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Substitution between domestic and foreign currency loans in Central Europe. Do central banks matter?[4]

In this paper we ask a question about the impact of monetary policy on total bank lending in the presence of a developed market for foreign currency denominated loans and potential substitutability between domestic and foreign currency loans. Our results, based on a panel of three biggest Central European countries (the Czech Republic, Hungary and Poland) confirm the existence of the substitution effect between these loans. Restrictive monetary policy leads to a decrease in domestic currency lending but simultaneously accelerates foreign currency denominated loans. This makes the central bank's job harder with respect to providing both, monetary and financial stability.

Introduction

Since the widespread introduction of Inflation Targeting strategies in many developed and emerging market countries, the role of monetary and credit aggregates has substantially decreased. Money and credit[5] are not treated as intermediate targets anymore and central banks, as well as analysts, pay much less attention to their developments than they used to back in the 1980's. Still, money and credit matter in monetary policy analysis of inflation targeters for several reasons. First, credit creation is considered an important driving vehicle transmitting monetary policy decisions on interest rates to the economy (e.g. Mishkin (1996), Bernanke and Blinder (1988)). Second, it has been shown in many countries that developments in monetary and credit aggregates can yield useful information about future real and nominal developments (Borio and Filardo (2004), Fisher et al. (2006), Gerlach and Svensson (2003)). Third, it has been recently argued that credit creation can be useful in assessing the overall created liquidity, even if, in the short and medium run, it does not affect consumer prices. This liquidity, it is argued, flows to capital or real estate markets, where it can generate price bubbles. These bubbles can threaten financial system and price stability in the future. As a result, inflation targeting central banks pay attention to money and credit developments, treating them as one of the inputs to their monetary policy decision making process.

In this paper we do not attempt to prove the usefulness of credit aggregates for monetary policy. Assuming that the analysed central banks care about credit creation[6] and may want to curb (or boost) lending, we ask the question what impact central banks have on bank lending in the presence of a developed market for foreign currency loans. In other words, we think of domestic and foreign currency loans as of close substitutes. Since the domestic central bank affects only the price of one of these goods (i.e. domestic credit) its impact on the total amount of loans granted can be small.

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[5] Throughout the paper the terms “loans” and “credit” will be used interchangeably.

[6] This can be seen for instance from their Inflation Reports, Financial Stability Reports and minutes of MPC meetings, e.g. CNB (2006), MNB (2006), NBP(2007).

We analyse empirically domestic and foreign currency loan[1] developments in a panel of three biggest Central European countries: the Czech Republic, Hungary and Poland. All these countries follow inflation targeting strategies and all have a substantial share of foreign currency loans in total loans to the private sector. Our study is not the first approach to credit expansion in Central and Eastern Europe. The investigated topics included e.g. estimating equilibrium level of credit-to-GDP for the new EU Member States and potential speed of the catching-up process, the possible impact of future euro adoption on the credit market developments in accession countries and the risk of crises related to excessive credit expansion. We have, however, not come across a study treating explicitly the substitution between domestic and foreign currency loans. Nevertheless, the reviewed papers point at problems related to rapid credit expansion and at risk associated with high share of foreign currency loans and thus will be briefly discussed below.

Several studies on rapid credit growth in Central and Eastern Europe discussed the risk to stability. The reason for this is that credit expansion is often included in a set of early warning indicators for banking distress. It should be, however, stressed that the majority of lending booms has not led to banking sector/balance of payments crises in the region[2].

The paper by Boissay et al. (2005) reviews a broad set of countries of the region (Croatia together with ten transition countries of Central and South-Eastern Europe that joined EU in 2004 and in 2007). The authors assess credit growth — especially in countries with fixed exchange rate regimes — as higher than justified by the factors elated to macroeconomic fundamentals and catching-up process[3]. The study by Backé et al. (2006) concentrates on equilibrium levels of credit-to-GDP ratios in the same sample of 11 transition economies. Taking into account the estimated corridor of deviation from equilibrium, the authors find that most of the reviewed countries[4] may have already come close to equilibrium by 2004 or even overshot it. In case of the biggest economies of the region (the Czech Republic, Poland and Hungary) they were rather on the undershooting side although the upper edge of the estimated band was close to the equilibrium level. Identifying cases of credit boom in Central and Eastern Europe motivated also the study by Kiss et al. (2006). The authors distinguish different definitions of excessive credit expansion (based on levels and growth rates) leading to different conclusions. On the one hand, considering credit-to-GDP ratios for economies under review, currently observed values seemed to be below levels justified by macroeconomic factors. On the other hand, assessment of credit growth brings about a mixed picture with Latvia and Estonia considered as potentially the most risky[5]. Other studies assess the risk associated with current credit expansions as not being a major cause for concern. Sirtaine and Skamnelos (2007) come to a conclusion that still, in the short term, the risk of an adjustment coming form a macroeconomic shock in Central and Eastern Europe is higher that the risk of deterioration originating from the banking crisis related to rapid credit growth.

Commenting the results of their studies, several of the cited authors (e.g. Kiss et al. (2006), Sirtaine and Skamnelos (2007)) marked that the high share of foreign currency denominated loans in private sector borrowing may be an additional concern for monetary policy in some countries, since monetary tighten-

1 The notion of foreign currency loans is understood here broadly – as including foreign currency denominated loans (that can be, technically, paid and repaid in a local currency after indexing any cash flows to changes in an exchange rate).

