Do central bank forecasts matter for professional forecasters?*

Jacek Kotłowski†

Abstract

This paper examines to what extent public information provided by the central bank affects the forecasts formulated by professional forecasters. We investigated empirically whether disclosing GDP and inflation forecasts by Narodowy Bank Polski (the central bank of Poland) reduced the disagreement in professional forecasters' expectations. The results only partially support the hypothesis on the coordinating role of the central bank existing in the literature. The main finding is that by publishing its projection of future GDP growth, the central bank was reducing the dispersion of one-year-ahead GDP forecasts. Our study indicates that the role of the central bank in reducing the forecasts dispersion was strengthening over time. We also found using non-linear STR models that the extent to which the projection release affected the dispersion of GDP forecasts varied over the business cycle. By disclosing its own projection the central bank reduced the disagreement among the forecasters the most in the periods when the economy moved from one phase of the business cycle to another. On the other hand, the release of CPI projection by NBP affected neither the cross-sectional dispersion nor the level of forecasts formulated by professional forecasters.

JEL: C24, E37, E52, E58

Keywords: Monetary policy, inflation targeting, forecasting, central bank communication, survey expectations, forecasts disagreement, STR models.

*The views expressed herein are those of the authors and not necessarily those of the Narodowy Bank Polski or the Warsaw School of Economics. We would like to thank the participants of the seminar at the Narodowy Bank Polski and Senamek seminar in the Institute of Econometrics at Warsaw School of Economics for valuable comments.

†Narodowy Bank Polski and Warsaw School of Economics; NBP, Poland, 00-919 Warsaw, Swietokrzyska 11/21; tel 0048 22 185 18 83; fax 0048 22 185 20 92; Email: jacek.kotlowski@nbp.pl

1 Introduction

Since the beginning of the 1990s several central banks have followed the Reserve Bank of New Zealand in adopting the inflation targeting strategy. The strategy of inflation targeting assumed that the central bank announces the numerical target for the inflation and tends to bring inflation to the target in the medium term explaining to the public the plans, objectives and decisions of the policymakers (Mishkin, 2002). Therefore the implementation of the inflation targeting scheme was followed by an increasing transparency of the monetary authorities. The central banks aimed to explain the decisions by publishing inflation reports, communiques after decisions on interest rates and the minutes from the meetings. One of the most influential communication instruments used by the central banks was the projection of future inflation and other key macroeconomic variables. As pointed out by Svensson (1997) (see also Goodhart, 2001) due to substantial lags in the monetary transmission mechanism, the central bank should target future inflation rather than current inflation. That is why the revealing of the outlook for the future macroeconomic situation might play a crucial role in explaining the motivation for the current decisions on monetary policy. Brzoza-Brzezina et al. (2013) investigated empirically whether the central banks, which publish the projection, took its results into account while deciding on own interest rates. They found that the monetary authorities reacted to the deviation of expected inflation from the target; however, the policy horizon differed across the banks. The baselines of the projection evolved over time. The central banks started publishing the projection derived by the assumption of constant interest rates. Then some of them moved to a projection based on market interest rates, which was perceived to be more likely than keeping interest rates unchanged for the whole forecast horizon. Finally, since the middle of the previous decade, several central banks decided to publish the projection with endogenous interest rates path, which according to Faust and Leeper (2005) would be more beneficial for the private agents than conditional forecasts in terms of forecasting future interest rates. However, disregarding the choice of interest rates used in the projection, the main role of publishing future paths of key macroeconomic variables was to explain to the public the context of the decisions taken by the monetary authority and to influence the inflation expectations of the private agents (Woodford, 2005). Following several other central banks, Narodowy Bank Polski (NBP) adopted in 1999 the inflation targeting strategy with the numerical target expressed in the CPI term. Since 2004, NBP started publishing the forecast of CPI inflation, while in 2005 the first GDP forecast was released.

In the paper we are going to establish to what extent the public information provided by Narodowy Bank Polski affected the forecasts formulated by professional forecasters. We investigated empirically whether disclosing GDP and inflation forecasts by NBP in the period 2006-2013 could have lowered the cross-sectional dispersion of professional forecasters expectations. Moreover, we aimed to identify other than NBP projection factors affecting the dispersion of GDP and inflation forecasts in the Polish economy.

This research merges two streams of the literature. The first one points out the role of the central bank in influencing the disagreement (cross-sectional dispersion) in private agents forecasts by providing public information. The second stream relates to the identification of macroeconomic factors affecting disagreement among forecasters.

The first stream reflects both tendencies observed in central banking during the last two decades: the enhancing transparency of monetary authorities and the adoption of inflation targeting schemes by many central banks. As

showed by Dincer and Eichengreen (2007, 2014) since the second half of the 1990s a large number of central banks increased their transparency. While transparency is perceived as a precondition of successful IT strategy (Svensson, 1997, Laxton and Freedman, 2009), the tendency of enhancing the transparency was evident not only among the banks which adopted an IT framework (Geraats, 2009). While research related to the impact of monetary policy transparency on macroeconomic outcome is very comprehensive (see Geraats, 2014 for a review), some authors focused more specifically on the issue of how the increased level of transparency affects disagreement among private forecasters. Swanson (2006) showed that the increased transparency of the FOMC since the late 1980s resulted in higher precision of the private sector forecasts of US interest rates in terms of both accuracy and dispersion. Beechey et al. (2011) analyzed the long-term inflation expectations in the euro area and in the US. They found that while both were reasonably well anchored, the dispersion of the US inflation expectations was higher than those of the euro area. Ehrmann et al. (2012) focused on the relationship between the level of transparency of the central bank and the dispersion of forecasts of key macroeconomic variables formulated by both professional forecasters and households. They analyzed data for 12 developed countries and concluded that the growth of transparency diminishes the dispersion of forecasts derived by professional forecasters but not by households. They also found that this relationship is non-linear. After exceeding a certain level of transparency, the further increase does not lower the dispersion of forecasts anymore. On the other hand Siklos (2013) analyzed a broader set of data containing professional private and public forecasts as well as different survey-based expectations and found that for a panel of nine developed economies enhencing the central banks' transparency led to the increase of the disagreement about future inflation. Ehrmann et al. (2012) point out the benefits from increasing the transparency of the monetary policy and argue that revealing the forecasts by the central banks may be beneficial for the public for at least two reasons: it may decrease the noise-to-signal ratio and may reduce the cost of collecting information. However in their theoretical paper Morris and Shin (2002) (see also the discussion in Svensson, 2006 and Morris et al., 2006) show that the coordinating effect caused by the public information may pose the risk of making the economy more exposed to common forecasts errors. It is worth noting that the risk may materialize only if the central bank is able to reduce the dispersion of the forecasts.

When analyzing the role of the central bank in affecting disagreement among forecasters, some authors investigated the impact of the implementation of inflation targeting strategy on private sector forecasts. Cecchetti and Hakkio (2009) tested for a panel of 15 countries tested whether the adoption of a direct inflation strategy by the central bank reduced the dispersion of inflation forecasts formulated by professional forecasters. They conducted a comprehensive analysis using several model specifications and concluded that the effect was negligible and significant only for some variants of the model. The outcome achieved by Cecchetti and Hakkio (2009) has been confirmed to some extent by Capistrán and Ramos-Francia (2010). For a group of 25 countries they found that the adoption of a direct inflation strategy has been successful in lowering the dispersion of inflation forecasts only for emerging economies, while for the developed countries this hypothesis has not been confirmed. They recognized that the full effect of implementation of an IT framework in emerging countries was visible after three years.

On the other hand several papers focus more specifically on the impact of disclosing quantitative projection of key macroeconomic variables on the dispersion of individual forecasts of the private sector. Fujiwara (2005)

tested whether the forecasts revealed by the Bank of Japan affected the forecasts formulated by professional forecasters and vice-versa. The results showed that while the Bank of Japan by publishing its forecasts influenced the forecasts of inflation derived by professional forecasters, the opposite causality did not hold. Hubert (2013) investigated to what extent the projection of future inflation and GDP growth released by the FOMC members influenced the dispersion of the forecasts derived by forecasters participating in Consensus Forecasts and Survey of Professional Forecasters. He found that by disclosing the projection the FOMC impacts negatively the dispersion of the short-term inflation forecasts – for the current year – while the dispersion of forecasts for the longer horizon (next year) remain unaffected. Moreover, the projection released by FOMC does not influence the dispersion of GDP forecasts for all horizons.

