

The relevance of financial frictions in V4 countries from the DSGE perspective

Stanislav TVRZ*

Economic and Monetary Analyses Department, National Bank of Slovakia, Imricha Karvaša 1, 813 25, Bratislava, Slovakia and Department of Economics, Faculty of Economics and Administration, Masaryk University, Lipová 41a, 602 00, Brno, Czech Republic.

Abstract

In this paper, the importance of the financial frictions in the countries of the Visegrád Group is compared using a set of estimated DSGE models with a financial accelerator. The results of the Bayesian estimation confirm the overall similarity of the V4 economies, with some notable differences. The estimates of the financial friction parameters are very similar across the V4 economies, which may be explained by the fact that most commercial banks operating in these economies are subsidiaries of large international groups, which treat the V4 markets in similar ways. According to the historical shock decomposition, the importance of the net worth shock for the development of real output is comparable to that of the domestic productivity shock or the total of foreign shocks. In the case of the inflation rate, the importance of the net worth shock is comparable to the sum of the foreign shocks. Since the net worth shock directly affects the development of the interest rate spread between the policy interest rate and the client interest rates, the financial frictions can have important implications for the monetary policy. Thus, the monetary authority should take into account the factors that can affect the development of the interest rate spread in the economy and potentially reduce the efficiency of the monetary transmission.

Keywords

DSGE model, financial accelerator, financial frictions, Great Recession.

JEL Classification: E37, E44, F45

* stanislav.tvrz@nbs.sk or tvrz@mail.muni.cz

The views expressed here are those of the author and do not necessarily reflect the position of the National Bank of Slovakia. The access to computing and storage facilities owned by parties and projects contributing to the National Grid Infrastructure MetaCentrum, provided under the programme *Projects of Large Infrastructure for Research, Development, and Innovations* (LM2010005), is greatly appreciated. This contribution is the result of Masaryk University's research project *MUNI/A/1235/2014*.

The relevance of financial frictions in V4 countries from the DSGE perspective

Stanislav TVRZ

1. Introduction

The recent turbulent period of the Great Recession, which started as a financial crisis in the United States and developed into a global economic crisis, gave rise to the issue of financial frictions. Thanks to the conservative business strategy and high capitalization, liquidity and rentability of their banking systems, the Visegrád Group countries were only marginally exposed to the subprime crisis. Only in Hungary was the situation complicated by the debt denominated in foreign currencies that inflated during the crisis together with the currency depreciation. In general, the V4 economies were mainly hit by the downturn of the foreign demand and by the increase in overall uncertainty that led to a growth of spreads between the policy interest rate and the client interest rates. In conditions of a perfectly competitive banking sector with no frictions, the commercial interest rates would be expected to follow the policy interest rate closely. However, this is not what was observed during the recent crisis. Apparently, there can be times when the development of commercial interest rates lags behind and/or differs significantly from the development of the policy interest rate. The idea of a frictionless banking sector therefore seems to be no longer plausible.

In this paper, we acknowledge the presence of financial frictions in the Visegrád economies and try to assess quantitatively the relative importance of the development in the financial sector for the real business cycle fluctuations in these economies in the long run relative to other exogenous driving forces.

The rest of the paper is organized as follows: Section 2 presents a literature review of financial friction modelling; Section 3 describes the structure of the DSGE model employed; Section 4 contains a description of the data set used for model estimation; Section 5 describes the calibration and estimation procedure; Section 6 presents the empirical results; and Section 7 concludes.

2. Financial friction modelling in the literature

A comprehensive review of the literature related to the financial frictions in DSGE models can be found for example in Brázdik et al. (2012). The survey summarized the development of the main theoretical

approaches to financial friction modelling from the seminal publications to recent extensions. There are three main financial friction mechanisms: cash-flow constraints, collateral constraints and financial regulations.

It was Bernanke et al. (1999) who introduced the financial accelerator mechanism into the New Keynesian DSGE framework. In their concept, a firm's balance sheet effects together with costly state verification give rise to the external finance premium that is paid by the borrowers on top of the opportunity cost of internal funds and act as a cash-flow constraint. The external finance premium behaves counter-cyclically and thus amplifies the effects of exogenous shocks. Christensen and Dib (2008) further extended the original concept by rewriting the debt contracts in nominal terms to reflect reality better and included money growth in the Taylor rule to model the monetary policy better. The implications of the financial accelerator for the monetary policy of the Czech economy were investigated for example by Ryšánek et al. (2012).

