

Financial shocks as a cause of real exchange rate fluctuations in Poland

– evidence from the Bayesian structural VAR models

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Abstract

This paper tackles the issue of shocks that are behind real exchange rate fluctuations in Poland. A stochastic macroeconomic model of an open economy along the lines proposed by Clarida and Galí (1994) constitutes a theoretical framework for the analysis. An empirical strategy is founded on Bayesian structural VAR models with the long-run identifying restrictions (zero and/or sign). We show that the traditional division into nominal and real shocks is not sufficient as it omits financial shocks. This distorts the results considerably. Using quarterly data spanning from 1995 until 2013q2 for real GDP, real exchange rate, and price level in Poland we examine three empirical specifications of the macroeconomic model that differ in the number of shocks included and the type of identifying restrictions imposed. Our main finding is that, contrary to the extant studies that either do not allow for financial shocks or find their impact to be rather weak in comparison with real shocks, financial shocks are important source of real exchange rate fluctuations in Poland. Using historical simulation we also show that the results are empirically consistent since the deviations of real exchange rate from its long-run equilibrium level have been dominated by financial shocks during the global financial crisis.

Keywords: *real exchange rate, Bayesian structural VAR, financial shocks*

JEL Classification: F41, C11

1. Introduction

Wide fluctuations of exchange rate of Polish zloty are facts of life. For example, in the run-up to the global financial crisis zloty appreciated by 14 per cent against the euro and then it collapsed by astonishing 28 per cent by the end of 2009q1. The natural suspicion is that at least part of this variability is not related to the real processes in an economy and as such undesirable. In other words, the exchange rate is not exclusively a mechanism which absorbs real shocks, but it is also a mechanism through which shocks can propagate in the economy.

The objective of the paper is to investigate the relative importance of financial shocks in driving the real exchange rate in Poland. We conjecture that the predominance of real shocks, typically found in the other studies oriented (see e.g. NBP, 2009, p. 163), is linked with the framework that allows on real shock(s) and monetary shock only. The problem is that floating exchange rate regime is more desirable if real shocks dominate, whereas pegged exchange

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rate is better if monetary shocks prevail³. Thus, assuming that the monetary authority acts rationally one should expect real shocks to predominate in countries with floating exchange rates. The picture changes if financial shocks are allowed – these could exert potentially adverse impact on both floaters and peggers (e.g. via balance sheet effects).

A broader look at shocks behind exchange rate changes is recommended in the context of monetary integration. Were Poland to join the Exchange Rate Mechanism II (ERM II) then the exchange rate would have to be stabilized. This in turn would be costly provided the real shocks indeed dominate. The paper is organised as follows. A rough outline of macroeconomic model used as theoretical motivation is sketched in the following section. Empirical methodology is briefly described in Section 3. Data and empirical results are discussed in Section 4. The last section concludes.

2. Macroeconomic model

We use the macroeconomic stochastic model of an open economy which is similar to the one presented by Clarida and Galí (1994)⁴. Their model consists of IS and LM relations, uncovered interest rate parity condition and price-setting equation. Three shocks can drive the real exchange rate: supply, demand, and monetary. This baseline model is extended to take into account financial shocks. A need for modification is obvious since the objective is to examine the role of financial shocks. But it is also important because without it, as shown by Dąbrowski (2012), demand and monetary shocks are in fact correlated and do not conform with their empirical counterparts (as the orthogonality is imposed in empirical part).

The decomposition of real exchange rate into exchange rate for tradables and differential in relative prices of non-tradables is our second modification. Following Froot and Rogoff (1995) we relate the latter with the real cost of capital. The former is determined by the equilibrium condition in the goods market. Due to space limitation we present the main long-run restrictions only. These are implied by the long-run solution of the extended model⁵. In the long-run only supply shocks exert influence on relative output and monetary shocks do not change any variable except for the relative price level. A response of real exchange rate for tradables is positive to demand shocks and negative to financial shocks.

³ Lahiri et al. (2008) call this ‘Mundell-Fleming’s dictum’.

⁴ See also the literature cited in their study. For an empirical approach based on a monetary model see e.g. Dąbrowski et al. (2013).

⁵ Details are available from authors upon request.

