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Reaction functions of the Polish central bankers. A logit approach

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Reaction functions of the Polish central bankers. A logit approach

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Abstract

Paper presents the analysis of individual reactions functions of Polish Monetary Policy Council (MPC) members in the years 2004–2005. In the period under study the Polish central bank (National Bank of Poland) used the bias in the monetary policy as an indicator of future interest rate movements and a change of bias without a change in the short-term interest rate resulted in shifts of the yield curve comparable to those which accompanied changes in the short-term interest rate. For that reason as a monetary policy instrument in the reaction functions we use a qualitative variable, which expresses the direction of change in the restrictiveness of the monetary policy proposed by the given member of the MPC (the change of bias and/or change of central bank short-term interest rate). Taking into account the qualitative nature of the dependent variable, we employ the ordered logit model, where several variants of the reaction functions are tested.

The results of the research indicate that the majority of the Polish MPC members acted forward looking rather then backward looking. The classical Taylor's backward looking reaction function has been rejected by the data for most MPC members. Moreover the substitution of the lagged inflation by the future inflation improved the quality of the all considered models. On the other hand in the forward looking reaction function with the inflation expectations formulated for 12 months ahead the variable expressing the expectations has been significant in 6 out of 7 individual functions. The research has been completed by the sensitivity analysis of the behaviour of the MPC members against changes in the current and future inflation and changes in the output gap.

Keywords: Monetary policy, policy rules, reaction function, ordered logit model
JEL codes: C35, E52, E58, F41

1. Introduction

The study attempts to identify individual reaction functions of the Polish Monetary Policy Council members in the period 2004–2005.

In this case, the term "central bank's reaction function" means the rule according to which the central bank sets the short-term interest rate (see Taylor [1993], [2001], Woodford [2003]). The central bank's reaction function, which describes the dependency between the basic instrument of monetary policy, i.e. the short-term interest rate, and each of its determinants (in most cases inflation, output gap and real exchange rate), is one of the key elements of monetary transmission mechanism. Together with the inflation equation and the IS curve, which describes the relation between the size of the output gap and the real interest rate, the central bank's reaction function is the most aggregated form of structural model of monetary transmission mechanism in a closed economy (in case of an open economy the model has to be extended to include an equation which explains changes in the real exchange rate) (Taylor [2001], see also Kokoszczyński *et al*. [2002]).

Many studies and papers in the field of monetary policy have been devoted to analysing the reaction function, and in most cases the monetary policy instrument was a continuous variable, most often the short-term interest rate from the money market (see e.g. Clarida *et al*. [1998], Kłos *et al*. [2004]).

In this study we applied a slightly different approach, according to which the dependent variable in the central bank's reaction function is a qualitative variable. This variable can have three different values (–1, 0 and 1), corresponding to such decisions of the central bank which lead to easing the monetary policy, leaving it unchanged or tightening the monetary policy. The qualitative nature of the dependent variable in the central bank's reaction function results from the fact that in the years 2004-2005 the Monetary Policy Council used the bias in the monetary policy as an indicator of future interest rate changes in (RPP [2004]). A detailed analysis of the yield curve in the period covered by the study indicates that a change of bias without a change in the short-term interest rate resulted in shifts of the yield curve comparable to those which accompanied changes in the short-term interest rate. For this reason, if the issue of bias were omitted in the study, this might distort the real picture of reactions of the Council to behaviour of the variables which together make up the central bank's reaction function.

Over the period covered by the study, MPC increased the interest rates three times and cut them four times, as well as made one change in bias of each kind: from neutral to

tightening, from tightening to easing, from easing to neutral and from neutral to easing. Eight meetings of the Council ended up with a decision to leave both the interest rates and the bias unchanged.

Taking into account the fact that the Monetary Policy Council is a collective body and in the period covered by the study most decisions were not taken unanimously, in this study we identified reaction functions for each Council member separately. The applied approach enabled an estimate of parameters of individual reaction functions and created the conditions for comparing the sensitivity of the Council members to changes in each determinant of the future inflation.

Due to the qualitative character of the dependent variable, the microeconometric approach is used, in which ordered logit model was chosen to describe the behaviour or the tested variable.

2. Reaction function of the Monetary Policy Council

2.1. The form of the reaction function

The point of departure for specification of the reaction function for Polish central bank may be the well known Taylor rule, which has been widely used to describe the process of decision making in the European Central Bank (Clarida *et al*. [1998]). This rule may be formulated as follows (Taylor [1999])

$$i_t = r + \hat{\pi} + \kappa(\pi_t - \hat{\pi}) + \lambda(y_t - y^*_t), \tag{1}$$

where $\kappa, \lambda \geq 0$, variable i_t represents the monetary policy instrument (short-term interest rate), while r is the value of the long-term real interest rate, which is constant in this approach. The long-term nominal interest rate is then the aggregate of the real rate r and the central bank's inflation target $\hat{\pi}$, which is constant as well. In the Taylor rule (1) variable π_t expresses the inflation rate, variable y_t is the actual real output, while y^*_t is the potential output. The difference $y_t - y^*_t$ is called the output gap.

On the basis of (1) the central bank changes the nominal interest rate i_t, if current inflation differs from the inflation target or if the actual GDP differs from the potential output.

To describe the process of decision making in the Monetary Policy Council in Poland in the period 2004–2005 we propose the extend the Taylor rule by including the real exchange

rate variable on the right hand side of equation (1). In a small open economy exchange rate affects the level of inflation either directly, by changes in prices of imported goods included in the inflation basket, or via the output gap. For that reason the exchange rate may be an indicator of inflationary pressure in the economy.

In its Monetary Policy Guidelines for the years 2005 and 2006, the Monetary Policy Council stated that *"in assessing the stance of monetary policy not only the level of real interest rates should be considered but also the level of real exchange rate."* (RPP [2004], RPP [2005]). That is why we may suppose that MPC, when setting interest rates, took into account not only changes in the current inflation and deviation of actual output from the potential one, but also changes in real exchange rate.

Such a reaction function corresponds to the central bank's policy rule proposed by Ball [1999] (see also McCallum and Nelson [2000] and Taylor [2001]) who suggests, for a small open economy, a form of the policy rule including, apart from the deviation of inflation from the inflation target and the output gap, also the real exchange rate. This function may be written in the form

$$i_t = \kappa(\pi_t - \hat{\pi}) + \lambda(y_t - y^*_t) + \varphi_0 e^r_t + \varphi_1 e^r_{t-1}, \tag{2}$$

where $\varphi_0 > 0$, $\varphi_1 < 0$, and variable e^r_t expresses the real effective exchange rate[1].

In this study, we will discuss three variants of the central bank's reaction function (2), which differ in their definitions of variables on the right-hand side of the equality sign and in the interpretation of the MPC behaviour.

The firsts variant of the reaction function represents the hypothesis that MPC in Poland is backward looking. In this variant, the reaction function includes the following variables: inflation rate lagged by one period, the variable expressing seasonally adjusted annual growth rate of industrial output, also lagged by one period, and the variable expressing the month's average value of the nominal EUR/PLN exchange rate. In contrast to the equation (2), the function suggested for the Polish economy includes the inflation rate lagged by one period[2], because the Council knows only last month's value of inflation when it takes decisions on the interest rates.