Financial frictions can also be introduced into the DSGE model by linking the creditworthiness of the borrowers to the value of their assets. This idea was introduced by Kiyotaki and Moore (1997), who presented a theoretical model with collateral constraints, in which the overall size of the debt that borrowers can obtain is limited by the value of their assets. Thus, a negative shock that causes a decline of the value of collateral leads to a restriction of the firm's borrowing and consequently a reduction of investment and consumption. Nominal debt contracts and real estate demand were introduced by Iacoviello (2005).

The third way of modelling financial frictions is oriented towards explaining specific features of the financial crises that take place on the supply side of financial markets. A DSGE model with an explicit banking sector was introduced by Goodfriend and McCallum (2007), in which commercial banks maximize their profits given the loan production technology and the demand for deposits and loans. The bank production function takes collateral and labour as inputs, as the labour is used to perform the loan monitoring. Cúrdia and Woodford (2009) presented a stylized model with an explicit banking sector and

heterogeneous households. Dib (2010) presented an interesting synthesis of the explicit banking sector modelling and a financial accelerator in a DSGE model framework.

3. Model

Given the goal of this paper and the focuses of different approaches to financial friction modelling, we decided to use the DSGE model with a financial accelerator proposed by Bernanke et al. (1999) for the analysis. This theoretical concept centres on the general properties of the business cycle and explicitly incorporates the credit spread, which is a desirable feature since it was the growth of interest rate spreads during the Great Recession that was one of the main manifestations of the financial frictions in the V4 economies. Specifically, we used a model framework developed by Shaari (2008), which incorporates the financial accelerator mechanism into the small open economy setting of Justiniano and Preston (2010). This tractable medium-sized model of a small open economy incorporates important real as well as nominal rigidities and allowed us to describe the V4 economies in reasonable detail. The model structure was altered slightly in the case of Slovakia to allow the regime switch capturing the accession to the monetary union. Otherwise, we departed from the original model specification of Shaari (2008) in modelling the foreign variables as a VAR(1) block, and we added an exogenous component to the development of the entrepreneurial net worth, the net worth shock. It is this exogenous shock that enabled us to capture the impact of factors such as uncertainty in the financial market that did not have an immediate impact on the profitability of the firms in the economy but did influence the development of interest rate spreads.

The model contains households, entrepreneurs, retailers, the central bank and the foreign sector. The households receive wages for supplied labour, government transfers, profits made by retailers and domestic and foreign bonds' returns. Domestic bonds pay a fixed nominal return in the domestic currency, while foreign non-contingent bonds provide a risk-adjusted nominal return denominated in the foreign currency. The debt-elastic risk premium contains an exogenous AR(1) component of risk premium or uncovered interest parity shock. The households then spend their earnings on consumption and domestic and foreign bond acquisition.

3.1 Entrepreneurs

Entrepreneurs play two important roles in the model. They run wholesale goods-producing firms and they produce and own the capital. The market of intermediate goods and the capital goods market are assumed to be competitive. The wholesale goods production is affected by the domestic productivity AR(1) shock, and the capital goods production is subject to capital adjustment costs. Entrepreneurs finance the production and ownership of capital K_t by their net worth N_t and borrowed funds. The cost of borrowed funds is influenced by borrowers' leverage ratio via the external finance premium:

$$EFP_t = \left(\frac{N_t}{Q_{t-1}K_t} \right)^{-\chi} \quad (1)$$

where Q_t is the real price of capital or Tobin's Q and χ is the financial accelerator parameter. To maximize their profit, entrepreneurs choose the optimal level of capital and borrowed funds. During each period, a proportion $(1 - A_t^{NW})\zeta$ of entrepreneurs leave the market and their equity $(1 - A_t^{NW})\zeta V_t$ is conveyed to households in the form of transfers. A_t^{NW} is a shock to the entrepreneurial net worth.¹ It influences the development of the net worth by changing the bankruptcy rate of entrepreneurs, and its positive innovations increase the survival rate of entrepreneurs. Its logarithmic deviation from the steady state is assumed to evolve according to the AR(1) process. ζ is the steady-state bankruptcy rate.