2 The link between credit expansion and banking sector/balance of payments crises has been broadly discussed in the literature, although without leading to a generally accepted conclusion. A short overview on the empirical literature on that issue can be found in Brzoza-Brzezina (2005).

3 According to Boissay et al. (2005) estimates the most excessive credit growth over the period 2001--2004 was recorded in: Bulgaria, Latvia, Lithuania, Estonia followed by Croatia and Hungary.

4 Those include primarily: Croatia, Estonia, Latvia and Bulgaria.

5 According to Kiss et al. (2006), in Hungary the dynamics of credit expansion can be explained by the convergence process. The Czech Republic and Poland were described as economies with no excessive credit growth.

ing may rather lead to increased foreign currency indebtedness than to credit growth slowdown. The issue of limited potential efficiency of monetary tools as a response to a credit boom related to currency mismatch was also noticed in other studies, e.g. in Hilbers et al. (2006) and Backé and Wójcik (2006), although it was never the main point of interest. A more explicit discussion on domestic and foreign currency lending can be found in a paper on the bank lending channel in Hungary by Horváth et al. (2006). The findings presented there seem to support the existence of a substitution effect between the two types of credit, though it must be stressed that the analysis was concentrated on the supply side of the market[1]. A similar study was conducted on monetary transmission in Poland by Wróbel and Pawłowska (2002). Analysing responses of private sector credit to monetary policy shocks, the authors formulated a hypothesis that their results may also point to a presence of the substitution effect. On the whole, the question of substitutability between domestic and foreign currency denominated loans and its consequences for monetary policy has been signalled in several studies, however, as a main research topic it has not yet received substantial attention.

We show that indeed domestic and foreign currency loans are close substitutes in the analysed countries (i.e. in the Czech Republic, Hungary and Poland). Although domestic interest rates affect negatively, as can be expected, domestic currency loans, they also affect positively foreign currency loans. Hence, consumers, facing higher borrowing costs in domestic currency simply turn to foreign credit. Our estimates show that foreign currency loans substitute a non-negligible part of the value of lost domestic currency loans after a monetary policy tightening. Although the results vary somewhat between models and countries, they point to the phenomenon that might pose a serious constraint on the ability of domestic monetary authorities to affect overall credit creation. The general result pointing at the substitution between domestic and foreign currency denominated loans is robust with respect to the model specification.

Model and data

Loan developments are difficult to model empirically. One reason is that we do not have a consistent economic theory about the determinants of loans. Standard microfounded models used for monetary policy analysis (e.g. Clarida et al. (1999), Rotemberg and Woodford (1998), Woodford (2003)) do not show any explicit role for loans. For this reason it is not fully obvious what variables should enter a model explaining loan demand. Moreover, recent advances in the analysis of monetary transmission (Bernanke and Blinder (1988), Kashyap and Stein (1995, 2000)) show that the loan market is relatively specific in the sense that we can expect loan demand and loan supply diverging frequently. In such a situation the observed quantity of new loans is a nonlinear (min) function of demand and supply. Such problems are relatively difficult to model empirically, in particular in the presence of short time series and uncertainty about the true data generating process[2].

For the above mentioned reasons we decided to follow the approach used relatively often in the empirical literature. As to the choice of the model, this approach ignores the possible supply-demand disequilibria, assuming that in the long run the two market sides must be equal. Since, on the aggregate level it is difficult to identify supply side factors, this approach to modelling concentrates on the demand side of the market. Regarding potential determinants of loan demand, the

[1] The authors investigated whether there is an asymmetric adjustment of bank loan supply to changes in interest rate, conditioned on specific characteristic of individual banks. They used panel data on Hungarian banks and followed Kashyap and Stein (1995, 2000).

[2] One possible approach is based on the disequilibrium modelling technique developed by Nelson and Maddala (1974). It has recently been applied to modelling lending to enterprises in the UK (Atanasova and Wilson (2004)) and analysing the Polish loan market (Hurlin and Kierzenkowski (2002)). However, our experience with this estimator based on simulations, was rather negative. The proper estimation required not only much longer data series that were available to us, but also a specification of the estimated equations perfectly matching the data generating processes.

standard approach accentuates primarily income (as measured by GDP) and the cost of borrowing (as measured by the real interest rate). Despite its limited theoretical appeal this approach has been successfully used for modelling loan demand in developed and developing countries (Calza et al. (2001), Calza et al. (2003), Hoffman (2001), Brzoza-Brzezina (2005)).

Our approach differs slightly from the one presented above because of the specific question we ask. Analysing substitutability between domestic and foreign currency loans we recognise that demand for any of these products can depend not only on its own price but also on the price of the potential substitute. Hence, modelling (real) demand for both, domestic and foreign currency loans we refer to the same set of explanatory variables: real income, the real cost of borrowing in domestic currency and the real cost of borrowing in foreign currency:

$$LD = f(Y, rD, rF, e) \quad (1)$$

$$LF = f(Y, rD, rF, e) \quad (2)$$

where L^D i L^F stand respectively for real domestic and foreign currency loans, Y denotes real GDP, r^D denotes the real domestic interest rate, r^F denotes the real foreign interest rate and e stands for the nominal exchange rate[1].

