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JEL: C32, E58, F41
Keywords: Markov switching DSGE models, inflation targeting, small open economy

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This paper analyzes changes in the monetary policy in the Czech Republic, Hungary, and Poland following the policy shift from exchange rate targeting to inflation targeting around the turn of the millennium. Applying a Markov-switching dynamic stochastic general equilibrium model, switches in the policy parameters and the volatilities of shocks hitting the economies are estimated and quantified. Results indicate the presence of regimes of weak and strong responses of the central banks to exchange rate movements as well as periods of high and low volatility. Whereas all three economies switched to a less volatile regime over time, findings on changes in the policy parameters reveal a lower reaction to exchange rate movements in the Czech Republic and Poland, but an increased attention to it in Hungary. Simulations for the Czech Republic and Poland also suggest their respective central banks, rather than a sound macroeconomic environment, being accountable for reducing volatility in variables like inflation and output. In Hungary, their favorable developments can be attributed to a larger extent to the reduction in the size of external disturbances.

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1 Introduction

Among other countries, the Central and Eastern European (CEE) transition economies of the Czech Republic, Poland, and Hungary adopted the monetary strategy of inflation targeting around the turn of the millennium. Officially announced inflation targets started to act as nominal anchors for monetary policy. Prior to that, the exchange rates of their respective currencies have explicitly been targeted by their central banks. The Czech National Bank (CNB) that has been committing to an exchange rate target against a currency basket composed of the German mark and the US dollar let the koruna float after not having being able to sustain devaluation pressures during May 1997. Consequently, inflation targeting was introduced as a new nominal anchor for monetary policy in the beginning of 1998. For most of the time since then the exchange rate has been given minor attention. However, at the end of 2013 the CNB announced to prevent an appreciation of its currency below 27 koruna per euro to tackle an ongoing undershooting of its inflation target while being confronted with the zero lower bound for policy rates. Somewhat different reads the story of the Hungarian forint. Prior to the introduction of inflation targeting, the national bank (MNB) has been operating a narrow +/- 2.25 percent crawling band regime for its currency. In the presence of large capital inflows, the MNB was not capable of preventing an excessive appreciation and to sufficiently sterilize the interventions at the same time to limit inflation pressures. Therefore, the exchange rate band was widened to 15 percent around the target rate against the euro in May 2001. An explicit inflation target to replace the exchange rate as a nominal anchor for monetary policy was introduced shortly thereafter. Hence, in contrast to the Czech Republic, the introduction of the inflation targeting framework did not come as a consequence of the central bank not being able to meet its exchange rate target due to capital outflows and resulting devaluation pressures. In Hungary, the switch from exchange rate to inflation targeting can rather be seen as an intentional policy change for a better fulfillment of the major objective of price stability. Nearly the same applies to Poland, where the national bank (NBP) gradually widened the band around a preannounced depreciation rate of its currency during the 1990s. The crawling band was finally abolished turning the zloty into a free floating currency in April 2000. Inflation targeting as a new framework for monetary policy was already introduced at the beginning of 1999. According to the International Monetary Fund (IMF) classification, the Polish and Czech currencies have become more flexible with the introduction of inflation targeting by moving from a managed floating to a free floating (Poland) and from a fixed to a managed floating regime (Czech Republic) respectively, whereas the forint remained being classified as a managed float. Following this, the move away from the exchange rate as a policy target did not lead to more flexibility of the

Hungarian currency, neither had its rate been kept fixed before. Nonetheless, the scope of its allowed movements has been substantially widened ahead of the introduction of the new monetary policy framework. Following the *de facto* classifications of Ilzetzki et al. (2010), none of the currencies has become more flexible. The actually realized strategy in terms of monetary policy responses to exchange rate movements before and after the target shift remains vague for all three central banks. Neither obvious is the actual timing of the switch as well as the persistence of the new strategy and especially the adherence to it in periods of crises. Following the seminal work of Taylor (1993), a broad field of literature on the estimation of monetary policy rules has emerged. The initial study that aimed at an explanation of policy rates through deviations of the inflation rate and output from their respective target values has been enhanced in many different ways. Examples include the introduction of an interest rate smoothing parameter (Clarida et al., 1998), specifications that feature other target variables, such as nominal GDP (McCallum, 2000), and the consideration of forward-looking variables (e.g. Batini and Haldane, 1999). Whereas monetary policy rules can be specified in a detailed manner to best fit historical data, they are most commonly estimated in a standalone way, not accounting for interactions between the monetary authority and the behavior of other agents in the economy. In particular, the extent to which policy measures can have an impact on the private sectors actions and expectations is not taken into account. In this context, dynamic stochastic general equilibrium (DSGE) models have gained importance. In contrast to univariate analyses, they provide a consistent framework for and thereby also a clearer interpretation of domestic and foreign economic shocks and the channels through which they affect particular variables. GalÌ and Monacelli (2005)Lubik and Schorfheide (2007) However, as outlined before, the economies under consideration in this paper have experienced structural and economic changes over the past decades. Whereas, due to their micro-foundation, parameters of estimated DSGE models have initially been regarded as invariant to policy changes, a large literature emerged arguing for the opposite. As one of the first, Fernndez-Villaverde and Rubio-Ramrez (2007) have found that standard DSGE model parameters are subject to drifts. In a recent study Hurtado (2014) built on their analysis and showed that estimated values of model parameters strongly depend on the underlying sample. Besides drifts in the values of structural parameters, there also seems to be a time-variance in the volatility of variables and disturbances hitting the economy, as the episode of the Great Moderation and the more turbulent periods before and thereafter suggest. To adequately account for changes as well as to quantify them, this paper estimates a simple small open economy model that allows for Markov-switches in its parameters and the volatilities of shocks. This paper adds to the emerging literature on estimated Markov-switching dynamic stochastic general equilibrium (MS-DSGE) models. As one of the first, Davig and Doh (2008) as well as Bianchi (2010) estimated simple models for the United States, putting a focus on switches in the interest rate rule. A more complex model based on the work of Justiniano and Preston (2010) has been estimated for the United Kingdom by Liu and Mumtaz (2010). A more simple model of the UK economy based on Lubik and Schorfheide (2007) by Chen and Macdonald (2012) analyzes optimal and realized policy rules in a regime switching context. The same model setup is used by Alstadheim et al. (2013) to estimate the central banks' responses to exchange rate movements in Canada, Norway, Sweden, and the UK. By applying the same framework to the Czech Republic, Hungary, and Poland, this study is the first, to the best of my knowledge, that analyzes monetary policy in CEE countries in a MS-DSGE model framework. By that, the timing and persistence of actual policy regime switches can be revealed. In addition, shifts in the central banks' strategies as well as in the volatility of shocks can be quantified. A revealed existence of different policy as well as volatility regimes further enables an assessment of the monetary policy compared to fictional scenarios in which different policy and volatility regimes are mixed. The achievement of objectives can thereby be classified as either a result of good policy or rather the presence of a favorable environment ("good luck"). Finally, the performance of the inflation targeting strategy can be evaluated in crises times.

The paper is organized as follows: Section 2 outlines the model framework, the estimation process is described in Section 3, estimation results and an assessment of the monetary policies is presented in Section 4, Section 5 concludes.

2 Model

The model follows the simplified version of Galí and Monacelli (2005) outlined in Lubik and Schorfheide (2007). It consists of a forward-looking IS curve, a Phillips curve, a monetary policy rule and an equation linking CPI inflation, the nominal exchange rate, and the terms of trade. In more detail, by assuming a perfect substitutability between a variety of goods produced in one country as well as between home and foreign goods, a unit elastic labor supply, and by abstracting from investment and government spending, the standard Euler equation of utility maximizing households results in the following log-linearized IS curve:

$$y_t = E_t y_{t+1} - (\tau + \mu)(R_t - E_t \pi_{t+1} - \rho_z z_t) - \alpha(\tau + \mu) E_t \Delta q_{t+1} + \alpha(2 - \alpha)\frac{1 - \tau}{\tau} E_t \Delta y^*_{t+1}, \quad (1)$$

with α being the share of imported goods in consumption, τ the intertemporal elasticity of substitution, and $\mu = \alpha(2 - \alpha)(1 - \tau)$. Intertemporal optimization of households results in consumption smoothing. Current values for consumption and thus output depend on their expected future realizations as well as the opportunity cost of current consumption in terms of foregone savings, the expected real interest rate $R_t - E_t\pi_{t+1}$. Furthermore, the rate of change in the terms of trade Δq_t, the relative price of imports in terms of exports, affects domestic output via the substitution of domestic for foreign goods. z_t is the growth rate of the global technology, reflecting the non-stationary part of domestic as well as foreign output y_t^*.

