S^k \cdot \left[\frac{\partial \gamma^k_{lm}}{\partial r^j_{lm}} \cdot L_m \cdot H^k\right] = 0$$

where (2.9)

$$H^j = [r^j_{lm} \cdot (1 - \psi^j_{Tm}) - \rho^j \cdot (1 - \psi^j_{Tm} - \psi^j_{Tm}(1 - \ell^j_m)) - \rho^h \cdot (\delta^j_m + \psi^j_{Tm}) - \psi^j_{Tm} \kappa^j - \pi - \Delta^j_m]$$

The corresponding first-order condition for the choice of deposit rate r^j_{dm} is:

$$-S^j \cdot \left[\frac{\gamma^j_{dm}}{r^j_{dm}} \cdot D_m \cdot [r^j_{dm} - \rho^j + \delta^j_m \rho^h - \pi^j - \Delta^j_m] - \gamma^j_{dm} D_m\right]$$
$$-\Sigma_{k \neq j} S^k \cdot \left[\frac{\gamma^k_{dm}}{r^j_{dm}} \cdot D_m \cdot [r^k_{dm} - \rho^k + \delta^k_m \rho^h - \pi^k - \Delta^k_m]\right] = 0 \tag{2.10}$$

Let θ_l denote the JxM matrix of "loan demand slopes" such that the $\theta^j_{lm} = \dfrac{\partial \gamma^j_{lm}}{\partial r^j_{lm}}$ is the partial derivative of the market share of the currency j loan with respect to the loan interest rate. The corresponding matrix for deposits is θ_d.[15]

2.1.5. Estimable Equations

The goal is to get a linear expression that states the interest rate gap between the currency j FX loan (deposit) and the local currency loan (deposit) as a function of all the relevant model variables. However, the first-order conditions that implicitly characterize the bank's optimal choices of interest rates are highly nonlinear. Therefore, two additional steps are needed to achieve a tractable expression. The first step is to take first-order Taylor approximations of the optimality conditions above. The second step is to expand the equations around the certainty symmetric equilibrium, where the markups and the

[15]It is assumed that the cross-price elasticities are zero. Furthermore, according to Equation 2.3, the default probabilities are independent of market shares - therefore, we have $\dfrac{\partial \psi^j_m}{\partial \gamma^j_{lm}} = 0$.

own- and cross-price elasticities are the same across currencies within the same market m. Solving for the reduced form and rearranging (the details of which are shown in the Appendix), the equations describing the local vs. FX interest rate gaps simplify to:[16]

$$
\begin{aligned}
r^h_{lm} - r^j_{lm} &= \alpha_0 + \alpha_1 \cdot (\theta^h_{lm} - \theta^j_{lm}) + \alpha_2 \cdot (y^j) + \alpha_3 \cdot (\delta^j_m) \\
&+\alpha_4 \cdot (\psi^h_m - \psi^j_m) + \alpha_5(\gamma^h_m - \gamma^j_m) + \alpha_6 \cdot (\Delta^h_m - \Delta^j_m) + (\epsilon^h_{lm} - \epsilon^j_{lm})
\end{aligned} \tag{2.11}
$$

$$
\begin{aligned}
r^h_{dm} - r^j_{dm} &= \beta_0 + \beta_1 \cdot (\theta^h_{dm} - \theta^j_{dm}) + \beta_2 \cdot (y^j) + \beta_3 \cdot (\delta^j_m) \\
&+\beta_5 \cdot (\gamma^h_m - \gamma^j_m) + \beta_6(\Delta^h_m - \Delta^j_m) + (\epsilon^h_{dm} - \epsilon^j_{dm})
\end{aligned} \tag{2.12}
$$

where $(\epsilon^j_{lm}; \epsilon^j_{dm})$ are residuals. The coefficient vectors of interest are $(\alpha;\beta)$[17].

In (2.11) and (2.12), the interest rates r on the left-hand side and market shares γ on the right-hand side are simultaneously determined. Since the bank acts as a monopolist, it takes account of the "volume" effect of its rate choices. Therefore, the slopes of loan demand and deposit supply functions $\Theta = (\theta_l; \theta_d)$ enter the bank's optimal interest rate decision. In what follows, the model is completed with a description of the demand (client) side of the model. Client's loan demand and deposit supply functions γ are described as functions of the interest rates r. The demand and supply sides are then simultaneously estimated.

2.2. *The Demand Side (Banking Clients)*

Banking clients can choose to take out loans in any one of the J currency denominations from the bank. They can also choose to hold deposits of any one currency denomination of their choice with the bank. Alternatively, clients can choose not to use banking services at all – this is their outside option for both the loan and deposit markets. For

[16]Note that inflation falls out of the interest rate gap equation, since banks in a given country deflate their profits by the same domestic inflation rate, irrespective of the market or currency denomination.

[17]Note that if we make the realistic simplifying assumption of symmetric cross-price elasticities, the $\alpha_1 \cdot (\theta^{j,h}_{lm} - \theta^{h,j}_{lm})$ and $\beta_1 \cdot (\theta^{j,h}_{lm} - \theta^{h,j}_{lm})$ terms fall out of the equations

each client, the country of residence c and the market m are predetermined.[18] Within their country and market of interest, the only choice of clients is therefore the currency denomination of the loan or deposit. Clients' decision problem is similar in both the loan and deposit markets – therefore, only the choice of loan currency is described below.

The demand side is analyzed using a static discrete choice model, based on Dick (2007). Clients' loan and deposit choices are modeled in a reduced form random coefficient conditional logit model. This formulation is more appropriate than the multinomial logit model, given that currency choices depend on both FX market and client traits. [19]

The "products" that clients choose from are the various currencies. The "outside option" (indexed by 0) is to not use banking services at all. Clients take the attributes of the loans and deposits as given. Let $(\lambda^j_{lm}; \lambda^j_{lm})$ denote the vectors of traits of loans and deposits, respectively, in market m of currency j. Let x denote the maturity of the loan (deposit), and t is the time period. In any given country c, the utility that client i in market m derives from a currency j product (loan or deposit) is linear in the supply-side attributes such that

$$U^j_{icmtx} = \lambda^j_{cm} + \eta^j_{icmtx} = \zeta^j_{1cm} \cdot r^j_{cmtx} + \zeta^j_{2cm} \cdot E\left(y^j\right) + \zeta^j_{3cm} \cdot \sigma^j + \zeta^j_{4cm} \cdot \Delta^j_{cmt} + \zeta^j_{4cm} \cdot \omega^j_{icmt} + \eta^j_{icmtx} \quad (2.13)$$

where

$$\begin{aligned} m &= 1...M \text{ markets} \\ j &= 1...J_m \text{ currencies} \\ i &= 1...I_m \text{ clients} \\ t &= 1...T \text{ time period} \\ x &= 1...X \text{ maturities} \end{aligned}$$

[18]This is equivalent to saying that the client decides the purpose of the loan first (real estate, consumption, etc.) – and the FX denomination later.

