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Transmission of monetary policy and exchange rate shocks under foreign currency lending

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Abstract

This paper analyses the differences in reaction of domestic and foreign currency lending to monetary and exchange rate shocks, using a panel VAR model estimated for three biggest Central and Eastern European countries (Poland, the Czech Republic and Hungary). Our results point toward a drop in domestic currency loans and an increase of foreign currency credit in reaction to monetary policy tightening in Poland and Hungary, suggesting that the presence of foreign currency debt weakens the transmission of monetary policy. A currency depreciation shock leads to an initial decline in foreign currency lending, but also in loans denominated in domestic currency as central banks react to a weaker exchange rate by increasing the interest rates. However, after several quarters, credit in foreign currency accelerates, indicating that borrowers start using it to substitute for depressed domestic currency lending.

JEL: E44, E52, E58

Keywords: foreign currency loans, lending currency structure, monetary policy and exchange rate shocks, CEE countries

1 Introduction

In many countries around the world, the credit structure is characterized by significant proportions of loans denominated in foreign currencies (FCLs). While this feature is also in place in some developed countries, it is exceptionally prevalent in the emerging economies (see e.g. Galindo and Leiderman (2005) and Hake et al. (2014) for evidence from Latin America or Kim et al. (2015) and Bougheas et al. (2016) for evidence from East Asia), in particular those from the Central and Eastern European (CEE) region.

As Figure 1 reveals, the CEE countries differ substantially in terms of the currency substitution. While the proportion of FCLs in the Czech Republic is only a little bit higher than in the advanced economies from the EU15 group, in some countries, in particular the Baltic states just before the euro adoption[1], the great majority of loans is denominated in foreign currencies. This feature is present not only in the sector of non-financial corporations, but also among households. Such big diversity in currency structure raises a question about its sources and implications of the widespread euroization of lending for country's macroeconomic situation.

Figure 1: Share of foreign currency loans by institutional sector
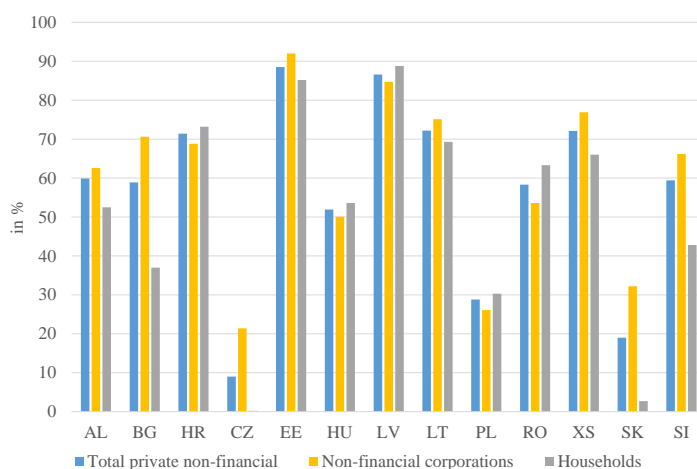
Notes: The percentage shares of foreign currency loans are based on the official statistics published by country's central banks and ECB. The shares are for 2014, except for Estonia, Latvia, Slovakia and Slovenia, for which they cover the year prior the euro adoption.

It has been well documented in the literature that the credit currency structure crucially affect the transmission of monetary policy (see e.g. Brzoza-Brzezina et al. 2017, Sirtaine and Skamnelos 2007). By affecting the domestic interest rate, the central

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[1]As discussed in the literature, the expectation of euro area entry increases the attractiveness of foreign currency loans as the exchange risk disappears after the euro adoption (see e.g. Fidrmuc et al. 2013, Neanidis 2010, Rosenberg and Tirpak 2009).

banks can influence the size of domestic currency lending. If the borrowers are able to substitute FCLs for domestic currency denominated loans, the role which the domestic interest rate plays for the economy may be greatly limited, making it more difficult for the central banks to efficiently conduct monetary policy. Many empirical studies have confirmed this effect and reported an increase of foreign currency loans after tightening of monetary policy. Using the panel of four CEE economies, Brzoza-Brzezina et al. (2010) show that more than a half of loans eliminated in response to the restrictive monetary policy is replaced with FCLs. The substitution effect between both types of lending in Hungary has been found by Horváth et al. (2006)[2]. The results of studies by Wróbel and Pawłowska (2002) and Kapuściński et al. (2016) point toward the presence of substitution effect in Poland.

The share of FCLs is, however, important not only because of its impact on the monetary policy transmission. High proportions of foreign currency loans create also an additional channel through which the exchange rate movements affect the real economy. The literature on currency mismatches indicates that conditional on the amount of credit issued in foreign currency, the exchange rate depreciation can tighten firm's financial conditions and hence curb its investment spending (Céspedes et al. 2004, Serena and Sousa 2017). Lower firms' investment can limit the positive impact which the weaker currency exert on output thanks to the increased competitiveness and boosting external demand (higher exports).

In this paper, we analyse how the economy responds to the monetary policy and depreciation shocks in the countries characterized by the high proportions of foreign currency credit. More specifically, we ask a question about the differences in reactions of domestic and foreign currency loans and changes in share of FCLs in total loans. Toward this aim, we use the data from three biggest CEE countries, i.e. Poland, the Czech Republic and Hungary, and estimate the Bayesian panel vector autoregressive (VAR) model with a hierarchical prior inspired from Jarociński (2010). This kind of estimation differs from the standard panel models as it allows for cross-subsectional heterogeneity, i.e. the VAR coefficients and residual variances are allowed to be unit-specific, though similar across the panel. The parameters' estimates are pushed towards the similar values as a prior distribution for the each country's coefficients is assumed to be centered at the common mean. Using the Bayesian approach allows to mitigate the problem of short samples available for the analysed countries and obtain more reliable results. In order to identify the monetary policy and exchange rate shocks, we impose a set of sign and zero restrictions.

Although the dynamics of both types of loans after the monetary policy shock in CEE countries has been already investigated by Brzoza-Brzezina et al. (2010), it is still worth to verify their results using different estimation method, more sophisticated

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[2]The similar study conducted for Latvia by Benkovskis (2008) failed to find the significant replacement of loans in domestic currency with loans in foreign currency.

identification scheme and more standard set of variables[3]. To the best of my knowledge, the formal analysis of the impact of exchange rate shocks on the loans currency structure in CEE region has not been so far conducted. This paper aims at filling this gap.

Overall, our empirical results confirm the significant differences in responses of both types of credit to monetary policy shock in Poland and Hungary. After monetary policy tightening, we observe the decrease in domestic currency lending and rise in foreign currency denominated loans. The reaction of loans in the Czech Republic is not statistically significant. The responses to the exchange rate shock point toward the decline in domestic currency loans. This drop can be attributed to the lower attractiveness of domestic currency lending resulting from the higher interest rates observed after the depreciation. The sign of the response of FCLs to exchange rate shock varies over the time horizon. The currency depreciation makes the FCLs less favourable and hence, just after the shock, we observe the drop in foreign currency lending. However, in several quarter, the FCLs accelerate, suggesting that the borrowers start to replace reduced domestic currency loans with loans in foreign currency. Moreover, our results show that in Poland and Hungary we observe statistically significant, though quantitatively weak, increase in share of foreign currency loans in total loans both after the monetary policy and exchange rate shocks. The changes in the loans structure in the Czech Republic are insignificant.

The rest of this paper is structured as follows. The next section collects the most important stylized facts about foreign currency lending. The third section presents the econometric model used in our analysis, describes the data and estimation procedure and discusses the identification scheme. The fourth section presents the results of the econometric analysis. The last section concludes.