In accordance with formula (2), the central bank reacts to inflation deviating from the inflation target, however, taking into account that the inflation target was constant in the

[1] Growth of e^r_t means depreciation of the real exchange rate.
[2] The analysis was based on monthly data.

period covered by the study, the deviation from target can be replaced with the inflation rate, which will not affect the estimate of the parameter connected with this variable. In the proposed reaction function, output gap was treated in the same way. Assuming that in the period covered by the study, that is 2004–2005, the potential rate of output growth was constant, the output gap from formula (2) was replaced with seasonally adjusted annual growth rate of industrial output (also from the preceding period), which information is available in the monthly cycle. Then, considering the small difference in inflation rates in Poland and in the European Union in the period covered by the study, the real exchange rate was replaced with the nominal one. In addition, the effective exchange rate was not chosen, and only the bilateral rate against euro was left in the reaction function[3].

Two other proposals of the reaction function correspond to the hypothesis that MPC in Poland acts forward looking.

In the second variant of the central bank's reaction function, on the right hand side there is only the expected inflation rate for 12 months. The inclusion in equation (2) of the expected inflation rate instead of the current inflation corresponds to the hypothesis that the Monetary Policy Council takes decisions concerning interest rates bearing in mind the future and not the current inflation value. This is consistent with "Monetary policy guidelines for 2005", where the Council expressed the opinion that *"because of delayed reaction of output and inflation to monetary policy, its influence on the current inflation is small. Any current action of the central bank affects price developments in the future, just as the current inflation is influenced by interest rate changes made several quarters before."* (RPP [2004]). In this variant the other two variables (i.e. seasonally adjusted growth rate of output and the growth rate of nominal exchange rate) are not used, which stays in line with the hypothesis that information derived from observation of lagged values of output gap and exchange rate are already included in the expectations concerning inflation in a year's time.

In the third variant of the reaction function, we assume that the Council does not react to current or expected values of inflation, output growth and exchange rate, but to deviations of actual values of these variables from the previous expectations. Consequently, in equation (2) the deviation of inflation from the inflation target is replaced with the difference between the expected inflation value for period t–1 and the actual value of this variable. In turn, the output gap is replaced with the difference between the expected annual industrial production growth dynamics for period t–1 and its actual realisation, while the exchange rate is replaced

[3] The results obtained for the nominal and real exchange rates were very similar and led to the same conclusions (see subsection 4.1).

with the difference between the real EUR/PLN exchange rate at the end of the given month and the earlier expectations relating to the value of this variable[4].

Summarising, the relevant variants of the reaction function of the Monetary Policy Council may be written as follows

$$\text{Variant I:} \quad i_t = \kappa_1 \pi_{t-1} + \lambda_1 \Delta_{12} y_{t-1} + \varphi_1 e^{avg}{}_t, \tag{3a}$$

$$\text{Variant II:} \quad i_t = \kappa_2 \pi^e{}_{t+12}, \tag{3b}$$

$$\text{Variant III:} \quad i_t = \kappa_3(\pi_{t-1} - \pi^e{}_{t-1}) + \lambda_3(\Delta_{12} y_{t-1} - \Delta_{12} y^e{}_{t-1}) + \varphi_3(e_t - e^e{}_t). \tag{3c}$$

In the model (3a)-(3c) symbols κ_i, λ_i, φ_i for $i = 1,2,3$ mean constant parameters of the central bank's reaction function, π_{t-1} expresses inflation rate in period t–1, $\pi^e{}_{t+12}$ expresses the expected inflation for period t+12 formulated in period t. In addition, variable $\Delta_{12} y^e{}_{t-1}$ represents the expectations as to the value of annual dynamics of industrial production growth in period t–1, while $\Delta_{12} y_{t-1}$ is the actual realisation of this variable. In turn $e^{avg}{}_t$ and e_t signify the values of nominal EUR/PLN exchange rate being, respectively, the month's average and the value at the end of the given month, while $e^e{}_t$ is the measure of expectations as to the value of EUR/PLN exchange rate at the end of the given month.

2.2. Data description

The study was based on monthly data for the period from February 2004 to July 2005 (a total of 18 observations). Inflation rate, calculated as the relative annual change in prices of consumer goods and services (variable cpi_t), and seasonally adjusted annual dynamics of industrial production growth (variable $prod_t$), were taken from the database of the Central Statistical Office. Values of the nominal exchange rate, both at the month end (variable e_t), and the monthly averages (variable $e^{avg}{}_t$), come from publications of the National Bank of Poland. Average expectations concerning the inflation level (variables $cpi^e{}_{t+12}$ and $cpi^e{}_{t-1}$), industrial production growth (variable $prod^e{}_{t-1}$) and EUR/PLN rate (variable $e^e{}_t$)[5] were

[4] In the third variant, the average monthly exchange rate was replaced with the value of exchange rate at the end of the month, since results of Reuters poll questionnaires used in this study do not contain expectations as to the average monthly value of exchange rate, but only as to the value of exchange rate at the end of the month.

[5] Undoubtedly a better measure of the future inflation rate expected by MPC would be a published inflation forecast prepared by the Council itself. However, the Council does not provide official inflation forecasts, while in this case it is impossible to use in the study the inflation forecasts originating from the inflation projection of NBP and it is so for several reasons. First, the projection is prepared on the assumption of unchanged interest

determined based on Reuters poll conducted every month among economists and bank analysts.

2.3. Definition of dependent variable in individual MPC members reaction functions

The reaction function in the form (3a)-(3c) was determined separately for each MPC member. The dependent variable in equations (3a)-(3c) is a qualitative variable and expresses the direction of change in the restrictiveness of the monetary policy proposed by the given member of the Monetary Policy Council. A change in the restrictiveness is reflected by a change of the reference rate or/and a change of bias in the monetary policy. Increase of the reference rate and change in bias from easing to neutral or from neutral to restrictive means increased restrictiveness of the monetary policy. If the interest rate is left unchanged and there is no change in bias, this indicates that restrictiveness of the monetary policy has not changed. Finally, reduction of the reference rate and change in bias from restrictive to neutral or from neutral to easing are interpreted as falling restrictiveness of the monetary policy[6].

Thus, dependent variable i_t determined separately for each member of the Monetary Policy Council may have the following values:

$$i_t = \begin{cases} -1 - \text{if in month } t \text{ the given Council member voted for easing of the monetary policy} \\ 0 \text{ - if in month } t \text{ the given Council member voted for leaving the restrictiveness unchanged} \\ 1 \text{ - if in month } t \text{ the given Council member voted for tightening the monetary policy.} \end{cases}$$

However, this definition of variable i_t does not guarantee that each observation can be unequivocally attributed the appropriate value of –1, 0 or 1, because in the period covered by the study there occurred a situation when certain MPC members at the same meeting voted for changing the bias from easing to neutral (that is for tightening the bias) while supporting the decision to cut interest rates. For this reason, additional assumptions had to be made for determining specific values of variable i_t:

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rates in the period covered by the projection, which does not have the be the most probable variant. Second, the projections were prepared at quarterly intervals and only from August 2004, which would significantly reduce the available statistical sample. Third, some Council members openly distanced themselves from the projections, stressing that they were projections of research staff of NBP and not projections of the Council.