Firms set their prices in a Calvo (1983) manner. Each period only a random fraction of $(1-\theta)$ firms is able to set their prices to their optimal values in terms of profit maximization. This results in the consideration of expected future price levels in the current price setting. For the aggregate economy's price level it follows that

$$\pi_t = \beta E_t \pi_{t+1} + \alpha\beta E_t \Delta q_{t+1} + \alpha \Delta q_t + \frac{\kappa}{\tau+\mu} y_t + \frac{\kappa+\mu}{\tau(\tau+\mu)} y_t^*. \tag{2}$$

$\kappa = (1-\theta)(1-\theta\beta)/\theta$ is a measure of the degree of price rigidity dependent on the Calvo parameter θ. The impact of import prices on consumer price inflation is captured by the inclusion of the terms of trade. The last two factors reflect reactions of the price level to the degree of capacity utilization. Domestic and foreign inflation, the terms of trade and the depreciation of the nominal exchange rate are linked under the assumption of purchasing power parity:

$$\Delta e_t = \pi_t - (1-\alpha)\Delta q_t - \pi_t^*. \tag{3}$$

Monetary policy is characterized by a Taylor (1993)-type rule. The central bank sets the nominal interest rate R_t in reaction to movements in the inflation rate, the output gap, and the nominal exchange rate depreciation:

$$R_t = \rho_R R_{t-1} + (1-\rho_R)(\psi_1 \pi_t + \psi_2 y_t + \psi_3 \Delta e_t) + \epsilon_t^R. \tag{4}$$

The remaining model variables, the terms of trade, technology as well as foreign output and inflation, are assumed to follow AR(1) processes:

$$\begin{aligned}
\Delta q_t &= \rho_q \Delta q_{t-1} + \epsilon_t^q && (5)\\
z_t &= \rho_z z_{t-1} + \epsilon_t^z && (6)\\
y_t^* &= \rho_{y^*} y_{t-1}^* + \epsilon_t^{y^*} && (7)\\
\pi_t^* &= \rho_{\pi^*} \pi_{t-1}^* + \epsilon_t^{\pi^*}, && (8)
\end{aligned}$$

with $\epsilon_t^x \sim NID(0, \sigma_x^2)$ for $x \in \{q, z, y^*, \pi^*\}$.

3 Estimation

3.1 Regime switching

The model presented above can be put into state space representation of the general form

$$\Gamma_0(\theta)X_t = \Gamma_1(\theta)X_{t-1} + \Psi(\theta)\epsilon_t + \Pi(\theta)\eta_t, \tag{9}$$

where X_t is a vector of endogenous variables, ϵ_t contains exogenous shocks, and η_t expectation errors. Γ_0, Γ_1, Ψ, and Π, are matrices, whereas θ contains the model parameters. The standard, time-invariant model can then be transformed into a regime switching version by letting the parameter vector θ being dependent on the exogenous stochastic process $S_t \in \{1, \ldots, M\}$ with M being the number of regimes that a Markov chain is allowed to follow. The transition probabilities with which the parameter vector is allowed to switch between different states takes the form:

$$\Pr[S_t = 2 \mid S_{t-1} = 1] = p_{12}, \tag{10}$$

The matrix of transition probabilities for one two-states Markov chain that is combined with the model equation can the be written as

$$P = \begin{bmatrix} p_{11} & p_{11} \\ p_{21} & p_{22} \end{bmatrix}, \tag{11}$$

leading to a representation of the above outlined model following Farmer et al. (2011):

$$\bar{\Gamma_0} X_t = \bar{\Gamma_1} X_{t-1} + \bar{\Psi}\epsilon_t + \bar{\Pi}\eta_t, \tag{12}$$

with $\bar{\Gamma_0}$, $\bar{\Gamma_1}$, $\bar{\Psi}$, and $\bar{\Pi}$ combining the structural parameters and the transition probabilities. When forming expectations, agents thus explicitly take into account the transition probabilities, since a switch to another regime in the following period would result in different parameter values and by that alter the dynamics of the model variables.

The system is solved according to the Newton method outlined in Maih (2015), an extension of the minimum state variables solution proposed by Farmer et al. (2011), and estimated by mean of Bayesian techniques using the RISE toolbox for Matlab. However, due to the introduction of Markov-switching parameters and their unobserved states, the standard Kalman filter cannot be applied to compute the value of the likelihood, since it would take into account all possible combinations of Markov states in the past. Instead, an algorithm proposed by Kim and Nelson (1999) is adopted that approximates the Kalman filter by limiting the number of states that is carried forward at each period, so that the Kalman filter becomes workable.

Along with the benchmark model M_0 with time-invariant parameters and shocks, six alternative specifications are estimated. In contrast to M_0, model M_1 allows for switches in the parameters of the interest rate rule, while M_2 is characterized by two regimes for the exogenous shocks. M_3 and M_4 combine the latter two specifications by allowing the policy parameters and the shocks to switch simultaneously. Whereas M_3 is characterized by one common Markov chain, M_4 sets up two independent chains for policy parameters and volatility respectively. Finally, M_5, M_6, and M_7 allow all coefficients and shocks to switch over the sample. In the first specification, all of them follow the same Markov chain. M_5 and M_6 again introduce two independent chains for policy parameters and shocks. The remaining coefficients then follow the same chain as the policy parameters (shocks) in the former (latter) specification.

3.2 Data

For the estimation the following five quarterly time series are used: log difference of real gross domestic product multiplied by 100 (ΔGDP_t), log difference of the consumer price index multiplied by 400 (ΔCPI_t), log difference of the terms of trade and the nominal exchange rate (NEER) index multiplied by 100 (ΔTOT_t and $\Delta NEER_t$), and the three-month interbank rate (INT_t).

All of the observable variables follow specific trends. These are the trends for the domestic output growth rates, for the inflation rate, as well as the domestic nominal interest rate. All of them, except for the latter, cannot been regarded as time-invariant. Taking the annual Polish inflation rate as an example, one obtains a sample average of more than 22 percent from 1994 to 1996 but only a value of less than 3 percent from 2000 to the present. Disregarding shifts in the average values of these parameters would result in imprecise assessments of the corresponding model variables, i.e. the deviations from the "correct" trend, and thus in inaccurate estimations of the whole model. In the presence of a strongly decreasing (increasing) trend over time, the detrending of the variables around their sample means, for example, leads to an overestimation (underestimation) of the model variables in former (more recent) times and vice versa. To avoid these misspecifications, the trend component of the observable variables is excluded using the Hodrick-Prescott filter.

The extracted cyclical components of the above mentioned time series are linked to the model variables via the following measurement equation:

$$\begin{bmatrix} \Delta GDP_t \\ \Delta CPI_t \\ INT_t \\ \Delta NEER_t \\ \Delta TOT_t \end{bmatrix} = \begin{bmatrix} \Delta y_t \\ 4\pi_t \\ 4R_t \\ \Delta e_t \\ \Delta q_t \end{bmatrix}. \tag{13}$$

Dependent on the availability of the time series, the estimation sample ranges from 1994 till 2013 for Poland and the Czech Republic and from 1993 till 2013 for Hungary.

3.3 Priors

The choice of priors and standard deviations of shocks (Table A.1) is guided by Lubik and Schorfheide (2007) and the methodologies described therein. For the price rigidity parameter κ and the intertemporal substitution elasticity parameter τ the prior means are both set at .5 with large standard deviations respectively. The latter is restricted to the interval from 0 to 1 to avoid singularity at $\tau = 1$. Identical priors are also set for the steady state interest rate $\bar{R}$ that is linked to the discount factor β according to $\beta = exp(-\bar{R}/400)$ at a mean of 2.5 and a standard deviation of 1. Priors for the import shares are set so as to match the respective ratios of imports to GDP over the sample. For the Czech Republic and Hungary (.6 and .7) these are nearly twice as large as the Polish equivalent (.35). Based on domestic inflation, the NEER, and a corresponding real effective exchange rate time series, foreign inflation is approximated for all three economies. Estimates for their AR(1) coefficients are then considered to form prior beliefs for ρ_{π^*}. They are centered at .2 with a standard deviation of .1. The shock innovations for the foreign inflation AR process range from 2.3 for the Czech Republic and 4.1 for Poland. Priors for the foreign output coefficients and innovations are based on AR(1) estimates of the ratios of Euro area to domestic GDP. Obtaining values between .70 and .88, a common prior mean of .8 with a standard deviation of .1 is chosen. The same applies for the innovation to the foreign output AR process whose priors are centered around .4. Equivalently, priors are set for the technology and the terms of trade processes, by fitting AR(1) processes to the domestic output growth rate and to the observed changes in the terms of trade respectively. By that, significant differences between the three economies are revealed for the innovations in the terms of trade equation leading to respective priors means from .7 for Hungary to 3.2 for Poland. All of the other values fall into a narrow range, so that the respective priors are assumed to be characterized by identical means and standard deviations around those estimates. Standard priors are chosen for the parameters of the monetary policy rule: the priors for the reaction parameter to inflation is centered around 1.5, the other two around .5, whereas the prior means for the AR coefficient are set to .5. For all of the aforementioned parameters, sufficiently large standard deviations are chosen. Finally, the priors for the transition probabilities are set in a way to allow for multiple backward and forward regime switches.