2 Stylized facts about foreign currency lending

The literature on foreign currency lending has formulated a number of observations and predictions about potential determinants of currency composition of loans. These papers include both purely empirical studies based on micro-level (see e.g. Fidrmuc et al. 2013) and macro-level (see e.g. Hake et al. 2014) data, and theoretical models (see e.g. Kolasa 2016). In this section we summarize the most important stylized facts about lending in foreign currency and briefly illustrate how its determinants identified in the literature are related to the proportion of foreign currency loans observed in the CEE region. To this end we use a simple correlation analysis based on an unbalanced panel of 13 CEE countries for the period 2003-2014. The sample details are reported in the

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[3]In order to analyse the impact of monetary policy shock on different types of credit, Brzoza-Brzezina et al. (2010) follow the traditional, frequentist approach, estimate standard VAR model and use Cholesky identification scheme. Instead of nominal interest rate, they use the real interest rate as one of the endogenous variables, which is not a common practice in monetary VAR models.

Appendix A.1. The calculated correlation coefficients are presented in Table 1. Moreover, Appendix A.2 depicts the plots of shares of FCLs versus each of the potential drivers of loans currency structure. All scatter plots present the unweighted data averages over the entire collected dataset.

Data on shares of FCLs in total outstanding loans to a private non-financial sector are annual and have been collected from each country's central bank official statistics. Other variables used in the correlation analysis are taken from standard data sources, such as World Bank's, OECD's and Eurostat databases and ECB statistics.

The great majority of studies on loans currency structure use the interest rate differential as the explanatory variable (see e.g. Barajas and Morales 2003, Luca and Petrova 2008). It seems to be quite intuitive that the interest rate differential, which reflects the difference between the price of domestic currency loans and foreign currency loans, should affect the proportion of FCLs positively. As discussed in the literature (Steiner 2011), the positive relationship between interest rate differential and popularity of foreign currency loans might also have a supply-side explanation: banks are eager to give cheaper credit in order to attract more new clients. Figure presented in the Appendix A.2 suggests that the relationship between the proportions of FCLs in total loans and interest rate differentials, calculated as the differences between the 3-month money market interest rates in a given country and the euro area interest rates, is positive. The results of correlation analysis confirm the positive relation between these two variables, though its strength seems to rather small.

Table 1: Correlations with share of foreign currency loans

	Correlation coefficient (p-value)
Interest rate differential	0.16 (0.09)
Interest rate standard deviation	0.21 (0.02)
CPI inflation	0.12 (0.21)
Standard deviation of CPI inflation	0.40 (0.00)
Relative (to mean) standard deviation of exchange rate	-0.43 (0.00)
Openness index	-0.05 (0.61)
GDP per capita	-0.20 (0.03)
Remittances balance to GDP ratio	-0.38 (0.00)
Net international investment position to GDP ratio	-0.46 (0.00)

Another factor which might affect the choice of the credit currency is the volatility of the interest rate (Hake et al. 2014). Bigger fluctuations of the domestic interest rate might encourage agents to shift to the foreign currency borrowings as their costs are relatively more stable. Our results indicate that this relationship is in place in the considered dataset. As a measures of interest rates, we use the data on 3-month money market interest rates.

Inflation (measured by the annual change of Consumer Price Index) and inflation volatility appear to be positively correlated with the degree of loans' euroization, see figure in the Appendix A.2. However, Table 1 indicates that this relation is statistically significant only in case of the latter variable at each used in the literature significance level. Higher inflation volatility translates into more volatile real interest rates and thus encourage more foreign currency borrowing. On the other hand, high inflation levels incentivise households to save in foreign currencies, which in turn results in higher foreign currency lending (Hake et al. 2014).

The evidence on the role of the exchange rate volatility for the currency substitution is rather mixed. On one hand, its higher volatility increases exchange rate risk, discouraging the borrowers from taking FCLs (see Barajas and Morales 2003, Csajbok et al. 2010). On the other hand, lenders, in particular those holding large foreign currency deposits, may increase supply of FCLs in order to protect themselves from exchange risk (Honig 2009). In the empirical literature there is no consensus, which factors (demand-side or supply-side) dominate. Our analysis indicates that there is a negative relationship between the relative (to the mean) standard deviation of the exchange rate and the proportion of foreign currency loans in the CEE countries. As a measure of exchange rates, we use the exchange rates in each country's national currency units per euro.

Another potential determinant of loans' euroization is the openness of economy. Relatively big imports and exports may require the foreign currency accounts to settle the transactions, which in turn induce more foreign currency borrowing. In this context, the literature has also stressed the so-called natural hedging argument (see Goswami and Shrikhande 2001), according to which the exporters receiving the payments in foreign currencies may wish to borrow in the same foreign currencies in order to mitigate exchange rate risk. It can also be, however, argued that foreign currency revenues from trade limit the necessity to take out the FCLs (Arteta 2002). Our results for trade openness (measured by the ratio of sum of exports and imports of goods and services to GDP) suggest no significant link with FCLs shares.

Our correlation analysis indicates that the degree of currency substitution decreases with GDP per capita. This result is not surprising as foreign currency borrowings tend to be more popular in the less developed economies (Luca and Petrova 2008). The ratio of the remittances balance (difference between remittances outflows and inflows) to GDP appears to be negatively associated with borrowing in foreign currencies. This seems to be both intuitive and consistent with results of other studies (see e.g. Fidrmuc et al. 2013) as earnings received in foreign currency can serve as a natural hedge against exchange rate fluctuations and thus make FCLs less risky. Another factor which may affect the loans currency structure is country's net international investment position, i.e. stock of external assets minus stock of external liabilities (Kolasa 2016). In general, it can be observed that countries with large negative NIIP to GDP ratios are characterized by higher proportion of FCLs. Results reported in Table 1 confirm that more indebted

countries tend to have higher shares of foreign currency borrowings.

To sum up this part of the analysis, our results for CEE region suggest that there is a positive link between the share of FCLs and interest rate differential, volatility of interest rate and variability of inflation. The proportion of foreign currency denominated loans seems to negatively related to the exchange rate variability, income level measured by GDP, remittances balance and net international investment position.

3   Econometric model

In the section, we estimate the random effect panel VAR model with a hierarchical prior inspired from Jarociński (2010). Broadly speaking, the main difference between this kind of estimation and the standard panel models lies in the fact that it allows for cross-subsectional heterogeneity, i.e. the VAR coefficients and residual variances are allowed to be unit-specific, though similar across the panel. A prior distribution for the each country's coefficients is assumed to be centered at the common mean, which pushes the parameters' estimates towards the similar values. The estimation is conducted with the use of the Bayesian Estimation, Analysis and Regression toolbox (BEAR) presented in Dieppe et al. (2016). Although the detailed description of the model can be found in Dieppe et al. (2016), we include it nevertheless so that the presentation is self-contained.

3.1   Panel VAR with a hierarchical prior

For each unit c in the panel, $c = 1 \dots$ C, we consider the following model:

$$y_{c,t} = A_c^1 y_{c,t-1} + \dots + A_c^p y_{c,t-p} + C_c w_t + e_{c,t} \tag{1}$$

where $y_{c,t}$ is a vector of n endogenous variables, w_t is a vector of m exogenous variables common for all units, $e_{c,t}$ is a vector of VAR innovations which are i.i.d. $N(0, \Sigma_c)$, p denotes number of lags and $t = 1 \dots$ T, denotes time periods.

In order to write the model in the matrix form, we first define a vector $x'_{c,t} = [y'_{c,t-1} \dots y'_{c,t-p} w'_t]$ and then stack vertically $y'_{c,t}$ and $x'_{c,t}$ for all t to obtain:

$$Y_c = X_c B_c + E_c \tag{2}$$

where Y_c and E_c are $T \times n$, X_c is $T \times k$ with $k = np + m$ and B_c is $k \times n$.

For convenience we rewrite the model in the vectorized form:

$$vec(Y_c) = (I_n \otimes X_c) \, vec(B_c) + vec(E_c) \tag{3}$$

and reformulate it as:

$$y_c = \bar{X}_c \beta_c + e_c \tag{4}$$

where $y_c = vec(Y_c)$ is $nT \times 1$, $\bar{X}_c = (I_n \otimes X_c)$ is $nT \times n(np + m)$, $\beta_c = vec(B_c)$ is $n(np + m) \times 1$, $e_c = vec(E_c)$ is $nT \times 1$ and is i.i.d. $N(0, \bar{\Sigma}_c)$ with $\bar{\Sigma}_c = \Sigma_c \otimes I_T$.