3. Structural Vector Autoregression with long-run restrictions

In this analysis three sets of Structural Vector Autoregression (SVAR) models will be considered. In the first group only three types of shocks will be studied. These are supply, demand and monetary shocks. In the second group the analysed models will be enlarged by additionally taking financial shocks into account. In both sets the shocks will be identified via zero restrictions imposed on the total impact matrix (see Blanchard and Quah, 1989). The third group of models differs from the second one in the type of restrictions used to identify shocks, as the mixture of zero and sign restrictions will be employed.

Let us consider a reduced form of an n – dimensional covariance stationary VAR process of order k (VAR(k)):

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \dots + A_k y_{t-k} + \Phi D_t + u_t, \quad u_t \sim WN(\Sigma_u), \quad t = 1, 2, \dots, T,$$

where D_t denotes the vector with non-stochastic variables, such as a constant, a deterministic trend, seasonal dummies, u_t is a white noise process with a covariance matrix Σ_u .⁶

In the empirical analysis of the sources of the exchange rate fluctuation, the shocks will be identified through restrictions imposed on the total impact matrix, which in the framework of covariance stationary VAR processes is of the following form:

$$\Xi_\infty = (I_n - A_1 - \dots - A_k)^{-1}.$$

By placing zero restrictions on this matrix we assume that some shocks do not have any total long-run effects. Such restrictions are very strong and for this reason their validity should be carefully examined. In our case, some of them are reasonable because they follow from the economic models. However in the group of models with four types of shocks we are forced to impose one additional excluding restriction to distinguish between demand and financial shocks. To examine whether (and how) this additional restriction affects empirical results we have decided to compare findings obtained in SVAR models with only Blanchard-Quah type of restrictions with those which could be drawn from the group of models combining zero and sign restrictions. The method proposed by Binning (2013) will be applied. In the first step of Binning's algorithm candidating values are generated from the posterior distribution of the reduced form VAR model and based on them an impact matrix which matches zero restrictions is constructed. In the second step the bunch of impulse responses are calculated and the sign restrictions are checked. If the generated responses do not fulfil the assumed restrictions they are discarded and the algorithm moves to the first step. It should be emphasised that by imposing sign restrictions the parameters space is truncated so the whole

⁶ In the empirical part we assume that u_t is a Gaussian white noise process.

statistical model is changed. In the Bayesian framework it could be formally compared to a model without such restrictions⁷.

4. Empirical results

The empirical analysis is mainly devoted to examination of the exchange rate fluctuation sources. We will focus our attention on the forecast error variance decomposition (FEVD). Additionally, the hypothetical paths of the exchange rate each with only one type of the identified shocks will be compared to the observed one.

As mentioned previously, the whole set of the analysed models can be divided into three groups, namely, three-variable structural VAR models, four-variable structural VAR models with zero restrictions and four-variable structural VAR models with zero and sign restrictions. In each group the empirical analysis starts from the reduced form VAR. To complete the definition of Bayesian VAR models we have to specify prior distributions of the parameters. In the presented analysis we will make use of the following priors: 1) inverted Wishart for Σ_u : $\Sigma_u \sim iW(6, S)$ with $S = 0.01I_4$; 2) matric-variate Normal for $A_s = \phi'$: $A_s \sim mN(0, \Sigma_u, h_s I)$, where h_s controls the degree of informativeness of the normal distribution and, in the presented work, is estimated with the inverted Gamma prior imposed ($h_s \sim iG(200, 3)$), i.e. $E(h_s) = 100$, $Var(h_s) = 10000$); and 3) matric-variate Normal for $A = (A_1 \ A_2 \ \dots \ A_k)'$: $A \sim mN(0, \Sigma_u, h\Omega)$ with $\Omega = diag\left(\frac{1}{2} I_n \ \frac{1}{2^2} I_n \ \dots \ \frac{1}{2^k} I_n\right)$ and estimated h , $h \sim iG(200, 3)$.

In each group, we have considered a set of five Bayesian VAR models with a constant and seasonal dummies which can differ in the number of lags (5 through 9). They were a priori equally possible (i.e. $p(M_k)=0,2$, where M_k denotes a VAR(k) model). To obtain the posterior probabilities the Savage-Dickey density ratio method (Verdinelli and Wasserman, 1995) was employed.