4 Results

4.1 Regime identification

A comparison of the log marginal data densities points at the inferiority of the time-invariant parameters model compared to most of the regime switching specifications (Table 1). However, in all three economies model M_1, allowing for switches in the parameters of the policy rule only, fits the observed data even worse. To put it different, models that feature regime switching shocks outperform those that assume time-invariance in the severity of disturbances hitting the economy. For all three economies Model M_2 fits the data best.

		Czech Rep.	Hungary	Poland
Time invariant	M_0	-664.50	-616.54	-740.74
Policy parameters only	M_1	-670.21	-618.64	-756.92
Volatility only	M_2	**-567.34**	**-606.04**	**-700.58**
Policy parameters and volatility (one chain)	M_3	-574.97	-615.10	-710.30
Policy parameters and volatility (two chains)	M_4	-580.49	-616.19	-717.97

Table 1: Log marginal data densities

Models in which all parameters are allowed to switch perform significantly worse in all three economies and are thus ignored in the further analyses and interpretations.

Czech Republic For the Czech Republic the estimation reveals periods of different monetary policy regimes as well as episodes of high and low volatility (Figure 1). As concerns the monetary policy, it is characterized by high responses to movements of either the exchange rate or the inflation rate and a lower attention to the other target variable respectively (Table A.2). The smoothed probabilities of being in the high exchange rate response regime suggest, in two out of three specifications, that a switch to the low response regime occurred in the middle of 1997. This finding nearly perfectly matches the abandonment of the exchange rate peg at the end of May. In addition, slightly lower probabilities of being in the high response regime in the year before reflect the widening of the koruna's fluctuation band and the consequential lower consideration of its movements in the conduct of monetary policy. Since the policy switch, the CNB has continuously been operating in the low exchange rate/high inflation response regime. In the single chain specification M_3 that suggests a switch back to the former policy strategy during the most recent financial crisis, regime probabilities seem to be rather driven by the identification of different regimes of the shock volatilities. One indication for this is the finding that the smoothed probabilities of being in the high volatility regime are virtually independent of the model setup and thus regardless of the consideration of different policy regimes. In addition, the estimate for the error term in the interest rate rule in M_3 is much higher in the high compared to the low volatility regime, with the difference being larger than in any other model setup. Hence, model M_3 possibly fails to correctly account for changes in the monetary policy rule. Instead, systematic reactions in the high exchange rate response regime seem to be partly declared as policy disturbances. One potential explanation for this could be the relatively short period of the former compared to the current policy strategy.

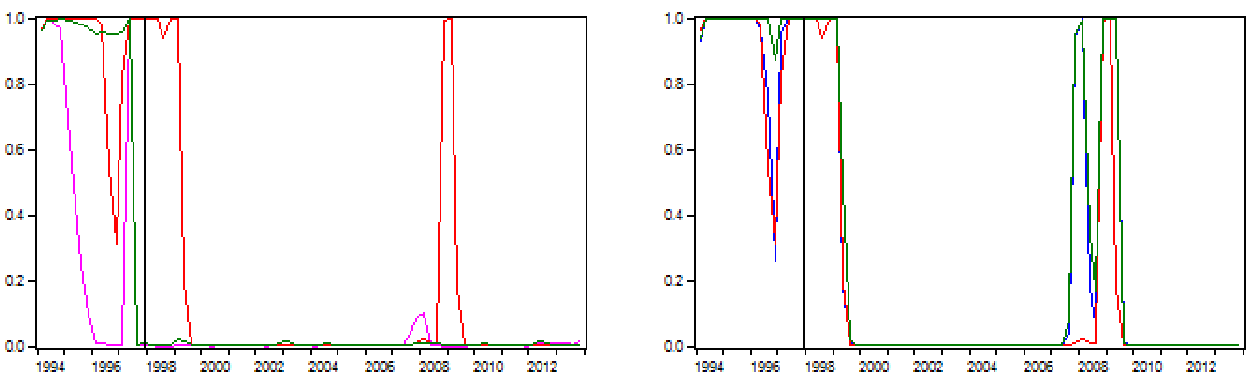

Figure 1: Smoothed probabilities of the high exchange rate response (left) and volatility regime (right) in the Czech Republic according to M_1 (magenta), M_2 (blue), M_3 (red), and M_4 (green). The black vertical line marks the official introduction of inflation targeting.

Estimation results of the specification M_4, according to which switches of the policy parameters and shock volatilities are governed by independent Markov chains, suggest the reactions of the CNB to movements of the exchange rate and output to have decreased remarkably and to be almost negligible under the present policy strategy. On the other hand and apart from an increased attention to the inflation rate, the degree of interest rate smoothing is nearly twice as large as under the former exchange rate targeting regime.

Volatilities of shocks that hit the Czech economy also vary substantially between the two identified regimes. Except for the foreign inflation shock, these are on average four times larger in the more turbulent environment. According to the smoothed probabilities, it has prevailed until the end of the Russian crisis of 1998 and thus throughout most of the

1990s. Apart from the financial crisis that started to erupt in 2007, the Czech Republic has remained in the low volatility regime since then. This overall higher persistence of the current volatility regime compared to its former counterpart is expressed in a lower transition probability. Even more persistent, by four times compared to the previous regime, is the current monetary policy strategy.

Hungary For Hungary the estimation identifies switches between different monetary policy strategies as well as high and low volatility regimes (Figure 2). Following the results, there have in general been smaller disturbances to the economy since 1996, when abstracting from the Russian crisis of 1998, the recent financial turmoil, and three domestic crises or speculative attacks on the forint. Compared to the other economies, the difference between the values of the shock coefficients in the two regimes is lower in Hungary (Table 4). Periods of strong and weak responses to exchange rate movements are also well identified for the specifications in which the policy parameters are allowed to switch independently of the shock variances. As in the Czech case, M_3 seems to partly attribute systematic policy changes to the error term. In general, periods of low volatility go along with a more aggressive reaction to inflation and also to the exchange rate. This does not come surprisingly, since Hungary has continued to manage is exchange rate despite having switched its target from the exchange rate to inflation. Thus, the left graphs in Figure 2 rather show switches in the monetary policy in general and hence the probabilities of being in the more recent inflation targeting regime. Abstracting from the smoothed probabilities implied by the rather volatility driven changes in M_3 and the countering of appreciation pressures and speculative attacks in 2002 and 2003, the MNB has maintained its policy strategy since the official introduction of inflation targeting in 2001. Its reaction to inflation pressures has strongly increased compared to the very low coefficient value in the former regime. The interest rate smoothing parameter is also around twice as large in the policy in place.

Poland For Poland the estimation reveals clear switches between high and low volatility regimes, independently of the model employed (Figure 3). Since 1996 Poland has experienced a rather calm macroeconomic environment. Estimations further suggest, that a regime switch in the monetary policy also took place at that time and hence prior to the official introduction of inflation targeting at the beginning of 1998. After the switch, periods of strong appreciations of the zloty following the accession to the European Union that led to interventions of the NBP are well identified by slightly higher probabilities of the old regime based on M_4 and a high volatility occurrence. Nevertheless, the extent to which the central bank reacted to variations in the currency price is very low in both regimes (Table 5).

