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Survey measures of inflation expectations in Poland: are they relevant from the macroeconomic perspective?

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ABSTRACT

This paper estimates different versions of the stylized New Keynesian model of the Polish economy, in which alternative measures of inflation expectations are used, that is, model-consistent (rational) expectations and survey-based expectations of consumers, enterprises and financial sector analysts. To compare dynamic properties of the models, we analyse propagation of the interest rate impulse, exchange rate impulse and a permanent change of inflation target. Differences in impulse responses pose the question which model should be treated as the most adequate. Analysis of in-sample inflation forecasting errors suggests that the model with rational expectations displays the lowest forecasting accuracy, while the model using expectations of enterprises is the best-performing model. In more general terms, our analysis suggests the best way of exploiting survey data on inflation expectations is not by using them as separate forward-looking information, alternative to macroeconomic models, but by combining both types of information.

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1. Introduction

The importance of expectations, including inflation expectations, is perceived as one of the pillars of the consensus on monetary policy prevailing in the central bank community in the years before the global financial crisis (Clarida, 2012). It results directly from the developments of macroeconomic theory, especially from the New Keynesian economics, that highlights the role of inflation expectations for price setting. Also in the current low inflation environment understanding the formation of inflation expectations and their impact on actual inflation seems highly important.

The aim of this paper is to assess the relevance of alternative measures of inflation expectations – including model-consistent expectations and survey-based measures of enterprises', financial sector analysts' and consumers' expectations – in a highly aggregated New Keynesian model of monetary policy transmission in Poland (MMPP). The sample period is determined by the availability of survey data – it starts in 2001 and

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ends in 2014. During this period monetary policy in Poland was conducted within the inflation targeting strategy.

Having different versions of the New Keynesian model estimated, we analyse their dynamic properties and assess how they differ from each other. We are particularly interested in comparing responses of the main macroeconomic variables to monetary impulses, including the interest rate impulse, exchange rate impulse and inflation target impulse. To select the best-performing measure of inflation expectations we evaluate forecasting properties of the models that use different proxies for this unobservable variable. In this way we try to respond to a more fundamental question, that is, if expectations data when used in forecasting models lead to better forecasting performance (Pesaran & Weale, 2006).

The paper has the following structure. Section 2 presents literature review. Section 3 describes data and models used in the empirical part of the study. Section 4 discusses the results. The final section concludes the study.

2. Literature review

Inflation expectations are in the centre of modern macroeconomic theory. Various specifications of the Phillips curve suggested by different schools of economic thought – that is, the expectations-augmented Phillips curve (Friedman, 1968; Phelps, 1967), the New Keynesian Phillips curve (NKPC, Goodfriend & King, 1997) or the hybrid New Keynesian Phillips curve (HNKPC, Fuhrer & Moore, 1995; Galí & Gertler, 1999; Roberts, 1997) – predict that inflation expectations have a direct impact on prices.

The New Keynesian models usually use the assumption of rational (model-consistent) or hybrid expectations, being to some extent forward-looking and to some extent backward-looking (e.g. Gerberding, 2001; Hubert & Mirza, 2014). In some studies survey-based measures of inflation expectations are used instead, although usually in single-equation models, describing price formation in isolation from the rest of macroeconomic relationships. In particular, direct measures of inflation expectations, based on consumer or professional economists' surveys, have been used in the literature to estimate different versions of the Phillips curve.¹ Henzel and Wollmershäuser (2006) estimate the hybrid Phillips curve for the euro zone, France, Germany, Italy, U.K. and U.S. using direct measures of economic experts' inflation expectations. In addition they present an overview of other studies, providing estimates of the hybrid Phillips curve for the euro area, Germany and U.S., in which various survey-based measures of inflation expectations were used. In all the cases under consideration direct measures of expectations appear statistically significant. Paloviita (2008) shows that the purely forward-looking Phillips curve in European economies is clearly outperformed by the New Classical and HNKPCs estimated with Consensus Economics survey data on inflation expectations. The HNKPC equations were also estimated with the use of survey-based measures of consumer inflation expectations in the euro area and its main economies by Forsells and Kenny (2010) and by Kokoszcyński, Łyziak, and Stanisławska (2010) for Poland and the Czech Republic. It is interesting to note that recent studies, focused on the analysis of post-crisis inflation performance, show that consumer inflation expectations – interpreted as proxies for enterprises' inflation expectations – are particularly useful in the estimation of the Phillips curve and crucial to

understand price dynamics in the recent period (e.g. Coibion & Gorodnichenko, 2015; Friedrich, 2014).²

Even if survey-based measures are commonly used in the empirical literature testing different specifications of the Phillips curve, the evidence on the relevance of model-consistent vs. survey-based measures based on the complete New Keynesian models is scarce. Using the panel of European economies Paloviita (2007) estimates standard, three-equation New Keynesian model with real time data and Consensus Economics survey measures of expected output gap and inflation. She shows that the model succeeds somewhat better with directly measured expectations and real time data than with rational expectations and revised (final) data. A similar study by Kortelainen, Paloviita, and Viren (2011) compares Generalized Method of Moments (GMM) and measured output gap and inflation expectations in estimating the conventional New Keynesian macro model for the euro area and the U.S. The results obtained with survey-based measures of expectations perform slightly better and strongly reduce the importance of lagged output and inflation terms.³ Fuhrer (2012) shows that survey-based expectations strongly dominate rational expectations in a DSGE model, eliminating the need for adding ad hoc model features such as indexation and habit formation, having limited support in the micro data.

The present study evaluates the role of different measures of inflation expectations from the point of view of the New Keynesian model of the Polish economy. The novelty of this research results not only from conducting analysis within a complete model of the economy, but also from the fact that we consider a broader set of inflation expectations' measures than usually used in empirical studies. These include expectations of consumers, enterprises and financial sector analysts, who form their predictions in various ways.⁴

3. Data and model

3.1. Survey data on inflation expectations

The measures of inflation expectations used in this study are based on survey data. In the case of consumers we use data from the survey conducted on monthly basis by the Polish Central Statistical Office (GUS). The question of price changes predicted in the 12-month horizon is qualitative and makes the respondents expecting price increases declare its magnitude relative to their perception of currently observed price dynamics.⁵ Inflation expectations of Polish enterprises are measured on the basis of quarterly surveys conducted by the National Bank of Poland (NBP's Quick Monitoring). Since 2008Q3 the survey question has been qualitative,⁶ while previously (i.e. 2001Q1–2008Q2) it was quantitative. The measure of producer inflation expectations is given by a combination of the results from the quantitative question (2001Q1–2008Q2) and expectations quantified on the basis of qualitative survey data (since 2008Q3).⁷

To quantify consumer and producer inflation expectations in Poland we use the probability method, proposed originally by Carlson and Parkin (1975) and then extended by Batchelor and Orr (1988). In line with the construction of the survey question, the quantified distribution of expected inflation, including its mean, depends both on the responses to the survey question and on the perceived rate of inflation. The latter factor serves the respondents expecting that prices will increase as a benchmark in selecting one of the

response categories to the survey questions (*prices will increase more rapidly/prices will increase at the same rate/prices will increase at slower rate*).