The coefficients included in β_c are assumed to be drawn from normal distribution with a mean $\bar{\beta}$ common for all units in the panel and common variance Σ_b, i.e. $\beta_c \sim N(\bar{\beta}, \Sigma_b)$.

For $\bar{\beta}$ we assume the non-informative uniform hyperprior:

$$\pi(\bar{\beta}) \propto 1 \tag{5}$$

The hyperprior for Σ_b resembles the coefficient covariance matrix of the Minnesota prior. More precisely, it is based on the $n(np + m) \times n(np + m)$ diagonal covariance matrix Ω_b in which:

1. elements which control the variance of the prior for parameters relating i-th endogenous variable to its own l-th lag are given by:

$$\sigma_{b_{ii}}^2 = \left(\frac{1}{l^{\lambda_3}}\right)^2 \tag{6}$$

2. elements which control the variance of the prior for parameters relating i-th endogenous variable to the l-th lag of the j-th variable are given by:

$$\sigma_{b_{ij}}^2 = \left(\frac{\sigma_i^2}{\sigma_j^2}\right)\left(\frac{\lambda_2}{l^{\lambda_3}}\right)^2 \tag{7}$$

3. elements which control the variance of the prior for parameters relating to exogenous variables are given by:

$$\sigma_{c_i}^2 = \sigma_i^2 \left(\lambda_4\right)^2 \tag{8}$$

In the above formulas, σ_i allow to adjust for the differences in the size of coefficients in β and are computed as the standard error from autoregressive models fitted by OLS and estimated for each of the endogenous variable on the pooled data from all units.

The covariance matrix Σ_b is then given by:

$$\Sigma_b = \left(\lambda_1 \otimes I_q\right)\Omega_b \tag{9}$$

where $q = n(np + m)$ and λ_1 determines the overall tightness of the prior and is treated as a random variable. For the prior for parameter λ_1, Jarociński (2010) and Gelman (2006) recommend inverse Gamma distribution with small shape parameters or uniform uninformative prior. In the BEAR toolbox, the first solution is implemented and the prior for λ_1 is given by:

$$\lambda_1 \sim IG(s/2, v/2) \tag{10}$$

For the error variances, the standard diffuse priors are used:

$$\pi(\Sigma_c) \propto |\Sigma_c|^{-\frac{n+1}{2}} \tag{11}$$

The priors used in estimation are conditionally conjugate, which allows obtaining the posterior distributions with the Gibbs sampler.

3.2 Data and estimation procedure

In our analysis we consider a panel consisting of three CEE countries: Poland, the Czech Republic and Hungary. Other countries from the region are excluded from the analysis either due to their currency regimes (currency boards in the Baltic countries) or limited availability of data on loans' currency structure.

For estimation, we use quarterly data. The sample spans the period from 1997q1 to 2008q4, which gives 48 observations for each country in the panel. We deliberately finish the sample in 2008 as we do not want to include the period of economic turmoil connected with global financial crisis. Moreover, Hungary introduced restrictions on lending in foreign currencies in 2010 (Yesin 2013) which significantly affected the sources of loans dynamics. Since then, the changes in the stock of foreign currency loans started to be driven mainly by the repayment of existing loans and not by the creation of the new ones. This source of changes in loans volumes seems to be less important from the perspective of the analysis carried out in this paper.

In the model, there are seven endogenous variables: four variables commonly used in the standard open economy monetary VAR models, i.e. output, prices, exchange rate and domestic interest rate, loans in domestic currency, loans in foreign currency and the price of foreign currency loans i.e. foreign interest rate.

Output in the model is measured as the log of real GDP at market prices of 2005. As a measure of prices, we use the log of GDP deflator. The exchange rates for the Czech Republic and Hungary are measured as the log of the weighted average of the exchange rates in national currency units per euro and per Swiss franc, where the weights are determined as the shares of loans in respective foreign currency in total foreign currency loans. We have more detailed data on FCLs structure for Poland and therefore while calculating the weighted exchange rate, we can additionally include the data on the exchange rate of Polish zloty per U.S. dollar. Domestic and foreign currency loans are measured as the logs of end-of-period stock of total outstanding loans to a private non-financial sector in, respectively, domestic and jointly all foreign currencies. Both domestic and foreign currency loans are expressed in national currency units. Since the foreign currency loans are converted to domestic currency, they are affected by the exchange rate movements. In order to disentangle this purely accounting effect which could bias our results, we adjust our FCLs data for changes in exchange rate. Interest rates are measured as the 3-month money market interest rates. For the foreign interest rates, we use the weighted average of the 3-month interest rate in the Euro Area and Switzerland (for the Czech Republic and Hungary) or in the Euro Area, Switzerland and the U.S. (for Poland) with the weights determined in the same way as for the exchange rates. Additionally, in the estimation, we include real output of the Euro Area as the exogenous control variable.

The data on the detailed structure of foreign loans is very limited. However, as we need it to calculate weighted interest and exchange rates, we use all available

information to construct best possible approximations. For the Czech Republic, we approximate the structure of FCLs to the private non-financial sector by the structure of FCLs to households only. The division of households' FCLs into those denominated in Swiss francs and those denominated jointly in all other foreign currencies starting from 2005q1 can be found in CHF Lending Monitor (see Yesin 2013). We assume that the loans in other foreign currencies consist of only those denominated in euro. For our approximation for Hungary, we use the information on the structure of housing loans. Since 2000q1 the Hungarian central bank has published the data on volumes of housing loans denominated in euro and those denominated jointly in all other foreign currencies. We assume that the loans in other foreign currencies consist of only those denominated in Swiss francs. For Poland, we do not have to make any approximations for the periods after 2004q1, since the detailed data on volumes of the private non-financial sector's FCLs in euro, Swiss francs and U.S. dollars is available. In each country, for the periods for which we do not have any information, we assume the same FCLs structure as in the last available quarter.

All time series used in the estimation are demeaned in order to get rid of country fixed effects. The data is taken from Eurostat (output, prices and interest rates), countries' central banks and CHF Lending Monitor (volumes and currency structures of loans) and IMF International Financial Statistics (exchange rates).

For maintaining the degrees of freedom, we estimate the VAR model with two lags. The posterior distributions of model coefficients are approximated using Gibbs sampler. From the generated sequence of 1 010 000 draws, the first 10 000 replications are dropped. In order to ensure that the draws used to simulate posterior distributions are not autocorrelated, only every 1 000th draw is kept. Therefore, the final estimates are based on 1 000 Gibbs replications. To evaluate the convergence of generated sequences we use Matlab codes from Blake and Mumtaz (2012) in which they implement the Geweke (1992) diagnostics for convergence of a Markov chain.

For our prior distributions, we choose the values of the parameters which are commonly used in the VAR literature (see Canova 2007). Hence, λ_2 is equal to 0.5, λ_3 is set to 2, λ_4 equals 100 000 and for s and v we choose 0.001. As a robustness check, we estimated the model with other used in the literature values of those parameters and found that this change does not affect the estimation results significantly.

3.3 Identification of monetary policy and exchange rate shocks

In order to identify monetary and exchange rate shocks, we use a set of zero and sign restrictions imposed on the immediate response of endogenous variables. The assumed restrictions are standard in the VAR literature, see e.g. Farrant and Peersman (2006), Jarociński (2010), An and Wang (2012) or Arratibel and Michaelis (2014), and are summarized in Table 2.

More precisely, for identification we assume the following set of restrictions:

1. Foreign interest rate, output and prices do not respond simultaneously neither to monetary policy nor exchange rate shock.

