NBP Narodowy Bank Polski

NBP Working Paper No. 224

Lessons from the crisis. Did central banks do their homework?

Aleksandra Hałka

NBP Working Paper No. 224

Lessons from the crisis. Did central banks do their homework?

Aleksandra Hałka

Economic Institute
Warsaw, 2015

Aleksandra Hałka – Narodowy Bank Polski

The views expressed herein are those of the author and not necessarily those of Narodowy Bank Polski. The author wish to thank Prof. Ryszard Kokoszczyński and the participants of NBP seminar whose invaluable feedback I benefited from in the course of my research.

Published by:
Narodowy Bank Polski
Education & Publishing Department
ul. Świętokrzyska 11/21
00-919 Warszawa, Poland
phone +48 22 185 23 35
www.nbp.pl

ISSN 2084-624X

Contents

Abstract

The outbreak of the global financial crisis triggered changes in thinking about the way monetary policy is conducted, in particular about the desired central banks' reaction function. However, a change in thinking does not necessarily mean that central banks really implemented these modifications. Therefore, I investigate whether four selected European central banks in small open economies – Česká Národní Banka, Magyar Nemzeti Bank, Narodowy Bank Polski and Sveriges Riksbank, have adjusted their reaction function to the new paradigm of how monetary policy should be conducted. To address this problem I use a logit model to see first, how the relative importance of inflation and GDP forecasts in the process of setting interest rates evolved over time, second, how the forecast horizon which central banks take into consideration when setting the interest rate has changed, and finally whether they conduct more accommodative monetary policy. The outcomes indicate that all banks after the Lehman Brother's collapse became more flexible in the way they conduct monetary policy. In order to maintain the stability of the whole economy they are ready to accept an extended period or greater deviations of inflation from the target, although each one in its own way – through extension of the forecasting horizon, the increase of the GDP's importance, permanent shift of the monetary policy stance to more accommodative one or a mixture of these factors.

JEL: C25 E52, E58

Keywords: central bank, reaction function, monetary policy, logit model, global financial crisis.

1 Introduction

The outbreak of the global financial crisis provoked a change in thinking about monetary policy. This change may be reflected in the modification of the way monetary policy is conducted and hence in the central banks' reaction function. In the course of the global financial crisis, central banks admitted that keeping inflation within the target is not sufficient to stabilize the economy, and apart from price stability they should also care more about financial and macroeconomic stability (e.g. Mishkin, 2011, Cukierman, 2013). According to Carney (2013) "(...) the experience of the crisis demonstrated the essential value of flexible inflation targeting as the dominant monetary policy framework (. . .)". On the contrary, Issing (2012) underlines that it puts the bank's credibility at risk when aside from the price stability mandate, the central bank also has to take responsibility for the real economy. Even before the outbreak of the global financial crisis, central bankers started to realize that "(. . .) monetary policy must keep its focus on medium-term macroeconomic stabilization issues (. . .)" (Dodge, 2008). To achieve not only price but also broader macroeconomic and financial stability, central banks should look not only at inflation but also other variables. As King (1994) declares "(. . .) the proper objective of monetary policy is to minimize the variability of inflation around the target rate and the variability of output (or employment) around a sustainable path consistent with stable inflation. (. . .)". That optimal choice leads to a policy reaction function describing how the central bank responds to shocks hitting the economy." It seems that there is a consensus among economists that output growth is one of the variables that should be taken into consideration during the process of formulating the monetary policy framework[1] (Svensson, 2000, Blanchard et al., 2010, Mishkin, 2011, Issing, 2012, Carney, 2013).

Central banks in general try to restore inflation to the target in a medium-term horizon of 6 do 8 quarters. However, as pointed out by Carney (2013), a longer targeting horizon can allow monetary policy to promote better adjustments to the prolonged weakness of the economy or financial imbalances. Moreover, he claims that central banks should recognize that the optimal targeting horizon may vary over time depending on the shocks that hit the economy.

Because of today's risk of the deflation trap, central banks may find themselves in a situation where they can either raise target inflation, or change the strategy of the monetary policy to price

[1]There is also another stream of the literature that advocate that central banks, when making decision on the interest rate, should take into account changes of the asset prices (Filardo, 2001, Cecchetti et al., 2002, Lowe and Borio, 2002, White, 2004). This inclusion of the asset prices is supposed to prevent formation of the asset bubbles and stabilize the economy. However, the results of the empirical studies are ambiguous (see e.g.: Rigobon and Sack, 2003 vs Bernanke and Gertler, 2000).

level targeting[2]. There is an ongoing debate as to whether central banks should raise their target inflation (see e.g.: Blanchard et al., 2010, Gagnon, 2010, McCallum, 2011). As some economists point out, it raises some questions, e.g.: will a central bank still be credible when changing the target; will that not unanchor inflation expectations? (for the discussion see e.g.: Bernanke, 2010 and Mishkin, 2011). Another issue, which the global financial crisis highlighted, is the horizon in which inflation should return to the target. The central bankers admitted that in some cases stabilizing the economy, may require inflation to deviate from the target for an extended period of time.[3] On the contrary to the proposition of rising targeted inflation, this idea brings less controversies.

The aim of this paper is to check empirically whether European central banks in small open economies that conduct autonomous monetary policy implemented some lessons learned from the crisis. In particular, I want to investigate if central banks enhanced the flexibility of their inflation targeting strategy after the collapse of the Lehman Brothers. In other words, do output developments gain relatively greater importance in comparison to pre-turmoil times? Additionally, I aim to determine whether central banks have changed the way they realize their mandate after the outbreak of the crisis.[4] Therefore, I will examine whether after the crisis, central banks have extended the forecast horizon which they take into consideration when setting the interest rate[5]. And finally, I will determine whether central banks conduct a more accommodative monetary policy after the outbreak of the crisis – accepting implicitly higher inflation.

The results indicate that all analyzed banks learned their lesson. In particular, all banks became more flexible targeters in order to maintain the stability not only of prices but also of the whole economy. However, the changes implemented by the banks differ. First, the Česká Národní Banka extended the forecast horizon which it takes into consideration when setting the interest rate. Second, the Magyar Nemzeti Bank increased the relative importance of the GDP forecasts as compared

[2]The supporters of this approach underline that it is a good mechanism that can help the economy to recover from the deflationary shocks that may direct monetary policy to zero lower bound. The highest benefits from price-level targeting are found in the models which allow for negative real interest rate. However, researchers underline that such models have unrealistic assumptions and assume an overly simplistic picture of the real economy. Also, the problem of communicating the goal to the public remains (for discussion see Bohm and Filáček, 2012).

[3]E.g. Weber (2015).

[4]Baxa et al. (2014) point out that changes in monetary policy stance are rather gradual.

[5]One have to distinguish between the optimal feedback horizon and optimal policy horizon (see Batini and Nelson, 2001). The first one is a horizon taken by the central bank into consideration when setting the interest rules assuming that the bank follows a simple monetary policy rule (decision on the interest rates depends on the deviation of the forecasting inflation form the target and the future output gap). In case of the optimal policy horizon it is assumed that central bank follows the optimal monetary policy rule. In the spirit of Batini and Nelson (2001) I empirically check which horizon is taken into account when setting the interest rate without considering whether this horizon is optimal or not.

with inflation forecasts. Third, the Narodowy Bank Polski also increased the relative importance of the GDP forecasts but did not change the forecast horizon which it takes into consideration when setting the interest rate. Additionally, all these three banks eased their monetary policy stance. Finally, the Sveriges Riksbank extended the forecast horizon which it takes into consideration when setting the interest rate.

The rest of the paper is organized as follows. Section 2 reviews the literature. In Section 3, I describe the data and the model used in the analysis. Section 4 contains the discussion of the results, and the conclusions are included in Section 5.