Quantifying enterprises' and consumers' inflation expectations we assume that expected inflation is normally distributed in the population. Currently available consumer price index (CPI) inflation, referred to in the survey question, is used as a proxy for inflation perceived by enterprises. As far as inflation perception of Polish consumers is concerned we relax the assumption that their perception corresponds to current CPI inflation. It is due to the fact that recent literature (Hałka & Łyziak, 2015) suggests that the perception of price changes by Polish consumers is based on a sub-basket of frequently bought goods and services.⁸ Moreover, Polish consumers disregard negative price changes of those items. Therefore the Consumer Perceived Price Index – the measure developed by Hałka and Łyziak (2015) to reflect consumers' perceptions and used in this study to quantify consumer inflation expectations – is significantly and systematically higher than CPI inflation.

Financial sector analysts are the third group of agents, whose inflation expectations we analyse in this study. We use monthly data on 12-month inflation expectations obtained from the surveys by Reuters.⁹

Heterogeneity of inflation expectations in Poland is clearly noticeable in the results presented below (Figure 1, Table 1). In terms of their averages, the quantified measure of consumer inflation expectations in the analysed period was significantly above expectations of remaining groups of economic agents. Relatively low volatility of inflation expectations of financial sector analysts reflects high degree of their anchoring to the NBP inflation target. Forecasting accuracy of inflation expectations of Polish enterprises and financial sector analysts is comparable to each other and significantly outperforms forecasting accuracy of consumer expectations. It should be noted that in contrast to consumer inflation expectations, errors of financial sector analysts' and enterprises' expectations are lower than errors of naive forecasts, given in each period by the recent available inflation.

3.2. Model

Macroeconomic relevance of expectations is analysed through the lenses of a small structural model of monetary policy, MMPP. Theoretical models of the New Keynesian economics have served as the reference point for the construction of the MMPP model. Its structure, presented below, accounts for four basic macroeconomic relationships, that is, the aggregate demand curve, the exchange rate equation, the Phillips curve and the

Table 1. Selected features of inflation expectations and CPI inflation in Poland.

Category	Average (%)	Standard dev. (p. p.)	Coefficient of variation (%)	MAE (p. p.)	RMSE
Enterprises' inflation expectations	3.0	1.3	43.6	1.5	1.9
Financial sector analysts' inflation expectations	2.8	0.9	32.9	1.4	1.7
Consumers' inflation expectations	4.4	1.9	43.3	2.5	3.0
CPI inflation	2.7	1.6	58.7	2.0 [*]	2.4 [*]

Notes: Quarterly data, sample: 2001Q1–2014Q2; [*] – Errors of naive forecasts.

Source: Own calculations on the basis of GUS, NBP and Reuters data.

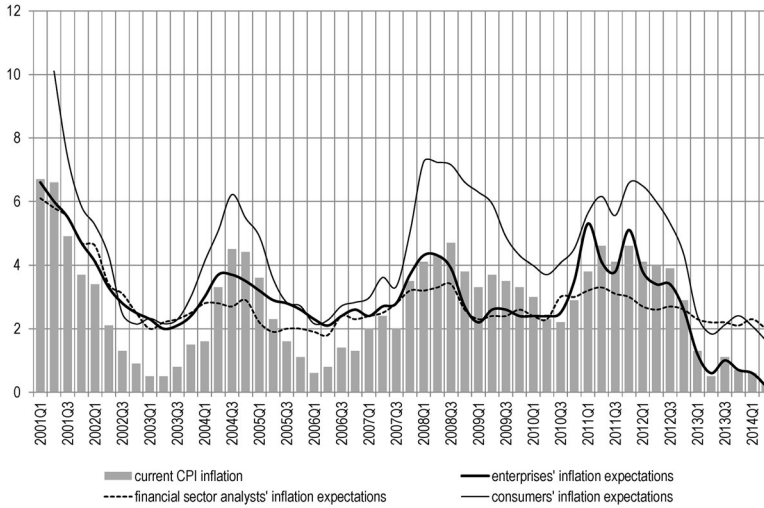


Figure 1. Inflation expectations and current CPI inflation in Poland. Notes: Inflation expectations are dated at the time when the surveys are conducted. Current CPI inflation measures the most recent CPI inflation available at the time when the surveys are conducted. In the case of measures of inflation expectations of consumers and financial sector analysts, available monthly, we consider their quarterly averages.

Source: GUS, NBP and Reuters data, own calculations.

monetary policy rule:

$$\hat{y}_t = \alpha_1 E_t \hat{y}_{t+1} + \alpha_2 \hat{y}_{t-1} + \alpha_3 \hat{r}_{t-1} + \alpha_4 \hat{s}_{t-1} + \alpha_5 \hat{y}_{t+1}^{EA} + \varepsilon_t^{\hat{y}}, \quad (1)$$

$$e_t = \beta E_t e_{t+1} + (1 - \beta) e_{t-1} + 0.25(i_t - i_t^{EA}) + \varepsilon_t^e, \quad (2)$$

$$\pi_t = \gamma_1 E_t \pi_{t+4} + \gamma_2 (\pi_{t-1}^{EA} + \Delta_4 e_{t-1}) + (1 - \gamma_1 - \gamma_2) \pi_{t-1} + \gamma_3 \hat{y}_{t-1} + \varepsilon_t^\pi, \quad (3)$$

$$i_t = \kappa_1 i_{t-1} + (1 - \kappa_1) [\kappa_2 (\pi_t - \pi_t^{tar}) + \kappa_3 \hat{y}_{t-1}] + \varepsilon_t^i, \quad (4)$$

where \hat{y} is the output gap, \hat{y}^{EA} – the output gap in the euro area, i – the nominal, short-term domestic interest rate, i^{EA} – the nominal, short-term interest rate in the euro area, r – the real, short-term domestic interest rate, \hat{r} – the real interest rate gap, e – the nominal effective exchange rate (NEER),¹⁰ s – the real effective exchange rate (REER), \hat{s} – the real effective exchange rate gap, π – the year-on-year CPI inflation, π^{EA} – the year-on-year HICP inflation in the euro area, while π^{tar} – the inflation target. E_t denotes the mathematical expectations operator, while Δ_4 is the 4-quarter difference operator. In the models that use survey-based measures of inflation expectations (π_{t+4}^e) there is an additional equation that explains their formation, treating expectations as a weighted average of past and future inflation (hybrid model of expectations):

$$\pi_{t+4}^e = \lambda \pi_{t-1} + (1 - \lambda) \pi_{t+4} + \varepsilon_t^{\pi^e}. \quad (5)$$

Estimating the MMPP model different measures of inflation expectations are used, that is, model-based inflation expectations (MMPP-RE model), producer inflation expectations (MMPP-E model), financial sector analysts' inflation expectations (MMPP-F model) as

well as consumers' inflation expectations (MMPP-C model). They are used in Equations (1) and (3), that is, in the IS curve (the real interest rate in the aggregate demand curve is calculated as the difference between the nominal short-term interest rate and expected inflation) and in the Phillips curve. The output gap, the real interest rate gap and the real exchange rate gap are calculated using the Hodrick–Prescott (HP) filter (Hodrick & Prescott, 1997).¹¹

We estimate the models as systems using the GMM. It is due to the fact that estimated models contain forward-looking variables. They are measured either with survey data, suffering from measurement errors or by their realized ex-post values. Both approaches generate endogeneity problems. In such circumstances the overall error in the equation with forward-looking variables becomes a combination of an exogenous shock and the measurement or forecast error of the forward-looking variables (Cermeño & Villagómez, 2012). Following literature all the versions of the MMPP models are estimated using past values of dependent variables as instruments (Beyer, Farmer, Henry, & Marcellino, 2008) in order to obtain a set of moment conditions imposing zero correlation between the right hand side variables and the error terms in each of the equations. The results of the Hansen *J*-test show that the null hypothesis of valid overidentifying restrictions cannot be rejected.¹² Estimation results are shown in Table 2.