It should be noticed that the real cost of borrowing in foreign currency, from the point of view of a resident, involves the nominal foreign interest rate deflated by (expected) domestic inflation and the expected change in the nominal exchange rate. Since we do not have consistent data on borrowers' expectations regarding inflation and the exchange rate, we deflate the interest rates with current domestic inflation and add the current exchange rate (or its growth rate, depending on the econometric approach) as a proxy for future expectations about the exchange rate.

As already stated, the analysis investigates credit developments in the Czech Republic, Hungary and Poland. Since there was no unified database with all necessary time series, the data has been collected from different sources (see Appendix 1). We use a panel of quarterly data for the period 1997Q1 – 2007Q1.

Endogenous variables have been defined as real loans to the private sector[2] denominated either in domestic or in foreign currency[3] (deflated in each case with the domestic GDP deflator). The calculations were based on average quarterly stocks of credit, only in the case of Hungary end of period stock was used (due to lack of monthly data).

Explanatory variables included GDP at market prices of the previous year, domestic and foreign real interest rates (quarterly averages of 3 month fixing interbank rates deflated with domestic GDP deflators) as well as Swiss Franc nominal exchange rates against national currencies (quarterly averages).

As for the foreign interest rate, we decided to use the Swiss Franc LIBOR 3M rate as a measure of nominal cost of foreign credit. The reason for that is the dominant share of Swiss Franc loans in total credit in Hungary and Poland. Although Euro is also an important currency in foreign indeb-

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[1] An increase in e means a depreciation of the local currency.

[2] Private sector is defined as corporations and households. Non-profit institutions serving households are often treated jointly with households but to ensure the comparability of time series across analysed countries (the data for those institutions was not available for the whole sample period for all countries) we excluded them from our definition of the private sector. However, taking into account the minor share of loans to non-profit institutions serving households, the results should not be affected by that decision.

[3] Foreign currency credit included jointly all loans denominated in foreign currency (i.e. Euro, Swiss Frank etc.) but the ue was expressed in units of domestic currencies.

tedness of the analysed countries, the Swiss interest rates can be well viewed as a proxy for the overall cost of foreign credit, since the two interest rates and exchange rates[1] (Swiss Franc and Euro) move closely together. The lack of data on detailed structure of foreign loans makes it impossible to use a weighted interest rate.

All variables were first tested for the order of integration (see Appendix 2). The tests pointed relatively unambiguously to a unit root in the GDP series and stationarity of real interest rates, which is consistent with several external studies (e.g. Shively (2001), Carpolare and Grier (2000)). The case with nominal exchange rates was not clear-cut, however, since in the countries under review an appreciation trend of real exchange rate can be observed (due to the catching-up process), we decided to treat the exchange rate as a variable integrated of order one.

Results

Since the theory gives us only weak guidance, a number of alternative empirical specifications of equations (1) and (2) have been tried in order to check the robustness of the results. Fortunately, the relevant conclusions are invariant to the specification chosen.

In our data set we have both stationary and non-stationary variables. In particular, our dependent variables *LDT* (total loans denominated in domestic currency) and *LFT* (total foreign currency loans) are *I(1)*. Therefore, in all the specifications the dependent variable is a quarter-on-quarter growth rate (i.e. change in log-level) of either real domestic currency loans or real foreign currency loans. Since there is always a considerable time lag between a decision to apply for a loan and the moment of actual granting the loan by a bank, we decided that all the variables enter the estimated equations with the lag of at least one quarter[2]. In addition, having in mind relatively short time dimension of our sample, we targeted at reasonably parsimonious specifications. Some experiments with data proved that it is enough to include at most two lags to achieve well-behaving residuals. The number of lags of the dependent variable was kept as low as necessary to just eliminate the autocorrelation in residuals.

As to explanatory variables, we used lagged levels of domestic (*rd*) and foreign currency (*rchf*) interest rates — following the discussion presented in the previous section. Further, we included rates of changes (i.e. differences of log-levels) for those variables that, according to earlier tests, might exhibit non-stationarity (i.e. exchange rates — *e* — and *GDP*). Such an approach allows us to interpret the estimated coefficients as elasticities or (in the case of interest rates) semi-elasticities.

As already mentioned, we used different empirical specifications to check the robustness of the results. We started with an error correction specification with the cointegrating vector estimated for our nonstationary variables. Next, we moved to a simple ADL model on stationary (differenced when necessary) variables and estimated the two equations[3] jointly using the SUR estimator. Finally, we took the same approach (ADL), but estimated the equations separately using the Arellano-Bond estimator. For the sake of completeness, for each of these empirical specifications we present the results based on three approaches to the models' dynamic structure. First, we report the results of the estimations where all the exogenous variables enter only as first lags. Second, we use first two lags of all exogenous variables. Finally, we show the results of a general-to-specific approach – we

[1] The correlation coefficient of Swiss Franc and Euro interest rates is above 95% (for the period of 1998Q4--2007Q2) and the correlation between exchange rates of domestic currencies (Koruna, Forint and Zloty) against Swiss Franc and Euro ranges between 92% and 97% for the same period. The use of Euro exchange rate does not change significantly the results of the analysis.

[2] In our sample it is confirmed by the data — once we tried to estimate specifications without the lagged dependent variables on the right hand side, the residuals exhibited strong autocorrelation.

[3] For domestic and foreign currency denominated loans.

start with first two lags of all the variables and than successively drop the variables with insignificant parameter estimates until all variables are significant at the 10% level.