The second stream of literature to which our paper refers is the research on the causes of disagreement among forecasters. While this topic is very broad, we focus only on the macroeconomic determinants of the dispersion of forecasts formulated by professional forecasters. This issue has been raised so far by several authors. Mankiw et al. (2004) analyzed the factors which affect the dispersion of inflation forecasts for the US economy and concluded that disagreement among forecasters is positively related to the level and volatility of inflation. D'Amico and Orphanides (2008) using SPF data found that dispersion of US inflation forecasts is positively correlated with the expected level of inflation. A similar SPF data set has been analyzed by Capistrán and Timmermann (2009), who provided the explanation for the shift in the US inflation forecast bias in the beginning of the 1980s, but also confirmed that higher current inflation and its volatility result in higher dispersion of inflation forecasts. A comprehensive analysis of the determinants of disagreement about key macroeconomic variables for the panel of G7 countries has been conducted by Dovern et al. (2012). They found that the dispersion of forecasts of the real variables depends on the phase of the business cycle – it intensifies during recession. As far as nominal variables are concerned, disagreement about inflation rises with its level and volatility and in contrast to disagreement about real variables it depends also on the institutional setting of the central bank. For countries with more independent central banks, the disagreement proved to be lower. These findings are in line with the outcome of the research about the impact of the central banks on the dispersion of forecasts previously discussed in the Introduction, where several control variables have also been used. The general conclusion from the literature is that disagreement about inflation depends positively on its level and volatility. Moreover disagreement about real variables but also about inflation, is lower during expansions than during recession.

Most of the research devoted to both the role of the central bank in influencing dispersion of the forecasts and the macroeconomic determinants of this dispersion concerns developed and large economies. Much less attention has been paid to the role of central banks projection in small open emerging economies more prone to the external shocks, where the role of the central bank in affecting the forecasts of professional forecasters may be different than in the developed countries. We would like to fill in this gap with our analysis.

In the research we found that by publishing its own projection of future GDP growth, Narodowy Bank Polski was reducing the dispersion of one-year-ahead GDP forecasts formulated by professional forecasters. Our study indicates also that the role of the projection release in decreasing the dispersion of GDP forecasts while strengthened over time, varied over business cycle. By disclosing its own projection the central bank reduced the disagreement among the forecasters the most in the periods when the economy moved from one phase of the

business cycle to another. Moreover the results show that the central bank influenced the level of GDP forecasts as well. On the other hand, the release of CPI projection by the central bank affected neither the cross-sectional dispersion nor a level (median) of forecasts formulated by professional forecasters.

We identified some determinants of the dispersion among the forecasters. In general, the cross-sectional dispersion of GDP forecasts was positively influenced by the volatility of industrial production and increased around turning points. Moreover, the dispersion was higher during slowdowns than in recovery phases. Finally, disagreement among forecasters grew with negative surprises when industrial production releases differed from the forecasts. The dispersion of one-year-ahead CPI forecasts depended positively on the level of inflation, on its volatility and on the phase of the business cycle. The disagreement among forecasters has also been affected by the volatility of oil prices, but proved to be resilient to exchange rate movements.

The rest of the paper is organized as follows. Section 2 describes the model and data we use. In Section 3 we present the empirical results for the linear model, followed by the robustness check in Section 4. In Section 5 we extend our analysis by allowing for assymetry in the reaction of the individual forecasts to the projection release. Section 6 concludes the paper.

2 Data and model

2.1 NBP forecasts

Since the beginning of the 1990s Narodowy Bank Polski has been realizing the process of disinflation, using the money growth as an intermediate target and conducting the crawling devaluation of the złoty vis-à-vis the basket of currencies with the band for exchange rate fluctuations. In 1999 NBP adopted the inflation targeting strategy with the target expressed in the CPI term (NBP, 1998, 2003). Enhancing the communication framework, NBP started publishing the projection of key macroeconomic variables, including future CPI inflation and GDP growth. The projection is owned by the staff. The first inflation forecast derived by the assumption of constant interest rates was released in September 2004, while the first GDP forecast was launched in June 2005. Initially the bank was disclosing only inflation and GDP forecasts, while in the meantime the forecast release has been extended by a broader set of key macroeconomic variables. The forecasts are derived using the macroeconometric model (N)ECMOD (see Budnik et al., 2009). The forecasts cover the current and two consecutive years, which results in a varying length of the forecast horizon: from 8 to 12 quarters. The GDP and inflation forecasts are published in the form of a fanchart with a central path.

The forecast is being disclosed in two steps. In the communique published immediately after the meeting of the Monetary Policy Council, the future paths of inflation and GDP growth are released. One week later, the whole projection with the broader set of the macroeconomic variables and the full description of the macroeconomic scenario is published. We assume that disclosure of the inflation and GDP forecasts by the bank would be sufficient to affect the forecasts of these two variables formulated by professional forecasters. That is why we associate the date of NBP projection release with the date of the MPC meeting when inflation and GDP forecasts are published, rather than with the date of the full projection release.

In 2004, NBP published the inflation forecasts twice (in June and December), and in the course of 2005

three times (in March, June and September). Since 2005 the inflation forecast has been accompanied by the GDP forecast (in June and September). In the years 2006-2007, the NBP projection with the broader set of macroeconomic indicators has been prepared four times a year and released always in the last week of the following months: January, May, August and November. While the forecasts of professional forecasters used in our research have been collected monthly up to the 10th of every month (see Section 2.2), the newly released projection might have potentially affected the forecasts formulated in February, June, September and December. Since 2008, the NBP projection has been disclosed three times a year. In the period 2008-2010, NBP published its forecasts in February, June and October. While the forecasts as in the previous years have been released in the last week of the month, they could be taken into account by private forecasters in polls conducted in March, July and November. Since 2011, the MPC meeting has been moved permanently one week ahead: from the last week of the month to the first week of the consecutive month. Thereby the date of release of the projection moved one week forward as well. However, while the forecasts are collected till the 10th of every month despite postponing the schedule of the meetings, the new NBP forecast was accessible for the analysts in the course of preparing their own forecasts in the same months as previously: March, July and November.

Despite the fact that the first inflation forecast was published in 2004 and the first GDP forecast in the course of 2005, we decided to start our sample for both variables from the beginning of 2006. Firstly, the common starting date allows us a better comparison of the results for these two indicators. Secondly, we wanted to cover with the sample the whole of the years when the projection of both variables was being released. Thirdly, we believe that the private forecasters needed some time to "learn" how to read the projection before they started to use it as a potential focal point.

To reflect the impact of the projection release on the dispersion of private sector forecasts, we constructed a dummy variable which takes the value of one in the months when the forecasters responding to the poll had in hand the newly released projection and zero otherwise. Our sample starts in 2006. In the years 2006-2007, the dummy variable equals one in February, June, September and December while in the period 2008-2013 in March, July and November.

2.2 Forecasts of professional forecasters

The forecasts of the professional forecasters used in our research come from the polls conducted monthly by Reuters among economists from commercial banks and other financial institutions. The first poll was launched in 1994 and since then the number of respondents and set of polled macroeconomic indicators has evolved over time. In the period 2006-2013 covered by our sample, the number of economists surveyed by Reuters ranged from 10 to 25. The respondents are asked for several short- and medium-term CPI inflation and GDP forecasts.

In case of CPI inflation, the economists are polled for the forecasts of the following indicators: (1) year-over-year inflation twelve months ahead ($y^{h=12}$), (2) year-over-year inflation one month ahead ($y^{h=1}$ – nowcasting), (3) year-over-year inflation in December of the current year, (4) the average inflation in the current year, (5) the average inflation in the next year. Unfortunately there are some missing values in the data. The first three time series are complete for the whole period covered by our sample, but for the two remaining there are substantial gaps which shorten significantly the time series. When choosing the inflation measure to be forecasted, we had

to decide between fixed-date and fixed-horizon forecasts. As pointed out by Hubert (2013), the fixed-horizon forecasts used to be preferable. In particular they do not need to be adjusted by the varying horizon effect. On the contrary, for the fixed-date forecasts the dispersion tends to decrease in the consecutive months of the year. Although this varying horizon effect can be removed by linear interpolation or seasonal dummies (see Dovern et al., 2012), such a procedure may distort the information stemming from the data. Moreover, if the projection is published regularly in the same months of the year, the seasonal dummies may coincide with the projection variable. For that reason and taking into account the substantial gaps in the time series of forecasts for the average current and next year inflation, we finally chose as a forecast variable the year-over-year inflation predicted twelve months ahead. We rejected the year-over-year inflation forecasted one month ahead while we believe that the projection would affect longer-term forecasts rather.[1]

As far as longer-term GDP forecasts are concerned, the economists are polled by Reuters for three different indicators: (1) year-over-year quarterly GDP growth four quarters ahead (2) average GDP growth in the current year, (3) average GDP growth in the next year. The first time series is a fixed-horizon forecast, while the two remaining indicators are fixed-date forecasts. Among the next year GDP forecasts, 16 observations are missing, while two other time series are complete. For the further analysis we chose accordingly the fixed-horizon forecast: year-over-year quarterly GDP growth four quarters ahead.

The main focus of the research is on the impact of the central bank's projection release on the dispersion of the forecasts formulated by the professional forecasters. As a measure of dispersion we chose the interquartile range (3rd quartile minus 1st quartile of individual forecasts), which is more robust to the presence of outliers than the standard deviation. The advantage of the interquartile range over standard deviation may be particularly important in the face of a relatively small number of respondents in some years.

