Modeling monetary policy in real time: Does discreteness matter?

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Abstract

This paper applies an empirical framework, combining the use of ordered probit approach, novel real-time data set and decision-making meetings of monetary authority as a unit of observation, to estimate highly systematic reaction patterns between policy interest rate decisions and incoming economic data. The study proposes a methodology to measure the empirical significance of the discrete nature of the dependent variable by assessing formally the statistical effects of using the conventional regression models for continuous dependent variables instead of the discrete-choice models. The paper demonstrates that both the discrete-choice approach and real-time policy-meeting data do matter in the econometric identification of monetary policy in Poland.

The study detects structural breaks in policy, which switched its focus from current to expected inflation and from exchange rate to real activity. The response to inflationary expectation is shown to be highly asymmetrical depending on whether the expectation is above or below the inflation target. The policy rate appears to be driven by key economic indicators without evidence for intentional interest-rate smoothing by central bank. The estimated rules explain correctly 95 percent of observed policy actions and surpass the market anticipation, made one day prior to a policy meeting, both in and out of sample.

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1 Introduction

> "The central bank must have a highly regular and predictable policy rule or response pattern that links policy actions to the state of the economy."
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> – W. Poole, then-President of the Federal Reserve Bank of St. Louis[1]
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> "It is not possible to make use of a simple policy rule, which could be known ex ante to market participants."
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> – Monetary Policy Council, National Bank of Poland[2]

The discreteness of policy rates, both in magnitude (the adjustments are typically made in multiples of 25 basis points) and timing (the policy actions take place usually 6-12 times a year) is a common feature of contemporary monetary policy-making in many countries. This study applies an empirical methodology (well suited for many central banks) in order to identify the monetary policy by combining the use of discrete-choice approach, real-time data and policymaking meetings of monetary authority as a unit of observation. The paper estimates highly systematic response patterns between the interest rate decisions of the National Bank of Poland (NBP) and incoming economic data, available both for policymakers and for private public in the real-time setting. The specification search is conducted with a wide spectrum of potential explanatory variables among those monitored by the central bank, and is refined by the Andrews' tests for a structural change with an unknown change point. This paper compares the discrete-response versus conventional continuous approach to estimate the policy rules, and also shows that using the monthly averages of ex post revised data instead of real-time non-aggregated data distorts our understanding of policy decisions.

A separate contribution of this paper is the compilation of Polish real-time data set incorporating the original time series, which were actually available to policymakers at each policy-setting meeting during the period 1998 - 2007. To the best of my knowledge, such a data set has never been used in modeling Polish monetary policy and has proved to be fruitful.

Many economic decisions rely on inflationary expectations, while inflation predictability depends on the consistency of monetary policy. More transparent and predictable behavior of central bank itself improves the transmission and effectiveness of monetary policy, as many academic economists and central banks' practitioners nowadays seem to agree[3]. Over the past two decades most central banks, including the NBP, have radically increased their public communication, as well as the disclosure of internal information and methodology used in monetary policy-making[4].

An obvious way to facilitate the predictability of monetary policy is to utilize a "rule", which is "nothing more than a systematic decision-making process that uses information in a consistent and predictable way" (Meltzer 1993). Starting at least with a classic paper by Kydland and Prescott (1977), many economists conclude that pre-commitment to a rule can

[1] See Poole (2003).

[2] See "Monetary policy guidelines" for the years 2005, 2006 and 2007; e.g., see NBP (2006), p. 5.

[3] See, e.g., Bernanke (2007), Blinder (1998, 2005), Carpenter (2004), Faust and Svensson (2001), Geraats (2001, 2002), Ingves (2007), Issing (2005), Kennedy (2008), Kohn (2008), Poole (2003, 2005), Thornton (2003).

[4] See Łyziak et al. (2006) on the transparency of NBP monetary policy.

have both beneficial and stabilizing outcomes[5]. Operating under the policy rule not only enhances a central bank's accountability, credibility and transparency, but, according to Poole (1999), "also provides the surest method to pass the accumulated knowledge about the effective operation of monetary policy to future generations", and, perhaps provides the only way of improving monetary policy practice. Indeed, in order to improve it we must obtain a clear empirical description of what is going to be improved, for example, an econometric identification of current policy. It is really difficult to evaluate the policy without describing it, using an algebraic formula or "rule".

In the light of the NBP statement that "it is not possible to make use of a simple policy rule which could be known ex ante to market participants" (NBP 2006), it is an interesting empirical exercise: to uncover a systematic component of a central bank's policy. Such econometric modeling can help market participants to make more efficient decisions by minimizing the uncertainty regarding future policy actions: "What the market needs to know is the policy response function by which the central bank acts in a consistent way over time" (Poole 2003). Besides, the policy rate is a key determinant of other short-term market interest rates. Furthermore, "if practitioners in financial markets gain a better understanding of how policy is likely to respond to incoming information, asset prices and bond yields will tend to respond to economic data in ways that further the central bank's policy objectives" (Bernanke 2007).

It must be the case that the central bank pursues the regularity of some sort, though there is no simple and fixed policy rule, mechanically followed under all circumstances. Rather, the central bank pays attention to a variety of statistical data and other information, and considers several alternative rules, used as policy guidelines and combined with anecdotal evidence and judgment. We can reasonably assume that the policy-generating process consists of two components, namely a regular and a non-regular component: the central bank reacts consistently to some internal sophisticated assessment of the economy, but occasionally (in the case of transitory or anomalous shocks to the economy, strike, financial crisis, natural disaster, etc.) departs from the regularity. The specific characteristics of the systematic component are inside a black box – they are unobservable for public. However, we can proxy for the underlying determinants of policy actions by looking at the consequential systematic links between adjustments to policy rates and movements in various observable fundamentals.

The estimated models, representing a simplification of true policy-making process, might effectively reflect its essence, and could be applied as a useful benchmark for explaining past policy decisions and predicting future ones, even though the NBP certainly does not view itself as implementing a "simple policy rule". Besides, knowing a central bank's correct "reaction function" is also a necessary element of macroeconomic models, used to forecast developments in the economy and to evaluate the effects of economic shocks and monetary and fiscal policy actions. Finally, "clarity about the central bank's policy objectives and strategy may help anchor the public's long-term inflation expectations, which can substantially improve the efficacy of policy and the overall functioning of the economy" (Bernanke 2007).

This paper differs from the previous empirical research on Polish monetary policy rules in the following aspects: (i) it accounts for the discreteness of policy rates by applying

[5] See, e.g., Barro and Gordon (1983a, 1983b), Barro (1986), Calvo (1978), Clarida et al. (2000), Dennis and Soderstrom (2006), Svensson (1999a, 1999b, 2002), Taylor (1993, 1999), Woodford (1999a). The "rules versus discretion" academic debate has a long history – see, e.g., Wicksell (1898), Simons (1936).

an ordered probit model; (ii) it models the policymakers' response to an information set available at the decision-making meetings of monetary authority rather than the relationship between the monthly or quarterly averages of policy rate and economic indicators; (iii) it avoids the distortion of information by using only the real-time data, i.e. the historical time series as they were known at any policy-making meeting, rather than the latest revised versions of data; (iv) it avoids the problem of simultaneity, which is typical for the time-aggregated data due to possible interactions between the policy rate and other economic variables that can happen during a period of aggregation; (v) it conducts thorough tests for structural changes in policy regime with unknown change point; (vi) it directly models the administered policy rate rather than the market short-term interest rates; (vii) it analyzes the period 1999 - 2007, when the short-term interest rates have been a principal tool and a single measure of monetary policy; (viii) instead of the level rules it estimates the difference rules that are more operational and transparent for public[6]; (ix) it is not focused on a limited amount of statistical data, but instead uses in the specification search a wide spectrum of economic and financial indicators; and (x) the estimated interest rate rules have far higher measures of fit and out-of-sample forecasting performance.

The paper proceeds as follows. Section 1.2 provides review of the related literature. Section 1.3 discusses the background of the monetary policy in Poland. Section 1.4 describes the data and methodology. Some econometric results are presented in Section 1.5. Section 1.6 demonstrates that both the real-time "policy-meeting" data do matter in the econometric identification of Polish monetary policy. Section 1.7 focuses on the comparison of the discrete-response versus conventional continuous approach to estimate the policy rules. The last section provides the summary and concludes.

2 Related literature

The literature on Polish monetary policy rules is summarized in Table 1. These studies estimate the interest rate rules for the period from 1991-1995 through 2000-2004. However, prior to 1998 the Polish monetary policy was rather eclectic with the managed exchange rate regime and changing policy instruments: the direct inflation targeting with the short-term interest rates as a principal tool of monetary policy was only fully implemented in 1999.

Several studies estimate NBP reaction functions in the context of vector autoregression (VAR) modeling of the Polish economy (Golinelli and Rovelli 2005, Hristov 2005, Kłos and Wróbel 2001, Kokoszczyński et al. 2006, Maliszewski 2003, Wróbel and Pawłowska 2002). However, the VARs are focused on identifying the monetary policy shocks and responses of key economic indicators to them rather than on identifying the interest rate reaction functions. The policy rules estimated using the VAR models typically have poor in- and out-of-sample forecasting performance, compared to the non-VAR models (see Rudebusch 1998a, b). Rudebusch points out the following shortcomings of the standard VAR interest rate rules: a) time-invariant and linear structure; b) a limited information set, which leads to omitting the relevant explanatory variables; and c) long distributed lags, resulting in spurious in-sample fitting.

Brzozowski (2004) and Mohanty and Klau (2004) estimate the non-VAR policy rules. Both studies use quarterly data averages (the latter also tries the monthly averages), short-

[6] See Orphanides and Williams (2006) for a comparison of the level and difference rule approaches under the framework of imperfect knowledge.

term market interest rates as a dependent variable and the Taylor-rule specification[7].

Only a few papers in the empirical literature on monetary policy rules apply the discrete regression techniques to address the discreteness of policy rates. Studies by Dupor et al. (2005), Hu and Philips (2004), Lapp et al. (2003) and Piazzesi (2005) use the ordered probit to model three possible policy choices (to decrease, leave unchanged or increase the interest rate) of the US Federal Reserve (Fed), while Dueker (1999) and Hamilton and Jorda (2002) employ the ordered probit with five categories (corresponding to 50, 25, 0, -25 and -50 basis point changes). Eichengreen et al. (1985) and Davutyan and Parke (1995) apply the dynamic ordered probit with three and five categories, respectively, to model the Bank of England's policy interest rate changes. Dolado et al. (2005) estimate the interest rate-setting behavior of the Banque de France, the Bundesbank, the Banco de España, and the Federal Reserve, using the ordered probit model with five categories. Podpiera (2007) combines the ordered probit and censored regressions to estimate the interest rate rules of the Fed and the Czech National Bank. Kotłowski (2006) estimates a triple-choice ordered logit, modeling the direction of change in the restrictiveness of monetary policy proposed by a given member of the Monetary Policy Council in Poland. The restrictiveness is measured by the proposed change of policy bias and/or change to the reference rate. Unfortunately, the sample includes only 18 monthly observations for the period 2004/02 – 2005/07, not enough for a reliable likelihood estimation.

A growing number of recent works employ real-time data to address the subsequent revisions of statistical data, and overwhelmingly show that different vintages of US, Japanese, Euro area, German, Swiss and Norwegian data lead to significantly different results[8]. Therefore, the estimation of policy rules based on ex post revised data distorts our understanding of past monetary policy – an obvious point, but one that is routinely neglected by most studies.

Using the decision-making meetings of monetary authorities as a unit of observation represents an approach that carefully mimics the actual decision-making process, but seems to be commonly ignored in the literature. Instead, researchers habitually estimate the systematic relationship between the monthly or quarterly averages of policy rates and economic variables.

3 Background of Polish monetary policy

In the 1995-1997 period the NBP conducted its monetary policy by controlling the money supply growth and targeting the exchange rate. The exchange rate regime was gradually transformed from a managed to a free-floating regime during the 1990s. The monthly rate of crawl was progressively reduced from 1.8 percent in 1991 to 0.3 percent in 1999. The pre-announced crawling peg system was superseded by the crawling band regime in May

[7] Taylor (1993) proposed a monetary policy rule, where the US Federal Reserve alters the federal funds rate (FFR) according to $FFR_t = \pi_t + 0.5Y_t + 0.5(\pi_t - \pi^*) + R$, where R - the "equilibrium" real interest rate, π^* - the long-run inflation target, π – the inflation rate over a year (as a proxy for the expected inflation), Y – the output gap (the percent deviation of real GDP from the potential one). Taylor assumed $R = 2$ and $\pi^* = 2$. The Taylor rule contributed to a better understanding of monetary policy and was widely modified and extended in a number of ways in the subsequent literature.

[8] See, e.g., Bernhardsen et al. (2004), Croushore and Stark (2001, 2003), Clausen and Meier (2005), Gerberding (2004), Gerdesmeier and Roffia (2005), Ghysels et al. (2000), Kamada (2004), Kugler et al. (2004), Lansing (2002), Orphanides et al. (2000), Orphanides (2001a, 2001b, 2002, 2003), Perez (2000), Runkle (1998), Sterken (2003), Tetlow and Ironside (2005).

1995. The crawling band width was widened from ±7 percent in 1995 to ±15 percent in 1999, and was finally abandoned – in April 2000 the zloty officially began to float. Actually, the NBP suspended foreign exchange interventions already in mid-1998, *de facto* entering the floating exchange rate regime (Pruski and Szpunar 2005). Consequently, during the 1990s the exchange rate has been steadily losing its role as an operating tool of monetary policy.

The critical institutional changes in Polish monetary policy occurred in 1998. In January the direct inflation targeting (DIT) was implicitly adopted as a primary monetary policy strategy. The DIT assumes the direct target for official consumer price index and a lack of indirect targets such as the money supply or exchange rate. In October the DIT was officially declared by the Monetary Policy Council (MPC) – a new independent policy-making body[9]. The MPC was founded in February 1998, soon after the independence of the NBP had been strengthened by the new Constitution and the new Act on the NBP. The Council consists of the President of the NBP and nine other members appointed in equal proportions by the President of Poland, the Sejm and the Senate of the Parliament for a term of six years.

The MPC immediately stopped the long-term interest rate operations by shortening the maximum maturity of NBP's money bills from 270 to 28 days, abandoned the monetary base targeting, expanded the exchange rate flexibility toward the free floating system, increased the role of short-term interest rates as a primary way of pursuing the DIT, and began declaring an inflation target in the form of annual growth rate of consumer price index. Since 1998 every fall the MPC announces the inflation target (along with the permissible bandwidth around it) to be attained by the end of next year (see Figure 1). From 1998 to 2006 the annual growth rate of consumer prices in Poland has dropped from 14 to less than 2 percent (see Figure 1) – arguably, an impressive outcome of implemented monetary policy[10].

Overall, since 1998 the short-term interest rates may undoubtedly be treated as a principal instrument and a single measure of Polish monetary policy. Since the policy rates have been always set administratively by the monetary authorities and have never been the outcome of market interaction of supply and demand, they are of special interest for econometric modeling.

There are three NBP policy rates. The reference rate[11], introduced in January 1998, sets the path of monetary policy and "determines the minimum yield obtainable on main open market operations, influencing, at the same time, the level of interbank deposit rates for comparable maturities" (NBP 2005). The deposit and lombard rates, introduced in 1993, set the fluctuation band for overnight interbank interest rates. The open market operations – the sale or purchase of securities or foreign currencies and issue of own-debt securities – help to balance the demand and supply of funds held by the commercial banks at the central bank, and have been used to manage the short-term interest rates on the interbank market since 1993.

[9] See NBP (1998).

[10] For the related applications of an ordered probit model with such a triple classification to study, for example, the US Federal funds rate target see, e. g., Dupor et al. (2005), Hu and Philips (2004), Lapp et al. (2003).

[11] The rate on 28-day (from 1998 to 2003), 14-day (from 2003 to 2005), and 7-day (since 2005 to present) NBP money market bills.

4 Data and modeling framework

4.1 Discreteness of policy rates

The dependent variable is a change (including non-zero ones) to the reference rate made by the MPC at a decision-making meeting. The NBP has always altered the levels of policy rates in discrete adjustments – the multiples of 25 basis points (a quarter of one percent). Table 2 shows the history of the reference rate for the period 1998/02 - 2006/10. The frequency distribution of the reference rate adjustments is reported in Table 3: all 105 historical rate changes took only eleven values, between -250 and 250 basis points. Table 3 and Figure 2 exhibit two distinct phases in the historical behavior of the reference rate: the high-volatility period prior to April 2002 (when all changes, except the first one in February 1998, were by absolute value between 100 and 250 basis points) and the low-volatility period since April 2002 (when all changes were by absolute value either 25 or 50 basis points).

The reference rate adjustments are distributed heterogeneously: 95 out of 105 changes fall into 5 out of 11 observed discrete cases. There are three or less observations in six categories of dependent variable. This is not sufficient for a reliable maximum likelihood estimation. A usual approach under such circumstances is to consolidate some adjacent categories with a small number of observations. For example, we could merge all observed changes into four categories: "decreases of 1% or more", "decreases of 0.25% or 0.50%", "no change" and "increases" with 8, 63, 20 and 14 observations, respectively. However, due to the two aforementioned periods with different volatility of the reference rate, such a quadruple classification does not allow for the conducting of the tests for structural change. Indeed, during the high-volatility period 1998/02 - 2002/03, all rate changes fall into following three categories: "decreases of 1% or more", "no change" or "increases", while during the low-volatility period 2002/04 - 2006/10 the only three realized cases are: "decrease of 0.25% or 0.50%", "no change" or "increases" (see Table 3). After splitting the sample at any point prior to March or after April 2002, the dependent variable will have a different number of categories (three and four) in the two sub-samples. Therefore, to make possible performing the parameter instability tests, all observed rate changes are combined into following three categories: "decrease", "no change" or "increase" (see Table 3). The only consequence of such consolidation is the loss of efficiency – adding (or deleting) another cut-point does not affect the structural latent model given by (1.1) and (1.2) below. However, it is still definitely able to represent the essence of the NBP operating policy.

Fortunately, after detecting a structural break in April 2002, the period 2002/04 - 2006/10 was analyzed using the finer quadruple classification: "down 0.50%", "down 0.25%", "no change" and "up" – with 3, 32, 11 and 9 observations, respectively (see Table 3). This classification closely corresponds to the historical policy rate adjustments in this period: only two observed adjacent categories – the "up 0.25%" and "up 0.50%" with one and two observations, respectively – have been consolidated.

4.2 Ordered probit model

To address the discreteness of dependent variable, this paper employs an ordered probit approach, which forms a probabilistic forecast of discrete adjustments to the policy rate as a nonlinear function of explanatory variables. This approach assumes an underlying level of the reference rate RR_t^* that would have been observed had the NBP been willing to make the continuous (rather than discrete) changes to the rate. At every policy-rate-setting meeting

t the NBP determines the change $\Delta RR_t^* = RR_t^* - RR_{t-1}^*$ in this latent rate according to the following formula:

$$\Delta RR_t^* = \mathbf{X}_t\boldsymbol{\beta} + \varepsilon_t, \tag{1}$$

where $\varepsilon_t \sim iid\ Normal(0, \sigma^2)$ and $\mathbf{X}_t$ is a matrix that may incorporate any data relevant for the policymakers and available at date t. Matrix $\mathbf{X}_t$ may include the variables in any form (levels, first and second differences) and at any original data frequency.

Although RR_t^* is unobserved, the NBP announces the official (i.e. observed) adjustments to the reference rate ΔRR_t^* according to the following rule:

$$\Delta RR_t = \begin{cases} k_1 & \text{if} \quad \Delta RR_t^* \leq \alpha_1, \\ k_j & \text{if} \quad \alpha_{j-1} < \Delta RR_t^* \leq \alpha_j \text{ and } 1 < j < J, \\ k_J & \text{if} \quad \alpha_{J-1} < \Delta RR_t^*, \end{cases} \tag{2}$$

where $k_1, k_2, \ldots, k_{J-1}, k_J$ – observed discrete-valued changes to the policy rate (multiples of the 25 basis points), J is a number of observed discrete cases, and $-\infty = \alpha_0 < \alpha_1 < \alpha_2 < \ldots < \alpha_{J-1} < \alpha_J = \infty$ are unknown thresholds to be estimated.

Assuming a Gaussian cumulative distribution function F of ε_t, it follows that the probabilities of observing each possible outcome of ΔRR_t are

$$\Pr(\Delta RR_t = k_j | \mathbf{X}_t, \boldsymbol{\beta}, \alpha) = \begin{cases} F(\alpha_1 - \mathbf{X}_t\boldsymbol{\beta}) & \text{if} \quad j = 1, \\ F(\alpha_j - \mathbf{X}_t\boldsymbol{\beta}) - F(\alpha_{j-1} - \mathbf{X}_t\boldsymbol{\beta}) & \text{if} \quad 1 < j < J, \\ 1 - F(\alpha_J - \mathbf{X}_t\boldsymbol{\beta}) & \text{if} \quad j = J. \end{cases} \tag{3}$$

The estimates of $\boldsymbol{\beta}$ and α can be obtained by making identifying assumptions (typically, that $Var(\varepsilon_t|\mathbf{X}_t) = 1$ and the intercept $\beta_0 = 0$) and maximizing the log likelihood function

$$\ln L = \sum_{t=1}^{N}\sum_{j=1}^{J} d_{tj} \ln[F(\alpha_j - \mathbf{X}_t\boldsymbol{\beta}) - F(\alpha_{j-1} - \mathbf{X}_t\boldsymbol{\beta})], \tag{4}$$

where N is the sample size, and $d_{tj} = 1$ if $\Delta RR_t = k_j$ and 0 otherwise.

4.3 Policy meetings as a unit of observation

The paper departs from a common practice of employing the quarterly or monthly data averages and instead uses more adequate sample construction. The sample observations are all MPC meetings, when the decisions on the policy rate have been made. The MPC has always taken such decisions once a month, during the second half of the month. The dependent variable is a reference rate change made at a given MPC meeting. The data on the right-hand-side variables is taken as it was observed at a date of making policy decision, so it consists of already predetermined variables, which are independent of the rate setting at that MPC meeting. The raw data is used in all types of original frequency: daily, monthly and quarterly.