Given the main question asked in the paper, the parameters for both domestic and foreign interest rates are of the primary interest. In what follows our discussion concentrates on interest rate semi-elasticities. However, we consider our specification to be controlling reasonably well for other relevant effects so no serious biases should be expected in the estimated coefficients. In what follows we present the three different empirical specifications. Since the conclusions are consistent across specifications, we present them jointly afterwards.

We start with the error correction specification. The results of the panel order of integration tests (see Appendix 2) led us to the conclusion that the real domestic and foreign currency lending, the real GDP and the exchange rates (all variables in log-levels, according to definitions presented in Appendix 1) are integrated of order one. As a natural next step we tested for possibility of the cointegration (again — in a panel setting) between these variables[1]. Although we deal with relatively short time series, the results presented in Table 2 suggest a possibility of the existence of a cointegrating vector. In the most general setting, the estimated equations of the error correction model for the country *i* and period *t* is:

$$\begin{aligned}\Delta LDT_{it} = \kappa_i^D + \sum_{k=1}^{3}\alpha_i^D \Delta LDT_{it-k} + \sum_{k=1}^{2}\beta_k^D \Delta GDP_{it-k} + \sum_{k=1}^{2}\gamma_k^D \Delta e_{it-k} + \\ + \sum_{k=1}^{2}\lambda_k^D rd_{it-k} + \sum_{k=1}^{2}\theta_k^D rchf_{it-k} + \delta^D ECT_{it-1}{}^D + \varepsilon_{it}{}^D\end{aligned} \qquad (3)$$

$$\begin{aligned}\Delta LFT_{it} = \kappa_i^F + \sum_{k=1}^{3}\alpha_i^F \Delta LFT_{it-k} + \sum_{k=1}^{2}\beta_k^F \Delta GDP_{it-k} + \sum_{k=1}^{2}\gamma_k^F \Delta e_{it-k} + \\ + \sum_{k=1}^{2}\lambda_k^F rd_{it-k} + \sum_{k=1}^{2}\theta_k^F rchf_{it-k} + \delta^F ECT_{it-1}{}^F + \varepsilon_{it}{}^F\end{aligned} \qquad (4)$$

The evidence for the statistical significance of the error correction term is somewhat mixed (see Table 3). Moreover, due to the short time span of the data available to the analysed countries it might be claimed that the results of cointegration analysis could be misleading[2]. Therefore, we decided to try also specifications assuming lack of the cointegrating relationship, where the ECT was not included (i.e. the coefficients δ^D and δ^F are constrained to 0).

Accordingly, further results are based on the assumption that there is no cointegrating relationship between potentially non-stationary variables. This means that our specification reduces to a distributed lag model:

$$\begin{aligned}\Delta LDT_{it} = \kappa_i^D + \sum_{k=1}^{3}\alpha_i^D \Delta LDT_{it-k} + \sum_{k=1}^{2}\beta_k^D \Delta GDP_{it-k} + \sum_{k=1}^{2}\gamma_k^D \Delta e_{it-k} + \\ + \sum_{k=1}^{2}\lambda_k^D rd_{it-k} + \sum_{k=1}^{2}\theta_k^D rchf_{it-k} + \varepsilon_{it}{}^D\end{aligned} \qquad (5)$$

$$\begin{aligned}\Delta LFT_{it} = \kappa_i^F + \sum_{k=1}^{3}\alpha_i^F \Delta LFT_{it-k} + \sum_{k=1}^{2}\beta_k^F \Delta GDP_{it-k} + \sum_{k=1}^{2}\gamma_k^F \Delta e_{it-k} + \\ + \sum_{k=1}^{2}\lambda_k^F rd_{it-k} + \sum_{k=1}^{2}\theta_k^F rchf_{it-k} + \varepsilon_{it}{}^F\end{aligned} \qquad (6)$$

[1] We used FM OLS procedure proposed by Pedroni (2000) since it allows some cross-sectional heterogeneity.

[2] Among other problems, there is an issue of only partial coverage of the business cycle.

Equations 5 and 6 were subject to two estimation procedures. First, they were estimated jointly using the seemingly unrelated regression (SUR) approach (Table 4). Second, we estimate them separately, using the Arellano-Bond estimator (Table 5). The former approach was motivated by the fact that, as we discussed in the previous section, equations (1) and (2) are dependent. Given no constraints on the supply side of the credit market, a potential borrower faces a joint decision — whether to apply for a loan (given current and expected economic conditions) and if so — in which currency the loan should be denominated. Therefore, the shocks in equations (1) and (2) could be dependent[1]. In order to benefit from this potential relationship, we estimated jointly equations for domestic and foreign currency loans using the SUR approach. Second, as a robustness check, we also report the results of the separate estimations for the both types of loans. In this case, given the dynamic nature of our panel models, we use the Arellano-Bond (1991) first-step estimator.

The most important conclusions, robust across all specifications and estimation methods, are as follows. First, the autoregressive feature of credit time series (for both domestic and foreign currency lending) is confirmed by estimation results, since the lagged dependent variable enters the equations usually with a statistically significant parameter. Second, estimates of the parameters for the GDP and interest rates have proper signs. An increase in economic activity results in more of both domestic and foreign currency lending. A higher domestic or foreign interest rate leads to a lower increase in lending in the respective currency — the effect of a higher borrowing cost. Third, changes in the foreign exchange rate seem to have no effect on domestic currency lending. What is interesting, however, is its impact on foreign currency loans. The estimation results consistently show that a depreciation of the domestic currency leads to a slower increase in foreign currency lending (an appreciation results in more foreign currency lending). If this last result is driven mostly by the demand factors (and anecdotal evidence from Poland supports this hypothesis) then behaviour of potential borrowers might not be fully rational[2].