However, the additional point of interest may be to investigate whether the projection published by the central bank acts as an attractor for the median of individual forecasts. Thus we wanted to check whether the median of forecasts formulated by professional forecasters moved toward the central path of projection after the new projection release. To test this hypothesis we used the measure proposed by Hubert (2013), which expresses the difference of distances between the median of individual forecasts and the central path of the projection in the consecutive months. This measure is constructed as follows:

$$\Delta Med_t^i = |Med_{t-1}^i - Proj_t^i| - |Med_t^i - Proj_t^i|, \tag{1}$$

where Med_t^i denotes the median of individual inflation or GDP forecasts (i = CPI or GDP) formulated in time t while $Proj_t^i$ is the central path of the projection in time t for CPI inflation or GDP growth respectively. If the NBP forecast acts as an attractor for individual forecasts, the absolute value of the distance between the central path and the median of forecasts should decrease in the months when the projection is released – the value of ΔMed_t^i should then be positive. To avoid the misinterpretation that the projection moves toward expectations of professional forecasters instead to the opposite, the proposed measure matches the median of individual forecasts in period $t-1$ with the projection valid in period t.

[1] As a robustness check, we conducted an analysis for the inflation forecasted for the December of the current year, removing the varying horizon effect with seasonal dummies. We see the effect of the projection release statistically insignificant.

2.3 Macroeconomic controls

The literature on the disagreement between forecasters (see Introduction) shows that the dispersions of the individual forecasts formulated by professional forecasters may be affected by several macroeconomic factors. When testing for the impact of the projection release on the dispersion, we should take them into account as control variables. We believe that as in advanced economies, also in the Polish economy the disagreement on inflation forecasts may be correlated with its level (INF) and volatility (INF_VOL), as raised by may authors (see for example Mankiw et al., 2004). To account for the latter, and following Capistrán and Timmermann (2009) and Ehrmann et al. (2012), we derived the volatility of inflation as the conditional variance from the GARCH(1,1) model with 2 lags to remove the autocorrelation. The potential next control variable was the industrial production growth (IP), which represents the phase of the business cycle. As pointed out by Dovern et al. (2012), the dispersion of inflation forecasts during the recession may be higher than during expansion. Furthermore, taking into account the relatively high share of the energy component in the CPI basket, we accounted for volatility of the BRENT oil prices (OIL_VOL) when considering the set of potential control variables. While Poland is a small open economy, we also included the volatility of the exchange rate (Polish złoty against euro – EX_RATE_VOL). The common control variable used by several authors (Dovern et al., 2012, Hubert, 2013) that we accounted for is the volatility of the interest rates (INT_RATE_VOL), which stands for the overall uncertainty of the monetary policy. Finally, we added the surprise variable expressing the ex post absolute error of the recent inflation forecast derived one month ahead (SURP_INF). We assume that the error in nowcasting current inflation may translate to the dispersion of longer-term forecasts.

As far as the dispersion of GDP forecasts is concerned, we accounted for industrial production growth (IP) reflecting the phase of the business cycle. We may also expect that disagreement on GDP growth may be potentially higher around the turning points of the business cycle. For that reason, we complemented the set of the control variables by the volatility of the industrial production growth (IP_VOL), which tend to rise as the economy approaches the turning points. The volatility has been calculated as the conditional variance from the GARCH (1,1) model. Moreover, as pointed out by Ehrmann et al. (2012), the volatility of inflation and industrial production growth may reflect the stage of difficulties in forecasting inflation and GDP respectively and by that may affect the dispersion of their forecasts. As in the disagreement on inflation, we also added exchange rates volatility (EX_RATE_VOL) and interest rates volatility (INT_RATE_VOL). The surprise variable in the model explaining GDP disagreement was the absolute forecasts error of the last monthly industrial production growth (SURP_IP) known in the moment of formulation of the forecasts. It is worth noting that some control variables were the same in the models explaining dispersion of both inflation and GDP forecasts (IP, EX_RATE_VOL, INT_RATE_VOL). When investigating the impact of the NBP projection release on the median of individual inflation and GDP forecasts, we employed the same control variables as in case of the dispersion. A detailed description of the control variables is contained in Table 1.

2.4 Model and estimation method

In the research we used single equation models estimated separately for inflation and GDP forecasts. In this section we discuss the linear models, we move to the non-linear case in Section 5. The models relate the dispersion of, respectively, inflation or GDP forecasts formulated by the professional forecasters to the variable expressing the impact of the NBP projection release (see Section 2.1) as well as other control macroeconomic variables affecting the overall dispersion (see Section 2.3). More specifically, the equation for dispersion of inflation forecasts can be written as follows:

$$IQR_t^{CPI} = \alpha_0^{d,CPI} + \alpha_1^{d,CPI} IQR_{t-1}^{CPI} + \alpha_2^{d,CPI} IQR_{t-2}^{CPI} + \delta^{d,CPI} Proj_t + \beta^{d,CPI} X_t^{CPI} + \varepsilon_t^{d,CPI}, \tag{2}$$

where IQR_t^{CPI} is a dispersion measure for individual CPI inflation forecasts (defined as interquartile range), $Proj_t$ stands for the dummy variable, which takes the value of one in the months when the newly released projection is accessible for the forecasters and zero otherwise, while the X_t^{CPI} is a vector of control variables for inflation forecasts. On the right hand side of the equation (2) we added two lags of dependent variable to account for persistency of forecasts dispersion and for removing the autocorrelation. The equation describing dispersion of GDP forecasts can be formulated as follows:

$$IQR_t^{GDP} = \alpha_0^{d,GDP} + \alpha_1^{d,GDP} IQR_{t-1}^{GDP} + \delta^{d,GDP} Proj_t + \beta^{d,GDP} X_t^{GDP} + \varepsilon_t^{d,GDP}, \tag{3}$$

where the dependent and explanatory variables in (3) are defined in the same way as in (2). Unlike equation (2), one lag of the dependent variable was sufficient to remove the autocorrelation from the data. We estimated the parameters of (2) and (3) separately using the LS method with Newey-West correction to account for potential heteroscedasticity and autocorrelation in the error term. The separate estimation of equations for inflation and GDP forecasts is widespread in the literature (Dovern et al., 2012, Hubert, 2013) and reflects the point of view that the common sources of disagreement for both stem from the control variables only. In other words, the disagreement on inflation may be correlated with a disagreement on future GDP growth, but only via common control variables. We followed this approach, but as a robustness check we estimated the parameters of both equations jointly, allowing for potential cross-correlation of error terms from both equations (see Section 4).

The models for testing the impact of the projection release on the median of individual forecasts have been constructed analogously. The equation explaining the change in distance of median of the CPI inflation forecasts to the central path of projection takes the following form:

$$\Delta Med_t^{CPI} = \alpha_0^{m,CPI} + \alpha_1^{m,CPI} \Delta Med_{t-1}^{CPI} + \delta^{m,CPI} Proj_t + \beta^{m,CPI} X_t^{CPI} + \varepsilon_t^{m,CPI}, \tag{4}$$

where ΔMed_t^{CPI} is a measure of change in the distance defined by (1) while the explanatory variables are the same as in (2).

The respective equation for the median of GDP forecasts can be expressed as follows:

$$\Delta Med_t^{GDP} = \alpha_0^{m,GDP} + \delta^{m,GDP} Proj_t + \beta^{m,GDP} X_t^{GDP} + \varepsilon_t^{m,GDP}, \tag{5}$$

where ΔMed_t^{GDP} defined by (1) measures the difference of distances between the median of individual GDP forecasts and the central path of the NBP projection. Accordingly, we estimated both equations separately by the LS method with Newey-West correction. In contrast to the previous equations in equation (5), we did not include the lagged dependent variables on the right hand side, which proved to be statistically insignificant.

3 Estimation results

The Figures 1a - 1b show the cross-sectional dispersion of individual CPI inflation and GDP forecasts over the sample. We can see that the dispersion for both figures has started rising since the onset of the global financial crises in the beginning of 2008, with the peak in the middle of 2009. Then the level of dispersion for both variables moderated but still remained relatively high.

As the preliminary data analysis, we investigated the average level of dispersion for inflation and GDP forecasts in the months when the newly released projection was accessible for the forecasters as well as in the months preceding and succeeding these dates. On Figure 1c we reveal the average dispersion values for individual inflation forecasts, while Figure 1d contains the dispersion of GDP forecasts respectively. We can see that for GDP forecasts the average dispersion in the months of the projection release seems to be lower than the preceding and succeeding months (the last plots on both figures relate to the remaining months while since 2008 the projection was released every four months). This pattern does not hold for the inflation where the dispersion in the months of the projection release seems to be even slightly higher than in the preceding and succeeding months.

3.1 Dispersion of GDP forecasts

While the results of our research indicate that the release of the NBP projection influenced the dispersion and the median of GDP forecasts but the CPI inflation forecasts proved to be broadly unaffected, we report the results for the GDP forecasts first.

