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Do Central Bank Forecasts Matter for Professional Forecasters?

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Abstract
This paper examines the extent to which the information provided by a central bank affects the forecasts formulated by professional forecasters. We empirically investigate whether the disclosure of GDP and inflation forecasts by the Narodowy Bank Polski reduces disagreement in professional forecasters' expectations. The results only partially support the hypothesis existing in the literature on the coordinating role of the central bank. The main finding is that by publishing its projection of future GDP growth, the central bank reduces the dispersion of one-year-ahead GDP forecasts. Our study indicates that the role of the central bank in reducing the forecasts' dispersion strengthens over time. Using non-linear models, we also find that the extent to which the projection release affects the dispersion of GDP forecasts varies over the business cycle. On the contrary, the release of CPI projections affects neither the cross-sectional dispersion nor the level of forecasts formulated by professional forecasters.

1. Introduction

Since the beginning of the 1990s, several central banks have followed the Reserve Bank of New Zealand in adopting an inflation targeting (IT) strategy, which assumes that the central bank announces the numerical target for inflation and tends to bring inflation to the target in the medium term, explaining the plans, objectives and decisions of policymakers to the public (Mishkin, 2002). Therefore, implementation of the inflation targeting scheme was followed by increasing transparency of the monetary authorities. Blinder *et al.* (2008) point out that enhancing transparency may help the central bank to achieve its goals, mainly by influencing the financial markets and increasing the predictability of its decisions. Central banks aim to explain their decisions by publishing inflation reports, communiqués after decisions on interest rates and the minutes of meetings.[1] One of the most influential communication instruments used by central banks is the projection of future inflation and other key macroeconomic variables.

As raised 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. Therefore, revealing the outlook for the future macroeconomic situation may play a crucial role in explaining the motivation for the current decisions on monetary policy and, furthermore, may influence the inflation expectations of private agents (Woodford, 2005). Brzoza-Brzezina *et al.* (2013) empirically investigate whether central banks, which publish the projections, took the projection results into account when deciding on their own interest rates. They

[1] Horvath and Karas (2013) analyze the communication strategy of the Czech National Bank (CNB) and find written communication more effective than oral communication.

find that the monetary authorities react to the deviation of expected inflation from the target; however, the policy horizon differs across the banks.

The disclosure of macroeconomic forecasts and therefore influence on the private agents' expectations may also shorten the lags in the monetary policy transmission mechanism. Moreover, by publishing internal forecasts, the central bank may enhance its reputation and credibility, which results in the reduction of the inflation bias (Geraats, 2005).

In our paper we focus on the effectiveness of the projection as a communication tool with respect to private sector expectations. In particular, we are going to establish the extent to which the projection published by the Narodowy Bank Polski (NBP) affects the coordination of forecasts formulated by professional forecasters. We investigate empirically whether disclosure of GDP and inflation forecasts by the NBP in the period 2006–2013 could have lowered the cross-sectional dispersion of professional forecasters' expectations.

We find that by publishing its own projection of future GDP growth, the Narodowy Bank Polski reduces the dispersion of one-year-ahead GDP forecasts. Our study also indicates that the role of the projection release in decreasing the dispersion of GDP forecasts, while generally strengthening over time, varies over the business cycle. By disclosing its own projection, the central bank reduces disagreement among forecasters most significantly in the periods when the economy moves from one phase of the business cycle to another. Moreover, our results show that the central bank influences the level of GDP forecasts as well, while the release of CPI projections by the central bank affects neither the cross-sectional dispersion nor the level (median) of forecasts formulated by professional forecasters.

We also identify some determinants of dispersion among forecasters. In general, the cross-sectional dispersion of GDP forecasts is positively influenced by the volatility of industrial production growth and increases around turning points of the business cycle. Moreover, the dispersion is higher during slowdowns than in recoveries. Finally, disagreement among forecasters grows with negative surprises when industrial production figures differ from the forecasts. The dispersion of one-year-ahead CPI forecasts depends positively on the level of inflation and its volatility and on the phase of the business cycle. Disagreement among forecasters is also affected by the volatility of oil prices, but proves to be resilient to exchange rate movements.

The rest of the paper is organized as follows: Section 2 roots the article in the existing literature. Section 3 describes the model and data we use. In Section 4 we present the empirical results for the linear model, followed by the robustness check in Section 5. In Section 6 we extend our analysis by allowing for asymmetry in the reaction of the individual forecasts to the projection release. Section 7 concludes the paper.

2. Literature Review

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

The first strand reflects the recent trends in central banking in the 1990s and 2000s: enhanced transparency of monetary authorities and the adoption of inflation targeting schemes by many central banks. As argued by Dincer and Eichengreen (2007, 2014), since the second half of the 1990s a large number of central banks have increased their transparency. Transparency is perceived as a precondition of a successful IT strategy (Svensson, 1997; Laxton and Freedman, 2009), but the tendency to enhance transparency was evident not only among the banks which adopted the IT framework, but also among other central banks (Geraats, 2009).

While the literature related to the impact of monetary policy transparency on the macroeconomic outcome is very comprehensive (for a review, see Geraats, 2014), some authors focus more specifically on the issue of how increased transparency affects disagreement among private forecasters. Swanson (2006) shows that the increased transparency of the Federal Open Market Committee (FOMC) since the late 1980s resulted in higher precision of private sector forecasts of US interest rates in terms of both accuracy and dispersion. Ehrmann *et al.* (2012) focus on the relationship between the level of transparency of the central bank and the dispersion of the forecasts of key macroeconomic variables formulated by both professional forecasters and households. They analyze data for 12 developed countries and conclude that the increase of transparency diminishes the dispersion of forecasts derived by professional forecasters but not by households. They also find 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 contrary, Siklos (2013) analyzes a broader set of data containing professional, private and public forecasts as well as different survey-based expectations and finds that for a panel of nine developed economies, an increase of the central banks' transparency leads to an increase of disagreement about future inflation.

Ehrmann *et al.* (2012) point out the benefits of enhancing the transparency of monetary policy and argue that the release of the forecasts by central banks may be beneficial for the public for at least two reasons: it may decrease the noise-to-signal ratio (as in the model proposed by Woodford, 2001) and reduce the cost of collecting information (see Mankiw and Reis, 2002). It is worth noting that in their theoretical paper Morris and Shin (2002) (see also Morris *et al.*, 2006) show that the coordinating effect caused by public information may pose the risk of making the economy more exposed to common forecast errors. However, Svenssion (2006) points out that the result obtained by Morris and Shin is a theoretical one and holds only if the public institution makes errors eight times larger than those of the private sector.