Equation (1) is the open-economy version of the IS curve. The domestic output gap is driven by the gaps of the real interest rate, real exchange rate and foreign output. The specification considers also a lagged and future economic activity among explanatory variables, however, estimation results indicate that the future macroeconomic performance in the euro area, the main trading partner of Poland, and the real interest rate are the only forward-looking terms statistically significant in this relationship.

Exchange rate equation (2) is based on the uncovered interest rate parity (UIP) condition. Defining it we follow Leitemo and Söderström (2005) and replace the assumption of rational exchange rate expectations, on which the UIP condition is based, with the hybrid model of the exchange rate expectations. It assumes that a part β of economic agents forms exchange rate expectations rationally, while the remaining group has static expectations.¹³ Estimation results indicate that approximately 36–44% of economic agents in Poland form exchange rate expectations in the rational manner.

Equation (3) is the hybrid specification of the NKPC (Galí & Gertler, 1999), which relates current CPI inflation to expected future inflation, lagged domestic and foreign inflation, output gap and the dynamics of the exchange rate.¹⁴ Estimation results show that with survey-based measures of inflation expectations the expectation term in the NKPC becomes significantly larger than in the model with rational expectations, although in all the cases the role of lagged inflation is somewhat stronger than the role of expected inflation. Kortelainen et al. (2011) present similar results for the euro area and the U.S., showing that the use of Consensus Forecasts of inflation expectations in the New Keynesian model reduces the importance of lagged inflation terms in the model. In the case of their study however, the lagged inflation is no longer needed in the model, which is not the case in the estimation of the MMPP models.¹⁵

Equation (4) is the monetary policy rule. We use the modified Taylor (1993) rule, allowing for interest rate smoothing (Clarida, Galí, & Gertler, 2000). The central bank is assumed to set the short-term interest rate based on its lagged value, the expected deviation of CPI inflation from the inflation target¹⁶ and the output gap. Estimation results confirm earlier

Table 2. Estimation results of different versions of the MMPP model.

Equation	Coefficient	Model MMPP-RE	MMPP-E	MMPP-F	MMPP-C
(1)	a_2	0.832*** (0.014)	0.839*** (0.011)	0.857*** (0.011)	0.779*** (0.024)
	a_3	-0.090*** (0.011)	-0.110*** (0.031)	-0.111*** (0.014)	-0.053** (0.024)
	a_4	-0.012*** (0.005)	-0.036*** (0.005)	-0.029*** (0.003)	-0.026*** (0.003)
	a_5	0.275*** (0.019)	0.264*** (0.019)	0.333*** (0.010)	0.381*** (0.020)
	adj. R^2	0.909	0.887	0.890	0.865
(2)	β	0.440*** (0.020)	0.389*** (0.030)	0.367*** (0.018)	0.365*** (0.018)
	adj. R^2	0.847	0.865	0.861	0.860
(3)	γ_1	0.224*** (0.014)	0.465*** (0.019)	0.406*** (0.021)	0.390*** (0.019)
	γ_2	0.011*** (0.002)	0.032*** (0.002)	0.026*** (0.002)	0.031*** (0.001)
	γ_3	0.260*** (0.017)	0.330*** (0.020)	0.414*** (0.022)	0.267*** (0.018)
	adj. R^2	0.873	0.917	0.887	0.913
(4)	κ_1	0.876*** (0.004)	0.876*** (0.004)	0.876*** (0.003)	0.877*** (0.003)
	κ_2	1.795*** (0.242)	1.826*** (0.257)	1.852*** (0.131)	1.892*** (0.154)
	κ_3	0.572*** (0.149)	0.547*** (0.159)	0.543*** (0.085)	0.512*** (0.099)
	adj. R^2	0.988	0.988	0.988	0.988
(5)	λ	x	0.623*** (0.021)	0.605*** (0.014)	0.903*** (0.008)
	adj. R^2		0.400	0.249	0.800
Hansen J -statistic		0.25 (0.99)	0.25 (0.99)	0.26 (0.99)	0.25 (0.99)
(p-value)					

Notes: Table presents GMM estimates from different versions of the small New Keynesian model (MMPP-RE – model with rational expectations, MMPP-E – model with the survey-based measure of enterprises' inflation expectations, MMPP-F – model with the survey-based measure of financial sector analysts' inflation expectations, MMPP-C – model with the survey-based measure of consumer inflation expectations). Standard errors in parentheses (***significant at the 1% level, **significant at the 5% level, *significant at the 10% level). The sample period is 2001Q1–2014Q1 (54 observations). The set of instruments contains lags of dependent variables, which seems a common choice in the literature (see: Beyer et al., 2008), that is, three lags of the output gap, NEER and CPI inflation. In the case of the HNKPC we experimented with additional instruments, as suggested in empirical studies (see Mavroeidis, Plagborg-Møller, & Stock, 2014, for a survey), that is, lags of wage inflation, oil price inflation and dynamics of import prices, but the results were approximately the same.

Source: Own calculations.

findings (see e.g. Sznajderska, 2014), that Polish monetary authorities dislike jumps in the short-term interest rates, which is reflected in high values of the interest rate smoothing parameter (0.88).

Equation (5) is the hybrid model of inflation expectations (Carlson & Valev, 2002; Gerberding, 2001; Heineman & Ullrich, 2006; Łyziak and Mackiewicz-Łyziak, 2014), used to describe survey-based measures of consumers', producers' and financial sector analysts' inflation expectations. It assumes that a certain fraction of economic agents, λ , use the backward-looking model to form opinions on future price developments,¹⁷ while the remaining agents form inflation expectations consistently with the rational expectations hypothesis. Estimation results show that approx. 40% of financial sector analysts and enterprises are forward-looking, while in the case of consumers this share is four times lower. Similarity of the way, in which enterprises and financial sector analysts in Poland form their expectations raises a more general question, if the assumption that price setters form their expectations in the way similar to consumers, not to professionals – as made in some recent studies (Coibion & Gorodnichenko, 2015; Friedrich, 2014) – is empirically plausible. Our results contradict this assumption, showing that price setters are much more sophisticated in forming their predictions than consumers. Our findings are in line with Bryan, Meyer, and Parker (2015), who indicate that U.S. firms' inflation expectations are very similar to the predictions of professional forecasters, despite a somewhat greater heterogeneity of expectations.

In the case of a dominant part of parameters, their values estimated in different versions of the MMPP model are significantly different from each other.¹⁸ It means that using different proxies for inflation expectations has a statistically significant impact on the estimation results. The monetary policy rule is the exception in this respect, since all the analogous coefficients in this equation are not statistically different from each other across different versions of the model. The same applies to the real interest rate coefficient in the aggregate demand curve of the MMPP-E and MMPP-F models as well as to the estimated degree of forward-lookingness in the exchange rate equation of the MMPP-F and MMPP-C models.

4. Discussion of the results

4.1. Responses to monetary impulses

Having the MMPP model estimated with different proxies for inflation expectations, we analyse differences among alternative versions of the model in terms of responses of the main macroeconomic variables to three monetary impulses, that is, the interest rate impulse, the exchange rate impulse and to a permanent change of the inflation target.