We estimated the parameters of model (3), explaining the dispersion of one-year-ahead GDP forecasts. In addition to the variable reflecting the NBP projection release, we used in the model the control variables listed in Section 2.3 (see Table 1 for details). Following the strategy "from general to specific", we initially estimated the model with the whole set of the control variables, eliminating successively the statistically insignificant ones. The estimation results have been collected in Table 2. After performing the selection procedure, we remained with two competitive models revealed in columns (7) and (8). The model in column (7) contains the following control variables: the growth of industrial production, its volatility, the surprise variable (absolute error of industrial production forecast one month ahead) and volatility of exchange rate. In the second model presented in column (8), the level of industrial production has been substituted by interest rates volatility. While the latter variable is a proxy for the overall volatility in the economy, the inclusion of this variable into the model may result in some sort of co-linearity with other control variables. That is why we present two models: the model which fits data the most (the model with the highest adjusted R2) and additionally the "second best" model selected from the initial set of variables described in Section 2.3 but with the exception of interest rates volatility. Moreover, in Table 2 we present the results for the models where the control variables have been included individually. From the

theoretical point of view, if the models in columns (7) or (8) are true, then the other models, which contain single control variables, are misspecified. However, due to the relatively small sample and high correlation between control variables, we decided to present the models with single explanatory variables as well.

The outcome collected in Table 2, shows that in all presented models, regardless of the set of control variables, the dummy variable standing for the impact of the NBP projection proved statistically significant at the 10 per cent significance level. The results for the full models, presented in columns (7) and (8), lead to the conclusion that the release of the GDP projection by NBP decreased the dispersion of individual GDP forecasts formulated by professional forecasters by 0.071-0.085, which stands for approx. 12 to 15 per cent of the overall dispersion.

The results show that the dispersion of GDP forecast is also positively affected by the volatility of industrial production, which may be explained two-fold. Firstly, it may reflect the fact that the stage of difficulties in forecasting the real variables rises with its volatility (Ehrmann et al., 2012). Secondly, while the volatility of the industrial production growth usually tends to increase around the turning points of the business cycle, this positive relationship means that the disagreement about future GDP growth is larger when the economy approaches the new phase of the cycle. Moreover, we observe the negative relationship between dispersion of GDP forecasts and the pace of growth of the industrial production, which can be interpreted that the dispersion of individual forecasts is lower during expansion than recession – the result confirmed by Dopke and Fritsche (2006) for Germany and by Dovern et al. (2012) for the panel of G7 countries. The disagreement about future GDP is also positively influenced by the volatility of the exchange rate. Finally, the dispersion of one-year-ahead GDP forecasts rises when the forecasters fail to predict the short-term development of industrial production – misinterpreting the current stance of the economy. In the competitive model from column (8) for which the initial set of control variables included the interest rates volatility, this variable proved to be statistically significant as well.

It is worth noting that all models presented in Table 2 fit the data quite well. The difference between R2, calculated for the final model in column (8) and the model with the only autoregressive component, amounts to 0.177 and according to F test, proved statistically significant.

3.2 Median of GDP forecasts

While we found that the release of the NBP projection affected the dispersion of GDP forecasts formulated by professional forecasters, we also investigated whether the projection acted as a focal point for the median of individual forecasts. We tested this hypothesis using equation (5) with the same initial set of control variables as in the case when the dependent variable was the dispersion of GDP forecasts. We analogously eliminated step by step the insignificant explanatory variables, and in Table 3 we present the results for the final model and for the models with single control variables as well. The results collected in Table 3 show that the variable reflecting the impact of the projection release proved statistically significant both in the final model in column (7) and in all remaining models with a single control variable (columns (2)-(6)). This finding allows us to conclude that by revealing its forecasts NBP affected the median of individual forecasts in the sense that the median of forecasts moved toward the central path of projection once the projection was released. The R2 measures for models presented in Table 3 are much lower than for the models listed in Table 2, but still statistically significant.

3.3 Dispersion of inflation forecasts

The next point of interest was to investigate whether the release of the NBP projection affects the dispersion of CPI inflation forecasts. As pointed out in Section 2, the inflation forecasts are derived for the twelve-month horizon. We formulated initially the model represented by equation (2), which contained the whole set of control variables described in Section 2.3. Then we eliminated the variables which proved to be insignificant. As in the model describing the dispersion of GDP forecasts in Section 3.1, we present two final specifications of the model: one with the interest rates volatility and one without this variable. These two specifications are complemented by models with single control variables. The results collected in Table 4 show that the variable reflecting the impact of the NBP projection release on the dispersion of inflation forecasts proved to be statistically insignificant. This outcome is robust across the models regardless of the choice of control variables. It means that by publishing its projection, NBP did not lower the dispersion of inflation forecasts formulated by professional forecasters.

However, basing ourselves on the models from Table 4, we may identify other macroeconomic factors affecting the dispersion of CPI inflation forecasts. Similar to the results achieved by Mankiw et al. (2004) for the US and Dovern et al. (2012) for the panel of G7 economies, the disagreement about future inflation depends positively on its current level and its volatility (the dependence of inflation disagreement on its volatility has also been reported by Ehrmann et al., 2012 for the set of 12 developed countries). Moreover, the dispersion of CPI forecasts falls during expansion and rises during recession – the sign of the coefficient at the variable reflecting industrial production growth is negative. This relationship between the phase of the business cycle and the disagreement on inflation has also been identified for some developed economies: for Italy, Japan and the UK by Dovern et al. (2012) and for the US by Hubert (2013). Surprisingly, despite the relatively high openness of the Polish economy, the dispersion of CPI forecasts was not affected by the volatility of the exchange rate. This result holds for both the full model, with all control variables, which proved to be statistically significant, and in the model with the volatility of the exchange rate as a single control variable. The explanation of this phenomenon may be two-fold. Having regard to the fact that the Polish currency was relatively stable in the period covered by our sample (2006-2013)[2] the first explanation is that the increase of exchange rate volatility might have been perceived by the forecasters as temporary and has not been translated into the medium-term inflation forecasts. According to the second hypothesis, the forecasters took into account that the pass-through of the changes in the exchange rate into the CPI inflation realizes to a large extent within one year, as reported by Łyziak et al. (2014). Then, when formulating the forecasts for the twelve-month horizon, they disregarded the movements of the exchange rate. On the contrary, the volatility of the oil prices which entered the initial model of dispersion proved to be statistically significant only in the model where this variable occurred as a single control variable (see Table 4, column (6)). The lack of its significance in the final models, with more than one control variable reported in columns (9) and (10), may be explained by high co-linearity with the inflation volatility, which captured to a large extent the volatility of oil prices. In general, the models for the dispersion of inflation forecasts presented in Table 4 fitted the data worse than analogous models for the dispersion of GDP forecasts displayed in Table 2.

[2]With the exception of the one-off shock depreciation in the beginning of 2009, caused by the increase of risk aversion on the global financial markets.

3.4 Median of inflation forecasts

In the last step we analyzed whether the projection published by NBP acted as an attractor for the median of individual inflation forecasts. Accordingly, we used equation (4) to check whether the median of the inflation forecasts moved toward the central path of the projection once the new projection was released. We followed the approach described in the previous sections by starting with the initial model with the whole set of control variables and eliminating successively the variables which proved statistically insignificant. We report the results in Table 5. The variable reflecting the impact of the projection release on the distance of the median of individual forecasts from the central projection paths was statistically insignificant in all the presented models. This outcome leads to the conclusion that the release of the projection did not affect the median of individual inflation forecasts in our sample.

4 Robustness check for the linear model

To strengthen the findings reported in Section 3, we conducted a robustness check in respect to the estimation method. Moreover, we investigated the stability of the results over time by varying the span of the sample.

In our basic linear models discussed in Section 3, we assumed that the dispersion of GDP and inflation forecasts formulated by the professional forecasters have been affected by several macroeconomic variables, but not by each other. Accordingly, we estimated the equation for GDP and inflation forecasts separately, assuming that the error terms in both equations are not cross-correlated. We emphasized that this approach is often used in literature (see Section 2.4) and reflects the point of view that the dispersion of GDP and inflation forecasts may co-move, but only due to the presence of common dispersion drivers when some explanatory variables in both equations are the same. However, as a robustness check we investigated whether the changes in disagreement about future GDP affected the disagreement about inflation also via the error term and vice-versa. Thus we estimated the equations for the dispersion of inflation and GDP forecasts (equations (2) and (3)) simultaneously using Zellner's seemingly unrelated regression (SUR), where the error term is allowed to be cross-correlated. We use the SUR method to estimate jointly the equations for the median of inflation and GDP forecasts as well (equations (4) and (5)). It has to be reminded from Sections 3.1 and 3.3 that when analyzing the dispersion of GDP and inflation forecasts, we accomplished the selection procedure with two alternative final models: the model with the interest rate volatility among the set of explanatory variables and the model in which this variable was initially excluded. Accordingly, while conducting the robustness check, we estimated with the SUR method two specifications of the joint dispersion model: without interest rates volatility in any of the equations (the specification for the respective equations comes from column (7) in Table 2 and column (9) in Table 4) and with this variable present in both equations (the specification has been taken from column (8) in Table 2 and column (10) in Table 4).