Let us start with three-dimensional models. The seasonally unadjusted quarterly data covering the period 1995Q1 through 2013Q2 for the first differences of gross domestic product, real exchange rate and price level will be analysed. The model with five lags (VAR(5)) achieved posterior probability higher than the assumed prior ($p(M_5|Y)=0,96$), so the following results are based on the analysis performed within this model. It is worth mentioning that the long-run responses of the variables to the identified shocks within this model are consistent with the theoretical reactions.

⁷ For the Bayesian model comparison see e.g. Wróblewska (2009) and the references therein.

Table 1 reveals that the real exchange rate has remained under an overwhelming influence of demand shocks: around 90 per cent of forecast error variance was accounted for by these shocks at all horizons. Even if one takes into account uncertainty related with this estimates, which is measured with a difference between the 84th and 16th quantiles of the posterior distribution (given in parentheses), the predominance of demand shocks is unquestionable⁸. The difference is around 25 percentage points and the estimate for the 16th quantile is around 75 per cent (the prosterior distribution is asymmetric). Interestingly, the remaining variability in the real exchange rate can be explained with supply shocks rather than nominal shocks. The contribution of the latter is negligible not only in the long-run, which is something to be expected because of the restrictions imposed, but also in the short-run. Even if one takes 84th quantile (instead of a median) the proportion of forecast error variance explained by nominal shocks is less than 2.5 per cent.

Figure 1 illustrates historical simulations. It compares the observed exchange rate path (solid line) to the time path resulting from putting all shocks, except the one considered, equal to zero (broken line)⁹. Additionally, the differences between these two paths are presented (bars). It is quite clear from the figure that demand shocks have been the main and almost sole driver of exchange rate changes. They explain episodes of strong real appreciation of Polish zloty that coincided with the times of relatively fast economic growth. Demand shocks were equally important in the slowdowns and recoveries when zloty depreciated considerably.

In the light of these findings one is tempted to conclude that even though the real exchange rate fluctuated widely, it was driven by real forces and its changes were just a reflection of underlying real processes in an economy. Such a conclusion is indeed in line with findings in the literature (e.g. Stążka-Gawrysiak, 2009; NBP, 2009, p. 163 and studies referenced therein). It, however, seems to be risky because the approach does not allow for exchange rate changes caused by financial shocks, e.g. capital flows triggered by changes in a risk premium.

Thus, we have decided to extend the analysis by explicitly taking financial shocks into account. The real exchange rate has been decomposed into the exchange rate for tradables and the difference in the relative prices of non-tradables. Unfortunately, since the long-run excluding restrictions based on the economic model are not sufficient to distinguish between demand and financial shocks, we have added the atheoretical restriction that excludes the long-run impact of financial shocks on the differential in relative price of non-tradables.

⁸ This quantile difference corresponds to 0.68 probability mass of posterior distributions.

⁹ We are putting shocks to zero after eight modelled points of the series (i.e. since 1999q3).

Forecast horizon h	Proportions of forecast error variance, h periods ahead, accounted for by					
	supply shocks		demand shocks		monetary shocks	
1	9.95	(24.63)	88.64	(25.00)	0.52	(2.41)
4	8.85	(23.13)	90.39	(23.37)	0.35	(1.04)
8	8.72	(23.34)	91.06	(23.36)	0.20	(0.59)
12	8.47	(23.51)	91.15	(23.52)	0.13	(0.39)
16	8.43	(23.76)	91.38	(23.76)	0.10	(0.29)
20	8.40	(23.68)	91.41	(23.69)	0.08	(0.24)

Notes: 1) the quantile $q_{0.84}$ $q_{0.16}$ differences in parentheses; 2) calculations performed in GAUSS 14, based on 200 thousand accepted MCMC draws after 500 thousand rejected.

Table 1 Posterior median of forecast error variance decomposition of the real exchange rate.



Notes: 1) solid line – the observed exchange rate path (a left axis); dotted line – the time path with only one type of shocks (a left axis); bars – the differences between the observed and simulated paths (a right axis); 2) calculations performed in GAUSS 14, based on 200 thousand accepted MCMC draws after 500 thousand rejected.

Fig. 1. The role of shocks identified in the three-variable VAR with zero long-run restrictions.

As previously, we start with the model selection procedure. The VAR(5) form obtained almost all the posterior probability ($p(M_5|Y) = 0,99996$) so it is employed for further analysis.