The interest rate impulse is defined as the increase of the short-term interest rate by 1 percentage point for 4 quarters. The monetary policy rule in this period is switched off, while in the subsequent quarters the interest rate is set according to the monetary policy rule. Table 3 presents maximum responses of selected macroeconomic variables of the model and the delays in the monetary transmission mechanism at its different stages. Figure 2 provides detailed responses to the interest rate impulse.

The NEER appreciates immediately after the interest rate impulse. The magnitude of this effect is relatively high in the model using consumer inflation expectations (MMPP-C). It seems intuitive given that the exchange rate is to a large extent forward-looking. It anticipates the responses of output gap and inflation to the monetary policy impulse, which in the MMPP-C model are smaller than in alternative versions of the model. It implies that after the period, in which the domestic interest rate is increased, it is reduced in the MMPP-C model to a relatively small extent.

Economic activity is affected by contractionary impulse of monetary policy with delay. The response of the output gap is relatively small in the MMPP-C model, while the models using enterprises' and financial sector analysts' inflation expectations display relatively

Table 3. Interest rate impulse, selected results.

Response of	Feature	Model			
		MMPP-RE	MMPP-E	MMPP-F	MMPP-C
NEER	Maximum response	1.58	1.56	1.47	1.80
	Quarter of maximum response	2	2	2	3
Output gap	Maximum response	-0.43	-0.56	-0.57	-0.28
	Quarter of maximum response	4	4	4	4
Inflation expectations	Maximum response	x	-0.44	-0.50	-0.38
	Quarter of maximum response		5	4	6
Inflation	Maximum response	-0.48	-0.72	-0.88	-0.46
	Quarter of maximum response	5	5	5	5

Source: Own calculations.

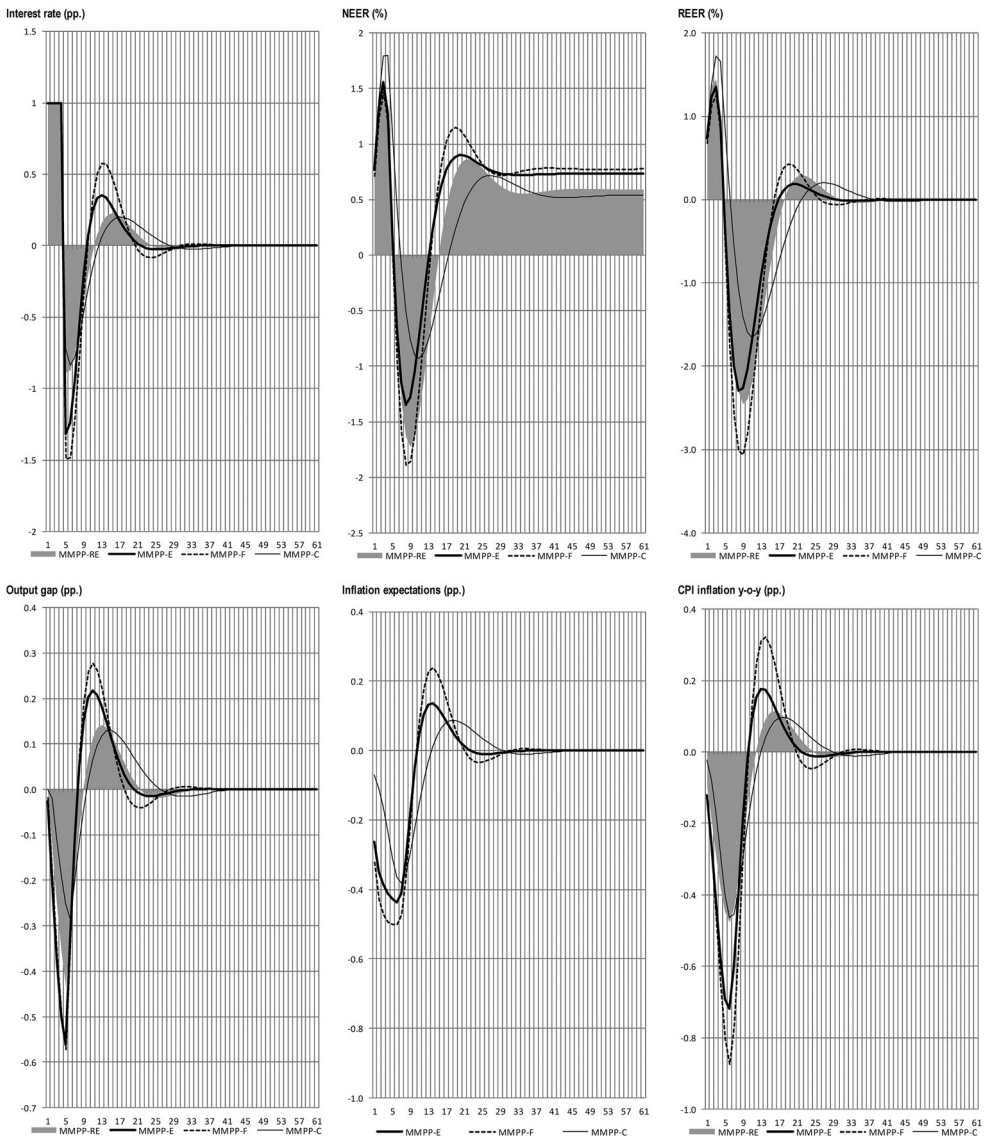


Figure 2. Interest rate impulse, detailed results.
Source: Own calculations.

strong responses, similar to each other. The peak response takes place in the 4th quarter after the impulse.

All the measures of inflation expectations we use in the MMPP model respond to the monetary policy impulse, although in the case of strongly backward-looking consumer expectations the reaction is smaller and more delayed than in the case of inflation expectations of financial sector analysts and enterprises.

The peak response of CPI inflation to the interest rate impulse occurs in the 5th quarter after the impulse, independently of the model under consideration, although its magnitude differs among them. It is relatively small in the models with model-consistent and

consumer inflation expectations (approx. -0.5 percentage point), while relatively large and similar to results of recent studies (Kapuściński et al., 2014) in the MMPP model with survey-based measures of enterprises' and financial sector analysts' inflation expectations (approx. 0.7 and 0.9 percentage point, respectively).

To analyse the exchange rate pass-through we make the NEER appreciate by 1 percentage point for 1 quarter. The responses of analysed macroeconomic variables to the exchange rate impulse (Table 4, Figure 3) differ significantly between the model with rational expectations on the one hand and models with survey-based measures of inflation expectations on the other hand. In general, the MMPP-RE model predicts smaller responses than the alternative models.

Following the exchange rate impulse the central bank reduces its short-term interest rate. The impact of the exchange rate impulse on economic activity is rather small, which probably results from the role played in Polish trade by international companies, which settle their accounts within a capital group (Kapuściński et al., 2014). The peak response of the output gap occurs with lags that are diversified across the models we use.

The exchange rate pass-through to consumer prices in the MMPP-RE model is low (0.07), while in the remaining models is stronger (0.14) and identical, independently of the survey-based measures of inflation expectations used. The magnitude of the exchange rate pass-through is broadly consistent with the range of estimates in the recent literature, oscillating between 0.06 (Kapuściński et al., 2014) and 0.18 (Demchuk et al., 2012).