2. Positive monetary policy shock leads to a rise in interest rate and exchange rate appreciation.

3. Positive exchange rate shock results in interest rate increase and exchange rate depreciation.

As in our analysis we focus primarily on the dynamics of different types of loans, we do not want to make any assumptions about their behaviour and we do not impose any restrictions on the response of lending in domestic and foreign currency neither to monetary nor to exchange rate shock.

Table 2: Sign and zero restrictions for identification scheme

	Monetary policy shock	Exchange rate shock
Foreign interest rate	0	0
Output	0	0
Prices	0	0
Interest rate	+	+
Exchange rate	−	+
Loans in domestic currency	●	●
Loans in foreign currency	●	●

Note: + denotes coefficients constrained to be positive, − denotes coefficients restricted to be negative, ● denotes no restrictions

Technically, the restrictions presented in Table 2 are imposed in the way proposed by Haberis and Sokol (2014). In the first step, we calculate the Cholesky factor of the residual covariance matrix, $\mathbf{C}$. In the second step, we multiply $\mathbf{C}$ by $\mathbf{Q}$ matrix obtained from QR decomposition of 7×7 random matrix drawn from the standard normal distribution. In the third step, we rotate the obtained product using Givens rotation matrices and get a candidate identification matrix $\mathbf{F}$ which satisfies $e_t \equiv \mathbf{F}\epsilon_t$, where ϵ_t denote orthogonal structural shocks. The number of Givens matrices used in the multiplication is equal to the number of imposed zero restrictions. Thus, in our case the candidate identification matrix is given by:

$$\mathbf{F} = \mathbf{C}\mathbf{Q}\prod_{i=1}^{6}\mathbf{G}_i\left(\theta_i\right) \tag{12}$$

where $\mathbf{G}_i\left(\theta_i\right)$ denotes the Givens rotation matrix parametrised by angle θ_i. The angles $\theta = [\theta_1, ..., \theta_6]$ are found by solving the system of six equations obtained by setting the elements of $\mathbf{F}$ matrix corresponding to responses of foreign interest rate, output and prices to monetary policy and exchange rate shocks to zero.

In the next step, we check whether the obtained **F** matrix is in line with the imposed sign restrictions. If the matrix satisfies the restrictions, it is stored. Otherwise, we draw another 7×7 matrix from the standard normal distribution and repeat the procedure from the second step.

4   Empirical results

Figure 2 depicts the 16th, 50th and 84th percentiles of the posterior distribution of impulse responses to a one standard deviation monetary policy shock for each country. Responses are presented over a 5-year horizon (20 quarters) after the shock.

The immediate responses of foreign and domestic interest rates, output, prices and exchange rate reflect our imposed identifying restrictions: output, prices and foreign interest rate are not affected, domestic interest rate increases and exchange rate appreciates. The shape of the responses is similar for each of the countries, but their amplitude differs across the considered economies.

The median initial response of the interest rate is equal to around 43 basis points in Hungary and Poland and less than 30 basis points in the Czech Republic. The rise in interest rates persists for 7 quarters in each country. The immediate appreciation ranges from 1.2% in the Czech Republic to 2.0% in Poland. The fall in the exchange rate is revered after 1.5 years.

The responses of output and prices are consistent with the literature. Following the contractionary monetary policy shock, we observe the negative and quite persistent response of output. In 20 quarters after the shock, the median output decline is still around 0.2% in all analysed economies. The price level response in first quarters after the shock is positive, but the uncertainty bands include zero so the increase is not statistically significant. After 3 quarters we observe statistically significant price decline. The response in price level is a bit less persistent than in output and it dies out after 5 years.

The median response of foreign interest rate is slightly negative. The confidence bands, however, put a lot of probability mass on both sides of zero. The analysed countries belong to the group of small open economies so foreign variables should not be affected by what happens in the domestic economy. Thus, lack of significant response of foreign interest rate to domestic monetary policy shock is not surprising.

The response of domestic currency loans to contractionary monetary policy shock is rather intuitive. The increase in the interest rate differential, which reflects the difference between the price of domestic and foreign currency loans, should negatively affect the first type of lending. The strongest median fall in domestic currency loans is observed in around 15 quarters after the shock and is equal to as much as 2.9% in Poland and only 1.8% both in the Czech Republic and Hungary. For the Czech Republic, the reaction of domestic currency loans is statistically insignificant along the whole 5-year horizon. The

estimate of the impulse response of lending in domestic currency in the Czech Republic is also the least precise.

The sign of the median reaction of foreign currency loans changes over the time horizon. After the initial, slight decline, we observe the FCLs increase. Drop in domestic currency lending and rise in foreign currency loans after tightening of monetary policy suggest that there is some degree of substitution between both types of lending. This conclusion is consistent with the results obtained by Brzoza-Brzezina et al. (2010) with the use of standard VAR model and Cholesky scheme for identification of monetary policy shock. The strongest median response of foreign currency loans is observed in about 1.5 years after the shock and ranges from 0.7% in the Czech Republic to 1.2% in Hungary. However, similarly to the domestic currency loans, the response of foreign currency lending in the Czech Republic is not statistically significant. After around 3 years, the median response of foreign currency loans starts to be negative. This drop can result from the exchange rate depreciation observed in the longer horizon. Weaker domestic currency makes FCLs less attractive and can deter potential borrowers from taking loans in foreign currency.