[19]An alternative formulation would be a nested logit model, with markets m as nests. However, the nested model is the same as the random coefficient model, with a random coefficient on the group-specific dummy variable only. The random coefficient model outlined here allows for a more flexible specification.

r^j_{cmtx} = interest rate in currency j

$E(y^j)$ = expected appreciation of currency j against local currency

$\sigma^{j,h}$ = std. dev. of implied yield of currency j against local currency

Δ^j_{cmt} = regulatory restrictions

ω^j_{icmt} = client wealth

η^j_{icmtx} = mean zero random disturbance

Some client characteristics are random and unknown to clients at the time of their decision-making. Client-specific shocks are correlated across currencies (stronger) and across markets (weaker). The random coefficient model specifies that the demand-side coefficients depend on the currency j, market m, country c, maturity x and time t.

$$\zeta^j_{cmtx} = \zeta^j + u^j_{cmtx} \tag{2.14}$$

If the goal is to identify currency-specific parameters (one of the estimated specifications), variation in the data across countries, markets, maturities and over time allows the identification of the currency-specific demand parameters. The coefficient vector ζ^j can be estimated as a weighted average of the country, market, maturity and time-specific coefficients. Using the empirical variance of the set of least squares estimates (Swamy 1971), consistent estimates $\hat{\zeta}$ can be obtained as follows.

Client i chooses currency denomination j if

$$U\left(\iota_{icmtx}; \nabla^j\right) > U\left(\iota_{icmtx}; \nabla^k\right) \tag{2.15}$$

where $j = 0$ is the local (domestic) currency and ∇ is the set of currency-specific characteristics. If the distribution of client characteristics $f(\iota_i)$ is known and B^j is the region of client characteristics such that currency j is chosen, the market share of currency j is:

$$\gamma^j = \int_{B^j} f(\iota)\, d\iota \tag{2.16}$$

If η^j_i is i.i.d extreme value $\exp(-\eta)$, this market share becomes:

$$\gamma^j = \frac{\exp\left(\lambda^j\right)}{\sum_{k=0}^{J} \exp\left(\lambda^k\right)} \tag{2.17}$$

Taking logs of Equation (2.17) yields a linear expression for the log-odds of choosing currency j.

$$\log \gamma^j_{cmtx} = \zeta^j_1 \cdot r^j_{cmtx} + \zeta^j_2 \cdot E\left(y^j\right) + \zeta^j_3 \cdot \sigma^j + \zeta^j_4 \cdot \Delta^j_{cmtx} + \zeta^j_5 \cdot \omega^j_{cmtx} \tag{2.18}$$

Subtracting the log-odds of choosing FX currency j from the log-odds of choosing the local currency h yields the following linearized log-odds ratio.

$$\log \gamma^h_{cmtx} - \log \gamma^j_{cmtx} = \zeta^j_1 \cdot \left(r^h_{cmtx} - r^j_{cmtx}\right) + \zeta^j_2 \cdot E\left(y^j\right) + \zeta^j_3 \cdot \left(\sigma^h - \sigma^j\right) + \zeta^j_4 \cdot \Delta^h_{cmtx} + \zeta^j_5 \cdot \omega^j_{cmtx} \tag{2.19}$$

Estimation of this equation yields consistent currency and type-specific coefficient estimates $\hat{\zeta}^j$ and market shares $\hat{\gamma}^j_{cmtx}$. In particular, $\hat{\gamma}^h_{cmtx} - \hat{\gamma}^j_{cmtx}$ is the excess probability that the banking client chooses the domestic currency over a foreign currency j.

At this point, the linear system of simultaneous equations consists of supply side equations (2.15 and 2.16) and a demand side equation (2.19). The endogenous variables are the market shares γ and interest rates r. The coefficients of interest $(\tilde{\alpha}; \tilde{\beta}; \zeta)$ can be estimated simultaneously from this system of equations. The estimates $\hat{\zeta}^j_{1cm}$ are the slopes of the inverse loan demand and deposit supply curves. Therefore, these estimates can serve as "data" for the θ^j_m variables in the supply-side equations.

The system of simultaneous equations is estimated using structural maximum likelihood techniques. A set of control variables is also included in the supply-side equation, such as inflation and the ratio of foreign assets to total assets in the banking sector. [20]

2.3. Data

The dataset covers 16 countries in the Central-Eastern European (CEE) region, with monthly frequency t from January 2000 to December 2011 (the exact coverage varies by

[20]The latter measure is included to capture the possibility that foreign-owned banks might be setting lower rates due to their cheap access to FX assets from their parent banks abroad.

country, depending on data availability).[21] These countries represent a broad range of FX lending, as well as regulatory traditions. [22] Data on loans (interest rates and loan and deposit volumes) are collected from national central banks' websites. The analysis focuses on newly issued loans and deposits, and the corresponding interest rates.[23] The markets m considered are (1) consumer (retail); (2) mortgage, and (3) non-financial corporations (corporate). Loan and deposit types are also broken down by maturity x: short-term (up to 1 year), medium-term (1-5 years for loans and 1-2 years for deposits), and long-term (over 5 years for loans and 2 years for deposits). Loans and deposits from each market and maturity category are also separated by currency denomination j: local currency, Euro (EUR), U.S. Dollar (USD) and Swiss Franc (CHF).[24]

Data on the explanatory variables come from various sources. Data on FX swap spreads κ, implied yields y, share of FX swap funding in total non-deposit funding δ, and spot and forward exchange rates S and F are taken from Datastream. Exchange rate expectations $E(y)$ are from Consensus Economics.[25] Data on macro variables (such as inflation and banks' share of foreign to total assets) are taken from central bank websites and the Economist Intelligence Unit's (EIU) Country Data. Data for the demand slopes θ come from estimation of the demand side of the model.