2 Literature Review

Discussion on monetary policy rules is well rooted in the literature[6]. This issue has gained a lot of attention since the seminal paper of Taylor (1993), who describes with a simple rule the monetary policy conducted by the FOMC. In his rule, the monetary policy instrument (short term interest rate) is a linear function of the current inflation and the output gap. This rule (or similar) is nowadays often used to describe the behavior of the inflation targeting of central banks. Taylor (1993) also argued that central banks that follow the rule improve their policy effectiveness.

According to Svensson (1997) inflation targeting strategy entails that a central bank has to target inflation forecast (which implies that the forecast serves as an intermediate target[7]). This means that under such approach, a central bank adjust its interest rate to ensure that the inflation is in the target within a certain horizon. A lot of research has since been done on what the optimal targeting rule is (among others: Rudebusch and Svensson, 1998, Giannoni and Woodford, 2004, Dieppe et al., 2005, Stráský, 2005), the optimal targeting horizon (among others: Batini and Nelson, 2001, Mishkin and Schmidt-Hebbel, 2001, Plantier, 2002) and the optimal target (among others: Svensson, 1997, Uchida and Fujiki, 2005, Bullard et al., 2008 and Ball, 2013).

The central banks very rarely reveal their loss function and the weight that they assign to the deviations of inflation from the target and the output gap.[8] Therefore, instead of deriving a monetary policy rule by minimizing the loss function, the rule is usually estimated empirically[9].

There is still an ongoing debate regarding which variables, apart from inflation, a monetary policy rule should include. A central bank must decide whether it focuses only in bringing inflation to the target (strict inflation targeting, Svensson, 1999) or apart from the aforementioned goal its aim is also to stabilize output and/or other macroeconomic variables (flexible inflation targeting)[10]. There is numerous empirical research which attempts to answer how central banks set the target. Clarida et al. (2000) compare the monetary policy for the US in the pre-Volcker and the Volcker and Greenspan era. They conclude that the pre-Volcker era allowed the possibility of inflation and output burst, while Volcker and Greenspan led strong anti-inflationary policy. Sutherland

[6] There is another debate whether central banks should follow rules or base their decisions on the discrete approach (for discussion see e.g. Fischer (1990), Taylor (1993), Lear, 2000). However in this paper I will not relate to this issue.

[7] "(...) the intermediate target is the expected level of inflation at some future date chosen to allow for the lag between changes in interest rates and the resulting changes in inflation.", King (1994).

[8] Sometimes the loss function also contains the interest rates' volatility, asset prices or other variables (see e.g. Mishkin, 2011).

[9] The respective weights can be derived from the micro-foundations. However, without knowing the right model they are subject to the model specification bias.

[10] E.g. asset prices – for discussion see Svensson, 2009, Blanchard et al., 2010,Issing, 2012, Carney, 2013.

(2010) presents research on the reaction function of the central banks in OECD countries. His results suggest that there is a group of countries in which monetary policy reacts only to the developments of inflation (Austria, the Czech Republic, Hungary, Poland, Sweden and the UK). A second group consists of the countries where monetary policy takes into account changes in both expected inflation and output gap (Canada, Iceland, New Zealand, Switzerland and the US). The outcomes for the euro area are varied. The findings of most research correlate the reaction of monetary policy to the inflation forecast and real economy condition's indicators (Gorter et al., 2007, Jansen and Haan, 2009, Boeckx, 2011). Others indicate that developments in the output growth are less or not important (Belke and Klose, 2009, Rosa, 2010), whereas some also indicate that other variables matter (Gerdesmeier and Roffia, 2004, Gerlach, 2007).

Research on the reaction function in the Central and Eastern European countries (CEE) is also comprehensive. Stráský (2005) analyzes the optimal rule for the Česká Národní Banka, Arlt and Mandel (2014) formulate and empirically verify the backward looking model of monetary policy rules for three central European banks – the CNB (Česká Národní Banka), MNB (Magyar Nemzeti Bank) and NBP (Narodowy Bank Polski) and find that the annual inflation rate, exchange rate, the ECB repo rate and the yearly growth rate of M2 are significant in the formulation of monetary policy in these banks. Kotłowski (2005) analyzes the reaction function of individual members of the monetary policy committee in the Narodowy Bank Polski. The results show that most of the members are forward looking and their decisions as regards the reaction to the deviations of inflation from the target are asymmetric. Brzozowski (2004) analyzing the preferences of the Polish central bank concludes that in the late 90's, the weight attached to the inflation stabilization objective in the NBP loss function was equal to the weight assigned to output gap stabilization.

3 The data and the model

3.1 The data

In the study, I use macroeconomic forecasts published by four central banks in European small open economies – the Česká Národní Banka (CNB), Magyar Nemzeti Bank (MNB), Narodowy Bank Polski (NBP) and Sveriges Riksbank (Riksbank) – which conduct autonomous monetary policy, are inflation targeters as well provide the CPI and GDP forecasts. Macroeconomic projection of the NBP and MNB is a conditional forecast based on the assumption of constant interest rate. On the contrary, the Riksbank's and CNB's projection have an endogenous interest rate.

The projections of the analyzed central banks are published 6 times a year in the case of the Riksbank[11], four times a year in the case of the CNB and MNB, and the NBP prepared projections four times a year until 2008, and three times per year since the beginning of 2008.

When dealing with the data, there are two problems to be solved. The first one is the change of the inflation target during the analyzed sample by the CNB. That is why I decided to correct all the inflation forecasts for the particular central bank's target. The second problem is the varying horizon of the forecasts in the case of the MNB, NBP and Riksbank. In the case of a varying forecast horizon, I would not be able to distinguish whether the central bank looks at the end of the horizon or the certain (e.g. 5) quarter ahead. Therefore, to solve this problem, I aggregate all forecasts beyond the 7th quarter (for the NBP and Riksbank) or the 5th quarter (for the MNB) using a simple average.

The dependent variable is the change of the monetary policy stance – easing, tightening or keeping it unchanged – which takes discrete values (see Section 3.2). However, in the analyzed period, three banks went beyond the standard monetary policy framework. The CNB encountered the problem of zero lower bound (ZLB) and decided not to ease the stance any further by cutting the rates.[12] Instead, it started to conduct more active exchange rate policy and introduced an exchange rate floor which was announced at the end of 2013. The Riksbank went further and decreased its main interest rate below zero and started purchases of nominal government bonds (February 2015). Although the MNB did not reach ZLB, in September 2013 it introduced the Funding for Growth Scheme (FGS) which can be treated as an instrument of monetary policy easing. In the case of the NBP, no unconventional instruments are used.[13] Therefore, I assume that the introduction of

[11] 3 times a year the Riksbank publishes a full projection, and 3 times a year it publishes an update.

[12] The CNB explained its decision not to lower the interest rates below zero, by the fact that its financial market faced excess liquidity, and lowering interest rates would not bring the expected effect.

[13] I might have treated the introduction of Forward Guidance as an unconventional policy instrument but it is

unconventional measures or the extension of the period in which they hold true is also a form of monetary policy easing.

The decisions of the monetary policy authorities are mostly made on a monthly basis but the projection of the CPI and GDP is disclosed less frequently. An exception is the Riksbank in which the Executive Board holds six monetary meetings a year at which it receives a Monetary Policy report with the newest forecasts. For the other three banks, I assumed that the forecast may influence not only the decision made during the meeting in which the projection is published but also the following one. Monetary authorities may refrain from making the decision in the meeting during which the projection is presented due to e.g. unfavorable market conditions or increased uncertainty. Furthermore, monetary authorities may anticipate changes to the projection and decide to change the monetary policy stance before the projection is released. Therefore, in the case of the CNB, MNB, and NBP, I include the dependent variable also for the decision made at the meetings before and after the projection publication.

