Looking for an Optimal Monetary Policy Rule: The Case of Poland under IT framework

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Abstract

The aim of the paper is to check the influence of the degree of forward-lookingness of economic agents on the optimal monetary policy rules, using several versions of a small, highly aggregated structural model describing the transmission mechanism in the spirit of the New Keynesian School. We show the optimal policy rule with the monetary authority loss function as an optimality criterion. We also study changes in the optimal policy rule resulting from the varying degree of forward-lookingness in the model and investigate the nature of the formal relationship between the degree of forward-lookingness of the model and the shape of the optimal monetary policy rule.

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1. Introduction

The aim of the paper is to check the influence of the degree of forward-lookingness of economic agents on the optimal monetary policy rules, using several versions of a small, highly aggregated structural model describing the transmission mechanism in the spirit of the New Keynesian School.

Forward-looking behaviour - although postulated by the economic theory - is represented in the fully estimated "benchmark" version of the model to a very limited degree. In particular, the short-run Phillips curve is mostly backward-looking (the expected inflation is only in about 10 percent forward-looking), exhibiting thus a feature that has been suggested by previous analyses of expectations from the survey data. Likewise, forward-lookingness of the forex market has been strongly rejected by the data, and therefore exchange rate in the model is also backward-looking. However, some form of forward-looking expectations is also introduced into the UIP condition through the interest rate term structure, allowing the expected interest rate changes affect the exchange rate path. There is also a forward-looking element in the IS curve – namely *ex ante* real interest rate (i.e. nominal interest rate deflated by consumers' inflation expectations). However, some studies strongly suggest changing degree of economic agents' forward lookingness, with the adoption of inflation targeting being one of the possible factors thereof. The EU accession is likely to further stimulate this process.

We also study changes in the optimal policy rule resulting from the varying degree of forward-lookingness in the model and investigate the nature of the formal relationship between the degree of forward-lookingness of the model and the shape of the optimal monetary policy rule.

The paper is built as follows: Section 2 is a short review of the related literature, in the Section 3 we discuss monetary and fiscal policy over the period 1990-2005, stressing their changes, since we believe that this was an important factor affecting expectations formation. Section 4 shows a small-scale structural model of the Polish economy, estimated with classical econometric method, Section 5 presents modifications introduced to the benchmark model and discusses some problems concerning its Bayesian estimation. Next, Section 6 is devoted to the discussion of results and Section 7 concludes. All tables and charts are in the Appendix.

2. Survey of related literature

There is a constantly growing body of literature on robust monetary rules with model uncertainty and imperfect knowledge about the structure of the economy. In this area of research robustness is usually understood as a reasonable behaviour of macroeconomic stability across differing assumptions on a true model of the economy.

Levin and Williams (2003) study three models differing with expectations formation and the degree of inflation persistence. The first one has pure New Keynesian features, i.e. it does not exhibit any persistence implying that both inflation and output gap depend on their future expected values. The second one stands in a clear opposition – it is entirely backward looking model of Rudebusch and Svensson (1999) with high persistence and the third one is the Fuhrer (2000) model with rational expectations but exhibiting persistence due to assumed habit formation. Levin and Williams show that a rule obtained for one model may be inappropriate for another. In particular, rules with interest rate smoothing perform well in the forward looking model, while the opposite is true for the backward looking one. Searching for a robust rule they prove that the one exhibiting moderate degree of smoothing performs well across the surveyed models, providing that the loss function puts nontrivial weight on both inflation and output stabilisation.

Adalid, Coenen and Mc Adam (2004) analyse the rules for models of the euro area. The models differ with respect to size and aggregation, degree of forward lookingness and adherence to micro foundations. Namely, they consider the Coenen-Wieland (2000) model of a small size for a closed economy, exhibiting inflation persistence that results from the assumed pattern of wage negotiations (today's wages are set with respect to past contracts), Smets-Wouters (2003) model, i.e. a New Keynesian DSGE model for a closed economy, the Area Wide Model (AWM) - a workhorse of the ECB inflation forecasting process, a medium size hybrid model for an open economy (exchange rate affects aggregate demand) with Keynesian effects in the short-run, and the neoclassical long-run. Finally, they use the Dis-aggregate Euro Area Model, a multi-country version of the Rudebusch and Svensson (1999) model. The authors confirm the results obtained for the models of the US economy, namely that the degree of forward lookingness is a crucial factor that determines policy rule – forward looking models perform better with a rule that exhibits interest rate smoothing, whereas backward looking ones require more aggressive policy. The rules which are optimal for backward looking models perform also quite well in the forward looking models, while the opposite is not true, i.e. a robust rule has only a limited degree of smoothing.