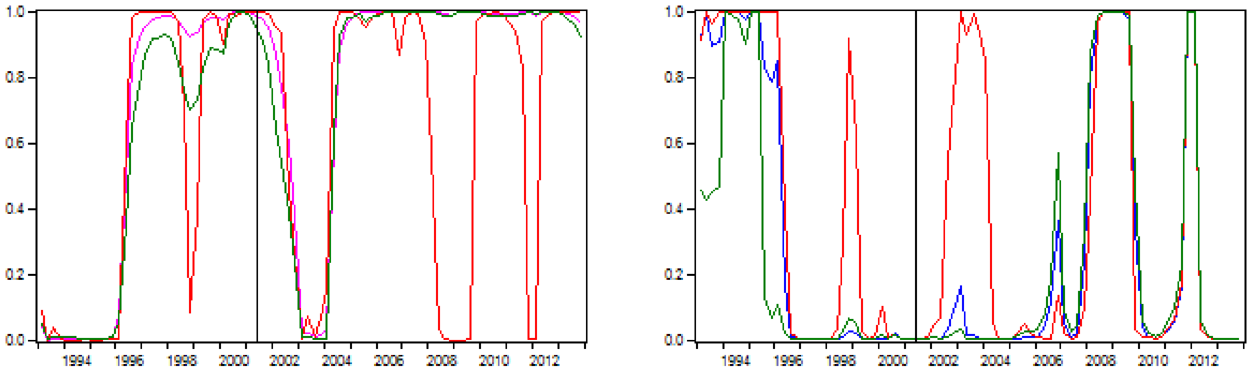

Figure 2: Smoothed probabilities of the high exchange rate response (left) and volatility regime (right) in Hungary according to M_2 (magenta), M_2 (blue), M_3 (red), and M_4 (green). The black vertical line marks the official introduction of inflation targeting.

Following the regime switch, the coefficient for inflation in the policy rule clearly increased, especially in the model specifications in which the policy parameters are allowed to switch independently. The opposite holds true for the output coefficient, which is smaller under

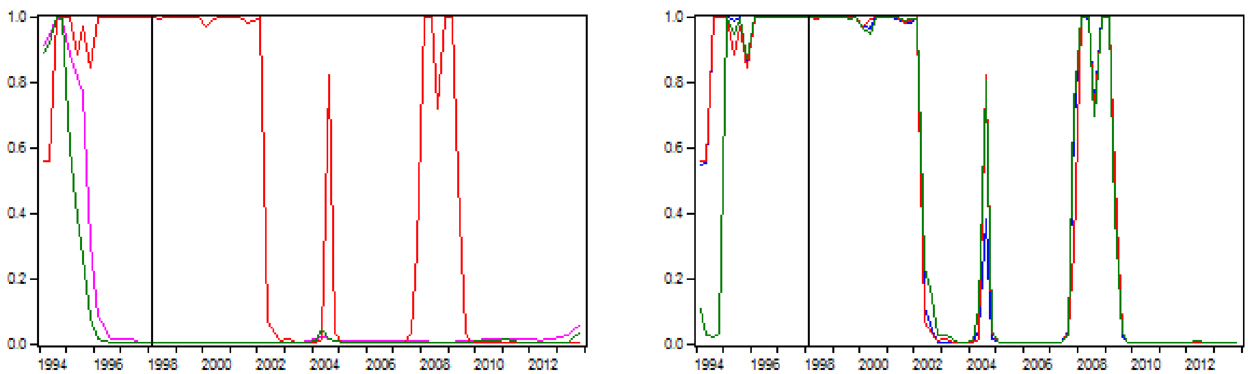

Figure 3: Smoothed probabilities of the high exchange rate response (left) and volatility regime (right) in Poland according to M_2 (magenta), M_2 (blue), M_3 (red), and M_4 (green). The black vertical line marks the official introduction of inflation targeting.

the new regime. The implied smoothed probabilities for the Polish economy being in a high volatility regime are nearly identical throughout the different models, suggesting changes in the standard deviations of shocks rather than of policy parameters being the main drivers of the estimated regime switches in M_3. In particular, this seems to apply to the recent financial crisis, in which the NBP is estimated to have maintained its policy strategy according to M_4 and also M_1.

4.2 Policy evaluation

After periods of low output growth and high inflation rates in the three economies during the 1990s, the former have increased whereas inflation rates have come down to levels only slightly above targets in advanced economies. At the same time, the volatilities of both variables markedly decreased following the official implementation of inflation targeting. One potential factor among others could have been a better performing monetary policy due to an increased experience and a higher credibility. Following this, private sector expectations of price level movements are expected to have increasingly mirrored the central banks' targets and by that substantially facilitated the achievement of the latter. On the other hand, a less volatile macroeconomic environment could have led to the observed success in the evolution of targeted variables. This factor seems to be particularly relevant for the highly open economies of the Czech Republic and Hungary. With exports and imports amounting to roughly two thirds of the respective GDP, they are strongly affected by foreign disturbances.

As the estimation results reveal, in all three economies the volatilities of shocks have decreased over time and by that facilitated the monetary policies under the nearly coexisting current strategies. Thus, for a correct assessment of their performances, the different underlying environments have to be correctly accounted for. Therefore, simulations are conducted for different combinations of policy and volatility regimes. As a benchmark serves the current monetary policy facing the current small-sized shocks to foreign output, foreign inflation, the terms of trade, and technology. The impacts of disturbances on the volatilities of target variables are quantified and compared to a scenario in which the current policy is confronted with the former highly volatile environment (scenario 1), a setup in which the old monetary policy regime faces the lower disturbances of the more recent years (scenario 2), and the old policy in the former high volatility environment (scenario 3).

To accurately account for policy changes and the regimes of high and low volatility, the three economies are analyzed based on the estimations of the model specification M_4 in which policy and volatility switches occur independently from each other. Shocks and model parameters, including the coefficients of the monetary policy rule, are set to their respective posterior modes. The calibrated models are simulated over 10,000 periods, dropping the first 3,000 observations.

Based on the simulation results, the extents to which the monetary authorities' efforts ("good policy") and the smoother macroeconomic environment ("good luck") have contributed to the favorable development of target variables are assessed. A central bank is considered having rather had "good luck" in the case of the old policy strategy being at least as effective as the strategy in place when facing the same environment. This requires shock impacts on the variables considered (output, inflation, interest rate, and nominal exchange rate depreciation) to be larger in the benchmark case (scenario 1) compared to scenario 2 (scenario 3). Lower effects in the benchmark case relative to scenario 2, as well as scenario 1 relative to scenario 3, would point at a "good policy" with the more recent regime being able to better handle disturbances of the same intensity. In addition, "good policy" is also attributed to a central bank if its current strategy is more effective than the former one, even in a more volatile environment. This holds true, if shock impacts are lower in scenario 1 compared to scenario 2. Finally, since all three central banks have retained their policy regimes during the high volatility periods of the recent financial crisis according to the estimations of most of the specifications, a higher effectiveness of scenario 1 compared to scenario 3 would also point at a correct policy decision in this respect.

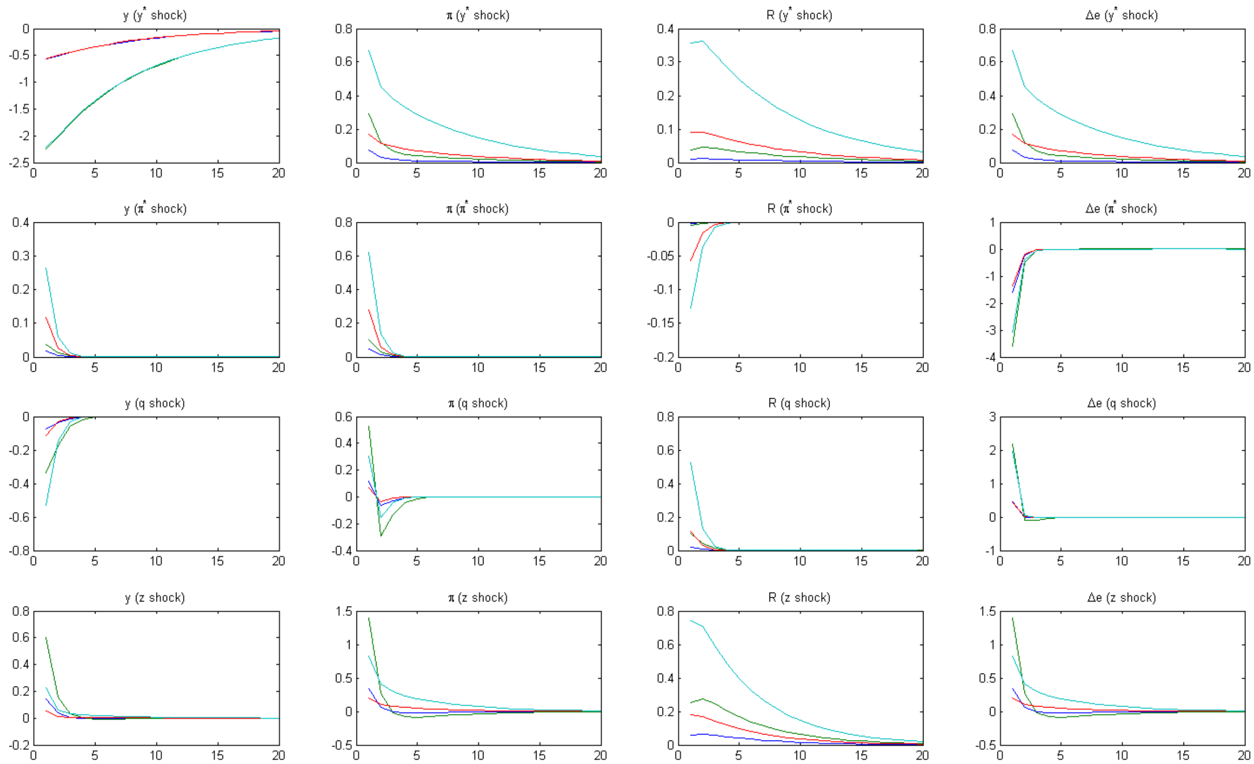

Figure 4: Impulse responses for the Czech Republic to one-standard deviation shocks. Figure depicts the actual policy and volatility (blue), actual policy and high volatility (green), former policy and low volatility (red), and former policy and high volatility (cyan).

