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Abstract

This paper estimates different versions of a stylised New Keynesian model of the Polish economy, in which alternative measures of inflation expectations are used. They include: model-based (rational) expectations as well as survey measures of inflation expectations formed by consumers, enterprises and financial sector analysts.

After estimating the models we verify to what extent the use of different measures of inflation expectations affects the assessment of the monetary transmission mechanism, the exchange rate pass-through and the sacrifice ratio. Simulation results show different responses in all the analysed areas. For example, the maximum reaction of CPI inflation to the interest rate impulse is almost twice bigger if the direct measures of financial sector analysts are used instead of model-consistent expectations. Also the model with survey-based measures of producer inflation expectations displays stronger response of inflation to monetary policy impulse than the model, in which rational expectations are assumed. Estimates of the exchange rate pass-through from the models with survey-based expectations are very similar to each other, but stronger than in the model with rational expectations. The sacrifice ratio seems similar in the case of all versions of the New Keynesian model except its version with consumer inflation expectations that shows significantly larger output loss resulting from a permanent reduction of the inflation target than the other models.

Differences in the assessment how monetary factors affect macroeconomic variables, particularly inflation, pose the question which model should be treated as the most adequate. To answer this question we run in-sample simulations, calculating inflation forecasting errors of all the models under consideration. We conclude that the model that assumes rational inflation expectations displays the lowest forecasting accuracy, while the model using inflation expectations of enterprises is the best-performing model. It suggests that the assumption of rational inflation expectations does not match the actual data well. Inflation expectations of Polish enterprises seem the most relevant from the macroeconomic point of view – more relevant than inflation expectations of consumers and financial sector analysts.

JEL: C54, D84, E17, E43.

Keywords: Inflation expectations, survey, New Keynesian model, monetary transmission mechanism, Poland.

1 Introduction

Inflation expectations are in the centre of modern macroeconomic theory. Various specifications of the Phillips curve suggested by different schools of economic thought – i.e. the expectations-augmented Phillips curve (Phelps 1967, Friedman 1968), the New Keynesian Phillips curve (NKPC; Goodfriend and King, 1997) or the hybrid New Keynesian Phillips curve (HNKPC; Fuhrer and Moore, 1995; Roberts, 1997) – predict that inflation expectations have a direct impact on prices. At the same time, empirical evidence on the role of inflation expectations in shaping behaviour of economic agents is rather limited. Probably the main reason for that is a lack of agreement how inflation expectations should be measured, implying that there are different proxies for this unobservable variable.

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). Some models use direct, survey-based measures of inflation expectations instead, although those are usually partial 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 a number of studies to estimate different versions of the Phillips curve.[1] Henzel and Wollmershaeuser (2006) estimate the hybrid Phillips curve for the euro zone, France, Germany, Italy, UK and US 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 US, 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 hybrid New Keynesian Phillips curves estimated with Consensus Economics survey data on inflation expectations. The hybrid New Keynesian Phillips curve 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 Kokoszczyński et al. (2010) for Poland and the Czech Republic. It is interesting to note that recent papers, 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 (e.g. Coibion and Gorodnichenko, 2013; Friedrich 2014).[2]

Even if survey-based measures are commonly used in the empirical literature testing different specification of the Phillips curve, the evidence on the relevance of model consistent vs. survey based measures from the complete New Keynesian models is scarce. Using European panel data Paloviita (2007) estimates a standard, 3-equation New Keynesian model with real time data and Consensus Economics survey measures of expected output gap and inflation. The study 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

[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.

Kortelainen at al. (2012) compares GMM and measured output gap and inflation expectations in estimating the conventional New Keynesian macro model for the euro area and the United States. The results obtained with survey-based measures of expectations perform slightly better and strongly reduce the importance of lagged output and inflation terms. Ormeño and Molnár (2015) show that survey-based measures of inflation expectations used in the DSGE model with adaptive learning allow avoiding unrealistic jumps in model-implied inflation expectations and contain additional information that is not present in the macro data alone.

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, stylised New Keynesian model of monetary policy transmission in Poland (MMPP).[3] The sample period is determined by the availability of survey data and starts in 2001, while ends in 2014.

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 the responses of the main macroeconomic variables represented in those models to monetary impulses, including the interest rate impulse, exchange rate impulse and inflation target impulse. To select the best-performing measure of inflation expectations, being relevant from the macroeconomic point of view, 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, i.e. if expectations data when used in forecasting models lead to better forecasting performance (Pesaran and Weale, 2006).

The paper has the following structure. Section 2 describes survey-based measures used in the study. Section 3 presents the structure of the MMPP model and discusses its estimation results with different measures of inflation expectations applied. Section 4 describes simulation results based on all the versions of the model and evaluates their forecasting accuracy. The final section concludes the study.

2 Survey-based measures of inflation expectations

In this part of the paper we present survey-based measures of inflation expectations of Polish consumers, enterprises and financial sector analysts used in estimating the small structural model of monetary policy (MMPP), built in the New Keynesian tradition.