When analyzing the role of the central bank in affecting disagreement among forecasters, some authors investigate the impact of implementation of an inflation targeting strategy on private sector forecasts. Cecchetti and Hakkio (2009) test for a panel of 15 countries whether the adoption of a direct inflation strategy reduces the dispersion of inflation forecasts formulated by professional forecasters and conclude that the effect is negligible. This outcome has been confirmed to some extent by Capistrán and Ramos-Francia (2010), who for a group of 25 countries find that the adoption of a direct inflation strategy has been successful in lowering the dispersion of inflation forecasts only for emerging economies.

There are fewer works focused specifically on the impact of disclosing quantitative projection of key macroeconomic variables on the dispersion of individual forecasts of the private sector. Fujiwara (2005) tests whether the forecasts revealed by the Bank of Japan affect the forecasts formulated by professional forecasters and *vice versa*, and shows that while the Bank of Japan by publishing its forecasts influences the forecasts of inflation derived by professional forecasters, the opposite causality does not hold. Hubert (2014) investigates to what extent the FOMC projection influences the dispersion of the forecasts derived by profes-sional forecasters and finds that by disclosing its projection the FOMC negatively impacts the dispersion of short-term inflation forecasts—for the current year—while the dispersion of forecasts for the longer horizon (next year) and for GDP forecasts remains unaffected. Filáček and Saxa (2012) analyze the impact of the projection published by the Czech National Bank (CNB) with an endogenous interest rate and exchange rate on the disagreement among the forecasts formulated by economists in the financial sector. They conclude that the forecasters coordinate their forecasts of inflation and interest rates once the projection is released. Conversely, the GDP and exchange rate forecasts remain broadly unaffected. They also find that enhance-ment of the communication framework by the CNB generally reduced the dispersion of forecasts in the financial sector.

The second strand of literature, which we follow in our paper, focuses on the causes of disagreement among forecasters. While this topic is very broad, we refer only to the macroeconomic determinants of the dispersion of forecasts formulated by professional forecasters. This issue has already been raised by several authors. Mankiw *et al.* (2004) analyze the factors which affect the dispersion of inflation forecasts for the US economy and conclude that disagreement among forecasters is positively related to the level and volatility of inflation. D'Amico and Orphanides (2008), using SPF data, find that the dispersion of US inflation forecasts is positively correlated with the expected level of inflation. A similar data set is analyzed by Capistrán and Timmermann (2009), who provide an explanation for the shift in the US inflation forecasts' bias at the beginning of the 1980s and also confirm that higher current inflation and its volatility result in higher dispersion of inflation forecasts. A comprehensive analysis conducted by Dovern *et al.* (2012) for the G7 countries show that the dispersion of forecasts of real variables depends on the phase of the business cycle—it intensifies during a recession. Hence disagreement about inflation rises along with its level and volatility and depends on the institutional setting of the central bank. The general conclusion from the literature is that disagreement about inflation depends positively on its level and volatility. Moreover, disagreement about real variables and about inflation is higher during recessions than during expansions.[2]

Most of the research devoted to both the role of the central bank in influencing the dispersion of forecasts and the macroeconomic determinants of such dispersion relates to developed and usually large economies. Much less attention has been paid to the role of central banks' projections in small open, emerging economies

[2] The similar findings stem from the research on the role of the central banks in affecting the forecasts' dispersion discussed previously in this section, where several control variables potentially affecting the dispersion are also considered.

with a short history of low inflation, which are more prone to external shocks. In such an economy the role of the central bank in affecting the forecasts of professional forecasters may be different than in developed countries. We would like to fill this gap with our analysis.

3. Data and Model

3.1 NBP Forecasts

In the 1990s, the Narodowy Bank Polski conducted a disinflation process, using monetary growth as an intermediate target and conducting a crawling devaluation of the Polish złoty *vis-à-vis* the basket of currencies within the band for exchange rate fluctuations. In 1999, the NBP adopted the inflation targeting strategy with the target expressed in the CPI term (NBP, 1998, 2003). Enhancing the communication framework, the NBP started publishing the projection of key macroeconomic variables, including future CPI inflation and GDP growth. The first inflation forecast was released in September 2004, while the first GDP forecast was released in June 2005. Initially the bank disclosed only inflation and GDP forecasts, while in the meantime the forecast release was extended by a broader set of key macroeconomic variables. The projection is owned by the staff and the forecasts are derived using the (N)ECMOD macroeconometric model (see Budnik *et al.*, 2009) under the assumption of constant interest rates.[3] The forecasts cover the current and two subsequent years, which results in a varying length of the forecast horizon: from nine to 12 quarters. The GDP and inflation forecasts are published in the form of a fanchart with a central path.

We start our sample at the beginning of 2006. In the years 2006–2007, the NBP projection was prepared four times a year and always released in the last week of the following months: January, May, August and November.[4] While the forecasts of professional forecasters used in our research were collected monthly up to the 10th of every month (see Section 3.2), the newly released projection might have poten-

[3] The assumption of constant interest rates over the whole projection horizon is probably not the most likely scenario and may potentially reduce the usefulness of the projection for the private sector forecasts, in particular in the periods of tightening or loosening of monetary policy. However, we believe that in our case the loss in information content due to this counterfactual assumption is negligible for at least two reasons. Firstly, as pointed out by Budnik *et al.* (2009), due to lags in the transmission mechanism, the maximum effect of change in the interest rate on inflation and GDP occurs after six to eight quarters while the horizon of the private sector forecasts studied in our research is shorter and accounts for one year only (see Section 3.2). Secondly, the impulse responses from the successive updates of the (N)ECMOD model, which is used for the derivation of the projection, are regularly disclosed to the public and broadly discussed, which enables the private forecasters to correct the projection derived using the assumption of constant interest rates with the expected change in the interest rate path. However, as a robustness check we investigated whether the role of the NBP projection in affecting the private sector forecasts is different in the months when the central bank changes the interest rates, thus making the projection potentially less useful, versus the months when the interest rates remain unchanged. The results do not support the hypothesis that the projection is less influential in the months when disclosure of the projection was followed by a change in monetary policy. The respective test statistics are available from the author upon request.

[4] The forecast is disclosed in two steps. In the communiqué 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 would be sufficient to affect the forecasts of these two variables formulated by professional forecasters. Therefore, we associate the date of the NBP projection release with the date of the MPC meeting when inflation and GDP forecasts are published, rather than with the date of dissemination of the full projection.

tially 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, the NBP published its forecasts in February, June and October. While, as in the previous years, the forecasts were 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. In 2011, the MPC meeting was moved permanently one week ahead: from the last week of the month to the first week of the following month. Thus the date of release of the projection moved one week forward as well. However, while the forecasts are collected by the 10th of every month despite changing the schedule of the meetings, the recent NBP forecast was accessible for analysts in the course of preparing their own forecasts in the same months as previously: March, July and November.