Czech Republic Impulse responses for the Czech Republic are presented in Figure 4. In the presence of shocks to foreign output and inflation, the impact on most domestic variables is lower under the current low exchange rate response regime (Table B.1). In all but two cases, the current strategy clearly outperforms the previous rule providing evidence of "good policy" rather than "good luck" to have been responsible for the reduction in the respective volatilities. Following foreign inflation shocks, this finding holds true even if the current policy operates in the high volatility environment, with the impact on the variables of interest being lower compared to the former policy in modest times. Exceptions to the superiority of the regime in place form the impact of a foreign output shock on domestic output that is nearly identical for both strategies and the effect of foreign inflation shocks on the exchange rate. Since the simulation results do not suggest a higher effectiveness of the old policy regime in the high volatility setup, the CNB has most likely prevented a larger transmission of foreign shocks to domestic output and inflation by maintaining its strategy during the most recent financial crisis The effects of terms of trade shocks on output and inflation are mixed. Whereas output is less affected by terms of trade shocks under the more recent regime, the opposite holds true for domestic inflation. Innovations to technology have a larger impact on domestic output, reflecting the only marginal consideration of the latter in the central bank's policy rule to counteract the disturbance. Domestic inflation is also stronger affected by the technology shock under the current policy, albeit only slightly. Not surprisingly, the higher degree of interest rate smoothing under the current regime results in a remarkably lower effect of all considered shocks on the interest rate. Finally, assuming a preference for some exchange rate stability, the more recent low exchange rate response regime performs at least nearly as good as the high response regime in the presence of all considered shocks.

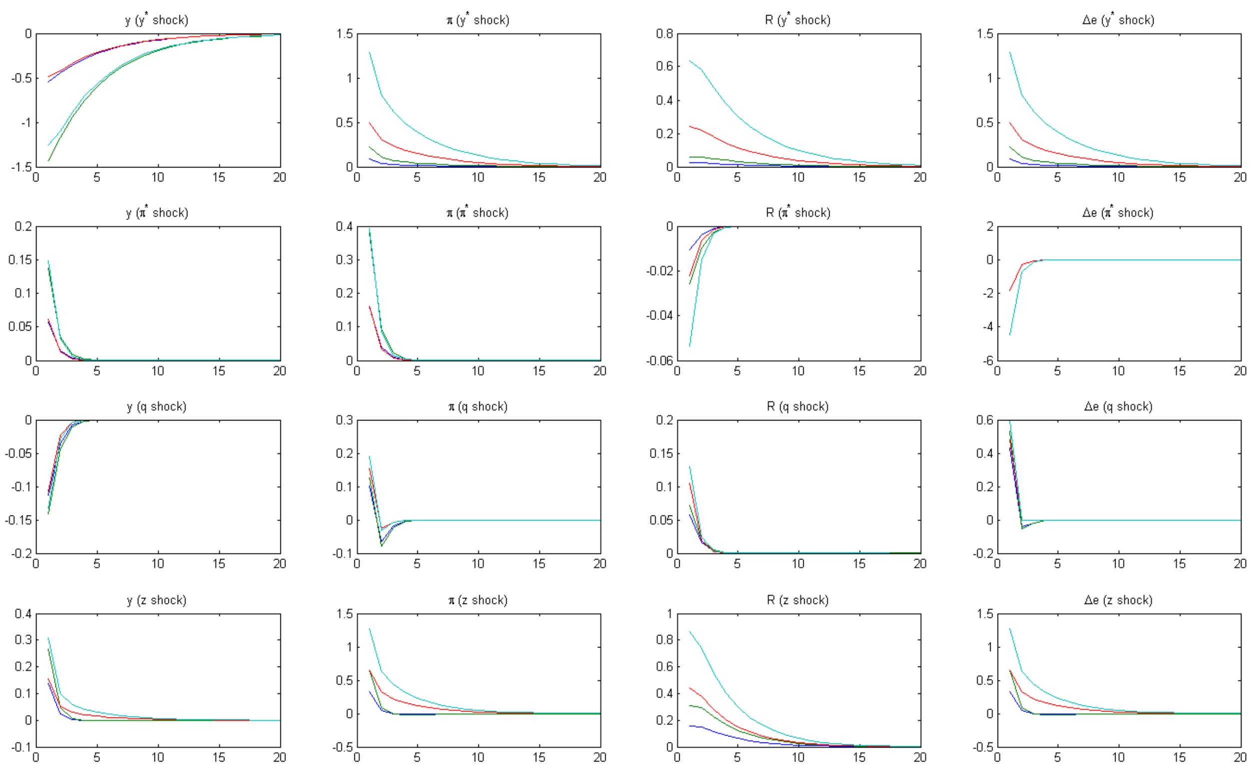

Figure 5: Impulse responses for Hungary to one-standard deviation shocks. Figure depicts the actual policy and volatility (blue), actual policy and high volatility (green), former policy and low volatility (red), and former policy and high volatility (cyan).

Hungary In Hungary, the current monetary policy regime is also characterized by a remarkably lower impact of foreign output shocks on inflation, the interest rate, and the exchange rate (Figure 5 and Table B.2). In this context, the policy in place outperforms the former strategy even in a more volatile environment. However, the impact on output given the same magnitude of shocks is larger than under the former regime. The effects of foreign inflation shocks on domestic output and inflation are nearly the same under both policy strategies. Hence, compared to the Czech Republic, there is less clear evidence for the policy in place to have been more effective than the old regime in reducing the effects of equal size external disturbances on target variables. At the same time, the current policy does not prove to be inferior to the former strategy, except for the vulnerability of domestic output to foreign output shocks. Regardless of the inconclusive evaluation of the monetary policy, a smoother macroeconomic environment appears to have considerably facilitated the central bank's efforts following the official implementation of inflation targeting. However, this finding holds true only for the two "clearly" external disturbances to foreign output and inflation. In the presence of terms of trade shocks, the current regime performs better when evaluated on the basis of the effects on domestic inflation and only slightly worse with regard to output fluctuations. In addition, output and inflation are less affected by technology shocks of either intensity under the policy in place. In this context, the current strategy performs better even in a higher volatility environment. Finally, a much higher degree of interest rate smoothing has lead to substantially lower effects of all shocks on the interest rate, while the increased attention to exchange rate movements has reduced the impact of all disturbances, except for the foreign inflation shock, under the current policy regime.