Our main finding, however, is that the domestic monetary policy might be counter-productive in the case of a lending boom fuelled by foreign currency denominated loans. We obtained very strong (and consistent across different specifications and estimation methods) evidence that an increase in the domestic interest rate results is more foreign currency denominated loans. Therefore, a monetary contraction, instead of curbing credit growth, leads rather to changes in currency composition of new loans.

The presented models convincingly show that domestic monetary policy acts (to some extent) in a counterproductive way. However, given their simple structure they are not capable in answering the question about the magnitude of the substitution effect. This is because any simulation of domestic and foreign credit reaction to an interest rate shock conducted on their basis would be prone to the criticism that it does not take into account the indirect effects on loans via exchange rate or output reaction. For this reason we decided to run also a panel VAR[3] on our data set and analyze the impulse responses of domestic and foreign currency loans to a domestic interest rate shock. The estimated VAR seems to reflect the basic features of the previously estimated models, i.e. the negative reaction of domestic loans and the positive reaction of foreign loans to a domestic interest rate shock. The substitution effect has been calculated by dividing newly created foreign currency loans

[1] For example, a deterioration in the general economic outlook should have a negative effect both on new domestic and foreign currency denominated lending.

[2] This is true if we assume that the exchange rate is non-stationary due to the real appreciation trend, as well as, if we assume that the exchange rate is mean-reverting.

[3] We used the codes developped by Zicchino and Love (2006).

by destroyed domestic currency loans after 16 quarters from the initial domestic interest rate shock[1]. We report the results for VARs with 1 and 2 lags in Table 1[2].

Table 1: Estimates of the substitution effect

	the Czech Republic	Hungary	Poland
VAR(1)	6%	39%	19%
VAR(2)	5%	31%	15%

The results are dispersed between countries which results directly from the different share of foreign currency loans in total loans, ranging from 11% in the Czech Republic to 45% in Hungary in 2007Q1. Consequently, the substitution effect in the Czech Republic may be considered negligible. However its magnitude in Poland and, in particular, in Hungary cannot be ignored by policymakers, in particular taking into account the continuously growing share of foreign currency loans in these countries. Given the simple approach these results should be interpreted with caution. Still, we believe that they document quite robustly not only the presence but also the nonnegligible size of the substitution effect in the region.

Conclusions

In this paper we asked the question what is the impact of monetary policy on total bank lending in the presence of a developed market for foreign currency denominated loans. The relevance of this question is motivated by the potentially high substitutability between domestic and foreign currency loans. Since the central bank has only impact on the cost of borrowing in domestic currency it cannot prevent lending in foreign currency and hence, may have only limited impact on total lending.

We based our empirical analysis on a panel of three biggest Central European countries: the Czech Republic, Hungary and Poland. The obtained results confirm that development of the market for foreign currency loans makes the job of the central bank more difficult. Although, as can be expected, a monetary tightening leads to a decrease in domestic currency lending, it has simultaneously an accelerating effect on foreign currency denominated loans. Therefore, instead of curbing credit growth, the central bank might rather end up changing the currency composition of new bank lending. Simulating the magnitude of the substitution effect shows a nonnegligible substitution between domestic and foreign currency loans in Poland and Hungary. Given the increasing share of foreign currency loans in these countries, this problem may worsen over time.

These results may be unpleasant for central banks for a number of reasons. First, significant substitutability between domestic and foreign currency loans may negatively impact upon the effectiveness of monetary policy transmission. Second, the popularity of foreign currency loans may make the “one instrument, two goals” problem related to providing price and financial system stability even more difficult to tackle. Foreign currency loans tend to be popular especially among households that usually do not hedge against exchange rate risk. If restrictive monetary policy accelerates foreign currency lending then it leads to more risk present in the households' balance sheets. Finally, as suggested in the literature, increased lending can result in nonfundamental increases in asset prices which, if suddenly reverted, can negatively impact on monetary and financial system stability. High substitution between domestic and foreign currency denominated loans makes central banks' attempts to prevent such outcomes even less effective.

[1] This was based on the most recent available observation of loan amounts outstanding for each country separately.

[2] Complete results from the VAR study can be obtained from the authors upon request.

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Appendix 1: Data sources

The following sources of data for the econometric model were used:

1. Loans to the private sector:

— Loans denominated in domestic currency (i.e. Czech Koruna) to the private sector (households + non-financial corporations) in the Czech Republic — source: Czech National Bank (CZK millions)

— Loans denominated in domestic currency (i.e. Hungarian Forint) to the private sector (households + non-financial corporations) in Hungary — source: National Bank of Hungary (HUF billions)

— Loans denominated in domestic currency (i.e. Polish Zloty) to the private sector (households + non-financial corporations) in Poland — source: National Bank of Poland (PLN millions)

— Loans denominated in foreign currency (all currencies other than domestic currency) to the private sector (households + non-financial corporations) in the Czech Republic — source: Czech National Bank (CZK millions)

— Loans denominated in foreign currency (all currencies other than domestic currency) to the private sector (households + non-financial corporations) in Hungary — source: National Bank of Hungary (HUF billions)

— Loans denominated in foreign currency (all currencies other than domestic currency) to the private sector (households + non-financial corporations) in Poland — source: National Bank of Poland (PLN millions)