The above data construction avoids the simultaneity problem, which can occur in modeling the systematic responses of policy rates' averages to economic variables' averages for a given month or quarter due to possible interactions between the policy rate and the other variables that can happen during a period of aggregation. Furthermore, this sample design mimics carefully the timing of policy decisions and availability of statistical data, and hence carefully simulates the actual policy-action-generating process.

4.4 What does the MPC watch?

The empirical research on monetary policy tends to focus on a limited amount of data. Indeed, the central banks look at everything and monitor hundreds of economic variables: "The central bank takes into account all available information about factors increasing or decreasing inflationary pressure and causing a rise or fall of probability of achieving the inflation target assumed in the given period" (NBP 1999). What does the MPC monitor? Typically at each policy-setting meeting the Council discusses an impact on the future inflation, resulting from the current tendencies and forecasts of various economic and financial factors such as: the prices and inflationary expectations; the real sector of economy; the money supply; credit and lending; the market interest rates; the exchange rates; the external economic conditions; the situation in the balance of payments and in public finance sector; the labor market and wages.

After each policy meeting the MPC issues a press statement, announcing the decision made and its justification. The Inflation Report, released quarterly, contains the description of monetary policy conduct during the last three months along with the minutes of MPC meetings. Starting in April 2007, the minutes of MPC meetings have been published separately each month, a week before the next policy-making meeting. This study utilizes careful reading of MPC statements in order to identify the determinants of policy actions, and considers a wide spectrum of economic and financial indicators as candidate explanatory variables.

Table 4 describes the data used in the specification search. The potential explanatory variables are divided into twelve groups: current inflation (price indexes), inflationary expectations, gross domestic product and its main components, other measures of real activity, real sector expectations, labor market and wages, employment expectations, market interest rates, exchange rates, exchange rates' expectations, foreign policy interest rates, lending and credit. All variables are measured in various forms: levels, growth rates over different time spans, spreads and deviations, moving averages, changes (or growth rates) since the last MPC meeting and since the date of the last non-zero move in the policy rate. Table 5 describes the transformations made to the original data. In addition, the study checks for asymmetric responses to the negative and positive shocks.

4.5 Real-time data

To make the realistic assumptions about the timing of latest information available to the MPC at any meeting in the past the study pays careful attention to the historical release dates of all candidate explanatory variables and carefully scrutinizes MPC press statements following each policy-setting meeting.

Major economic data are released at either monthly or quarterly intervals with a publication lag of up to three months. Some monthly economic indicators are usually available for the policymakers with a one-month lag, while the others are known with a two-month

lag. The policy decisions sometimes take place in a middle of the month, prior to some regular data releases, as happened, for example, at a meeting on December 16-17, 2003, when "until the meeting of the Council the November figures relating to the industrial and construction sector output, retail sales, the PPI, the unemployment rate, base inflation and inflationary expectations were not disclosed" (NBP 2003). All the above-mentioned indicators are typically available for the previous month. Similarly, the availability of quarterly data at each meeting varies from month to month and from year to year, depending on the varying dates of quarterly data releases and MPC meetings. For example, at a meeting on November 24$^{\text{th}}$, 2004 the third quarter's data on GDP was already available, while at a meeting on November 26$^{\text{th}}$, 2003, the most recent available data related to the second quarter only.

Table 6 reports the timing and availability of quarterly and monthly statistical data at each policy meeting. The information on historical release calendars for all potential regressors was gathered both from the official web-sites and via requests to appropriate statistical agencies. The data released daily is taken for the business day preceding the day of the meeting itself.

To avoid the distortion of information, this study compiles and uses the novel Polish real-time data set, containing the historical time series actually available to the policymakers at each decision-making meeting during the period 1998-2007. The latest versions of data commonly used in the empirical research may differ from the real-time data due to revisions. Table 4 describes the "MPC meeting" data set, which contains the real-time vintages of about 140 economic and financial indicators such as: price indexes; inflationary expectations; gross domestic product and its main components; data from business tendency survey in construction, industry and retail trade and Reuters survey of commercial banks' analysts; industrial production; retail and whole sale of goods; investments; labor market and wages; market interest rates; exchange rates; foreign policy rates; and lending and credit. Most of the above variables are not subject to statistical revisions, so the real-time aspect of these data deals only with the accurate synchronization of the dates of policy decisions and timing of data releases. The variables that have been revised since the beginning of sample period include: the consumer price index; the real indexes and values (in current prices) of domestic demand, final consumption expenditure of households, gross domestic product, gross fixed capital formation and gross value added; the industrial production, both total and manufacturing; and the registered number of unemployed persons.

4.6 Tests for structural change

This study thoroughly checks for breaks in policy regime using Andrews' sup-LR test for structural change with an unknown change point (due to Andrews 1993). It is the generalization of Chow breakpoint test for a wide class of linear and non-linear parametric models. Instead of testing for a single break at a given point, in Andrews' test the likelihood ratios between the restricted and unrestricted models are computed for all points in the testing period (in the restricted model, the parameters are restricted to be constant for the whole period, while in the unrestricted one the parameters are estimated separately for the two sub-periods). To do so, the first 34 and the final 35 observations in the sample period 1999/02 – 2006/10 are preserved, the separate estimations for each sub-sample are performed, and the LR is computed for each monthly point from November 2001 through November 2003. The point with the maximum LR is the best candidate for the structural

change, provided that the LR exceeds an asymptotical critical value, which depends on the size, both the whole sample and of the testing period.

5 Estimation results

5.1 Tests for stationarity

All variables are checked for stationarity using the Augmented Dickey-Fuller (ADF) unit root tests. The lag order of lagged first differences of dependent variable in the tests is chosen according to a criterion of no serial correlation among residuals. The serial correlation among residuals up to the twelfth order is checked using the Ljung-Box Q-statistic. Table 7 reports the stationarity tests for all variables used in the reported results. All but two are stationary at a significance level of less than 5 percent. The indexes of gross domestic product and gross value added (growth rate in percent since corresponding period of the previous year) $GDPnaiy$ and $GVATnaiy$ are stationary at 7 percent level; however, it is likely due to insufficient power of the test due to the small sample size.

5.2 An interim year of 1998

The estimated reaction functions become more regular if the first twelve MPC meetings, from February 1998 through January 1999, are omitted from the sample. For example, Table 10 compares the estimations of two specifications for the periods 1998/03-2002/03 and 1999/02-2002/03: specification 10.1, which includes the month-to-month change in the deviation of annual rate of $CPIxac$ less administratively controlled prices from the inflation target and exchange rate of zloty to euro, and specification 10.2, which includes two measures of current inflation: Ind_CPI_T – an indicator variable, equaled to one, when CPI is above the inflation target, and zero otherwise, and $CPxac\_T\_YC$ – the change in the deviation of annual rate of core CPI less administratively controlled prices from the inflation target since the date of the last move in the policy rate. Dropping observations prior to February 1999 results in the considerable increase of parameters' estimates and improvements of fit in both specifications: LR (likelihood ratio) is 31.0 vs. 40.2 for model 10.1 and 21.5 vs. 39.3 for model 10.2, count R^2 (proportion of correct predictions) is 0.71 vs. 0.87 and 0.69 vs. 0.95, McKelvey & Zavoina R^2 is 0.67 vs. 0.96 and 0.50 vs. 0.97, respectively.

The detected significant differences in policy behavior before and after February 1999 can be explained by the following institutional facts. First, the year of 1998 represented a period of gradual transition (an "interim" year – see Polański (2004) for more information) from the monetary base targeting to a new framework of DIT that was officially declared only in October 1998 and that was formally supposed to be implemented since the beginning of 1999. Second, in the middle of 1998, the zloty started floating de facto – obviously, this switch from the a managed to a floating exchange rate regime affected the conduct of interest rate policy later on. Third, the monetary policy in 1998 was complicated by the Russian crisis in August – a strong external demand shock, which cut short Polish exports to Russia and boosted the supply in the domestic market. The four rate cuts by a total amount of 6 percent from September 1998 through January 1999 were caused to a large extent by the Russian default and appear to be the sample outliers.

Therefore, a sample from 1999/02 through 2006/10 is used for the further estimation.

5.3 The stability of policy responses

The Andrews' sup-LR tests with unknown change point detect highly significant structural breaks in the year of 2002 for many two-variable specifications, chosen among more than hundred and sixty economic indicators from Table 4. For example, Figure 3 shows the plot of sup-LR test for the specification with $ExInf\_T\_M$ (monthly change in the spread between the expected rate of inflation over the next 12 months from Ipsos survey and the inflation target) and $GVARna\_Y$ (the annual growth rate of gross value added in current prices less annual growth rate of CPI for the corresponding quarter). The models, including instead of gross value added other measures of real activity, such as the real gross domestic product and real domestic demand, have the similar patterns of sup-LR tests and also reveal the drastic structural break in April 2002. The dating of the structural break precisely matches the cut-off point between the above-discussed two sub-periods with high and low volatilities of the reference rate changes.

The separate estimations of four specifications, all including inflationary expectation $ExInf\_T\_M$, but different measures of real activity for the two sub-periods 1999/02-2002/03 and 2002/04-2006/10 are reported in Table 8. The difference in the fit before and after April 2002 is impressive for all four specifications. For example, for the specification 8.2 with $ExInf\_T\_M$ and $GDPRna\_Y$ (the annual growth rate of gross domestic product in current prices less annual growth rate of CPI for the corresponding quarter) the LR is 11.97 vs. 75.18, count R^2 is 0.71 vs. 0.98 and McKelvey & Zavoina R^2 is 0.41 vs. 0.97; besides, $ExInf\_T\_M$ is not significant at 36% level prior to April 2002, but significant at 1% level since then.

Table 9 compares four two-variable models, estimated for both sub-periods separately, and all including the same measure of real activity $GDPnaiy$ (the growth rate in percent since corresponding period of previous year of the index of gross domestic product), but different measures of current or expected inflation. The response to real activity becomes much stronger (the parameter estimates are 2-4 times larger) and more systematic in the second sub-period (p-values are smaller than 0.01 percent) than in the first one (p-values are between 1 and 7 percent). The responses to all three measures of current inflation are significant at 5% level in both sub-samples. However, the measure of expected inflation $ExInf\_T\_M$ is not significant at 17% level prior to April 2002, but significant at 0.1% level later on (see model 9.1). The overall fit of all specifications is much better for the second sub-period than for the first. More importantly, Table 9 demonstrates a clear shift from the backward-looking to forward-looking policy behavior: the measures of current inflation have a far more systematic relationship with the policy rate than the inflationary expectation prior to April 2002, but vice versa since then. Indeed, the best model for the first sub-period – the specification 9.4 with the backward-looking measure of inflation $CPIxac\_T\_YM$ (the monthly change in the deviation of annual rate of core CPI less administratively controlled prices from the inflation target) – has a much better fit than the specification 9.1 with forward-looking measure of inflation ($ExInf\_T\_M$): LR is 25.63 vs. 7.81, count R^2 is 0.82 vs. 0.71, McKelvey & Zavoina R^2 is 0.69 vs. 0.28. Quite the reverse, the best model for the second period – the forward-looking specification 9.1 – definitely outperforms all specifications with the measures of current inflation, including the best one among them, the specification 9.2 with $CPIxmf\_T\_YM$ (the monthly change in the deviation of annual rate of core CPI less the most volatile and fuel prices from the inflation target): LR is 69.92 vs. 46.68, count R^2 is 0.91 vs. 0.86, McKelvey & Zavoina R^2 is 0.91

vs. 0.73.

5.4 Policy reaction prior to April 2002

Table 10 presents the parameter instability tests for the two two-variable specifications, which also reveal the structural break in April 2002. The specification 10.1 includes $Ereu$ (the exchange rate of zloty to euro) and $CPIxac\_T\_YM$. The specification 10.2 contains two measures of current inflation: Ind_CPI_T – an indicator variable, equaled to one, when CPI is above the inflation target, and zero otherwise, and $CPxac\_T\_YC$ – the change in the deviation of annual rate of core CPI less administratively controlled prices from the inflation target since the date of last move in the policy rate. Figure 4 also shows the plot of sup-LR test for structural change with unknown change point for the model 10.1. The tests detect the structural break in April 2002 for both specifications 10.1 and 10.2 at significance levels 1% and 5%, respectively. The fit of both models is certainly better for the first sub-period compared to the second one: LR is 40.20 vs. 15.17 (for model 10.1) and 39.26 vs. 28.91 (for model 10.2), count R^2 is 0.87 vs. 0.62 and 0.95 vs. 0.73, McKelvey & Zavoina R^2 is 0.96 vs. 0.32 and 0.97 vs. 0.57, respectively. The reaction to exchange rate is significant at 1% level prior to April 2002 and not significant at 9% level since then. The response to current inflation is several times stronger prior to April 2002 than later on. In the first sub-period, both specifications have considerably better fits than any model including the inflation and real activity measures from Table 9, and vice versa in the second sub-period.

These results show that in the first sub-period the NBP mainly paid attention to the current inflation and reacted to the real activity far less, but to the exchange rate far more regular than in the second sub-period.

5.5 Interest rate smoothing?

The autocorrelation of policy rates is frequently attributed to the intentional interest-rate smoothing and intrinsic gradualism of central bank behavior. The empirical estimations of central bank reaction functions often treat such a sluggish adjustment of policy rates as endogenous to the central bank and incorporate a lagged interest rate on the right-hand side. The estimated significant coefficient on the lagged dependent variable is commonly viewed as evidence of "monetary policy inertia" or "interest-rate smoothing", and is explained by the central banks conservatism, the dislike of frequent reverses in the direction of interest rates' changes, the desire to reduce volatility in the financial markets, the caution caused by the imperfect knowledge of current state and structure of economy, and the desire to make the future path of short-term interest rates more predictable[12].

Alternatively, the observed partial adjustment of policy rates can be explained by the slow cyclical fluctuations of key macroeconomic indicators, such as inflation or output growth, which exogenously drive the central bank decisions. For example, Poole (2003) argues that there is no partial adjustment: "... future policy actions are almost entirely contingent on the arrival of new information." Moreover, as Rudebusch (2002, 2006) has recently demonstrated, the actual real-world amount of endogenous policy inertia is quite

[12] See, e.g., Amato and Laubach (1999), Bernanke (2004), Brainard (1967), Estrella and Mishkin (1999), Goodfriend (1987, 1991), Goodhart (1996, 1999), Levin et al. (1999), Lowe and Ellis (1997), Orphanides (2003), Sack (2000), Sack and Wieland (2000), Smets (1998), Woodford (1999b).

low and the illusion of it can reflect the mistaken omission of autocorrelated determinants of policy from the estimated reaction function[13].

Is there any evidence for the purposeful inertia of Polish interest-rate policy? The first-order Pearson correlation coefficients for the reference rate are 0.96 and 0.99 for the periods 1999/02-2002/03 and 2002/04-2006/10, respectively, while the first-order correlation coefficients for the changes to the reference rate are far smaller, 0.11 and 0.54, correspondingly. Table 11 reports the results of first-order autoregression of the reference rate changes before and after April 2002 in the context of ordered probit model (see models 11.1.1 and 11.2.1, respectively). The difference is substantial: in the first sub-sample the lagged dependent variable is not significant at a level of 34%, but significant at a level of 1% in the second one. Thus, the existence of partial adjustment in the context of policy rule in differences does not seem to be an issue in the first sub-period at all. Not surprisingly, the lagged reference rate changes added to the specifications 10.1 and 10.2 (the favored models for the first sub-period) are not significant at 20% and 40% level, respectively (see models 11.1.2 and 11.1.3). The LR-tests confirm also the redundancy of first two lags of dependent variable with p-values 0.07 and 0.26 for specifications 10.1 and 10.2, respectively.

Nevertheless, in spite of strong autoregressive property of the reference rate changes after April 2002, the lagged reference rate change, added to the specifications 8.2 and 8.3 (the favored models for the second sub-periods), is not significant at 56% and 55% level, respectively (see models 11.2.2 and 11.2.3). The LR-tests overwhelmingly reject also the relevance of two lags of dependent variable with p-values 0.85 and 0.52, respectively. The lagged reference rate change does not provide additional explanatory power, when inflation expectation and real activity indicator are employed.

Thus, during the entire period of study the policy rate appears to be driven by the key economic variables without evidence of deliberate interest-rate smoothing by the central bank. The observed positive serial correlation of the reference rate changes after April 2002 arise from the NBP's systematic responses to persistent shocks in the real sector of economy. Indeed, the gross domestic product and gross value added demonstrate strong positive autocorrelation – Pearson correlation coefficients are 0.90 and 0.95 for $GDPRna\_Y$ and $GVATnaiy$, respectively. On the contrary, prior to April 2002 the NBP does not react to the real activity, but reacts to the changes in the CPI; these changes, however, appear to be less autocorrelated – the Pearson correlation coefficient is 0.28 for $CPIxac\_T\_YM$.

5.6 Comparison with market anticipation

How well does the market foresee the decisions on the policy interest rate? As a measure of market anticipation, I use the forecast of next change to the reference rate from the Reuters survey of bank analysts in Poland. The survey is conducted two to three times a month among 12-22 analysts from commercial banks and is usually updated for the last time one day prior to a MPC meeting. Since February 1999, all individual forecasts of forthcoming rate changes have been in the range from -200 to 200 basis points. I combine the individual forecasts into three categories ("cut", "no change" and "hike") to compare them with the models' predictions. The predicted choice is that with the highest predicted probability. Alternatively, I also use the movements in the Warsaw interbank offer rates (WIBOR) employing them as an explanatory variable in the ordered probit model. For

[13] See also Castelnuovo (2003, 2006), English et al. (2003), Gerlach-Kristen (2004), Groth and Wheeler (2008), Lansing (2002), Sack (2000).

example, the spread between the WIBOR and reference rates at a day prior to an MPC policy meeting is assumed to represent the market ability to predict MPC decisions.

The market does a good job in anticipating the next monetary policy decisions. Table 12 presents the market anticipation during two sub-periods, prior to and after April 2002. The spreads between the 3-, 6-, 9-, and 12-month WIBOR and reference rate predict the policy decisions far better than rates with shorter maturities. The 6-month WIBOR demonstrates the best likelihood in both sub-samples, predicting correctly 82 and 85 percent of forthcoming policy decisions with the average likelihood of observed outcomes 77 and 81 percent in the first and second sub-periods, respectively. Bank analysts from the Reuters survey foresee 87 and 89 percent of forthcoming policy actions with the average likelihood of observed outcomes 80 and 82 percent, correspondingly (see Table 13).

However, the predictive power of market anticipation is clearly inferior when compared to the models 10.2 (for the first sub-sample) and 8.2 (for the second): though the model-implied forecasts are not optimized with respect to percentage of correct predictions, they predict 95 and 98 percent of next policy decisions with the average likelihood of observed outcomes 83 and 90 percent, respectively (see Table 13). Even one day before an MPC meeting the market anticipated the following day's policy decision far worse than the estimated simple rules, including only two economic indicators, the data on which is generally available for the public even earlier!

5.7 Policy reaction after April 2002

In contrast to the first sub-period, since April 2002 the measures of expected inflation and real activity predict the changes in the reference rate better than any other combination of economic indicators from Table 4. The further specification tuning for the period 2002/04 – 2006/10 is performed with the following four categories of dependent variable: "down 0.50%", "down 0.25%", "no change" and "up 0.25% or 0.50%" with 3, 32, 11 and 9 observations, respectively. This quadruple classification depicts the actual policy decisions after April 2002 almost ideally: only a single 0.25% hike was combined with the two observed 0.50% hikes into a joint category.

Table 16 presents the four models: the specification 16.1 with $ExInf\_T\_M$, $GDPnaiy$ and $ExInf\_T\_M$ multiplied by the dummy variable Ind_ExInf_T (equaled one, when the expected inflation is above the inflation target, and zero otherwise); the specification 16.2, which in addition to the above three variables includes $WIBOR12m\_ZP$ (the change since the last MPC meeting in the 12-month WIBOR if the change is positive, and zero otherwise); and the specifications 16.3 and 16.4, which are the same as 16.1 and 16.2, respectively, but instead of $GDPnaiy$ they include $GVATnaiy$ (the index of gross value added total, growth rate in percent since corresponding period of previous year).

The NBP appears to respond far aggressively to the spread between the expected inflation and inflation target, when the expected inflation is above the target (the coefficient estimate is several times bigger). The estimated models 16.1 and 16.3, including only inflationary expectation and real activity measures, have remarkable measures of fit: the count R^2 is 0.91 and McKelvey & Zavoina R^2 is 0.96 for both models. Adding changes in the 12-month WIBOR to the models 16.1 and 16.3 considerably improves the log likelihood from -15.51 to -7.13 (model 14.2) and from -15.49 to -8.15 (model 16.4), respectively. The models 16.2 and 16.4 correctly predict 53 and 52 out of 55 policy decisions (forecasting performance – 96% and 95%), correspondingly. Not only do financial markets watch the

NBP, but vice versa! Indeed, the MPC press releases indicate that the Council pays attention to the movements in the market long-term money rates as an indicator of future inflation. Definitely, changes in the WIBOR include extra forecasting information about future inflation not encompassed by the inflationary expectation of individual consumers from the Ipsos survey.

Table 14 reports the market anticipations of the reference rate changes, represented by the models including the spreads between the 1-, 3-, 6-, 9- and 12-month WIBOR and reference rates and estimated by the ordered probit with four categories. The specification 14.3 with the spread between 6-month WIBOR and reference rates has the best likelihood. Table 15 compares the predictions of the next policy decision, implied by the models 16.1 and 16.2, with the market anticipation, represented by predictive ability of the movements in the spread between 6-month WIBOR and reference rates (model 14.3) and by the forecast from the Reuters survey of banks' analysts. The spread between 6-month WIBOR and reference rates and bank analysts predict, respectively, 69 and 84 percent of next policy decisions correctly with the average likelihood of observed outcomes 63 and 78 percent and with a mean absolute error (MAE) of 10.27 and 7.25 basis points, respectively. Also noteworthy is the fact that the market anticipations are made one day prior to an MPC meeting. However, the simple model 16.1, based on inflationary expectations from the Ipsos survey and GDP, data on which is available for the public much earlier than one day prior to a policy meeting, without doubt does better job than the market: it predicts correctly 91 percent of next policy actions with average likelihood of observed outcomes 84 percent and 4.60 basis points MAE, though once again the ordered probit model is not optimized with respect to the proportion of correct predictions. If at a day prior to an MPC meeting the banks' analysts accurately paid attention to the movements in the 12-month WIBOR in addition to the inflationary expectations from the Ipsos survey and GDP, they would be able to predict (see model 16.2 in the Table 15) 96 percent of next policy decisions instead of 84 percent as they did, making only 2.84 instead of 7.25 basis points MAE with the average likelihood of observed outcomes 0.92 instead of 0.78.