2.1 Survey data on inflation expectations

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:

> *"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".*

[3]The first version of the MMPP model was calibrated and used in Demchuk et al. (2012), section III.3.

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, while previously (i.e. 2001Q1-2008Q2) it was quantitative. In contradiction to a similar question in the GUS consumer survey, the Quick Monitoring question 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".*

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).[4]

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.[5]

2.2 Quantification of inflation expectations of consumers and enterprises

To quantify consumer and producer inflation expectations in Poland we use probability method, proposed originally by Carlson and Parkin (1975) and then extended by Batchelor and Orr (1988).

There are three main assumptions of probability quantification methods that – without going into technical details – should be mentioned in order to illustrate the operation of those methods. The first assumption refers to the type of the distribution of expected inflation in the population, which is usually treated as a normal distribution. Even if other types of distributions are also tested in the literature, it seems that quantification results results are not much different from those based on the assumption that inflation expectations are normally distributed (see: Łyziak, 2010 for a discussion and the most important references). The second assumption refers to a measure of perceived inflation that serves the respondents expecting that prices will increase as a benchmark while 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"*). Two proxies are usually considered in this respect: either the most recent official CPI statistics available to respondents or the measure derived on the basis of an additional survey question concerning price changes during last 12 months.[6] The final feature of the probability quantification method that should be mentioned

[4] Lyziak (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 aggregate them 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).

[5] Since November 2000 till December 2010 and in March 2011 the Reuters survey question concerned 11-month horizon.

[6] In the case of GUS consumer survey this question has the following form: *"In your opinion, is the price level now compared to that 12 months ago: (1) much higher; (2) moderately higher; (3) a little higher; (4) about the same; (5) lower; (6) don't know".*

is thinking in terms of sensitivity intervals (indifference intervals). Probability methods assume that among respondents reporting that prices will increase at the same rate there are not only agents expecting that the annual price dynamics in 12 months will correspond exactly to the perceived rate of inflation, but also agents, whose expectations fall within a sensitivity interval centred on the perceived rate of inflation. Similarly, the response that prices will be stable is assumed to be chosen by agents expecting that future inflation will fall within an interval centred on zero.

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.

Quantifying enterprises' and consumers' inflation expectations to be used in the New Keynesian model we assume that expected inflation is normally distributed in the population. Currently available 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 and Łyziak, 2015) suggests that the perception of price changes by Polish consumers is based on a sub-basket of frequently bought goods and services.[7] 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.

2.3 Overview of survey-based measures of inflation expectations

Figure 1 presents survey-based measures of inflation expectations used in the study, while Table 1 summarizes their selected features.

Existing literature (Łyziak, 2013; Łyziak, 2014) indicates 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.

This separation is clearly visible in the results presented below (Figure 1, Table 1).[8] 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. 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 contradiction to consumer inflation expectations, expectational errors of financial sector analysts' and enterprises' expectations are lower than errors of naive forecasts.

[7] 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.

[8] It is therefore debatable, at least from the Polish perspective, if consumer inflation expectations should be used as a proxy for enterprises' inflation expectations, as assumed in some recent studies (e.g. Coibion and Gorodnichenko, 2013)

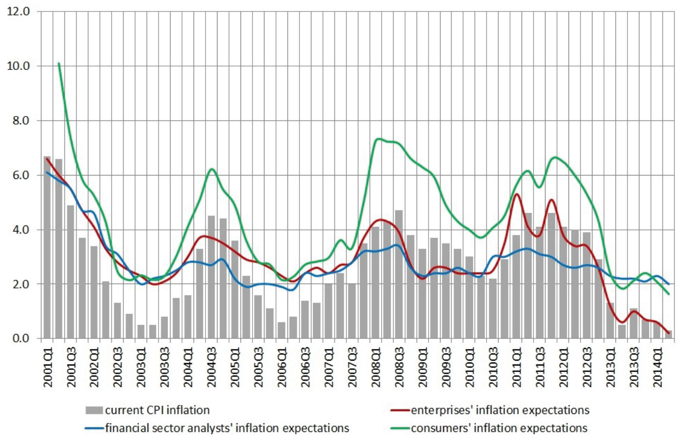

Figure 1: Inflation expectations and current CPI inflation in Poland

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

Notes: quarterly data, sample: 2001Q1-2014Q2; [*] – mean absolute error of naive forecasts.