2. GDP at market prices of 2000 (Millions of national currency — i.e. Czech Koruna, Hungarian Forint and Polish Zloty respectively

— the Czech Republic, Hungary, Poland — source: Eurostat

3. GDP deflator (prices of the previous year = 100)

— the Czech Republic, Hungary, Poland — own calculations based on Eurostat data

4. Nominal interest rate — Interbank Rates (3 Month, Fixing)

— the Czech Republic, Hungary, Poland, Switzerland — source: EcoWin

5. Nominal exchange rate — Swiss Franc exchange rates against national currency

— the Czech Republic, Hungary, Poland — own calculations based on EcoWin data

Appendix 2: Panel unit root tests

Real domestic currency loans
log-levels

Exogenous variables: Individual effects
Automatic selection of lags based on SIC: 0 to 2

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-0.528	0.299
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	1.037	0.850
ADF - Fisher Chi-square	2.485	0.870
PP - Fisher Chi-square	1.981	0.922

Exogenous variables: None
Automatic selection of lags based on SIC: 0 to 2

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	2.635	0.996
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	0.904	0.989
PP - Fisher Chi-square	0.988	0.986

Real domestic currency loans
first differences

Exogenous variables: Individual effects
Automatic selection of lags based on SIC: 0 to 1

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-3.116	0.001
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-3.431	0.000
ADF - Fisher Chi-square	25.820	0.000
PP - Fisher Chi-square	30.760	0.000

Exogenous variables: None
Automatic selection of lags based on SIC: 0 to 2

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-3.099	0.001
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	16.074	0.013
PP - Fisher Chi-square	31.689	0.000

Real foreign currency loans
log-levels

Exogenous variables: Individual effects
Automatic selection of lags based on SIC: 0 to 1

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-0.993	0.160
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	0.623	0.734
ADF - Fisher Chi-square	7.555	0.273
PP - Fisher Chi-square	4.704	0.582

Exogenous variables: None
Automatic selection of lags based on SIC: 0 to 1

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	1.891	0.971
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	3.114	0.794
PP - Fisher Chi-square	1.895	0.929

Real foreign currency loans
first differences

Exogenous variables: Individual effects
Automatic selection of lags based on SIC: 0

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-4.874	0.000
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-5.419	0.000
ADF - Fisher Chi-square	38.541	0.000
PP - Fisher Chi-square	38.961	0.000

Exogenous variables: None
Automatic selection of lags based on SIC: 0 to 1

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-5.286	0.000
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	34.949	0.000
PP - Fisher Chi-square	42.380	0.000

Real GDP log-levels		
Exogenous variables: Individual effects		
Automatic selection of lags based on SIC: 0 to 5		
Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-0.514	0.304
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	2.479	0.993
ADF - Fisher Chi-square	4.934	0.552
PP - Fisher Chi-square	5.932	0.431
Exogenous variables: None		
Automatic selection of lags based on SIC: 1 to 3		
Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	4.003	1.000
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	0.006	1.000
PP - Fisher Chi-square	0.001	1.000

Real GDP first differences		
Exogenous variables: Individual effects		
Automatic selection of lags based on SIC: 0 to 2		
Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-2.587	0.005
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-3.074	0.001
ADF - Fisher Chi-square	20.142	0.003
PP - Fisher Chi-square	13.443	0.037
Exogenous variables: None		
Automatic selection of lags based on SIC: 0 to 2		
Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-1.163	0.122
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	7.221	0.301
PP - Fisher Chi-square	6.519	0.368

Exchange rate log-levels		
Exogenous variables: Individual effects		
Automatic selection of lags based on SIC: 0		
Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-2.502	0.006
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-1.671	0.047
ADF - Fisher Chi-square	19.130	0.004
PP - Fisher Chi-square	24.466	0.000
Exogenous variables: None		
Automatic selection of lags based on SIC: 0		
Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	0.911	0.819
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	2.413	0.878
PP - Fisher Chi-square	2.365	0.883

Exchange rate first differences		
Exogenous variables: Individual effects		
Automatic selection of lags based on SIC: 0		
Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-7.966	0.000
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-7.329	0.000
ADF - Fisher Chi-square	55.580	0.000
PP - Fisher Chi-square	58.093	0.000
Exogenous variables: None		
Automatic selection of lags based on SIC: 0		
Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-8.832	0.000
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	78.886	0.000
PP - Fisher Chi-square	79.136	0.000

Real domestic interest rates levels

Exogenous variables: Individual effects

Automatic selection of lags based on SIC: 0 to 1

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-2.084	0.019
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-2.177	0.015
ADF - Fisher Chi-square	18.316	0.006
PP - Fisher Chi-square	6.265	0.394

Exogenous variables: None

Automatic selection of lags based on SIC: 0 to 1

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-3.532	0.000
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	27.370	0.000
PP - Fisher Chi-square	10.611	0.101

Real foreign interest rates levels

Exogenous variables: Individual effects

Automatic selection of lags based on SIC: 1 to 5

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-2.900	0.002
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-2.269	0.012
ADF - Fisher Chi-square	15.525	0.017
PP - Fisher Chi-square	9.018	0.173

Exogenous variables: None

Automatic selection of lags based on SIC: 1 to 5

Method	Statistic	Prob.#
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-4.196	0.000
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	25.091	0.000
PP - Fisher Chi-square	30.837	0.000