3.2 Retailers

There are two types of retailers in the model – home goods retailers and foreign goods retailers. Both types of retailers were assumed to operate in conditions of monopolistic competition. Home goods retailers buy domestic intermediate goods at wholesale prices and sell the final home goods to the consumers. Foreign goods retailers buy goods from foreign producers at the wholesale price and resell the foreign goods to the domestic consumers. The difference between the foreign wholesale price expressed in the domestic currency and the final foreign goods price, that is, the deviation from the law of one price, was determined by the exogenous AR(1) shock. By Calvo-type price setting and inflation indexation of the retailers, the nominal rigidities were introduced into the model.

¹ Since the net worth shock directly influences the interest rate spread between policy rates and commercial interest rates, it can also be related to the perceived riskiness of the would-be

borrowers in the economy. Similarly, the effects of the shock could be interpreted in terms of collateral.

3.3 Central bank

The central bank determines the nominal interest rate in accordance with the following forward-looking Taylor interest rate rule (small-letter variables denote deviations from the steady state, i.e. the gap):

$$r_t = \rho \cdot r_{t-1} + (1 - \rho) \cdot [\beta_\pi \cdot E(\pi_{t+1}) + \Theta_y \cdot E(y_{t+1})] + \varepsilon_t^{MP} \quad (2)$$

where r_t is the nominal policy interest rate, ρ is a smoothing parameter, β_π is the weight parameter of expected inflation $E(\pi_{t+1})$ and Θ_y is the weight parameter of the expected output gap $E(y_{t+1})$. Deviations of the interest rate from the interest rate rule were explained as monetary policy i.i.d. shocks ε_t^{MP} .

3.4 Foreign sector

Following Christiano et al. (2011), the foreign economy variables – real output, CPI inflation and nominal interest rate, were modelled using a structural VAR(1) model as described in equation (3):

$$\begin{pmatrix} y_t^* \\ \pi_t^* \\ r_t^* \end{pmatrix} = \begin{pmatrix} \rho_{y^*y^*} & \rho_{y^*\pi^*} & \rho_{y^*r^*} \\ \rho_{\pi^*y^*} & \rho_{\pi^*\pi^*} & \rho_{\pi^*r^*} \\ \rho_{r^*y^*} & \rho_{r^*\pi^*} & \rho_{r^*r^*} \end{pmatrix} \begin{pmatrix} y_{t-1}^* \\ \pi_{t-1}^* \\ r_{t-1}^* \end{pmatrix} + \begin{pmatrix} 1 & 0 & 0 \\ \sigma_{\pi^*y^*} & 1 & 0 \\ \sigma_{r^*y^*} & \sigma_{r^*\pi^*} & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_t^{y^*} \\ \varepsilon_t^{\pi^*} \\ \varepsilon_t^{r^*} \end{pmatrix} \quad (3)$$

3.5 Regime switch

In the case of the Slovak economy, the structure described above is relevant only to the period prior to the accession to the euro area, that is, until the end of 2008. Following Senaj et al. (2010), an additional observable time series was included in the model to indicate the deterministic regime switch to the monetary union after the beginning of 2009. The regime switch changed two model equations, the uncovered interest parity (UIP) condition and the Taylor rule. The original forward-looking UIP condition (log-linear)

$$rer_{t+1} - rer_t = (r_t - \pi_{t+1}) - (r_t^* - \pi_{t+1}^*) + \psi^B \cdot z_t + a_t^{UIP} \quad (4)$$

describes the development of the real exchange rate rer_t in terms of the real interest rate differential and the risk premium that is a function of net foreign assets z_t and contains an exogenous AR(1) component, the UIP shock. As in the monetary union the development of the real exchange rate is no longer influenced by the

fluctuating nominal exchange rate, which is fixed to the central parity, the UIP equation simplifies to

$$rer_t - rer_{t-1} = \pi_t^* - \pi_t \quad (5)$$

and the development of the real exchange rate is driven simply by the inflation differential.