In the final simulation we assume that the central bank attempts to reduce inflation permanently by 1 percentage point. Monetary authorities announce a reduction of the inflation target and adjust the short-term interest rate to the new target. The results of the simulations (Table 5, Figure 4) show that the sacrifice ratios obtained from MMPP-F model and MMPP-E model are lower than in the MMPP-RE model, while the highest output loss required to reduce inflation permanently by 1 percentage point characterizes the MMPP-C model.

There are two main determinants of the sacrifice ratio in the estimated models. The first one is the degree of forward-lookingness of inflation expectations. From this perspective, the highest sacrifice ratio obtained from the MMPP-C model can be explained with the fact that consumer inflation expectations are strongly backward-looking. The second factor that has impact on the estimated costs of disinflation is the degree of inertia in the hybrid NKPC. A relatively high sacrifice ratio in the MMPP-RE model, despite fully forward-looking inflation expectations, results from the fact that the weight of past inflation in the hybrid NKPC is the highest among analysed models (see Table 2).

Table 4. Exchange rate impulse, selected results.

Response of	Feature	Model			
		MMPP-RE	MMPP-E	MMPP-F	MMPP-C
Output gap	Maximum response	-0.02	-0.06	-0.05	0.05
	Quarter of maximum response	4	1	2	3
Inflation expectations	Maximum response	x	-0.09	-0.09	-0.11
	Quarter of maximum response		4	4	4
Inflation	Maximum response	-0.06	-0.14	-0.14	-0.14
	Quarter of maximum response	4	4	4	4

Source: Own calculations.

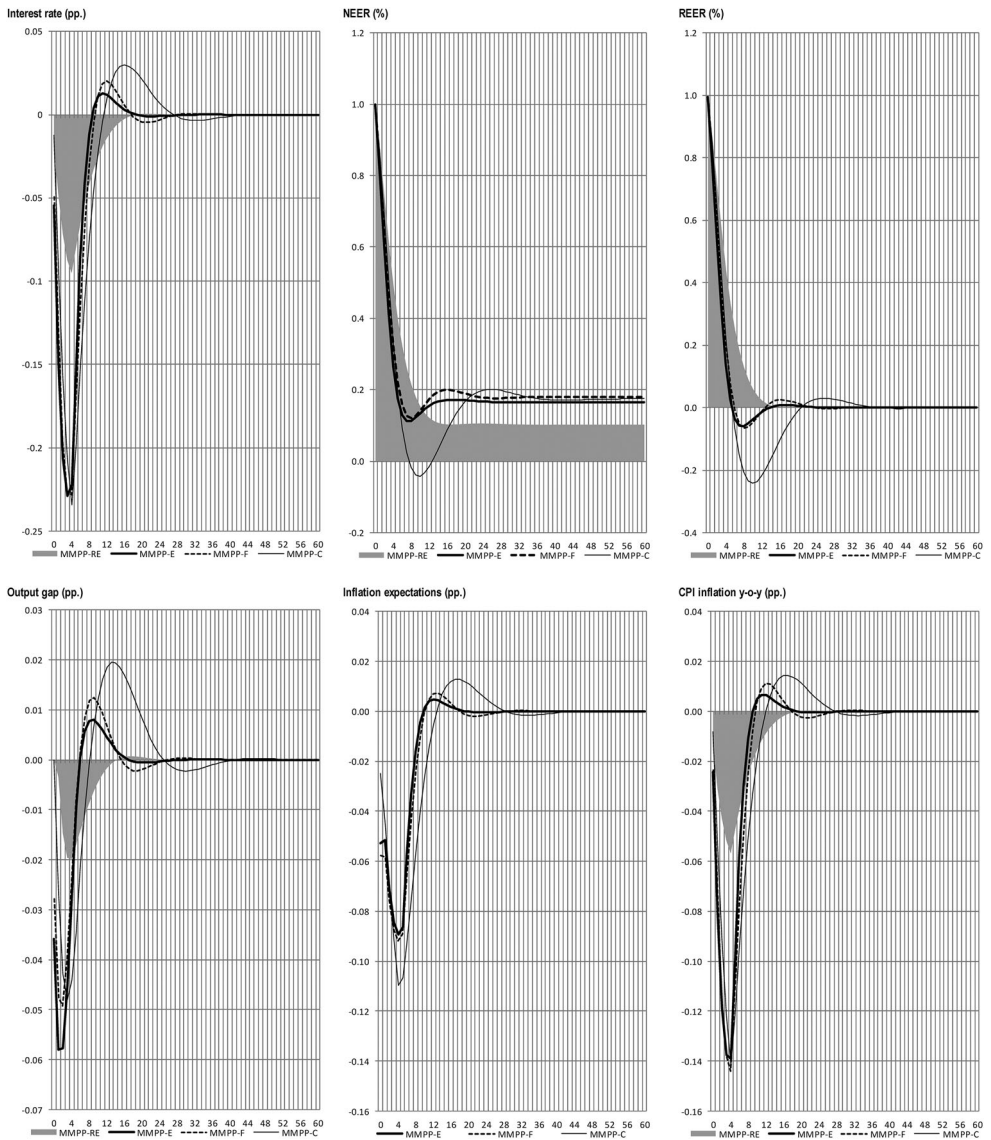


Figure 3. Exchange rate impulse, detailed results.
Source: Own calculations.

Table 5. Permanent change of inflation target, selected results.

Response of	Feature	Model			
		MMPP-RE	MMPP-E	MMPP-F	MMPP-C
Interest rate	Maximum response	0.22	0.33	0.33	0.47
	Quarter of maximum response	0	0	0	0
Cumulative output loss (sacrifice ratio)	Maximum response	-1.41	-1.27	-1.18	-2.91
	Quarter of maximum response	x	14	12	80
Inflation	Maximum response	-1.16	-1.07	-1.12	-1.00
	Quarter of maximum response	10	14	12	80

Source: Own calculations.