The explanatory variables are the CPI and GDP forecasts. As mentioned before, I correct the CPI forecast for the inflation target of particular central banks. Usually in the research on the reaction function, the output gap is used. However, I use GDP forecasts instead of output gap for three reasons. First, it is not always clear at which gap (output or unemployment) the central banks are looking. Moreover, it would be important to know exact time when the gap was calculated due to revisions of the data (especially the revisions of the output growth)[14]. Second, not all central banks publish their forecast of the output gap. Third, the use of my estimates based on HP filter leads to biased estimates especially at the end of the sample due to its shortness. Moreover, demeaning of the GDP may also give biased estimates because after the crisis, the potential GDP growth is probably lower than before.[15]

Additionally, instead of introducing all forecasted horizons into the model, I aggregate the whole path of the forecast, both for the CPI and GDP, using the weights received from the Gaussian function[16]:

difficult to decide whether prolonging or ending it should be treated as easing or tightening of the monetary policy in Poland, due to the changing environment. However, Baranowski and Gajewski (2016) point out that Forward Guidance was credible for professional forecasters.

[14]The use of the real-time versus revised data is an additional problem when analyzing the reaction function. Orphanides (2001) shows that the policy recommendations differ considerably depending on the data used for the study, therefore it is important to rely on the data that was available during the decision-making process. Čapek (2014) analyzing three CEE countries – The Czech Republic, Hungary and Poland, also finds that the monetary policy rules differ significantly depending on the kind of data used. This is especially visible in cases of sensitivity to the changes of the output growth which is very often subjected to significant and numerous revisions.

[15]For the discussion see: CEPR (2014).

[16]In order to make the coefficients directly comparable the weights are normalized to sum up to one. Similar approach is used by Brzoza-Brzezina et al. (2013).

$$f(h) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \tag{1}$$

In such way, I aggregate the whole path of inflation and the GDP forecast, separately, to two variables, each of them described by two parameters – mean (μ) and standard deviation (σ). There are two reasons for this. First, aggregation reduces the number of the estimated parameters, which in the case of a short sample and potentially highly correlated forecasts may cause problems. Second, when accounting for the whole distribution of the forecast instead of one particular horizon, I allow the central bank to take into consideration the whole path of the forecast. Depending on the value of (σ), the central bank may look at one particular horizon (low σ) or at the whole path (high σ).

I allow μ to range from 0 (nowcasting) to 5 quarters for the CNB and MNB or to 8 quarters for the NBP and Riksbank (the end of the forecasting horizon). As for the standard deviation I use three different values – 0.5 (the central bank focuses more substantially on one particular horizon), 1 (the central bank focuses more on one particular horizon, but also takes into account the remaining horizons) and 1.5 (the central bank looks more at other horizons).

The estimation period is 1Q2006 (in the case of the Riksbank it is 1Q2007[17]) up to the projection released before March 2015, which in the case of the CNB and Riksbank is 1Q2015 and in the case of the MNB and NBP is the 4Q2014 (Table 1 summarizes the features of the projections of the analyzed central banks).

Table 1: Features of the CPI and GDP projection of the CNB, MNB, NBP and Riksbank

	No of obs.	Sample	Forecasting horizon	Target	Unconventional policy	No of projections per year
CNB	37	1Q2006 – 1Q2015	5 quarters	2% (3% until end of 2009)	Exchange rate floor	4
MNB	36	1Q2006 – 4Q2014	5-10 quarters	3%	Funding for Growth Scheme	4
NBP	29	1Q2006 – 4Q2014	8-11 quarters	2,5%	Non	3 (until 2007 4 times a year)
Riksbank	47	1Q2007 – 1Q2015	8-13 quarters	2%	Negative interest rate and purchases of nominal government bonds	6

Source: Central banks' documents and websites.

[17]Before 2007 the Riksbank's forecast were conditional forecasts based on the assumption of the constant interest rate.

3.2 The model

Decisions on the interest rates are not made in a continuous way, but during meetings with predefined dates. Moreover, the interest rates are usually changed in small steps (e.g. 15 bp or 25 bp). Therefore, the choice of the model which assumes that interest rate is a continuous variable[18] may not be the most efficient solution. That is why some authors decide to the use of the discrete choice models where the dependent variable is the change of the interest rate[19]. Additionally in my research the dependent variable covers unconventional policy measures, which, from their construction, are discrete variables. Following this stream in the literature and taking into account discrete nature of the unconventional policy measures, I employ the ordered logit model to address the research problem.

In the models with the discrete dependent variable one assume that central bank has unobservable desired level of monetary policy stance (I_t^*) which depend on the deviation of future inflation from the target and future output gap. This monetary policy stance can be adjusted by the authorities on every meeting when a new projection of the CPI and GDP is available. The abovementioned relation can be written as:

$$I_t^* = f(\tilde{\pi}_t^f(k), f(\tilde{y}_t^f(l)) \tag{2}$$

where:

$\tilde{\pi}_t^f(k) = \sum_{h=0}^{k} f(h)(\pi_{t+h}^f - \bar{\pi}_{t+h})$ and $\tilde{y}_t^f(l) = \sum_{h=0}^{l} f(h)(y_{t+h}^f)$

$f(h)$- is a Gaussian density function as in equation (1);

I_t^* - the monetary policy stance (unobservable) in the period t;

k - is the number of forecasting horizons for inflation;

l - is the number of the forecasting horizons for the GDP;

π_{t+h}^f - is an inflation forecast formulated in time t for the period $t+h$;

y_{t+h}^f- is a GDP forecast in time t for the period $t+h$;

$\bar{\pi}_{t+h}$ – is the inflation target in the period $t+h$.

However, what the agents observe are the discrete changes of the interest rate (or changes in the scope of the unconventional monetary policy instruments) made during the meetings. If the change of the desired monetary policy stance stemming from the changes in the CPI and GDP forecast exceeds certain level then the central bank adjust the interest rate. In fact the central bank has two

[18] E.g. Batini and Haldane (1999), Clarida et al. (2000), Stráský (2005), Gorter et al. (2007).

[19] E.g. Eichengreen et al. (1985), Gascoigne and Turner (2004), Dolado et al. (2005), Kotłowski (2005), Carstensen (2006), Gerlach (2007), Jansen and Haan (2009), Boeckx (2011), Brzoza-Brzezina et al. (2013).

tolerance levels – α_1 below which central bank relax monetary policy and α_2 above which central bank tightens monetary policy; between monetary policy stance is kept unchanged.

Therefore one can define the unobservable variable ΔI_t^* which is the difference between the desired by the central bank (I_t^*) and the previous observed by the agents (I_{t-1}) monetary policy stance as:

$$\Delta I_t^* = I_t^* - I_{t-1} \tag{3}$$

which develops according to:

$$\Delta I_t^* = \mathbf{X}_t'\beta + \varepsilon_t,\ \varepsilon_t \sim N(0, \sigma_x^2) \tag{4}$$

where $\mathbf{X}_t = \left(\tilde{\pi}_t^f(k),\ \tilde{y}_t^f(l)\right)$ expresses the set of explanatory variables from equation (2) and β is a vector of unknown parameters. Moreover it is assumed that the error term in equation (4) is normally distributed.

The relationship between observable change of the monetary policy stance z_t and changes in preferred by the central bank stance ΔI_t^* can be written as:

$$\begin{cases} z_t = -1 & if \quad \Delta I_t^* < \alpha_1 \\ z_t = 0 & if \quad \alpha_1 \leq \Delta I_t^* < \alpha_2 \\ z_t = 1 & if \quad \Delta I_t^* \geq \alpha_2 \end{cases} \tag{5}$$

where the limit points α_1 and α_2 are estimated.