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

3.2 Forecasts of Professional Forecasters

The forecasts of professional forecasters used in our research come from polls conducted monthly by Reuters among economists from commercial banks and other financial institutions. In the period covered by our sample (2006–2013), the number of economists surveyed by Reuters ranges from 10 to 25. The respondents are asked for several short- and medium-term CPI inflation and GDP forecasts. As the forecast variables we choose the year-over-year CPI inflation predicted twelve months ahead and year-over-year quarterly GDP growth four quarters ahead. Both variables are fixed-horizon forecasts.

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 choose the interquartile range (3rd quartile minus 1st quartile of individual forecasts), which is more robust than the standard deviation to the presence of outliers. The advantage of the interquartile range over the standard deviation may be particularly important in the face of a relatively small number of respondents in some years.

However, an additional point of interest may be whether the projection published by the central bank acts as an attractor for the median of individual forecasts. Thus, we also check whether the median of forecasts formulated by professional forecasters moves toward the central path of projection after the new projection release. To test this hypothesis, we use the measure proposed by Hubert (2014), which expresses the difference of distances between the median of individual forecasts and the central path of the projection in consecutive months. This measure is constructed as follows:

$$\Delta Med_t^i = \left| Med_{t-1}^i - Proj_t^i \right| - \left| Med_t^i - Proj_t^i \right| \quad (1)$$

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 the expectations of professional forecasters rather than *vice versa*, the proposed measure matches the median of individual forecasts in period $t-1$ with the projection valid in period t.

3.3 Macroeconomic Controls

The literature on disagreement between forecasters (see Section 2) 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 take these macroeconomic factors into account as control variables.

We believe that, as in advanced economies, in the Polish economy disagreement on inflation forecasts may be correlated with level (INF) and volatility (INF VOL) of inflation, as raised by many 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 derive the volatility of inflation as the conditional variance from the GARCH(1,1) model with two lags to remove the autocorrelation. The next potential control variable is industrial production growth (IP), which may represent the phase of the business cycle. As pointed out by Dovern *et al.* (2012), the dispersion of inflation forecasts during a recession may be higher than during an expansion. Furthermore, taking into consideration the relatively large share of the energy component in the CPI basket, we account for the volatility of the BRENT oil prices (OIL VOL). Because Poland is a small open economy, we also include the volatility of the exchange rate (the Polish złoty against the euro—EX RATE VOL). Subsequently, following several authors (Dovern *et al.*, 2012; Hubert, 2014) we include the volatility of the interest rates (INT RATE VOL) in the model, which stands for the overall uncertainty of the monetary policy. Finally, we add 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 the current inflation may influence the dispersion of longer-term forecasts.

With respect to the dispersion of GDP forecasts, we account for industrial production growth (IP) reflecting the phase of the business cycle. Furthermore, we may expect that disagreement on GDP growth may be potentially higher around the turning points of the business cycle. For that reason, we complement the set of the control variables with the volatility of industrial production growth (IP VOL), which tends to rise as the economy approaches turning points. Similarly, as in the case of inflation, we also add exchange rate volatility (EX RATE VOL) and interest rate volatility (INT RATE VOL). Finally, as the surprise variable in the model explaining GDP disagreement we include the absolute forecasts error of the last monthly industrial production growth (SURP IP) known at the moment of formu-

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 is calculated as conditional volatility from the GARCH (1,1) model.

lation of the forecasts. It is worth noting that some control variables are 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 employ the same control variables as in case of dispersion. A detailed description of the control variables is contained in *Table 1*.

3.4 Model and Estimation Method

In our research we use single equation models estimated separately for inflation and GDP forecasts. In this section we discuss the linear models. However, in Section 6 we extend our analysis, allowing for the non-linearity of the reaction of forecasters to the projection release. The models relate the dispersion of, respectively, inflation or GDP forecasts formulated by professional forecasters to the variable expressing the impact of the NBP projection release (see Section 3.1) as well as other control macroeconomic variables affecting the overall dispersion (see Section 3.3). More specifically, the equation for dispersion of inflation or GDP forecasts can be written as follows:

$$IQR_t^{(i)} = \alpha_0 + \sum_{k=1}^{K} \alpha_k IQR_{t-k}^{(i)} + \delta Proj_t + \beta X_t^{(i)} + \varepsilon_t \qquad (2)$$

where $IQR_t^{(i)}$ is a dispersion measure (defined as an interquartile range) for individual inflation or GDP forecasts (i = CPI or GDP), $Proj_t$ 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 $X_t^{(i)}$ is a vector of control variables for inflation or GDP forecasts. We also add some lags of dependent variables in equation (2), which are set empirically to account for the persistence of forecast dispersion and for removing the autocorrelation.

We estimate the parameters of (2) specified for inflation and GDP forecasts separately using the LS method with the 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, 2014) and reflects the assumption that the common sources of disagreement for both stem from the control variables only. In other words, disagreement on inflation may be correlated with disagreement on future GDP growth, but only via common control variables. We follow this approach, but as a robustness check we estimate the parameters of both equations jointly, allowing for potential cross-correlation of error terms from both equations (see Section 5).

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

$$\Delta Med_t^{(i)} = \alpha_0 + \sum_{k=1}^{K} \alpha_k \Delta Med_{t-k}^{(i)} + \delta Proj_t + \beta X_t^{(i)} + \varepsilon_t \tag{3}$$

where $\Delta Med_t^{(i)}$ is a measure of the change in the distance defined by (1), while the explanatory variables are the same as in (2). Accordingly, we estimate both equations for the median separately using the LS method with the Newey-West correction.

4. Estimation Results

4.1 Dispersion of GDP Forecasts

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

We estimated the parameters of model (2), which explains the dispersion of one-year-ahead GDP forecasts. In addition to the variable reflecting the NBP projection release, we used the control variables listed in Section 3.3 (see *Table 1* for details) in the model. Following the "from general to specific" strategy, we initially estimated the model with the whole set of the control variables, successively eliminating the statistically insignificant ones. The estimation results are collected in *Table 2*.