Figure 2: Impulse responses to monetary policy shocks, 16th, 50th and 84th percentiles of the posterior
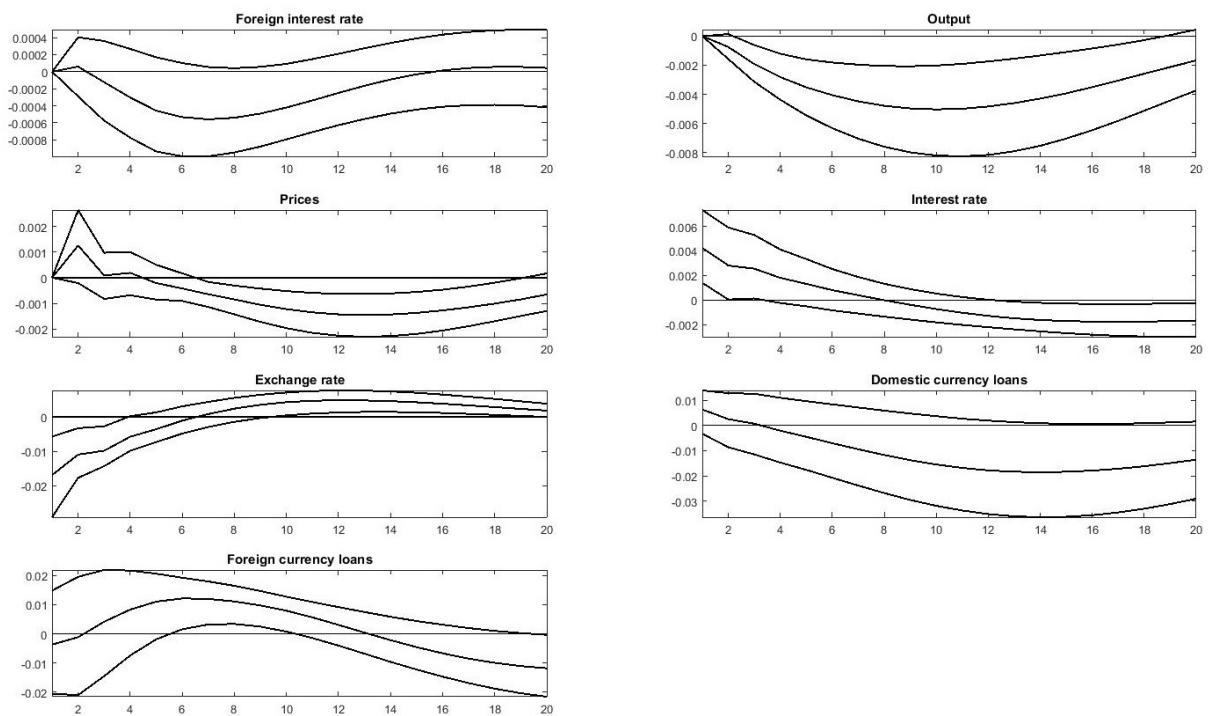
Poland
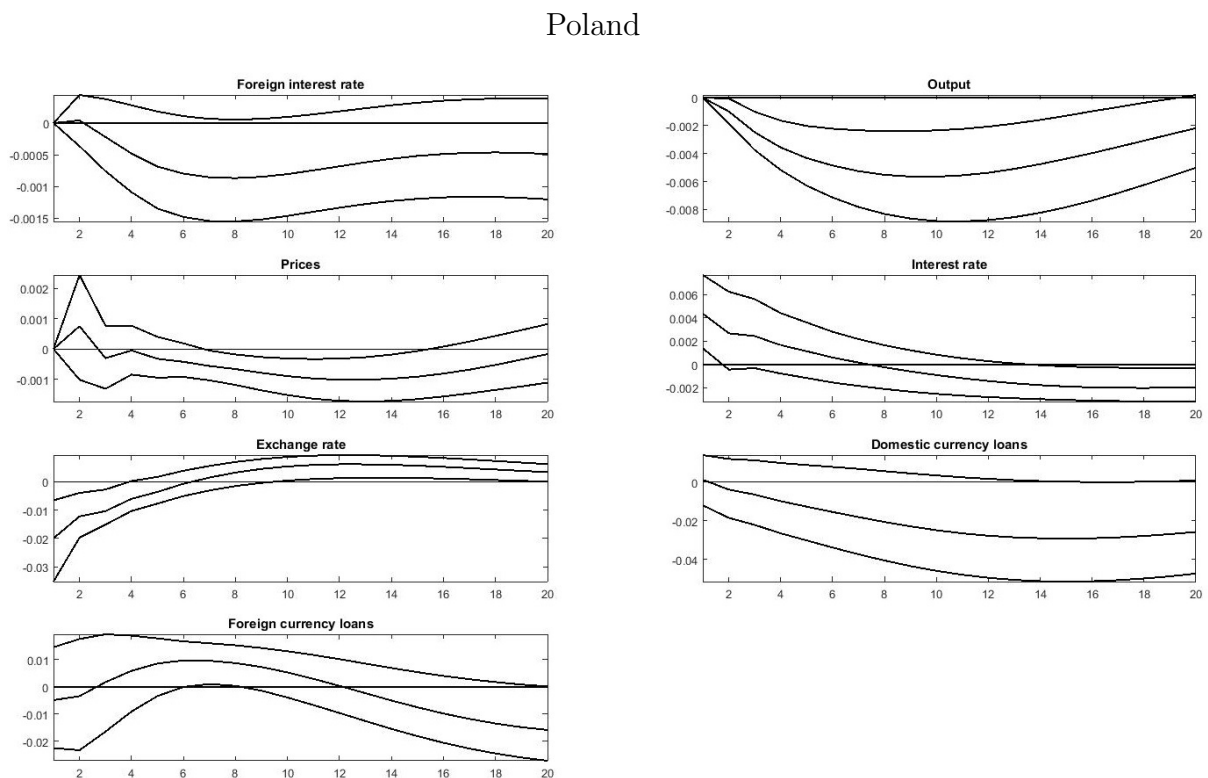
the Czech Republic
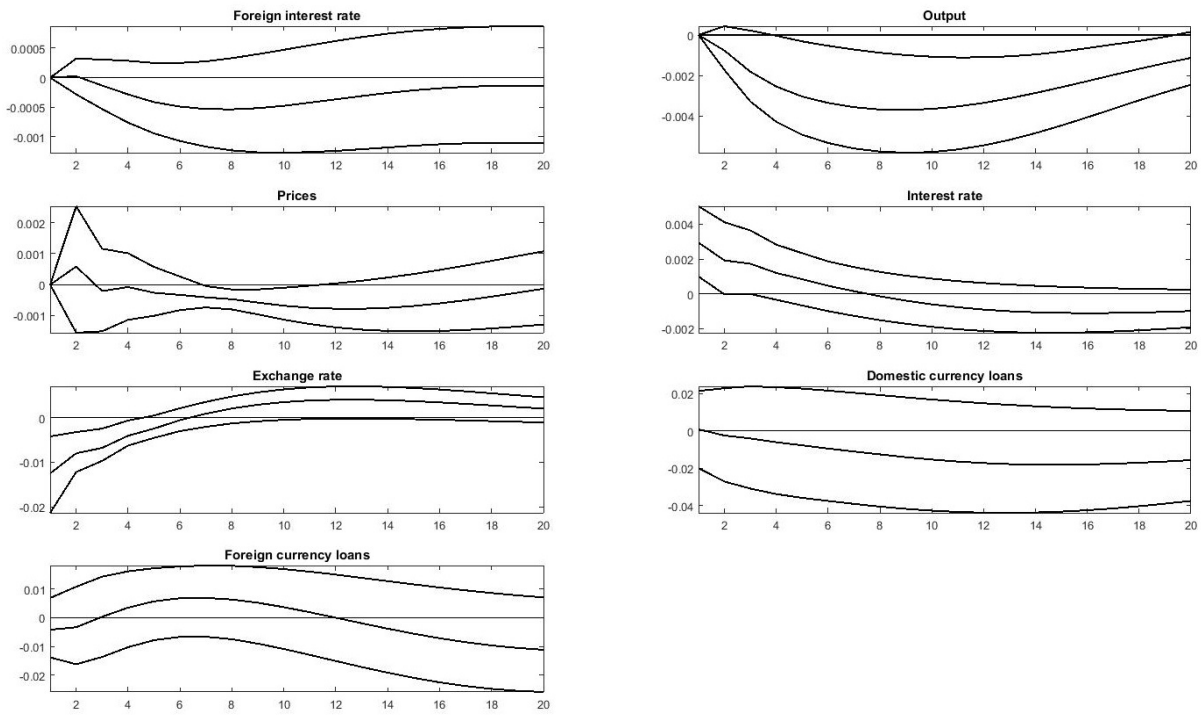
Hungary

Figure 3 presents median impulse response to a one standard deviation exchange rate shock together with 68% confidence interval. As for the monetary policy shock, the responses are plotted for a 5-year horizon after the shock.

The identified exchange rate shock is associated with the median exchange rate depreciation of 1.1% in the Czech Republic, 1.6% in Hungary and 2.1% in Poland. Consistently with the imposed restriction, the exchange rate depreciation is followed by the rise in the domestic interest rate. The strongest median interest rate increase is observed in the second quarter after the shock and ranges from 33 basis points in the Czech Republic to 59 basis points in Poland.

The literature provides rather mixed evidence on the sign of output reaction after the exchange rate depreciation (see Arratibel and Michaelis 2014). On the one hand, weaker currency encourages more exports and thus can lead to output increase. On the other hand, depreciation is accompanied by the higher interest rate, which in turn exerts negative pressure on output. Our empirical results suggest that the second effect prevails. This result is consistent with the analysis conducted by Kapuściński et al. (2016) for the Polish economy.

In the first periods, depreciation leads to the inflation increase which is in line with the general consensus on the pass-through of the exchange rate shock on the price level. In the longer horizon, the impact of higher interest rates seems to dominate and we observe a slight decline in prices. As for the monetary policy shock, the response of foreign interest rate to exchange rate shock is mostly statistically insignificant.