Combining equations (4) and (5) I can express the probability of tightening, loosening or keeping monetary policy stance unchanged as a cumulative density function of the standard normal distribution (see Liao, 1994 for details)[20].

In this model, the dependent variable is a discrete one and may take the values of -1, 0 and 1. I code "-1" as the easing of monetary policy – easing means lowering the interest rate, introducing unconventional policy measures and the expansion or prolonging their duration. I code tightening of the monetary policy as "1" – the increase of interest rates, ending unconventional policy measures or shortening their duration. "0" is for all the remaining cases.

[20] Similar model is used by Gerlach (2007). However, in his analysis he includes also money growth because according to the ECB, changes in actual money growth play a role in its monetary policy strategy (ECB (1998))

4 Results

The aim of the research is to investigate first, whether the relative relevance of the CPI or GDP forecasts for the decisions on monetary policy change over time. Second, whether the forecast horizon which central banks take into consideration when setting the interest rate has changed after the outbreak of the crisis. And third, whether there is a permanent shift in monetary policy stance. In order to address these questions, I employ a two-step procedure.

In the first step, I estimate ordered probit models (like in equation (5)) which contain all possible combinations of the aggregated forecasts (for all possible values of parameters: mean (μ) and standard deviation (σ)). However, in order to examine how the monetary policy evolved over time, the estimation is done in the rolling sample (with the fixed window of 21 observations[21]). In the second step, for each central bank, for each estimated subsample the best model is chosen based on the log-likelihood criterion[22].

Based on the model results, I calculate (1) the ratio of parameter estimates of the CPI forecast to the GDP forecast, which can be interpreted as relative importance of the CPI for the decisions of the central bank in comparison to the GDP, (2) the forecast horizon which central bank takes into consideration when setting the interest rate – mean (μ) in the CPI and GDP distribution function in the best model, and finally, (3) an indicator that would denote changes of the monetary policy stance – the limit points from the equation (5).

4.1 The relative importance of inflation and GDP

In three out of four central banks' documents one can read that the monetary authorities are convinced that flexible inflation targeting is a good way of conducting monetary policy after the crisis. The Deputy Governor of the MNB, Ferenc Karvalits during his speech at Reuters Summit stated that "Monetary policy of the Magyar Nemzeti Bank has a clear objective: price stability. This does not mean that we are narrowly looking only at inflation forecasts, but rather, in a broader context, we want to contribute to longer term predictability in the Hungarian economy. I am convinced that price stability cannot be attained and maintained without longer term predictability." (Karvalits, 2009). In the NBP's Monetary Policy Guidelines for 2014 one can read about "(. . .) a shift towards

[21] Withal, the parameters' statistics in logit models have asymptotic t distribution. Therefore, for small samples, which is this case, when analyzing the results of the models, one has to interpret them with caution.

[22] Another commonly used criterion is pseudo-R^2. However, both criterion give the same results. To strengthen the results I provide as a robustness check the charts comparing the maximum values of the log likelihood function for the different values of the investigated parameters in the rolling window. It allows to assess whether the change in forecast horizon resulting from the changes in value of likelihood function is not coincidental.

more flexible implementation of inflation targeting strategy." (NBP, 2013). And Riksbank in its Annual Report 2010 more clearly stated that „the Riksbank conducts what is generally referred to as flexible inflation targeting. (...) A well-balanced monetary policy in normally a question of finding an appropriate balance between stabilizing inflation around the inflation target and stabilizing the real economy." (Riksbank, 2010). In the CNB's documents there is a focus mainly on inflation. Therefore I would expect growing role of the GDP forecasts in case of the first three central banks and stable or even insignificant importance of the GDP forecast in case of the CNB.

The results of the analysis in general confirm what stems from the official documents of analyzed central banks. The outcomes show that the MNB, NBP and the Riksbank take into account both the CPI and GDP forecasts when deciding on the monetary policy parameters. The only exception is the CNB which, when setting interest rates, focuses only on the CPI forecasts.

The importance of the CPI forecast in the CNB grew[23] until the outbreak of the global financial crisis followed by a significant drop at the end of the sample (see Figure 5, first row). As for the GDP forecast, the parameter estimate is statistically insignificant most of the time and becomes significant only in the last quarter.

According to the expectations, in the case of the MNB and NBP the relative importance of the GDP forecast slowly grows. The monetary policy when setting interest rates focused more, over time, on the GDP forecast than on the inflation forecast (see Figure 1).

In the Riksbank, the situation is different. Until 2010 the relative importance of the GDP forecast has grown. However with the increasing concern about the possibility of deflation in the Swedish economy the monetary policy authorities began to pay more attention to the CPI forecasts what resulted in a series of interest rate's cuts[24].

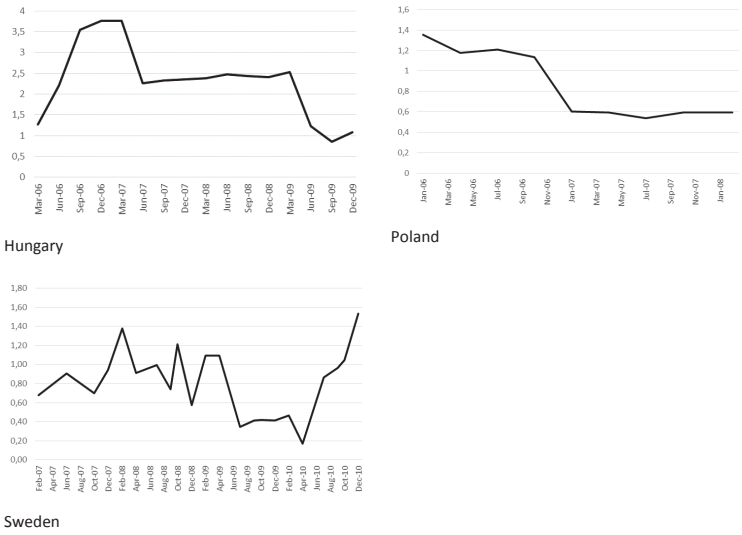
These results indicate that with the increase of the vulnerabilities on the global financial markets, the flexibility of the Polish and Hungarian monetary policy (in the sense of paying more attention to behavior of the GDP variable) started to grow. On the contrary, the Riksbank in due time paid more attention to inflation, and the CNB focuses only on inflation. However, it may also be the case that these last two central banks take variables other than the GDP into consideration. However, the findings for the analyzed countries are not comparable with the outcomes of other authors. The results cover different time span or use different model approach (interest rate as a continuous or discrete variable). For example Sutherland (2010) shows that monetary policy reacts only to

[23] I case of the CNB I am not able to calculate the relative importance of the CPI and the GDP forecast as the GDP forecast is insignificant.

[24] The growing relative importance of the CPI forecast can be perceived as contradictory to the declaration included in the Annual Report 2010.

the developments of future inflation with output growth being insignificant for Hungary, Poland and Sweden, among others. Withal, in his research he does not account for the unconventional monetary policy measures (as his sample ends before 2010) and assumes that interest rate is a continuous variable.

Figure 1: Relative importance of the CPI and GDP forecast in the rolling window for the MNB, NBP and Riksbank



.
Note: The date on the horizontal axis indicates the date of the first observation in the rolling window.
Source: Own calculations.