Newey-West bandwidth selection using Bartlett kernel

Automatic selection of maximum lags

Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Appendix 3: Estimation Results

[std. errors] (p-values) {t-statistics}
(1), (4) – First lags of all exogenous variables (2), (5) – First two lags of all exogenous variables (3), (6) – General-to-specific, starting with specification with first two lags of all exogenous variables
Sargan - Sargan test of over-identifying restrictions
Arellano-Bond (1) - Arellano-Bond test that average autocovariance in residuals of order 1 is 0: H0: no autocorrelation
Arellano-Bond (2) - Arellano-Bond test that average autocovariance in residuals of order 2 is 0: H0: no autocorrelation

Table 2: Panel group FMOLS results

Cointegrating Eq:	ECT^D	ECT^F
LDT_{t-1}	1.00	
LFT_{t-1}		1.00
GDP_{t-1}	-0.40 {15.53}	-0.68 {10.44}
e_{t-1}	1.39 {-2.53}	1.13 {0.15}
_cons	-4.74	1.48
Cointegration test##:	Null: Unit root	
group rho-stat	2.06**	1.78*
group pp-stat	2.48**	2.02**
group adf-stat	2.22**	1.40***

##All reported values are distributed N(0,1)
Panel stats are weighted by long run variances

Table 3: Estimation results using Arellano-Bond estimator, specification with ECT

	First lags of all exogenous variables		First two lags of all exogenous variables		General-to-specific	
	(1) ΔLDT	(4) ΔLFT	(2) ΔLDT	(5) ΔLFT	(3) ΔLDT	(6) ΔLFT
ΔLDT_{t-1}	0.384*** [0.096] (0.000)		0.369*** [0.099] (0.000)		0.369*** [0.093] (0.000)	
ΔLDT_{t-2}	0.042 [0.104] (0.688)		0.067 [0.106] (0.535)		0.063 [0.098] (0.522)	
ΔLDT_{t-3}	0.212** [0.092] (0.022)		0.234** [0.098] (0.017)		0.238*** [0.090] (0.008)	
ΔLFT_{t-1}		0.493*** [0.093] (0.000)		0.253** [0.102] (0.013)		0.468*** [0.091] (0.000)
ΔLFT_{t-2}				0.316*** [0.095] (0.001)		

ΔGDP $_{t-1}$	0.512 [0.667] (0.443)	-0.736 [1.25] (0.556)	0.561 [0.908] (0.537)	-1.459 [1.658] (0.379)		
ΔGDP $_{t-2}$			-0.134 [0.851] (0.875)	2.254 [1.552] (0.146)		
Δe $_{t-1}$	0.032 [0.078] (0.677)	-0.625*** [0.170] (0.000)	0.015 [0.080] (0.853)	-0.598*** [0.159] (0.000)		-0.579*** [0.160] (0.000)
Δe $_{t-2}$			0.061 [0.079] (0.444)	-0.378** [0.165] (0.022)		
rd $_{t-1}$	-0.298*** [0.090] (0.001)	0.307* [0.181] (0.091)	-0.632** [0.275] (0.022)	-0.869* [0.502] (0.084)	-0.340*** [0.092] (0.000)	
rd $_{t-2}$			0.309 [0.278] (0.266)	1.147** [0.508] (0.024)		0.417** [0.178] (0.019)
rchf $_{t-1}$	0.087 [0.086] (0.314)	-0.007 [0.172] (0.968)	0.802** [0.366] (0.029)	1.018 [0.681] (0.135)	0.585** [0.276] (0.034)	
rchf $_{t-2}$			-0.690** [0.350] (0.049)	-1.031 [0.649] (0.112)	-0.478* [0.262] (0.068)	
ECT^D	-0.02* [0.012] (0.097)		-0.069 [0.13] (0.179)		-0.020* [0.011] (0.066)	
ECT^F		-0.033** [0.015] (0.025)		-0.029** [0.014] (0.039)		-0.032** [0.011] (0.002)
Arellano-Bond (1)	-7.09*** (0.000)	-6.11*** (0.000)	-7.34*** (0.000)	-8.18*** (0.000)	-7.56*** (0.000)	-6.16*** (0.000)
Arellano-Bond (2)	-0.28*** (0.000)	1.03 (0.303)	-0.52 (0.605)	-0.52 (0.601)	-0.27 (0.789)	1.16 (0.247)
Sargan	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)

Table 4: Estimation results - seemingly unrelated regression

	First lags of all exogenous variables		First two lags of all exogenous variables		General-to-specific	
	(1) ΔLDT	(4) ΔLFT	(2) ΔLDT	(5) ΔLFT	(3) ΔLDT	(6) ΔLFT
ΔLDT $_{t-1}$	0.496*** [0.085] (0.000)		0.498*** [0.086] (0.000)		0.499*** [0.086] (0.000)	
ΔLDT $_{t-2}$						
ΔLFT $_{t-1}$		0.449*** [0.087] (0.000)		0.270*** [0.095] (0.004)		0.307*** [0.091] (0.001)
ΔLFT $_{t-2}$		0.203** [0.82] (0.013)		0.315*** [0.089] (0.000)		0.292*** [0.089] (0.001)