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

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

3 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, i.e. the aggregate demand curve, the exchange rate formula, the Phillips curve and the monetary policy rule:

$$\hat{y}_t = \alpha_1 E_t \hat{y}_{t+1} + \alpha_2 y_{t-1} + \alpha_3 \hat{r}_{t-1} + \alpha_4 \hat{s}_{t-1} + \alpha_5 \hat{y}^{EA}_{t+1} + \varepsilon^{\hat{y}}_t \tag{1}$$

$$e_t = \beta E_t e_{t+1} + (1-\beta)\, e_{t-1} + 0.25\left(i_t - i^{EA}_t\right) + \varepsilon^e_t \tag{2}$$

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

$$i_t = \kappa_1 i_{t-1} + (1-\kappa_1)\left[\kappa_2\left(\pi_t - \pi^{tar}_t\right) + \kappa_3 \hat{y}_{t-1}\right] + \varepsilon^i_t \tag{4}$$

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)[9], 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 ($\pi^e_{t|t+4}$) there is an additional equation that explains their formation, treating expectations as a weighted average of past and future inflation (hybrid model of expectations):

$$\pi^e_{t|t+4} = \lambda \pi_{t-1} + (1-\lambda)\,\pi_{t+4} + \varepsilon^{\pi^e}_t \tag{5}$$

Estimating the MMPP model different measures of inflation expectations are used, i.e. 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 both in the Phillips curve and 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). The output gap, the real interest rate gap and the real exchange rate gap are calculated using the Hodrick-Prescott filter.

To estimate the models we use the GMM method. It is due to the fact that even if the residuals from the OLS estimation of the above equations seem not strongly correlated with each other, different right-hand side variables can suffer from measurement errors or simultaneity problem. Estimation results are shown in Table 2.

Equation (1) is the open-economy version of the IS curve. The domestic output gap is determined by the real interest rate gap, real exchange rate gap and foreign output. The specification considers also a lead and a lag of the output gap among explanatory variables, however, estimation results indicate that the future output gap in the euro area, the main trading partner of Poland, and the real interest rate gap 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.[10] 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 New Keynesian Phillips Curve (Galí and 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. Having not only expected future inflation, but also lagged inflation in the model can be motivated with different theoretical concepts (Kokoszczyński 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). Other similar explanation is based on the assumption that the standard Calvo pricing model, used in the derivation of

[9]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.

[10]A similar approach was used by Argov and Elkayam (2010).

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 and Gertler, 1999). Finally, the Relative Wage Model (Fuhrer and Moore, 1995) results also in the hybrid version of the NKPC.[11] 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. (2012) present similar results for the euro area and the United States, 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 not longer needed in the model, which is not the case in the estimation of the MMPP models.[12]

Equation (4) is the monetary policy rule. We use the modified Taylor (1993) rule, allowing for interest rate smoothing (Clarida et al., 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 target[13] and the output gap. Estimation results confirm earlier findings (see e.g. Baranowski, 2011; Sznajderska, 2014), suggesting 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 a hybrid model of inflation expectations, used to endogenise survey-based measures of consumers', producers' and financial sector analysts' inflation expectations. It assumes that a certain fraction of economic agents, λ, use static model to form opinions on future price developments, while 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.

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. 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.

[11] In the case of MMPP-RE model hybrid specification of the NKPC can also reflect heterogeneity of the formation of inflation expectations by economic agents. 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 prices decisions.

[12] Moreover, the results for the euro area and US show also that with measured expectations the lagged output gap term in the IS curve becomes smaller (Kortelainen et al., 2012). We do not observe such impact in the Polish model. It is probably due to the fact that Kortelainen at al. (2012) use Consensus Forecasts of output gap and inflation, while our analysis focuses on inflation expectations only.

[13] 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.).

Equation	Coefficient	Model			
		MMPP-RE	MMPP-E	MMPP-F	MMPP-C
(1)	α_2	0.832***	0.839***	0.857***	0.779***
		(0.014)	(0.011)	(0.011)	(0.024)
	α_3	-0.090***	-0.110***	-0.111***	-0.053**
		(0.011)	(0.031)	(0.014)	(0.024)
	α_4	-0.012***	-0.036***	-0.029***	-0.026***
		(0.005)	(0.005)	(0.003)	(0.003)
	α_5	0.275***	0.264***	0.333***	0.381***
		(0.019)	(0.019)	(0.010)	(0.020)
	adj. R^2	0.909	0.887	0.890	0.865
(2)	β	0.440***	0.389***	0.367***	0.365***
		(0.020)	(0.030)	(0.018)	(0.018)
	adj. R^2	0.847	0.865	0.861	0.860
(3)	γ_1	0.224***	0.465***	0.406***	0.390***
		(0.014)	(0.019)	(0.021)	(0.019)
	γ_2	0.011***	0.032***	0.026***	0.031***
		(0.002)	(0.002)	(0.002)	(0.001)
	γ_3	0.260***	0.330***	0.414***	0.267***
		(0.017)	(0.020)	(0.022)	(0.018)
	adj. R^2	0.873	0.917	0.887	0.913
(4)	κ_1	0.876***	0.876***	0.876***	0.877***
		(0.004)	(0.004)	(0.003)	(0.003)
	κ_2	1.795***	1.826***	1.852***	1.892***
		(0.242)	(0.257)	(0.131)	(0.154)
	κ_3	0.572***	0.547***	0.543***	0.512***
		(0.149)	(0.159)	(0.085)	(0.099)
	adj. R^2	0.988	0.988	0.988	0.988
(5)	λ	-	0.623***	0.605***	0.903***
			(0.021)	(0.014)	(0.008)
	adj. R^2	-	0.400	0.249	0.800
J-stat		0.251	0.251	0.262	0.253
J-prob		0.99	0.99	0.99	0.99