[6] At this stage of the research we ignore the interdependencies between particular MPC members, which in fact may have an impact on their final decisions (see Lombardelli *et al*. [2002])

- voting, at the same time, for reduction of interest rates (falling restrictiveness) and for change of bias from easing to neutral (rising restrictiveness) is treated in aggregate as no change of the restrictiveness of the monetary policy, that is $i_t = 0$;
- voting, at the same time, for cutting interest rates and against change of bias from neutral to easing is interpreted as voting for easing of the monetary policy, that is $i_t = -1$;
- only the results of final voting were taken into account, i.e. if, during several partial votes at the given meeting, any Council member supported e.g. interest rate reduction, but in the final vote he/she was in favour of leaving the rates unchanged, then this result was treated as no change in the restrictiveness of the monetary policy, that is $i_t = 0$.

Table 1 presents, for each member of the Monetary Policy Council, values of variable i_t, which expresses the proposed direction of changes in the restrictiveness of the monetary policy. These values were determined based on the voting results published by the National Bank of Poland in "Inflation Reports" for 2004–2005.

Table 1. Values of dependent variable in individual reaction functions of each MPC member

	Variable Name	02.04	03.04	04.04	05.04	06.04	07.04	08.04	09.04	10.04	11.04	12.04	01.05	02.05	03.05	04.05	05.05	06.05	07.05
Leszek Balcerowicz	*LB*	0	0	1	0	1	1	1	0	0	0	0	0	0	-1	0	0	-1	0
Jan Czekaj	*JC*	0	0	1	0	1	0	1	0	0	0	0	-1	-1	-1	0	-1	-1	-1
Dariusz Filar	*DF*	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	-1	0
Stanisław Nieckarz	*SN*	0	0	0	0	1	0	0	0	0	0	0	-1	-1	-1	0	0	-1	-1
Marian Noga	*MN*	0	0	1	0	1	1	1	0	0	0	0	0	0	-1	0	0	-1	0
Stanisław Owsiak	*SO*	0	0	1	0	1	0	1	0	0	0	0	0	-1	-1	0	-1	-1	-1
Mirosław Pietrewicz	*MP*	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	0	-1	-1	-1
Andrzej Sławiński	*AS*	0	0	1	0	1	1	1	0	0	0	0	-1	-1	-1	0	-1	-1	-1
Halina Wasilewska-Trenkner	*HWT*	0	0	1	0	1	1	1	0	0	0	0	0	0	-1	0	0	-1	0
Andrzej Wojtyna	*AW*	0	0	1	0	1	1	1	0	0	0	0	-1	-1	-1	0	-1	-1	-1

Source: Own calculations; Reports on Inflation 2004–2005.

It is worth observing that, according to the definition of variable i_t adopted in our study, in the period covered by the study Marian Noga and Halina Wasilewska-Trenkner voted always in the same way as Leszek Balcerowicz. In all the meetings taken into account here, also Andrzej Sławiński and Andrzej Wojtyna voted in the same way. Therefore, the empirical part of this paper will focus only on 7 individual functions of the Council members.

The results of these analyses will be presented in section 4, while section 3 describes the testing method applied in this paper, that is, a logit analysis.

3. Ordered logit model

3.1. Model form

The form of MPC reaction function was identified based on ordered logit model in which the dependent variable is a qualitative variable, but its subsequent categories, when quantified, may be ordered from the lowest to the highest one (see e.g. Pindyck, Rubinfeld [1991], Liao [1994], Maddala [1998]). In this model we assume that when taking decisions in the field of monetary policy, each Council member has a certain specified utility function which may be described using a non-observable variable I_t^* (where t is the number of the subsequent period – in this case month). Next we assume that the level of utility, that is, the value of variable I_t^*, depends on the values of variables used in the central bank's reaction function as explanatory variables, which may be written in a general form as

$$I_t^* = \beta_1 x_{1t} + \beta_2 x_{2t} + ... + \beta_k x_{kt} + \varepsilon_t = \mathbf{x}_t^T \boldsymbol{\beta} + \varepsilon_t \text{ dla } t = 1,...,T \quad (4)$$

where x_{it}, for $i = 1,..., k$ means the variables making up the central bank's reaction function, β_i reflects the value of the parameter which measures the influence of i-th variable on the level of utility of a Council member, while ε_t is the random disturbance with zero expected value and constant variance. In this study, according to equation (2) the explanatory variables in formula (4) may be: deviation of inflation from inflation target, output gap and pace of increase of exchange rate.

In accordance with the assumption, I_t^* is a non-observable variable. We know, however, that the value of this variable, that is the level of utility of a Council member, conditions the decision taken by him/her as regards the interest rates or the bias in the monetary policy. Therefore, even though we do not have the values of variable I_t^*, instead we may observe the decisions of the Council member, which depend directly on the value of this variable. The relation between values of variable Y_t, which describes the decisions of an MPC member[7], and the non-observable index I_t^* may be expressed as follows (cf. e.g. Liao [1994])

[7] Variable y_t in section 3 corresponds to variable i_t in the remaining part of the paper.

$$y_t = -1 \text{ if } -\infty < I_t^* < \tau_1, \tag{5a}$$

$$y_t = 0 \text{ if } \tau_1 \le I_t^* < \tau_2, \tag{5b}$$

$$y_t = 1 \text{ if } \tau_2 \le I_t^* < \infty. \tag{5c}$$

Formulas (5a)-(5c) mean that if non-observable variable I_t^*, which in accordance with (4) constitutes a linear combination of variables making up the central bank's reaction function, is lower than a certain limit value τ_1, then the given MPC member will decide to loosen the monetary policy (that is, to reduce interest rates or to change the bias from restrictive to neutral or from neutral to easing). If variable I_t^* is within the range from τ_1 to τ_2, then the Council member will vote for leaving the rates and the bias unchanged. Finally, if variable I_t^* exceeds the limit value of τ_2, then the given Council member will vote for tightening the monetary policy (that is, for increase of interest rates or changing the bias to a more restrictive one).

Therefore, the dependency described above indicates that increased value of variable I_t^* is accompanied by increased restrictiveness of the monetary policy, preferred by the given Council member.

Assuming a specific distribution for the random component ε_t the parameters of equation (4) may be estimated using the maximum likelihood method. In the literature of the subject the two most often used types of distribution are: normal distribution and logistic distribution. In the first case, the analysed model is called probit model; in the second case we get a logit model (Pindyck, Rubinfeld [1991]). For the purposes of this study it was assumed that random component ε_t had logistic distribution.

Having selected the appropriate distribution, we can determine the conditional probabilities of the Council member taking a decision to ease, leave unchanged or tighten the monetary policy.