Concerning domestic currency loans, they respond negatively to the positive exchange rate shock, albeit in Poland and the Czech Republic this response seems to be insignificant. Drop in domestic currency loans is rather reasonable as the exchange rate depreciation is followed by the increase in interest rate, which in turn makes the lending in domestic currency less attractive.
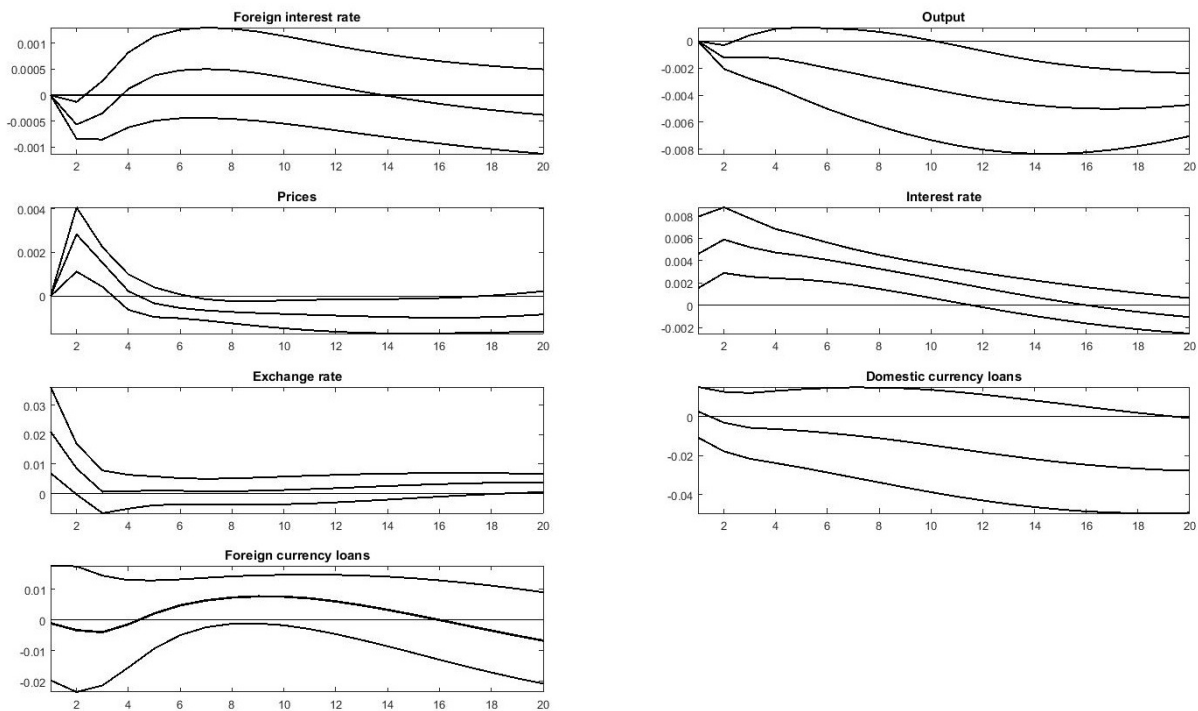
The dynamics of foreign currency loans is driven by two forces which affect their movements in the opposite directions. In response to the realisation of the depreciation shock, borrowers can reduce their demand for foreign currency loans. However, this shock leads also to tightening of the monetary policy and thus trims domestic currency lending. As a result, if some kind of substitution effect is in place, some borrowers may decide to replace less attractive domestic currency loans with loans in foreign currency.

Just after the depreciation shock, the median response of foreign currency lending in Poland and the Czech Republic is negative, suggesting that the borrowers limit their foreign currency lending in reaction to the realisation of the exchange rate risk. The largest decline is observed after around 2 quarters and amounts to 0.4% in Poland and 0.6% in the Czech Republic. After 5 quarters, the impact of tighter monetary policy starts to dominate and borrowers increase their demand for FCLs in order to substitute for less favorable domestic currency loans. In around 3.5 years after the depreciation shock, we again observe a drop in the median response of FCLs. In Hungary, the effects of higher interest rates and exchange rate depreciation seem to balance each other in first quarters after the shock and the volume of FCLs basically does not change. In the longer horizon, the shape of the impulse response is similar to the one observed
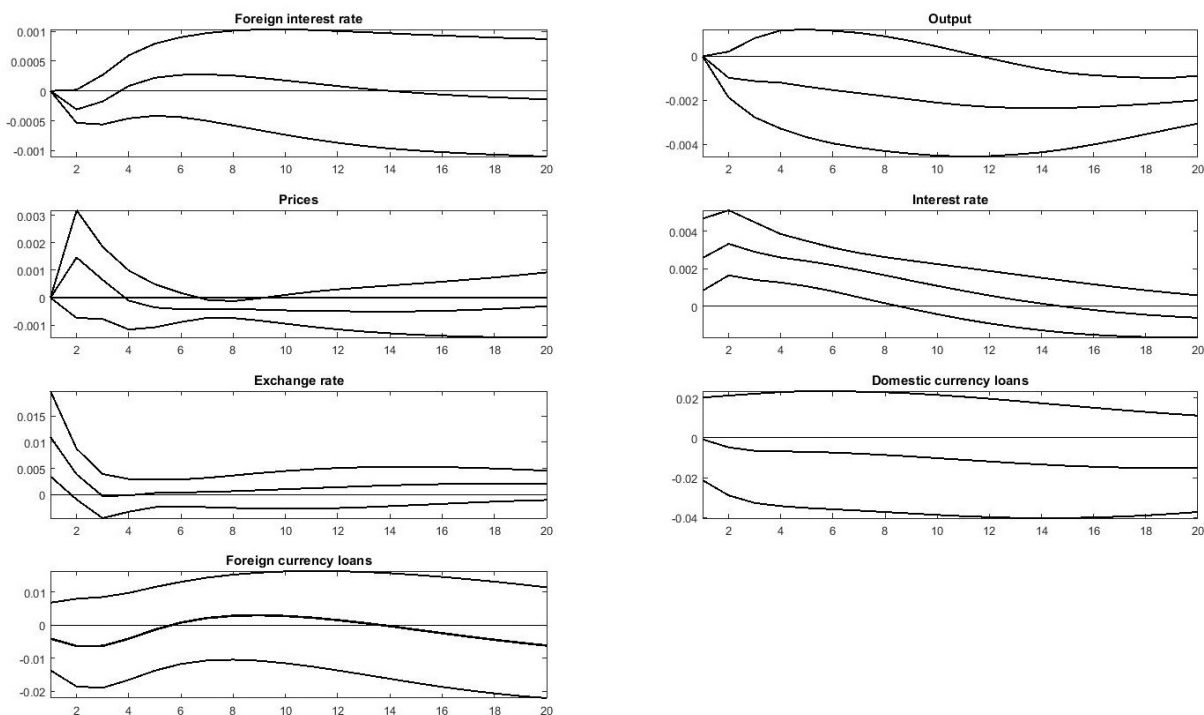
in Poland and the Czech Republic. In all analysed countries, FCLs responses have a considerable probability mass on both sides of zero.

Figure 3: Impulse responses to exchange rate shocks, 16th, 50th and 84th percentiles of the posterior
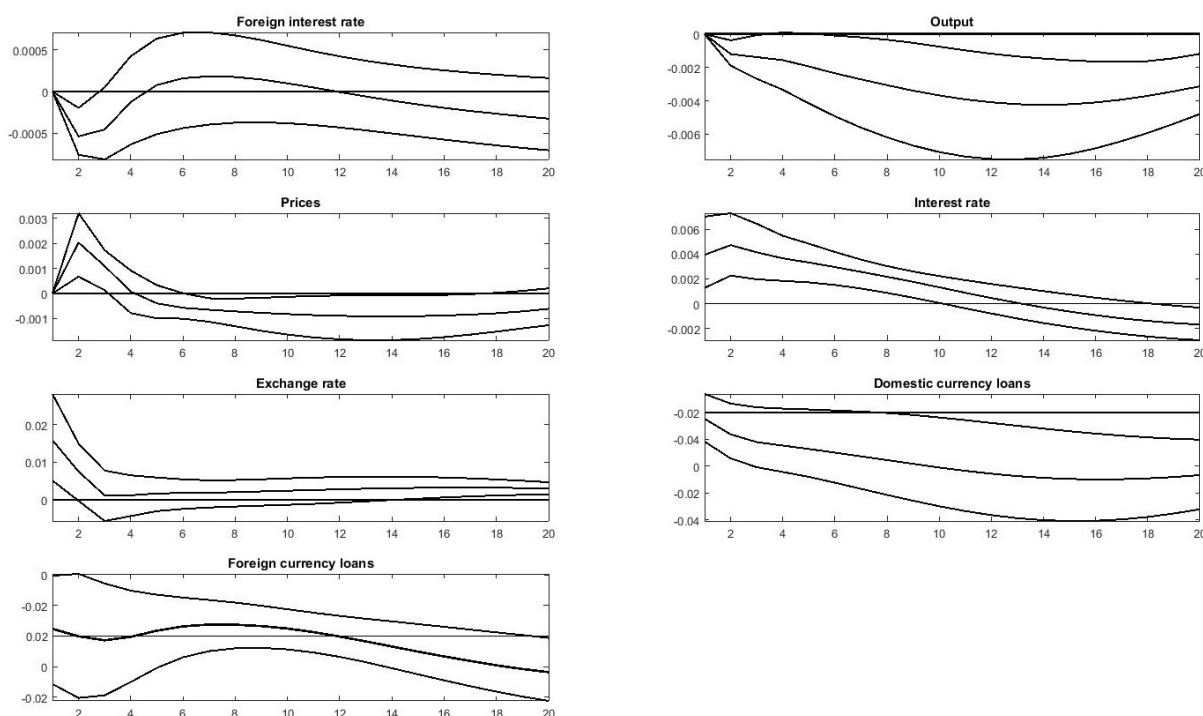
Poland