We report the results of this robustness check in Table 6. In columns (1) and (2) we present the first model for the disagreement on GDP and inflation forecasts without interest rates volatility. Column (1) reports the parameters estimates of the equation for GDP forecasts and column (2) reveals the equation for inflation forecasts. Respectively columns (3) and (4) contain the second model for dispersion of individual GDP and inflation forecasts with interest rates volatility among the set of explanatory variables. Finally, in columns (5)

and (6) we report the results for the model describing the change in distance between the median of individual forecasts and the central path of the projection. In general, the accounting for the cross-correlation of the error term did not affect significantly the results discussed in the Section 3. In both models explaining the disagreement about the future GDP, the variable reflecting the impact of the projection release remained statistically significant at the 10 per cent level. This variable also proved statistically significant in the model for the median of individual GDP forecasts (column (5)). The change of the estimation method did not affect the results for inflation at all. As reported in Section 3.3 and 3.4, the release of the projection by NBP affected neither the dispersion nor the median of the individual forecasts.

Finally, we investigated the stability of the relationship between the release of the NBP projection and the dispersion and median of individual forecasts over time. We estimated the models for the dispersion and median of inflation and GDP forecasts for the 4-year rolling sample. For the estimation we used the LS method with Newey – West correction as discussed in Section 3. On Figures 2a - 2f we presented the estimates of the parameters reflecting the impact of the projection release on the dispersion and the median of individual forecasts, followed by the band of +/- 2 standard errors.

We can see that the impact of the projection release on the dispersion of GDP forecasts (Figures 2b and 2d) was strengthening over time and began to be statistically significant some years after the central bank started publishing the projection. This outcome may be interpreted two-fold. Firstly, it may be evidence of the growing credibility of GDP forecasts published by NBP. However, this strengthening of the role of the NBP projection in affecting the dispersion of the individual forecasts coincided with the onset of the global financial crises. That is why the growing impact of the central bank projection on the dispersion of GDP forecasts formulated by private forecasters may be related to the increase of uncertainty about global economic activity that enhanced the coordinating effect of public information, as pointed out by Morris and Shin (2002). On the contrary, the projection acted as an attractor for the median of individual GDP forecasts only in the first half of the sample, while in the second part of the sample this relationship was weakening (Figure 2f). The impact of the projection release on both dispersion and median of individual inflation forecasts was insignificant over the whole sample (Figures 2a, 2c and 2e).

5 Non-linear model

The results discussed in Section 3.1 indicate that the dispersion of individual GDP forecasts depends on the phase of the business cycle, which stays in line with the results reported also for other economies. Accordingly, we may expect that the role of the central bank projection in affecting the dispersion of individual forecasts may be different in respect to the level of economic activity. To test this hypothesis we extended the linear model (3) on GDP disagreement and introduced asymmetry in the response of individual GDP forecasts to the release of NBP projection. We accounted for the non-linearity using the Smooth Transition Regression (STR) model which takes the following form:

$$IQR_t^{GDP} = \alpha_0^{nd,GDP} + \alpha_1^{nd,GDP} IQR_{t-1}^{GDP} + (1 - G(s_t;\gamma,c)) \cdot \delta_1^{nd,GDP} Proj_t + \\ + G(s_t;\gamma,c) \cdot \delta_2^{nd,GDP} Proj_t + \beta^{nd,GDP} X_t^{GDP} + \varepsilon_t^{nd,GDP}, \tag{6}$$

where $G(s_t;\gamma,c)$ is a transition function allowing for the non-linear relationship between the measure of disagreement among the forecasters (IQR) and the variable $Proj_t$, which stands for the projection release. We investigated two alternative transition functions usually proposed in the literature, either the logistic function:

$$G(s_t;\gamma,c) = (1 + \exp\{-\gamma(s_t - c)\})^{-1} \ \gamma > 0 \tag{7}$$

or the exponential function:

$$G(s_t;\gamma,c) = 1 - \exp\{-\gamma(s_t - c)^2\} \ \gamma > 0. \tag{8}$$

The variable s_t in (7) and (8) is called the transition variable, c is a threshold parameter, while γ is a transition parameter, which measures the speed of transition from one regime to another. The restriction $\gamma > 0$ is an identifying restriction. The STR models refer to the STAR models proposed by Granger and Teräsvirta (1993) and Teräsvirta (1994). The transition functions described by (7) and (8) are bounded between 0 and 1. It means that the parameter measuring the impact of the projection release on the disagreement among the forecasters may vary between $\delta_1^{nd,GDP}$ and $\delta_2^{nd,GDP}$ along with the transition variable s_t. The logistic function (7) tends to zero for very large negative values of the transition variable and approaches one for very large positive values. The exponential function (8) tends to unity for very large both positive and negative values of the transition variable and is close to zero for the transition variable s_t equal to the value of the threshold parameter c.

Our point of interest was to check whether the response of the dispersion of individual GDP forecasts to the NBP projection release depended on the phase of the business cycle. That is why in the role of the transition variable we used the industrial production growth (as listed in Table 1), which corresponds to the level of economic activity[3]. If the STR model with the logistic transition function (7) is true, it implies that after the release of the projection by the central bank the reduction in the dispersion of individual forecasts is different (probably smaller) in recovery than in the slowdown phase. On the other hand, the validity of the STR model with the exponential transition function (8) means that the release of the projection reduces the dispersion to different extent when the economy is either in the recovery or in the recession than when the economic growth is moderate (the industrial production growth is close to the value of the threshold parameter). Therefore both transition functions refer to different economic hypotheses.

We started our analysis with testing the presence of non-linearity in the form proposed by the model (6) against the linear model (3). We used the approach introduced by Granger and Teräsvirta (1993), where the non-linear model (6) with the logistic or exponential transition function was substituted by its appropriate Taylor series expansion around $\gamma = 0$. As suggested by Teräsvirta (2004) we used a third order Taylor series expansion for the logistic transition function and a second order Taylor series expansion for the exponential transition function. In both cases the results of the test (see Table 7) allowed us to reject the null hypothesis of linearity in favour of

[3]In fact we used the three-month average of the y-o-y industrial production growth.

non-linearity.

In the next step we selected between the STR models with logistic and exponential transition functions. We used the testing procedure developed by Escribano and Jordá (1999). We estimated first the parameters of the second order Taylor expansion of the STR model with exponential transition function, which is the auxiliary regression for this test:

$$\begin{array}{c} IQR_t^{GDP} = \alpha_0^{nd,GDP} + \alpha_1^{nd,GDP} IQR_{t-1}^{GDP} + \delta^{nd,GDP} Proj_t + \beta^{nd,GDP} X_t^{GDP} + \\ +\lambda_1 Proj_t s_t + \lambda_2 Proj_t s_t^2 + \lambda_3 Proj_t s_t^3 + \lambda_4 Proj_t s_t^4 + \varepsilon_t^{nd,GDP} \end{array}, \tag{9}$$

Then we tested two hypothesis:

$$H_{0E} : \lambda_2 = \lambda_4 = 0$$

and

$$H_{0L} : \lambda_1 = \lambda_3 = 0$$

Following Escribano and Jordá (1999) we selected the STR model with logistic (exponential) transition function if the minimum p-value is obtained for H_{0L} (H_{0E}). The p-values from this joint test are collected in the last row of Table 7. The results are clearly in favour of the exponential transition function over the logistic function.

In Table 7 we presented the estimation results for both models: with logistic and exponential transition functions. Column (1) contains the parameter estimates for the logistic- and column (2) for the exponential transition function. In the case of the STR model with the logistic transition function the estimates of the parameters related to the NBP projection are very close to each other for the regimes of both low and high economic activity (reflected by industrial production growth). The null hypothesis of the equality of both parameters cannot be rejected at any reasonable significance level. While this model was rejected by Escribano-Jorda test, we will not discuss the results in more details.

According to the selection procedure the asymmetry in the reaction of the disagreement among the forecasters to the release of the central bank projection is better fitted by the STR model with the exponential transition function. In the case of this model the parameter estimate related to the regime of moderate production growth (in the neighborhood of the threshold parameter c) is highly negative and significantly larger than for the regime of very high and very low production growth. Moreover the parameter related to the latter regime proved to be statistically insignificant. Given these results we may conclude that the role of the NBP projection in reducing the disagreement among the forecasters was more substantial in the periods when the economy moved from one phase of the business cycle to another (from the slowdown to the recovery or the opposite). The estimate of the threshold parameter indicates that the disclosure of NBP projection affected the dispersion of individual forecasts the most when the growth of industrial production was close to 4 per cent. It is worth noting that the other control variables affecting the dispersion of GDP forecasts remained in general statistically significant as in the case of the linear model.

6 Conclusions

In the paper we investigated whether by publishing its forecasts NBP affected the dispersion of individual GDP and inflation forecasts formulated by professional forecasters. Our main finding is that by revealing its own projection of future GDP growth, the central bank was reducing the dispersion of one-year-ahead individual GDP forecasts. We found that the role of central bank projection in decreasing the dispersion of the forecasts derived by professional forecasters was strengthening over time. On the one hand, it may be interpreted as evidence of increasing credibility of the central bank and its projection. However, while the second part of the sample covers the global financial crises, the growing impact of the central bank forecasts on the dispersion of GDP forecasts may be related to the increase of overall uncertainty that enhanced the coordinating effect of public information. The extension of our model to the non-linear case leads to the conclusion that the extent to which the projection release affected the dispersion of GDP forecasts varied over the business cycle. By disclosing its own projection the central bank reduced the disagreement among the forecasters the most in the periods when the economy moved from one phase of the business cycle to another.