The setting of the policy interest rate is decided outside the member economy of the monetary union. Due to the size of the Slovak economy and its share of the total euro area GDP, we could consider the nominal interest rate to be given exogenously. Even though there is no longer independent decision making on the policy interest rate in the domestic economy, following Siena (2014), we allowed for the deviation of the domestic and foreign interest rates due to the risk premium. Therefore, the Taylor rule equation (2) is replaced by

$$r_t = r_t^* - \psi^B \cdot z_t - a_t^{UIP} \quad (6)$$

This decision was motivated by the experience of the European debt crisis, which showed that the availability of external funds (foreign bonds) remains rather heterogeneous across the euro area countries.

4. Data

Quarterly time series of eight observables were used for the purposes of estimation. These time series cover the period between the second quarter of 1999 and the second quarter of 2014 and contain 61 observations.

Seasonally adjusted time series of the real gross domestic product (GDP), harmonised consumer price index (CPI), three-month policy interest rate and real investment were used for the domestic economy. The foreign economy was represented by the 17 euro area countries and was captured by the seasonally adjusted time series of the real GDP, CPI and three-month policy interest rate. Time series of the real exchange rate² were also used for the purposes of estimation. These time series were obtained from Eurostat, the European Central Bank and the databases of individual national banks.

The original time series were transformed prior to estimation to express the logarithmic deviations from their respective steady states. The logarithmic deviations of the observables from their trends were calculated with the use of the Hodrick–Prescott (HP) filter.³ To mitigate the end-of-sample bias of the HP filter, the level data were prolonged with the VAR

² The values of the real exchange rate of the Slovak economy after its accession to the euro area were obtained in accordance with the model definition of the real exchange

rate, specifically by considering the development of the inflation differential.

³ The parameter of the HP filter λ was set to 1600, a value that is commonly used for quarterly data.

forecast⁴ before the calculation of the logarithmic deviations.

5. Calibration and estimation

We decided to calibrate several deep structural parameters to values that are commonly reported in the literature: discount factor $\beta = 0.995$, capital share in production $\alpha = 0.35$, capital depreciation rate $\delta = 2.5\%$ and, following Shaari (2008), households' share of the labour supply $\Omega = 99\%$ and steady-state mark-up $\mu = 1.2$.

The remaining model parameters were estimated using the random walk Metropolis–Hastings algorithm as implemented in the Dynare toolbox for Matlab. Two parallel chains of 1,000,000 draws each were generated during the estimation. The first 50% of draws were discarded as a burn-in sample. The scale parameter was set to achieve an acceptance rate around 30%. The prior densities of the model parameters were set in the same way for all 4 economies to identify the structural differences captured in the data.

6. Empirical results

In this section, we present the results of the estimation of the structural parameters of the V4 economies as well as the historical shock decomposition of the main macroeconomic variables. The common prior densities together with the posterior densities of the Czech model are presented in Table 2 in the appendix. Table 3, which is also included in the appendix, contains the comparison of the posterior means for all the V4 economies in absolute terms and relative to the results of the Czech model.

6.1 Posterior estimates

The posterior estimates are generally very similar across all four Visegrád economies. There are, however, important differences.

The debt-elastic risk premium ψ^B varies significantly, which suggests that the impact of the change in the foreign debt (net foreign assets) on the risk premium of the foreign bonds differs markedly across the V4 countries. The lower debt-elastic risk premium in the Czech economy suggests that forex dealers are less sensitive to the external balance of the Czech economy in relation to the exchange rate, which correlates with its status as a regional safe haven for

investors. This probably results from the transparent monetary policy of the CNB and the relatively tight fiscal policy.

The difference in preference bias for foreign goods γ can be explained by the greater openness of the export-oriented Czech and Slovak economies in comparison with the relatively self-sustaining Polish economy. In terms of the exports to GDP ratio, the Hungarian economy is actually more open than the economy of the Czech Republic. However, given the large share of foodstuffs in the consumption basket of households, the estimate may be influenced by the relatively self-sufficient agricultural sector in Hungary and the relatively larger share of imported groceries in the Czech economy. In addition, the Czech and Slovak economies are more tightly integrated into the car manufacturing supply chain and are more influenced by the economic performance of Germany.

According to parameter η , there are notable differences in the elasticity of substitution between foreign and domestic goods, which can be related to the different consumer preferences in the V4 economies.