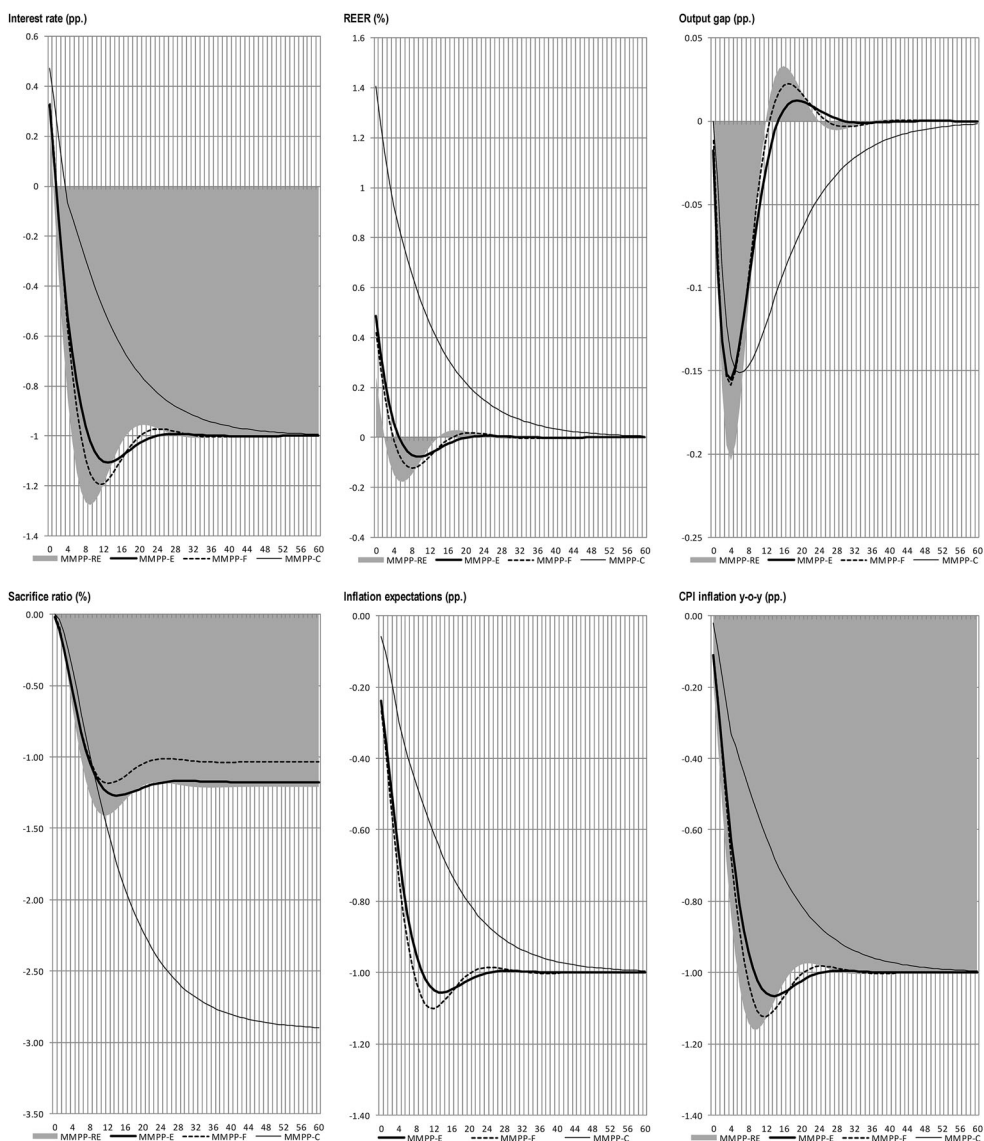


Figure 4. Permanent change of inflation target, detailed results.
Source: Own calculations.

With the increase of the degree to which inflation expectations are forward-looking, the price dynamics in the economy approaches the new monetary policy target more quickly and the increase of interest rates by a central bank required to reduce inflation is smaller.

4.2. Forecasting accuracy

As it is shown in previous parts of the paper, the choice of a particular measure of inflation expectations to be used in the New Keynesian model of the Polish economy has influence on its dynamic properties. The question, which naturally arises at this

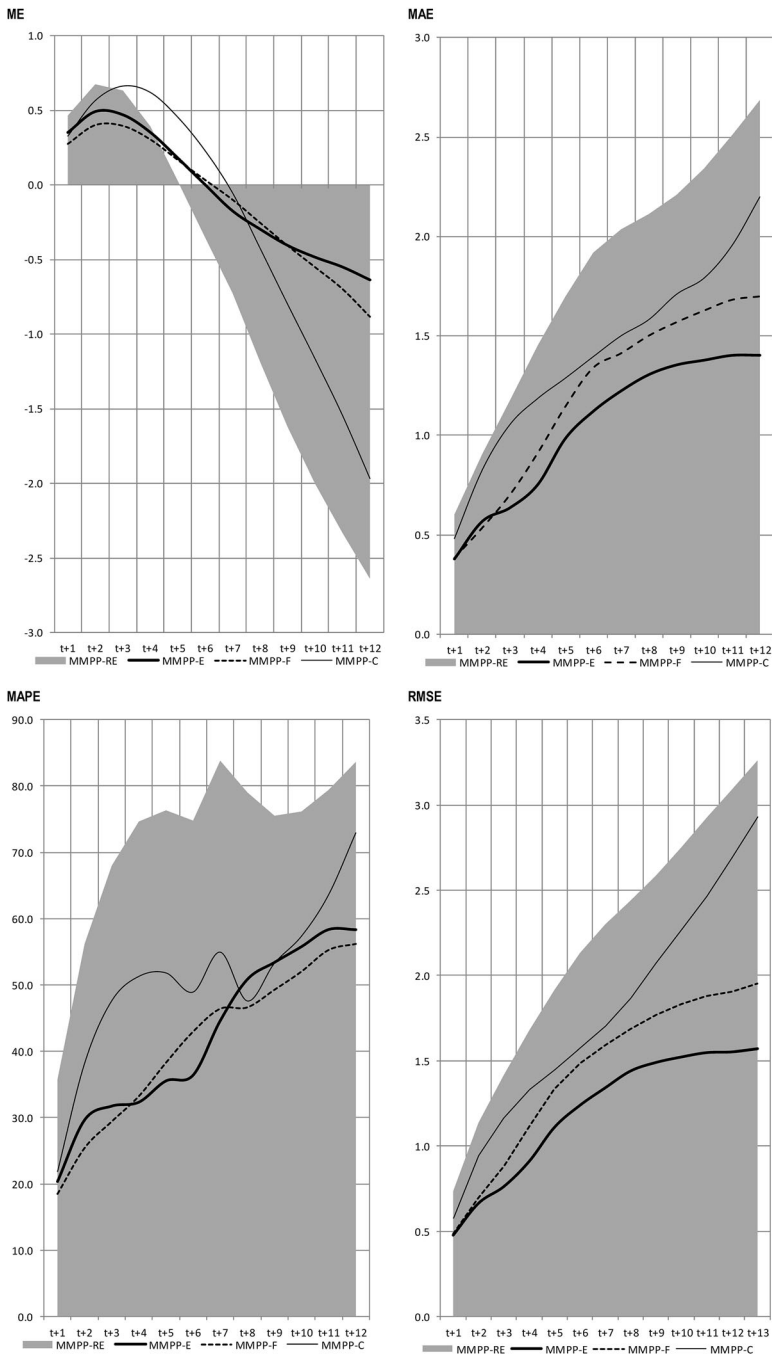


Figure 5. Forecasting accuracy.
Sources: Own calculations.

stage, is as to which version of the MMPP model offers the most accurate picture of the macroeconomic dynamics in the Polish economy. To answer it we conduct additional simulations that verify forecasting accuracy of alternative versions of the MMPP

Table 6. The results of the Diebold–Mariano (1995) test.