To test again for evidence of deliberate interest-rate smoothing, I added the lagged dependent variable to the specifications 16.1 and 16.3 (see models 17.1 and 17.2 from Table 17, respectively). In both cases the lagged rate change is not significant at a level of 50 percent, at least. The LR-tests show the insignificance of adding three lags of dependent variable to both models at 5% and 8% levels, respectively. The lagged reference rate changes do not provide additional explanatory power, when inflation expectation and real activity measure are included into the model; however, the reference rate itself and its first difference are autocorrelated with correlation coefficient 0.99 and 0.54, respectively. Once again, the observed monetary policy inertia does not seem to be a consequence of intentional interest-rate smoothing by the central bank.

In Figure 5, the upper graph plots the actual and predicted reference rate changes, and the lower one plots the actual and expected changes for the specification 16.4. A particular policy decision is predicted if its predicted probability exceeds the predicted probabilities of the alternatives. The expected changes are computed using the formula $E(Y|X) = -0.5\Pr(Y = -0.5|X) - 0.25\Pr(Y = -0.25|X) + m\Pr(Y > 0|X)$, where $m = (0.5+0.5+0.25)/3 = E(Y|Y > 0, X)$ – sample mean of "hike" category. The model-implied forecast of discrete policy changes is not only very accurate – it correctly predicts 52 out of 55 decisions, but also it is made with high degree of certainty: the average likelihood (i.e., the average predicted probability of realized outcomes) is 0.91, and the mean absolute

error between actual and expected policy changes is 3.10 basis points. Figure 6 reports the predicted probabilities of all four possible policy actions on the background of the observed changes to the reference rate.

All estimated models from Table 16 satisfy the parallel regression assumption with p-values from 0.17 to 0.37, making it superfluous to employ the generalized ordered probit model, which is too richly parameterized for our small sample size. To make the further models' diagnostics Figure 7 reports the correlograms of generalized residuals[14] from models 16.2 and 16.4: the null of no serial correlation among residuals up to the twelfth order is overwhelmingly accepted at least at 60% and 44% level, respectively. It makes unessential to use far more computationally demanding dynamic ordered probit approach that accounts for the serial correlation among residuals, but cannot be directly estimated by maximizing the likelihood function.

Table 18 compares the actual and predicted policy decisions. The model anticipates all hikes and 50 basis points cuts, and overlooks only two 25 basis points cuts and one no change. The 'adjusted noise-to-signal' ratios[15] for four possible policy actions - 'hike', 'no change', '0.25% cut' and '0.50% cut' – are, correspondingly, 0%, 4.5%, 2.8% and 2.2%. The above noise measures are far lower than the reported ones in the related triple-choice ('hike', 'no change', and 'cut') empirical models for the US Federal Open Market Committee's decisions on the Federal funds rate target. For example, in Hu and Phillips (2004) these ratios for hikes, no changes and cuts are 3.8%, 44.6% and 8.5%, while in Piazzesi (2005) they are 10.6%, 71.8% and not defined, respectively.

5.8 Out-of-sample forecasting

An out-of-sample forecasting exercise is performed for the period 2006/03 through 2007/10, including 20 policy decisions of the MPC. The out-of-sample forecasting is compared to the market anticipation of policy actions, represented by the probabilities of four possible policy choices ("increase", "no change", "0.25% decrease", and "0.50% decrease"), derived from the individual forecasts made by commercial banks' analysts in the Reuters survey one day prior to an MPC meeting. In this survey, each analyst predicts the most likely level of the reference rate to be set at a meeting. The predicted rate's level can be easily transformed into the predicted change; during the period 2006/03 – 2007/10 only two likely outcomes were anticipated: either 'no change' or '0.25% hike'. The probability of a particular outcome is its fraction amongst all of the predicted choices. The final prediction is the most popular outcome, i.e. the choice with the largest predicted probability. Recently, the banks' analysts were highly successful in forecasting the following day's policy decision: in the period 2005/07 – 2007/10 they correctly anticipated 27 policy actions out of 28; while in the period 2002/04 – 2005/06 only 30 out of 39.

Table 19 reports the out-of-sample forecast along with the market anticipation. The out-of sample predictions are accomplished using specifications 16.3 and 16.4, estimated for

[14] The generalized residuals are defined as uncorrelated with the explanatory variables of the model. See Chesher and Irish (1987), and Gourieroux et al. (1987) for details.

[15] An adjusted noise-to-signal ratio, introduced by Kaminsky and Reinhart (1999), is defined as follows: let A denote the event that the decision is predicted and has occurred; let B denote the event where the decision is predicted but has not occurred; let C denote the event where the decision is not predicted but has yet occurred; let D denote the event where the decision is not predicted and has not occurred. The desirable outcomes fall into categories A and D, while noisy ones fall into categories B and C. A perfect prediction would contain no entries in B and C, while a noisy prediction would have many entries in B and C, but few in A and D. The adjusted noise-to-signal ratio is defined as $[B/(B+D)]/[A/(A+C)]$.

the period 2002/04 - 2006/02 without rolling re-estimations[16]. The model 16.3 predicts all seventeen "no changes", making a mistake in the timing of first hike (May instead of April 2007), failing to foresee the second hike in June 2007 (only predicting it with probability 25%), and correctly forecasting the last hike in August 2007. The model 16.4 predicts all seventeen "no changes" and all three hikes, erroneously forecasting only the timing of first hike – May instead of April. The market correctly foresees all seventeen "no changes", but only two of three rate hikes, overlooking a rate increase in June 2007.

The policy decision in April 2007 appears to be rather atypical. An MPC press release, following the meeting, reports that "according to the April inflation projection, the growth of consumer prices will be lower than in the January projection over the whole projection horizon... In the Council's assessment, in the second half of 2007 CPI inflation will temporarily decrease markedly below the inflation target of 2.5%." (NBP 2007). However, despite the decline in NBP inflation projections, the MPC decided to increase the policy rates, because "in the Council's assessment, in the medium term, the probability of inflation running above the target is larger than the probability of its running below the target, which persuaded the Council to tighten the monetary policy".

The MPC judgment with respect to the future inflation has been confirmed in the next month by an increase in the expected rate of inflation over the next 12 months from the Ipsos survey: in May it raised by 0.7% compared to 0.1% in April. Both models predict for May an "increase" with almost complete certainty. However, the rate was not changed in May – the MPC reacted preemptively already in April.

The estimated ex-post policy rules, even those with high measures of in-sample fit, generally have a quite low out-of-sample forecasting performance, caused by the instability of the policy regime and/or the small-sample biasedness of estimation. The conducted out-of sample forecasting demonstrates the structural stability of estimated policy reaction up to 20 months ahead, almost ideally predicts all policy moves and outperforms the market anticipations, made one day prior to each policy meeting.

6 Does real-time 'policy-meeting' data matter?

A common approach to identify the monetary policy rules is to estimate the relationship between monthly or quarterly averages of policy rate and economic indicators, using data currently available for an econometrician. In reality, the policy decisions are usually made 6-12 times per year, and the policymakers react to the incoming original non-aggregated data, as it was known at a day of policy meeting. By and large, the information set used in the policy-making process may differ from one used by the econometrician thanks to three reasons: data revisions, inaccurate aligning the timing of data releases and policy decisions, and time aggregation.

This section assesses the statistical effects of using the ex post revised and time-aggregated data on the empirical identification of Polish monetary policy. The policy rules, estimated using the real-time data and decision-making meetings as a unit of observation, are compared with the rules, estimated using the currently available data at monthly frequency. Since the policy-making meetings have taken place every month and only once per month during the sample period, the two data sets – the real-time "MPC-meeting" data set, which

[16] The models 16.3 and 16.4, estimated over the sub-period 2002/04 – 2006/02, have the following measures of fit: LR is 79.55 and 94.73, count R^2 is 0.89 and 0.96, McKelvey & Zavoina R^2 is 0.96 and 0.99.

mimics as much as possible the true information set used in the policy-making process, and the ex post revised monthly data set used by the econometrician – have the same number of observations. Moreover, they have absolutely the same values of dependent variable – monthly changes to the reference rate. This allows us to apply the same regression technique (an ordered probit) for estimation of alternative policy rules, and provides a straightforward way to compare them. However, the values of right-hand-side variables in two data sets are in general not identical. Therefore, we will determine whether these discrepancies can lead to statistically different inference.

How to align the timing of left- and right-hand side variables in the revised monthly data set? We can apply the same assumption for all variables in the data set by allowing, say, a month's lag in the arrival of monthly statistical data, i.e. we can match the reference rate change in a given month with the values of independent variables for a previous month. However, to give the revised averaged data the best chance to match the data truly available for policymakers, I use such a lag length that is typical for a given series. For example: inflationary expectation from the Ipsos survey is usually available for a current month, without a lag; CPI is typically available for a previous month, i.e. with a month lag; the quarterly data on GDP and components is usually released with a two-month lag.

The estimations of the same four specifications as in Table 16 are performed for both data sets for the period 2002/04 – 2006/10 using the ordered probit model with four categories of dependent variable: "0.50% or 0.25% increase", "no change", "0.25% decrease", and "0.50% decrease". Table 20 reports the policy rules' estimations based on the ex post revised monthly data. The differences between the estimations, using the real-time and revised data sets, are in favor of the real-time one: for the specifications 16.1 and 16.3, log likelihood lowers from -15.51 and -15.49 (see Table 16) to -18.20 and -17.24 (see Table 20), and the percentage of correctly predicted outcomes decreases by 6% and 4%, respectively. The time-aggregation effect is not strong in this case, because during the period of study, the MPC have always taken policy decisions during the second half of each month after all major statistical releases, including inflationary expectations and GDP. All regressors remain highly significant, and parameters' estimates are not statistically different. Such results are not surprising: these models are based on two indicators, released monthly: inflationary expectation measure, which is never revised, and GDP index, which is only slightly revised. The observed difference in goodness-of-fit is, however, caused mainly by these minor revisions.

The difference drastically changes for the specifications 16.2 and 16.4, which contain an extra variable $WIBOR12m\_ZP$: the log likelihood drops from -7.13 and -8.15 to -18.4 and -17.22, the percentage of correctly predicted outcomes decreases by 11% and 8%, respectively. The coefficient on $WIBOR12m\_ZP$ becomes highly insignificant with the revised monthly data (p-values are 0.72 and 0.82 for specifications 16.2 and 16.4, respectively), while being significant at 3% level with the real-time data. These results are not surprising either: though the data on WIBOR is never revised, the calendar month averaging overlooks the critical information about the movements in the WIBOR between MPC meetings and in the days around them.

Table 21 compares the estimation performed using the two alternative data sets for the specification including $ExInf\_T\_M$, $GDPRna\_Y$, and $ExInf\_T\_M*Ind\_ExInf\_T$: the use of revised monthly data decreases the log likelihood from -19.04 to -29.48, and lowers the percentage of correctly predicted outcomes by 9%. Now the differences in the goodness-of-fit are far larger than for the specifications 16.1 and 16.3, including $GDPnaiy$

and $GVATnaiy$ instead of $GDPRna\_Y$, respectively. Indeed, the difference between the real-time and revised versions of $GDPRna\_Y$ is more substantial: the correlation coefficient between the latest revised vintage of $GDPRna\_Y$ and its real-time version is 0.72, while for both $GDPnaiy$ and $GVATnaiy$ the correlation is about 0.99.

Thus, despite the facts that the degree of ex post revisions of statistical data in Poland is quite low and the policy-making meetings take place regularly in the second half of each month, which diminish the difference between the two alternative sample constructions, the real-time data set with the decision-making meetings of monetary authority as a unit of observation is shown to produce statistically different estimation results with better measures of fit. The calendar month averages are not capable of detecting the strong systematic relationship between intermeeting changes in the daily financial market data (closely monitored by the central bank) and policy rate changes.

Thus, the use of a real-time data set with the policy-making meetings as a unit of observation does matter in the econometric identification of Polish monetary policy!

7 Does discreteness matter?

The used ordered probit model (OPM) elegantly accounts for the discreteness of policy rate and the impact of explanatory variables. However, can we address the above problems via the conventional simpler linear regression model (LRM)? This section compares the performance of OPM and LRM in order to show that using special regression methods for a discrete dependent variable does make a difference in the econometric identification of Polish monetary policy.

Such a comparison is complicated because the OPM, based on the maximum likelihood (ML), is designed to estimate the probabilities of limited discrete outcomes of the dependent variable while the LRM, based on the ordinary least squares (OLS), is designed to estimate the expected value of dependent variable, which is assumed to be an unlimited continuous one. Therefore, all measures of fit for the LRM (such as the coefficient of determination R^2, etc.) cannot be constructed for the OPM, because they are based on the OLS, and cannot be directly compared with the pseudo R^2 measures of fit for the OPM, since they are all based on the ML.

It is appealing to estimate the LRM by ML as a generalized linear model (GLM) with identity link function and normal probability distribution, and compare it with the OPM using some kind of test for non-nested models, for instance, Santos Silva's test (Silva 2001), based on the likelihood. However, the comparison of GLM and OPM on the basis of the likelihood is still not legitimate. The problem is with the likelihood per se: the likelihood functions of GLM and OPM have different natures. In the OPM (as in other models for a categorical dependent variable), the individual observation's contribution to the likelihood is the probability of observing the realized discrete event, while in the GLM the likelihood is not the probability (the integral under the *p.d.f.* between the two cut-points), but rather the value of the continuous normal *p.d.f.* at some point (hence, it can be greater than one).

Unfortunately, it seems impossible to construct a formal test based on the likelihood to compare the LRM and OPM. Are there any other appropriate ways to compare them? One possible approach is to define the expected value of the dependent variable $E(Y|\mathbf{X})$ for the OPM and compare it with its LRM counterpart. For the LRM the $E(Y|\mathbf{X}) = \mathbf{Xb}$, where coefficients $\mathbf{b}$ are estimated by OLS or ML; for the OPM we can naturally assume that the $E(Y|\mathbf{X}) = -0.5\Pr(Y = -0.5|\mathbf{X}) - 0.25\Pr(Y = -0.25|\mathbf{X}) + (0.5+0.5+0.25)\Pr(Y > 0|\mathbf{X})/3$,

where probabilities are estimated by ML[17]. Then we can calculate, for example, the mean absolute error, i.e. the arithmetic average of absolute differences between the observed and expected rate changes (denoted as "MAE of $E(Y|\mathbf{X})$").

An alternative approach is to compute the conditional distribution of rate changes by defining the probabilities of discrete events for the LRM and to compare them with the OPM counterparts. Let us ignore for a moment the discreteness of policy rate and evaluate the following simple LRM using OLS:

$$\Delta RR_t = \mathbf{X}_t\boldsymbol{\beta} + \varepsilon_t, \tag{5}$$

where ΔRR_t – the reference rate change, $\mathbf{X}_t$ - vector of explanatory variables, and ε_t – disturbance term, assumed to be distributed as *i.i.d.* $Normal(0, \sigma^2)$. We can define the probabilities of discrete outcomes of ΔRR_t as

$$\begin{aligned}
\Pr(\Delta RR_t = -0.50) &= \Pr(-\infty < \mathbf{X}_t\boldsymbol{\beta} + \varepsilon_t < c_1),\\
\Pr(\Delta RR_t = -0.25) &= \Pr(c_1 < \mathbf{X}_t\boldsymbol{\beta} + \varepsilon_t < c_2),\\
\Pr(\Delta RR_t = 0) &= \Pr(c_2 < \mathbf{X}_t\boldsymbol{\beta} + \varepsilon_t < c_3),\\
\Pr(\Delta RR_t \geq 0.25) &= \Pr(c_3 < \mathbf{X}_t\boldsymbol{\beta} + \varepsilon_t < \infty),
\end{aligned}$$

where $-\infty < c_1 < c_2 < c_3 < \infty$ are some known fixed cut-points.

These probabilities can be computed using the normal cumulative distribution function F of ε_t and estimated OLS coefficients $\boldsymbol{\beta}$ as follows

$$\begin{aligned}
\Pr(\Delta RR_t = -0.50) &= F(c_1 - \mathbf{X}_t\boldsymbol{\beta}),\\
\Pr(\Delta RR_t = -0.25) &= F(c_2 - \mathbf{X}_t\boldsymbol{\beta}) - F(c_1 - \mathbf{X}_t\boldsymbol{\beta}),\\
\Pr(\Delta RR_t = 0) &= F(c_3 - \mathbf{X}_t\boldsymbol{\beta}) - F(c_2 - \mathbf{X}_t\boldsymbol{\beta}),\\
\Pr(\Delta RR_t \geq 0.25) &= 1 - F(c_3 - \mathbf{X}_t\boldsymbol{\beta}).
\end{aligned} \tag{6}$$

Let us refer to such a LRM, extended to estimate the probabilities of discrete events, as to a 'rounded linear regression' model (RLRM). To compute the probabilities in (6) we just have to choose the values of cut-points.

The probabilities of discrete outcomes for the RLRM in (1.6) can be now contrasted to the corresponding probabilities for the OPM in (1.3). For example, we can compute and compare the percentage of correctly predicted outcomes, where the predicted outcome is the outcome with the highest probability (denoted as 'Count R^2'), the proportion of correct predictions beyond the number that would be correctly guessed by choosing the outcome category with the largest percentage of observed cases (denoted as 'Adjusted count R^2'), and the average predicted probability of realized outcomes, i.e. the average likelihood of individual observations (denoted as 'Average likelihood').

The above measures of fit are useful in comparing competing models, but can only provide some level of rough guidance in selecting the preferred model. Without conducting a formal test, however, it is unclear which model is the best one. Formal comparison of RLRM and OPM can be undertaking by noting that the former is actually a special case of the latter.

[17] The $E(Y|Y > 0, \mathbf{X})$ is taken to be equal to (0.5+0.5+0.25)/3, which is the sample mean.

Indeed, the formulas (1.6) are identical to ones for a censored interval regression model (also known as a 'grouped regression' model), which is defined by (1.1)-(1.4) like the OPM, but with the fixed cut-points c_j instead of estimated α_j and estimated $\sigma^2 = Var(\varepsilon_t|\mathbf{X}_t)$ instead of assumed to be equal to one. The interval regression model (IRM) can be estimated by maximizing the log likelihood function $\ln L$ of $\boldsymbol{\beta}$ and σ:

$$\ln L = \sum_{t=1}^{N}\sum_{j=1}^{J} d_{tj} \ln[F(c_j - \mathbf{X}_t\boldsymbol{\beta}) - F(c_{j-1} - \mathbf{X}_t\boldsymbol{\beta})], \tag{7}$$

where in our case $j = 1, 2, 3, 4$; N is the sample size; $d_{tj} = 1$ if $\Delta RR_t = k_j$ and 0 otherwise; $\{k_1, k_2, k_3, k_4\} = \{-0.5, -0.25, 0, \text{greater than } 0.25\}$ – four categories of the reference rate changes; and F is the normal cumulative distribution function with mean zero and variance σ^2.

The probabilities of discrete events in the IRM and RLRM, though given by the same formulas in (1.6), are, in general, different, because in the RLRM the β and σ^2 are estimated by minimizing the squares of residuals from the equation (1.5), while in the IRM the β and σ are estimated by maximizing the log likelihood function in (1.7) from the equation (1.1). Yet, the probabilities and likelihood, defined respectively by (1.6) and (1.7), for the RLRM are identical to ones for the IRM, if β and σ^2 in the IRM are constrained to be equal to the OLS estimates from the LRM instead of being estimated by maximizing (1.7). In this respect our extended RLRM is a special case of IRM. Furthermore, the IRM itself is actually nested in the OPM, since we can treat the OPM as a more general model, in which the assumption of fixed thresholds is relaxed (so the thresholds have to be estimated) and the intercept β_0 and $Var(\varepsilon_t|\mathbf{X}_t)$ are fixed to be the same as they have been estimated in the IRM (as a rule, $Var(\varepsilon_t|\mathbf{X}_t)$ and β_0 in the OPM are assumed to be equal to one and zero, respectively, but these identifying assumptions are arbitrary and affect only the slope coefficients in $\boldsymbol{\beta}$ – they do not affect the estimated probabilities and likelihood).

Thus, the IRM is nested in the OPM, if $Var(\varepsilon_t|\mathbf{X}_t)$ and β_0 in the OPM are assumed to be equal to their counterparts from the IRM. Consequently, all three models – the RLRM, which is equivalent to the constrained IRM with the β_{LRM} and σ^2_{LRM}, the unconstrained IRM, and the OPM with $Var(\varepsilon_t|\mathbf{X}_t) = \sigma^2_{IRM}$ and $\beta_0 = \beta_{0_{IRM}}$ – are nested inside each other, can be estimated by ML and, hence, may be compared using, for example, the likelihood ratio chi-square test[18].

Table 22 presents the two LRM, estimated for the period 2002/04 – 2006/10 by OLS with the same specifications as in the OPM 16.3 and 16.4, using the historical (not classified) values of the reference rate changes. The coefficients of determination are about 0.68, and the coefficients on $ExInf\_T\_M$ and $GVATnaiy$ are significant at 1% level for both specifications. However, in contrast to the OPM, in the specification 14.3 the LRM coefficient on $ExInf\_T\_M * Ind\_ExInf\_T$ is not significant at 24% level, and in the specification 16.4 both the coefficients of $ExInf\_T\_M * Ind\_ExInf\_T$ and $WIBOR12m\_ZP$ are not significant at 29% and 61% level, respectively, while all being significant in both OPM specifications at 2% level at most. These results send the preliminary signal about

[18] See Hausman et al. (1992) for the related comparison of LRM estimated by OLS and OPM in this context. They set up the extended 'rounded' version of LRM as a special case of OPM, in which all the thresholds are fixed and equally spaced, and apply the Wald chi-square test to check this restrictions. This is the only known to me example of formal testing of the LRM against the OPM in the literature.

incapability of LRM to be an adequate substitute to OPM.