There are quite large differences in the posterior estimates of the capital adjustment costs ψ^I , implying different efficiency levels of the transformation of investment into capital stock. The higher capital adjustment costs in Hungary and Poland suggest a lower level of investment efficiency.

The estimates of the financial friction parameters are quite similar across the V4 economies, with the capital to net worth ratio slightly higher in the Czech economy and the bankruptcy rate slightly lower in Hungary. This result may be explained by the fact that most commercial banks operating in these economies are subsidiaries of large international groups, which treat the CEE (Central and Eastern Europe) markets in similar ways.

The posterior estimates of the Taylor rule parameters show slightly higher smoothing and a lower output gap weight in the Czech economy than in the remaining V4 economies. In general, the estimated parameters of the Taylor rule correspond to the fact that the central banks in the Visegrád countries operate in more or less strict inflation-targeting regimes.

6.2 Historical shock decomposition

The historical shock decomposition of the real output and inflation between 2001Q1⁵ and 2014Q2 was

⁴ The VAR(3) model was considered for the foreign economy; the VAR(1) model with three exogenous foreign variables was considered for the domestic economy. The forecast for the next eight quarters was calculated.

⁵ The share explained by the initial values in the shock decomposition had mostly dissipated by 2001.

calculated next. The shares explained by particular exogenous shocks are presented in Table 1.

The historical fluctuations of the real output are explained predominantly by the shock in the law of one price, uncovered interest parity shock and monetary policy shock. The importance of the net worth shock is comparable to the domestic productivity shock or the total of foreign shocks. However, the net worth shock in the Czech economy explains only about half as much as the foreign shocks. This result correlates with the high estimate of the foreign goods preference bias in the Czech economy, its high level of openness and its relatively tight integration into the euro area economy. At the same time, the financial sector in the Czech economy is relatively robust and stable. The share explained by the net worth shock is the largest in the Polish economy, which is the biggest and least open of the Visegrád economies. It is also worth mentioning the comparatively low share of real output volatility explained by the monetary policy shock in the Czech economy, which can be related to the lower output gap weight in the Taylor rule.

Table 1 Shock decomposition of real output and inflation

Real output	UIP	LOP	Y	MP	NW	R*	P*	Y*
CZ	17	27	12	16	9	5	3	11
SK	21	27	10	19	13	3	2	6
PL	16	26	8	19	15	3	2	5
HU	19	27	13	20	11	2	2	5
Inflation rate	UIP	LOP	Y	MP	NW	R*	P*	Y*
CZ	15	11	31	22	5	5	2	10
SK	18	9	31	24	8	2	1	6
PL	19	12	21	25	8	2	1	5
HU	20	15	27	23	6	2	1	5

Source: author's calculations. Notes: UIP – uncovered interest parity shock, LOP – law of one price shock, Y – productivity shock, MP – monetary policy shock, NW – net worth shock, R* – foreign interest rate shock, P* – foreign inflation rate shock and Y* – foreign output shock. The sums of the shock contributions might not add up to 100 per cent due to the rounding error.

The historical deviations of the inflation rate were driven mainly by the shocks in domestic productivity, monetary policy and uncovered interest parity. The importance of the net worth shock for the development of the inflation rate is usually comparable to the sum of foreign shocks. The Czech economy is once again an exception, because the share explained by foreign shocks is more than three times as large as the share explained by the net worth shock there. The overall significance of the net worth shock for the development of inflation is somewhat lower in the Czech economy than in the rest of the V4 economies and it is slightly higher in Poland and Slovakia. It is worth pointing out the comparatively small share of inflation volatility explained by the uncovered interest parity shock in the

Czech economy, which might suggest that the Czech currency is somewhat more resilient than the remaining Central European currencies and could be related to the lower debt-elastic risk premium elasticity, but it could also be influenced by the intervention regime established in November 2013. The smaller share of the law of one price shock in the Slovak economy may be explained by the euro area membership. It may be more difficult for importers to impose radically different prices on the local market when they are denominated in the same currency. On the other hand, the shares of inflation volatility explained by the law of one price and uncovered interest parity shocks are the highest in the Hungarian economy, where the fiscal imbalances have caused the forint to fluctuate quite wildly in the past.