When financial shocks are allowed the picture changes dramatically. It is obvious from Table 2 that the real exchange rate (for tradables) was mainly driven by financial shocks not by demand shocks. In all forecast horizons a contribution to forecast error variance by financial shocks is close to or more than 60 per cent whereas a proportion accounted for by demand shocks decreased considerably from 90 per cent to 25 per cent. Even if one takes more cautious view on the significance of financial shocks, i.e. looks at the 16th quantile, their contribution is still above 40 per cent and they dominate over other shocks¹⁰. Supply and

¹⁰ It is in contrast to 3-5 per cent found by Stażka-Gawrysiak (2009).

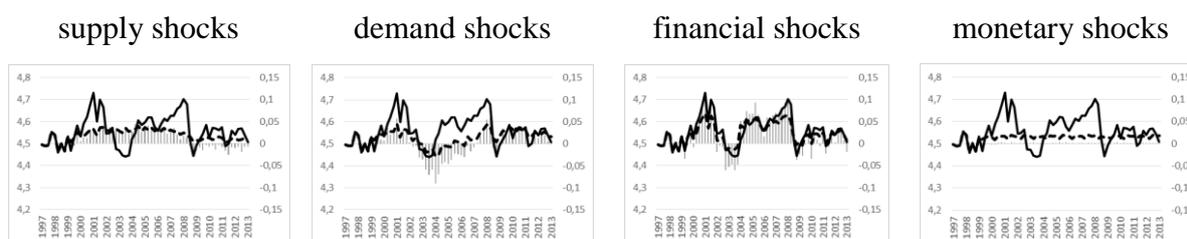
monetary shocks, have similar contributions in both specifications, around 8 per cent and less than 1 per cent respectively.

Historical simulations are presented in Fig. 2. Though the leading role in two episodes of large appreciation (2000-2001 and 2007-2008) was played by financial shocks, demand shocks pushed the exchange rate in the same direction. It is interesting to observe that appreciation in 2004-2006 was not driven by demand shocks: after the adjustment following the recession of 2001, when they became negative, they remained to be such even in the recovery period. This is intriguing. Both demand and financial shocks can be used to explain the episodes of depreciation in 2002-2003 and at the end of 2008.

Forecast horizon h	Proportions of forecast error variance, h periods ahead, accounted for by							
	supply shocks		demand shocks		financial shocks		monetary shocks	
1	8.93	(22.70)	26.72	(29.94)	58.66	(33.64)	0.49	(2.37)
4	7.94	(21.22)	24.61	(29.04)	62.23	(33.02)	0.36	(1.05)
8	7.78	(21.48)	23.80	(29.29)	63.39	(33.61)	0.20	(0.57)
12	7.69	(21.72)	23.48	(29.62)	63.70	(34.15)	0.14	(0.39)
16	7.55	(21.82)	23.39	(29.85)	63.96	(34.56)	0.10	(0.30)
20	7.56	(22.05)	23.34	(29.96)	64.09	(34.69)	0.08	(0.24)

Notes: see Table 1.

Table 2 Posterior median of forecast error variance decomposition of the real exchange rate for tradables in the VAR with zero long-run restrictions.



Notes: see Figure 1.

Fig. 2. The role of shocks identified in the four-variable VAR with zero long-run restrictions.

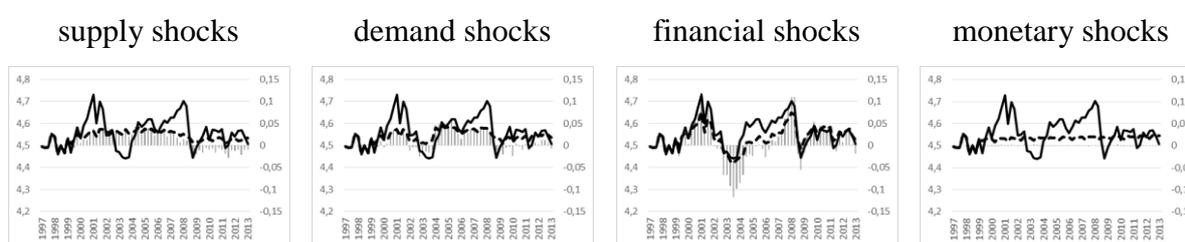
The results from the analysis that allows on financial shocks cast considerable doubt on the conclusions drawn from the first group of models. Though the real shocks play an important role in the exchange rate fluctuations one simply cannot argue that they dominate. The problem with the four-variables approach is that we have imposed, somewhat arbitrarily, the