Table 23 compiles the goodness-of-fit measures of two specifications 16.3 and 16.4, obtained for estimations in the context of RLRM (which is equivalent to the constrained IRM with all coefficients β and σ^2 restricted to be the OLS ones from the LRM), unconstrained IRM and OPM. The RLRM are estimated using four alternative sets of fixed cut-points: biased-toward-tightening [-0.5, -0.25, 0], biased-toward-easing [-0.25, 0, 0.25], equally-spaced [-0.375, -0.125, 0.125] and zero-inflated [-0.5, -0.25, 0.25]. The RLRM have practically the same likelihood and other measures of fit for both specifications, being unable (like the LRM) to detect the predictive power of additional variable $WIBOR12m\_ZP$. The RLRM with equally-spaced and zero-inflated thresholds correctly predict 78 and 73 percent of observed rate's changes and have very similar log likelihood (about -36) and MAE (about 10 basis points); their fit is considerably higher than the fit of RLRM with the other two sets of thresholds, biased-toward-tightening and biased-toward-easing, where the percent of correct predictions is about 55 and 43, the log likelihood is about -55 and -52, and MAE is about 17 and 14 basis points, respectively. The equally-spaced and zero-inflated thresholds seem to be rather reasonable assumptions: the RLRM have practically the same MAE as the LRM (about 10 basis points), while biased-toward-tightening and biased-toward-easing cut-points lead to larger MAE than the LRM equivalent.

The estimations of unconstrained IRM are reported only for the equally-spaced and zero-inflated thresholds[19]. The likelihood maximization in the IRM with the equally-spaced cut-points produces similar estimates of intercept and slope coefficients for $ExInf\_T\_M$ and $GVATnaiy$ as in the RLRM (for instance, for the specification 16.4 they are (standard errors are in parentheses), respectively, -0.381 (0.041), 0.201 (0.058), and 0.079 (0.011) in the LRM and -0.367 (0.031), 0.202 (0.046), and 0.074 (0.009) in the RLRM) and the same 10 basis points MAE, but triples the size and considerably improves the significance of slope coefficients for $ExInf\_T\_M * Ind\_ExInf\_T$ and $WIBOR12m\_ZP$ (p-values are 0.291 and 0.619 in the RLRM versus 0.004 and 0.107 in the IRM, respectively), and increases the log likelihood from -36.2 to -29.7. Moreover, in the IRM with zero-inflated thresholds the likelihood maximization alters the estimates of intercept and all four slope coefficients for $ExInf\_T\_M$, $GVATnaiy$, $ExInf\_T\_M * Ind\_ExInf\_T$ and $WIBOR12m\_ZP$: -0.381 (0.041), 0.201 (0.058), 0.079 (0.011), 0.106 (0.099) and 0.058 (0.115) in the RLRM versus -0.530 (0.029), 0.275 (0.052), 0.101 (0.009), 0.508 (0.106) and 0.424 (0.115) in the IRM, respectively. It also makes all coefficients to be significant at the level less than 1%, increases the log likelihood from -36.16 to -15.58, and reduces the MAE from 10 to 5 basis points. In contrast to the RLRM, the ML estimation of IRM reveals a large difference between the specifications with equally-spaced and zero-inflated cut-points. The zero-inflated thresholds, where the distance between the cut-points in the "no change" category is twice bigger than in the "-0.25% decrease" category, result in considerable improvement of fit, compared to the equally-spaced ones, where these distances are the same: the log likelihood is -15.58 versus -29.70, and the MAE is 5 versus 10 basis points.

Finally, the OPM demonstrates the further sharp improvement of fit, compared to the RLRM and IRM: for example, in the specification 16.4 the log likelihood raises to -8.2 (versus -36.2 and -15.6 for the RLRM and IRM, respectively), the MAE drops to 3 basis points

[19] The IRM estimations with the biased-toward-tightening and biased-toward-easing sets of cut-points have only different intercept estimates, but produce the same slope coefficients, probabilities and likelihood as with the equally-spaced cut-points, because all three sets have the same distances between adjacent cut-points and differ among themselves by a parallel shift of 12.5 basis points.

(versus 10 and 5, respectively), the proportion of correct predictions reaches 95% (versus 78% and 87%). The OPM seems to more adequately reflect the central bank reluctance to move the policy rate by allowing the underlying continuous rate changes and estimated cut-points to have the different scale with the observed discrete changes. In our case, the OPM estimates the distance between the cut-points for the "no change" category to be almost four times bigger than for the "-0.25% decrease" category in both specifications.

To formally compare the OPM, IRM and RLRM, estimated with the same data set for two specifications, Table 23 reports the results of likelihood ratio chi-square tests of several versions of RLRM and IRM with alternative sets of cut-points against a more general unconstrained OPM that nests all of the above ones. All tests are in favor of the OPM: imposed by the null hypothesis constraints are rejected at marginal 7% significance level only for one model, the IRM with the specification 16.3 and zero-inflated cut-points, while for all other models, they are overwhelmingly rejected at less than 1% level.

Thus, not only does the OPM reveal considerably better measures of fit than the RLRM and IRM, but it is also clearly superior on the basis of formal statistical test. The information gained by a more complex discrete-response technique like OPM is not attainable with the simpler continuous-response linear regression techniques.

Ergo, discreteness does matter!

8 Summary and conclusions

> "It is highly desirable that policy practice be formalized to the maximum possible extent. Or, more precisely, monetary economists should embark on a program of continuous improvement and enhanced precision of the Fed's monetary rule..."
>
> – W. Poole, then-President of the Federal Reserve Bank of St. Louis[20]

The aim of this study is not to describe the current practice of Polish monetary policy by an algebraic equation, or "rule". Rather, the paper allows the data to speak in support of the statement that the policy decisions are highly predictable by observing the arriving economic and financial news in the real-time setting and using an appropriate econometric technique. Though the NBP looks at everything in formulating policy decisions, the estimated reaction functions, based on a small number of economic variables, correctly explain 95 percent of observed discrete policy adjustments in the period 1999/02 – 2006/10. In an out-of-sample forecasting of next twenty monthly policy decisions from 2006/03 through 2007/10 the empirical model correctly predicts seventeen 'no changes' and three 'hikes', erroneously forecasting only the timing of one hike with a monthly lag. Such forecasting performance surpasses the market anticipations of next policy move, made one day prior to a policy meeting. The market (represented by the Reuters survey of banks' analysts) correctly predicted only 84 percent of policy-rate decisions in the period 1999/02 – 2006/10 and overlooked one hike in the period 2006/03 – 2007/10.

The reported in- and out-of-sample forecasting performance, exceeding the typical one in the literature, is shown to be (at least, partially) a consequence of the employed empirical methodology, combining the use of regression techniques for a discrete dependent variable, real-time data and decision-making meetings of monetary authority as a unit of observation. This methodological framework carefully mimics the actual policy-action-generating process

[20] See Poole (2006).

since: (i) most major central banks alter interest rates by discrete-valued adjustments; (ii) policy decisions are naturally made using information available in the real-time setting; and (iii) they are typically made 8-12 times per year at special policy-making meetings. However, the empirical studies routinely estimate the monetary policy rules by: (i) applying the regression methods for a continuous dependent variable; (ii) using currently available series of economic data; and (iii) analyzing the systematic responses of policy rate's averages to economic data averages for a given month or quarter. Obviously, such practice distorts the actual data-generating process because: (i) regression methods for a continuous dependent variable are shown to be inadequate when the dependent variable is discrete; (ii) the latest versions of statistical data may differ from the real-time ones due to revisions; and (iii) time aggregation of data misaligns the timing of policy decisions and the availability of statistical data as well as raising the problem of simultaneity.

On the other hand, it is not apparent that these distortions are significant enough to make a difference from a practical point of view, i.e. in the econometric identification of monetary policy rules. This issue has been only partially analyzed in the literature. It was demonstrated for several countries that ex post revised and real-time data lead to significantly different estimation results. There were only a few studies that model the policy rules using a discrete choice approach. To the best of my knowledge, there were no attempts to assess how the use of discrete regression techniques affects the empirical identification of monetary policy; neither were there any attempts to estimate the policy rules using the decision-making meetings of monetary authority as a unit of observation. This study assesses separately the statistical effects of using the linear OLS regression model instead of ordered probit one and the latest revised monthly-averaged data instead of real-time one with the policy-making meetings as a unit of observation. The formal comparison shows that discreteness and real-time data do matter in the empirical identification of Polish monetary policy.

The proposed methodological framework is well suited to identify the monetary policy of many central banks and can help market participants to minimize the uncertainty about the future monetary policy actions.

The performed ordered probit analysis of the response patterns between the reference rate changes and incoming economic real-time data reveals briefly the following:

- The first twelve policy decisions of the MPC prior to February 1999 (during an interim period of transition to a new policy regime) significantly differ from the regular policy reactions since then.
- The systematic policy responses demonstrate remarkable structural differences prior to and since April 2002. In its reaction to the deviation of inflation from the target, the NBP has shifted from the backward- to forward-looking behavior.
- Prior to April 2002, in the period of fighting the high inflation the NBP reacted to the real activity measures far less, but to the exchange rate far more regular than since then, in the period of stabilizing the low inflation.
- The NBP reacts highly asymmetrically to the changes in inflationary expectations, depending on whether the expected inflation is above or below the inflation target.
- The policy rates appear to be driven by the key economic indicators without evidence for deliberate interest-rate smoothing by the central bank.

Figures

Figure 1: Actual and target rates of inflation in Poland

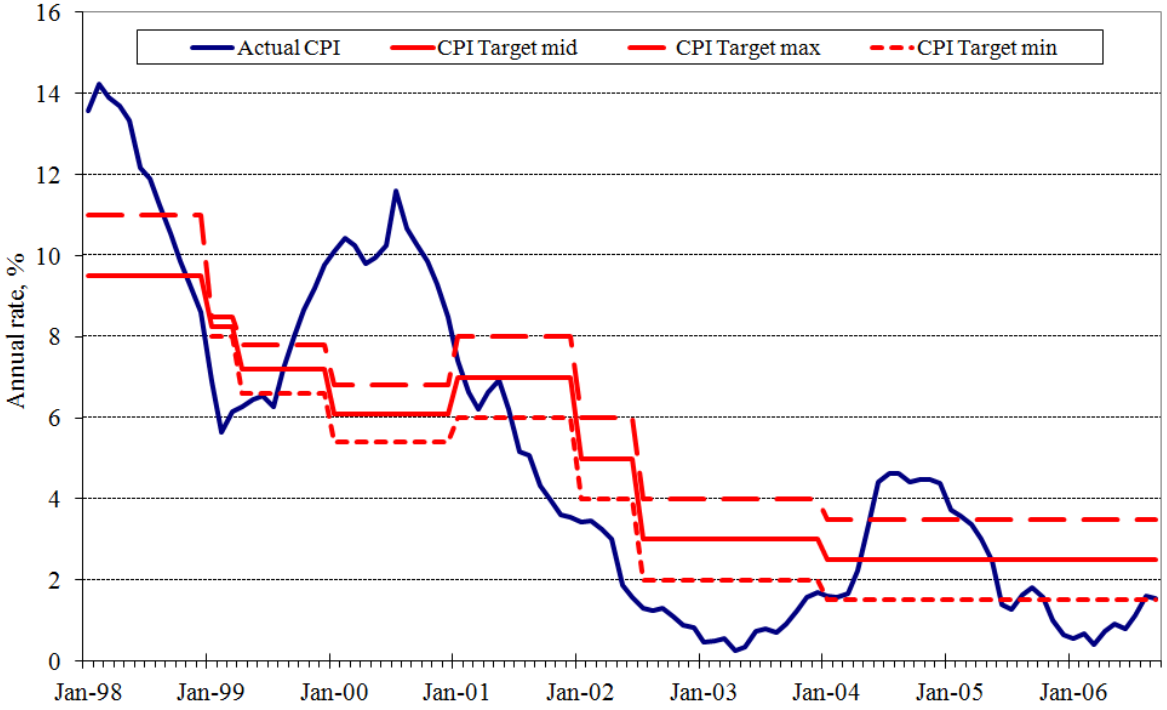


Figure 2: Changes to NBP reference rate

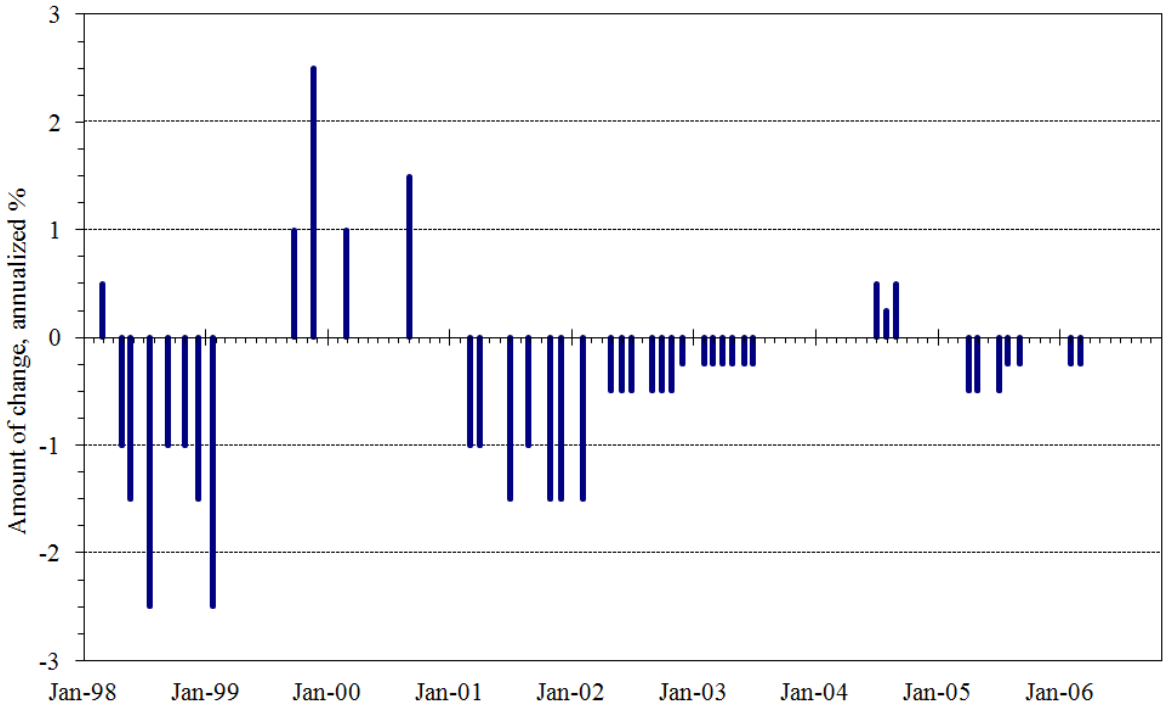
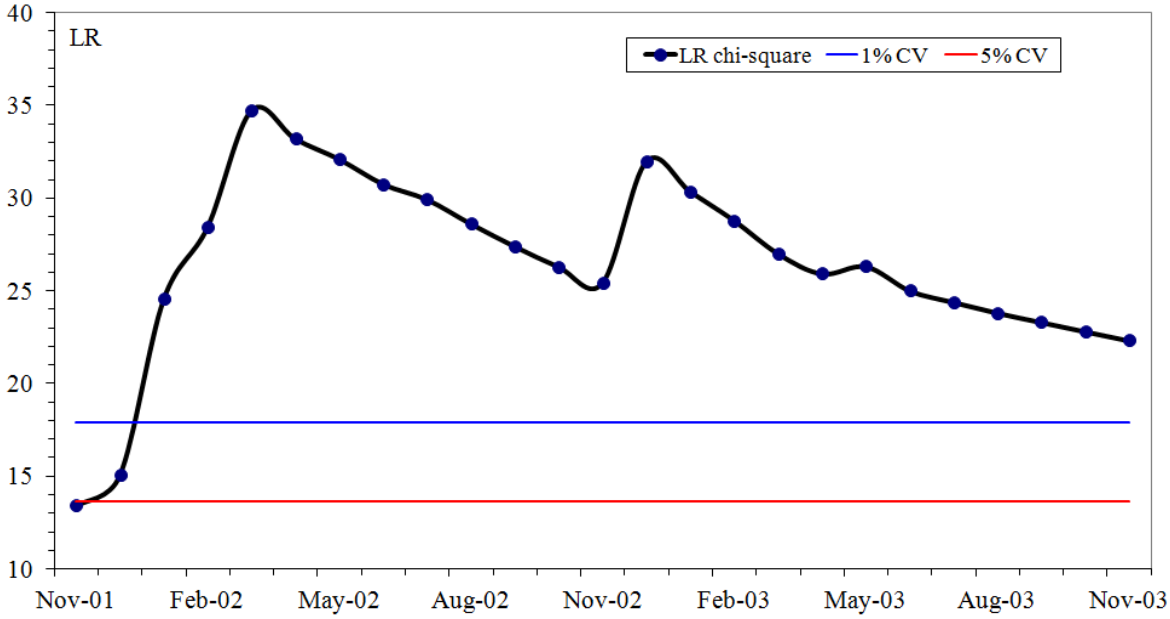
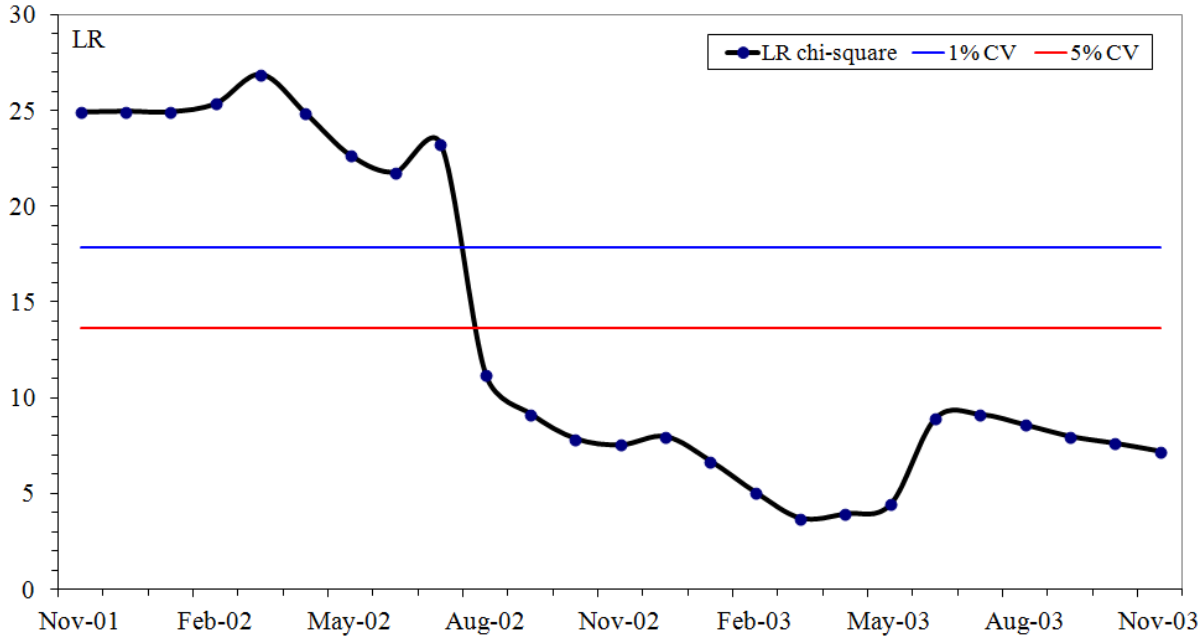


Figure 3: Andrews' sup-LR test for structural change with unknown change point



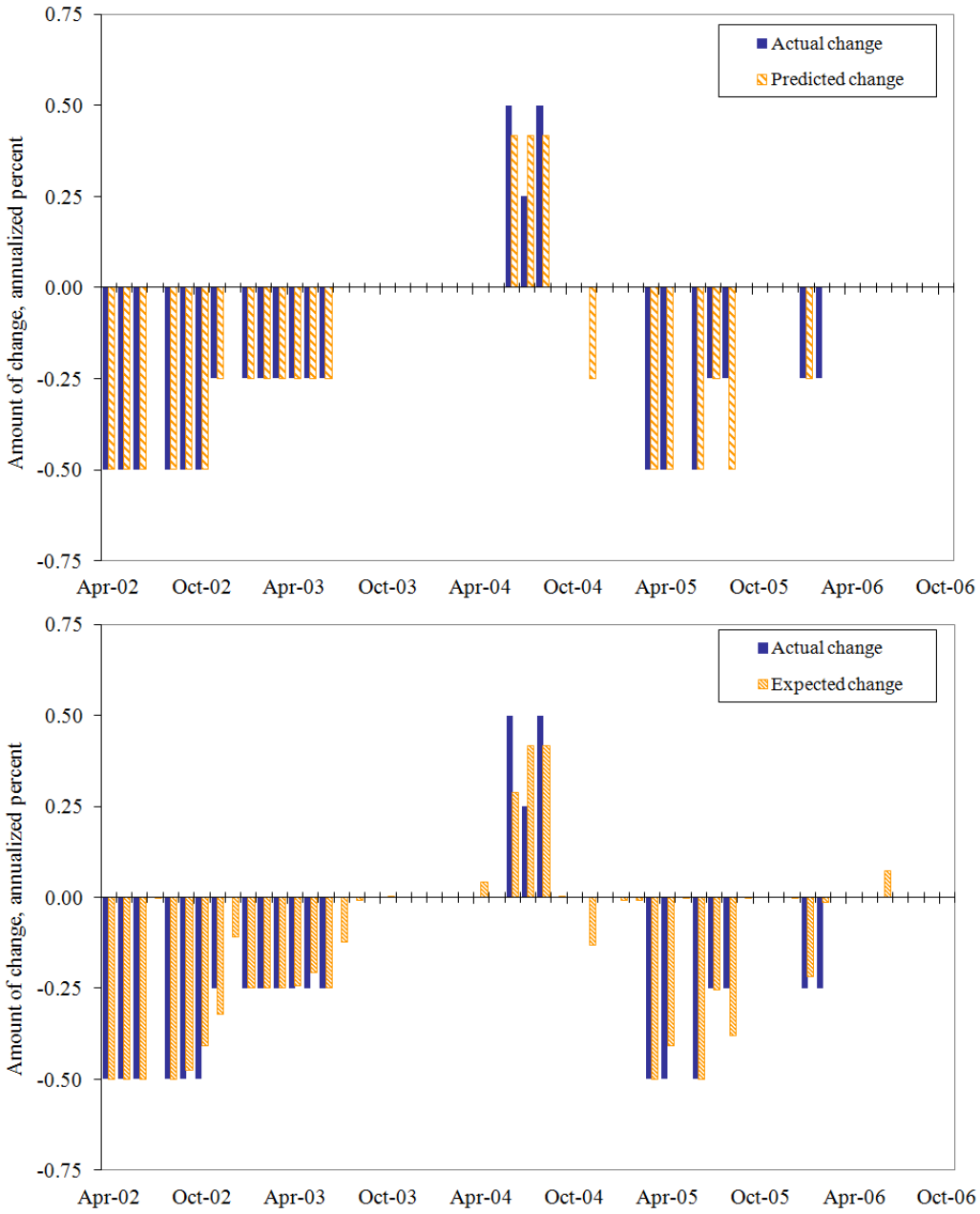
Notes:
Dependent variable: ΔRR_t;
Independent variables: $GVARna\_Y$ and $ExInf\_T\_M$;
Model: Ordered probit with three categories: 'up', 'no change', 'down';
Sample: 1999/02 - 2006/10.