Orphanides and Willimas (2004) focus on robust rules in a case of a structural change in the economy and imperfect knowledge of both a central bank and private agents about the "true" structure of the economy. In particular, a structural change in the economy makes both natural interest rate and natural unemployment rate evolve, so the monetary policy decision making body cannot observe their precise values. Orphanides and Williams discard the usual assumptions governing formation of expectations of the private agents. Namely, instead of assuming that the agents know perfectly the structure of the economy, they adopt a competing assumption that private agents know correctly the structure, but only learn about the parameters in the model's relationships. Using a two-equation model of the U.S. economy with habit formation and a hybrid Phillips curve, Orphanides and Williams show that if one assumes learning and imperfect knowledge about the natural rate, monetary policy should react more aggressively with respect to inflation and less aggressively with respect to unemployment gap relative to an optimal policy under the assumption of a perfect knowledge. The more inertial monetary policy, the smaller is the effect of a central bank misperception of the natural rate of interest. Therefore, a so-called difference rule performs well in the case of time varying natural rate, but significantly worse if the natural rate is constant and known by the central bank. Gaspar and Smets (2002) further develop the issue of monetary policy response when private sector is learning. They show that with perpetual learning a large weight on output gap stabilisation may lead to unhinging inflation expectations when a series of cost-push shocks hit the economy in the same direction.

A review of these papers leads us to a somewhat contradictive conclusion: interest rate smoothing is desirable if the true model is forward-looking, but not for a backward-looking one. On the other hand, if there is uncertainty about the true value of natural rates – either interest or unemployment, a rule with interest rate smoothing performs better[1].

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[1] It should be stressed however, that the lead-lag structure of the Phillips curve in the Orphanides and Williams model is 0.5 and 0.5, i.e. it is more forward looking than some of the other models considered above (e.g. AWM), but monetary policy should react much more aggressively to inflation disturbances than to the output gap.

3. Monetary and fiscal policies in Poland: a short history of the last 15 years

3.1 Monetary policy

Today's shape of the Polish monetary policy results from three important factors: first, monetary policy was to support the stabilisation plan and restructuring of the foreign debt in the early 90s. Second, it had to be adjusted to meet the needs of the economy undergoing a transition from centrally planned to the market economy[2]. Finally, monetary policy has been to support the EU entry and the adoption of the euro. In such conditions, monetary policy had to undergo many substantial changes over these years. In this section we shall briefly characterise monetary policy evolution[3], and show that monetary policy framework that can be considered as homogenous, emerged only after 1999.

Up to 1993 monetary policy was dominated by a stabilisation plan and debt restructuring. Over this period, the final goal was inflation reduction. The National Bank of Poland[4] (NBP) used two intermediate targets, namely exchange rate and net domestic assets of the banking sector to implement this goal. After the failure of using interest rate as an operational target in 1990, NBP resorted to administrative tools (credit limits). Only in 1993 with the expansion of budget deficit and the increasing role of T-bills in banks assets, NBP started to conduct open market operations, but short-term interest rate control was clearly visible in the money market a bit later, namely in 1994.

In the early 90s exchange rate policy was to a large extent independent of interest rate policy due to controls and limits imposed on capital flows and high country risk that discouraged foreign investors. Exchange rate was used to achieve two, somewhat contradictive goals, namely it served as a nominal anchor, but also to increase foreign exchange reserves (via increased exports) to ensure an ordered service of the foreign debt. The latter of these goals was supported by a predetermined monthly exchange rate depreciation, whereas the former by the informal rule to maintain the monthly depreciation lower than expected PPI increase.

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[2] Until 1990 none of the market mechanisms worked in Poland. Thus, the evolution of monetary policy necessarily embraced a gradual abandonment of administrative tools and regulations.

[3] For a more detailed description see: Kokoszczyński, Durjasz (1998) and Kokoszczyński, Łyziak, Przystupa, Wróbel (forthcoming 2006).

[4] i.e. Polish central bank.