The probability, conditional on the values of variables making up vector $\mathbf{x}_t$, of easing of the monetary policy can be expressed as

$$P(y_t = -1 | \mathbf{x}_t) = P(I_t^* < \tau_1 | \mathbf{x}_t) = P(\mathbf{x}_t^{\mathrm{T}}\boldsymbol{\beta} + \varepsilon_t < \tau_1 | \mathbf{x}_t) = P(\varepsilon_t < \tau_1 - \mathbf{x}_t^{\mathrm{T}}\boldsymbol{\beta} | \mathbf{x}_t) =$$
$$= F(\tau_1 - \mathbf{x}_t^{\mathrm{T}}\boldsymbol{\beta}) \tag{6}$$

which, after adoption of the assumption of logistic distribution of the random component e_t, finally gives us

$$P(y_t = -1|\ \mathbf{x}_t) = \frac{\exp(\tau_1 - \mathbf{x}_t^T\boldsymbol{\beta})}{1+\exp(\tau_1 - \mathbf{x}_t^T\boldsymbol{\beta})}. \tag{7a}$$

In the same way we can express also the conditional probabilities of lack of change in the monetary policy and tightening of the monetary policy

$$P(y_t = 0|\ \mathbf{x}_t) = \frac{\exp(\tau_2 - \mathbf{x}_t^T\boldsymbol{\beta})}{1+\exp(\tau_2 - \mathbf{x}_t^T\boldsymbol{\beta})} - \frac{\exp(\tau_1 - \mathbf{x}_t^T\boldsymbol{\beta})}{1+\exp(\tau_1 - \mathbf{x}_t^T\boldsymbol{\beta})}, \tag{7b}$$

$$P(y_t = 1|\ \mathbf{x}_t) = 1 - \frac{\exp(\tau_2 - \mathbf{x}_t^T\boldsymbol{\beta})}{1+\exp(\tau_2 - \mathbf{x}_t^T\boldsymbol{\beta})}. \tag{7c}$$

Using formulas (7a)-(7c), the logarithm of likelihood function for the analysed logit model may be formulated in the following form

$$L(\boldsymbol{\beta}, \boldsymbol{\tau}|\mathbf{y}, \mathbf{X}) = \prod_{j=-1}^{1}\prod_{y_t=j} P(y_t = j|\mathbf{x}_t, \boldsymbol{\beta}, \boldsymbol{\tau}) =$$

$$= \prod_{t=1}^{T}\left[\left(\frac{\exp(\tau_1 - \mathbf{x}_t^T\boldsymbol{\beta})}{1+\exp(\tau_1 - \mathbf{x}_t^T\boldsymbol{\beta})}\right)\left(\frac{\exp(\tau_2 - \mathbf{x}_t^T\boldsymbol{\beta})}{1+\exp(\tau_2 - \mathbf{x}_t^T\boldsymbol{\beta})} - \frac{\exp(\tau_1 - \mathbf{x}_t^T\boldsymbol{\beta})}{1+\exp(\tau_1 - \mathbf{x}_t^T\boldsymbol{\beta})}\right)\left(1 - \frac{\exp(\tau_2 - \mathbf{x}_t^T\boldsymbol{\beta})}{1+\exp(\tau_2 - \mathbf{x}_t^T\boldsymbol{\beta})}\right)\right]. \tag{8}$$

Estimators of $\boldsymbol{\beta}$ parameters and $\boldsymbol{\tau}$ limit points obtained as a result of maximising the likelihood function (8) are consistent and asymptotically efficient (Maddala [1998]). The measure of goodness of fit in ordered logit models (and generally in models of qualitative dependent variables) is the so-called McFadden's pseudo-R^2 coefficient, which may lie in the range between 0 and 1. The closer McFadden's pseudo-R^2 is to unity, the better the model fits real data.

3.2. Interpretation of β parameters

In accordance with formula (4) the value of parameter β_i expresses a change in the value of variable I_t^* caused by unit increment of the value of variable x_{it}. However, due to the non-observable nature of variable I_t^*, it is more interesting to interpret $\boldsymbol{\beta}$ parameters in terms of changing probability that variable Y_t will assume a specific value –1, 0 or 1 depending on

changes in values of explanatory variables in equation (4). In particular, the following relations can be analysed here:

- change in the value of probability that the given MPC member will vote for easing of the monetary policy ($y_t = -1$), resulting from unit increment of explanatory variable x_{it}, that is

$$\frac{\partial P(y_t = -1)}{\partial x_{it}} = -\beta_i \frac{\exp(\tau_1 - \mathbf{x}_t^T \boldsymbol{\beta})}{(1 + \exp(\tau_1 - \mathbf{x}_t^T \boldsymbol{\beta}))^2} = -\beta_i P(y_t = -1)[1 - P(y_t = -1)] \tag{9a}$$

- change in the value of probability that the given MPC member will vote for tightening the monetary policy ($y_t = 1$), resulting from unit increment of explanatory variable x_{it}, that is

$$\frac{\partial P(y_t = 1)}{\partial x_{it}} = \beta_i \frac{\exp(\tau_2 - \mathbf{x}_t^T \boldsymbol{\beta})}{(1 + \exp(\tau_2 - \mathbf{x}_t^T \boldsymbol{\beta}))^2} = \beta_i [1 - P(y_t = 1)] P(y_t = 1) \tag{9b}$$

Formulas (9a) and (9b) indicate that, due to the non-linear form of equations (7a)-(7c), marginal effects of changes of the variables x_{it} depend on the values of all explanatory variables used in the given model. For this reason, parameters β_i for $i = 1,...,k$ should be interpreted for specific values of variables making up the model of vector $\mathbf{x}_t$. Nevertheless, equation (9b) clearly demonstrates that the direction of changes in the value of probability that monetary policy will tighten depends only on the sign of parameter β_i. Positive value of β_i means that growing x_{it} will result in growing value of this probability, while its negative value will cause probability to fall.

3.3. Interpreting limit points $\boldsymbol{\tau}$

In an ordered logit model with multiple explanatory variables, limit values of τ_1 and τ_2 making up vector $\boldsymbol{\tau}$ do not have a direct interpretation. However, in a model with a single explanatory variable we may interpret quotients τ_1/β_1 and τ_2/β_1, which in accordance with formulas (4) and (5a)–(5c) determine the range of variability for the explanatory variable with which the given MPC member will vote for leaving the restrictiveness of the monetary policy unchanged. Therefore, the explanatory variable values smaller than τ_1/β_1 imply a decision on easing of the monetary policy, while values greater than τ_2/β_1 imply a decision to tighten it. Since on one variant of the analysed reaction function of MPC (variant II) there is only one explanatory

variable, in the empirical part of the paper for this model we will also present an interpretation of quotients τ_1/β_1 and τ_2/β_1.

3.4. Forecasting based on ordered logit model

Substituting in formulas (7a)-(7c) estimates of parameters $\hat{\boldsymbol{\beta}}$ and $\hat{\boldsymbol{\tau}}$ instead of their true values $\boldsymbol{\beta}$ and $\boldsymbol{\tau}$ we can calculate theoretical values of conditional probabilities of reduction, lack of change or increase in the restrictiveness of the monetary policy, that is

$$\hat{P}(y_t = -1 | \mathbf{x}_t) = \frac{\exp(\hat{\tau}_1 - \mathbf{x}_t^T \hat{\boldsymbol{\beta}})}{1 + \exp(\hat{\tau}_1 - \mathbf{x}_t^T \hat{\boldsymbol{\beta}})}, \tag{10a}$$

$$\hat{P}(y_t = 0 | \mathbf{x}_t) = \frac{\exp(\hat{\tau}_2 - \mathbf{x}_t^T \hat{\boldsymbol{\beta}})}{1 + \exp(\hat{\tau}_2 - \mathbf{x}_t^T \hat{\boldsymbol{\beta}})} - \frac{\exp(\hat{\tau}_1 - \mathbf{x}_t^T \hat{\boldsymbol{\beta}})}{1 + \exp(\hat{\tau}_1 - \mathbf{x}_t^T \hat{\boldsymbol{\beta}})}, \tag{10b}$$

$$\hat{P}(y_t = 1 | \mathbf{x}_t) = 1 - \frac{\exp(\hat{\tau}_2 - \mathbf{x}_t^T \hat{\boldsymbol{\beta}})}{1 + \exp(\hat{\tau}_2 - \mathbf{x}_t^T \hat{\boldsymbol{\beta}})}. \tag{10c}$$

Next, according to the rule of maximal probability[8], we can forecast the decisions taken by the given Council member for each time period t. This means that the forecast is this value of y_t for which the theoretical value of probability is the highest.