Data on default probabilities ψ are simulated based on Equation 2.3 – as functions of the mean and standard deviation of the implied yield, the length of the loan contract and the LGD. The dataset on regulations Δ is an updated version of the regulatory index constructed by Rosenberg and Tirpak (2009). Data on LGD rates are based on the calculations of Gupton et al. (2000).[26] The variables and data sources are summarized in Table .12.

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[21] The countries are: Albania, Belarus, Bosnia, Bulgaria, Croatia, Estonia, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Serbia, Slovakia, Slovenia, and the Ukraine.

[22] For instance, FX lending has been very popular in Hungary, while it is less prevalent in other countries.

[23] Since the stock of existing/previously issued loans responds very slowly to interest rate changes, using data on newly issued volumes is much more informative and appropriate for the analysis.

[24] Local currency and EUR is present in all markets. CHF and USD presence varies by country.

[25] Where data on predictions and expectations of future exchange rates are not available, forward exchange rates are used instead. Standard deviations of yields are also calculated from this dataset.

[26] Gupton et al. (2000) calculate loan default rates based on Moody's loan default data. Mortgage recovery rate is proxied by the authors' estimate of the median $(1 - LGD)$ on senior secured debt to single-loan borrowers, which is 79.5 percent. Household consumer loan $(1 - LGD)$ is approximated by the median recovery rate for single-loan unsecured senior debt, which is 73 percent. Corporate $(1 - LGD)$ is proxied by the median recovery rate for multiple-loan secured senior debt, which is 72.8 percent.

3. Estimation Results

Tables reporting the estimation results are listed at the end of the paper. As described above, the supply side and demand-side equations are estimated simultaneously. The regressions are run according to four different specifications. The first formulation examines the "overall" results for loans and deposits, averaged across all markets, presented in Table 1. The second specification, which looks at coefficients by market segment (consumer, mortgage and corporate), is presented in Tables 2 through 5.2. The third specification looks at results by currency (EUR, USD and CHF). These results are presented in Tables 5.3 through 5.3. Finally, the results are broken down by maturity (short, long and medium term). These results are presented in Tables 5.4 through 5.4. The reported results are elasticities and semi-elasticities.

It is instructive to note that in all the interest rate regressions described below, the dependent variable is the difference (expressed in terms of percentage points) between the relevant interest rate in the local currency minus the corresponding interest rate in the given FX currency. The explanatory variables are the local currency characteristics, minus the FX currency characteristics. Therefore, the coefficients indicate how the interest rate gap between the local and FX currency responds to an increase in the local currency trait relative to the FX trait. Similarly, in the market share regressions the dependent variable is the local currency market share minus the given FX currency market share. This is also the excess probability that clients choose the local currency over the FX currency. The coefficients indicate how a marginal increase in the difference between the local and FX currency traits affects the relative market shares (the excess probability of choosing the local currency).

3.1. Overall Results

The overall, aggregated interest rate results in Table 1 are generally in line with the model's predictions. As loan demand in the FX currency market becomes steeper (more interest rate-sensitive) relative to the local currency, the gap between local and FX loan rates shrinks. This is in line with the theory of the monopolistic firm: when the demand (and corresponding marginal revenue) curve becomes steeper, the monopolistic bank would choose to make fewer loans at a higher price. In line with the prediction of interest parity, the expected appreciation of the local currency causes banks to charge relatively lower rates on their local currency loans, shrinking the interest rate gap. When the local currency takes up a larger share of the overall loan and deposit markets, banks charge significantly higher loan rates and pay lower deposit rates than on FX currencies. Importantly, the deregulation of FX banking in a country causes banks to charge relatively lower rates on their FX currency loans. However, they also offer relatively lower FX deposit rates in such deregulated markets. Domestic inflation has a strong impact on relative interest rates as well. A one percentage point rise in local inflation causes banks to raise local lending rates by .18 percentage points more than FX rates. However, this inflation pass-through is far less than complete. This could be caused by the fact that domestic inflation is the "relevant" inflation tax on both the local and FX currency loans. As a result, banks raise both rates in response to inflation with the local rates rising somewhat faster. The local-FX deposit rate gap also rises with inflation. However, this increase of .09 percentage points is less than that observed in the case of loans. Therefore, banks compensate depositors to a lesser extent for inflation than the compensation they charge for themselves on loans.

In line with the previous literature (Csajbok et al. 2010), banks with significant FX funding available to them charge relatively lower FX loan rates. A one percentage point increase in the share of FX assets on banks' balance sheet lowers the relative FX lending rate by .10 percentage points. Such banks also offer relatively higher FX deposit rates. Since the sample period covers the global financial crisis, also included in the analysis is an indicator variable to capture the potential regime change resulting from the onset of the financial crisis. All else equal, the average local - FX interest rate gap was 2.26 percentage points lower, and the average local - FX deposit rate gap was 3.01 higher before the onset of the financial crisis in 2008. These widening loan rate and shrinking deposit rate spreads since the crisis are interesting phenomena that warrant further, more detailed analysis.[27]

[27] Another potential regime change in the CEEC region is the completion of the transition period of the banking system. However, since in most CEECs this process concluded in the early 2000s (prior to the onset of FX-based lending), this effect is not analyzed here.

The third and fourth columns of Table 1 present the aggregated results for the demand-side market share regressions. Somewhat surprisingly, a relatively higher local lending rate is associated with a greater market share of local currency loans. A potential explanation is that in the presence of fixed interest rate loan contracts negotiated for many years to come, the relationship between contemporaneous market shares and interest rates can be blurred. In line with the model's predictions, expected appreciation of the local currency causes the relative share of local currency loans to increase significantly. A one percent rise in such expected appreciation increases the relative market share of local currency loans by 5.72 percent. When the local - FX exchange rate is more stable, banking clients are willing to hold a significantly greater (relative) fraction of their savings in the form of domestic deposits. While FX banking deregulation does not appear to have a significant effect on contemporaneous market shares, it is interesting that "richer" clients are more likely to borrow in local currency [28] and hold FX currency deposits. Such clients hold a relatively greater share of local loans (as compared to FX loans) and lower share of local currency deposits. In fact, a one percent increase in savings per capita is associated with a .74 percent increase in the probability of local currency borrowing, and a .10 percent decrease in the likelihood of holding local currency deposits. As expected, clients are more likely to borrow in FX in countries where banks hold a greater fraction of FX funds on their books. Such countries also see a relatively higher probability of FX deposit accumulation. The market share regressions also underline the importance of the onset of the financial crisis. Since the onset of the crisis, the local - FX loan market share gap has widened, and the local - FX deposit market share gap has shrunk significantly. The implication is that clients have become significantly more likely to borrow in the local currency, but hold deposits in FX since the onset of the crisis.