auxiliary long-run restriction for identification purposes which has not been justified by the economic theory. Since it may affect the empirical results, we have additionally performed the analysis in the third group of SVAR models in which we make use of the sign restrictions resulting from the theoretical model. Thus, we identify the demand shocks by assuming that they have no long-run effect on GDP, they positively affect prices and the exchange rate for tradables and lower the relative price of non-tradables. The financial shocks in turn have no long-run impact on GDP, but they negatively influence both real exchange rate and relative price of non-tradables, and they increase prices. In this set of SVAR models the analysis also starts with the Bayesian model comparison. As in both previous cases the SVAR(5) achieved above 0.95 posterior probability, so the subsequent outcomes are obtained within this model.

Forecast horizon h	Proportions of forecast error variance, h periods ahead, accounted for by							
	supply shocks		demand shocks		financial shocks		monetary shocks	
1	9.65	(23.58)	18.15	(48.59)	64.58	(53.85)	0.48	(2.12)
4	8.72	(22.28)	21.11	(52.14)	62.88	(56.45)	0.38	(1.04)
8	8.47	(22.64)	22.46	(53.81)	61.91	(58.26)	0.22	(0.59)
12	8.27	(22.89)	22.98	(54.74)	61.51	(58.83)	0.16	(0.41)
16	8.35	(23.11)	23.05	(55.30)	61.30	(59.31)	0.12	(0.31)
20	8.21	(23.07)	23.29	(55.61)	61.10	(59.57)	0.09	(0.25)

Notes: see Table 1.

Table 3 Posterior median of forecast error variance decomposition of the real exchange rate for tradables in the VAR with zero and sign long-run restrictions.



Notes: see Figure 1.

Fig. 3. The role of shocks identified in the four-variable VAR with sign long-run restrictions.

The main message from Table 3 is that the decomposition of forecast error variance is essentially unchanged in comparison to the previous group of models. Financial shocks account for 60 per cent of forecast error variance at all horizons and are by far the most

important driver of the real exchange rate. This optimistic finding, however, has to be tempered by a quite large uncertainty about our estimates of the contribution of financial shocks which is twice as large as in the case with auxiliary zero restriction. The same holds for the contribution of demand shocks: here the posterior distribution is flatter as well.

The predominance of financial shocks is confirmed by historical simulations presented in Figure 3. The results are quite similar to those in Figure 2. There are, however, two important differences. First, the appreciation in 2004-2006 was driven by real shocks. This is something to be expected since the economic growth was relatively strong at that time (on average 5 per cent annually). What is more, the demand shocks were positive, so their behaviour, unlike to the case of auxiliary zero restriction, is no longer puzzling. Financial factors started to play a prominent role in the run-up to the crisis, i.e. in 2007. Second, both the depreciation at the end of 2008 and the subsequent rebound in the exchange rate were driven by financial shocks with relatively small contribution from other shocks. At the beginning of 2010 the real exchange rate returned to its average level in 2004-2006. Thus, though the appreciation in the period preceding the crisis can be treated as a misalignment, the depreciation that followed was excessive: the exchange rate overshot its normal level. These differences should not obscure the general finding: the results confirm our conjecture that financial shocks matter.

Conclusion

Three empirical specifications of macroeconomic model of an open economy have been used in order to assess the relative importance of financial shocks in driving the real exchange rate in Poland. Our results lend support to two general conclusions. First, in line with the other studies, we have found that the exchange rate of Polish zloty is a shock absorber: its changes are indeed driven by real processes. Their significance, however, is overestimated if one allows for real and monetary shocks only. Second, financial shocks are important in explaining the real exchange rate changes. Our conservative estimate is that their contribution is 30 per cent which seems to be quite large in comparison to the impact previously found in the literature. This finding is robust to alternative specifications of long-run restrictions.

We would like to conclude with a reservation: our results should not be interpreted as evidence against the floating exchange rate regime. Though financial shocks turn out to be an important driver of exchange rate, our results do not suggest that the shocks can be ‘switched off’ by fixing an exchange rate. In the light of the direct observation of economic performance of peggers and floaters in Central Europe the working hypothesis could rather be that the

fixed exchange rate regime does not protect against the external financial shocks, although the propagation mechanism is definitely different. This issue, however, requires further research.

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