Since the estimates of the structural parameters of financial frictions were estimated very similarly in all four Visegrád economies, the differences in the shares explained by the net worth shock are mainly produced by idiosyncratic events and particular realizations of net worth shock innovations. What can be related to the structural differences between the Visegrád economies captured by the posterior estimates presented in the previous section is the relative importance of different types of shocks.

7. Conclusion

In this paper, we presented the results of the estimation of a set of DSGE models with a financial accelerator for the four Visegrád Group economies. A small open economy model was estimated for the Czech, Polish and Hungarian economies and a similar model with a deterministic regime switch was estimated for the economy of Slovakia because of the adoption of the euro in 2009.

The results of the estimation confirmed the overall similarity of the V4 economies, with some notable differences in the estimates of debt-elastic risk premium elasticity, foreign goods preference bias and capital adjustment costs. The estimates of the financial friction parameters were very similar across the V4 economies, which may be explained by the fact that most commercial banks operating in these economies are subsidiaries of large international groups, which treat the CEE (Central and Eastern Europe) markets in similar ways

According to the historical shock decomposition, the exogenous fluctuations of the entrepreneurial net worth explain the non-negligible share of volatility of the main macroeconomic variables. In the case of real output, the importance of the net worth shock is comparable to that of the domestic productivity shock or the total of foreign shocks. In the case of the inflation rate, the importance of the net worth shock is usually

comparable to the sum of foreign shocks. However, in the Czech economy, the relative importance of foreign shocks is in both cases much greater due to its high degree of openness and relatively tight integration into the euro area economy.

The net worth shock directly affects the development of the interest rate spread between the policy interest rate and the client interest rates in the economy. The results obtained from the shock decomposition therefore suggest that the financial frictions can have important implications for the long-run dynamics of the real output and inflation in the Visegrád Group countries. Thus, the monetary policy should take into account the factors that can affect the development of the interest rate spread in the economy and potentially reduce the efficiency of the monetary transmission.

References

- BERNANKE, B. S., GERTLER, M., GILCHRIST, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of Macroeconomics*, Vol. 1. Amsterdam: Elsevier, 1341–1393. [http://dx.doi.org/10.1016/S1574-0048\(99\)10034-X](http://dx.doi.org/10.1016/S1574-0048(99)10034-X)
- BRÁZDIK, F., HLAVÁČEK, M., MARŠÁL, A. (2012). Survey of research on financial sector modeling within DSGE models: What Central banks can learn from it. *Czech Journal of Economics and Finance* 62(3): 252–277.
- CHRISTENSEN, I., DIB, A. (2008). The financial accelerator in an estimated new Keynesian model. *Review of Economic Dynamics* 11(1): 155–178. <http://dx.doi.org/10.1016/j.red.2007.04.006>
- CHRISTIANO, L. J., TRABANDT, M., VALENTIN, K. (2011). Introducing financial frictions and unemployment into a small open economy model. *Journal of Economic Dynamics and Control* 35(12): 1999–2041. <http://dx.doi.org/10.1016/j.jedc.2011.09.005>
- CÚRDIA, V., WOODFORD, M. (2009). Credit Frictions and Optimal Monetary Policy. *BIS Working Paper*, No. 278. Basel: Bank for International Settlements.
- DIB, A. (2010). Banks, Credit Market Frictions, and Business Cycles. *Working Paper*, No. 2010–24. Ottawa: Bank of Canada.
- GOODFRIEND, M., MCCALLUM, B. (2007). Banking and interest Rates in Monetary Policy Analysis: A Quantitative Exploration. *Journal of Monetary Economics* 54(5): 1480–1507. <http://dx.doi.org/10.1016/j.jmoneco.2007.06.009>
- IACOVIELLO, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American Economic Review* 95(3): 739–764. <http://dx.doi.org/10.1257/0002828054201477>
- JUSTINIANO, A., PRESTON, B. (2010). Monetary policy and uncertainty in an empirical small open economy model. *Journal of Applied Econometrics* 25(1): 93–128.
- KIYOTAKI, N., MOORE, J. (1997). Credit chains. *Journal of Political Economy* 105(2): 211–248. <http://dx.doi.org/10.1086/262072>
- RYŠÁNEK, J., TONNER, J., TVŘZ, S., VAŠÍČEK, O. (2012). Monetary policy implications of financial frictions in the Czech Republic. *Czech Journal of Economics and Finance* 62(5): 413–429.
- SENAJ, M., VÝŠKRABKA, M., ZEMAN, J. (2010). MUSE: Monetary union and Slovak economy model. *Ekonomický časopis* 60(5): 435–459. <http://dx.doi.org/10.2139/ssrn.1878387>
- SHAARI, M. H. (2008). *Analyzing Bank Negara Malaysia's Behaviour in Formulating Monetary Policy: An Empirical Approach*. Doctoral thesis. Canberra: The Australian National University.
- SIENA, D. (2014). The European monetary union and imbalances: Is it an anticipation story? *Working paper*, No. 501. Paris: Banque de France.