Horizon	Feature:	Absolute errors			Squared errors		
		MMPP-E model relative to:			MMPP-E model relative to:		
		MMPP-RE	MMPP-F	MMPP-C	MMPP-RE	MMPP-F	MMPP-C
t + 1	DM statistic	−3.584***	0.076	−2.173**	−3.731***	−0.658	−2.129**
	p-value	0.000	0.940	0.030	0.000	0.511	0.033
t + 2	DM statistic	−2.941***	−0.023	−2.844***	−3.286***	−1.152	−2.881***
	p-value	0.003	0.981	0.004	0.001	0.249	0.004
t + 3	DM statistic	−3.373***	−1.693*	−3.483***	−3.452***	−2.332**	−3.342***
	p-value	0.001	0.090	0.000	0.001	0.020	0.001
t + 4	DM statistic	−3.661***	−2.914***	−3.235***	−3.639***	−3.120***	−2.897***
	p-value	0.000	0.004	0.001	0.000	0.002	0.004
t + 5	DM statistic	−3.122***	−2.977***	−2.058**	−3.581***	−3.664***	−2.219**
	p-value	0.002	0.003	0.040	0.000	0.000	0.026
t + 6	DM statistic	−3.111***	−3.194***	−1.608	−3.616***	−3.548***	−2.179**
	p-value	0.002	0.001	0.108	0.000	0.000	0.029
t + 7	DM statistic	−3.077***	−2.505**	−2.189**	−3.703***	−3.372***	−2.435**
	p-value	0.002	0.012	0.029	0.000	0.001	0.015
t + 8	DM statistic	−2.929***	−2.821***	−1.890*	−3.715***	−2.778***	−2.549**
	p-value	0.003	0.005	0.059	0.000	0.005	0.011
t + 9	DM statistic	−3.005***	−1.844*	−1.998**	−3.949***	−2.557**	−2.625***
	p-value	0.003	0.065	0.046	0.000	0.011	0.009
t + 10	DM statistic	−4.238***	−2.056**	−1.894*	−4.238***	−2.485**	−2.703***
	p-value	0.000	0.040	0.058	0.000	0.013	0.007
t + 11	DM statistic	−3.504***	−2.164**	−2.491**	−4.422***	−2.517**	−3.079***
	p-value	0.000	0.030	0.013	0.000	0.012	0.002
t + 12	DM statistic	−3.983***	−2.365***	−3.140***	−4.550***	−2.831***	−3.691***
	p-value	0.000	0.018	0.002	0.000	0.005	0.000

*Significant at the 10% level.

**Significant at the 5% level.

***Significant at the 1% level.

Source: Own calculations.

model. More specifically, we conduct in-sample counter-factual simulations, in which we forecast future paths of macroeconomic variables, with a particular focus on inflation. The first counter-factual forecast starts in 2005Q1, while the last one – in 2011Q4.

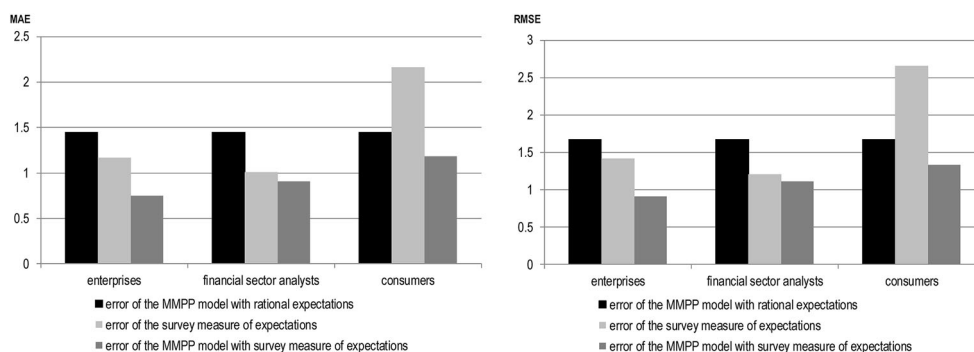


Figure 6. Forecasting accuracy gains from using survey-based measures in the MMPP model. Notes: The figures compare 4-quarter-ahead forecasting errors (MAE and RMSE) of the MMPP-RE model with errors of raw survey-based measures of different groups of economic agents and errors based on the MMPP model with survey-based measures of inflation expectations. The sample under consideration is homogenous and corresponds to the sample used in assessing forecasting accuracy of different versions of the MMPP model (Section 4.2), that is, 2005Q1–2014Q2.

Sources: Own calculations.

Based on theoretical values obtained we calculate the measures of forecast accuracy, including: the mean error (ME), the mean absolute error (MAE), the mean absolute percentage errors (MAPE) and the root mean squared error (RMSE) for different forecast horizons.

The results of our analysis (Figure 5) suggest that in the case of all analysed groups of economic agents the models with survey-based inflation expectations outperform the MMPP-RE model in terms of MAE, MAPE and RMSE.¹⁹ It can be observed that both rational (model-consistent) and consumer inflation expectations used in the MMPP model give significantly worse outcomes in terms of forecasting accuracy than survey-based measures of inflation expectations of financial sector analysts and enterprises. Taking into account MAE, MAPE and RMSE we can conclude that the measure of enterprises' inflation expectations in the MMPP model is the best-performing measure of expectations.²⁰ In the horizon of effective monetary transmission (4–6 quarters), the MAE of the MMPP-E model accounts for approx. 56% of MAE based on the MMPP-RE model, 73% of MAE based on the MMPP-C model and 84% of MAE of the MMPP-F model.

A formal comparison of forecasting accuracy of the models under consideration with the use of Diebold–Mariano (1995) test, confirms that the MMPP-E model is superior in terms of forecasting properties relative to the remaining ones. Only in the short-term forecasting horizons (quarters $t + 1$ and $t + 2$) the differences in forecasts errors obtained from MMPP-E model and MMPP-F model are not statistically different from each other, both in the case of the test based on absolute errors and squared errors (Table 6).

In order to deepen our understanding of the role of survey-based measures in forecasting inflation we compare 4-quarter-ahead forecasting errors based on MMPP-RE model with expectational errors of individual survey-based measures of inflation expectations and with forecasting errors of the MMPP models that use survey information on inflation expectations (Figure 6). It can be observed that independently of the criterion applied (MAE or RMSE) survey-based measures of inflation expectations of enterprises and financial sector analysts display lower absolute errors than the MMPP model with rational expectations, while consumer inflation expectations are less accurate than the MMPP-RE model. However, the usefulness of survey measures of inflation expectations is fully manifested after including them in the forecasting model. In the case of all groups of agents under consideration, but especially enterprises, the errors generated by the MMPP models, in which those measures are used, are lower than both the forecasting errors of the MMPP-RE model and expectational errors of raw survey measures of expectations. It suggests that, conditional on the type of the model we use, the best way of exploiting survey data on inflation expectations is not by using them as a separate forward-looking information, alternative to macroeconomic models, but by combining both types of information.

The main result from our analysis, indicating a particularly high usefulness of survey measures of enterprises' inflation expectations in modelling inflation in Poland, seems consistent with theoretical considerations, perceiving inflation expectations of price setters as the most relevant from the macroeconomic perspective. Expectations of Polish enterprises declared in the survey seem to reflect not only their subjective beliefs concerning an abstract variable, but – to a large extent – they are likely to be related to actual plans of price changes enterprises have for the near future.

5. Conclusions

The results presented in this study are meaningful from the point of view of two research questions: Should we use survey-based measures of inflation expectations in modelling and forecasting inflation? What are the features of the monetary transmission mechanism in Poland and how their model assessment depends on the measure of inflation expectations we rely on?

The answer to the former question is positive. Our analysis suggests the best way of exploiting survey data on inflation expectations is not by using them as a separate forward-looking information, alternative to macroeconomic models, but by combining both types of information. Survey measures of inflation expectations of Polish consumers, financial sector analysts and, particularly, enterprises, used in the small stylized New Keynesian MMPP, improve its forecasting properties relative to its type with rational (model-consistent) expectations. In line with macroeconomic theory, inflation expectations of enterprises seem the most powerful in this respect. As such, they should be treated as an important element of the information set monitored by monetary policy-makers and used in forecasting models.