4.2 The forecast horizon

Only two central banks clearly communicated that they see the necessity of extending the period in which inflation returns to the target. The first one is the Riksbank, which in one of the documents states "It is therefore possible to allow inflation to deviate from the target temporarily, as part of a deliberate strategy to stabilize production and employment. This is also one of the reasons why deviations from the inflation target can at times be larger than the tolerance internal." (Riksbank, 2010). The second one is NBP, which in the Monetary Policy Guidelines for 2012 published that "In order to maintain consistency between attempting to keep inflation at the target and supporting financial system stability, under certain conditions it may be necessary to lengthen the inflation target horizon (. . .)." (NBP, 2011).

The outcomes of the research for the Riksbank is according to the expectations. In the case of

the Riksbank[25] the forecast horizon which it takes into consideration when setting the interest rate is increasing, which is in line with the statement of the monetary policy authorities.

On the contrary, in the case of Poland, the horizon for the CPI and GDP remains unchanged. Additionally the NBP may be perceived as not a very forward looking bank – for the CPI, the important horizon is nowcasting and for the GDP it is one quarter-ahead forecast.

A similar increase of the CPI forecasts' horizon as in the Riksbank, can be seen in the case of the CNB. The forecast horizon which it takes into consideration when setting the interest rate for both variables – the CPI and GDP – is increasing, however one must keep in mind that the GDP variable is statistically insignificant.

The MNB in due time lowered the CPI and GDP forecasts' horizon which it takes into consideration when setting the interest rate. At the beginning, the MNB was looking at three to four quarters ahead, and with the outbreak of the subprime crisis it lowered this horizon for the GDP to the current data (nowcasting), while for inflation, it lowered the horizon to one quarter ahead (since 2009). However, the last quarters of the sample show a reversion of the trend, with a growing horizon for inflation.

This unintuitive result (a lack of extension of the forecast horizon) for the NBP may stem from the fact that Poland it is the only analyzed country that was not affected significantly by the global financial crisis and faced no recession.[26] In the case of Hungary (shortening of the forecast horizon), which experienced a recession after the collapse of Lehman Brothers, this outcome may be explained to some extent by higher uncertainty as to the future, especially due to the strongly changing overall economic policy.

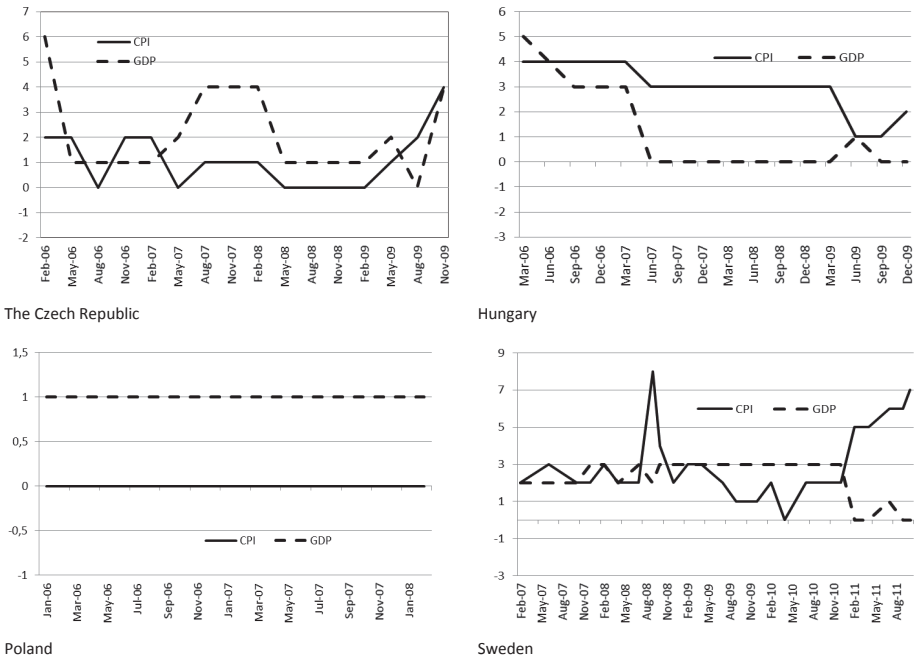
By using a Gaussian function to aggregate forecasts for the CPI and GDP, I also check if central banks are focused on one particular horizon or on the whole path. The findings indicate that all central banks focus more on one particular forecast horizon (low standard deviation).

Surprisingly the horizon at which the central banks look is shorter for the CPI than for the GDP, with the exception of the MNB. One would expect a reverse relationship because the impact of the monetary policy on the GDP is quicker than that on the CPI. Furthermore, inflation in the

[25] However, the interpretation of the results for the CNB and the Riksbank is conducted slightly different than for the other two banks. In the case of these two banks the projection of future GDP and inflation is derived with the endogenous interest rate. Therefore it is not possible to identify exact horizon taken into account by the central bank when setting the interest rate, because model is usually set up in such way to bring the inflation to the target within the forecast horizon. However it does not change the conclusions as to the shortening or extension of the forecast horizon. For these two central banks, outcomes of the research point rather to the horizon prior to bringing inflation back to target. Withal, if the results indicate extension or shortening of the moment preceding the return of inflation to the target, and thus the moment of inflation reaching the target, then, assuming the similarity of the trajectory of this return, the conclusions from the analysis remain valid.

[26] In Poland there was no concern about financial stability after the outbreak of the financial crisis.

Figure 2: The forecast horizon which central banks take into consideration when setting the interest rate



Note: The date on the horizontal axis indicates the date of the first observation in the rolling window.
Source: Own calculations.

long run is shaped by the changes in the exchange rate and the GDP.

4.3 The permanent shift in monetary policy stance

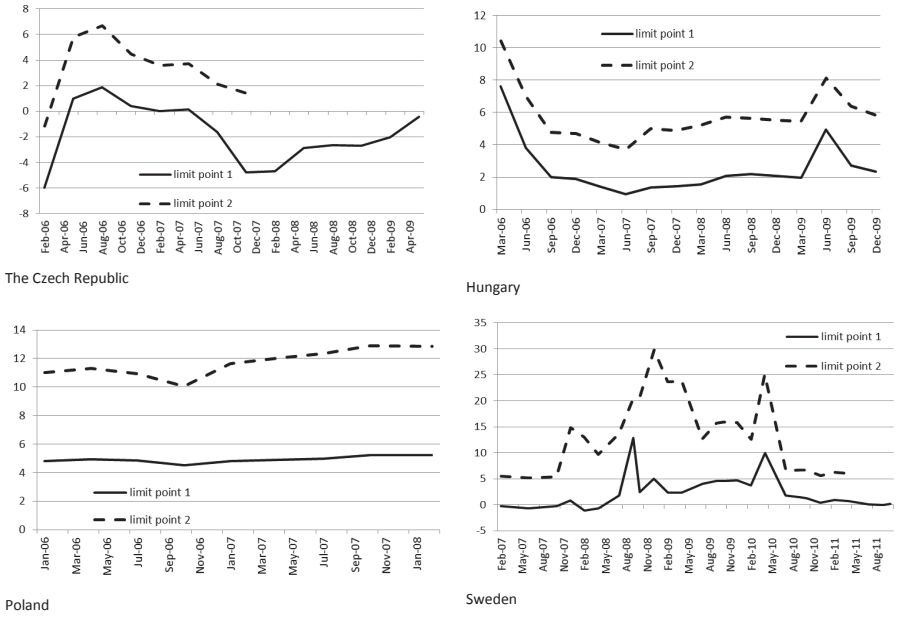
The limit points indicate the general attitude of the central bank towards monetary policy. As in the logit models, the values of the limit points differentiate between the decision of the central bank to lower (raise) the interest rates or to keep them unchanged. If the limit points increase (or decrease) in time it means that the central bank becomes more "dovish" (or "hawkish").