We also identified some determinants of the dispersion among professional forecasters. In general, the cross-sectional dispersion of GDP forecasts was positively influenced by the volatility of industrial production, which may be interpreted that the dispersion was increasing around turning points of the business cycles. Moreover, the dispersion was higher during slowdowns than in recovery phases. Finally, the disagreement among forecasters grew with negative surprises when current industrial production releases differ from the forecasts. The findings show that the central bank influenced the level of GDP forecasts as well. The median of individual forecasts moved toward the central path of the projection after the projection release.

On the other hand, the release of the CPI projection by the central bank affected neither the cross-sectional dispersion nor the level (median) of forecasts formulated by professional forecasters. The dispersion of one-year-ahead CPI forecasts depended positively on the level of inflation and on its volatility. Moreover, the dispersion was higher during slowdown than during recovery. The disagreement among forecasters has been also affected by the volatility of oil prices, but proved to be resilient to exchange rate movements.

Our results showed that in the Polish economy during the last decade the coordinating effect of public information was stronger for GDP than for inflation forecasts. One of the explanations for this outcome may be that within the inflation targeting framework the very numerical inflation target may act as a nominal anchor for inflation forecasts as argued by Łyziak (2013), which is not the case for GDP forecasts. Another potential explanation is that during the global economic crisis, which covered most of our sample, the uncertainty was higher for GDP while inflation remained relatively stable, and as a consequence, private agents rather sought a focal point for the former than for the latter variable.

References

Beechey, Meredith J., Benjamin K. Johannsen, and Andrew T. Levin (2011) 'Are Long-Run Inflation Expectations Anchored More Firmly in the Euro Area Than in the United States?' *American Economic Journal: Macroeconomics* 3(2), 104–29

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

Budnik, Katarzyna, Michal Greszta, Michal Hulej, Marcin Kolasa, Karol Murawski, Michal Rot, Bartosz Rybaczyk, and Magdalena Tarnicka (2009) 'The new macroeconometric model of the Polish economy.' Technical Report

Capistrán, Carlos, and Allan Timmermann (2009) 'Disagreement and Biases in Inflation Expectations.' *Journal of Money, Credit and Banking* 41(2-3), 365–396

Capistrán, Carlos, and Manuel Ramos-Francia (2010) 'Does Inflation Targeting Affect the Dispersion of Inflation Expectations?' *Journal of Money, Credit and Banking* 42(1), 113–134

Cecchetti, Stephen G., and Craig Hakkio (2009) 'Inflation targeting and private sector forecasts.' NBER Working Papers 15424, National Bureau of Economic Research, Inc, October

D'Amico, Stefania, and Athanasios Orphanides (2008) 'Uncertainty and disagreement in economic forecasting.' Technical Report

Dincer, N. Nergiz, and Barry Eichengreen (2007) 'Central Bank Transparency: Where, Why, and with What Effects?' NBER Working Papers 13003, National Bureau of Economic Research, Inc, March

_ (2014) 'Central Bank Transparency and Independence: Updates and New Measures.' *International Journal of Central Banking* 10(1), 189–259

Dopke, Jorg, and Ulrich Fritsche (2006) 'When do forecasters disagree? An assessment of German growth and inflation forecast dispersion.' *International Journal of Forecasting* 22(1), 125–135

Dovern, Jonas, Ulrich Fritsche, and Jiri Slacalek (2012) 'Disagreement Among Forecasters in G7 Countries.' *The Review of Economics and Statistics* 94(4), 1081–1096

Ehrmann, Michael, Sylvester Eijffinger, and Marcel Fratzscher (2012) 'The Role of Central Bank Transparency for Guiding Private Sector Forecasts.' *Scandinavian Journal of Economics* 114(3), 1018–1052

Escribano, Alvaro, and Oscar Jordá (1999) 'Improved testing and specification of smooth transition regression models.' In *Nonlinear Time Series Analysis of Economic and Financial Data,* ed. Philip Rothman, vol. 1 of *Dynamic Modeling and Econometrics in Economics and Finance* (Springer US) pp. 289–319

Faust, Jon, and Eric M. Leeper (2005) 'Forecasts and inflation reports: An evaluation: Paper presented at a sveriges riksbank seminar, inflation targeting: Implementation, communication and effectiveness'

Fujiwara, Ippei (2005) 'Is the central bank's publication of economic forecasts influential?' *Economics Letters* 89(3), 255–261

Geraats, Petra M. (2009) 'Trends in Monetary Policy Transparency.' *International Finance* 12(2), 235–268

_ (2014) 'Monetary Policy Transparency.' Technical Report

Goodhart, Charles A.E. (2001) 'Monetary transmission lags and the formulation of the policy decision on interest rates.' *Review* (Jul), 165–186

Granger, Clive W. J., and Timo Teräsvirta (1993) *Modelling Non-Linear Economic Relationships* number 9780198773207. In 'OUP Catalogue.' (Oxford University Press)

Hubert, Paul (2013) 'FOMC forecasts as a focal point for private expectations.' Documents de Travail de l'OFCE 2013-12, Observatoire Francais des Conjonctures Economiques (OFCE), July

Laxton, Douglas, and Charles Freedman (2009) 'Inflation Targeting Pillars; Transparency and Accountability.' IMF Working Papers 09/262, International Monetary Fund, December

Łyziak, Tomasz (2013) 'Formation of inflation expectations by different economic agents.' *Eastern European Economics* 51(6), 5–33

Łyziak, Tomasz, Mariusz Kapuściński, Ewa Stanisławska, Jan Przystupa, Ewa Wróbel, and Anna Sznajderska (2014) 'Monetary policy transmission mechanism in Poland. What do we know in 2013?' Technical Report

Mankiw, N. Gregory, Ricardo Reis, and Justin Wolfers (2004) 'Disagreement about Inflation Expectations.' In 'NBER Macroeconomics Annual 2003, Volume 18' NBER Chapters (National Bureau of Economic Research, Inc) pp. 209–270

Mishkin, Frederic (2002) 'Inflation Targeting.' In *Encyclopedia of Macroeconomics,* ed. Howard Vane and Brian Snowdon (Editors) (Edward Elgar: Cheltenham UK) pp. 361–365

Morris, Stephen, and Hyun Song Shin (2002) 'Social Value of Public Information.' *American Economic Review* 92(5), 1521–1534

Morris, Stephen, Hyun Song Shin, and Hui Tong (2006) 'Social Value of Public Information: Morris and Shin (2002) Is Actually Pro-Transparency, Not Con: Reply.' *American Economic Review* 96(1), 453–455

NBP (1998) 'Medium-Term Strategy of Monetary Policy (1999-2003).' Technical Report, Narodowy Bank Polski

_ (2003) 'Monetary Policy Strategy beyond 2003.' Technical Report, Narodowy Bank Polski

Siklos, Pierre L. (2013) 'Sources of disagreement in inflation forecasts: An international empirical investigation.' *Journal of International Economics* 90(1), 218–231

Svensson, Lars E. O. (1997) 'Inflation forecast targeting: Implementing and monitoring inflation targets.' *European Economic Review* 41(6), 1111–1146

Svensson, Lars E. O. (2006) 'Social Value of Public Information: Comment: Morris and Shin (2002) Is Actually Pro-Transparency, Not Con.' *American Economic Review* 96(1), 448–452

Swanson, Eric T. (2006) 'Have Increases in Federal Reserve Transparency Improved Private Sector Interest Rate Forecasts?' *Journal of Money, Credit and Banking* 38(3), 791–819

Teräsvirta, Timo (1994) 'Specification, estimation, and evaluation of smooth transition autoregressive models.' *Journal of the american Statistical association* 89(425), 208–218

Teräsvirta, Timo (2004) 'Smooth transition regression modeling.' In *Applied Time Series Econometrics,* ed. H. Lütkepohl and M.Krätzig (Cambridge University Press, Cambridge UK)

Woodford, Michael (2005) 'Central-bank communication and policy effectiveness.' Technical Report

Tables and figures

Table 1: Description of the control variables.

Variable	Description
INF	CPI inflation (y-o-y).
INF_VOL	Volatility of CPI inflation.
IP	Industrial production growth (y-o-y).
IP_VOL	Volatility of industrial production growth.
OIL_VOL	Volatility of BRENT oil prices.
EX_RATE_VOL	Volatility of monthly log differences in EURPLN exchange rate.
SURP_INF	Ex post absolute error of the recent inflation forecast derived one month ahead.
SURP_IP	Ex post absolute error of the recent industrial production forecast derived one month ahead.
INT_RATE_VOL	Squared changes in logs of the NBP reference rate.

Note: The volatility of: CPI inflation, industrial production, exchange rate changes and oil prices have been calculated as conditional volatility from GARCH (1,1) model.