Figure 4: Andrews' sup-LR test for structural change with unknown change point



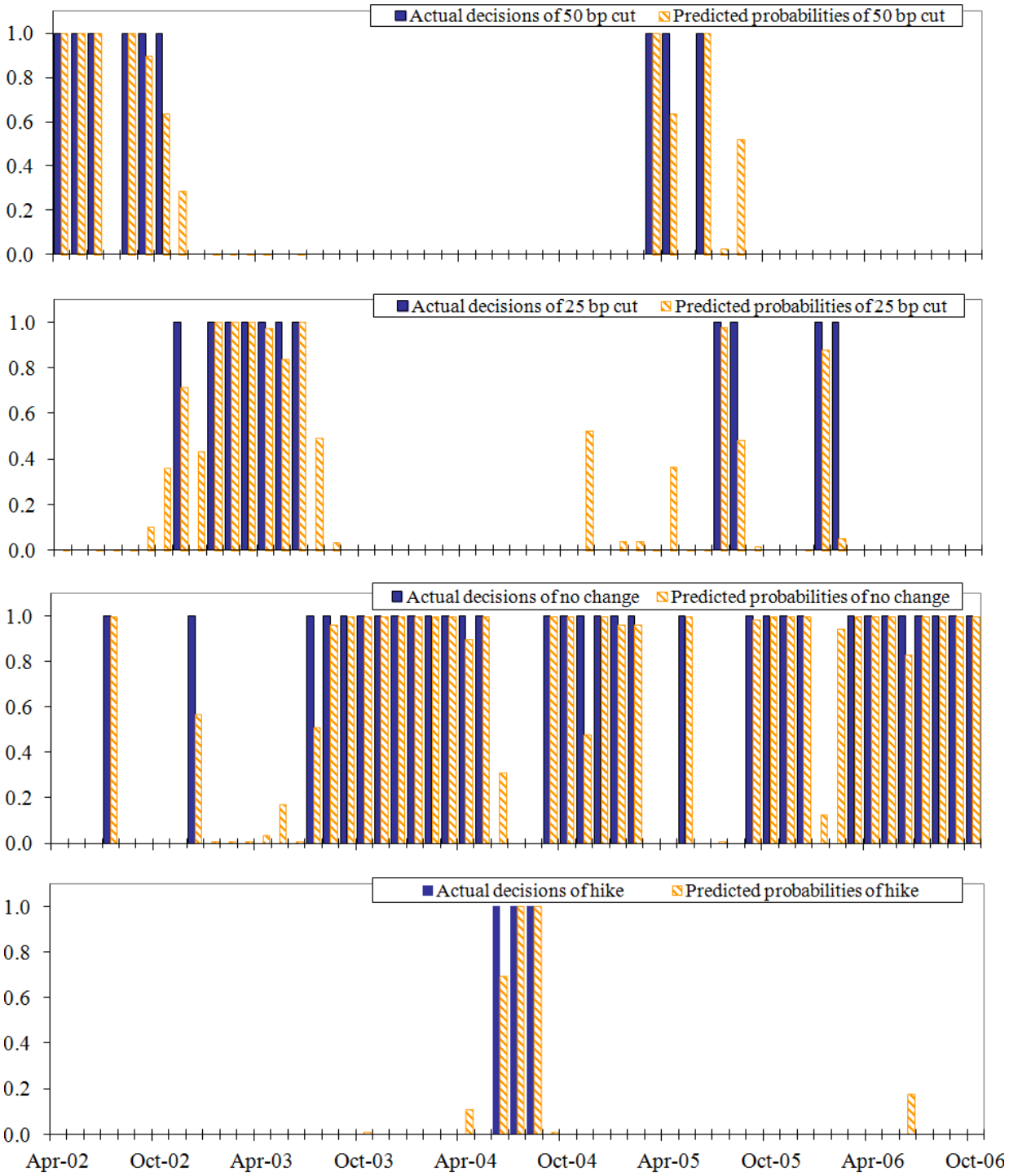
Notes:
Dependent variable: ΔRR_t;
Independent variables: *EReu* and *CPIxac_T_YM*;
Model: Ordered probit with three categories: 'up', 'no change', 'down';
Sample: 1999/02 - 2006/10.

Figure 5: Actual, predicted and expected MPC decisions



Notes: The ordered probit estimations are performed for the specification 16.4 with four categories of dependent variable - change to the reference rate: 'hike', 'no change', '0.25% cut' and '0.50% cut'. A particular choice is predicted if its predicted probability exceeds the predicted probabilities of the alternatives. If a 'hike' is predicted, it is shown as a (0.5+0.5+0.25)/3 increase. The expected changes are computed using formula: E(Y|X) = P(Y=-0.5|X)*(-0.5) + P(Y=-0.25|X)*(-0.25) + P(Y=0|X)*(0) + P(Y>0|X)*(0.5+0.5+0.25)/3, where (0.5+0.5+0.25)/3 = E(Y|Y>0, X) – sample mean of "hike" category.

Figure 6: Estimated probabilities of MPC decisions



Notes: The ordered probit estimations are performed for the specification 16.4.

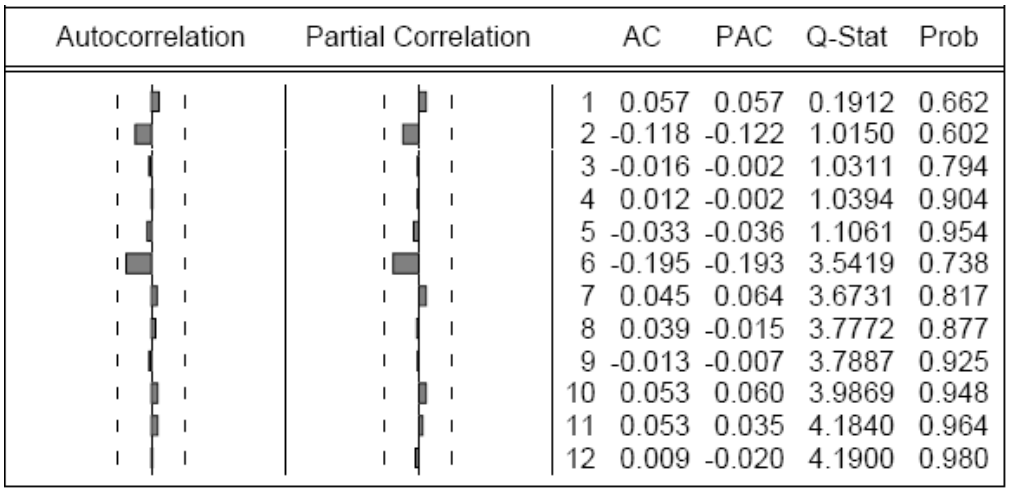
Figure 7: Correlograms of generalized residuals from ordered probit models

Model 16.2

Dependent variable: the reference rate change with four outcome categories: "increase", "no change", "0.25% decrease", and "0.50% decrease".

Independent variables: *ExInf_T_M, GDPnaiy, ExInf_T_M*Ind_ExInf_T, WIBOR12m_ZP*.

Sample: 2002/04 – 2006/10.



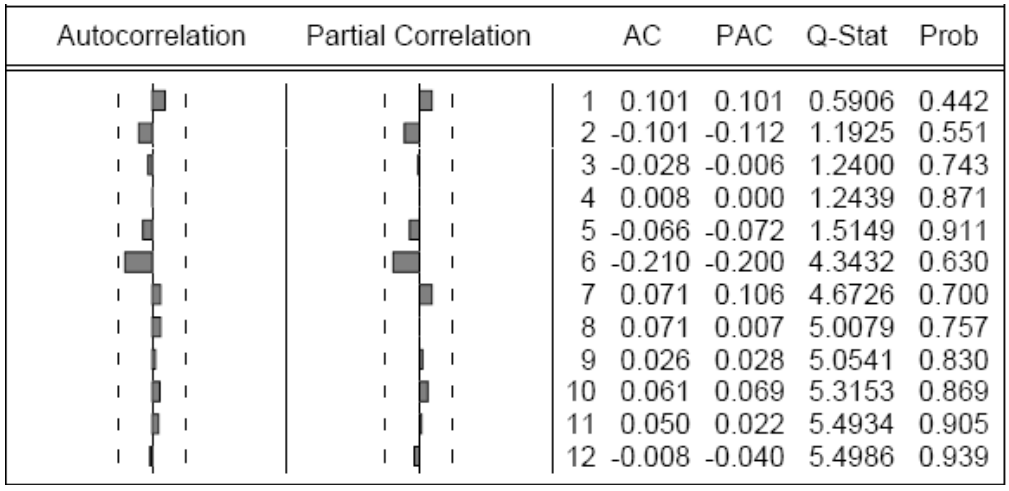
	AC	PAC	Q-Stat	Prob
1	0.057	0.057	0.1912	0.662
2	-0.118	-0.122	1.0150	0.602
3	-0.016	-0.002	1.0311	0.794
4	0.012	-0.002	1.0394	0.904
5	-0.033	-0.036	1.1061	0.954
6	-0.195	-0.193	3.5419	0.738
7	0.045	0.064	3.6731	0.817
8	0.039	-0.015	3.7772	0.877
9	-0.013	-0.007	3.7887	0.925
10	0.053	0.060	3.9869	0.948
11	0.053	0.035	4.1840	0.964
12	0.009	-0.020	4.1900	0.980

Model 16.4

Dependent variable: the reference rate change with four outcome categories: "increase", "no change", "0.25% decrease", and "0.50 % decrease".

Independent variables: *ExInf_T_M, GVATnaiy, ExInf_T_M*Ind_ExInf_T, WIBOR12m_ZP*.

Sample: 2002/04 – 2006/10.



	AC	PAC	Q-Stat	Prob
1	0.101	0.101	0.5906	0.442
2	-0.101	-0.112	1.1925	0.551
3	-0.028	-0.006	1.2400	0.743
4	0.008	0.000	1.2439	0.871
5	-0.066	-0.072	1.5149	0.911
6	-0.210	-0.200	4.3432	0.630
7	0.071	0.106	4.6726	0.700
8	0.071	0.007	5.0079	0.757
9	0.026	0.028	5.0541	0.830
10	0.061	0.069	5.3153	0.869
11	0.050	0.022	5.4934	0.905
12	-0.008	-0.040	5.4986	0.939

Tables

Table 1: Summary of empirical literature on Polish monetary policy rules

Study	Sample	Dependent variable	Estimation method	Data frequency	Interest rate equation specification	Notes
Brzozowski (2004)	1995-2003	Short-term market rate	OLS	quarterly	The CPI, the deviation of the real GDP from the potential one, the first difference and lagged level of the dependent variable	The output gap is significant (at 10%) only prior to 2000; real exchange rate is never significant
Golinelli, Rovelli (2005)	1991-2001	Difference b/w domestic & foreign short-term rates	VAR, 3-stage OLS	quarterly	The lagged dependent variable, and expected deviation of domestic inflation from the foreign one	The output gap (capacity utilization ratio) is not significant; stability tests fail to reject the parameters' constancy
Hristov (2005)	1993-2004	Treasury bill rate	Bayesian SVAR	monthly	The monetary aggregate M2, exchange rate, CPI, industrial production, money market rates reported by Frankfurt banks	
Kłos, Wróbel (2001)	1995-2000	The reference rate	SVAR, OLS	monthly	The inflation rate, and rate of growth of real credit to non-financial sector	
Kokoszczyński et al. (2006)	1995-2002	1-month WIBOR	SVAR, GMM	monthly	The log of price level, industrial output (deviation from the trend), and money aggregate M1	The policy is evaluated using Bernanke-Mihov index of monetary conditions
Kotłowski (2006)	2004-2005	Policy bias and reference rate	Ordered logit model	monthly	The deviations of CPI, industrial production and nominal exchange rate EUR/PLN from their expectations, and growth rate of real exchange rate EUR/PLN	The reaction functions are estimated individually for all MPC's members. The sample includes only 18 observations.
Maliszewski (2003)	1995-2002	Combination of 1-month WIBOR and exchange rate	Bayesian SVAR	monthly	The CPI, industrial production index and EMBI+	The model allows for a limited time-variation of parameters with the switch in February 1998
Mohanty, Klau (2004)	1995-2002	Short-term WIBOR	OLS	quarterly	The CPI, output gap, and lagged dependent variable	The real effective exchange rate is not significant; the response to negative inflation shock is stronger than to positive one (Poland is an outlier among the other countries)
	1998-2002		GMM	monthly	The expected CPI and output gap, and lagged dependent variable	
Wróbel, Pawłowska (2002)	1995-2002	1- and 3-month WIBOR	SVAR, OLS	monthly	The CPI (the only variable significant for the whole sample), broad money M2 (losing its role after 1997), lagged nominal effective exchange rate (gradually losing its role while becoming more and more freely floating), current account deficit with respect to GDP (strengthening its role after 1996), lagged credit to the non-financial sector or deposits of private individuals (having a primary role before 2000 and then gradually replaced by the industrial output gap)	

Table 2: History of the NBP reference rate

Date of MPC meeting*	Reference rate, %	Amount of change, %	Date of MPC meeting*	Reference rate, %	Amount of change, %
1998-02-25	24.00	0.50	2002-07-19	8.50	0.00
1998-03-18	24.00	0.00	2002-08-28	8.00	-0.50
1998-04-22	23.00	-1.00	2002-09-25	7.50	-0.50
1998-05-20	21.50	-1.50	2002-10-23	7.00	-0.50
1998-06-17	21.50	0.00	2002-11-27	6.75	-0.25
1998-07-16	19.00	-2.50	2002-12-18	6.75	0.00
1998-08-19	19.00	0.00	2003-01-29	6.50	-0.25
1998-09-09	18.00	-1.00	2003-02-26	6.25	-0.25
1998-10-28	17.00	-1.00	2003-03-26	6.00	-0.25
1998-11-18	17.00	0.00	2003-04-24	5.75	-0.25
1998-12-09	15.50	-1.50	2003-05-28	5.50	-0.25
1999-01-20	13.00	-2.50	2003-06-25	5.25	-0.25
1999-02-17	13.00	0.00	2003-07-18	5.25	0.00
1999-03-24	13.00	0.00	2003-08-27	5.25	0.00
1999-04-21	13.00	0.00	2003-09-30	5.25	0.00
1999-05-27	13.00	0.00	2003-10-29	5.25	0.00
1999-06-16	13.00	0.00	2003-11-26	5.25	0.00
1999-07-21	13.00	0.00	2003-12-17	5.25	0.00
1999-08-18	13.00	0.00	2004-01-21	5.25	0.00
1999-09-22	14.00	1.00	2004-02-25	5.25	0.00
1999-10-20	14.00	0.00	2004-03-31	5.25	0.00
1999-11-17	16.50	2.50	2004-04-27	5.25	0.00
1999-12-15	16.50	0.00	2004-05-26	5.25	0.00
2000-01-26	16.50	0.00	2004-06-30	5.75	0.50
2000-02-23	17.50	1.00	2004-07-28	6.00	0.25
2000-03-29	17.50	0.00	2004-08-25	6.50	0.50
2000-04-26	17.50	0.00	2004-09-29	6.50	0.00
2000-05-24	17.50	0.00	2004-10-27	6.50	0.00
2000-06-21	17.50	0.00	2004-11-24	6.50	0.00
2000-07-19	17.50	0.00	2004-12-15	6.50	0.00
2000-08-30	19.00	1.50	2005-01-26	6.50	0.00
2000-09-19	19.00	0.00	2005-02-25	6.50	0.00
2000-10-25	19.00	0.00	2005-03-30	6.00	-0.50
2000-11-29	19.00	0.00	2005-04-27	5.50	-0.50
2000-12-20	19.00	0.00	2005-05-25	5.50	0.00
2001-01-22	19.00	0.00	2005-06-29	5.00	-0.50
2001-02-28	18.00	-1.00	2005-07-27	4.75	-0.25
2001-03-28	17.00	-1.00	2005-08-31	4.50	-0.25
2001-04-26	17.00	0.00	2005-09-28	4.50	0.00
2001-05-30	17.00	0.00	2005-10-26	4.50	0.00
2001-06-27	15.50	-1.50	2005-11-30	4.50	0.00
2001-07-20	15.50	0.00	2005-12-21	4.50	0.00
2001-08-22	14.50	-1.00	2006-01-31	4.25	-0.25
2001-09-26	14.50	0.00	2006-02-28	4.00	-0.25
2001-10-25	13.00	-1.50	2006-03-29	4.00	0.00
2001-11-28	11.50	-1.50	2006-04-26	4.00	0.00
2001-12-19	11.50	0.00	2006-05-31	4.00	0.00
2002-01-30	10.00	-1.50	2006-06-28	4.00	0.00
2002-02-27	10.00	0.00	2006-07-26	4.00	0.00
2002-03-27	10.00	0.00	2006-08-30	4.00	0.00
2002-04-26	9.50	-0.50	2006-09-27	4.00	0.00
2002-05-29	9.00	-0.50	2006-10-25	4.00	0.00
2002-06-26	8.50	-0.50			

Notes: * Dates of taking the policy decisions; Source: National Bank of Poland.

Table 3: Frequency distribution of NBP reference rate changes

Historical changes to NBP reference rate

Amount of change, %	Frequency		
	1998/02 to 2002/03	2002/04 to 2006/10	1998/02 to 2006/10
2.50	1		1
1.50	1		1
1.00	2		2
0.50	1	2	3
0.25		1	1
0.00	31	32	63
-0.25		11	11
-0.50		9	9
-1.00	6		6
-1.50	6		6
-2.50	2		2
Total:	50	55	105

NBP reference rate changes, consolidated into three and four categories

Outcome category	Frequency		
	1998/02 to 2002/03	2002/04 to 2006/10	1998/02 to 2006/10
Increase	5	3	8
No change	31	32	63
Decrease	14	20	34
Total:	50	55	105
Increase		3	
No change		32	
0.25% decrease		11	
0.50% decrease		9	
Total:		55	

Source: National Bank of Poland and author's compilations.