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 percent level, ** – significant at the 5 percent level, * – significant at the 10 percent level). The sample period is 2001Q1-2014Q1. The set of instruments contains (three) lags of dependent variables, which seems a common choice in the literature (see: Beyer et al., 2008). In the case of the hybrid New Keynesian Phillips curve we experimented with additional instruments, as suggested in empirical studies (see Mavroeidis at al., 2014, for a survey), i.e.: lags of wage inflation, oil price inflation and dynamics of import prices, but the results were approximately the same.

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

4 Empirical analysis

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 generated responses of the main macroeconomic variables to three monetary impulses, i.e.: the interest rate impulse, the exchange rate impulse and to a permanent change of the inflation target. The results of the first simulation illustrate the operation of the monetary transmission mechanism, the results of the second simulation allow assessing the exchange rate pass-through, while the results of the third show the sacrifice ratio, i.e. the cumulative output loss required to reduce inflation permanently by 1 percentage point.

Anticipating the results presented in detail in subsequent parts of this section of the paper we can conclude that in general, impulse responses obtained from all the models under consideration share some common features, consistent with the results reported in existing literature on the monetary transmission mechanism in Poland (e.g. Demchuk et al., 2012; Kapuściński et al., 2014). Firstly, the lags of the monetary transmission mechanism are similar to earlier studies and even if the strength of this mechanism differes among the models we estimate, it falls in the range suggested in the existing literature. Secondly, the results concerning the exchange rate pass-through are similar across all the versions of the MMPP models with survey-based measures of inflation expectations and consistent with previous results reported in the literature and suggesting that the exchange rate exerts statistically significant influence on price developments. Thirdly, simulation results confirm that the impact of the exchange rate on the real activity is rather small. Fourthly, due to violation of the rational expectations hypothesis and rigidities in the Polish economy, a permanent reduction of inflation requires output loss and the estimated sacrifice ratio is similar to previous estimates.

At the same time there are some differences in the results obtained from the models using different measures of inflation expectations. We analyse them in subsequent parts of this section.

4.1.1 Interest rate impulse

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 does not operate (so the impulse is equal exactly to 1 percentage point), while in the subsequent quarters the interest rate is set according to the monetary policy rule. Table 3 presents maximum responses of main 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.

There are different channels of the monetary transmission mechanism represented in the MMPP model, including the interest rate channel, the exchange rate channel and the inflation expectations channel. All of them support each other in bringing inflation down after the contractionary impulse of monetary policy.

The nominal effective exchange rate appreciates immediately after the interest rate impulse. The magnitude of this effect is relatively strong 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.

The real activity is affected by contractionary impulse of monetary policy. 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 strong responses, similar to each other. The peak response takes place in the 4th quarter after the impulse.

Central banks try to affect expectations in the economy, because it makes the monetary policy decisions more effective and less costly. All the measures of inflation expectations we use in the MMPP model do 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 using 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 case of the MMPP model with survey-based measures of enterprises' and financial sector analysts' inflation expectations (approx. 0.7 and 0.9 percentage point respectively).

4.1.2 Exchange rate pass-through

Analysing the exchange rate pass-through we make the nominal effective exchange rate (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 alternative models.

Following the exchange rate impulse the central bank reduces its short-term interest rate. The impact of the exchange rate impulse on the real activity is rather small, which can result from the role played in Polish trade by international companies, which settle their accounts within a capital group (Kapusciński 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).

4.1.3 Sacrifice ratio

The way, in which inflation expectations are formed, is highly important from the point of view of costs of monetary policy. Therefore 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 case of 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 ration 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 expectations built in this model, results from the fact that the weight of past inflation in the NKPC of this model is the highest among analysed models (see Table 2).

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.

Impulse to:	Response of:	Feature	Model			
			MMPP-RE	MMPP-E	MMPP-F	MMPP-C
Interest rate	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