Three out of four central banks – the CNB, MNB and the NBP – have permanently shifted their monetary policy stance to a more accommodative over time (Figure 3). This means that these central banks are ready to accept a higher inflation deviation from the target for the sake of more stable output growth. Moreover, in the spirit of Blanchard et al. (2010), in the future these central

banks may be ready to accept higher inflation rates to avoid facing ZLB.

On the contrary, the results for the Riskbank may be a little surprising since, in over time, the monetary policy becomes tighter. This means that the Riksbank facing the ZLB could not or did not want to lower the interest rate below zero as it implied the beginning of the unconventional monetary policy.[27] The interpretation of this may be twofold. First, negative interest rates are "uncharted territories" and it is difficult to predict their influence on the real economy. Therefore, the Riksbank wanted to avoid this for as long as possible. Second, the Riskbank was concerned about the growing bubble on the housing market[28] and its decision not to lower the interest rate below zero can be interpreted as leaning against the wind.

Figure 3: The monetary policy stance



Note: The date on the horizontal axis indicates the date of the first observation in the rolling window.
Source: Own calculations.

[27] My sample covers only one observation (last one) in which the Riksbank decided on the unconventional monetary policy instruments - lowered the interest rate below zero and started the purchase of nominal government bonds with maturities from 1 year up to around 5 years, see Riksbank (2015).

[28] The Riskbank throughout 2014 indicated that together with the lowering of the interest rates there is growing risk associated with household indebtedness and indicated that reforms are needed for a better-functioning housing market, e.g. Riksbank (2014).

5 Conclusions

The aim of this research is to check empirically how the behavior of central banks has changed after the outbreak of the global financial crisis. The results indicate that all the banks have changed their way of setting interest rates, however in each case the change is different. This indicates that there is no common pattern, but that the changes depend heavily on country-specific factors such as the situation on the financial market, the economy slack, as well reforms connected with the real economy.

The Česká Národní Banka extended the forecast horizon which it takes into consideration when setting the interest rate. Additionally the CNB's monetary stance became more accommodative.

The Magyar Nemzeti Bank increased the weight put on the GDP and lowered for the CPI after the outbreak of the global financial crisis, together with the shortening of the forecast horizon. Similarly to the CNB, the MNB started to conduct more accommodative monetary policy.

Although in the case of the Narodowy Bank Polski we do not observe changes of the forecast horizon, this bank also started to put more weight on the GDP forecast as compared to CPI forecast. Besides, the NBP's monetary policy has become more accommodative.

In the case of the Riksbank, we do not observe an increase of the importance of the GDP, however there is an extension of the forecast horizon which it takes into consideration when setting the interest rate. Additionally, the monetary policy stance points to a tighter policy, however this is probably connected with the initial unwillingness of the Riksbank to lower interest rates below zero.

The results show that all the banks are ready to accept an extended period or larger deviations of inflation from the target in order to maintain the stability of the whole economy and become more flexible inflation targeters, although each one in its own way – through the extension of the forecast horizon which it takes into consideration when setting the interest rate, increase of the importance of the output growth, permanent shift of the monetary policy stance to more accommodative one or a mixture of these factors.

To sum up, the central banks faced different problems after the outbreak of the global financial crisis. They encountered zero lower bound, banking sector crisis, risk related to the stock of the credits denominated in the foreign currency etc. Although all central banks were operating under different economic conditions, each of them came to the same conclusion – they have to change the current strategy of the monetary policy to more flexible one; sometimes using the unconventional monetary policy instruments. However each of them did it in slightly different manner.

References

Arlt, Josef, and Martin Mandel (2014) 'The Reaction Function of Three Central Banks.' *Prague Economic Papers* 2014(3), 269–289

Ball, Laurence M. (2013) 'The Case for Four Percent Inflation.' *Central Bank Review* 13(2), 17–31

Baranowski, Paweł, and Paweł Gajewski (2016) 'Credible Enough? Forward Guidance and Perceived National Bank of Poland's Policy Rule.' *Applied Economics Letters.* forthcoming

Batini, Nicoletta, and Andrew Haldane (1999) 'Forward-Looking Rules for Monetary Policy.' In 'Monetary Policy Rules' NBER Chapters (National Bureau of Economic Research, Inc) pp. 157–202

Batini, Nicoletta, and Edward Nelson (2001) 'Optimal horizons for inflation targeting.' *Journal of Economic Dynamics and Control* 25(6-7), 891–910

Baxa, Jaromír, Roman Horváth, and Bořek Vašíčiek (2014) 'How Does Monetary Policy Change? Evidence On Inflation-Targeting Countries.' *Macroeconomic Dynamics* 18(03), 593–630

Belke, Ansgar, and Jens Klose (2009) 'Does the ECB Rely on a Taylor Rule? - Comparing Ex-post with Real Time Data.' Ruhr Economic Papers 133, Rheinisch-Westfoelisches Institut foer Wirtschaftsforschung (RWI), Ruhr-University Bochum, TU Dortmund University, University of Duis-burg-Essen

Bernanke, Ben, and Mark Gertler (2000) 'Monetary Policy and Asset Price Volatility.' NBER Working Papers 7559, National Bureau of Economic Research, Inc, February

Bernanke, Ben. S. (2010). Testimony before the Joint Economic Committee of Congress, April 14, 2010

Blanchard, Olivier, Giovanni Dell'Ariccia, and Paolo Mauro (2010) 'Rethinking Macroeconomic Policy.' *Journal of Money, Credit and Banking* 42(s1), 199–215

Boeckx, Jef (2011) 'Estimating monetary policy reaction functions : A discrete choice approach.' Working Paper Research 210, National Bank of Belgium, February

Bohm, Jiří, and Jan Filáček (2012) 'Price-Level Targeting. A Real Alternative to Inflation Targeting?' *Czech Journal of Economics and Finance (Finance a uver)* 62(1), 2–26

Brzoza-Brzezina, Michał, Jacek Kotłowski, and Agata Miśkowiec (2013) 'How forward-looking are central banks? Some evidence from their forecasts.' *Applied Economics Letters* 20(2), 142–146

Bullard, James, Costas Azariadis, and Gaetano Antinolfi (2008) 'The Optimal Inflation Target in an Economy with Limited Enforcement.' 2008 Meeting Papers 915, Society for Economic Dynamics

Carney, Mark (2013). Memorial Lecture University of Alberta Edmonton, Alberta 1 May 2013

Carstensen, Kai (2006) 'Estimating the ECB Policy Reaction Function.' *German Economic Review* 7, 1–34

Cecchetti, Stephen G., Hans Genberg, and Sushil Wadhwani (2002) 'Asset Prices in a Flexible Inflation Targeting Framework.' NBER Working Papers 8970, National Bureau of Economic Research, Inc, May

CEPR (2014) *Secular Stagnation: Facts, Causes and Cures* (CEPR Press)

Clarida, Richard, Jordi Gali, and Mark Gertler (2000) 'Monetary Policy Rules And Macroeconomic Stability: Evidence And Some Theory.' *The Quarterly Journal of Economics* 115(1), 147–180

Cukierman, Alex (2013) 'Monetary policy and institutions before, during, and after the global financial crisis.' *Journal of Financial Stability* 9(3), 373–384

Dieppe, Alistair, Keith Kster, and Peter McAdam (2005) 'Optimal Monetary Policy Rules for the Euro Area: An Analysis Using the Area Wide Model.' *Journal of Common Market Studies* 43(3), 507–537

Dodge, David (2008). The Eric Hanson Memorial Lecture at the Economics Department University of Alberta Edmonton, 4 February 2008

Dolado, Juan J., Ramon Maria-Dolores, and Manuel Naveira (2005) 'Are monetary-policy reaction functions asymmetric?: The role of nonlinearity in the Phillips curve.' *European Economic Review* 49(2), 485–503