Table 4: Real-time MPC-meeting data set

Variable description	Mnemonics	Release frequency	Seasonal adjustment	Sourse	Release schedule
Price indexes					
Consumer price index	CPI	M	nsa	GUS	9
Consumer price index, excl. administratively controlled prices	CPIxac	M	nsa	GUS & NBP	8
Consumer price index, excl. the most volatile prices	CPIxmv	M	nsa	GUS & NBP	8
Consumer price index, excl. the most volatile and fuel prices	CPIxmvf	M	nsa	GUS & NBP	8
Consumer price index, excl. food and fuel prices	CPIxff	M	nsa	GUS & NBP	8
Consumer price index, 15% trimmed mean	CPItri	M	nsa	GUS & NBP	8
Business tendency survey in retail trade - Prices of sold goods	BTSRspr	M	nsa	GUS	11
Inflationary expectations					
Expected annual rate of CPI over next 12 months, percent	ExInf	M	nsa	Ipsos & NBP	4
CPI forecast by banking analysts by the end of the year, annual rate in percent	ReuCPI_Dec	M	nsa	Reuters	4
CPI forecast by banking analysts over next 11 months, annual rate in percent	ReuCPI_11m	M	nsa	Reuters	4
CPI forecast by banking analysts for the previous month, annual rate in percent	ReuCPI_prm	M	nsa	Reuters	4
CPI average annual rate forecast by banking analysts for the next year, percent	ReuCPI_nya	M	nsa	Reuters	4
PPI forecast by banking analysts for the previous month, annual rate in percent	ReuPPI_prm	M	nsa	Reuters	4
PPI forecast by banking analysts over next 11 months, annual rate in percent	ReuPPI_11m	M	nsa	Reuters	4
CPI central projection by NBP for the current quarter, annual rate in percent	NBP_CPI_cq	Q	nsa	CPI inflation projections, published in the NBP's Inflation Reports since August 2004. Since 2006 they are prepared for MPC's meetings in January, April, July and October	
CPI central projection by NBP for the next quarter, annual rate in percent	NBP_CPI_1q	Q	nsa		
CPI central projection by NBP over next two quarters, annual rate in percent	NBP_CPI_2q	Q	nsa		
CPI central projection by NBP over next three quarters, annual rate in percent	NBP_CPI_3q	Q	nsa		
CPI central projection by NBP over next four quarters, annual rate in percent	NBP_CPI_4q	Q	nsa		
CPI central projection by NBP over next five quarters, annual rate in percent	NBP_CPI_5q	Q	nsa		
CPI central projection by NBP over next six quarters, annual rate in percent	NBP_CPI_6q	Q	nsa		
CPI central projection by NBP over next seven quarters, annual rate in percent	NBP_CPI_7q	Q	nsa		
CPI central projection by NBP over next eight quarters, annual rate in percent	NBP_CPI_8q	Q	nsa		
Business tendency survey in industry - Expected selling prices of products	BTSIerpr	M	nsa	GUS	11
Business tendency survey in retail trade - Expected prices of goods	BTSRepr	M	nsa	GUS	11
Gross domestic product and main components					
Domestic demand, current prices, bln PLN	Demna	Q	nsa	GUS	3
Final consumption expenditure of households, current prices, bln PLN	FCEhna	Q	nsa	GUS	3
Gross domestic product, current prices, bln PLN	GDPna	Q	nsa	GUS	3
Gross fixed capital formation, current prices, bln PLN	GFCFna	Q	nsa	GUS	3
Gross value added, current prices, bln PLN	GVAna	Q	nsa	GUS	3
Index of domestic demand, growth rate in percent since corresponding period of previous year	Demnaiy	Q	nsa	GUS	3
Index of final consumption expenditure of households, growth rate in percent since corresponding period of previous year	FCEhnaiy	Q	nsa	GUS	3
Index of gross domestic product, growth rate in percent since corresponding period of previous year	GDPnaiy	Q	nsa	GUS	3
Index of gross fixed capital formation, growth rate in percent since corresponding period of previous year	GFCFnaiy	Q	nsa	GUS	3
Index of gross value added, total, growth rate in percent since corresponding period of previous year	GVATnaiy	Q	nsa	GUS	3
Annual growth rate of gross domestic product less annual growth rate of CPI, percent	GDPRna_Y	Q	nsa	GUS	3
Annual growth rate of gross value added less annual growth rate of CPI, percent	GVARna_Y	Q	nsa	GUS	3
Other measures of real activity					
Business tendency survey in construction - General economic situation	BTSCges	M	nsa	GUS	11
Business tendency survey in construction - Capacity utilization	BTSCcu	M	nsa	GUS	11
Business tendency survey in construction - Financial situation	BTSCfs	M	nsa	GUS	11
Business tendency survey in construction - General business tendency climate	BTSCcli	M	nsa	GUS	11
Business tendency survey in industry - General economic situation	BTSIges	M	nsa	GUS	11
Business tendency survey in industry - Current stocks of finished products	BTSIsfp	M	nsa	GUS	11
Business tendency survey in industry - General business tendency climate	BTSIcli	M	nsa	GUS	11
Business tendency survey in industry - Current volume of sold production	BTSIsold	M	nsa	GUS	11
Business tendency survey in retail trade - General economic situation	BTSRges	M	nsa	GUS	11
Business tendency survey in retail trade - Stocks of goods	BTSRsg	M	nsa	GUS	11
Business tendency survey in retail trade - General business tendency climate	BTSRcli	M	nsa	GUS	11
Business tendency survey in retail trade - Amount of goods sold	BTSRsold	M	nsa	GUS	11
Sold production of industry, total, current prices, bln PLN	IndProdT	M	nsa	GUS	7
Sold production of industry, manufacturing, bln PLN	IndProdM	M	nsa	GUS	7
Retail sale of goods, current prices	RetailS	M	nsa	GUS	8
Wholesale of goods by trade enterprises, current prices	WholeS	M	nsa	GUS	8
Investments newly started, number of tasks in thousands	InvStart	3Q	nsa	GUS	17
Real sector expectations					
Business tendency survey in construction - Expected general economic situation	BTSCeges	M	nsa	GUS	11
Business tendency survey in construction - Expected financial situation	BTSCefs	M	nsa	GUS	11
Business tendency survey in industry - Expected general economic situation	BTSIeges	M	nsa	GUS	11
Business tendency survey in industry - Expected volume of sold production	BTSIesold	M	nsa	GUS	11
Business tendency survey in industry - Expected domestic and foreign order-books	BTSIedfob	M	nsa	GUS	11
Business tendency survey in industry - Expected ability to pay the current debts	BTSIeabpay	M	nsa	GUS	11
Business tendency survey in retail trade - Expected general economic situation	BTSReges	M	nsa	GUS	11

Variable description	Mnemonics	Release frequency	Seasonal adjustment	Sourse	Release schedule
Business tendency survey in retail trade - Expected orders placed with suppliers	BTSReo	M	nsa	GUS	11
Business tendency survey in retail trade - Expected ability to pay the current debts	BTSReabpay	M	nsa	GUS	11
Sold production of industry forecast by banking analysts for the previous month, annual rate in percent	ReuIndOut_prm	M	nsa	Reuters	4
Sold production of industry average annual rate forecast by banking analysts for the next year, percent	ReuIndOut_prm	M	nsa	Reuters	4
Gross domestic product annual rate forecast by banking analysts for the previous quarter, percent	ReuGDP_prq	M	nsa	Reuters	4
Gross domestic product annual rate forecast by banking analysts for the current quarter, percent	ReuGDP_cq	M	nsa	Reuters	4
Gross domestic product average annual rate forecast by banking analysts for the current year, percent	ReuGDP_cya	M	nsa	Reuters	4
Gross domestic product annual rate forecast by banking analysts for the next quarter, percent	ReuGDP_1q	M	nsa	Reuters	4
Gross domestic product annual rate forecast by banking analysts over the next 2 quarters, percent	ReuGDP_2q	M	nsa	Reuters	4
GDP central projection by NBP for the current quarter, annual rate in percent	NBP_GDP_cq	Q	nsa	GDP projections,	
GDP central projection by NBP for the next quarter, annual rate in percent	NBP_GDP_1q	Q	nsa	published in NBP	
GDP central projection by NBP over next two quarters, annual rate in percent	NBP_GDP_2q	Q	nsa	Inflation Reports	
GDP central projection by NBP over next three quarters, annual rate in percent	NBP_GDP_3q	Q	nsa	since May 2005.	
GDP central projection by NBP over next four quarters, annual rate in percent	NBP_GDP_4q	Q	nsa	Since 2006 they	
GDP central projection by NBP over next five quarters, annual rate in percent	NBP_GDP_5q	Q	nsa	are prepared for	
GDP central projection by NBP over next six quarters, annual rate in percent	NBP_GDP_6q	Q	nsa	MPC meetings in	
GDP central projection by NBP over next seven quarters, annual rate in percent	NBP_GDP_7q	Q	nsa	January, April,	
GDP central projection by NBP over next eight quarters, annual rate in percent	NBP_GDP_8q	Q	nsa	July and October	
Labour market and wages					
Unemployed persons, mln, LFS (BAEL)	UnemplLFS	Q	nsa	GUS	12
Unemployed persons, urban areas, mln, LFS (BAEL)	UnempluLFS	Q	nsa	GUS	12
Unemployment rate in %, total, LFS (BAEL)	URLFS	Q	nsa	GUS	12
Unemployment rate in %, males, LFS (BAEL)	URmLFS	Q	nsa	GUS	12
Unemployment rate in %, urban areas, LFS (BAEL)	URuLFS	Q	nsa	GUS	12
Unemployment rate in %, persons aged 15-24 years, LFS (BAEL)	UR1524LFS	Q	nsa	GUS	12
Economically inactive persons, mln, LFS (BAEL)	EcinactLFS	Q	nsa	GUS	13
Employed persons, mln, LFS (BAEL)	EmplLFS	Q	nsa	GUS	13
Activity rate, total, LFS (BAEL)	ARLFS	Q	nsa	GUS	13
Activity rate, urban areas, LFS (BAEL)	ARuLFS	Q	nsa	GUS	13
Employment rate, total, LFS (BAEL)	ERLFS	Q	nsa	GUS	13
Employment rate, urban areas, LFS (BAEL)	ERuLFS	Q	nsa	GUS	13
Registered unemployed persons, mln	Unempl	M	nsa	GUS	8
Number of employed, corporate sector, total, mln	EmplCS	M	nsa	GUS	8
Average employment, corporate sector, total, mln	EmplCSav	M	nsa	GUS	8
Average employee earnings (wages and salaries), total, corporate sector, thousands PLN	EarnCS	M	nsa	GUS	8
Average monthly gross wages and salaries, nominal, total, thousands PLN	Wagemav	Q	nsa	GUS	6
Employment expectations					
Business tendency survey in construction - Expected employment	BTSCeem	M	nsa	GUS	11
Business tendency survey in industry - Expected employment	BTSIeem	M	nsa	GUS	11
Business tendency survey in retail trade - Expected employment	BTSReem	M	nsa	GUS	11
Market interest rates					
Warsaw Interbank Offer Rate (WIBOR), 1-month, annualized percent	WIBOR1m	D	nsa	Reuters	D
Warsaw Interbank Offer Rate (WIBOR), 3-month, annualized percent	WIBOR3m	D	nsa	Reuters	D
Warsaw Interbank Offer Rate (WIBOR), 6-month, annualized percent	WIBOR6m	D	nsa	Reuters	D
Warsaw Interbank Offer Rate (WIBOR), 9-month, annualized percent	WIBOR9m	D	nsa	Reuters	D
Warsaw Interbank Offer Rate (WIBOR), 12-month, annualized percent	WIBOR12m	D	nsa	Reuters	D
52-week Treasury bill rate, average yield from the last auction prior to a MPC meeting, annualized percent	TB52w	IR	nsa	Ministry of Finance	n/a
Interest rates' expectations					
52-week Treasury bill yield forecast by banking analysts by the end of current month, annualized percent	Reu52w_cm	M	nsa	Reuters	4
52-week Treasury bill yield forecast by banking analysts over next 12 months, annualized percent	Reu52w_12m	M	nsa	Reuters	4
3-month WIBOR forecast by banking analysts by the end of current month, annualized percent	ReuWibor3M_cm	M	nsa	Reuters	4
3-month WIBOR forecast by banking analysts over next 12 months, annualized percent	ReuWibor3M_12m	M	nsa	Reuters	4
2-year Treasury bond yield forecast by banking analysts by the end of current month, annualized percent	Reu2y_cm	M	nsa	Reuters	4
2-year Treasury bond yield forecast by banking analysts over next 12 months, annualized percent	Reu2y_12m	M	nsa	Reuters	4
5-year Treasury bond yield forecast by banking analysts by the end of current month, annualized percent	Reu5y_cm	M	nsa	Reuters	4
5-year Treasury bond yield forecast by banking analysts over next 12 months, annualized percent	Reu5y_12m	M	nsa	Reuters	4

Variable description	Mnemonics	Release frequency	Seasonal adjustment	Sourse	Release schedule
10-year Treasury bond yield forecast by banking analysts by the end of current month, annualized percent	Reu10y_cm	M	nsa	Reuters	4
10-year Treasury bond yield forecast by banking analysts over next 12 months, annualized percent	Reu10y_12m	M	nsa	Reuters	4
Reference rate forecast by banking analysts by the end of current month, annualized percent	ReuRR_cm	M	nsa	Reuters	4
Reference rate forecast by banking analysts over next 12 months, annualized percent	ReuRR_12m	M	nsa	Reuters	4
Exchange rates					
Average monthly exchange rate, PLN/USD	ERUSm	M	nsa	NBP	19
Average monthly exchange rate, PLN/EUR	EREUm	M	nsa	NBP	19
Daily exchange rate, PLN/USD	ERUS	D	nsa	NBP	D
Daily exchange rate, PLN / (DM up to 31.12.1998 / EUR from 1.1.1999)	EREU	D	nsa	NBP	D
Exchange rates' expectations					
Exchange rate PLN/EUR forecast by banking analysts by the end of current month	ReuEReu_cm	M	nsa	Reuters	4
Exchange rate PLN/EUR forecast by banking analysts over next 12 months	ReuEReu_12m	M	nsa	Reuters	4
Exchange rate PLN/USD forecast by banking analysts by the end of current month	ReuERus_cm	M	nsa	Reuters	4
Exchange rate PLN/USD forecast by banking analysts over next 12 months	ReuERus_12m	M	nsa	Reuters	4
Foreign policy interest rates					
US Federal funds rate target, annualized percent	dFFR	D	nsa	US Federal Reserve	D
Main ECB target rate: minimum bid rate on the main refinancing operations of the Eurosystem, annualized percent	dECBR	D	nsa	European Central Bank	D
Lending and credit					
MFI's loans to private corporations, bln PLN	Loanpc	M	nsa	NBP	2
MFI's loans to private corporations, total, bln PLN	Loanpct	M	nsa	NBP	2
MFI's loans and other claims on households, bln PLN	Claimh	M	nsa	NBP	2
MFI's loans and other claims on households, total, bln PLN	Claimht	M	nsa	NBP	2
MFI's loans to households, bln PLN	Loanh	M	nsa	NBP	2
MFI's loans to households, total, bln PLN	Loanht	M	nsa	NBP	2
MFI's loans and other claims to non-financial corporations, bln PLN	Claimnfc	M	nsa	NBP	2
MFI's loans and other claims to non-financial corporations, total, bln PLN	Claimnfct	M	nsa	NBP	2
MFI's loans to non-financial corporations, bln PLN	Loannfc	M	nsa	NBP	2
MFI's loans to non-financial corporations, total, bln PLN	Loannfct	M	nsa	NBP	2
MFI's loans and other claims on non-financial sector, bln PLN	Claimnfs	M	nsa	NBP	2
MFI's loans and other claims on non-financial sector, total stocks, bln PLN	Claimnfst	M	nsa	NBP	2
MFI's credit to domestic residents, bln PLN	Cred	M	nsa	NBP	2
Deposits and other liabilities of MFIs to non-financial corporations, bln PLN	Depnfc	M	nsa	NBP	2
Deposits and other liabilities of MFIs to non-financial corporations, total stocks, bln PLN	Depnfct	M	nsa	NBP	2
Deposits and other liabilities of MFIs to non-financial sector, bln PLN	Depnfs	M	nsa	NBP	2
Deposits and other liabilities of MFIs to non-financial sector, total stocks, bln PLN	Depnfst	M	nsa	NBP	2
Deposits and other liabilities of MFIs to households, bln PLN	Deph	M	nsa	NBP	2
Deposits and other liabilities of MFIs to households, total, bln PLN	DepHT	M	nsa	NBP	2
Housing loans to households, bln PLN	Hloanh	M	nsa	NBP	2
Housing loans to households, total, bln PLN	HloanT	M	nsa	NBP	2
Deposits and other liabilities of MFIs to other domestic residents in zloty, bln PLN	DepDRes	M	nsa	NBP	2
Deposits and other liabilities of MFIs to other domestic residents in zloty and foreign currency, bln PLN	DepDResT	M	nsa	NBP	2
Deposits and other liabilities of MFIs to central government in zloty, bln PLN	DepGov	M	nsa	NBP	2
Deposits and other liabilities of MFIs to central government in zloty and foreign currency, bln PLN	DepGovT	M	nsa	NBP	2
Inter-MFI's liabilities in zloty, bln PLN	DepiMFI	M	nsa	NBP	2
Inter-MFI's liabilities in zloty and foreign currency, bln PLN	DepiMFIT	M	nsa	NBP	2
Loans and other claims of MFIs to other domestic residents in zloty, bln PLN	ClaimDRes	M	nsa	NBP	2
Loans and other claims of MFIs to other domestic residents in zloty and foreign currency, bln PLN	ClaimDResT	M	nsa	NBP	2
Loans and other claims of MFIs to central government in zloty, bln PLN	ClaimGov	M	nsa	NBP	2
Loans and other claims of MFIs to central government in zloty and foreign currency, bln PLN	ClaimGovT	M	nsa	NBP	2
Inter-MFI's claims in zloty, bln PLN	ClaimiMFI	M	nsa	NBP	2
Inter-MFI's claims in zloty and foreign currency, bln PLN	ClaimiMFIT	M	nsa	NBP	2

Notes: Release frequencies: D - daily, M - monthly, Q - quarterly, 3Q - second, third and fourth quarters, D – daily, IR – irregular.Release schedules: see Table 1.6 for the availability of statistical data at MPC's meetings for all release schedules. Seasonal adjustment: sa - seasonally adjusted, nsa - not seasonally adjusted.

Table 5: Transformations of original data.

Transformation description	Mnemonics
(Percentage) change since the previous business day	_D
Five-day moving average	_5da
Three-week moving average	_3wa
(Percentage) change since the previous month	_M
(Percentage) change since the previous quarter	_Q
(Percentage) change since the corresponding period of previous year	_Y
Three-month moving average	_3ma
Four-quarter moving average of the (percentage) change since the corresponding period of previous year	_4qa
Change since the previous MPC's meeting	_Z
Change since the date of the last non-zero adjustment to the reference rate	_C
Deviation from the target rate (for CPI)	_T
Original value of variable if it is positive, and zero otherwise	_P
Original value of variable if it is negative, and zero otherwise	_N
Spread between some variable X and the reference rate	X_RR
First-order lagged variable	_L1
Indicator variable: one if X is equal to or above the inflation target, zero otherwise	Ind_X_T

Notes: The transformations can be combined, for example, _YM means the change since the previous month to (percentage) change since the corresponding period of previous year, or _YC means the change since the date of the last non-zero adjustment to the reference rate to (percentage) change since the corresponding period of previous year.

Table 6: Availability of latest statistical data at MPC meetings

Date of MPC meeting	Release schedule											
	# 2	# 3	# 4	# 6	# 7	# 8	# 9	# 11	# 12	# 13	# 17	# 19
1998-02-25	01-98	Q3-97	02-98	Q4-97	01-98	01-98	01-98	01-98	Q4-97	Q4-97	Q3-97	01-98
1998-03-18	02-98	Q3-97	03-98	Q4-97	02-98	02-98	02-98	02-98	Q4-97	Q4-97	Q4-97	02-98
1998-04-22	03-98	Q4-97	04-98	Q4-97	03-98	03-98	03-98	03-98	Q4-97	Q4-97	Q4-97	03-98
1998-05-20	04-98	Q4-97	05-98	Q1-98	04-98	04-98	04-98	04-98	Q1-98	Q1-98	Q4-97	04-98
1998-06-17	05-98	Q4-97	06-98	Q1-98	05-98	05-98	05-98	05-98	Q1-98	Q1-98	Q4-97	05-98
1998-07-16	06-98	Q1-98	07-98	Q1-98	06-98	06-98	06-98	06-98	Q1-98	Q1-98	Q4-97	06-98
1998-08-19	07-98	Q1-98	08-98	Q2-98	07-98	07-98	07-98	07-98	Q2-98	Q2-98	Q2-98	07-98
1998-09-09	08-98	Q1-98	09-98	Q2-98	07-98	07-98	07-98	08-98	Q2-98	Q2-98	Q2-98	08-98
1998-10-28	09-98	Q2-98	10-98	Q2-98	09-98	09-98	09-98	09-98	Q3-98	Q2-98	Q2-98	09-98
1998-11-18	10-98	Q2-98	11-98	Q3-98	10-98	10-98	10-98	10-98	Q3-98	Q3-98	Q3-98	10-98
1998-12-09	11-98	Q2-98	12-98	Q3-98	10-98	10-98	10-98	11-98	Q3-98	Q3-98	Q3-98	11-98
1999-01-20	12-98	Q3-98	01-99	Q3-98	12-98	12-98	12-98	12-98	Q3-98	Q3-98	Q3-98	12-98
1999-02-17	01-99	Q3-98	02-99	Q4-98	01-99	01-99	01-99	01-99	Q4-98	Q4-98	Q3-98	01-99
1999-03-24	02-99	Q4-98	03-99	Q4-98	02-99	02-99	02-99	02-99	Q4-98	Q4-98	Q4-98	02-99
1999-04-21	03-99	Q4-98	04-99	Q4-98	03-99	03-99	03-99	03-99	Q4-98	Q4-98	Q4-98	03-99
1999-05-27	04-99	Q4-98	05-99	Q1-99	04-99	04-99	04-99	04-99	Q1-99	Q4-98	Q4-98	04-99
1999-06-16	05-99	Q4-98	06-99	Q1-99	05-99	05-99	05-99	05-99	Q1-99	Q1-99	Q4-98	05-99
1999-07-21	06-99	Q1-99	07-99	Q1-99	06-99	06-99	06-99	06-99	Q1-99	Q1-99	Q4-98	06-99
1999-08-18	07-99	Q1-99	08-99	Q2-99	07-99	07-99	07-99	07-99	Q1-99	Q1-99	Q2-99	07-99
1999-09-22	08-99	Q2-99	09-99	Q2-99	08-99	08-99	08-99	08-99	Q1-99	Q1-99	Q2-99	08-99
1999-10-20	09-99	Q2-99	10-99	Q2-99	09-99	09-99	09-99	09-99	Q1-99	Q1-99	Q2-99	09-99
1999-11-17	10-99	Q2-99	11-99	Q3-99	10-99	10-99	10-99	10-99	Q1-99	Q1-99	Q3-99	10-99
1999-12-15	11-99	Q2-99	12-99	Q3-99	11-99	11-99	11-99	11-99	Q1-99	Q1-99	Q3-99	11-99
2000-01-26	12-99	Q3-99	01-00	Q3-99	12-99	12-99	12-99	12-99	Q1-99	Q1-99	Q3-99	12-99
2000-02-23	01-00	Q3-99	02-00	Q4-99	01-00	01-00	01-00	01-00	Q1-99	Q1-99	Q3-99	01-00
2000-03-29	02-00	Q4-99	03-00	Q4-99	02-00	02-00	02-00	02-00	Q1-99	Q1-99	Q4-99	02-00
2000-04-26	03-00	Q4-99	04-00	Q4-99	03-00	03-00	03-00	03-00	Q1-99	Q1-99	Q4-99	03-00
2000-05-24	04-00	Q4-99	05-00	Q1-00	04-00	04-00	04-00	04-00	Q1-99	Q1-99	Q4-99	04-00
2000-06-21	05-00	Q1-00	06-00	Q1-00	05-00	05-00	05-00	05-00	Q1-00	Q1-00	Q4-99	05-00
2000-07-19	06-00	Q1-00	07-00	Q1-00	06-00	06-00	06-00	06-00	Q1-00	Q1-00	Q4-99	06-00
2000-08-30	07-00	Q1-00	08-00	Q2-00	07-00	07-00	07-00	07-00	Q1-00	Q1-00	Q2-00	07-00
2000-09-19	08-00	Q1-00	09-00	Q2-00	08-00	08-00	08-00	08-00	Q2-00	Q2-00	Q2-00	08-00
2000-10-25	09-00	Q2-00	10-00	Q2-00	09-00	09-00	09-00	09-00	Q2-00	Q2-00	Q2-00	09-00
2000-11-29	10-00	Q2-00	11-00	Q3-00	10-00	10-00	10-00	10-00	Q2-00	Q2-00	Q3-00	10-00
2000-12-20	11-00	Q3-00	12-00	Q3-00	11-00	11-00	11-00	11-00	Q3-00	Q3-00	Q3-00	11-00
2001-01-22	12-00	Q3-00	01-01	Q3-00	12-00	12-00	12-00	12-00	Q3-00	Q3-00	Q3-00	12-00
2001-02-28	01-01	Q3-00	02-01	Q4-00	01-01	01-01	01-01	01-01	Q4-00	Q3-00	Q3-00	01-01
2001-03-28	02-01	Q4-00	03-01	Q4-00	02-01	02-01	02-01	02-01	Q4-00	Q4-00	Q4-00	02-01
2001-04-26	03-01	Q4-00	04-01	Q4-00	03-01	03-01	03-01	03-01	Q4-00	Q4-00	Q4-00	03-01
2001-05-30	04-01	Q4-00	05-01	Q1-01	04-01	04-01	04-01	04-01	Q4-00	Q4-00	Q4-00	04-01
2001-06-27	05-01	Q1-01	06-01	Q1-01	05-01	05-01	05-01	05-01	Q4-00	Q4-00	Q4-00	05-01
2001-07-20	06-01	Q1-01	07-01	Q1-01	06-01	06-01	06-01	06-01	Q4-00	Q1-01	Q4-00	06-01
2001-08-22	07-01	Q1-01	08-01	Q2-01	07-01	07-01	07-01	07-01	Q1-01	Q1-01	Q2-01	07-01
2001-09-26	08-01	Q2-01	09-01	Q2-01	08-01	08-01	08-01	08-01	Q2-01	Q2-01	Q2-01	08-01
2001-10-25	09-01	Q2-01	10-01	Q2-01	09-01	09-01	09-01	09-01	Q2-01	Q2-01	Q2-01	09-01
2001-11-28	10-01	Q2-01	11-01	Q3-01	10-01	10-01	10-01	10-01	Q3-01	Q3-01	Q3-01	10-01
2001-12-19	11-01	Q3-01	12-01	Q3-01	11-01	11-01	11-01	11-01	Q3-01	Q3-01	Q3-01	11-01
2002-01-30	12-01	Q3-01	01-02	Q3-01	12-01	12-01	12-01	01-02	Q3-01	Q3-01	Q3-01	12-01
2002-02-27	01-02	Q3-01	02-02	Q4-01	01-02	01-02	01-02	02-02	Q4-01	Q3-01	Q3-01	01-02
2002-03-27	02-02	Q4-01	03-02	Q4-01	02-02	02-02	02-02	03-02	Q4-01	Q4-01	Q4-01	02-02
2002-04-26	03-02	Q4-01	04-02	Q4-01	03-02	03-02	03-02	04-02	Q4-01	Q4-01	Q4-01	03-02
2002-05-29	04-02	Q4-01	05-02	Q1-02	04-02	04-02	04-02	05-02	Q1-02	Q4-01	Q4-01	04-02
2002-06-26	05-02	Q1-02	06-02	Q1-02	05-02	05-02	05-02	06-02	Q1-02	Q1-02	Q4-01	05-02
2002-07-19	06-02	Q1-02	07-02	Q1-02	06-02	06-02	06-02	07-02	Q1-02	Q1-02	Q4-01	06-02
2002-08-28	07-02	Q1-02	08-02	Q2-02	07-02	07-02	07-02	08-02	Q2-02	Q1-02	Q2-02	07-02