Table 3: Interest rate impulse, selected results

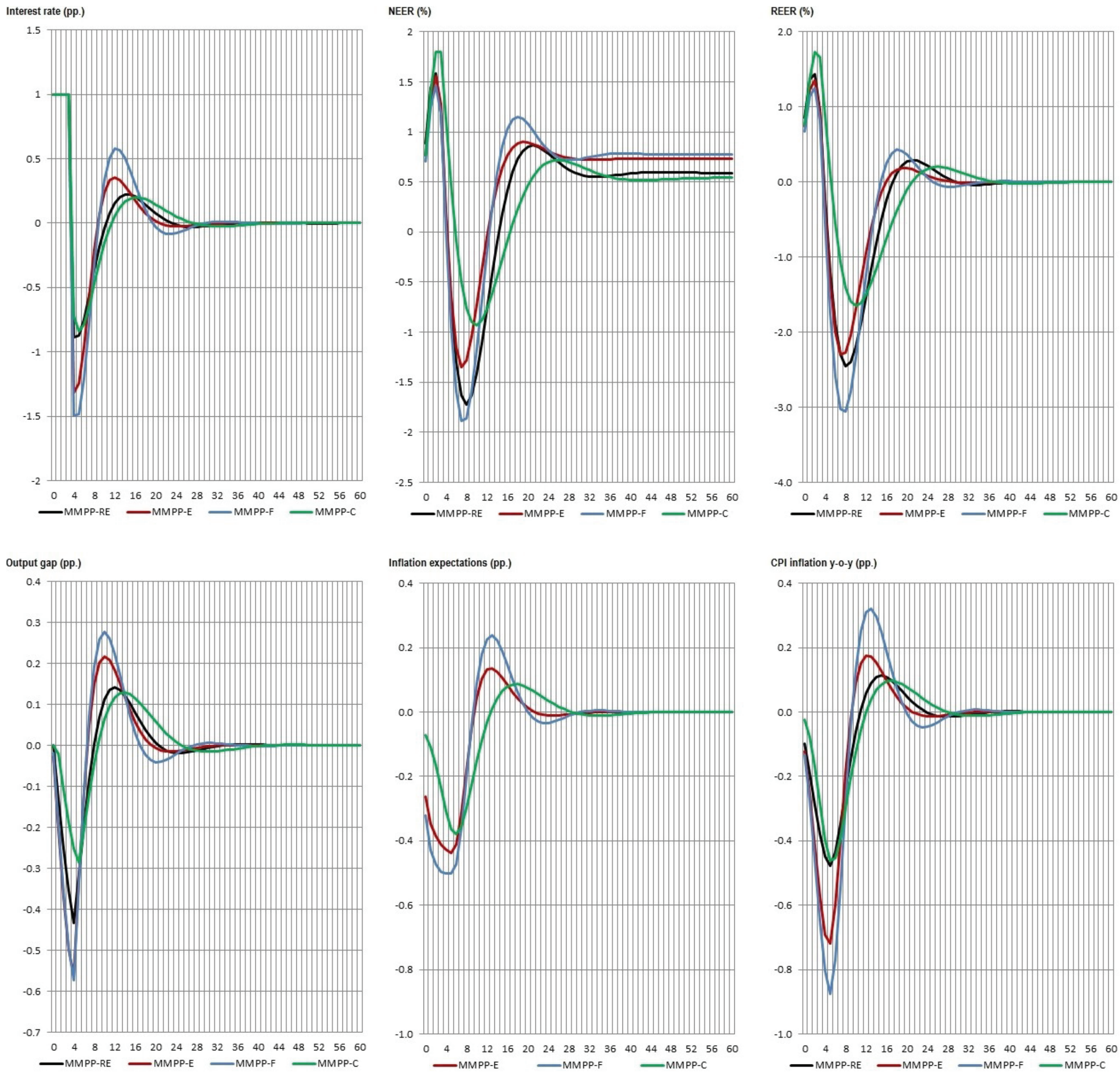

Figure 2: Interest rate impulse, detailed results

Impulse to:	Response of:	Feature	Model			
			MMPP-RE	MMPP-E	MMPP-F	MMPP-C
NEER	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