[28] Another explanations for the positive correlation between wealth and the relative prevalence of local currency lending is that countries with higher domestic savings have lower external debt. These countries might have been able to maintain lower domestic interest rates in light of their limited external indebtedness, which contribute to the spread of domestic currency lending.

3.2. Results by Market

Examination of the estimation results by market in Tables 2 through 5.2 reveals significant cross-market differences for both loans and deposits. In particular, the consumer and mortgage markets appear to “behave“ similarly, whereas the corporate market results are rather different in comparison. For instance, banks charge significantly higher local lending rates when the probability of local borrowing is higher in the consumer and mortgage markets, but this relationship is reversed in the corporate market (Table 2). Furthermore, banks with more FX assets on their books charge significantly higher corporate FX loan rates relative to domestic rates, while the opposite is observed in the consumer and mortgage markets. Differences in the crisis-effect are also interesting. While the local - FX loan rate gap has widened since the crisis in the consumer and mortgage markets, this rate spread has shrunk in the corporate market. A similar pattern is observed looking at relative market shares, as shown in Table 5.2.

The significant disparity of the corporate sector results highlights the fact that this market is fundamentally different from the retail and mortgage markets. There are several explanations for these disparities. First, banks have much less market power in the corporate sector: large corporations in particular tend to dictate the terms of loans in their dealings with banks. Second, exchange rate risk is much more limited in the corporate sector, as FX loans are generally offset with matching FX deposits. Third, corporations are more likely to choose FX loans, as they are also more likely to earn income in FX.[29]

The cross-market differences are less pronounced in the case of deposits (Table 5.2). The results are stronger in the retail market (potentially due to more variation in the data). Interestingly, interest parity appears to fail in this market. The onset of the financial crisis has had a more profound impact on the consumer deposit market, lowering the local - FX rate spread by 3.34 percentage points as compared to the 1.04 percentage point decline in the corporate market. A relatively higher local deposit rate makes clients more likely to hold local currency deposits in the consumer market, but not in the corporate market. A stable exchange rate makes clients more willing to hold domestic deposits.

[29]Thanks to Adam Banai for bringing attention to these empirical regularities.

3.3. *Results by Currency*

Tables 5.3 through 5.3 explore the results broken down by currency, across all markets and maturities. The lending rate and market share regressions reveal that the Local - EUR and Local - CHF results are quite similar to each other, and to the overall loan results in Table 1. However, these results are rather different from the Local - USD coefficient estimates. For instance, a rise in the interest rate elasticity of FX loan demand and a greater market share of the local currency loans cause the local - USD spread to rise significantly, unlike in the other FX markets. A further difference is that the deregulation of FX banking is associated with a relative *rise* in USD lending rates, as opposed to the EUR and CHF rates. (Table 5.3). The coefficient estimates are generally the greatest in magnitude in the USD currency results. It is interesting to note that the onset of the financial crisis has had the smallest impact on the USD market. While the post-crisis spreads are 4.18 and 3.84 percentage points larger in the case of the EUR and CHF currencies, the crisis has caused a somewhat smaller increase in the USD spreads (3.38 percentage points). The nature of these cross-currency differences suggest that banks' behavior is less monopolistic in their USD lending as compared to the EUR and CHF lending. This is likely due to the fact that USD lending has historically been associated with the corporate sector, a market segment where banks' market power is lower (as discussed above).

Looking at the demand side of the market (shown in Table 5.3), EUR - CHF similarities weaken but still remain apparent. The under-valuation of exchange rate risk is only observed in the case of EUR loans. As ER stability falls, the relative probability of EUR borrowing rises significantly. Interestingly, the relative probability of borrowing in EUR has increased significantly since the crisis, but has fallen for USD and CHF loans.

Table 5.3 shows that the same patterns of EUR vs. USD cross-currency differences are also present in the deposit markets. The crisis effect is much stronger for USD deposits. Whereas the local - EUR deposit rate gap has shrunk only 1.54 percentage points since the crisis, the local - USD gap has fallen by 5.58 percentage points. The third and fourth columns of Table 5.3 show that the EUR market is the most interest rate-sensitive: a one percentage point decrease in the relative EUR deposit rate causes the probability of holding EUR deposits to fall by three times as much as for USD deposits. Interestingly, wealthier clients hold more EUR deposits, but less USD deposits (relative to local deposit shares). The financial crisis has not affected the relative share of USD deposits.

Beyond the explanatory variables considered here, the relative prevalence of the various currency denominations are also related to institutional and historical factors. For instance, corporate lending tends to be denominated in USD as discussed above, and the widespread use of EUR deposits is a continuation of the earlier dominance of the German Mark. Since these factors are time-invariant and common across countries, they are captured in the constant (intercept) term of the regressions.

3.4. Results by Maturity

Loan regressions broken down by maturity (Tables 5.4 and 5.4) show that the signs and significance levels of coefficients are very similar across the three maturities (short-term, medium-term and long-term). However, there are significant differences in the magnitudes of the coefficients. Short-term loans and deposits appear to be the most responsive to client and market characteristics, followed by medium and long-term maturities. For instance, FX banking deregulation causes short-term lending rates to fall by as much as 1.76 percentage points relative to the local currency equivalent. This response is only .09 percentage points in the case of long-term loans. The crisis effect is also much greater for short-term loans (a post-crisis spread increase of 3.75 percentage points versus .78 percentage points for long-term loans). Table 5.4 shows the same striking patterns: clients' short-term borrowing is more responsive than longer maturities. For instance, a one percent increase in client wealth reduced the probability of FX borrowing by 1.27 percent. The comparable effect for long-term borrowing is only .63 percent. The crisis effect is as much as nine times as high for short-term loans as for long-term loans.

The maturity-specific deposit regressions (Tables 5.4 and 5.4) do not show any patterns in terms of the signs and magnitudes of coefficients across maturities. Expected appreciation of the local currency lowers the deposits rates banks offer for all maturities - but this effect is by far the strongest in case of short-term deposits. FX banking deregulation reduces long-term FX deposit rates the most. The crisis effect is significant only on long-term deposit rates (Table 5.4). The probabilities of FX borrowing show substantial variation across maturities (Table 5.4). For instance, expected appreciation of the domestic currency discourages short-term FX deposits but encourages long-term ones (coefficients of 13.16 and −7.54, respectively). The probability of holding short-term FX deposits has increased significantly since the crisis, whereas the likelihood of holding long-term FX deposits has fallen. The model's overall explanatory power is much higher for medium and long-term than short-term deposits.