Date of MPC meeting	Release schedule											
	# 2	# 3	# 4	# 6	# 7	# 8	# 9	# 11	# 12	# 13	# 17	# 19
2002-09-25	08-02	Q2-02	09-02	Q2-02	08-02	08-02	08-02	09-02	Q2-02	Q2-02	Q2-02	08-02
2002-10-23	09-02	Q2-02	10-02	Q2-02	09-02	09-02	09-02	10-02	Q2-02	Q2-02	Q2-02	09-02
2002-11-27	10-02	Q2-02	11-02	Q3-02	10-02	10-02	10-02	11-02	Q2-02	Q2-02	Q3-02	10-02
2002-12-18	11-02	Q2-02	12-02	Q3-02	11-02	11-02	11-02	11-02	Q3-02	Q2-02	Q3-02	11-02
2003-01-29	12-02	Q3-02	01-03	Q3-02	12-02	12-02	12-02	01-03	Q3-02	Q3-02	Q3-02	12-02
2003-02-26	01-03	Q3-02	02-03	Q4-02	01-03	01-03	01-03	02-03	Q4-02	Q3-02	Q3-02	01-03
2003-03-26	02-03	Q4-02	03-03	Q4-02	02-03	02-03	02-03	03-03	Q4-02	Q4-02	Q4-02	02-03
2003-04-24	03-03	Q4-02	04-03	Q4-02	03-03	03-03	03-03	04-03	Q4-02	Q4-02	Q4-02	03-03
2003-05-28	04-03	Q4-02	05-03	Q1-03	04-03	04-03	04-03	05-03	Q1-03	Q4-02	Q4-02	04-03
2003-06-25	05-03	Q1-03	06-03	Q1-03	05-03	05-03	05-03	06-03	Q1-03	Q1-03	Q4-02	05-03
2003-07-18	06-03	Q1-03	07-03	Q1-03	06-03	06-03	06-03	06-03	Q1-03	Q1-03	Q4-02	06-03
2003-08-27	07-03	Q1-03	08-03	Q2-03	07-03	07-03	07-03	08-03	Q1-03	Q1-03	Q2-03	07-03
2003-09-30	08-03	Q2-03	09-03	Q2-03	08-03	08-03	08-03	09-03	Q2-03	Q2-03	Q2-03	08-03
2003-10-29	09-03	Q2-03	10-03	Q2-03	09-03	09-03	09-03	10-03	Q2-03	Q2-03	Q2-03	09-03
2003-11-26	10-03	Q2-03	11-03	Q3-03	10-03	10-03	10-03	11-03	Q2-03	Q2-03	Q3-03	10-03
2003-12-17	11-03	Q2-03	11-03	Q3-03	10-03	10-03	11-03	11-03	Q2-03	Q2-03	Q3-03	11-03
2004-01-21	12-03	Q3-03	01-04	Q3-03	12-03	12-03	12-03	12-03	Q3-03	Q3-03	Q3-03	12-03
2004-02-25	01-04	Q4-03	02-04	Q4-03	01-04	01-04	01-04	02-04	Q4-03	Q3-03	Q3-03	01-04
2004-03-31	02-04	Q4-03	03-04	Q4-03	02-04	02-04	02-04	03-04	Q4-03	Q4-03	Q4-03	02-04
2004-04-27	03-04	Q4-03	04-04	Q4-03	03-04	03-04	03-04	04-04	Q4-03	Q4-03	Q4-03	03-04
2004-05-26	04-04	Q4-03	05-04	Q1-04	04-04	04-04	04-04	05-04	Q4-03	Q4-03	Q4-03	04-04
2004-06-30	05-04	Q1-04	06-04	Q1-04	05-04	05-04	05-04	06-04	Q1-04	Q1-04	Q4-03	05-04
2004-07-28	06-04	Q1-04	07-04	Q1-04	06-04	06-04	06-04	07-04	Q1-04	Q1-04	Q4-03	06-04
2004-08-25	07-04	Q1-04	08-04	Q2-04	07-04	07-04	07-04	08-04	Q1-04	Q1-04	Q4-03	07-04
2004-09-29	08-04	Q2-04	09-04	Q2-04	08-04	08-04	08-04	09-04	Q2-04	Q2-04	Q2-04	08-04
2004-10-27	09-04	Q2-04	10-04	Q2-04	09-04	09-04	09-04	10-04	Q2-04	Q2-04	Q2-04	09-04
2004-11-24	10-04	Q2-04	11-04	Q3-04	10-04	10-04	10-04	11-04	Q2-04	Q2-04	Q3-04	10-04
2004-12-15	11-04	Q3-04	12-04	Q3-04	10-04	11-04	11-04	11-04	Q2-04	Q2-04	Q3-04	11-04
2005-01-26	12-04	Q3-04	01-05	Q3-04	12-04	12-04	12-04	01-05	Q3-04	Q3-04	Q3-04	12-04
2005-02-25	01-05	Q3-04	02-05	Q4-04	01-05	01-05	01-05	02-05	Q3-04	Q3-04	Q3-04	01-05
2005-03-30	02-05	Q4-04	03-05	Q4-04	02-05	02-05	02-05	03-05	Q4-04	Q4-04	Q4-04	02-05
2005-04-27	03-05	Q4-04	04-05	Q4-04	03-05	03-05	03-05	04-05	Q4-04	Q4-04	Q4-04	03-05
2005-05-25	04-05	Q4-04	05-05	Q1-05	04-05	04-05	04-05	05-05	Q4-04	Q4-04	Q4-04	04-05
2005-06-29	05-05	Q1-05	06-05	Q1-05	05-05	05-05	05-05	06-05	Q1-05	Q1-05	Q4-04	05-05
2005-07-27	06-05	Q1-05	07-05	Q1-05	06-05	06-05	06-05	07-05	Q1-05	Q1-05	Q4-04	06-05
2005-08-31	07-05	Q2-05	08-05	Q2-05	07-05	07-05	07-05	08-05	Q1-05	Q1-05	Q2-05	07-05
2005-09-28	08-05	Q2-05	09-05	Q2-05	08-05	08-05	08-05	09-05	Q2-05	Q2-05	Q2-05	08-05
2005-10-26	09-05	Q2-05	10-05	Q2-05	09-05	09-05	09-05	10-05	Q2-05	Q2-05	Q2-05	09-05
2005-11-30	10-05	Q3-05	11-05	Q3-05	10-05	10-05	10-05	11-05	Q2-05	Q2-05	Q3-05	10-05
2005-12-21	11-05	Q3-05	12-05	Q3-05	11-05	11-05	11-05	11-05	Q2-05	Q2-05	Q3-05	11-05
2006-01-31	12-05	Q3-05	01-06	Q4-05	12-05	12-05	12-05	01-06	Q3-05	Q3-05	Q3-05	12-05
2006-02-28	01-06	Q3-05	02-06	Q4-05	01-06	01-06	01-06	02-06	Q3-05	Q3-05	Q3-05	01-06
2006-03-29	02-06	Q4-05	03-06	Q4-05	02-06	02-06	02-06	03-06	Q4-05	Q4-05	Q4-05	02-06
2006-04-26	03-06	Q4-05	04-06	Q4-05	03-06	03-06	03-06	04-06	Q4-05	Q4-05	Q4-05	03-06
2006-05-31	04-06	Q1-06	05-06	Q1-06	04-06	04-06	04-06	05-06	Q4-05	Q4-05	Q4-05	04-06
2006-06-28	05-06	Q1-06	06-06	Q1-06	05-06	05-06	05-06	06-06	Q1-06	Q1-06	Q4-05	05-06
2006-07-26	06-06	Q1-06	07-06	Q1-06	06-06	06-06	06-06	07-06	Q1-06	Q1-06	Q4-05	06-06
2006-08-30	07-06	Q2-06	08-06	Q2-06	07-06	07-06	07-06	08-06	Q1-06	Q1-06	Q2-06	07-06
2006-09-27	08-06	Q2-06	09-06	Q2-06	08-06	08-06	08-06	09-06	Q2-06	Q2-06	Q2-06	08-06
2006-10-25	09-06	Q2-06	10-06	Q2-06	09-06	09-06	09-06	10-06	Q2-06	Q2-06	Q2-06	09-06

Notes: See Table 4 to determine according to which schedule each variable has been released.

Table 7: Augmented Dickey-Fuller unit root tests

Variable	Augmented Dickey-Fuller (ADF) unit root tests					P-values of the Ljung-Box Q-statistic of 12-order serial correlation among residuals
	Testing period	Model*	Lag length	t-statistic	P-value**	
ΔRR	1998/04 - 2007/08		2	-3.07	0.002	0.718
ExInf_T_M	1998/05 - 2007/08		2	-4.70	0.000	0.287
GDPnaiy	1998/09 - 2007/08	C	6	-2.90	0.049	0.737
GDPRna_Y	1998/05 - 2007/08	C	2	-2.78	0.065	0.956
GVATnaiy	1998/10 - 2007/08	C	7	-2.81	0.060	0.783
GVARna_Y	1998/07 - 2007/08	C	4	-3.86	0.003	0.537
CPI_T_YM	1999/03 - 2007/08		12	-5.47	0.000	0.922
CPIxac_T_YC	1999/04 - 2007/08	C	12	-3.61	0.007	0.999
CPIxac_T_YM	1999/04 - 2007/08		12	-4.40	0.000	0.881
CPIxmvf_T_YM	1999/04 - 2007/08		12	-5.33	0.000	0.914
Ereu	1993/01 - 2007/08	C	8	-3.09	0.028	0.216
WIBOR12m_ZP	2001/04 - 2007/08	C	0	-6.31	0.000	0.891
WIBOR12m_RR	2001/03 - 2007/08	C	0	-2.82	0.005	0.084
WIBOR9m_RR	2001/04 - 2007/08	C	1	-2.40	0.017	0.312
WIBOR6m_RR	1998/03 - 2007/08	C	0	-3.93	0.003	0.171
WIBOR3m_RR	1998/03 - 2007/08	C	0	-4.84	0.000	0.401
WIBOR1m_RR	1998/03 - 2007/08	C	0	-5.61	0.000	0.878
WIBOR3m_C	1998/03 - 2007/08	C	0	-4.98	0.000	0.725

Notes:The null hypothesis in ADF test: a series has a unit root.
The null hypothesis of the Ljung-Box Q-test of serial correlation: there is no serial correlation in the residuals up to 12th order.
* C - constant; ** MacKinnon (1996) one-sided p-values.
All tests are performed using Eviews 5.0.

Table 8: Tests for structural change

Dependent variable - change to the reference rate	Model 8.1		Model 8.2		Model 8.3		Model 8.4	
	ExInf_T_M	*GDPnai_Y*	*ExInf_T_M*	*GDPRna_Y*	*ExInf_T_M*	*GVATnai_Y*	*ExInf_T_M*	*GVARna_Y*
Full sample: 1999/02 - 2006/10 (93 observations)								
Parameter estimate	0.62	0.48	0.49	0.44	0.60	0.47	0.53	0.38
Standard error	0.21	0.09	0.22	0.08	0.21	0.09	0.22	0.08
P-Value	0.004	<0.001	0.025	<0.001	0.004	<0.001	0.014	<0.001
Log likelihood	-56.21		-55.56		-57.84		-58.12	
Likelihood ratio	44.27		45.59		41.01		40.46	
Count R^2	0.68		0.69		0.66		0.69	
Adj. count R^2	0.12		0.15		0.06		0.15	
McKelvey & Zavoina R^2	0.51		0.52		0.48		0.48	
Sup-LR test for structural change with unknown change point								
Change point *	April 2002		April 2002		April 2002		April 2002	
Max LR **	37.43		45.53		40.40		34.72	
First sub-sample: 1999/02 - 2002/03 (38 observations)								
Parameter estimate	0.30	0.29	0.21	0.34	0.30	0.28	0.24	0.29
Standard error	0.22	0.13	0.24	0.13	0.22	0.13	0.23	0.12
P-Value	0.175	0.023	0.368	0.007	0.179	0.026	0.301	0.016
Log likelihood	-26.17		-24.09		-26.28		-25.79	
Likelihood ratio	7.81		11.97		7.59		8.56	
Count R^2	0.71		0.71		0.71		0.71	
Adj. count R^2	0.00		0.00		0.00		0.00	
McKelvey & Zavoina R^2	0.28		0.41		0.27		0.30	
Second sub-sample: 2002/04 - 2006/10 (55 observations)								
Parameter estimate	5.27	1.12	9.35	1.76	5.57	1.23	5.24	0.79
Standard error	1.54	0.27	3.13	0.52	1.61	0.30	1.56	0.20
P-Value	0.001	<0.001	0.003	0.001	0.001	<0.001	0.001	<0.001
Log likelihood	-11.33		-8.70		-11.36		-14.97	
Likelihood ratio	69.92		75.18		69.85		62.64	
Count R^2	0.91		0.98		0.93		0.87	
Adj. count R^2	0.78		0.96		0.83		0.70	
McKelvey & Zavoina R^2	0.91		0.97		0.92		0.90	

Notes: Tests are performed for ordered probit models with three outcome categories of dependent variable: "increase", "no change", "decrease". Two threshold estimates are not reported.

* Testing period: 2001/11 - 2003/11. ** Andrews' asymptotical critical values:

Table 9: Responses to real activity and inflation

Dependent variable - change to the reference rate	Model 9.1		Model 9.2		Model 9.3		Model 9.4	
	GDPnai_Y	*ExInf_T_M*	*GDPnai_Y*	*CPIxmvf_T_YM*	*GDPnai_Y*	*CPI_T_YM*	*GDPnai_Y*	*CPIxac_T_YM*
	First sub-sample: 1999/02 - 2002/03 (38 observations)							
Parameter estimate	0.29	0.30	0.28	1.45	0.41	1.41	0.37	1.70
Standard error	0.13	0.22	0.15	0.51	0.17	0.44	0.17	0.49
P-Value	0.023	0.175	0.063	0.004	0.016	0.001	0.031	0.001
Log likelihood	-26.17		-21.28		-18.80		-17.26	
Likelihood ratio	7.81		17.59		22.56		25.63	
AIC	60.34		50.55		45.59		42.52	
Count R^2	0.71		0.76		0.82		0.82	
Adj. count R^2	0.00		0.18		0.36		0.36	
McKelvey & Zavoina R^2	0.28		0.57		0.65		0.69	
	Second sub-sample: 2002/04 - 2006/10 (55 observations)							
Parameter estimate	1.12	5.27	0.71	1.29	0.73	0.94	0.73	1.05
Standard error	0.27	1.54	0.16	0.50	0.15	0.48	0.16	0.45
P-Value	<0.001	0.001	<0.001	0.010	<0.001	0.049	<0.001	0.021
Log likelihood	-11.33		-22.95		-24.32		-23.39	
Likelihood ratio	69.92		46.68		43.93		45.79	
AIC	30.66		53.89		56.65		54.79	
Count R^2	0.91		0.86		0.82		0.84	
Adj. count R^2	0.69		0.53		0.36		0.43	
McKelvey & Zavoina R^2	0.91		0.73		0.70		0.72	

Notes: The ordered probit estimations are performed with three outcome categories of dependent variable: "increase", "no change", "decrease". Two threshold estimates are not reported.

Table 10: Tests for structural change

Dependent variable - change to the reference rate	Model 10.1		Model 10.2	
	Ereu	*CPIxac_T_YM*	*Ind_CPI_T*	*CPIxac_T_YC*
Full sample: 1999/02 - 2006/10 (93 observations)				
Log likelihood	-62.10		-50.84	
Count R^2	0.63		0.72	
Adj. count R^2	0.00		0.24	
McKelvey & Zavoina R^2	0.40		0.63	
Test for structural change with unknown change point				
Change point *	April 2002		April 2002	
Max LR **	26.84		17.12	
First sub-sample: 1999/02 - 2002/03 (38 observations)				
Parameter estimate	10.73	4.60	8.10	2.65
Standard error	3.96	1.81	3.67	0.91
P-Value	0.007	0.011	0.027	0.004
Log likelihood	-9.97		-10.44	
Likelihood ratio	40.20		39.26	
Count R^2	0.87		0.95	
Adj. count R^2	0.55		0.82	
McKelvey & Zavoina R^2	0.96		0.97	
Second sub-sample: 2002/04 - 2006/10 (55 observations)				
Parameter estimate	1.05	1.01	1.71	0.95
Standard error	0.63	0.37	0.51	0.24
P-Value	0.094	0.006	<0.001	<0.001
Log likelihood	-38.71		-31.84	
Likelihood ratio	15.17		28.91	
Count R^2	0.62		0.73	
Adj. count R^2	0.09		0.35	
McKelvey & Zavoina R^2	0.32		0.57	
Sample: 1998/03 - 2002/03 (49 observations)				
Parameter estimate	2.36	1.70	0.63	0.80
Standard error	0.95	0.47	0.39	0.21
P-Value	0.013	<0.001	0.111	<0.001
Log likelihood	-26.24		-31.03	
Likelihood ratio	31.04		21.45	
Count R^2	0.71		0.69	
Adj. count R^2	0.22		0.17	
McKelvey & Zavoina R^2	0.67		0.50	

Notes: Tests are performed for ordered probit models with three outcome categories of dependent variable: "increase", "no change", "decrease". Two threshold estimates are not reported.

* Testing period: 2001/03 - 2004/07; ** Andrews' asymptotical critical values: 'CV 1%' = 19.08, 'CV 5%' = 14.87.