While the variable expressing interest rate volatility is a proxy for the overall volatility in the economy, the inclusion of this variable in the model may result in some sort of co-linearity with other control variables. Therefore, we present two final models: the model which best fits the data (the model with the highest adjusted R^2) and the "second best" model selected with the initial set of control variables which excluded interest rate volatility from the beginning. Additionally, in *Table 2* we also present the results for the models where the control variables are included individually. From the theoretical point of view, if the full models in columns (7) and (8) are true, then the models which contain only a single control variable 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. After the selection procedure, we remain with two competitive models shown in columns (7) and (8). The final model in column (7) contains the following

Table 2 Estimation Results—Dispersion of GDP Forecasts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dispersion of GDP forecasts (-1)	0.547*** (0.072)	0.506*** (0.0680)	0.455*** (0.068)	0.528*** (0.069)	0.435*** (0.086)	0.483*** (0.081)	0.344*** (0.063)	0.329*** (0.084)
NBP projection	-0.078** (0.039)	-0.085** (0.043)	-0.078** 0.039)	-0.081** (0.037)	-0.071* (0.038)	-0.080** (0.039)	-0.081** (0.040)	-0.079** (0.039)
IP VOL		0.033* (0.020)					0.026 (0.017)	0.025* (0.014)
IP			-0.011** (0.005)				-0.008* (0.005)	
SURP IP				0.025** (0.010)			0.021* (0.011)	0.020* (0.011)
EX RATE VOL					4.822*** (1.514)		3.169* (1.836)	4.780*** (1.639)
INT RATE VOL						16.92* (9.82)		16.36* (8.59)
Const	0.284*** (0.043)	0.131** (0.099)	0.398*** (0.062)	0.244*** (0.043)	0.140** (0.063)	0.290*** (0.048)	0.127** (0.110)	0.001 (0.087)
R^2	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

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

control variables: growth of industrial production and its volatility, the surprise variable (absolute error of the industrial production forecast one month ahead) and volatility of the exchange rate. In the second competitive model (with interest rate volatility) presented in column (8), the industrial production growth proves to be statistically insignificant.

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 proves statistically significant at the 10% 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 the NBP decreases the dispersion of individual GDP forecasts formulated by professional forecasters by 0.079–0.081, which represents approximately 14% of the overall dispersion.

The results from *Table 2* show that the dispersion of the GDP forecasts is also positively affected by the volatility of industrial production growth, which may be explained in two ways. Firstly, it may reflect the fact that the stage of difficulties in forecasting the real variables rises with their volatility (Ehrmann *et al.*, 2012). Secondly, while the volatility of industrial production growth usually tends to increase around the turning points of the business cycle, this positive relationship means that disagreement about future GDP growth is greater when the economy approaches the next phase of the cycle.

Moreover, we observe the negative relationship between the dispersion of GDP forecasts and the pace of growth of industrial production,[5] which may imply

[5] However, in the model presented in column (8) the industrial production growth proves to be statistically insignificant, which is likely due to high co-linearity with interest rates volatility.

Table 3 Estimation Results—Median of GDP Forecasts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NBP projection	0.071* (0.038)	0.074** (0.036)	0.069* (0.037)	0.068* (0.037)	0.065* (0.037)	0.076* (0.039)	0.078** (0.034)
IP VOL		-0.023* (0.012)					-0.036*** (0.011)
IP			0.005* (0.003)				0.008** (0.003)
SURP IP				0.015 (0.011)			0.027** (0.012)
EX RATE VOL					-2.288 (1.477)		
INT RATE VOL						8.253* (4.301)	15.12** (5.941)
Const	-0.008 (0.024)	0.115 0.071	-0.035 (0.032)	-0.038 (0.041)	0.092* (0.055)	-0.023 (0.030)	0.059 (0.067)
R^2	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

Notes: 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. For a detailed description of the control variables, see *Table 1*. AR(1) test is the p-value of the LM test for autocorrelation. HAC standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

that the dispersion of individual forecasts is lower during expansions than recessions—a result confirmed by Döpke and Fritsche (2006) for Germany and by Dovern *et al.* (2012) for the panel of G7 countries. Disagreement about future GDP growth is also positively influenced by the volatility of the exchange rate. Finally, the dispersion of one-year-ahead GDP forecasts rises when forecasters fail to predict the current industrial production data.

It is worth noting that all models presented in *Table 2* fit the data quite well. The difference between R^2, calculated for the final model in column (8) and the model with the only autoregressive component (not reported here), amounts to 0.177 and, according to F test, proves statistically significant.

4.2 Median of GDP Forecasts

While we find that the release of the NBP projection affects the dispersion of GDP growth forecasts formulated by professional forecasters, we also investigated whether the projection acts as a focal point for the median of individual forecasts. We tested this hypothesis using equation (3) with the same initial set of control variables as in the case of dispersion in Section 4.1. In *Table 3* we present the results for the final model and for the models with single control variables as well. The results show that the variable reflecting the impact of the projection release proves 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, the NBP affects the median of individual forecasts in the sense that the median of forecasts moves toward the central path of projection once the projection is released.

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*** (0.136)	0.403*** (0.132)	0.355** (0.136)	0.376*** (0.137)	0.260** (0.122)	0.348** (0.139)	0.363** (0.140)	0.321*** (0.143)	0.239** (0.097)	0.215** (0.109)
Dispersion of CPI forecasts (-2)	0.164** (0.077)	0.138* (0.076)	0.147* (0.079)	0.154** (0.075)	0.064 (0.075)	0.157** (0.076)	0.138* (0.076)	0.172** (0.065)		
NBP projection	0.034 (0.035)	0.011 (0.037)	0.037 (0.036)	0.030 (0.035)	0.042 (0.034)	0.034 (0.035)	0.037 (0.036)	0.024 (0.034)	0.016 (0.033)	0.030 (0.032)
INF VOL		1.001* (0.547)							0.913* (0.494)	
INF			0.023* (0.013)						0.019* (0.010)	0.025** (0.010)
SURP INF				0.110 (0.146)						
IP					-0.012*** (0.003)				-0.015*** (0.004)	-0.013*** (0.004)
OIL VOL						5.610*** (1.861)				
EX RATE VOL							1.776 (1.209)			
INT RATE VOL								14.47*** (2.699)		9.472** (3.909)
Const	0.202*** (0.047)	0.082 (0.087)	0.155*** (0.057)	0.191*** (0.050)	0.366*** (0.039)	0.182*** (0.046)	0.144** (0.064)	0.202*** (0.051)	0.259*** (0.094)	0.335 (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

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

4.3 Dispersion of Inflation Forecasts

Another point of interest was whether the release of the NBP projection affects the dispersion of CPI inflation forecasts. As pointed out in Section 3.2, the inflation forecasts are derived for a twelve-month horizon. We initially formulated the model represented by equation (2), which contains the whole set of control variables described in Section 3.3. Then we eliminated the variables that proved to be insignificant. As in the model describing the dispersion of GDP forecasts in Section 4.1, we present two final specifications of the model: one with interest rate 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 proves 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, the NBP does not reduce the dispersion of inflation forecasts formulated by professional forecasters.