Table 4: Exchange rate impulse, selected results

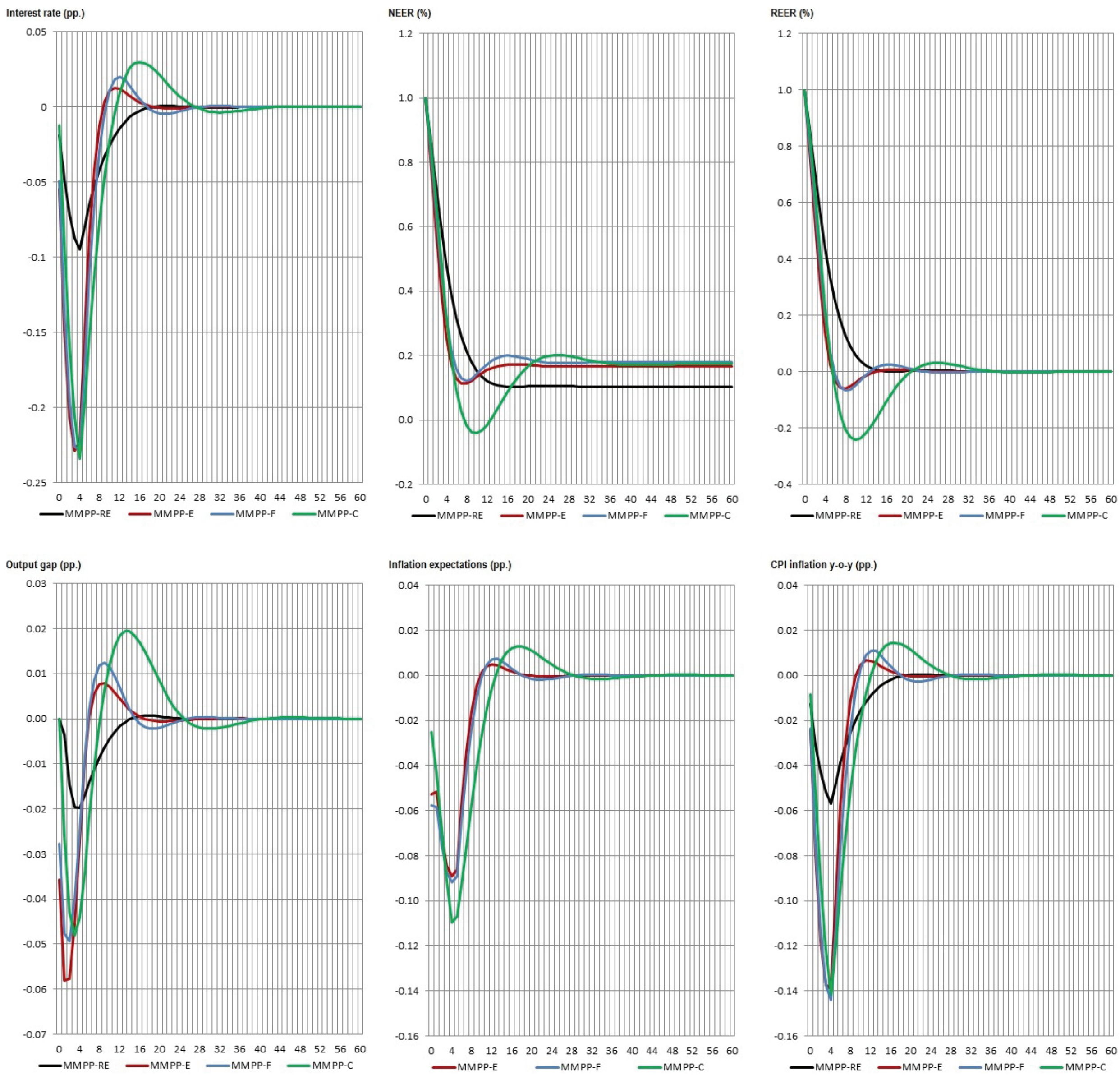

Figure 3: Exchange rate impulse, detailed results

Impulse to:	Response of:	Feature	Model			
			MMPP-RE	MMPP-E	MMPP-F	MMPP-C
Inflation target	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
	Inflation expectations	maximum response	x	-1.06	-1.10	-1.00
		quarter of maximum response		14	12	80
	Inflation	maximum response	-1.16	-1.07	-1.12	-1.00
		quarter of maximum response	10	14	12	80