Poland Simulations for Poland reveal a clear superiority of the policy regime in place compared to its former counterpart (Figure 6 and Table B.3). Except for the slightly stronger effect of a foreign output shock on domestic output, the impacts of all disturbances on output and inflation are lower under the more recent strategy, hinting at the Polish central bank to have realized a "good policy" in the aftermath of the regime switch. With regard to foreign inflation shocks, the current policy outperforms the former one even in a more turbulent environment. The same holds true for the effects of foreign output disturbances on domestic inflation. The results thus suggest that by not altering its policy during the recent financial crisis, the NBP reduced the transmission of foreign shocks to domestic variables compared to the alternative former regime. In contrast to the other two economies considered, the Polish central bank is estimated to have lowered the degree of interest rate smoothing following the regime switch. Consequently, the interest rate shows stronger reactions to equal size shocks in most of the cases. Similar to the Czech Republic, the reduced consideration of the

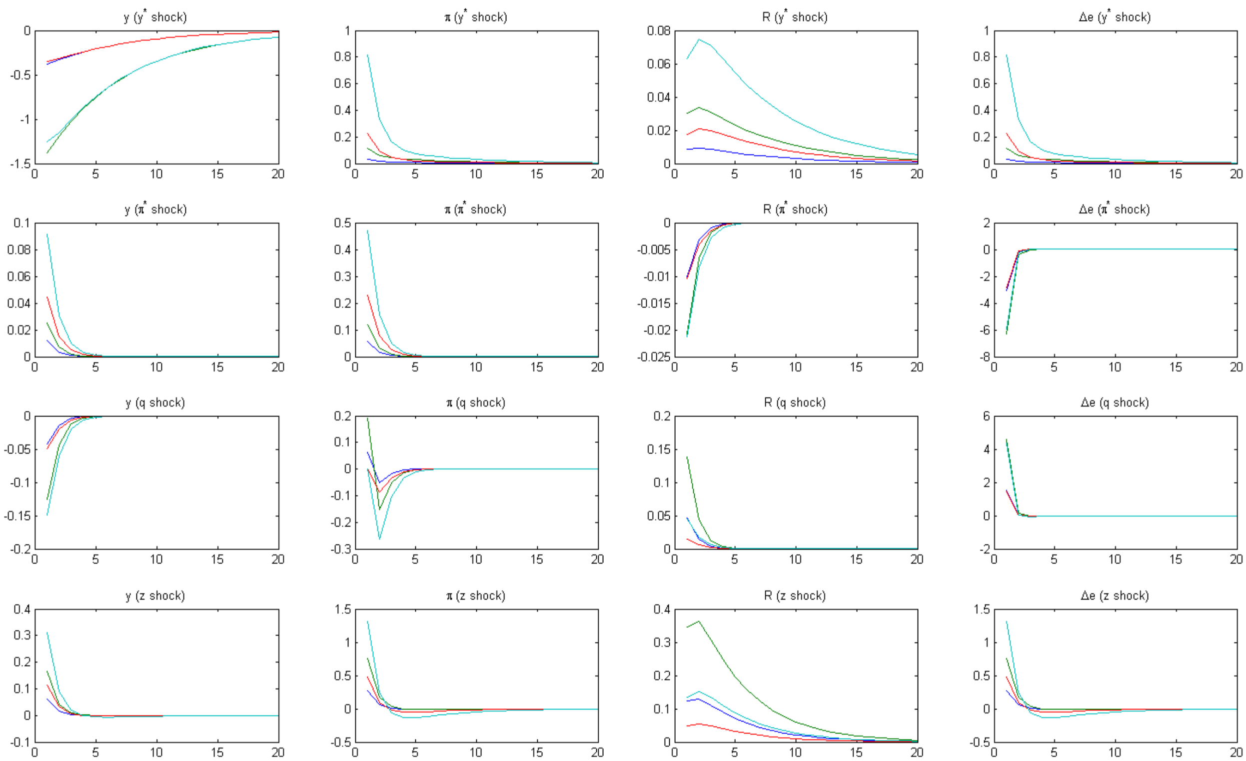

Figure 6: Impulse responses for Poland to one-standard deviation shocks. Figure depicts the actual policy and volatility (blue), actual policy and high volatility (green), former policy and low volatility (red), and former policy and high volatility (cyan).

exchange rate in the central bank's reaction function does not result in substantially higher shock effects under the current low exchange rate response regime.

5 Conclusive remarks

In a simple Markov-switching small open economy framework this paper analyzes possible switches in the monetary policy regimes of the Czech Republic, Hungary, and Poland following the implementation of inflation rather than exchange rate targeting as their policy strategy. For the Czech Republic and Poland the estimation reveals switches from high to low exchange rate response regimes that go along with a reduction in the volatility of shocks and a more prominent consideration of inflation in the central banks' policy rules. In both economies the switches implied by the smoothed state probabilities occurred shortly before the official introduction of inflation targeting. In Hungary, on the other hand, the central bank is estimated to have increased its response to exchange rate movements after the introduction of the new strategy. This finding reflects the ongoing managing of the forint's rate over the regarded sample and despite the repeal of exchange rate targeting. Analogously to the other two economies, the consideration of the inflation rate in the policy rule increased, whereas the volatilities of shocks remarkably declined. Simulations of the model calibrated to allow the different policy strategies to operate under identical conditions characterized by equal size shocks also point at the success of monetary policy in the Czech Republic and Poland in stabilizing output growth and inflation in the recent years rather than this outcome being the result of a less volatile macroeconomic environment. In Hungary, the reduction in the volatilities of target variables is to a larger extent also attributable to the decrease in the magnitude of external disturbances.

References

Alstadheim, R., H. C. Bjørnland, and J. Maih (2013): "Do central banks respond to exchange rate movements? A Markov-switching structural investigation," Working Paper 2013/24, Norges Bank.

Batini, N. and A. Haldane (1999): "Forward-Looking Rules for Monetary Policy," in *Monetary Policy Rules*, National Bureau of Economic Research, Inc, NBER Chapters, 157–202.

Bianchi, F. (2010): "Regime Switches, Agents' Beliefs, and Post-World War II U.S. Macroeconomic Dynamics," Working Papers 10-39, Duke University, Department of Economics.

Calvo, G. A. (1983): "Staggered prices in a utility-maximizing framework," *Journal of Monetary Economics*, 12, 383–398.

Chen, X. and R. Macdonald (2012): "Realized and Optimal Monetary Policy Rules in an Estimated Markov-Switching DSGE Model of the United Kingdom," *Journal of Money, Credit and Banking*, 44, 1091–1116.

Clarida, R., J. Gali, and M. Gertler (1998): "Monetary Policy Rules in Practice: Some International Evidence," *European Economic Review*, 42, 1033–1067.

Davig, T. and T. Doh (2008): "Monetary policy regime shifts and inflation persistence," Research Working Paper RWP 08-16, Federal Reserve Bank of Kansas City.

Farmer, R. E., D. F. Waggoner, and T. Zha (2011): "Minimal state variable solutions to Markov-switching rational expectations models," *Journal of Economic Dynamics and Control*, 35, 2150–2166.

GalÌ, J. and T. Monacelli (2005): "Monetary Policy and Exchange Rate Volatility in a Small Open Economy," *The Review of Economic Studies*, 72, 707–734.

Galí, J. and T. Monacelli (2005): "Monetary Policy and Exchange Rate Volatility in a Small Open Economy," *The Review of Economic Studies*, 72, 707–734.

Ilzetzki, E., C. M. Reinhart, and K. S. Rogoff (2010): "Exchange Rate Arrangements Entering the 21st Century: Which Anchor Will Hold?" mimeo, University of Maryland and Harvard University.

Justiniano, A. and B. Preston (2010): "Monetary policy and uncertainty in an empirical small open-economy model," *Journal of Applied Econometrics*, 25, 93–128.

Kim, C.-J. and C. R. Nelson (1999): *State-Space Models with Regime Switching: Classical and Gibbs-Sampling Approaches with Applications*, vol. 1 of *MIT Press Books*, The MIT Press.

Liu, P. and H. Mumtaz (2010): "Evolving macroeconomic dynamics in a small open economy: an estimated Markov-switching DSGE model for the United Kingdom," Bank of England working papers 397, Bank of England.

Lubik, T. A. and F. Schorfheide (2007): "Do central banks respond to exchange rate movements? A structural investigation," *Journal of Monetary Economics*, 54, 1069–1087.

Maih, J. (2015): "Efficient perturbation methods for solving regime-switching DSGE models," Working Paper 1/2015, Norges Bank.

McCallum, B. T. (2000): "Alternative Monetary Policy Rules: A Comparison with Historical Settings for the United States, the United Kingdom, and Japan," *Economic Quarterly*, 49–79.

Taylor, J. B. (1993): "Discretion versus policy rules in practice," *Carnegie-Rochester Conference Series on Public Policy*, 39, 195–214.