However, from the models presented in *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, disagreement about future inflation depends positively on its current level and volatility (the dependence of inflation disagreement on inflation volatility is also reported by Ehrmann *et al.*, 2012, for the set of 12 developed countries). Moreover, the dispersion of CPI forecasts diminishes during expansions and rises during recessions—the sign of the coefficient at the variable reflecting industrial production growth is negative. This relationship between the phase of the business cycle and disagreement on inflation is also identified for some developed economies: Italy, Japan and the UK by Dovern *et al.* (2012) and for the US by Hubert (2014).

Surprisingly, despite the relatively high degree of openness of the Polish economy, the dispersion of CPI forecasts is not affected by the volatility of the exchange rate. This result holds both for the full model with all control variables and the model with the volatility of the exchange rate as a single control variable. There may be two explanations of this phenomenon. Taking into consideration the fact that the Polish currency was relatively stable in the period covered by our sample (2006–2013)[6], the first explanation is that the increase of exchange rate volatility may be perceived by forecasters as temporary and thus does not translate into the medium-term inflation forecasts. According to the second hypothesis, forecasters take into account that the pass-through of the exchange rate movements into the CPI inflation materializes mainly within one year, as reported by Łyziak *et al.* (2014). Thus, when formulating the forecasts for the twelve-month horizon, they disregard the movements of the exchange rate. Conversely, the volatility of oil prices, which enter the initial model of dispersion, proves to be statistically significant only in the model where this variable occurs 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

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

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*** (0.092)	-0.299*** (0.090)	-0.312*** (0.091)	-0.316*** (0.089)	-0.331*** (0.090)	-0.365*** (0.082)	-0.306*** (0.093)	-0.332*** (0.083)	-0.375*** (0.075)
NBP projection	0.004 (0.042)	0.011 (0.041)	0.005 (0.042)	-0.0001 (0.043)	-0.0006 (0.041)	0.002 (0.040)	0.004 (0.042)	0.004 (0.040)	0.011 (0.039)
INF VOL		-0.409 (0.405)							-0.448 (0.393)
INF			0.012 (0.011)						0.022* (0.011)
SURP INF				0.090 (0.178)					
IP					0.005* (0.003)				0.003 (0.003)
OIL VOL						-8.550*** (2.128)			-7.726*** (2.348)
EX RATE VOL							0.350 (0.971)		0.080 (1.155)
INT RATE VOL								-9.641*** (2.762)	
Const	0.022 (0.019)	-0.071 (0.053)	-0.012 (0.033)	0.009 (0.030)	-0.004 (0.026)	0.080*** (0.021)	0.007 0.042	0.039** (0.020)	0.048 (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

Notes: 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. For a detailed description of the control variables, see *Table 1*. AR(1) test is the p-value of the LM test for autocorrelation. HAC standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

inflation volatility, which, to a large extent, captures the volatility of oil prices. In general, the models for the dispersion of inflation forecasts presented in *Table 4* do not fit the data as well as the analogous models for the dispersion of GDP forecasts displayed in *Table 2*.

4.4 Median of Inflation Forecasts

In the next step, we analyze whether the projection published by the NBP acts as an attractor for the median of individual inflation forecasts. Accordingly, we use equation (3) to check whether the median of the inflation forecasts moves toward the central path of the projection once the new projection is released. Thus, the variable reflecting the impact of the projection release on the distance of the median of individual forecasts from the central projection path is statistically insignificant in all the presented models (see *Table 5*). This outcome leads to the conclusion that the release of the projection affects neither the dispersion nor the median of the individual inflation forecasts in our sample. Thus, the interpretation is not straightforward. Firstly, within the inflation targeting framework professional forecasters may use the very numerical inflation target as a nominal anchor for inflation forecasts as argued by Łyziak (2013). Secondly, in the period of global economic crisis, which encompasses most of our sample, the forecasters may have attributed higher uncertainty to GDP forecasts than inflation and as a consequence they sought a focal point for the former rather than for the latter variable.

5. Robustness Check for the Linear Model

To strengthen the findings reported in Section 4, we conducted a robustness check with 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 4, we assume that the dispersions of GDP and inflation forecasts formulated by professional forecasters are affected by several macroeconomic variables, but do not affect each other. Accordingly, we estimated the equations for GDP and inflation forecasts separately, assuming that the error terms in both equations are not cross-correlated. As argued in Section 3.4, this approach is often used in the literature and reflects the assumption that the dispersions 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.

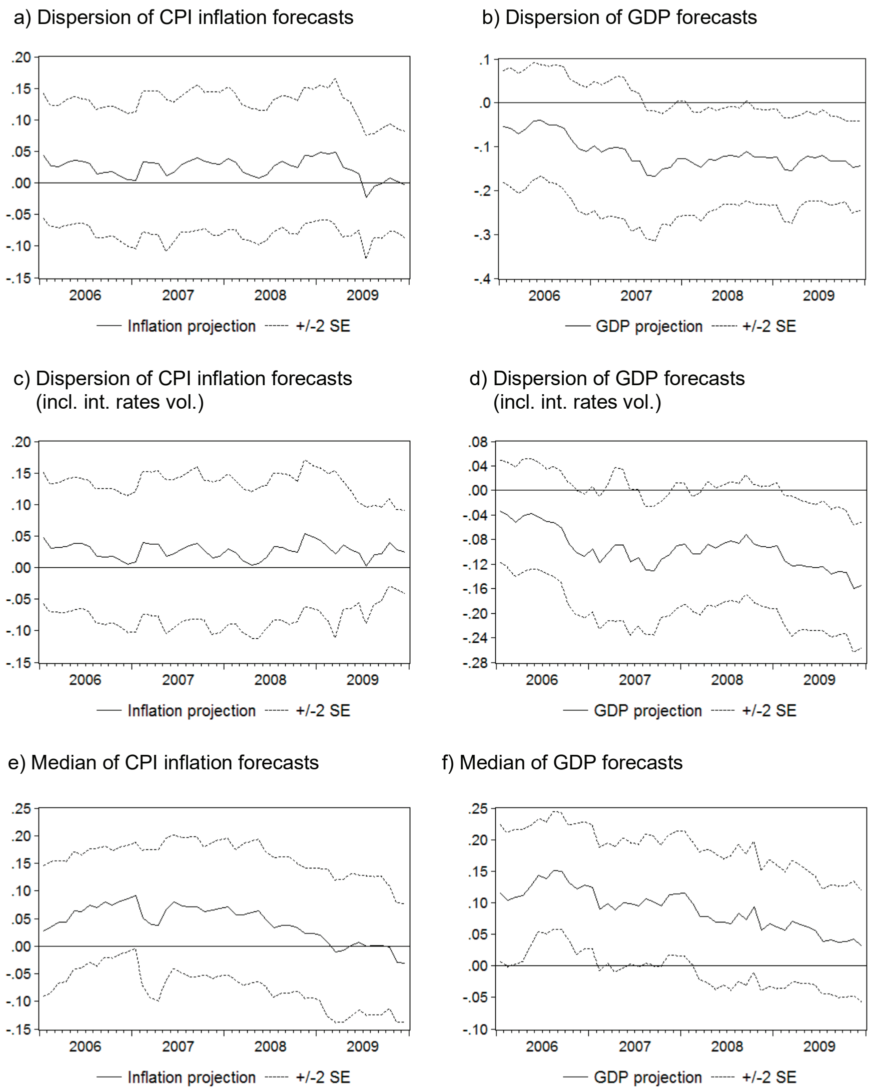
However, as a robustness check we investigated whether the changes in disagreement about future GDP growth affect disagreement about inflation also *via* the error term and *vice versa*. Therefore, we estimated the equations for the dispersion of inflation and GDP forecasts simultaneously using Zellner's seemingly unrelated regression (SUR), where the error term is allowed to be cross-correlated. We also used the SUR method to estimate the equations for the median of inflation and GDP forecasts jointly. In general, accounting for the cross-correlation of the error term does not significantly affect the results discussed in Section 4. In both models explaining disagreement about future GDP growth (with and without interest rate volatility), the variable reflecting the impact of the projection release remains statistically significant at the 10% level.[7] This variable also proves statistically significant in the model for the median of individual GDP forecasts. The change of the estimation method does not affect the results for inflation at all. As reported in Section 4.3 and 4.4, the release of the projection by the NBP affects neither the dispersion nor the median of the individual inflation forecasts.