ΔGDP_{t-1}	1.524***	1.187	1.295	-0.734	1.544***	
	[0.567]	[0.885]	[0.876]	[1.552]	[0.567]	
	(0.007)	(0.180)	(0.139)	(0.636)	(0.007)	
ΔGDP_{t-2}			0.610	3.556**		2.520***
			[0.800]	[1.403]		[0.859]
			(0.446)	(0.011)		(0.003)
Δe_{t-1}	0.028	-0.779***	0.026	-0.610***		-0.649***
	[0.076]	[0.156]	[0.077]	[0.152]		[0.152]
	(0.711)	(0.000)	(0.736)	(0.000)		(0.000)
Δe_{t-2}			0.035	-0.415***		-0.397**
			[0.076]	[0.158]		[0.158]
			(0.645)	(0.009)		(0.012)
rd_{t-1}	-0.127*	0.258*	-0.594**	-0.795*	-0.119*	
	[0.072]	[0.144]	[0.257]	[0.477]	[0.072]	
	(0.078)	(0.073)	(0.021)	(0.096)	(0.097)	
rd_{t-2}			0.452*	1.088		0.363***
			[0.252]	[0.482]		[0.136]
			(0.073)	(0.024)		(0.007)
$rchf_{t-1}$	-0.045	-0.228*	0.589*	0.730		
	[0.065]	[0.122]	[0.347]	[0.640]		
	(0.485)	(0.062)	(0.089)	(0.254)		
$rchf_{t-2}$			-0.612*	-1.012		-0.280**
			[0.333]	[0.621]		[0.114]
			(0.066)	(0.103)		(0.014)
κ	-0.005	-0.022*	-0.006	-0.041***	-0.004	-0.039***
	[0.006]	[0.012]	[0.007]	[0.013]	[0.006]	[0.011]
	(0.455)	(0.063)	(0.181)	(0.001)	(0.551)	(0.001)

Correlogram of residuals – regressions of ΔLDT

	(1)				(2)				(3)			
lag	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob
1	-0.079	-0.079	0.748	0.387	-0.092	-0.092	0.994	0.319	-0.079	-0.079	0.747	0.387
2	-0.014	-0.020	0.770	0.680	-0.041	-0.050	1.196	0.550	-0.029	-0.035	0.846	0.655
3	0.174	0.172	4.459	0.216	0.059	0.051	1.615	0.656	0.169	0.165	4.345	0.227
4	0.069	0.099	5.042	0.283	-0.060	-0.052	2.047	0.727	0.067	0.096	4.898	0.298

Correlogram of residuals – regressions of ΔLFT

	(4)				(5)				(6)			
lag	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob	AC	PAC	Q-Stat	Prob
1	-0.081	-0.081	0.764	0.382	0.016	0.016	0.030	0.862	0.011	0.011	0.013	0.909
2	-0.032	-0.038	0.883	0.643	0.038	0.037	0.197	0.906	0.007	0.007	0.018	0.991
3	0.204	0.200	5.834	0.120	0.103	0.102	1.463	0.691	0.102	0.102	1.270	0.736
4	0.048	0.083	6.114	0.191	-0.050	-0.055	1.760	0.780	-0.056	-0.059	1.647	0.800

Table 5: Estimation results using Arellano-Bond estimator, specification without ECT

	First lags of all exogenous variables		First two lags of all exogenous variables		General-to-specific	
	(1) ΔLDT	(4) ΔLFT	(2) ΔLDT	(5) ΔLFT	(3) ΔLDT	(6) ΔLFT
ΔLDT_{t-1}	0.419*** [0.091] (0.000)		0.419*** [0.095] (0.000)		0.435*** [0.089] (0.000)	
ΔLFT_{t-1}		0.411*** [0.101] (0.000)		0.221* [0.114] (0.051)		0.291*** [0.106] (0.006)
ΔGDP_{t-1}	1.315** [0.588] (0.025)	0.354 [1.025] (0.730)	0.912 [0.927] (0.325)	-0.644 [1.699] (0.705)	1.349** [0.584] (0.021)	
ΔGDP_{t-2}			0.626 [0.844] (0.458)	2.836* [1.536] (0.065)		1.956** [0.979] (0.046)
Δe_{t-1}	0.032 [0.078] (0.687)	-0.525*** [0.181] (0.004)	0.050 [0.083] (0.544)	-0.343* [0.182] (0.060)		-0.419** [0.178] (0.019)
Δe_{t-2}			0.062 [0.081] (0.442)	-0.114 [0.149] (0.446)		
rd_{t-1}	-0.197* [0.105] (0.060)	0.603*** [0.228] (0.008)	-0.584** [0.271] (0.031)	-0.839 [0.524] (0.109)	-0.243*** [0.091] (0.008)	
rd_{t-2}			0.395 [0.268] (0.141)	1.655*** [0.567] (0.003)		0.867*** [0.233] (0.000)
$rchf_{t-1}$	-0.116 [0.127] (0.358)	-0.710*** [0.264] (0.007)	0.581 [0.366] (0.112)	0.785 [0.703] (0.264)		
$rchf_{t-2}$			-0.762** [0.357] (0.033)	-1.606** [0.728] (0.027)		-0.787*** [0.264] (0.003)
Arellano-Bond (1)	-5.200*** (0.000)	-6.230*** (0.000)	-5.100*** (0.000)	-6.220*** (0.000)	-5.110*** (0.000)	-6.340*** (0.000)
Arellano-Bond (2)	-0.730 (0.467)	0.820 (0.414)	-0.830 (0.409)	1.630 (0.104)	-0.760 (0.449)	1.180 (0.238)
Sargan	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)	(1.000)