Eichengreen, Barry, Mark W Watson, and Richard S Grossman (1985) 'Bank Rate Policy under the Interwar Gold Standard: A Dynamic Probit Model.' *Economic Journal* 95(379), 725–45

Filardo, Andrew J. (2001) 'Should monetary policy respond to asset price bubbles?: some experimental results.' Research Working Paper RWP 01-04, Federal Reserve Bank of Kansas City

Fischer, Stanley (1990) 'Rules versus discretion in monetary policy.' In *Handbook of Monetary Economics,* ed. M. Friedman B. and H. Hahn F., 1 ed., vol. 2 (Elsevier) chapter 21, pp. 1155–1184

Gagnon, Joseph (2010). Discussion of "Should Central Banks Raise Their Inflation Targets?" by Bennett McCallum. "Revisiting Monetary Policy in a Low Inflation Environment," at the Federal Reserve Bank of Boston on October 15-16, 2010

Gascoigne, Jamie, and Paul Turner (2004) 'Asymmetries in Bank of England monetary policy.' *Applied Economics Letters* 11(10), 615–618

Gerdesmeier, Dieter, and Barbara Roffia (2004) 'Empirical Estimates of Reaction Functions for the Euro Area.' *Swiss Journal of Economics and Statistics (SJES)* 140(I), 37–66

Gerlach, Stefan (2007) 'Interest Rate Setting by the ECB, 1999-2006: Words and Deeds.' *International Journal of Central Banking* 3(3), 1–46

Giannoni, Marc, and Michael Woodford (2004) 'Optimal Inflation-Targeting Rules.' In 'The Inflation-Targeting Debate' NBER Chapters (National Bureau of Economic Research, Inc) pp. 93–172

Gorter, Janko, Jan Jacobs, and Jakob de Haan (2007) 'Taylor Rules for the ECB using Consensus Data.' DNB Working Papers 160, Netherlands Central Bank, Research Department, December

Issing, Otmar (2012) 'Central banks - paradise lost.' IMES Discussion Paper Series 12-E-10, Institute for Monetary and Economic Studies, Bank of Japan

Jansen, David-Jan, and Jakob De Haan (2009) 'Has ECB communication been helpful in predicting interest rate decisions? An evaluation of the early years of the Economic and Monetary Union.' *Applied Economics* 41(16), 1995–2003

Karvalits, Ferenc (2009). Speech at Reuters Summit, Vienna 2009

King, Mervyn (1994). IFS Annual Lecture 1994 delivered at the Chartered Accountants' Hall, London on 1 June 1994

Kotłowski, Jacek (2005) 'Reaction functions of the Polish central bankers. A logit approach.' Working Papers 18, Department of Applied Econometrics, Warsaw School of Economics, May

Lear, William Van (2000) 'A review of the rules versus discretion debate in monetary policy.' *Eastern Economic Journal* 26(1), pp. 29–39

Liao, T.F. (1994) *Interpreting probability models: logit, probit, and other generalized linear models* Quantitative Applications in the Social Sciences (Sage Publications, Thousand Oaks, London, Delhi)

Lowe, Philip, and Claudio Borio (2002) 'Asset prices, financial and monetary stability: exploring the nexus.' BIS Working Papers 114, Bank for International Settlements, July

McCallum, Bennett T. (2011) 'Should central banks raise their inflation targets? Some relevant issues.' *Economic Quarterly* (2Q), 111–131

Mishkin, Frederic S. (2011) 'Monetary Policy Strategy: Lessons From The Crisis.' In *Approaches to monetary policy revisited - lessons from the crisis, 6th ECB Central Banking Conference, 18-19 November 2010,* ed. Marek Jarocinski, Frank Smets, and Christian Thimann (European Central Bank) pp. 67–118

Mishkin, Frederic S., and Klaus Schmidt-Hebbel (2001) 'One Decade of Inflation Targeting in the World: What Do We Know and What Do We Need to Know?' NBER Working Papers 8397, National Bureau of Economic Research, Inc, July

NBP (2011). Monetary Policy Guidelines for 2012

_ (2013). Monetary Policy Guidelines for 2014

Orphanides, Athanasios (2001) 'Monetary Policy Rules Based on Real-Time Data.' *American Economic Review* 91(4), 964–985

Plantier, Christopher (2002) 'The appropriate time horizon for monetary policy.' (Reserve Bank of New Zealand)

Rigobon, Roberto, and Brian Sack (2003) 'Measuring The Reaction Of Monetary Policy To The Stock Market.' *The Quarterly Journal of Economics* 118(2), 639–669

Riksbank (2010). Annual Report 2010

_ (2014). Repo rate decision on 2 July 2014

_ (2015). Repo rate decision on 11 February 2015

Rosa, Carlo (2010) 'What is the ECB Reaction Function? A Static and Dynamic Probit Analysis.' Royal Economic Society 2010 Conference

Rudebusch, Glenn D, and Lars E. O. Svensson (1998) 'Policy Rules for Inflation Targeting.' CEPR Discussion Papers 1999, C.E.P.R. Discussion Papers, October

Stráský, Jan (2005) 'Optimal Forward-Looking Policy Rules in the Quarterly Projection Model of the Czech National Bank.' Research and Policy Notes 2005/05, Czech National Bank, Research Department, December

Sutherland, Douglas (2010) 'Monetary Policy Reaction Functions in the OECD.' OECD Economics Department Working Papers 761, OECD Publishing, May

Svensson, Lars E. O. (1997) 'Optimal Inflation Targets, 'Conservative' Central Banks, and Linear Inflation Contracts.' *American Economic Review* 87(1), 98–114

_ (1999) 'Price-Level Targeting versus Inflation Targeting: A Free Lunch?' *Journal of Money, Credit and Banking* 31(3), 277–95

_ (2000) 'Open-economy inflation targeting.' *Journal of International Economics* 50(1), 155–183

_ (2009). Flexible Inflation Targeting: Lessons from the Financial Crisis," speech at the workshop "Towards a New Framework for Monetary Policy? Lessons from the Crisis," organized by the De Nederlandsche Bank, Amsterdam, September 21, 2009

Taylor, John B. (1993) 'Discretion versus policy rules in practice.' *Carnegie-Rochester Conference Series on Public Policy* 39(1), 195–214

Uchida, Hirofumi, and Hiroshi Fujiki (2005) 'Optimal inflation target under uncertainty.' *Japan and the World Economy* 17(4), 470–479