4. Results of analysis of individual reaction functions of member of the Monetary Policy Council

4.1. Reaction function with lagged inflation, output gap and exchange rate – MPC acts backward looking (variant I)

In the first case analysed in accordance with equation (3a), the individual reaction functions of MPC members were composed of: inflation rate lagged by one period, seasonally adjusted annual dynamics of industrial production growth lagged by one period and average monthly pace of growth of the nominal EUR/PLN exchange rate. The results of estimations demonstrated, however, that for the majority of MPC members (*LB*/*MN*/*HWT*, *MP*, *SN*, *DF*,

[8] This method is applied due to the fact that in practice theoretical values of probabilities are almost never equal to 1. However, Franses *at al*. [1999] point out that if the number of decisions of a certain type (e.g. to ease the monetary policy) is significantly smaller than the number of other decisions, this approach is not always right.

JC) both the variable expressing the lagged inflation rate and the variable representing changes in the nominal exchange rate proved statistically insignificant. The elimination of the exchange rate variable from the reaction function didn't change the results. The lagged inflation was significant (at 10% level) only in the equations for *AS*/*AW* and *SO*. For other MCP members lagged inflation proved insignificant as well.

For that reason, equation (3a) was re-specified: the lagged inflation rate was replaced with the current one, which gave the following form of the reaction function

$$i_t = \kappa_1 \pi_t + \lambda_1 \Delta_{12} y_{t-1} + \varphi_1 e^{śr}{}_t, \tag{11}$$

Formula (11) corresponds to the hypothesis that MPC members, when taking a decision in month t, consider the level of inflation in month t, and not in month t–1, preceding the Council's meeting. Taking into account the fact that in month t the Council members know only the level of inflation in month t–1 (inflation figures are published with a delay of approx. 14 days), this hypothesis means that they are able to correctly anticipate future inflation changes in the timeframe of at least one month. Thus the equation (11) represents the hypothesis that MPC members act forward looking.

Having re-specified the general form of the Council's reaction function in accordance with formula (11), we re-estimated the parameters of individual reaction functions for each Council member and the results indicate that in all seven individual reaction functions the variable which describes the growth rate of the exchange rate again proves statistically insignificant (at significance level of 10%)[9]. However, this time in most estimated equations the variable expressing the inflation rate was statistically significant. In addition, for all the analysed functions the value of McFadden's pseudo-R2 coefficient was significantly greater than in the previous case, which proves that the goodness of fit of model (11) for real data was better than that of model (3a). These results lead to the conclusion that MPC members act forward looking rather then backward looking. Detailed results of the estimations are presented in Table 2.

The values presented in Table 2 indicate that for each of the seven individual reaction functions the value $prod_{t-1}$, which expresses the rate of industrial production growth, was statistically significant at the level of significance equal to 10%. In turn, with this level of

[9] It should be stressed that statistics determined as a quotient of the parameter estimate and the corresponding standard error has in logit models only asymptotic Student's t-distribution, therefore in case of models construed for small samples (which applies to this study) any inferences as to the statistical significance of variables should be treated with great caution.

significance, variable cpi_t representing the current inflation rate was significant in 4 out of 7 equations, while in one (for *JC*) it was only slightly beyond the range of significance. The influence of current values of variable cpi_t on decisions of a Council member proved to be statistically insignificant in the case of reaction functions for *SN* (p-value = 0.1676) and *MP* (p-value = 0.3375)[10].

Table 2. Results of estimations for individual reaction functions of MPC members – variant I

Council Member	Variable	Parameter Estimate	Standard Error	p-value	pseudo-R2	$\frac{\partial P(y_t = 1)}{\partial cpi_t}$	$-\frac{\partial P(y_t = -1)}{\partial cpi_t}$	$\frac{\partial P(y_t = 1)}{\partial prod_{t-1}}$	$-\frac{\partial P(y_t = -1)}{\partial prod_{t-1}}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
LB/MN/HWT	*cpi*	98.32	57.45	0.0870	0.282	0.5%	0.5%	1.2%	1.3%
	prod(-1)	24.87	13.14	0.0584					
JC	*cpi*	84.20	51.74	0.1036	0.352	0.3%	2.0%	0.8%	6.7%
	prod(-1)	28.47	10.99	0.0096					
DF	*cpi*	158.72	89.06	0.0747	0.358	0.3%	0.2%	0.5%	0.3%
	prod(-1)	31.93	18.99	0.0928					
SN	*cpi*	76.54	55.46	0.1676	0.307	0.1%	1.6%	0.3%	4.6%
	prod(-1)	22.67	10.68	0.0338					
SO	*cpi*	101.69	55.07	0.0648	0.357	0.3%	2.1%	0.7%	5.5%
	prod(-1)	27.10	11.07	0.0144					
MP	*cpi*	79.18	82.55	0.3375	0.576	-	1.7%	-	7.9%
	prod(-1)	37.84	18.96	0.0460					
AS/AW	*cpi*	109.25	55.77	0.0501	0.382	0.4%	2.6%	1.0%	7.4%
	prod(-1)	30.62	11.69	0.0088					

Source: Own calculations. Column 7 (8) contains the marginal probability of increasing (decreasing) restrictiveness of the monetary policy, corresponding to a rise (fall) of current inflation by 0.1 percentage point from 2.5%, with the assumption that production growth dynamics was the mean sample value, that is, 8.8%. Similarly, column 9 (10) contains the marginal probability of increase (decrease) of restrictiveness of the monetary policy corresponding to a rise (fall) of industrial production growth dynamics lagged by one period by 1 percentage point from 8.8%, with inflation rate equal to 2.5%. For *MP* the marginal probabilities of increase in the restrictiveness of the monetary policy were not calculated, because this MPC member, in accordance with the definition adopted in the paper, never voted for tightening the monetary policy in the period covered by our study.

Analysis of marginal probabilities indicates that with inflation rising by 0.1 p. p. the increase of probability of tightening of monetary policy is the greatest for *LB/MN/HWT* (column 7); while with inflation dropping by 0.1 p. p. the greatest increase of probability of easing of monetary policy occurs for *AS/AW* (column 8). Also, the strongest reaction to growing industrial production can be seen in the decisions of *LB/MN/HWT* (column 9); while dropping production results in the highest growth of probability of easing of the monetary

[10] In these two models the influence of inflation lagged by one period was also statistically insignificant.

policy in the case of *MP* and again *AS/AW* (column 10). Out of all the models that were taken into account, the reaction function constructed for *MP* proved to be the best fit for empirical data (the highest value of McFadden's pseudo-R2 coefficient).