Table 11: Tests for interest rate smoothing

First sub-sample: 1999/02 - 2002/03	Model 11.1.1		Model 11.1.2			Model 11.1.3	
	RRC_L1	*Ereu*	*CPIxac_T_YM*	*RRC_L1*	*Ind_CPI_T*	*CPIxac_T_YC*	*RRC_L1*
Parameter estimate	0.34	15.02	6.08	-1.04	8.53	2.70	-0.59
Standard error	0.36	6.42	2.79	0.82	3.86	0.94	0.71
P-Value	0.347	0.019	0.029	0.205	0.027	0.004	0.406
			Goodness-of-fit measures				
Log likelihood	-29.63		-9.02			-10.08	
Likelihood ratio	0.90		42.11			39.99	
AIC	65.25		28.04			30.16	
Count R^2	0.71		0.84			0.89	
Adj. count R^2	0.00		0.45			0.64	
McKelvey & Zavoina R^2	0.03		0.98			0.97	
Second sub-sample: 2002/04 - 2006/10	Model 11.2.1		Model 11.2.2			Model 11.2.3	
	RRC_L1	*ExInf_T_M*	*GDPRna_Y*	*RRC_L1*	*ExInf_T_M*	*GVATnai_Y*	*RRC_L1*
Parameter estimate	1.59	8.66	1.59	0.48	5.48	1.14	0.42
Standard error	0.35	3.10	0.56	0.84	1.60	0.33	0.71
P-Value	<0.001	0.005	0.004	0.568	<0.001	<0.001	0.553
			Goodness-of-fit measures				
Log likelihood	-34.26		-8.54			-11.19	
Likelihood ratio	24.05		75.49			70.20	
AIC	74.53		27.09			32.38	
Count R^2	0.73		0.96			0.93	
Adj. count R^2	0.35		0.91			0.83	
McKelvey & Zavoina R^2	0.45		0.97			0.92	

Notes: The ordered probit setimations are performed with three outcome categories of dependent variable: "increase", "no change", "decrease". Two threshold estimates are not reported.

Table 12: Market anticipation of policy decisions

Specification	*WIBOR1m_RR*	*WIBOR3m_RR*	*WIBOR6m_RR*	*WIBOR9m_RR*	*WIBOR12m_RR*
			First sub-sample: 1999/02 - 2002/03		
Parameter estimate	1.24	1.85	1.71		
Standard error	0.39	0.48	0.45		
P-Value	0.002	<0.001	<0.001		
			Goodness-of-fit measures		
Log likelihood	-23.55	-16.90	-14.45		
Likelihood ratio	13.04	26.35	31.25		
AIC	53.11	39.80	34.90		
Count R^2	0.71	0.79	0.82		
Adj. count R^2	0.00	0.27	0.36		
McKelvey & Zavoina R^2	0.42	0.72	0.77		
			Second sub-sample: 2002/04 - 2006/10		
Parameter estimate	6.77	8.12	5.78	4.42	3.49
Standard error	1.42	1.80	1.36	1.04	0.80
P-Value	<0.001	<0.001	<0.001	<0.001	<0.001
			Goodness-of-fit measures		
Log likelihood	-30.01	-17.61	-16.35	-17.47	-18.81
Likelihood ratio	32.55	57.36	59.89	57.64	54.97
AIC	66.03	41.22	38.69	40.94	43.61
Count R^2	0.80	0.87	0.85	0.84	0.82
Adj. count R^2	0.52	0.70	0.65	0.61	0.57
McKelvey & Zavoina R^2	0.59	0.84	0.87	0.86	0.84

Notes: The ordered probit estimations are performed with three outcome categories of dependent variable - change to the reference rate: "increase", "no change", and "decrease". Two threshold estimates are not reported.

Table 13: Comparison with market anticipation

First sub-sample: 1999/02 - 2002/03	*WIBOR6m_RR*	Reuters survey	Model 10.2
Proportion of correct predictions	0.82	0.87	0.95
Average likelihood of observed rate changes	0.77	0.80	0.83
Second sub-sample: 2002/04 - 2006/10	*WIBOR6m_RR*	Reuters survey	Model 8.2
Proportion of correct predictions	0.85	0.89	0.98
Average likelihood of observed rate changes	0.81	0.82	0.90

Notes: The predictions are made in terms of three possible policy choices: "increase", "no change", or "decrease" in the reference rate. The predicted choice is one with the highest predicted probability.

Model 8.2: *ExInf_T_M* and *GDPRna_Y*. Model 10.2: *Ind_CPI_T* and *CPIxac_T_YC*.

Table 14: Market anticipation of policy decisions in 2002/04 - 2006/10

Specification	Model 14.1 *WIBOR1m_RR*	Model 14.2 *WIBOR3m_RR*	Model 14.3 *WIBOR6m_RR*	Model 14.4 *WIBOR9m_RR*	Model 14.5 *WIBOR12m_RR*
Parameter estimate	4.91	5.16	3.86	3.15	2.68
Standard error	1.07	0.94	0.72	0.61	0.53
P-Value	<0.001	<0.001	<0.001	<0.001	<0.001
			Goodness-of-fit measures		
Log likelihood	-48.02	-37.29	-34.53	-34.59	-35.04
Likelihood ratio	24.07	45.52	51.04	50.92	50.03
AIC	104.03	82.59	77.06	77.19	78.08
Count R^2	0.71	0.71	0.69	0.67	0.65
Adj. count R^2	0.30	0.30	0.26	0.22	0.17
McKelvey & Zavoina R^2	0.43	0.68	0.74	0.76	0.76
Score test for equal slopes assumption	17.91 P-Value: <0.001	11.85 P-Value: 0.003	7.16 P-Value: 0.028	4.28 P-Value: 0.117	2.91 P-Value: 0.234

Notes: The ordered probit estimations are performed with four outcome categories of dependent variable - change to the reference rate: "increase", "no change", "0.25% decrease", and "0.50 % decrease". Three threshold estimates are not reported.

Count R^2 is the proportion of correct predictions. The predicted choice is one with the highest predicted probability. Adj. count R^2 is the proportion of correct predictions beyond the number that would be correctly guessed by choosing the outcome category with the largest percentage of observed cases.

Table 15: Comparison with market anticipation

Forecast	*WIBOR6m_RR* (model 14.3)	Reuters survey	Model 16.1	Model 16.2
Proportion of correct predictions	0.69	0.84	0.91	0.96
Average likelihood of observed rate changes	0.63	0.78	0.84	0.92
MAE of E(Y|X), basis points	10.27	7.25	4.60	2.84

Notes: The predictions are made in terms of four possible policy choices: "increase", "no change", "decrease -0.25%", or "decrease -0.50%" in the reference rate. The predicted choice is one with the highest predicted probability.

"MAE of E(Y|X)" is a mean absolute error, calculated with respect to the actual observed (non-consolidated) reference rate changes, where E(Y|X) = P(Y=-0.5|X)*(-0.5) + P(Y=-0.25|X)*(-0.25) + P(Y=0|X)*(0) + P(Y>0|X)*(0.375).

Model 16.1: *ExInf_T_M, GDPnaiy, ExInf_T_M* Ind_ExInf_T*.

Model 16.2: *ExInf_T_M, GDPnaiy, ExInf_T_M* Ind_ExInf_T, and WIBOR12m_ZP*.

Table 16: Policy rules in 2002/04 - 2006/10

Specification	Model 16.1			Model 16.2				Model 16.3			Model 16.4			
	ExInf_T_M	*GDPnaiy*	*ExInf_T_M* Ind_ExInf_T*	*ExInf_T_M*	*GDPnaiy*	*ExInf_T_M* Ind_ExInf_T*	*WIBOR12m_ZP*	*ExInf_T_M*	*GVATnaiy*	*ExInf_T_M* Ind_ExInf_T*	*ExInf_T_M*	*GVATnaiy*	*ExInf_T_M* Ind_ExInf_T*	*WIBOR12m_ZP*
Parameter estimate	4.02	1.44	8.99	11.36	4.65	28.48	32.43	4.19	1.56	8.83	9.18	3.90	21.34	24.59
Standard error	1.20	0.29	2.80	5.04	1.92	11.51	14.65	1.23	0.32	2.68	3.68	1.47	8.11	10.56
P-Value	<0.001	<0.001	0.001	0.024	0.015	0.013	0.027	<0.001	<0.001	0.001	0.013	0.008	0.009	0.020
Thresholds	α_1	α_2	α_3	α_1	α_2	α_3		α_1	α_2	α_3	α_1	α_2	α_3	
Parameter estimate	0.74	3.16	12.42	2.96	12.25	43.83		0.94	3.34	12.63	2.95	9.68	34.12	
Standard error	0.55	0.76	2.75	1.44	5.37	18.16		0.59	0.78	2.74	1.37	3.90	12.94	
P-Value	0.182	<0.001	<0.001	0.040	0.023	0.016		0.107	<0.001	<0.001	0.031	0.013	0.008	
Goodness-of-fit measures														
Log likelihood		-15.51			-7.13				-15.49			-8.15		
Likelihood ratio		89.07			105.84				89.13			103.80		
AIC		43.03			28.26				42.97			30.31		
Count R^2		0.91			0.96				0.91			0.95		
Adj. count R^2		0.78			0.91				0.78			0.87		
McKelvey & Zavoina R^2		0.96			1.00				0.96			0.99		
Adjusted Estrella R^2		0.89			0.96				0.89			0.95		
Cragg-Uhler-2 R^2		0.90			0.96				0.90			0.96		
Score test for the equal slopes assumption		8.79 P-value: 0.185			8.64 P-value: 0.373				9.02 P-value: 0.173			9.24 P-value: 0.322		

Notes: The ordered probit estimations are performed with four outcome categories of dependent variable: "0.50% or 0.25% increase", "no change", "0.25% decrease", and "0.50% decrease".

Table 17: Tests for interest rate smoothing in 2002/04 - 2006/10

Specification	Model 17.1				Model 17.2			
	ExInf_T_M	*GDPnaiy*	*ExInf_T_M* Ind_ExInf_T*	*RRC_L1*	*ExInf_T_M*	*GVATnaiy*	*ExInf_T_M* Ind_ExInf_T*	*RRC_L1*
Parameter estimate	4.05	1.41	9.03	0.74	4.23	1.53	8.95	1.01
Standard error	1.20	0.30	2.79	1.49	1.26	0.32	2.70	1.53
P-Value	<0.001	<0.001	0.001	0.618	<0.001	<0.001	<0.001	0.509
	Goodness-of-fit measures							
Log likelihood	-15.39				-15.27			
Likelihood ratio	89.32				89.56			
AIC	44.78				44.54			
Count R^2	0.93				0.93			
Adj. count R^2	0.83				0.83			
McKelvey & Zavoina R^2	0.96				0.96			

Notes: The ordered probit estimations are performed with four outcome categories of dependent variable: "0.50% or 0.25% increase", "no change", "0.25% decrease", and "0.50% decrease". Three threshold estimates are not reported.

Table 18: In-sample prediction of policy rate changes

Actual decision	Predicted decision					Total	Adjusted noise to signal ratio, %
	hike	no change	0.25% cut	0.50% cut	Correct		
hike	3	0	0	0	3	3	0
no change	0	31	1	0	31	32	4.5
0.25% cut	0	1	9	1	9	11	2.8
0.50% cut	0	0	0	9	9	9	2.2
Total	3	32	10	10	52	55	

Notes:

Sample period: 2002/04 - 2006/10.

The ordered probit estimations are performed for the specification 16.4.

A particular choice is predicted if its predicted probability exceeds the predicted probabilities of the alternatives.

An 'adjusted noise-to-signal ratio', introduced by Kaminsky and Reinhart (1999), is defined as follows. Let *A* denote the event that the decision is predicted and occurred; let *B* denote the event that the decision is predicted but not occurred; let *C* denote the event that the decision is not predicted but occurred; let *D* denote the event that the decision is not predicted and not occurred. The desirable outcomes fall into categories *A* and *D*, while noisy ones fall into categories *B* and *C*. A perfect prediction would have no entries in *B* and *C*, while a noisy prediction would have many entries in *B* and *C*, but few in *A* and *D*. The 'adjusted noise-to-signal' ratio is defined as $[B/(B+D)]/[A/(A+C)]$.

Table 19: Out-of-sample forecasting of next change to the reference rate

Period	03-2006	04-2006	05-2006	06-2006	07-2006	08-2006	09-2006	10-2006	11-2006	12-2006	01-2007	02-2007	03-2007	04-2007	05-2007	06-2007	07-2007	08-2007	09-2007	10-2007
Actual change, %	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.25**	**0**	**0.25**	**0**	**0.25**	**0**	**0**
Forecast by Model 16.3																				
Pr(y=-0.50%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pr(y=-0.25%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pr(y=0%)	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.99**	**0.99**	**1.00**	**1.00**	**0.94**	**1.00**	**0.84**	**0.97**	0.00	**0.75**	**0.94**	0.00	**1.00**	**1.00**
Pr(y>=0.25%)	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.06	0.00	0.16	0.03	**1.00**	0.25	0.06	**1.00**	0.00	0.00
Predicted change, %	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.25**	**0**	**0**	**0.25**	**0**	**0**
Forecast by Model 16.4																				
Pr(y=-0.50%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pr(y=-0.25%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pr(y=0%)	**1.00**	**1.00**	**1.00**	**0.64**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	0.00	0.03	**0.86**	0.00	**1.00**	**1.00**
Pr(y>=0.25%)	0.00	0.00	0.00	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.00**	**0.97**	0.14	**1.00**	0.00	0.00
Predicted change, %	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.25**	**0.25**	**0**	**0.25**	**0**	**0**
Market anticipation (forecast from Reuters survey of banks' analysts)																				
Pr(y=-0.50%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pr(y=-0.25%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pr(y=0%)	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**0.95**	0.05	**1.00**	**0.90**	**1.00**	0.19	**1.00**	**0.89**
Pr(y>=0.25%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	**0.95**	0.00	0.10	0.00	**0.81**	0.00	0.11
Predicted change, %	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.25**	**0**	**0**	**0**	**0.25**	**0**	**0**

Notes: Model 16.3: ExInf_T_M, GVATnaiy, ExInf_T_M*Ind_ExInf_T; Model 16.4: ExInf_T_M, GVATnaiy, ExInf_T_M*Ind_ExInf_T, WIBOR12m_ZP.
The forecasting by models 16.3 and 16.4 is performed using ordered probit models estimated for the period 2002/04-2006/02 without rolling re-estimation.
The predicted choice is that with the highest probability.

Table 20: Policy rules in 2002/04 - 2006/10, based on revised data at monthly frequency

Specification	Model 16.1			Model 16.2				Model 16.3			Model 16.4			
	ExInf_T_M	*GDPnaiy*	*ExInf_T_M* Ind_ExInf_T*	*ExInf_T_M*	*GDPnaiy*	*ExInf_T_M* Ind_ExInf_T*	*WIBOR12m_ZP*	*ExInf_T_M*	*GVATnaiy*	*ExInf_T_M* Ind_ExInf_T*	*ExInf_T_M*	*GVATnaiy*	*ExInf_T_M* Ind_ExInf_T*	*WIBOR12m_ZP*
Parameter estimate	4.04	1.43	6.04	4.05	1.45	6.12	-0.06	4.07	1.66	8.33	4.05	1.67	8.43	-0.04
Standard error	1.20	0.30	1.92	1.21	0.31	1.96	0.16	1.25	0.35	2.28	1.25	0.36	2.34	0.18
P-Value	<0.001	<0.001	0.002	<0.001	<0.001	0.002	0.723	0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.823
Thresholds	α_1	α_2	α_3	α_1	α_2	α_3		α_1	α_2	α_3	α_1	α_2	α_3	
Parameter estimate	1.34	3.52	11.94	1.36	3.54	12.05		1.55	3.77	13.58	1.56	3.79	13.67	
Standard error	0.64	0.83	2.48	0.65	0.84	2.53		0.70	0.88	2.87	0.70	0.88	2.92	
P-Value	0.037	<0.001	<0.001	0.036	<0.001	<0.001		0.026	<0.001	<0.001	0.025	<0.001	<0.001	
Goodness-of-fit measures														
Log likelihood		-18.20			-18.14				-17.24			-17.22		
AIC		48.40			50.27				46.48			48.44		
Count R^2		0.85			0.85				0.87			0.87		
Adj. count R^2		0.65			0.65				0.70			0.70		
McKelvey & Zavoina R^2		0.95			0.95				0.96			0.96		

Notes: The ordered probit estimations are performed with four outcome categories of dependent variable – monthly change to the reference rate: "0.50% or 0.25% increase", "no change", "0.25% decrease", and "0.50% decrease".

Table 21: Comparison of policy rules, based on revised and real-time data

Specification	*ExInf_T_M*	*GDPRna_Y*	*ExInf_T_M* Ind_ExInf_T*
Real-time data available at MPC meetings			
Parameter estimate	3.35	1.47	9.12
Standard error	1.03	0.36	2.81
P-Value	0.001	<0.001	0.001
Thresholds	α_1	α_2	α_3
Parameter estimate	0.81	2.72	12.12
Standard error	0.61	0.78	3.86
P-Value	0.187	<0.001	0.002
Goodness-of-fit measures			
Log likelihood		-19.04	
AIC		50.07	
Count R^2		0.85	
Adj. count R^2		0.65	
McKelvey & Zavoina R^2		0.96	
Revised data at monthly frequency			
Parameter estimate	3.74	0.80	5.77
Standard error	0.96	0.19	1.64
P-Value	<0.001	<0.001	<0.001
Thresholds	α_1	α_2	α_3
Parameter estimate	0.87	2.14	7.81
Standard error	0.60	0.64	1.59
P-Value	0.148	<0.001	<0.001
Goodness-of-fit measures			
Log likelihood		-29.48	
AIC		70.96	
Count R^2		0.76	
Adj. count R^2		0.43	
McKelvey & Zavoina R^2		0.89	

Notes: The ordered probit estimations are performed with four outcome categories of dependent variable – change to the reference rate: "0.50% or 0.25% increase", "no change", "0.25% decrease", and "0.50% decrease" for the period 2002/04 - 2006/10.

Table 22: Policy rules, estimated using linear OLS regression

Specification	Model 16.3				
	Intercept	*ExInf_T_M*	*GVATnai_Y*	*ExInf_T_M* Ind_ExInf_T*	
Parameter estimate	-0.380	0.203	0.080	0.115	
Standard error	0.040	0.058	0.011	0.097	
P-Value	<0.001	0.001	<0.001	0.241	
	Goodness-of-fit measures				
F-Statistic	37.55				
Pr > F	<0.001				
Root MSE	0.1319				
R^2	0.688				
Adj. R^2	0.670				
Durbin-Watson D	1.881				
Specification	Model 16.4				
	Intercept	*ExInf_T_M*	*GVATnai_Y*	*ExInf_T_M* Ind_ExInf_T*	*WIBOR12m_ZP*
Parameter estimate	-0.381	0.201	0.079	0.106	0.058
Standard error	0.041	0.058	0.011	0.099	0.115
P-Value	<0.001	0.001	<0.001	0.291	0.619
	Goodness-of-fit measures				
F-Statistic	27.81				
Pr > F	<0.001				
Root MSE	0.1328				
R^2	0.690				
Adj. R^2	0.665				
Durbin-Watson D	1.959				

Notes: Sample: 2002/04 – 2006/10.
Dependent variable: historical (non-consolidated) change to the reference rate made at a policy meeting of the MPC.

Table 23: Comparison of linear, rounded linear, interval and ordered probit models.

Model:		LRM	RLRM				IRM		OPM
Model 16.3: *ExInf_T_M, GVATnaiy, ExInf_T_M*Ind_ExInf_T*									
Cut points	c_1		-0.50	-0.25	-0.375	-0.50	-0.375	-0.50	0.94
	c_2		-0.25	0.00	-0.125	-0.25	-0.125	-0.25	3.34
	c_3		0.00	0.25	0.125	0.25	0.125	0.25	12.63
Goodness-of-fit measures									
MAE of E(Y|X), bp		9.92	17.22	14.44	10.16	10.36	10.02	6.03	4.50
Count R^2			0.55	0.42	0.78	0.73	0.69	0.87	0.91
Adjusted count R^2			-0.09	-0.39	0.48	0.35	0.26	0.70	0.78
Average likelihood			0.46	0.46	0.56	0.66	0.65	0.79	0.84
Log likelihood			-55.25	-52.87	-36.45	-36.64	-30.94	-19.18	-15.49
Likelihood ratio chi-square tests									
# of constraints			6	6	6	6	3	3	
Chi-square statistic			79.53	74.76	41.92	42.31	30.90	7.39	
P-value			0.000	0.000	0.000	0.000	0.000	0.060	
Model 16.4: *ExInf_T_M, GVATnaiy, ExInf_T_M*Ind_ExInf_T, WIBOR12m_ZP*									
Cut points	c_1		-0.50	-0.25	-0.375	-0.50	-0.375	-0.50	2.95
	c_2		-0.25	0.00	-0.125	-0.25	-0.125	-0.25	9.68
	c_3		0.00	0.25	0.125	0.25	0.125	0.25	34.12
Goodness-of-fit measures									
MAE of E(Y|X), bp		9.87	17.26	14.36	10.07	10.31	9.96	5.38	3.10
Count R^2			0.55	0.44	0.78	0.73	0.71	0.87	0.95
Adjusted count R^2			-0.09	-0.35	0.48	0.35	0.30	0.70	0.87
Average likelihood			0.46	0.46	0.56	0.66	0.65	0.82	0.91
Log likelihood			-54.88	-52.36	-36.21	-36.16	-29.70	-15.58	-8.15
Likelihood ratio chi-square tests									
# of constraints			7	7	7	7	3	3	
Chi-square statistic			93.45	88.41	56.11	56.02	43.10	14.85	
P-value			0.000	0.000	0.000	0.000	0.000	0.002	

Notes: LRM - linear regression model estimated by OLS; RLRM – extended 'rounded linear regression' model, which is identical to the constrained interval regression model with all coefficients β and σ^2 restricted to be the same as in the LRM, estimated by OLS; IRM - interval regression model; OPM - ordered probit model.

Sample period: 2002/04 - 2006/10. The estimations are performed with four outcome categories of dependent variable - change to the reference rate: "0.50% or 0.25% increase", "no change", "0.25% decrease", and "0.50% decrease".

In the RLRM, IRM and OPM the E(Y|X) = P(Y=-0.5|X)*(-0.5) + P(Y=-0.25|X)*(-0.25) + P(Y=0|X)*(0) + P(Y>0|X)*(0.5+0.5+0.25)/3, where (0.5+0.5+0.25)/3 = E(Y|Y>0, X). In the LRM the E(Y|X) = X*b. "MAE of E(Y|X)" - mean absolute error - is calculated with respect to the actual observed (non-consolidated) reference rate changes.

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