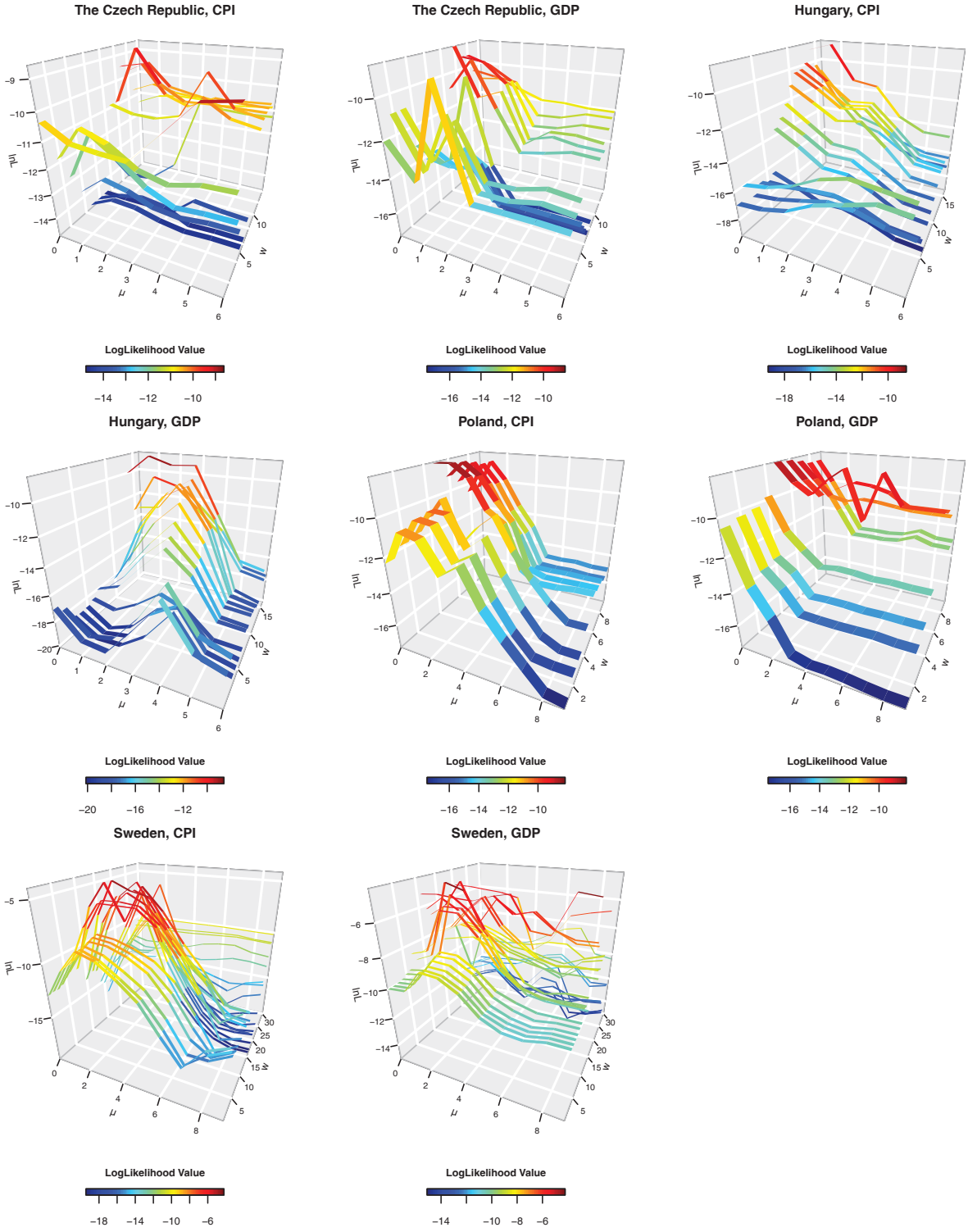
Čapek, Jan (2014) 'Historical Analysis of Monetary Policy Reaction Functions: Do Real-Time Data Matter?' *Czech Journal of Economics and Finance (Finance a uver)* 64(6), 457–475

Weber, Axel A. (2015) 'Rethinking Inflation Targeting.' http://www.project-syndicate.org/commentary/rethinking-inflation-targeting-price-stability-by-axel-weber-1-2015-06. Accessed: 2015-09-02

White, William R (2004) 'Making macroprudential concerns operational.' *Proceedings of the symposium on financial stability policy–challenges in the Asian era* pp. 47–62

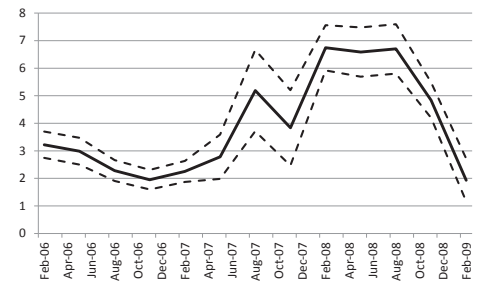
6 Annex

Figure 4: The maximum value of the log likelihood function

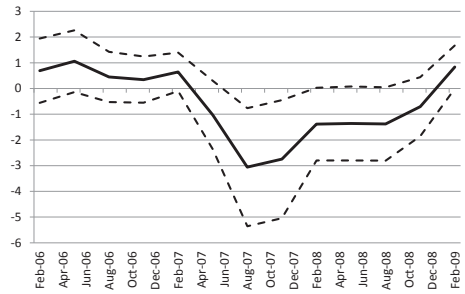


Note: Each plot shows the maximum value of the log likelihood function calculated for different values of μ parameter for the CPI (or GDP) in respect to the value to μ parameter of the GDP (or CPI) variable in the selected rolling window (w).
Source: Own calculations.

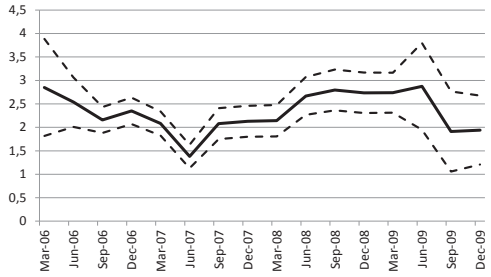
Figure 5: The parameter for the CPI and GDP forecast in the rolling window for the analyzed banks and the 90% confidence interval



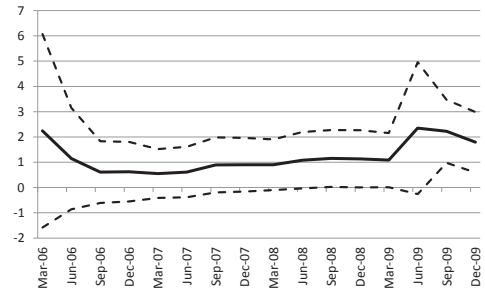
The Czech Republic - CPI



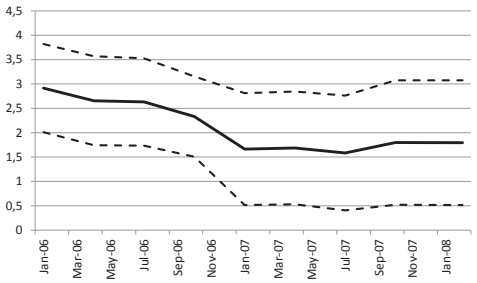
The Czech Republic - GDP



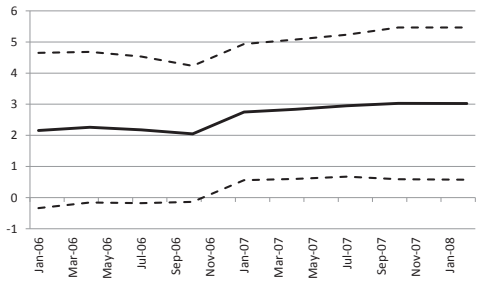
Hungary - CPI



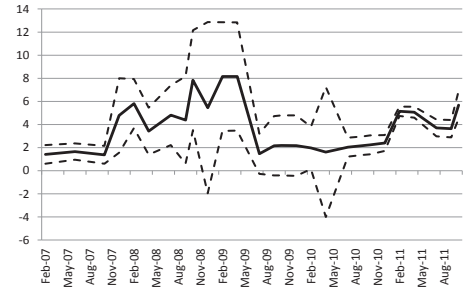
Hungary - GDP



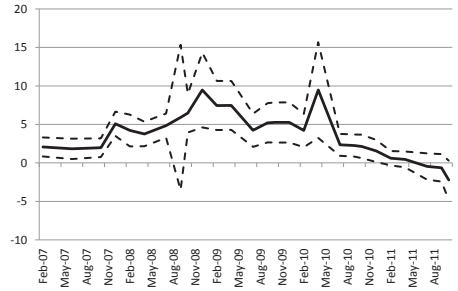
Poland - CPI



Poland - GDP



Sweden - CPI



Sweden - GDP

Note: The date on the horizontal axis indicates the date of the first observation in the rolling window.
Source: Own calculations.

www.nbp.pl