As the next stage of this part of our study, we compared the forecasting performance of the models discussed above. Table 3 contains a comparison of the actual decisions of MPC members and the forecasts of these decisions determined using the rule of maximal probability (see subsection 3.4).

Table 3. Comparison of forecasting performance of individual reaction functions of MPC members – variant I

Council Member	Decision Designation	Number of Actual Decisions	Number of Correct Decisions	Error	Total Error
LB/MN/HWT	-1 0 1	2 12 4	1 14 3	1 -2 1	4
JC	-1 0 1	6 9 3	5 12 1	1 -3 2	6
DF	-1 0 1	1 13 4	0 15 3	1 -2 1	4
SN	-1 0 1	5 12 1	5 13 0	0 -1 1	2
SO	-1 0 1	5 10 3	5 12 1	0 -2 2	4
MP	-1 0 1	6 12 -	6 12 -	0 0 -	0
AS/AW	-1 0 1	6 8 4	5 10 3	1 -2 1	4

Source: Own calculations.

Based on the results presented in Table 3, one may assume that the model proposed for description of the reaction function of *MP* displays the best forecasting performance. In case of this model, all 18 decisions were forecast correctly (correct decisions), however, it is worthwhile to observe that, according to the classification adopted in this paper, *MP* never voted for tightening the monetary policy, which allowed us to reduce the number of analysed categories to two and undoubtedly contributed to obtaining such a high accuracy of forecasts.

The least accurate forecasts were obtained based on the model constructed for *JC*. In this event, as many as six times the forecast determined using the rule maximal probability differed from the real decisions taken by this Council member.

In total, the mean forecast error for all the analysed models was approx. 19% (24 erroneous indications out of 126 possible ones).

For each of the analysed reaction functions, on the basis of formulas (11a)-(11c) also theoretical values of probability of increase no change or decrease of the restrictiveness of the monetary policy were determined on the assumption that inflation was below, in the middle and above the permitted fluctuation range for the inflation target set at 2.5+/-1%.

Table 4. Theoretical values of conditional probabilities for selected inflation levels

Council Member	CPI = 1.5%			CPI = 2.5%			CPI = 3.5%		
	$P(y_t = -1)$	$P(y_t = 0)$	$P(y_t = 1)$	$P(y_t = -1)$	$P(y_t = 0)$	$P(y_t = 1)$	$P(y_t = -1)$	$P(y_t = 0)$	$P(y_t = 1)$
LB/MN/HWT	13.7%	84.4%	1.9%	5.6%	89.4%	5.0%	2.2%	85.5%	12.3%
JC	58.3%	40.4%	1.3%	37.6%	59.4%	3.1%	20.6%	72.6%	6.8%
DF	4.7%	94.9%	0.4%	1.0%	97.3%	1.7%	0.2%	91.8%	8.0%
SN	46.1%	53.4%	0.5%	28.5%	70.4%	1.1%	15.6%	82.0%	2.4%
SO	52.3%	46.7%	1.0%	28.4%	68.9%	2.7%	12.5%	80.3%	7.1%
MP	48.5%	51.5%	0.0%	29.9%	70.1%	0.0%	16.2%	83.8%	0.0%
AS/AW	67.1%	31.7%	1.2%	40.6%	56.0%	3.4%	18.7%	71.9%	9.4%

Source: Own calculations. For *MP* the values of probabilities of increased restrictiveness of the monetary policy are equal to zero, because this MPC member, according to the definition adopted in this paper, never voted for tightening the monetary policy in the period covered by the study. All conditional probabilities were determined for the same level of industrial production growth dynamics equal to the sample's mean, i.e. 8.8%.

The values put together in Table 4 show that if the inflation rate is equal to the lower limit of the inflation target[11], then the highest probability of easing the monetary policy may be ascribed to Council members *AS* and *AW* (67.1%). For *DF* the probability of easing of monetary policy is in this situation the smallest and equals only 4.7%.

With inflation equal to the upper target limit, a decision to tighten the monetary policy is most likely for the Council members *LB*, *MN* and *HWT*. The one who would be the least

[11] The lower limit of the inflation target is understood here as the lower limit of the permissible range of inflation fluctuations when the target is 2.5%.

willing to vote for tightening of monetary policy with this inflation level would be *SN* (save for *MP*, who, according to model, never took such decisions). Therefore it is clear that the behaviour of MPC members in situations when inflation is close to the lower and upper limit of the permissible range of fluctuations is somewhat asymmetrical.

Considerable asymmetry becomes apparent also when we consider the behaviour of the Council members, described on the basis of the model, when the inflation rate is equal to the inflation target, that is 2.5%. In as many as five cases the probability of easing of monetary policy is considerably higher than the probability of tightening it and only for one Council member (*DF*) this probability is slightly lower. However, it is worth pointing out that all conditional probabilities in Table 4 were calculated with the assumption that at the given moment the annual dynamics of industrial production growth was equal to 8.8% (which is the mean value of the sample). With different values of this variable the distributions of probabilities would undoubtedly be different. Consequently, finding out whether the Council members are characterised by asymmetry in taking decisions in case of high or low inflation depends on what real production growth the Council will consider as matching the potential growth[12].

4.2. Reaction function with inflation expectations – MPC acts forward looking (variant II)

In the second part of the study we analysed individual reaction functions of MPC members corresponding to equation (3b), where the only explanatory variable was the variable expressing market expectations as to the inflation level in 12 months' time. In accordance with the hypothesis formulated here, the Council, instead of reacting to determinants of future inflation, that is current inflation, the size of output gap and the pace of increase of the exchange rate, reacts only to changes of inflation forecast prepared for a period roughly corresponding to the period of influence of monetary policy (12 months). The results of estimations for this variant of the function are presented in Table 5.

[12] For most Council members this asymmetry disappears only when we adopt the production dynamics of approx. 13.5%.

Table 5. Results of estimations for individual reaction functions of MPC members – variant II

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Council Member	Variable	Parameter Estimate	Standard Error	p-value	pseudo-R2	$\frac{\partial P(y_t=1)}{\partial cpi\_e_{t+12}}$	$-\frac{\partial P(y_t=-11)}{\partial cpi\_e_{t+12}}$
LB/MN/HWT	cpi^e_{t+12}	575.21	309.84	0.063	0.282	5.2%	1.2%
JC	cpi^e_{t+12}	512.15	198.17	0.010	0.292	3.9%	9.7%
DF	cpi^e_{t+12}	856.15	562.28	0.128	0.302	4.2%	0.1%
SN	cpi^e_{t+12}	312.67	156.37	0.046	0.171	1.1%	5.5%
SO	cpi^e_{t+12}	767.01	303.81	0.012	0.439	3.0%	7.0%
MP	cpi^e_{t+12}	476.40	198.85	0.017	0.392	-	9.3%
AS/AW	cpi^e_{t+12}	531.77	201.63	0.008	0.297	5.5%	9.9%

Source: Own calculations. Column 7 contains marginal probabilities of tightening of the monetary policy (corresponding to the rise of future inflation by 0.1 p. p. from 2.5%), while column 8 contains marginal probabilities that the restrictiveness of the monetary policy will fall (corresponding to a drop in future inflation by 0.1 p. p. from 2.5%).