Appendix

Table 2 Prior and posterior densities of the Czech model

			Prior		CZ Posterior	
Parameter	Distribution		Mean	Std	Mean	Std
Structural parameters						
Υ	Habit persistence	B	0.60	0.05	0.60	0.05
Ψ	Inv. elast. of lab. supply	G	2.00	0.50	1.30	0.35
ψ^B	Debt-elastic risk premium	G	0.05	0.02	0.03	0.01
η	Home/foreign elast. subst.	G	0.65	0.10	0.53	0.09
κ	Price indexation	B	0.50	0.10	0.49	0.09
γ	Pref. bias to foreign goods	B	0.40	0.15	0.42	0.08
θ_H	Home goods Calvo	B	0.70	0.10	0.80	0.03
θ_F	Foreign goods Calvo	B	0.70	0.10	0.83	0.03
ψ^I	Capital adjustment costs	G	8.00	3.00	12.2	2.90
Financial frictions						
Γ	Capital/net worth ss ratio	G	2.00	0.50	1.45	0.23
ς	Bankruptcy rate	B	0.025	0.015	0.06	0.01
χ	Financial accelerator	G	0.05	0.015	0.05	0.01
Taylor rule						
ρ	Interest rate smoothing	B	0.70	0.10	0.86	0.02
β_π	Inflation weight	G	1.50	0.20	1.84	0.23
θ_y	Output gap weight	G	0.50	0.20	0.19	0.05

Notes: B – beta distribution, G – gamma distribution.

Table 3 Posterior means comparison

Parameter		CZ		SK		PL		HU	
Structural parameters									
Υ	Habit persistence	0.60	(1)	0.58	(0.97)	0.60	(1)	0.60	(1)
Ψ	Inv. elast. of lab. supply	1.30	(1)	1.50	(1.15)	1.39	(1.07)	1.43	(1.1)
ψ^B	Debt-elastic risk premium	0.03	(1)	0.04	(1.65)	0.04	(1.39)	0.04	(1.71)
η	Home/foreign elast. subst.	0.53	(1)	0.65	(1.23)	0.52	(0.98)	0.61	(1.16)
κ	Price indexation	0.49	(1)	0.55	(1.13)	0.54	(1.11)	0.56	(1.16)
γ	Pref. bias to foreign goods	0.42	(1)	0.35	(0.82)	0.23	(0.54)	0.21	(0.49)
θ_H	Home goods Calvo	0.80	(1)	0.83	(1.03)	0.81	(1)	0.83	(1.03)
θ_F	Foreign goods Calvo	0.83	(1)	0.80	(0.96)	0.82	(0.99)	0.78	(0.94)
ψ^I	Capital adjustment costs	12.20	(1)	17.16	(1.41)	21.76	(1.79)	23.56	(1.93)
Financial frictions									
Γ	Capital/net worth ss ratio	1.45	(1)	1.29	(0.89)	1.27	(0.87)	1.30	(0.89)
ς	Bankruptcy rate	0.06	(1)	0.07	(1.02)	0.07	(1.04)	0.05	(0.75)
χ	Financial accelerator	0.05	(1)	0.05	(0.98)	0.05	(1.09)	0.04	(0.92)
Taylor rule									
ρ	Interest rate smoothing	0.86	(1)	0.73	(0.85)	0.64	(0.74)	0.68	(0.79)
β_π	Inflation weight	1.84	(1)	1.73	(0.94)	2.00	(1.09)	1.72	(0.94)
θ_y	Output gap weight	0.19	(1)	0.25	(1.34)	0.28	(1.47)	0.26	(1.37)

Notes: relative to CZ in parentheses.