Formation of inflation expectations differs among analysed groups of economic agents. Interestingly, inflation expectations of Polish enterprises display a similar degree of forward-lookingness to financial sector analysts' inflation expectations. Therefore the assumption that consumer inflation expectations can be treated as adequate proxy for price-setters inflation expectations, made in some recent studies (e.g. Coibion & Gorodnichenko, 2015), seems debatable.

Simulations performed with the use of the New Keynesian model with survey-based measures of enterprises' inflation expectations suggest that the impact of changes in the interest rate and exchange rate on CPI inflation is stronger than in the model with rational expectations, while the sacrifice ratio estimated on the basis of the MMPP-E model is slightly lower than in the model with rational expectations.

Notes

1. Direct measures of expectations are also used in other forecasting models. Scheufele (2011) examines the properties of qualitative inflation expectations collected from economic experts for Germany. Results from different standard forecasting models (such as AR, ARMA, random walk or Phillips curve models) are compared with models employing survey measures. It appears that a model using survey expectations outperforms most of the competing models. However, the forecast quality may be further improved by completely taking into account information from some financial indicators. As far as different survey measures are considered, the author shows that the Carlson–Parkin (1975) method assuming normality of expected inflation performs significantly better than the regression method and the balance statistic.
2. On the other hand we should mention empirical studies, in which the use of survey-based measures of inflation expectations in the context of the Phillips curve estimation is questioned. Nunes (2010) argues that even if survey expectations can be a determinant of inflation dynamics, rational expectations seem to be dominant, therefore estimating the Phillips curve only with survey expectations can be misleading. Mazumder (2011) shows that the NKPC estimates with survey-based measures of consumers' and professional forecasters' inflation expectations, produces a counter-intuitive negative and significant coefficient on procyclical marginal cost.

3. Brissimis and Magginas (2008) show that lagged inflation terms in the Hybrid New Keynesian Phillips curve, intended to capture inflation inertia, are not significant when survey measures of inflation expectations are used instead of rational expectations.
4. Previous studies (Łyziak, 2013; Łyziak, 2014) indicate that in terms of formation of inflation expectations in Poland there is a clear separation between enterprises and financial sector analysts on the one hand and consumers on the other hand. In particular, the degrees of anchoring and forward-lookingness of inflation expectations of financial sector analysts and enterprises are significantly higher than in the case of strongly backward-looking consumer inflation expectations.
5. GUS survey question has the following form: *By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will: (1) increase more rapidly; (2) increase at the same rate; (3) increase at a slower rate; (4) stay about the same; (5) fall; (6) don't know.*
6. The survey question in the NBP Quick Monitoring is similar to the question in the GUS consumer survey, but additionally provides the respondents with the most recent CPI inflation figure: *In ... [here: the month with the most recent CPI index available] CPI inflation was ... % in annual terms. In your opinion during next 12 months prices will: (1) rise faster than at present, (2) rise at the same rate, (3) rise more slowly, (4) stay at their present level, (5) go down, (6) difficult to say.*
7. Łyziak (2013) underlines that there are some doubts whether combining survey data in this way is coherent, which is not only due to the fact that the nature of survey questions is different, but also because in the qualitative question the current CPI inflation is referred to, which can anchor the opinions on future price changes. Therefore, he proposes an alternative measure of producer inflation expectations, different from the main one in the first sub-period. Quantitative expectations of individual enterprises are translated into implied (individual) responses to the qualitative survey question, and then they are aggregated and used to quantify inflation expectations with the probability method.

A similar measure of producer inflation expectations was used additionally in the estimation of the MMPP model, but the results seem less satisfactory than those based on the measure of enterprises' expectations, being a combination of the results from the quantitative question (2001Q1–2008Q2) and expectations quantified on the basis of qualitative survey data (since 2008Q3).

8. It is relatively broad and includes: food and non-alcoholic beverages, tobacco, housing and energy carriers, medical products, fuels, communication services, newspapers and articles and products for personal care.
9. Since November 2000 till December 2010 and in March 2011 the Reuters survey question concerned 11-month horizon.
10. According to a convention applied, the exchange rate is defined as a number of units of foreign currency equivalent to one unit of domestic currency. Hence increase of the exchange rate is the appreciation of the domestic currency.
11. Alternatively, to assess the robustness of the results, gaps were calculated using Christiano–Fitzgerald (CF) filter (Christiano & Fitzgerald, 2003).
12. The results of additional tests suggest that our models are not expected to suffer from the weak instrument problem. *F*-statistics on the joint significance of instruments in the first stage regression are the following (*p*-values in parentheses): for the output gap: 17.1 (0.00), for the nominal effective exchange rate: 37,796.2 (0.00), for CPI inflation: 128.7 (0.00), for the short-term interest rate: 99.7 (0.00).
13. A similar approach was used by Argov and Elkayam (2010).
14. Having not only expected future inflation, but also lagged inflation in the model can be motivated with different theoretical concepts (Kokoszcyński et al., 2010). One of them suggests that only a fraction of price-setters reoptimize their prices, while others apply a simple price indexation formula, with indexation tied to the past inflation rate (Christiano et al., 2005). A similar explanation is based on the assumption that the standard Calvo pricing model, used in the derivation of the NKPC, applies only to a subset of firms changing prices in a given

period, while the remaining group adjusts their prices according to a rule of thumb, depending on the lagged inflation (Galí & Gertler, 1999). Finally, the Relative Wage Model (Fuhrer & Moore, 1995) results also in the hybrid version of the NKPC.

In the MMPP-RE model the hybrid specification of the NKPC can also reflect heterogeneity of the formation of inflation expectations by economic agents and the importance of inflation inertia in the formation of inflation expectations (Woodford, 2007). In this view, only some firms are fully forward-looking and set prices in the optimal way, while the rest of them are backward-looking and use rule of thumb in their price decisions.

15. Moreover, the results for the euro area and U.S. show also that with measured expectations the lagged output gap term in the IS curve becomes smaller (Kortelainen et al., 2011). We do not observe such impact in the Polish model. It is probably due to the fact that Kortelainen et al. (2011) use Consensus Forecasts of output gap and inflation, while our analysis focuses on inflation expectations only.
16. While adopting inflation targeting in 1998 the Monetary Policy Council of the National Bank of Poland set the medium-term inflation target at a level below 4% at the end of 2003, but there were also short-term targets for the ends of subsequent years announced. After completing the disinflation process monetary authorities in Poland were confronted with the goal of strengthening price stability and making inflation expectations of economic agents firmly anchored. Since 2004 the central bank has targeted inflation at 2.5% (with a tolerance band of ± 1 pp.).
17. More specifically, it is the static model of expectations, in which inflation expectations are formed on the basis of recently available inflation.
18. We used the *t*-test on the equality of coefficients.
19. In this respect we are in line with findings of Ang, Bekeart and Wei (2007), who show that surveys have information absent in standard statistical models used to forecast inflation.
20. This conclusion is robust with respect to the way, in which gaps are obtained. Using in the models Christiano–Fitzgerald (CF) filter to obtain cycle measures of the real gross domestic product, real interest rate and the real effective exchange rate we confirm that the MMPP model with enterprises' inflation expectations produces the smallest forecasting errors. Dynamic properties of MMPP-E models with CF and HP gaps are very similar to each other. Results available on request from the author.

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Disclosure statement

No potential conflict of interest was reported by the author.

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