Out of all the analysed functions, only in the model describing the way *DF* takes decisions did the variable expressing the level of future inflation prove statistically insignificant (at significance level equal to 10%). In five models this variable was significant at significance level of 5%, and in one at significance level of 10%. In all the models, the signs of parameter estimates proved to be consistent with the expectations - increasing level of future inflation results in growing probability of tightening the monetary policy. The increase in the inflation expectations results in the highest increase of probability of tightening the monetary policy in models for *AS/AW* and *LB/MN/HTW*. On the other hand, a drop in future inflation results in the highest growth of probability of easing monetary policy in the reaction functions constructed for *AS/AW*, *JC* and *MP*. Considering both these cases together, one may say that *AS* and *AW* display the strongest reactions to changes in future inflation.

When evaluating the forecasting performance of the estimated models (see Table 6), one can say that the real decisions taken by a Council member match to the greatest extent the reaction functions construed for *MP* and *SN*, while the greatest number of "miss" decisions (failed forecasts) occurred in the case of models for *LB/MN/HWT*, *JC*, *DF* and *SO*. It is also worth pointing out that the mean forecast error for all models jointly is 25.4% and is greater than the mean forecast error for reaction functions in the form (3a) estimated in subsection 4.1, which error was 19%.

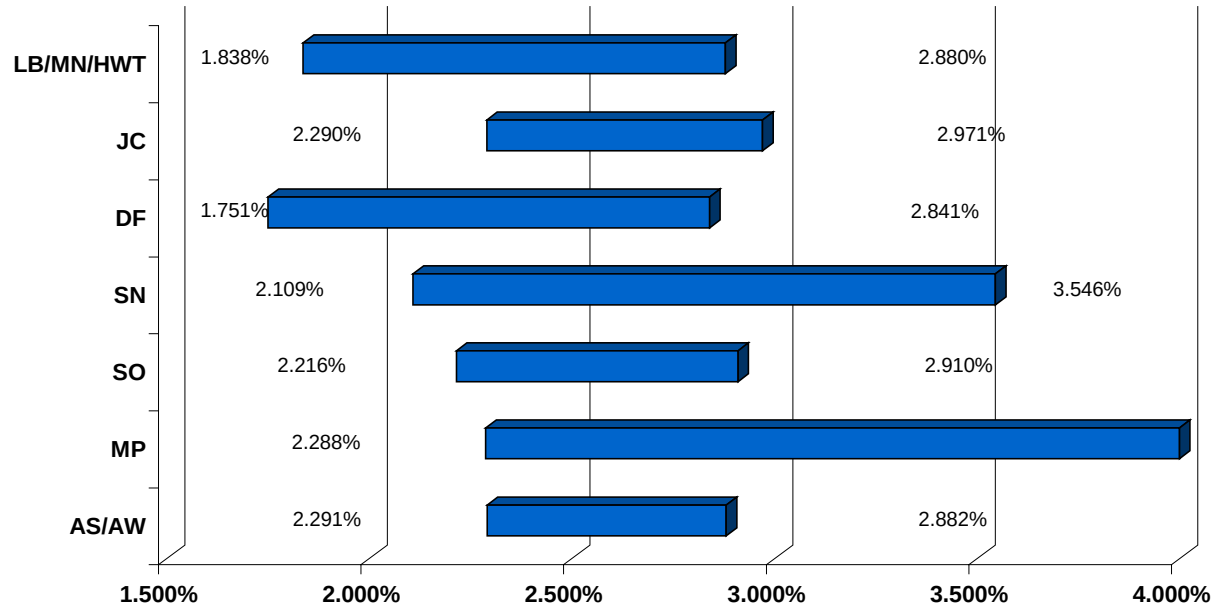
Table 6. Comparison of forecasting performance of individual reaction functions of MPC members – variant II

Council Member	Decision Designation	Number of Actual Decisions	Number of Correct Decisions	Error	Total Error
LB/MN/HWT	-1 0 1	2 12 4	1 15 2	1 -3 2	6
JC	-1 0 1	6 9 3	6 12 0	0 -3 3	6
DF	-1 0 1	1 13 4	0 16 2	1 -3 2	6
SN	-1 0 1	5 12 1	5 13 0	0 -1 1	2
SO	-1 0 1	5 10 3	5 13 0	0 -3 3	6
MP	-1 0 1	6 12 -	5 13 -	1 -1 -	2
AS/AW	-1 0 1	6 8 4	6 10 2	0 -2 2	4

Source: Own calculations.

Since in the variant of the reaction function (3b) discussed in this subsection there is only one explanatory variable cpi^{e}_{t+12}, on the basis of estimates of the limit points $\hat{\tau}_1$ and $\hat{\tau}_2$ as well as an estimate $\hat{\beta}$ which appears with this variable, one cay determine the boundary values of variable cpi^{e}_{t+12} for which, in accordance with formulas (5a)-(5c) there occurs a change in the decision of the Council member. As we mentioned in subsection 3.3, we calculate boundary values for variable cpi^{e}_{t+12} by dividing the values of $\hat{\tau}_1$ and $\hat{\tau}_2$ by the estimate $\hat{\beta}$. These values, determined separately for each of the analysed individual reaction functions of the Council members, are shown on Chart 1.

Chart 1. Boundary values of inflation forecasts for decisions taken by MPC members



Source: Own calculations.

The range of variability for future inflation rate (variable cpi^{e}_{t+12}) marked on the chart corresponds to a Council member's decision to vote for leaving the restrictiveness of the monetary policy unchanged[13]. Therefore, if the forecast of future inflation assumes a value below the lower limit of this range, then the given MPC member will vote for easing the monetary policy, and if this value goes above the upper limit of the range, he/she will vote for tightening it. The data presented on the chart indicate that the lowest boundary values (both the upper and lower one) were obtained in the reaction functions estimated for *DF* and *LB/MN/HWT*. The highest lower boundary value of future inflation can be found in the reaction function for *AS/AW*, followed by reaction functions for *MP* and *JC*. The highest upper boundary value (with the exception of *MP*)[14] was obtained for the reaction function of *SN*.

In the light of the above results (assuming that the reaction function for each MPC member may be described using equation (3b) and that, consequently, decisions of Council members depend solely on the forecast of future inflation), one can state that in the analysed period *DF* put forward the tightest monetary policy, being followed by *LB*, *MN* and *HWT*, while the promoted of the least tightening policy was *MP*. It is also worthwhile to observe that

[13] One should remember that in the general case forecasts of the dependent variable based on an analysis of boundary values and according to the rule of maximal probability may be different.
[14] For *MP* the discussed range of variability for variable cpi^{e}_{t+12} is unlimited on the right.

the ones who conducted the most active monetary policy in the analysed period were AS/AW and *JC* (the narrowest range of ”indifference” for variable cpi^{e}_{t+12}) with *MP* and *SN* being the most passive ones (the broadest range of ”indifference”).

4.3. Reaction function with deviations of expectations from the actual realisations of variables – MPC acts forward looking (variant III)

The third analysed variant of MPC reaction function (3a)-(3c) expresses the hypothesis in which the Council changes the parameters of monetary policy if the current figures concerning inflation, industrial production growth (being an approximation of the output gap) and exchange rate differ from the previous expectations. In this case, estimations concern the parameters of equation (3c) and all explanatory variables except for exchange rate were lagged by one period (these were the data the Council had at the time of taking decisions).