4. Summary and Conclusion

This paper has used simultaneous equations analysis to explore the role that various bank, market and client traits play in determining the patterns of foreign currency-based lending and deposit taking. Using a uniquely detailed, newly constructed dataset on new stocks of loans and deposits in 16 CEE economies between 2000 and 2011, the analysis extends the previous literature by (1) simultaneously examining banks' choice of interest rates and clients' choice of loan/deposit currency denomination in a structural framework; (2) examining the explanatory role of a broader set of bank, client and country traits; and (3) estimating the model by currency, market segment and maturity.

Comparison across market segments show striking similarity in the "behavior" of the consumer and mortgage markets, vis-a-vis the corporate market. Looking at currency denominations separately, there are strong similarities in how EUR and CHF loan rates respond to market and client traits, vis-a-vis the USD rates. This pattern holds up for market share regressions as well. These results are likely due to the fact that the corporate sector (where the use of USD is the most prevalent) is fundamentally different from the retail and mortgage sectors in its market power and risk traits.

In the maturity-specific regressions, another interesting pattern emerges. While the coefficient signs are very consistent across maturities, short-term lending rates respond much stronger to market and client traits than medium or long-term rates. Highly significant across all the specifications is the result that FX loans have become cheaper relative to local loans since the onset of the 2008 financial crisis, while the probability of FX borrowing has fallen nonetheless. In deposit markets, FX deposit rates and the probability of holding FX deposits have both increased since the onset of the crisis.

In relation to previous literature, this study's results confirm the role of banks' cheap FX funding from parent banks abroad (Csajbok et al 2010) as a driver of the prevalence of FX lending in the CEE region. Results also support the claims of previous literature that exchange rate stability and high inflation causes banks to charge relatively lower interest rates on FX loans. These results also hold for FX deposit rates. There is only limited support for the claim that exchange rate stability and high inflation would also cause clients to shift their banking activities over to FX denomination. Results do not generally support the hypothesis from previous literature that a major contributor of the quick spread of FX banking was clients' underestimation of the exchange rate risk involved. There is also no evidence that banks' underestimation of default risk has been an important driver of widespread FX lending.

Some important extensions remain. First, in light of the fact that the corporate sector is fundamentally different from the retail and mortgage markets, there is a possibility that the currency and maturity-specific regressions are biased by the inclusion of this sector. Therefore, a useful robustness check would be to redo the analysis with the exclusion of the corporate sector from all specifications. Second, this paper's simulated default risk measure did not produce enough variation to be included in several of the specifications, and produced less than reliable estimates in others. As a result, a more detailed and thorough analysis and modeling of the interaction of default and credit risk is needed. Third, the issue of time-dependence is important to address in any analysis that looks at stocks (cumulative volumes) in the loan and deposit markets. While this paper attempted to minimize the issue of time dependence by using data only on newly issued loans and deposits and their corresponding interest rates, a concern over the relevance of current vs. past interest rates remain. A useful extension would be to redo the analysis using first-differenced data, to further eliminate fixed effects and bias from past banking choices.

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5. Tables

5.1. Overall Results - across all markets, countries, maturities and currencies

Table 1: Aggregate Results: Interest Rates and Market Shares.

Independent Variables	Dependent Variables:			
	Interest Rate Gaps		Market Share Gaps	
	Lending	Deposits	Lending	Deposits
Interest Rate Gap	–	–	0.24*	0.05
			(1.40)	(0.04)
Loan Demand Elasticity Gap	−2.56*	–	–	
	1.40			
Deposit Supply Elast. Gap	–	–	–	0.52
				(0.53)
Exp. Local Appreciation	−15.84***	−0.74	5.72*	−2.95
	(4.85)	(1.42)	(2.95)	(1.95)
ER Stability	–	–	0.64	13.23***
			(5.78)	4.41)
Default Probability Gap	–	–	–	–
Market Share Gap	0.71***	−0.12	–	–
	(0.07)	(0.09)		
FX Lending Deregulation	0.99***	1.29***	−0.04	−0.06
	(0.20)	(0.11)	(0.12)	(0.09)
Domestic Inflation	0.18***	.09***	−0.02	−0.01
	(0.03)	(0.02)	(0.02)	(0.01)
FX Funding of Banks	.10***	−0.04***	−0.12***	−0.09***
	(0.01)	(0.01)	(0.01)	(0.01)
Pre-crisis	−2.26***	3.01***	−2.52***	4.63***
	(0.21	(0.03	(0.45)	(0.22)
Savings per capita	–	–	0.74***	−0.10***
			(0.08)	(0.02)
R^2	0.36	0.19	0.14	0.76

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

5.2. *Results by Market*

Table 2: Loan Rates by Market: Local Interest Rates in Excess of FX Lending Rates.

Independent Variables	Consumer Market	Mortgage Market	Corporate Market
Loan Demand Elasticity Gap	12.85***	7.45	4.72***
	(3.49)	(5.26)	(1.59)
Exp. Local Appreciation	−10.80	−18.07***	4.92
	(11.87)	(5.34)	(8.29)
Default Probability Gap	0.44***	–	–
	(0.10)		
Market Share Gap	0.36**	0.21	−2.12***
	(0.15)	(0.14)	(0.13)
FX Lending Deregulation	−1.34***	1.67***	0.12
	(0.52)	(0.25)	(0.24)
Domestic Inflation	0.15**	0.04	0.60***
	(0.07)	(0.05)	(0.06)
FX Funding of Banks	0.11***	0.18***	−0.16***
	(0.02)	(0.01)	(0.01)
Pre-crisis	−1.43***	−2.91***	8.18***
	(0.45)	(0.27)	(0.54)
R^2	0.47	0.57	0.32

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

Table 3: Loan Market Shares by Market: Share of Local Currency Loans in Excess of FX Loan Shares.