the Czech Republic

Hungary

The impulse responses of loans in domestic and foreign currencies presented in Figures 2 and 3 give a valuable picture of the dynamics of both types of lending. However, they do not bring any information about the changes in loans currency composition. Although the reactions of loans are insignificant for some horizons, it is still possible that they generate a considerable movement in the lending currency structure. In order to investigate this issue, we plot the responses of the share of foreign currency loans in total loans to both shocks, see Figure 4. As a starting point for calculation of the responses, we use the whole sample average of the percentage share of FCLs, which is equal to 21.7% in Poland, 14.4% in the Czech Republic and 29.9% in Hungary.

The impact of both monetary policy and depreciation shock on the share of foreign currency lending is positive, though only in Poland and Hungary statistically significant. The strongest median responses to monetary policy and exchange rate shocks are observed in around, respectively, 2 years and 3 years after the shock. Quantitatively the effect of both shocks on the currency structure seems to be rather weak. The change in the FCLs share after monetary policy and exchange rate shocks amount to 0.4 percentage points in Hungary and respectively 0.5 and 0.4 percentage points in Poland. The effect of the second shock is more prolonged. In 5 years after the shock, the impact of the monetary policy shock is insignificant in all countries, whereas the change in the share of foreign currency loans after the exchange rate shock still amounts to around 0.3 percentage points both in Poland and Hungary.

Figure 4: Impulse responses of share of foreign currency loans
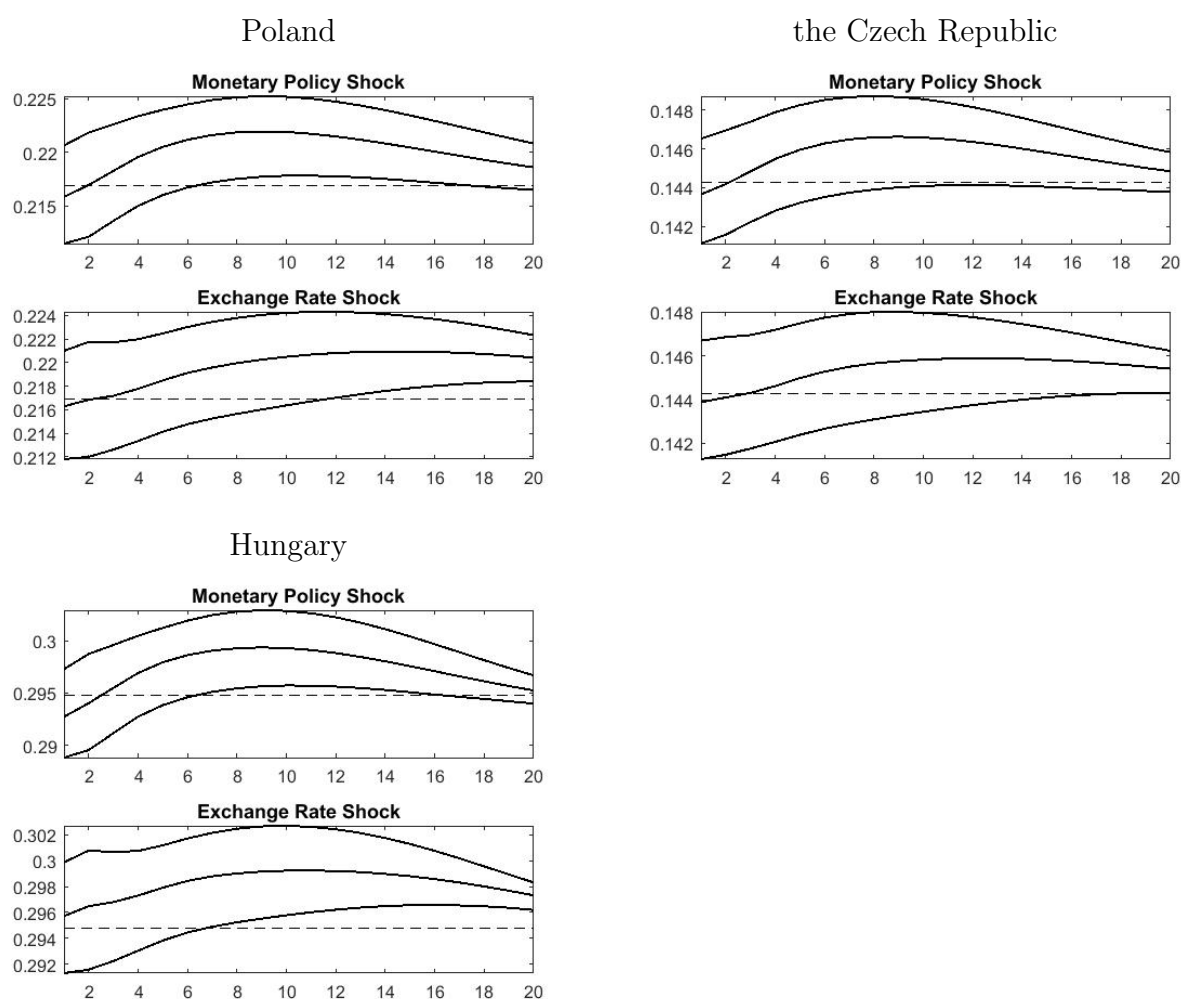
Poland

the Czech Republic

Hungary

All in all, our empirical results indicate the significant differences in responses of both types of credit to monetary policy shock in Poland and Hungary. After monetary policy tightening, we observe the decrease in domestic currency lending and rise in foreign currency denominated loans. The reaction of loans in the Czech Republic is not statistically significant. The uncertainty bands of reaction of loans to depreciation shocks are wider and, except for the domestic currency loans in Hungary, include zero. The median responses point toward the decline in domestic currency loans. This drop can be attributed to the lower attractiveness of domestic currency lending resulting from the higher interest rates observed after the depreciation. The sign of the median response of FCLs to exchange rate shock varies over the time horizon. The currency depreciation makes the FCLs less favourable and hence, just after the shock, we observe the drop in foreign currency lending. However, in several quarter, the FCLs accelerate, suggesting that the borrowers start to replace reduced domestic currency loans with loans in foreign currency. Moreover, our results show that in Poland and Hungary we

observe statistically significant, though quantitatively weak, increase in share of foreign currency loans in total loans both after the monetary policy and exchange rate shocks.

5 Conclusions

This paper analyses the differences in responses of domestic currency and foreign currency lending to monetary policy and exchange rate shocks. To this end, we estimate the Bayesian random effect panel VAR model with a hierarchical prior, using the data from the three biggest CEE countries, i.e. Poland, the Czech Republic and Hungary. For shock identification, we impose a set of sign and zero restrictions.