However, the obtained results demonstrate that in each of the seven individual reaction functions that we considered both the variable expressing the deviation of industrial production growth dynamics forecast from the actual realisation of this variable and the variable which is the difference between the forecast and the real value of exchange rate were statistically insignificant (at significance level of 10%). For this reason, these variables were removed from equation (3c), and Table 7 presents the results of estimations for the reaction function in which the sole explanatory variable was the variable being the difference between the forecast and the actual realisation of inflation for the period preceding the Council’s decision.

Table 7. Results of estimations for individual reaction functions of MPC members –variant III

Council Member	Variable	Parameter Estimate	Standard Error	p-value	pseudo-R2
LB/MN/HWT	cpi_{t-1} - cpi^{e}_{t-1}	357.86	219.03	0.102	0.096
JC	cpi_{t-1} - cpi^{e}_{t-1}	350.17	204.33	0.087	0.088
DF	cpi_{t-1} - cpi^{e}_{t-1}	263.96	218.59	0.227	0.059
SN	cpi_{t-1} - cpi^{e}_{t-1}	660.79	291.55	0.023	0.255
SO	cpi_{t-1} - cpi^{e}_{t-1}	387.85	210.62	0.066	0.107
MP	cpi_{t-1} - cpi^{e}_{t-1}	287.24	241.27	0.234	0.074
AS/AW	cpi_{t-1} - cpi^{e}_{t-1}	400.05	217.18	0.065	0.105

Source: Own calculations.

Only in 4 out of 7 individual reaction functions did the explanatory variable prove significant at significance level equal to 10%. In addition, the goodness of fit of models to the empirical data (pesudo-R2) was significantly lower than in both variants of the reaction function analysed in subsections 4.1 and 4.2.

Since the results did not confirm the hypothesis formulated in this subsection, the models presented in Table 7 were not analysed any further.

5. Summary

This paper presents an attempt at identifying the individual reaction functions of each MPC member in the period from February 2004 to July 2005. Applying the microeconometric approach, we tested three different variants of the reaction function and analysed their prognostic features.

The analysis concerned: (1) the classical backward looking reaction function proposed by Ball [1999] and including the deviation of inflation from the inflation target, seasonally adjusted annual dynamics of industrial production growth (being an approximation of the output gap) and the pace of increase of exchange rate; (2) the forward looking reaction function including only the future inflation forecast with forecast timeframe corresponding to the period of influence of monetary policy (12 months); (3) the forward looking reaction function including deviations of inflation forecasts, industrial production growth and exchange rate from their actual realisations.

The main conclusions from the study can be expressed as follows:

1) The hypothesis that MPC members act backward looking (variant I of the reaction function) has not been confirmed by the data. Most Council members, when taking decisions on the parameters of monetary policy, take into account the future inflation values and lagged values of industrial production growth. No Council member considers changes in exchange rate in these decisions. In variant I, in all the analysed individual reaction functions of Council members, the variable describing the pace of increase of exchange rate proved statistically insignificant. On the other hand, the variable expressing the annual dynamics of industrial production growth lagged by one period proved statistically significant in all models. In addition, inclusion in the function of current inflation rate (which in fact may be interpreted as future inflation rate because MPC members do not know it yet at the time of taking the decisions) instead of the inflation rate lagged by one period significantly improved the quality of all analysed models. This

means that Council members, when taking decisions, consider the values of future and not past inflation and may be an evidence that MPC acts forward looking rather than backward looking.

2) Based on variant I of the analysed model one may say that a rise in current inflation results in the highest increase of probability of tightening the monetary policy in the reaction functions for *LB*, *HWT* and *MN*, while falling inflation increases to the greatest extent the probability of easing the monetary policy in the reaction functions constructed for *AS* and *AW*. Similarly, growing industrial production has the greatest influence on the decisions to tighten monetary policy taken by *LB*, *HWT* and *MN*, while falling production most likely translates into decisions aimed at easing the monetary policy taken by *MP*.
3) Decisions of most MPC members in the field of tightening or easing of the monetary policy are, to a considerable extent, asymmetrical. When inflation is equal to the inflation target and the annual rate of industrial production growth is equal to the sample's mean value (8.8%), in the case of Council members *JC*, *SN*, *SO*, *MP*, *AS* and *AW* the probability of easing of the monetary policy is much higher than the probability of tightening it. These probabilities become equal only when the rate of industrial production growth reaches approx. 13.5%. For the remaining MPC members (*LB*, *HWT*, *MN*, *DF*), when production growth dynamics is 8.8%, the probabilities that they will take a decision to tighten or ease monetary policy are similar.
4) The results of estimations for variant II of the model indicate that in as many as six out of seven analysed individual reaction functions the variable expressing inflation forecast for the 12 months to come was statistically significant. This may be the evidence for the forward looking behaviour of the MPC members. However, both the goodness of fit for empirical data (pseudo-R2) and the forecasting performance of these models were worse than those for models analysed in modified variant I (with the future inflation instead of the lagged one).
5) Based on an analysis of estimates of limit values $\hat{t}_1$ and $\hat{t}_2$ in individual reaction functions corresponding to equation (3b) (variant II of the model), one can state that in the period covered by the study the person with a preference for the most restrictive monetary policy was *DF* followed by *LB*, *MN* and *HWT*, while the least restrictive policy was promoted by *MP*. The most active monetary policy in this period was that of *AS*, *AW* and *JC*, while *MP* and *SN* conducted the most passive policies.
6) There was no confirmation for the hypothesis that MPC considers, when taking decisions, the deviations of current values of inflation, industrial production growth and exchange

rate from their earlier forecasts. In the models corresponding to the third analysed variant of reaction function (3c), all variables which expressed the deviation of forecast of industrial production growth from the actual realisation of this variable, all variables which were the difference between the forecast and actual exchange rate, as well as 3 out of 7 variables describing the difference between real and forecasted inflation were statistically insignificant. In addition, the goodness of fit of the models to real data was significantly lower than for the models in variants I and II of the reaction function.

In the summary we can say that MPC members act forward looking rather than backward looking. The classical backward looking reaction function has been rejected by the data for most MPC members (variant I). The substitution of the lagged inflation by the future inflation improved the quality of the all considered models. Moreover in the forward looking reaction functions with the inflation expectations formulated for 12 months ahead (variant II) the variable expressing the expectations has been significant in 6 out of 7 individual functions. The hypothesis that MPC reacts on deviations of current values of inflation, industrial production growth and exchange rate from their earlier forecasts (variant III) has not been confirmed by the data. Thus in our opinion the rejection of the hypothesis presented in variant III of the reaction function doesn't change the general outcome revealing the forward looking behaviour of the MPC members.

However, when interpreting the obtained results, one should bear in mind that the study was based on a relatively short sample, with only 18 observations, while certain elements of statistical inference used in this paper (in particular the assessment of statistical significance of explanatory variables in the model – see footnote 9), have mainly asymptotical character in logit models.

Moreover, the forecasts of inflation, industrial production growth or exchange rate used here were the average expectations of economists and market analysts determined on the basis of Reuters questionnaire, while MPC in its decisions could take into account other available forecasts. Therefore the results should be approached with appropriate caution and it would be worthwhile to repeat the study for a longer sample and, maybe, also for a different set of explanatory variables.

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