Table 5: Permanent change of inflation target, selected results

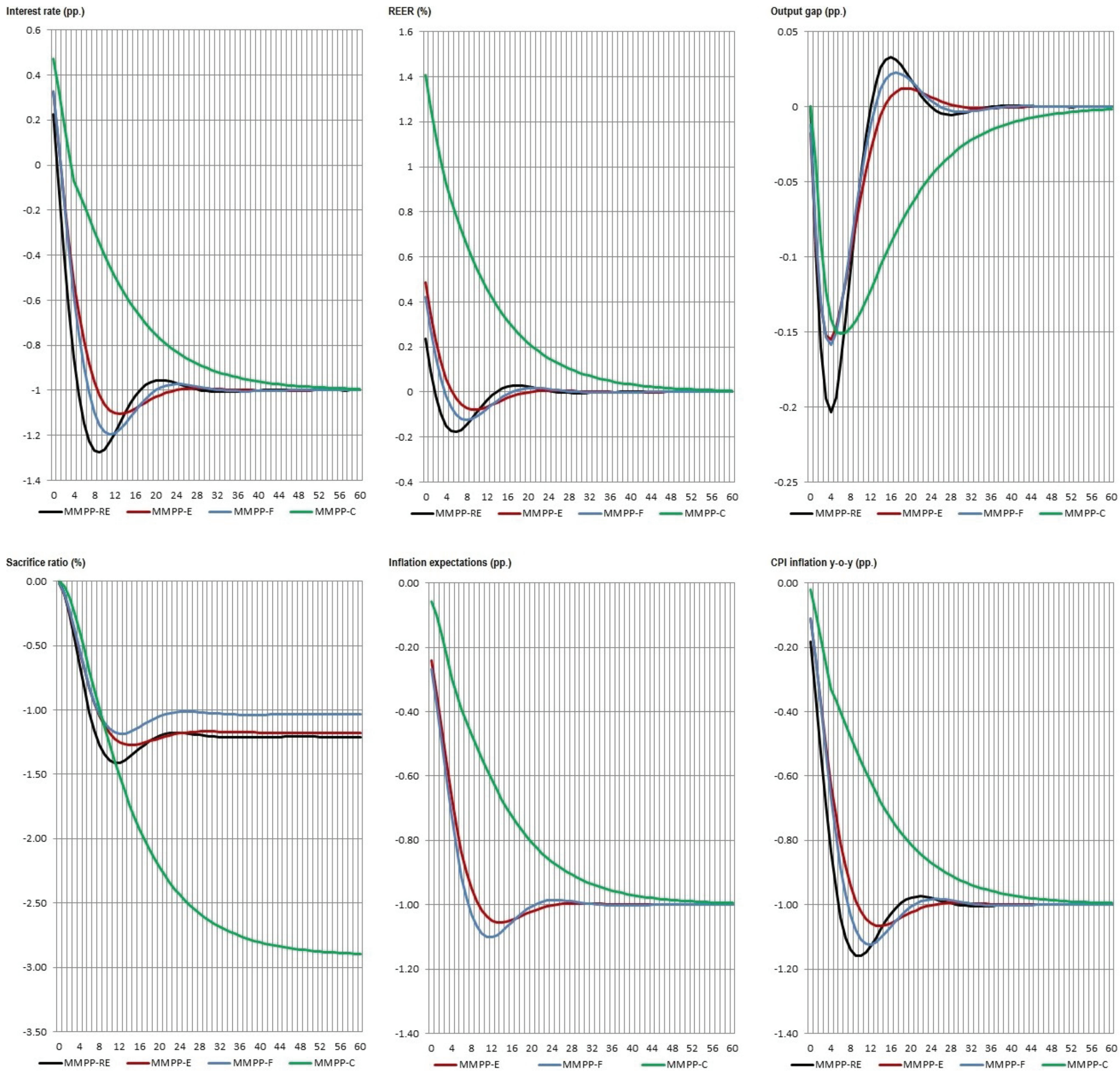

Figure 4: Permanent change of inflation target, detailed results

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 the detailed results concerning the operation of the monetary transmission mechanism. The question, which naturally arises at this 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 this question we conduct additional simulations that verify forecasting accuracy of alternative versions of the MMPP 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. Based on theoretical values obtained we calculate the measures of forecast accuracy, including: the mean error (ME), the mean absolute error (MAE) and the mean absolute percentage errors (MAPE) 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 using survey-based inflation expectations outperform the MMPP-RE model in terms of absolute forecasting errors (MAE and MAPE). 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. It should be noted, however, than in the case of each of the groups of economic agents considered forecasting accuracy of the models, in which their inflation expectations are used, is better than forecasting accuracy of inflation expectations measures themselves (see Table 1 for a comparison).

Taking into account MAE and MAPE we can conclude that the measure of enterprises' inflation expectations is the best-performing measure of expectations. In the horizon of effective monetary transmission (4-6 quarters), the mean absolute error 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.

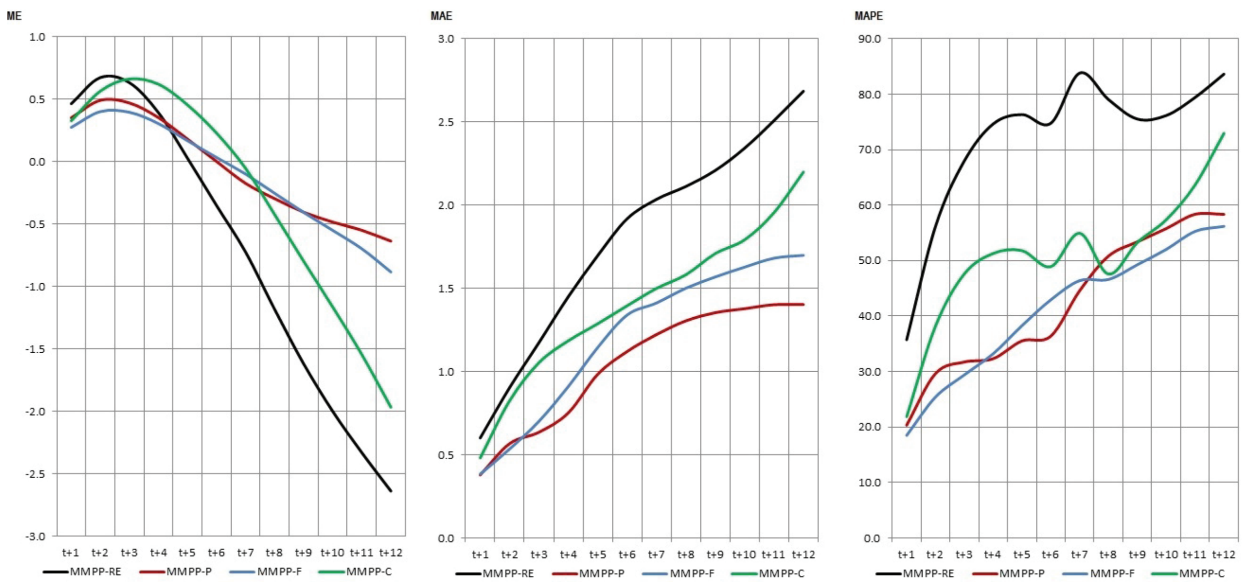

Figure 5: Forecasting accuracy

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).