A Priors and posteriors

	Dens.	Czech Rep. Mean	Czech Rep. S.d.	Hungary Mean	Hungary S.d.	Poland Mean	Poland S.d.
$\bar{R}$	G	2.50	1.00	2.50	1.00	2.50	1.00
α	B	0.60	0.10	0.70	0.15	0.35	0.10
τ	B	0.50	0.20	0.50	0.20	0.50	0.20
κ	G	0.50	0.25	0.50	0.25	0.50	0.25
ψ_1	G	1.50	0.50	1.50	0.50	1.50	0.50
ψ_2	G	0.25	0.15	0.25	0.15	0.25	0.15
ψ_3	G	0.25	0.15	0.25	0.15	0.25	0.15
ρ_R	B	0.50	0.25	0.50	0.25	0.50	0.25
ρ_q	B	0.30	0.15	0.30	0.15	0.30	0.15
ρ_z	B	0.30	0.15	0.30	0.15	0.30	0.50
ρ_{y^*}	B	0.80	0.10	0.80	0.10	0.80	0.10
ρ_{π^*}	B	0.20	0.10	0.20	0.10	0.20	0.10
σ_R	InvG	0.50	4.00	0.50	4.00	0.50	4.00
σ_q	InvG	1.30	4.00	0.70	4.00	3.20	4.00
σ_z	InvG	1.00	4.00	1.00	4.00	1.00	4.00
σ_{y^*}	InvG	0.40	4.00	0.40	4.00	0.40	4.00
σ_{π^*}	InvG	2.30	4.00	2.70	4.00	4.10	4.00
P_{12}	B	0.10	0.05	0.10	0.05	0.10	0.05
P_{21}	B	0.10	0.05	0.10	0.05	0.10	0.05
Q_{12}	B	0.10	0.05	0.10	0.05	0.10	0.05
Q_{21}	B	0.10	0.05	0.10	0.05	0.10	0.05

Table A.1: Prior distributions

	Priors			M_0		M_1				M_2				M_3				M_4			
	Dens.	Mean	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.
R	B	2.50	1.00	2.0921	0.0115	2.0899	0.0099			2.0883	0.0083			2.0903	0.0068			2.0874	0.0075		
α	B	0.60	0.10	0.4990	0.0086	0.5012	0.0072			0.4983	0.0060			0.5107	0.0049			0.4980	0.0053		
τ	B	0.50	0.20	0.1030	0.0047	0.1054	0.0037			0.1120	0.0031			0.1152	0.0027			0.1135	0.0028		
κ	G	0.50	0.25	2.1199	0.0123	2.1210	0.0105			1.4334	0.0071			1.5735	0.0060			1.4389	0.0064		
ψ_1	G	1.50	0.50	1.3776	0.0099	0.7133	0.0074	1.4372	0.0086	1.7514	0.0075			1.5353	0.0059	1.6262	0.0060	1.2890	0.0060	1.6979	0.0067
ψ_2	G	0.25	0.15	0.0860	0.0089	0.0940	0.0077	0.0963	0.0077	0.0632	0.0058			0.3097	0.0049	0.0223	0.0040	0.1904	0.0054	0.0564	0.0052
ψ_3	G	0.25	0.15	0.1350	0.0090	0.3032	0.0078	0.0818	0.0076	0.0626	0.0059			0.1568	0.0049	0.0930	0.0048	0.3550	0.0053	0.0607	0.0053
ρ_R	B	0.50	0.25	0.6580	0.0082	0.1752	0.0074	0.7865	0.0060	0.8739	0.0037			0.6418	0.0049	0.9084	0.0026	0.4696	0.0054	0.8988	0.0028
ρ_q	B	0.30	0.15	0.0367	0.0089	0.0360	0.0075			0.0978	0.0060			0.0522	0.0049			0.1135	0.0054		
ρ_z	B	0.30	0.15	0.6796	0.0069	0.7514	0.0054			0.8140	0.0048			0.8525	0.0037			0.8172	0.0042		
ρ_{y^*}	B	0.80	0.10	0.7355	0.0086	0.7180	0.0074			0.8852	0.0060			0.9060	0.0048			0.8743	0.0054		
ρ_{π^*}	B	0.20	0.10	0.1289	0.0087	0.1322	0.0074			0.1712	0.0060			0.1362	0.0049			0.1426	0.0054		
σ_R	IG	0.50	4	0.3864	0.0086	0.2583	0.0066			0.4999	0.0060	0.0933	0.0035	0.6949	0.0048	0.0764	0.0026	0.4356	0.0054	0.0748	0.0025
σ_q	IG	1.30	4	1.7250	0.0109	1.7262	0.0094			3.3459	0.0105	0.7160	0.0060	3.4729	0.0088	0.7683	0.0049	3.2735	0.0094	0.7059	0.0054
σ_z	IG	1.00	4	0.4853	0.0087	0.3278	0.0071			0.7903	0.0059	0.1621	0.0051	0.6484	0.0049	0.1369	0.0040	0.6740	0.0054	0.1619	0.0045
σ_{y^*}	IG	0.40	4	0.2136	0.0083	0.2180	0.0072			0.4094	0.0062	0.0985	0.0037	0.4350	0.0049	0.0985	0.0030	0.3999	0.0055	0.1004	0.0033
σ_{π^*}	IG	2.30	4	2.5808	0.0131	2.5786	0.0113			3.7892	0.0112	1.6456	0.0075	3.5919	0.0089	1.9656	0.0067	3.7079	0.0100	1.6553	0.0068
p_{12}	B	0.01	0.05			0.0770	0.0076							0.0981	0.0049			0.0944	0.0054		
p_{21}	B	0.01	0.05			0.0286	0.0056							0.0314	0.0042			0.0242	0.0042		
q_{12}	B	0.01	0.05							0.1049	0.0061							0.0908	0.0054		
q_{21}	B	0.01	0.05							0.0614	0.0059							0.0542	0.0051		

Table A.2: Estimation results for Czech Republic. For the models M_1, M_2, M_3, and M_4 the results in the right two columns refer to the high exchange rate response or high volatility regime respectively.

	Priors			M_0		M_1				M_2				M_3				M_4			
	Dens.	Mean	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.
R	B	2.50	1.00	2.0918	0.0127	2.0911	0.0112			2.0906	0.0116			2.0898	0.0111			2.0903	0.0106		
α	B	0.70	0.10	0.6006	0.0095	0.5768	0.0083			0.5755	0.0086			0.5713	0.0082			0.5697	0.0078		
τ	B	0.50	0.20	0.1501	0.0048	0.1451	0.0041			0.1406	0.0038			0.1417	0.0036			0.1356	0.0033		
κ	G	0.50	0.25	1.6435	0.0119	1.3509	0.0096			1.8804	0.0114			1.6164	0.0102			1.7561	0.0102		
ψ_1	G	1.50	0.50	1.2130	0.0101	2.1290	0.0115	0.7825	0.0086	1.3711	0.0096			1.9539	0.0109	1.0402	0.0082	2.0707	0.0107	0.8727	0.0078
ψ_2	G	0.25	0.15	0.1497	0.0098	0.2115	0.0085	0.3589	0.0086	0.1205	0.0088			0.1116	0.0084	0.1856	0.0084	0.1549	0.0080	0.2377	0.0079
ψ_3	G	0.25	0.15	0.1228	0.0093	0.2157	0.0086	0.0756	0.0084	0.1440	0.0085			0.1854	0.0082	0.1078	0.0082	0.2093	0.0079	0.1054	0.0079
ρ_R	B	0.50	0.25	0.6170	0.0086	0.8178	0.0063	0.3357	0.0085	0.6544	0.0071			0.8252	0.0053	0.4312	0.0083	0.7950	0.0055	0.3605	0.0079
ρ_q	B	0.30	0.15	0.0707	0.0099	0.0733	0.0087			0.0686	0.0089			0.0768	0.0085			0.0688	0.0081		
ρ_z	B	0.30	0.15	0.7933	0.0065	0.7858	0.0061			0.7500	0.0060			0.7934	0.0058			0.7344	0.0056		
ρ_{y^*}	B	0.80	0.10	0.8037	0.0098	0.7273	0.0088			0.8219	0.0087			0.8156	0.0084			0.7978	0.0080		
ρ_{π^*}	B	0.20	0.10	0.1543	0.0095	0.1668	0.0084			0.1848	0.0086			0.1719	0.0083			0.1662	0.0079		
σ_R	IG	0.50	4	0.3630	0.0091	0.2884	0.0073			0.5244	0.0084	0.2829	0.0076	0.1829	0.0059	0.5397	0.0082	0.4654	0.0078	0.2589	0.0065
σ_q	IG	1.30	4	0.8218	0.0096	0.8222	0.0085			0.9673	0.0082	0.7392	0.0085	0.7210	0.0082	0.9482	0.0080	0.9424	0.0076	0.7627	0.0079
σ_z	IG	1.00	4	0.3501	0.0086	0.3670	0.0079			0.7222	0.0082	0.3157	0.0081	0.2679	0.0078	0.5104	0.0081	0.6559	0.0076	0.3343	0.0075
σ_{y^*}	IG	0.40	4	0.1941	0.0066	0.1952	0.0057			0.2898	0.0093	0.1083	0.0039	0.1122	0.0040	0.2645	0.0086	0.2868	0.0083	0.1093	0.0033
σ_{π^*}	IG	2.30	4	3.0325	0.0159	3.0301	0.0142			4.5793	0.0173	2.0466	0.0118	2.0860	0.0115	4.1136	0.0159	4.8764	0.0164	2.0139	0.0108
p_{12}	B	0.01	0.05			0.0377	0.0065							0.0775	0.0074			0.0425	0.0059		
p_{21}	B	0.01	0.05			0.0778	0.0083							0.1160	0.0080			0.0801	0.0073		
q_{12}	B	0.01	0.05							0.1105	0.0087							0.1240	0.0079		
q_{21}	B	0.01	0.05							0.0588	0.0078							0.0630	0.0070		

Table A.3: Estimation results for Hungary. For the models M_1, M_2, M_3, and M_4 the results in the right two columns refer to the high exchange rate response or high volatility regime respectively.