Table 2: Estimation results - dispersion of GDP forecasts.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dispersion of GDP forecasts (-1)	0.547***	0.506***	0.455***	0.528***	0.435***	0.483***	0.344***	0.329***
	(0.072)	(0.0680)	(0.068)	(0.069)	(0.086)	(0.081)	(0.063)	(0.084)
NBP projection	-0.078**	-0.085**	-0.078**	-0.081**	-0.071*	-0.080**	-0.081**	-0.079**
	(0.039)	(0.043)	(0.039)	(0.037)	(0.038)	(0.039)	(0.040)	(0.039)
IP_VOL		0.033*					0.026	0.025*
		(0.020)					(0.017)	(0.014)
IP			-0.011**				-0.008*	
			(0.005)				(0.005)	
SURP_IP				0.025**			0.021*	0.020*
				(0.010)			(0.011)	(0.011)
EX_RATE_VOL					4.822***		3.169*	4.780***
					(1.514)		(1.836)	(1.639)
INT_RATE_VOL						16.92*		16.36*
						(9.82)		(8.59)
Const	0.284***	0.131**	0.398***	0.244***	0.140**	0.290***	0.127**	0.001
	(0.043)	(0.099)	(0.062)	(0.043)	(0.063)	(0.048)	(0.110)	(0.087)
R2	0.31	0.36	0.38	0.35	0.37	0.39	0.45	0.48
AR (1) test	0.397	0.380	0.196	0.363	0.145	0.374	0.147	0.273

Note: The dependent variable is the dispersion of individual GDP forecasts. The detailed description of control variables: see Table 1. AR(1) is p-value of LM test. HAC standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Estimation results - median of GDP forecasts.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NBP projection	0.071*	0.074**	0.069*	0.068*	0.065*	0.076*	0.078**
	(0.038)	(0.036)	(0.037)	(0.037)	(0.037)	(0.039)	(0.034)
IP_VOL		-0.023*					-0.036***
		(0.012)					(0.011)
IP			0.005*				0.008**
			(0.003)				(0.003)
SURP_IP				0.015			0.027**
				(0.011)			(0.012)
EX_RATE_VOL					-2.288		
					(1.477)		
INT_RATE_VOL						8.253*	15.12**
						(4.301)	(5.941)
Const	-0.008	0.115	-0.035	-0.038	0.092*	-0.023	0.059
	(0.024)	0.071	(0.032)	(0.041)	(0.055)	(0.030)	(0.067)
R2	0.023	0.055	0.048	0.038	0.044	0.050	0.188
AR (1) test	0.925	0.955	0.846	0.892	0.944	0.735	0.807

Note: The dependent variable is the change in distance between the median of individual GDP forecasts and the central path of the NBP projection in months t and t-1. The detailed description of control variables: see Table 1. AR(1) is p-value of LM test. HAC standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Estimation results - dispersion of CPI inflation forecasts.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dispersion of CPI forecasts (-1)	0.377***	0.403***	0.355**	0.376***	0.260**	0.348**	0.363**	0.321***	0.239**	0.215**
	(0.136)	(0.132)	(0.136)	(0.137)	(0.122)	(0.139)	(0.140)	(0.143)	(0.097)	(0.109)
Dispersion of CPI forecasts (-2)	0.164**	0.138*	0.147*	0.154**	0.064	0.157**	0.138*	0.172**	-	-
	(0.077)	(0.076)	(0.079)	(0.075)	(0.075)	(0.076)	(0.076)	(0.065)	-	-
NBP projection	0.034	0.011	0.037	0.030	0.042	0.034	0.037	0.024	0.016	0.030
	(0.035)	(0.037)	(0.036)	(0.035)	(0.034)	(0.035)	(0.036)	(0.034)	(0.033)	(0.032)
INF_VOL		1.001*							0.913*	
		(0.547)							(0.494)	
INF			0.023*						0.019*	0.025**
			(0.013)						(0.010)	(0.010)
SURP_INF				0.110						
				(0.146)						
IP					-0.012***				-0.015***	-0.013***
					(0.003)				(0.004)	(0.004)
OIL_VOL						5.610***				
						(1.861)				
EX_RATE_VOL							1.776			
							(1.209)			
INT_RATE_VOL								14.47***		9.472**
								(2.699)		(3.909)
Const	0.202***	0.082	0.155***	0.191***	0.366***	0.182***	0.144**	0.202***	0.259***	0.335
	(0.047)	(0.087)	(0.057)	(0.050)	(0.039)	(0.046)	(0.064)	(0.051)	(0.094)	(0.054)
R2	0.23	0.24	0.24	0.23	0.31	0.25	0.24	0.30	0.38	0.39
AR (1) test	0.843	0.556	0.949	0.562	0.137	0.881	0.892	0.471	0.282	0.186

Note: The dependent variable is the dispersion of individual CPI inflation forecasts. The detailed description of control variables: see Table 1. AR(1) is p-value of LM test. HAC standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Estimation results - median of CPI inflation forecasts.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Median of CPI forecasts (-1)	-0.306***	-0.299***	-0.312***	-0.316***	-0.331***	-0.365***	-0.306***	-0.332***	-0.375***
	(0.092)	(0.090)	(0.091)	(0.089)	(0.090)	(0.082)	(0.093)	(0.083)	(0.075)
NBP projection	0.004	0.011	0.005	-0.0001	-0.0006	0.002	0.004	0.004	0.011
	(0.042)	(0.041)	(0.042)	(0.043)	(0.041)	(0.040)	(0.042)	(0.040)	(0.039)
INF_VOL		-0.409							-0.448
		(0.405)							(0.393)
INF			0.012						0.022*
			(0.011)						(0.011)
SURP_INF				0.090					
				(0.178)					
IP					0.005*				0.003
					(0.003)				(0.003)
OIL_VOL						-8.550***			-7.726***
						(2.128)			(2.348)
EX_RATE_VOL							0.350		0.080
							(0.971)		(1.155)
INT_RATE_VOL								-9.641***	
								(2.762)	
Const	0.022	-0.071	-0.012	0.009	-0.004	0.080***	0.007	0.039**	0.048
	(0.019)	(0.053)	(0.033)	(0.030)	(0.026)	(0.021)	0.042	(0.020)	(0.083)
R2	0.095	0.099	0.103	0.099	0.130	0.184	0.096	0.148	0.214
AR (1) test	0.761	0.690	0.756	0.732	0.844	0.663	0.780	0.879	0.581

Note: The dependent variable is the change in distance between the median of individual CPI inflation forecasts and the central path of the NBP projection in months t and t-1. The detailed description of control variables: see Table 1. AR(1) is p-value of LM test. HAC standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Estimation results - robustness check.

	(1)	(2)	(3)	(4)	(5)	(6)
	Model 1		Model 2		Model 3	
Dependent variable	GDP dysp	Inflation dysp	GDP dysp	Inflation dysp	GDP med	Inflation med
Dependent variable (-1)	0.337***	0.224**	0.322***	0.204**		-0.377***
	(0.090)	(0.094)	(0.086)	(0.092)		(0.095)
NBP projection	-0.081*	0.016	-0.080*	0.030	0.078*	0.004
	(0.046)	(0.043)	(0.044)	(0.040)	(0.043)	(0.036)
IP	-0.008**	-0.015***		-0.013***	0.008**	
	(0.004)	(0.003)		(0.003)	(0.003)	
IP_VOL	0.026**		0.025**		-0.036***	
	(0.013)		(0.012)		(0.013)	
SURP_IP / SURP_INF	0.019*		0.018		0.027**	
	(0.012)		(0.011)		(0.012)	
EX_RATE_VOL	3.085*		4.702***			
	(1.850)		(1.675)			
INF		0.019		0.026*		0.018
		(0.014)		(0.014)		(0.012)
INF_VOL		0.898		0.889*		
		(0.623)		(0.472)		
OIL_VOL						-9.117***
						(2.641)
INT_RATE_VOL			16.63***		0.151***	
			(4.736)		(0.051)	
Const	0.139	0.267**	0.013	0.342***	0.058	0.032
	(0.115)	(0.103)	(0.089)	(0.069)	(0.073)	(0.041)
R2	0.55	0.45	0.48	0.39	0.19	0.20
AR (1) test	0.292		0.434		0.508	

Note: The dependent variable in columns (1) - (4) is the dispersion of individual GDP or CPI inflation forecasts. The dependent variable in columns (5) - (6) is the change in distance between the median of individual GDP or CPI inflation forecasts and the central path of the NBP projection in months t and t-1.The detailed description of control variables: see Table 1. AR(1) is p-value of the Portmanteau test. SUR standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

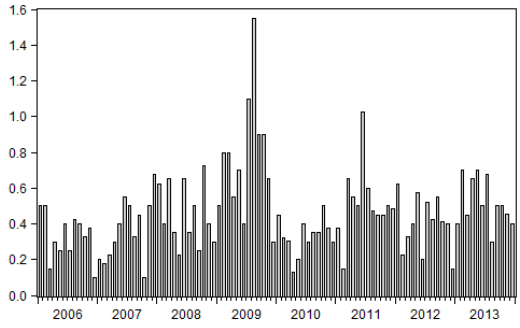
Table 7: Estimation results - non-linear models.