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 statistics	-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 statistics	-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 statistics	-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 statistics	-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 statistics	-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 statistics	-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 statistics	-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 statistics	-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 statistics	-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 statistics	-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 statistics	-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 statistics	-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

Notes: *** – significant at the 1 percent level, ** – significant at the 5 percent level, * – significant at the 10 percent level.

Table 6: The results of the Diebold-Mariano (1995) test

Finally, 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 shows 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 suggest 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. This conclusion applies especially for survey measures of inflation expectations formed by enterprises.

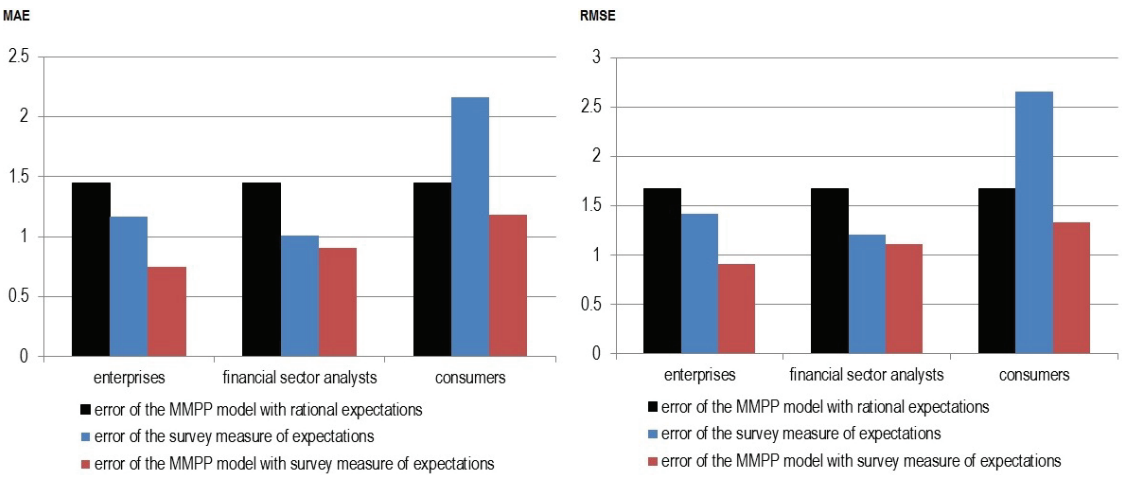

Figure 6: Forecasting accuracy gains from using survey-based measures in the MMPP model

The results discussed above seem consistent with theoretical considerations, perceiving inflation expectations of price setters as the most relevant from the macroeconomic perspective. In the case of enterprises expectations declared in the survey reflect not only their subjective beliefs concerning an abstract variable, but – to a large extent – they are likely to reflect actual plans of price changes enterprises have for the near future.

5 Conclusions

The results presented in this paper are meaningful from the point of view of two research question: 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?

The answer to the former question, conditional on the type of the macro model we use, is positive. Survey-based measures of inflation expectations of Polish consumers, financial sector analysts and, particularly, enterprises, used in the small New Keynesian model of monetary policy do improve its forecasting properties relative to its version with rational (model-consistent) expectations. In line with macroeconomic theory and intuition, inflation expectations of enterprises seem the most relevant from the macroeconomic perspective. As such, they should be treated as an important element of the information set used by monetary policymakers.

Simulations performed with the use of the stylised 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. After the increase of the short-term interest rate by 1 percentage point for 4 quarters, CPI inflation is reduced by -0.72 percentage point in the 5th quarter after the monetary policy contraction. After 1% appreciation of the NEER for 1 quarter, CPI inflation is reduced by 0.14 percentage point in the 4th quarter after the exchange rate impulse. The sacrifice ratio estimated on the basis of the MMPP model with enterprises inflation expectations is about 1.27% – slightly less than in the model with rational expectations. It is due to the fact that the weight of past inflation in the hybrid NKPC in the MMPP-RE model is larger than in the MMPP-E model.

The analysis, whose results are presented in this paper, can be extended in different directions. Three of them seem especially appealing. Firstly, it would be interesting to confront forecasting accuracy of different versions of the MMPP model used in this paper with forecasting accuracy of atheoretical models, such as Vector Autoregression (VAR) models. Secondly, evaluating out-of-sample forecasting errors could be important to assess the robustness of the findings reported above. Finally, using not only survey-based measures of inflation expectations, but also direct measures of expectations related to economic activity, would make the analysis complete. However, defining such expectations in the context of consumer and producer surveys can be more problematic than in the case of expectations of financial sector analysts.

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