All in all, our empirical results suggest that there are significant differences in responses of both types of credit to monetary policy shock in Poland and Hungary. Contractionary monetary policy decreases domestic currency lending, but simultaneously raises the volume of foreign currency denominated loans. This observation seems to confirm the conclusion from previous studies about the substitutability of both types of credit and indicates that the presence of FCLs weakens the role of monetary policy. In the Czech Republic, the reactions of both domestic currency and foreign currency denominated loans to the monetary policy shock are not statistically significant.

The uncertainty bands of reaction of loans to depreciation shocks are wider and, except for the domestic currency loans in Hungary, include zero. The median responses to exchange rate shock point toward the decline in domestic currency loans. This drop can be attributed to the lower attractiveness of domestic currency lending resulting from the higher interest rates observed after the depreciation. The sign of the median response of FCLs to exchange rate shock varies over the time horizon. The currency depreciation makes the FCLs less favourable and hence, just after the shock, we observe the drop in foreign currency lending. However, in several quarter, the FCLs accelerate, suggesting that the borrowers start to replace reduced domestic currency loans with loans in foreign currency. Moreover, our results show that in Poland and Hungary we observe statistically significant, though quantitatively weak, increase in share of foreign currency loans in total loans both after the monetary policy and exchange rate shocks. The changes in the loans composition in the Czech Republic are insignificant.

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A Appendices

A.1 Sample used in correlation analysis

Country	Currency structure
Albania	2008 - 2014
Bulgaria	2003 - 2014
Croatia	2003 - 2014
Czech Republic	2003 - 2014
Estonia	2003 - 2010
Hungary	2003 - 2014
Latvia	2003 - 2013
Lithuania	2004 - 2014
Poland	2003 - 2014
Romania	2007 - 2014
Serbia	2010 - 2014
Slovakia	2005 - 2008
Slovenia	2005 - 2006

A.2 Drivers of loans currency structure vs. share of foreign currency loans

Interest rate differential vs. FCLs share
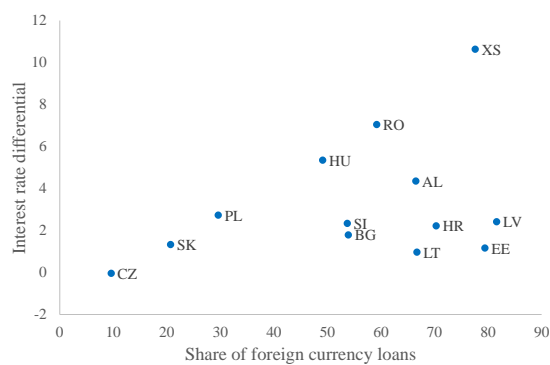
Interest rate standard deviation vs. FCLs share
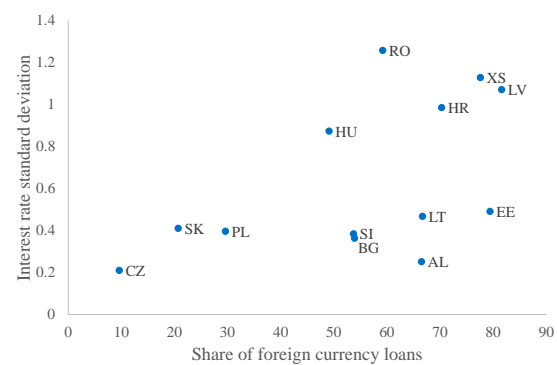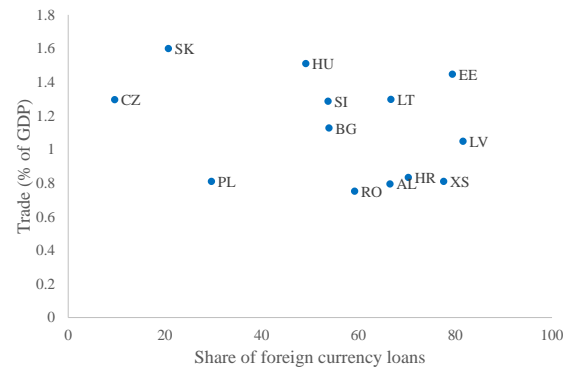
CPI inflation vs. FCLs share
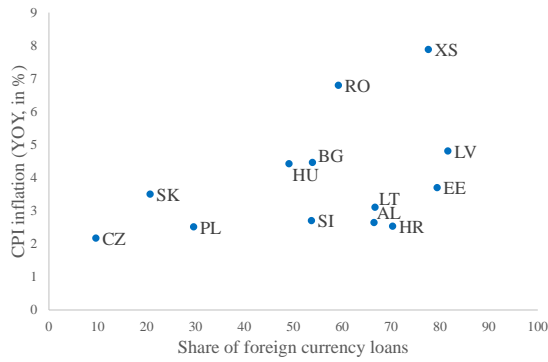
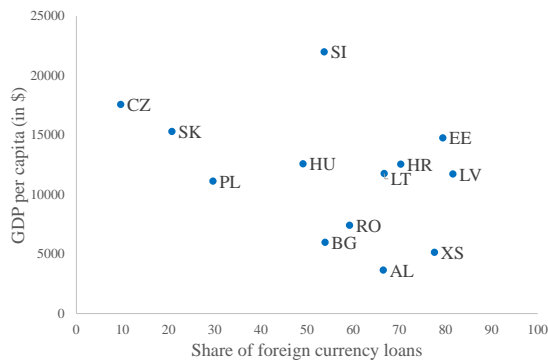## Standard deviation of CPI inflation vs. FCLs share
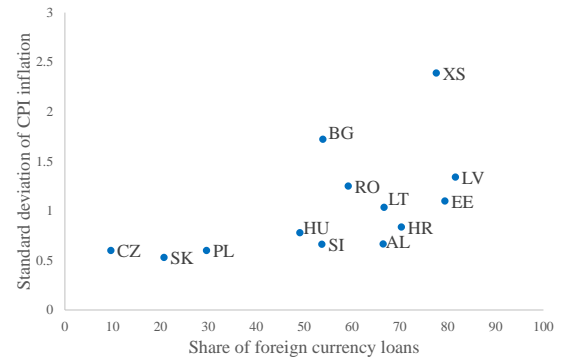
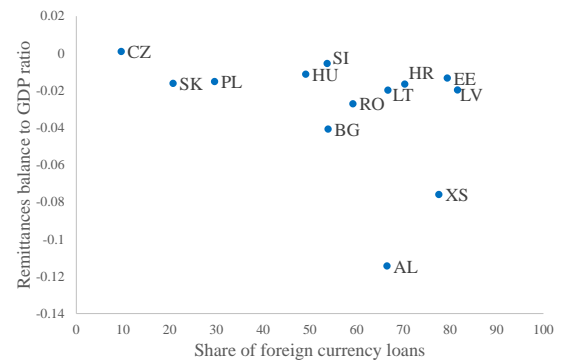## Exchange rate relative standard deviation vs. FCLs share
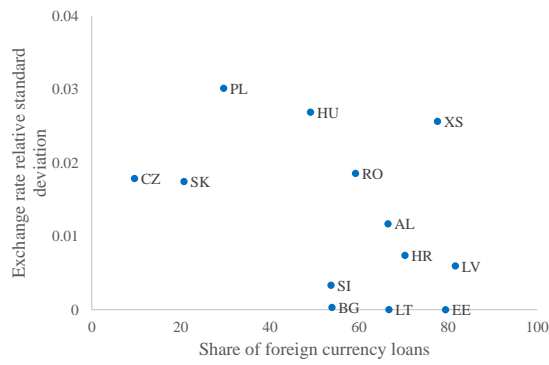
Openness index vs. FCLs share

GDP per capita vs. FCLs share

Remittances balance to GDP ratio vs. FCLs share

Net international investment position to GDP ratio vs. FCLs share