	Priors			M_0		M_1				M_2				M_3				M_4			
	Dens.	Mean	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.	Mode	S.d.
R	B	2.50	1.00	2.0927	0.0074	2.0924	0.0070			2.0926	0.0073			2.0928	0.0071			2.0924	0.0075		
α	B	0.35	0.10	0.1564	0.0051	0.1536	0.0044			0.1502	0.0040			0.1561	0.0038			0.1588	0.0038		
τ	B	0.50	0.20	0.0540	0.0039	0.0529	0.0032			0.0636	0.0025			0.0679	0.0023			0.0704	0.0024		
κ	G	0.50	0.25	1.2080	0.0065	1.2566	0.0061			0.9743	0.0054			0.9033	0.0052			1.1775	0.0060		
ψ_1	G	1.50	0.50	2.0998	0.0078	1.3026	0.0061	2.3458	0.0077	2.0940	0.0074			1.8563	0.0069	2.0329	0.0071	1.1927	0.0059	2.3167	0.0080
ψ_2	G	0.25	0.15	0.1569	0.0061	0.2078	0.0056	0.1164	0.0056	0.0957	0.0055			0.2377	0.0053	0.0694	0.0053	0.1964	0.0055	0.0786	0.0057
ψ_3	G	0.25	0.15	0.0611	0.0060	0.1520	0.0055	0.0643	0.0054	0.0557	0.0053			0.0691	0.0054	0.0604	0.0053	0.1457	0.0055	0.0619	0.0055
ρ_R	B	0.50	0.25	0.7766	0.0052	0.8820	0.0055	0.7647	0.0048	0.8376	0.0040			0.7413	0.0052	0.8826	0.0037	0.9258	0.0050	0.8079	0.0043
ρ_q	B	0.30	0.15	0.0549	0.0060	0.0569	0.0056			0.0641	0.0055			0.0674	0.0054			0.0613	0.0057		
ρ_z	B	0.30	0.50	0.7599	0.0055	0.7482	0.0050			0.7942	0.0047			0.8043	0.0044			0.7880	0.0047		
ρ_{y^*}	B	0.80	0.10	0.7227	0.0058	0.7357	0.0054			0.8515	0.0055			0.8564	0.0054			0.8569	0.0057		
ρ_{π^*}	B	0.20	0.10	0.0773	0.0059	0.0743	0.0055			0.0723	0.0055			0.0729	0.0053			0.0665	0.0056		
σ_R	IG	0.50	4	0.2952	0.0057	0.2747	0.0052			0.3436	0.0054	0.1176	0.0042	0.3889	0.0053	0.0901	0.0033	0.3143	0.0056	0.1632	0.0047
σ_q	IG	3.20	4	3.8202	0.0100	3.8215	0.0095			5.0930	0.0114	1.8137	0.0069	5.1343	0.0112	1.7311	0.0066	5.2095	0.0119	1.7377	0.0070
σ_z	IG	1.00	4	0.4720	0.0058	0.5088	0.0054			0.6260	0.0053	0.2427	0.0053	0.5784	0.0052	0.2443	0.0051	0.6777	0.0054	0.2444	0.0055
σ_{y^*}	IG	0.40	4	0.1905	0.0062	0.1896	0.0052			0.3341	0.0056	0.0994	0.0043	0.3504	0.0055	0.0997	0.0040	0.3624	0.0058	0.0998	0.0038
σ_{π^*}	IG	4.10	4	5.0125	0.0112	5.0177	0.0107			6.3138	0.0126	3.1826	0.0090	6.2696	0.0124	3.2308	0.0089	6.4105	0.0132	3.1168	0.0093
p_{12}	B	0.01	0.05			0.0854	0.0053							0.0863	0.0053			0.0915	0.0055		
p_{21}	B	0.01	0.05			0.0288	0.0051							0.0661	0.0052			0.0299	0.0045		
q_{12}	B	0.01	0.05							0.0773	0.0054							0.0883	0.0056		
q_{21}	B	0.01	0.05							0.0678	0.0054							0.0780	0.0055		

Table A.4: Estimation results for Poland. For the models M_1, M_2, M_3, and M_4 the results in the right two columns refer to the high exchange rate response or high volatility regime respectively.

B Simulation results

	Low volatility		High volatility	
	Current policy	Former policy	Current policy	Former policy
		ϵ^{y^*}		
y	1.1735	1.1609	4.6740	4.6241
π	0.0831	0.2770	0.3309	1.1035
R	0.0263	0.2075	0.1046	0.8263
Δe	0.0831	0.2770	0.3309	1.1035
		ϵ^{π^*}		
y	0.0179	0.1199	0.0401	0.2686
π	0.0471	0.2828	0.1054	0.6336
R	0.0022	0.0592	0.0050	0.1326
Δe	1.6106	1.3752	3.6078	3.0804
		ϵ^{q}		
y	0.0832	0.1185	0.3858	0.5496
π	0.1309	0.0732	0.6072	0.3393
R	0.0239	0.1158	0.1106	0.5372
Δe	0.4630	0.4155	2.1471	1.9266
		ϵ^{z}		
y	0.1492	0.0574	0.6212	0.2391
π	0.3413	0.2500	1.4210	1.0410
R	0.1367	0.3477	0.5691	1.4475
Δe	0.3413	0.2500	1.4210	1.0410

Table B.1: Simulated standard deviations of model variables following one-standard deviation shocks in the Czech Republic.

	Low volatility		High volatility	
	Current policy	Former policy	Current policy	Former policy
		ϵ^{y^*}		
y	0.9199	0.8455	2.4137	2.2185
π	0.1023	0.6933	0.2684	1.8192
R	0.0443	0.4434	0.1162	1.1634
Δe	0.1023	0.6933	0.2684	1.8192
		ϵ^{π^*}		
y	0.0584	0.0620	0.1413	0.1502
π	0.1622	0.1645	0.3927	0.3982
R	0.0115	0.0229	0.0277	0.0554
Δe	1.8634	1.8606	4.5119	4.5053
		ϵ^{q}		
y	0.1189	0.1093	0.1469	0.1350
π	0.1199	0.1537	0.1481	0.1899
R	0.0600	0.1060	0.0742	0.1310
Δe	0.4261	0.4760	0.5265	0.5881
		ϵ^{z}		
y	0.1375	0.1688	0.2697	0.3312
π	0.3318	0.7921	0.6509	1.5542
R	0.2783	0.7155	0.5460	1.4039
Δe	0.3318	0.7921	0.6509	1.5542

Table B.2: Simulated standard deviations of model variables following one-standard deviation shocks in Hungary.

	Low volatility		High volatility	
	Current policy	Former policy	Current policy	Former policy
		ϵ^{y^*}		
y	0.7351	0.7096	2.6695	2.5768
π	0.0404	0.2507	0.1467	0.9104
R	0.0207	0.0470	0.0751	0.1707
Δe	0.0404	0.2507	0.1467	0.9104
		ϵ^{π^*}		
y	0.0128	0.0469	0.0264	0.0965
π	0.0605	0.2411	0.1245	0.4959
R	0.0106	0.0112	0.0219	0.0231
Δe	3.0297	2.8575	6.2313	5.8772
		ϵ^{q}		
y	0.0444	0.0542	0.1331	0.1626
π	0.0820	0.0952	0.2457	0.2854
R	0.0482	0.0163	0.1445	0.0488
Δe	1.5074	1.4430	4.5192	4.3259
		ϵ^{z}		
y	0.0619	0.1167	0.1715	0.3235
π	0.2772	0.4907	0.7685	1.3608
R	0.2569	0.1089	0.7124	0.3020
Δe	0.2772	0.4907	0.7685	1.3608

Table B.3: Simulated standard deviations of model variables following one-standard deviation shocks in Poland.