We also 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 four-year rolling sample using the LS method with the Newey-West correction as proposed in Section 4. In *Figures 1a–1f* we present the estimates of the parameters reflecting the impact of the projection release on the dispersion and median of individual forecasts, followed by the band of +/- 2 standard errors.

The results indicate that the impact of the projection release on the dispersion of GDP forecasts (*Figures 1b* and *1d*) strengthens over time and starts to be statistically significant some years after the central bank starts publishing projections. This outcome may be interpreted in two ways. It may be evidence of the growing credibility of GDP forecasts published by the NBP. However, this strengthening of the role of the NBP projection in affecting the dispersion of individual forecasts

[7] The estimation results are available from the author upon request.

Figure 1 Coefficients Stability—Rolling Sample



Notes: 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 four-year rolling sample. On the horizontal axis we set the starting date of the rolling sample. *Figures 1a–1b* refer to the models for the dispersion without interest rate volatility in the initial set of the control variables (column (9) in *Table 4* and column (7) in *Table 2*), while *Figures 1c–1d* refer to the dispersion models with interest rate volatility (column (10) in *Table 4* and column (8) in *Table 2*). *Figures 1e–1f* refer to the models for the median presented in column (9) in *Table 5* and column (7) in *Table 3* respectively.

Source: Own calculations.

coincides with the onset of the global financial crisis. Thus, the growing impact of the central bank's projection on the dispersion of GDP forecasts formulated by private forecasters may also be related to the increase of uncertainty about global economic activity, which consequently enhances the coordinating effect of public information, as pointed out by Morris and Shin (2002). On the other hand, the projection acts as an attractor for the median of individual GDP forecasts in the first half of the sample only, while in the second half this relationship weakens (*Figure 1f*). The impact of the projection release on both the dispersion and median of individual inflation forecasts is insignificant over the whole sample (*Figures 1a, 1c* and *1e*).

6. Non-Linear Model

The findings discussed in Section 4 indicate that the dispersion of individual inflation and GDP forecasts depends on the phase of the business cycle, which is in accordance with the results reported for other economies (see the literature review in Section 2). Accordingly, we may expect that the role of the central bank's projection in affecting the dispersion of individual forecasts may be different with respect to the level of economic activity. As pointed out by Woodford (2001), private agents use the information provided by the central bank to extract signals from the noise included in the data. While the noise and uncertainty in the economy are perceived to vary over time and tend to increase during recessions (see Bloom *et al.,* 2012)[8], we may expect that the projection disclosed by the central bank reduces the forecasts' dispersion to a different extent over the business cycle. To test this hypothesis, we extended the linear model (2) and introduced asymmetry in the response of individual inflation and GDP forecasts to the release of the NBP projection. We accounted for the non-linearity using the Smooth Transition Regression (STR) model, which takes the following form:

$$\begin{aligned} IQR_t^{(i)} = \alpha_0^{nd} + \alpha_1^{nd} IQR_{t-1}^{(i)} + \left(1 - G\left(s_t;\gamma,c\right)\right)\delta_1^{nd} Proj_t + \\ + G\left(s_t;\gamma,c\right)\delta_2^{nd} Proj_t + \beta^{nd} X_t^{(i)} + \varepsilon_t^{nd} \end{aligned} \tag{4}$$

where $G\left(s_t;\gamma,c\right)$ is a transition function allowing for the non-linear relationship between the measure of disagreement among forecasters ($IQR^{(i)}$ for i = CPI or GDP) 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:

$$G\left(s_t;\gamma,c\right) = \left(1 + exp\left\{-\gamma\left(s_t - c\right)\right\}\right)^{-1} \qquad \gamma > 0 \tag{5}$$

or the exponential function:

$$G\left(s_t;\gamma,c\right) = 1 - exp\left\{-\gamma\left(s_t - c\right)^2\right\} \qquad \gamma > 0 \tag{6}$$

The variable s_t in (5) and (6) is the transition variable, c is a threshold parameter and γ is a transition parameter, which measures the speed of transition from one regime to another. The restriction $\gamma > 0$ is an identifying restriction.

[8] However, Dovern *et al.* (2012) point out that disagreement about GDP forecasts will also rise when economic growth accelerates considerably.

The STR models refer to the STAR models proposed by Granger and Teräsvirta (1993) and Teräsvirta (1994). The transition functions described by (5) and (6) are bounded between 0 and 1. This means that the parameter measuring the impact of the projection release on disagreement among forecasters may vary between δ_1^{nd} and δ_2^{nd} along with the transition variable s_t. The logistic function (5) tends toward zero for very large negative values of the transition variable and approaches one for very large positive values. The exponential function (6) tends toward unity for very large values (both positive and negative) of the transition variable s_t and is close to zero when s_t is equal to the value of the threshold parameter c.