Independent Variables	Consumer Market	Mortgage Market	Corporate Market
Interest Rate Gap	0.06*	0.02	−0.34***
	(0.03)	(0.05)	(0.02)
Exp. Local Appreciation	7.94*	−2.99	−3.35
	(4.44)	(4.33)	(3.40)
ER Stability	13.48	6.81	20.91***
	8.34	9.15	6.14
FX lending Deregulation	0.48**	0.45**	−0.13
	(0.22)	(0.21)	(0.10)
Savings Per Capita	0.68***	1.06***	–
	(0.11)	(0.17)	
Domestic Inflation	0.14***	−0.07*	−0.03
	(0.03)	(0.04)	(0.08)
FX Funding of Banks	−0.06***	−0.09***	−0.07***
	(0.01)	(0.03)	(0.01)
Pre-crisis	−3.21***	−6.30***	4.19***
	(0.62)	(0.82)	(0.43)
R-square	0.47	0.41	0.58

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

Table 4: Deposits by Market: Interest Rates and Market Shares.

Independent Variables	Dependent Variables:			
	Interest Rate Gaps		Market Share Gaps	
	Consumer	Corporate	Consumer	Corporate
Interest Rate Gap	–	–	0.06*	−0.72***
			(0.04)	(0.20)
Dep. Supply Elasticity Gap	2.92***	−55.53*	–	–
	(0.58)	(30.76)		
Exp. Local Appreciation	4.72***	−27.32***	−3.95*	−5.93
	(1.62)	(7.07)	(1.60)	(10.02)
ER Stability	–	–	16.66***	–
			(3.62)	
Market Share Gap	0.01	−0.41***	–	–
	(0.17)	(0.11)		
FX Lending Deregulation	1.18***	1.42***	−0.09	0.36
	(0.13)	(0.17)	(0.08)	(0.30)
Domestic Inflation	0.08***	0.07	−0.01	0.10
	(0.02)	(0.04)	(0.01)	(0.08)
FX Funding of Banks	−0.04***	−0.01	−0.08***	−0.09
	(0.02)	(0.04)	(0.01)	(0.05)
Pre-crisis	3.34***	1.04*	3.34***	–
	(0.64)	(0.62)	(0.21)	
Savings Per Capita	–	–	0.03	−3.16**
			(0.02)	(1.39)
R^2	0.23	0.50	0.87	0.26

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

5.3. *Results by FX Currency*

Table 5: Loan Rates by FX Currency: Local Interest Rates in Excess of FX Lending Rates.

Independent Variables	Local-EUR Rates	Local-USD Rates	Local-CHF Rates
Loan Demand Elasticity Gap	−24.25***	14.79***	−5.03
	(7.77)	(3.01)	(4.17)
Exp. Local Appreciation	3.76	−31.91**	−35.30***
	(5.34)	(14.35)	(8.71)
Default Probability Gap	−0.91	2.66**	−0.55
	(0.69)	(1.06)	(3.21)
Market Share Gap	1.38***	−2.44***	0.06
	(0.09)	(0.21)	(0.17)
FX Lending Deregulation	1.06***	−1.95***	1.61***
	(0.28)	(0.32)	(0.37)
Domestic Inflation	0.21***	0.92***	−0.11
	(0.04)	(0.11)	(0.08)
FX Funding of Banks	0.11***	0.21***	0.19***
	(0.01)	(0.07)	(0.02)
Pre-crisis	−4.18***	−3.38*	−3.84***
	(0.31)	(1.81)	(0.60)
R^2	0.41	0.39	0.54

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

Table 6: Loan Market Shares by FX Currency: Share of Local Currency Loans in Excess of FX Loan Shares.

Independent Variables	Local-EUR Shares	Local-USD Shares	Local-CHF Shares
Interest Rate Gap	0.59***	−0.23***	0.09***
	(0.03)	(0.03)	(0.03)
Exp. Local Appreciation	−0.93	−21.54***	2.46***
	(3.69)	(5.67)	(3.65)
ER Stability	−19.22***	–	39.29***
	(6.51)		(5.92)
FX lending Deregulation	−0.55***	−0.50*	0.25
	(0.19)	(0.26)	(0.15)
Savings Per Capita	−0.01	1.08	0.88***
	.09	.88	.12
Domestic Inflation	−0.11***	0.19***	−0.05*
	(0.03)	(0.05)	(0.03)
FX Funding of Banks	−0.07***	0.03***	−0.05**
	(0.01)	(0.03)	(0.02)
Pre-crisis	3.10***	−7.57	−6.40***
	(0.54)	(8.30)	(0.58)
R-square	–	0.44	0.71

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

Table 7: Deposits by FX Currency: Interest Rates and Market Shares.

Independent Variables	Dependent Variables:			
	Interest Rate Gaps		Market Share Gaps	
	Local-EUR	Local-USD	Local-EUR	Local-USD
Interest Rate Gap			0.22***	0.07*
			(0.05)	(0.04)
Dep. Supply Elasticity Gap	−3.40***	82.51***		
	(0.65)	(12.09)		
Exp. Local Appreciation	−25.03***	4.30**	−1.50	−0.08
	(6.71)	(1.71)	(4.41)	(1.70)
ER Stability	−68.38***	−3.61		
			(17.44)	(3.95)
Market Share Gap	0.05	−0.68***		
			(0.10)	(0.19)
FX Lending Deregulation	0.79***	1.55***	−0.16	−0.27***
	(0.13)	(0.17)	(0.10)	(0.10)
Domestic Inflation	0.13***	0.08**	−0.07***	0.06***
	(0.02)	(0.04)	(0.01)	(0.02)
FX Funding of Banks	−0.04***	−0.08***	−0.09***	−0.05***
	(0.01)	(0.02)	(0.01)	(0.01)
Savings Per Capita			−0.14***	0.24***
			(0.02)	(0.06)
Pre-crisis	1.54***	5.58***	4.62***	−0.02
	(0.43)	(0.66)	(0.27)	(0.62)
R^2	0.31	0.29	0.90	0.78

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

5.4. *Results by Maturity*

Table 8: Loan Rates by Maturity: Local Interest Rates in Excess of FX Lending Rates.

Independent Variable	Short-term ≤ 1yr.	Medium-term 1-5 yr.	Long-term ≥5yr.
Loan Demand Elasticity Gap	−1.40	−4.86*	−5.94**
	(3.07)(	2.79)	(2.55)
Exp. Local Appreciation	−42.98**	−20.10**	−9.51
	(18.39)	(8.17)	(6.57)
Default Probability Gap	–	−4.66***	−0.99
		(1.56)	(0.83)
Market Share Gap	0.52**	0.42***	0.20**
	(0.11)	(0.13)	(0.10)
FX Lending Deregulation	1.76***	1.26***	0.09
	(0.39)	(0.34)	(0.30)
Domestic Inflation	0.24***	0.26***	0.14***
	(0.08)	(0.06)	(0.05)
FX Funding of Banks	0.13***	0.11***	0.09***
	(0.02)	(0.01)	(0.01)
Pre-crisis	−3.75***	−2.08***	−0.78**
	(0.48)	(0.34)	(0.31)
R^2	0.42	0.48	0.37

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

Table 9: Loan Market Shares by Maturity: Share of Local Currency Loans in Excess of FX Loan Shares.