	(1)	(2)
	Logistic STR model	Exponential STR model
Dependent variable (-1)	0.345***	0.334***
	(0.064)	(0.064)
NBP projection - regime 1	-0.078*	-0.394***
	(0.046)	(0.062)
NBP projection - regime 2	-0.099*	-0.051
	(0.056)	(0.045)
Transition parameter (γ)	28.82	1.052***
	(1.5e+06)	(0.378)
Threshold parameter (c)	13.12	4.353***
	(2.3e+04)	(0.124)
IP	-0.008	-0.008
	(0.005)	(0.005)
IP_VOL	0.026	0.029*
	(0.017)	(0.017)
SURP_IP	0.021*	0.019*
	(0.011)	(0.010)
EX_RATE_VOL	3.140	3.624*
	(1.899)	(1.863)
Const	0.126	0.101
	(0.111)	(0.111)
R2	0.45	0.47
AR (1) test	0.125	0.170
Linearity test (pLM)	0.035	0.064
EJ test (pW)	0.253	0.020

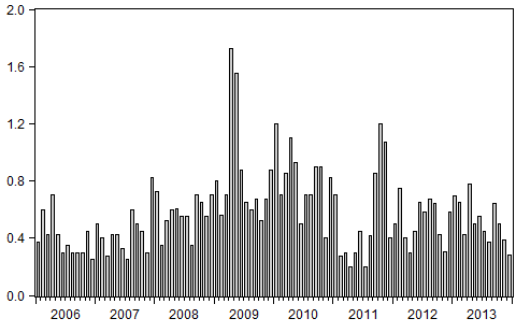
Note: The numbers in column (1) refer to STR model with logistic transition function while the numbers in column (2) refer to STR model with exponential transition function. The detailed description of control variables: see Table 1. AR(1) is p-value of LM test. HAC standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The pLM denotes p-value of LM statistic in the test of non-linearity as discussed in Section 5 (the test regressions are respectively: third order Taylor series approximation for STR model with logistic transition function and second order Taylor series approximation for STR model with exponential transition function). The pW is p-value of Wald statistic in the Escribano-Jorda test for the STR model selection (logistic against exponential).

Figure 1: Cross-sectional dispersion of individual CPI and GDP forecasts.

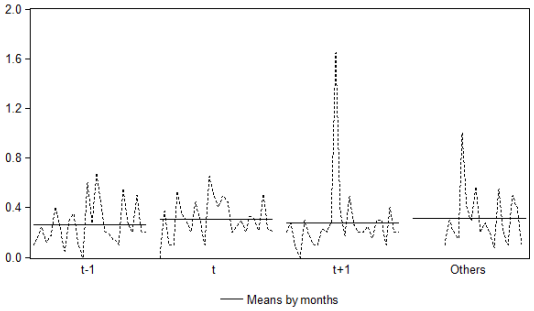
a) Dispersion of CPI inflation forecasts



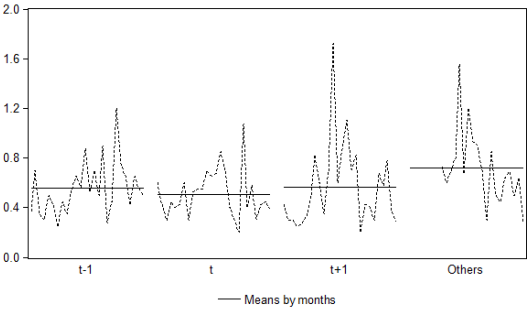
b) Dispersion of GDP forecasts



c) Dispersion of CPI inflation forecasts - means by months



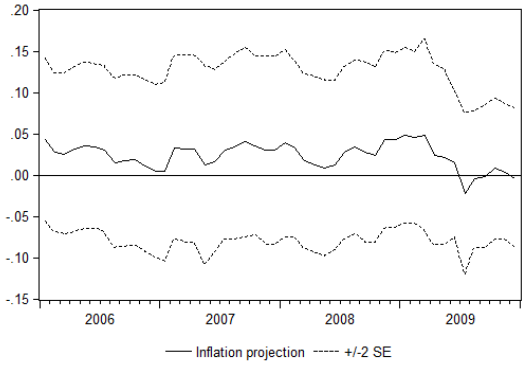
d) Dispersion of GDP forecasts - means by months



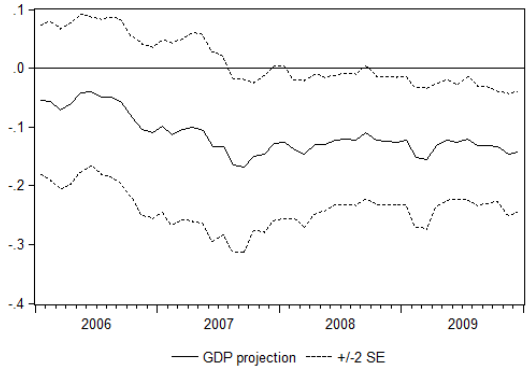
Note: Figures 1c - 1d reveal the average level of dispersion for inflation and GDP forecasts in the months when the newly released projection was accessible for the forecasters as well as in the months preceding and succeeding these dates. The last plots on both figures relate to the remaining months, while since 2008 the projection was released every four months. Source: Reuters.

Figure 2: Coefficients stability - rolling sample.

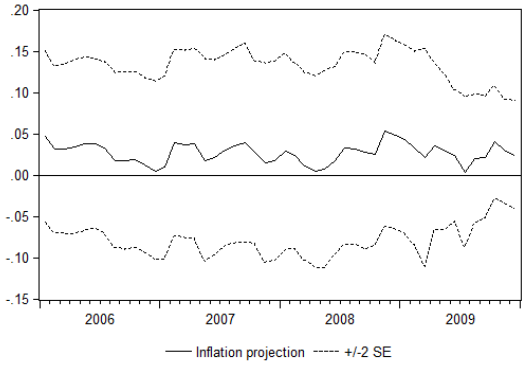
a) Dispersion of CPI inflation forecasts



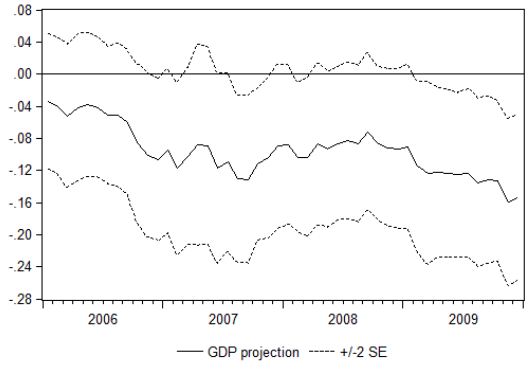
b) Dispersion of GDP forecasts



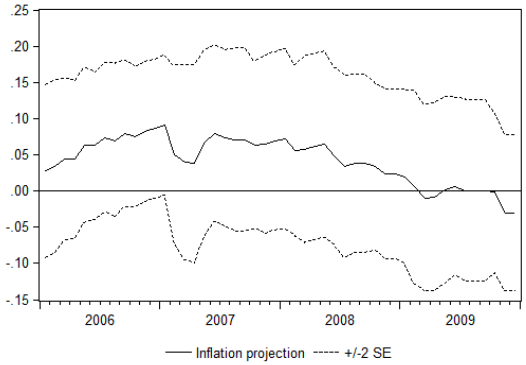
c) Dispersion of CPI inflation forecasts (incl. int. rates vol.)



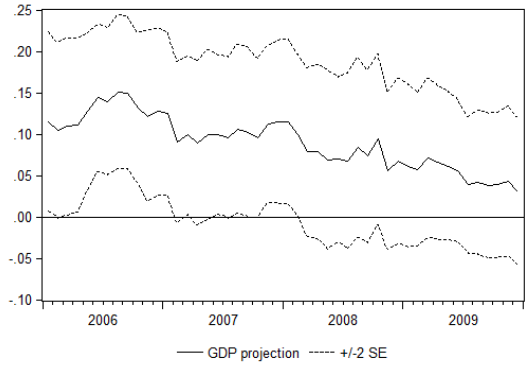
d) Dispersion of GDP forecasts (incl. int. rates vol.)



e) Median of CPI inflation forecasts



f) Median of GDP forecasts



Note: The figures display the estimates of the parameters reflecting the impact of the projection release on the dispersion or median of individual forecasts followed by the band of +/- 2 standard errors calculated for the 4-year rolling sample. On the horizontal axis we set the starting date of the rolling sample. The figures 2a - 2b refer to the models for the dispersion without interet rates volatility in the initial set of the control variables (column (9) in Table 4 and column (7) in Table 2), while the figures 2c - 2d refer to the dispersion models with interest rates volatility (column (10) in Table 4 and column (8) in Table 2). The figures 1e - 1f are related to the models for the median presented in column (9) in Table 5 and column (7) in Table 3 respectivelly. Source: Reuters.