We were interested in checking whether the response of the dispersion of individual inflation and GDP forecasts to the NBP projection release depends on the phase of the business cycle. Therefore, as the transition variable we used industrial production growth (as listed in *Table 1*), which corresponds to the level of economic activity.[9] If the STR model with the logistic transition function (5) 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 a recovery than in a slowdown. On the other hand, the validity of the STR model with the exponential transition function (6) means that the release of the projection reduces the dispersion to a different extent when the economy is either in recovery or in recession than when economic growth is moderate (industrial production growth is close to the value of the threshold parameter). Therefore, both transition functions refer to different economic hypotheses.

We start our analysis with testing the presence of general STR non-linearity in the form proposed by model (4) against linear model (2). Following the procedure developed by Escribano and Jordá (2001), we first estimate the parameters of the second-order Taylor series expansion of the STR model with the exponential transition function around $\gamma = 0$, which is the auxiliary regression for this test:

$$\begin{aligned} IQR_t^{(i)} &= \alpha_0^{nd} + \alpha_1^{nd} IQR_{t-1}^{(i)} + \delta^{nd} Proj_t + \beta^{nd} X_t^{(i)} + \\ &+ \lambda_1 Proj_t s_t + \lambda_2 Proj_t s_t^2 + \lambda_3 Proj_t s_t^3 + \lambda_4 Proj_t s_t^4 + \varepsilon_t^{nd} \end{aligned} \tag{7}$$

The null hypothesis of linearity is:

$$H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$$

and may be tested using the LM statistic.

Firstly, we test for the presence of non-linearity in the model describing the dispersion of inflation forecasts. The p-value for this test amounts to 0.241 and we fail to reject the null hypothesis of linearity. The estimation results for both: the logistic and exponential transition functions indicate that the NBP projection does not affect the dispersion of inflation forecasts under any of the regimes (columns (1) and (2) in *Table 6*).

Secondly, we test for non-linearity in the model for disagreement about future GDP and find the p-value to be equal to 0.064. In this case we reject linearity in favor

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

Table 6 Estimation Results—Non-Linear Models

	(1)	(2)	(3)	(4)
Dependent variable	**Dispersion of CPI inflation forecasts**		**Dispersion of GDP forecasts**	
Transition function	**Logistic**	**Exponential**	**Logistic**	**Exponential**
Dependent variable (-1)	0.236** (0.101)	0.238** (0.107)	0.345*** (0.064)	0.334*** (0.064)
NBP projection—regime 1	0.023 (0.039)	0.090 (3.27e + 02)	-0.078* (0.046)	-0.394*** (0.062)
NBP projection—regime 2	-0.019 (0.073)	0.015 (0.037)	-0.099* (0.056)	-0.051 (0.045)
Transition parameter (γ)	28.37 (4.16e + 06)	19.58 (1.16e + 06)	28.82 (1.5e + 06)	1.052*** (0.378)
Threshold parameter (c)	12.17 (5.91e + 04)	2.273 (2.82e + 04)	13.12 (2.3e + 04)	4.353*** (0.124)
IP	-0.015*** (0.004)	-0.015*** (0.004)	-0.008 (0.005)	-0.008 (0.005)
INF	0.018* (0.010)	0.020** (0.010)		
INF VOL	0.880* (0.509)	0.846* (0.508)		
IP VOL			0.026 (0.017)	0.029* (0.017)
SURP IP			0.021* (0.011)	0.019* (0.010)
EX RATE VOL			3.140 (1.899)	3.624* (1.863)
Const	0.266*** (0.096)	0.264*** (0.097)	0.126 (0.111)	0.101 (0.111)
R^2	0.38	0.38	0.45	0.47
AR (1) test	0.129	0.243	0.125	0.170

Notes: The numbers in columns (1) and (2) refer to the STR model for the dispersion of inflation forecasts with the logistic and exponential transition functions, respectively. Columns (3) and (4) report the results for the STR model for the dispersion of GDP forecasts. For a detailed description of the control variables, see *Table 1*. AR(1) test is *the p*-value of the LM test for autocorrelation. HAC standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

of non-linearity. Accordingly, in the further analysis we focus only on the model for the dispersion of GDP forecasts.

In the next step using the approach described by Escribano and Jordá (2001), we select between the STR models with logistic and exponential transition functions. Therefore, we test two hypotheses:

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

and

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

We choose the STR model with the logistic (exponential) transition function if the minimum p-value is obtained for $H_{0L}\left(H_{0E}\right)$, conditionally on rejecting linearity.

The *p*-values for this test in the model explaining the dispersion of GDP forecasts amount to 0.020 for the H_{0E} and 0.253 for the H_{0L} respectively. These results are clearly in favor of the exponential transition function over the logistic function.

In *Table 6* we present the estimation results for the two non-linear models for GDP forecasts with the logistic (column (3)) and exponential (column (4)) transition functions. In the case of the STR model with the logistic transition function, we get similar estimates of the parameters related to the NBP projection for both the regimes of low and high economic activity (as measured by industrial output growth). The null hypothesis of the equality of both parameters cannot be rejected at any reasonable significance level. Since this model is also rejected by the Escribano-Jordá test, we will not discuss the results in more detail.

According to our selection procedure, the asymmetry in the reaction of disagreement about GDP forecasts to the release of the central bank's projection is captured better 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 regimes of very high and very low production growth. Moreover, the parameter related to the latter regime proves to be statistically insignificant. Given these results, we may conclude that the role of the NBP projection in reducing disagreement among forecasters is more substantial in the periods when the economy moves from one phase of the business cycle to another (from slowdown to recovery or the opposite). If we assume that the role of the central bank's projection is to help private forecasters to extract a signal from the noise present in the data and therefore to reduce uncertainty as argued by Woodford (2001), the interpretation of our results may be that professional forecasters treat the projection as a focal point when the expected (rather than the current) uncertainty is growing. The estimate of the threshold parameter indicates that the disclosure of the NBP projection affects the dispersion of individual GDP forecasts the most when the growth of industrial production is close to 4%. It is worth noting that the other control variables affecting the dispersion of GDP forecasts generally remain statistically significant as in the case of the linear model.

7. Conclusions

In this paper we investigated whether by publishing its forecasts the NBP affects 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 reduces the dispersion of one-year-ahead individual GDP forecasts. We find that the role of the central bank's projection in decreasing the dispersion of forecasts derived by professional forecasters strengthens over time. This may be interpreted as evidence of the increasing credibility of the central bank and its projection. However, while the second part of the sample covers the global financial crisis, the growing impact of the central bank's forecasts on the dispersion of private GDP forecasts may also 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 affects the dispersion of GDP forecasts varies over the business cycle. By disclosing its own projection, the central bank reduces disagreement among forecasters the most in the periods when the economy moves from one phase of the business cycle to another.