Explanatory Variable	Short-term ≤ 1yr.	Medium-term 1-5 yr.	Long-term ≥5 yr.
Interest Rate Gap	0.24***	0.05*	0.05
	(0.03)	(0.03)	(0.05)
Exp. Local Appreciation	13.49	5.08	−0.76
	(9.34)	(3.67)	(4.36)
ER Stability	–	−31.78*	−14.88
		(16.15)	(18.64)
FX lending Deregulation	0.06	0.27*	−0.03
	(0.21)	(0.16)	(0.20)
Savings Per Capita	1.27***	1.00***	0.63***
	(0.16)	(0.12)	(0.18)
Domestic Inflation	−0.08*	−0.01	0.03
	(0.04)	(0.03)	(0.04)
FX Funding of Banks	−0.11***	−0.13***	−0.11***
	(0.03)	(0.01)	(0.03)
Pre-crisis	−18.80***	−4.61***	−2.01**
	(1.67)	(0.73)	(1.02)
R-square	0.35	0.50	0.12

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

Table 10: Deposit Rates by Maturity: Local Rates in Excess of All FX Deposit Rates.

Explanatory Variable	Short-term ≤1 yr.	Medium-term 1-2 yr.	Long-term ≥2 yr.
Dep. Supply Elasticity Gap	−1.16	2.90***	3.42***
	(0.92)	(0.65)	(1.28)
Exp. Local Appreciation	−27.99***	−17.41	3.74
	(7.90)	(11.02)	(2.62)
Market Share Gap	0.22***	0.77***	0.60***
	(0.08)	(0.14)	(0.22)
FX Lending Deregulation	0.45***	2.02***	2.25***
	(0.17)	(0.21)	(0.21)
Domestic Inflation	0.13***	0.05*	−0.04
	(0.04)	(0.03)	(0.03)
FX Funding of Banks	0.07*	0.02	0.02
	(0.04)	(0.01)	(0.02)
Pre-crisis	−0.35	0.77	1.67**
	(0.67)	(0.53)	(0.83)
R^2	0.17	0.29	0.43

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

Table 11: Deposit Market Shares by Maturity: Share of Local Currency Deposits in Excess of FX Deposit Shares.

Explanatory Variable	Short-term ≤1 yr.	Medium-term 1-2 yr.	Long-term ≥2 yr.
Interest Rate Gap	0.36***	0.46***	0.37***
	(0.07)	(0.06)	(0.04)
Exp. Local Appreciation	13.16**	1.07	−7.54***
	(6.43)	(8.33)	(1.57)
FX lending Deregulation	−0.35**	−0.89***	−0.52***
	(0.15)	(0.20)	(0.13)
Savings Per Capita	−0.25***	0.19	0.71***
	(0.05)	(0.20)	(0.18)
Domestic Inflation	−0.05	−0.03	−0.03*
	(0.04)	(0.02)	(0.02)
FX Funding of Banks	−0.09***	−0.06***	−0.04***
	(0.03)	(0.02)	(0.01)
Pre-crisis	6.73***	1.20	−4.10**
	(0.82)	(2.25)	(1.79)
R-square	0.22	0.75	0.88

Note: * indicates statistical significance at 10% levels, ** at 5% levels and *** at 1% levels.

6. Figures

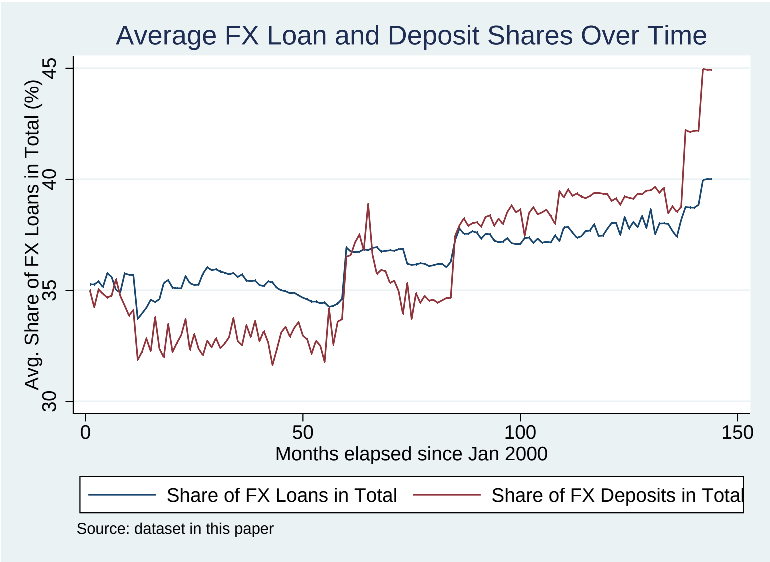

Figure 1:

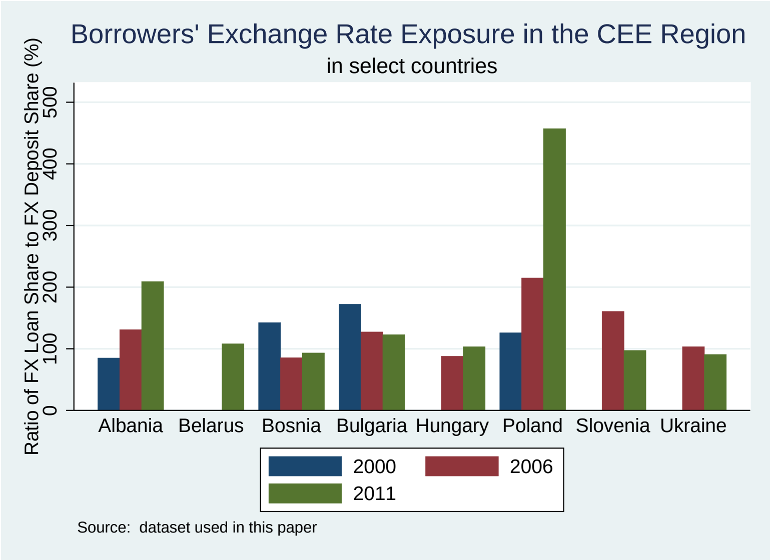

Figure 2:

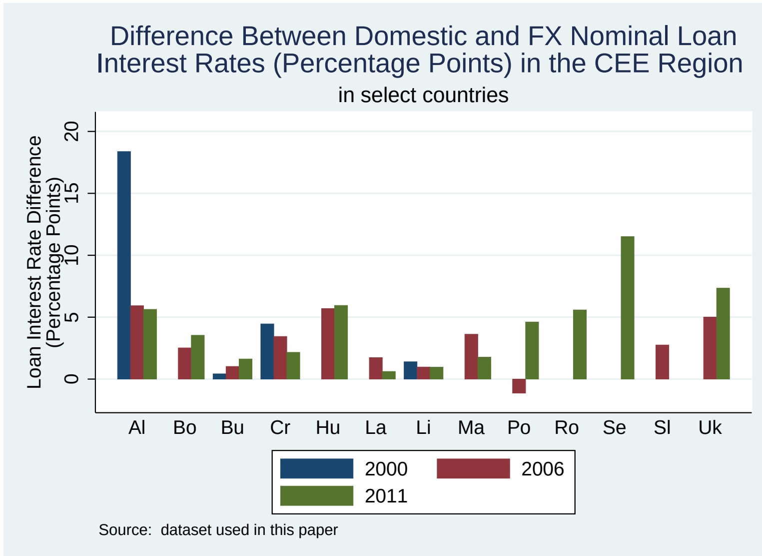

Figure 3:

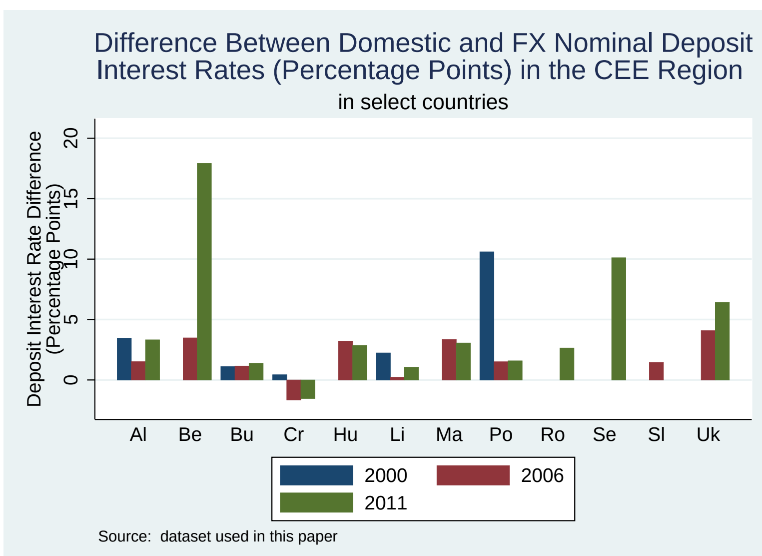

Figure 4:

Appendix .1. Data Appendix

Table .12: Summary of Model Variables and Empirical Measures.

Variable Name	Notation	Empirical Measure
Loan Interest Rate	r_l	Avg. monthly rates on new loans (CB sites)
Deposit Interest Rate	r_d	Avg. monthly rates on new deposits (CB sites)
Client Wealth	ω	Per Capita Savings (World Bank)
Loan & Deposit Volumes	$(L; D)$	Total monthly new volumes (CB sites)
Market Shares	γ	Calculated from loan volumes
Default Probabilities	ψ	Calculated from first-time hitting CDF
FX Restrictions	Δ	FX Regulatory Index (Rosenberg & Tirpak 2009)
Forward & Spot ER's	$(F; S)$	Avg. of daily rates over month (Datastream)
Currency Appreciation	y	Calculated from forward & spot exchange rates
Exp. Appreciation	$E(y)$	Exp. Appr. of FX (Consensus Economics)
FX Swap Spread	κ	Calculated from spot & forward ER's using CIP
FX Spread Influence	χ	Weighted Average of FX Swap Spreads
Interbank Rates	ρ	Monthly Interbank Interest Rates (CB sites)
ER Volatility	σ	Volatility of monthly returns over tenure
Slope of Loan Demand	θ	Estimated from Demand-side of Model
Loss Given Default	ℓ	Data based on Gupton et al. (2000)

Appendix .2. Model Appendix

$$r^j_{lm} = \alpha_0 \cdot (1 - \xi_l) + \tilde{\alpha}_1 \cdot (\Sigma_k \theta^{k,j} - \xi_l \Sigma_k \Sigma_j \theta^{j,k}) + \alpha_2 \cdot \rho^j + \alpha_3 \cdot (\delta^j_m \kappa^j - \xi_d \Sigma_k \delta^k_m \kappa^k) + \tilde{\alpha}_4 \cdot (\psi^j - \xi_l \Sigma_k \psi_k)$$

$$+ \tilde{\alpha}_5 \cdot (\gamma^j_l - \xi_l \Sigma_k \gamma^k_l) + \alpha_6 \cdot (\Delta^j_m - \xi_l \Sigma_k \Delta^k_m) + \alpha_8 (1 - \xi_l) \pi + \epsilon^j_{lm} \tag{.1}$$

$$r^j_{dm} = \beta_0 \cdot (1 - \xi_d) + \tilde{\beta}_1 \cdot (\Sigma_k \theta^{k,j} - \xi_d \Sigma_k \Sigma_j \theta^{j,k}) + \beta_2 \cdot \rho^j + \beta_3 \cdot (\delta^j_m \kappa^j - \xi_d \Sigma_k \delta^k_m \kappa^k) + \tilde{\beta}_5 \cdot (\gamma^j_d - \xi_d \Sigma_k \gamma^k_d)$$

$$+ \beta_6 \cdot (\Delta^j_m - \xi_d \Sigma_k \Delta^k_m) + \epsilon^j_{dm} \tag{.2}$$

are the log-linearized interest rate choices. For both loans and deposits, $\xi = \frac{\theta^{k,j}}{\theta^{j,j}}$ is constant across all currencies in the symmetric equilibrium around which the Taylor expansion is taken. Furthermore, $(1 + \xi) \cdot (\tilde{\alpha}; \tilde{\beta}) = (\alpha; \beta)$.