We also identify some determinants of dispersion among professional forecasters. In general, the cross-sectional dispersion of GDP forecasts is positively influenced by the volatility of industrial production growth—dispersion increases around turning points of the business cycle. Moreover, dispersion is higher during slowdowns than in recovery phases. Finally, disagreement among forecasters grows with negative surprises when current industrial production releases differ from the forecasts. The findings show that the central bank influences the level of GDP forecasts as well. The median of individual forecasts moves toward the central path of the projection after the projection release.

Conversely, the release of the CPI projection by the central bank affects neither the cross-sectional dispersion nor the level (median) of forecasts formulated by professional forecasters. The dispersion of one-year-ahead CPI forecasts depends positively on the level of inflation and on its volatility. Moreover, dispersion is higher during slowdowns than during recoveries. Disagreement among forecasters is also affected by the volatility of oil prices, but proves to be resilient to exchange rate movements.

Our results show that in the Polish economy during the last decade, the coordinating effect of public information is 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, which is not the case for GDP forecasts. Another possible explanation is that during the global economic crisis, which covers most of our sample, uncertainty for GDP was higher, while inflation at that time remained relatively stable and, as a consequence, private agents sought a focal point for the former variable rather than for the latter.

REFERENCES

Bloom N, Floetotto M, Jaimovich N, Saporta-Eksten I, Terry SJ (2012): Really Uncertain Business Cycles. *NBER Working Papers*, no. 18245.

Blinder A, Ehrmann M, Fratzscher M, Haan J de, Jansen D-J (2008): Central Bank Communication and Monetary Policy: A Survey of Theory and Evidence. *Journal of Economic Literature*, 46(4):910–45.

Brzoza-Brzezina M, Kotłowski J, Miśkowiec A (2013): How forward-looking are central banks? Some evidence from their forecasts. *Applied Economics Letters*, 20(2):142–146.

Budnik K, Greszta M, Hulej M, Kolasa M, Murawski K, Rot M, Rybaczyk B, Tarnicka M (2009): The new macroeconometric model of the Polish economy. *NBP Working Papers*, no. 62.

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

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

Cecchetti SG, Hakkio C (2009): Inflation targeting and private sector forecasts. *NBER Working Papers*, no. 15424.

D'Amico S, Orphanides A (2008): Uncertainty and disagreement in economic forecasting. (Technical Report.) *Board of Governors of the FRS*, *Finance and Economics Discussion Series*, no. 2008-56.

Dincer NN, Eichengreen B (2007): Central Bank Transparency: Where, Why, and with What Effects? *NBER Working Papers*, no. 13003.

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

Döpke J, Fritsche U (2006): When do forecasters disagree? An assessment of German growth and inflation forecast dispersion. *International Journal of Forecasting*, 22(1):125–135.

Dovern J, Fritsche U, Slacalek J (2012): Disagreement Among Forecasters in G7 Countries. *Review of Economics and Statistics*, 94(4):1081–1096.

Ehrmann M, Eijffinger S, Fratzscher M (2012): The Role of Central Bank Transparency for Guiding Private Sector Forecasts. *Scandinavian Journal of Economics*, 114(3):1018–1052.

Escribano A, Jordá O (2001): Testing nonlinearity: Decision rules for selecting between logistic and exponential STAR models. *Spanish Economic Review*, 3(3):193–209.

Filáček J, Saxa B (2012): Central Bank Forecasts as a Coordination Device: Evidence from the Czech Republic. *Czech Economic Review*, 6(3):244–264.

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

Geraats PM (2005): Transparency and Reputation: The Publication of Central Bank Forecasts. *B. E. Journal of Macroeconomics*, 5(1):1–28.

Geraats PM (2009): Trends in Monetary Policy Transparency. *International Finance*, 12(2):235–268.

Geraats PM (2014): Monetary Policy Transparency. *CESifo Working Paper Series*, no. 4611.

Goodhart CAE (2001): Monetary transmission lags and the formulation of the policy decision on interest rates. *Federal Reserve Bank of St. Louis Review*, July:165–186.

Granger CWJ, Teräsvirta T (1993): *Modelling Non-Linear Economic Relationships*. Oxford University Press.

Horvath R, Karas P (2013): Central Bank Communication and Interest Rates: The Case of the Czech National Bank. *Finance a uver-Czech Journal of Economics and Finance*, 63(5):454–464.

Hubert P (2014): FOMC forecasts as a focal point for private expectations. *Journal of Money, Credit and Banking*, 46(7):1381–1420.

Laxton D, Freedman C (2009): Inflation Targeting Pillars; Transparency and Accountability. *IMF Working Papers*, no. 262.

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

Łyziak T, Kapuściński M, Stanisławska E, Przystupa J, Wróbel E, Sznajderska A (2014): Monetary policy transmission mechanism in Poland. What do we know in 2013? *NBP Working Papers*, no. 180.

Mankiw NG, Reis R (2002): Sticky Information versus Sticky Prices: A Proposal To Replace the New Keynesian Phillips Curve. *Quarterly Journal of Economics*, 117(4):1295–1328.

Mankiw NG, Reis R, Wolfers J (2004): Disagreement about Inflation Expectations. *NBER Macroeconomics Annual 2003*, vol. 18:209–270.

Mishkin F (2002): Inflation Targeting. In: Vane H, Snowdon B (Eds): *Encyclopedia of Macro-economics*. Cheltenham (UK), Edward Elgar, pp. 361–365.

Morris S, Shin HS (2002): Social Value of Public Information. *American Economic Review*, 92(5): 1521–1534.

Morris S, Shin HS, Tong H (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 (Narodowy Bank Polski) (1998): *Medium-Term Strategy of Monetary Policy (1999–2003)*.

NBP (2003): *Monetary Policy Strategy beyond 2003*.

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

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

Svensson LEO (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 ET (2006): Have Increases in Federal Reserve Transparency Improved Private Sector Interest Rate Forecasts? *Journal of Money, Credit and Banking*, 38(3):791–819.

Teräsvirta T (1994): Specification, estimation, and evaluation of smooth transition autoregressive models. *Journal of the American Statistical Association*, 89(425):208–218.

Woodford M (2005): Central-bank communication and policy effectiveness. *NBER Working Papers*, no. 11898.

Woodford M (2001): Imperfect common knowledge and the effects of monetary policy. *NBER Working Papers*, no. 8673.