Foreign private debt restructuring in 1994 as well as the resolution of bad debts problem in the domestic banking system significantly lowered the country risk and induced a large capital inflow. This in turn resulted in the current account surplus[5], a considerable surplus liquidity of the banking system, increase in money supply and the upward pressure on the exchange rate. These phenomena made a serious problem for the central bank, since on one hand, it targeted money supply but on the other it had still to care about the level of foreign reserves. NBP decided to put more stress on a quick build-up of foreign reserves at a cost of somewhat higher inflation first, but once they reached the desired level, the central bank started a more rigorous disinflation process with more aggressive exchange rate policy. Thus, next years brought about gradual but profound changes in the exchange rate regime, namely its evolution from fixed to the pure float[6]. The process started in May 1995 – since then exchange rate could float within a certain range around central parity. This range was enlarged from ±7% at the beginning of the flotation process to ±15% in 1999. Moreover, to offset the inflationary pressures and negative impact on inflationary expectations coming from monthly predetermined path of exchange rate depreciation, NBP gradually reduced this rate. *De jure* pure float was introduced in April 2000. However since 1999 a *de facto* regime was very close to the pure float.

Up to 1997 monetary aggregate (M2) was used as an intermediate goal of monetary policy, with short-term interest rate in 1995 and then reserve money (M0) serving as an operational target. The change of the operational target was a result of capital inflows and surplus liquidity of the banking system[7] as well as a then-existing possibility of debt monetization by the central bank[8]. In these circumstances central bank lost its impact on longer-term bond yields and in fact its instrument independence. Using reserve money as the operational target was not successful either (once again the obligation of debt monetization was an obstacle in the efficient control of the targeted variable).

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[5] It was not a sole cause of a fast growing C/A surplus. Due to a significant price differential between Poland and neighbouring countries, there was a big increase in the cross-border trade.

[6] Pure float was introduced de jure in April 2000, however de facto regime very close to the pure float functioned since 1999.

[7] To absorb surplus liquidity NBP resorted to issuing its own bills with long-term maturities (up to 273 days).

[8] The *maximal* level of debt monetization was set in the central bank law, but the parliament usually suspended this clause and instead adopted another one, compelling the central bank to monetize "not less than" a certain amount of the debt.

The year 1998 makes a breakthrough in the Polish monetary policy. Since then debt monetization was prohibited by the new constitutional law as well as by other legal acts. Monetary policy was to be conducted by a newly introduced decision making body – Monetary Policy Council (MPC) that consisted of 10 persons elected for a six years term by the president of the state and the parliament[9]. The newly elected MPC members decided to change monetary policy framework from money supply targeting to inflation targeting and to use short-term interest rate as the policy instrument[10]. The IT framework is still in use and, as one may expect, will be valid at least until the ERM2 entry.

Inflation targeting was at first introduced implicitly; only in 1999 it became the explicitly declared monetary framework. At the time, although inflation had been continuously falling, Poland still experienced two-digit inflation rate. Thus, the MPC decided that reducing inflation below 4% at the end of 2003 would be its principal goal. In this aim it intensified the process of the exchange rate liberalisation. Since the target set only for the year ending the MPC term would be difficult to use operationally, the MPC used to set a target for each year, either as a range, or as a point (with - or without a band). As soon as inflation seemed to credibly stabilise at a low level and the process of disinflation has been over – the MPC defined the inflation target as a permanent one and set it at 2.5% ± 1pp. This level seemed to be appropriate from both the future fulfilment of the Maastricht criteria and GDP growth perspectives.

Over the time, the MPC tried to make the IT system more transparent. This includes a decision to publish the NBP staff's inflation forecast since August 2004, to be explicit about the way the current state of the economy is evaluated (e.g. the role of core inflation), to explain the way MPC would react to the supply shocks, to express its commitment to react symmetrically in the episodes of inflation missing the target. On the other hand, NBP has also got a negative experience with the IT. This embraces a failure to meet inflation targets over the period 1998-2004 and changing twice the targets in the course of the year with all consequences for credibility, a failure to anchor inflationary expectations of private individuals and backward-lookingness of the monetary policy.

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[9] Up to 1998 all decisions were taken by the central bank governor.
[10] At first NBP conducted open market operations with the maturity of 28 days, In 2003 they were shortened to 14 days and in 2005 – to 7 days.

3.2. Fiscal policy 1990-2005.

Comparing to the monetary policy, fiscal policy was probably a bit less variable. What is more important, the main changes occurred at the beginning of the transition, but as we shall argue – the next changes will have to come in a near future.

Before 1990 the main purpose of budget formulation process in the so called centrally planed economies was to translate the government's economic plans, which were specified in terms of material and physical inputs and outputs, into public sector inputs and outputs in financial terms. This means that instead of controlling the allocation of public resources, the fiscal planning process was controlled by the government's overall economic plan (developed by the central planning institution). On the other hand, it induced budgeting from a perspective of needs (defined by the pre-established norms) without accounting for resource availability, what led to the construction of unrealistic budgets.

Collapse of the communist rule in 1989 started with reshaping of the centrally planned system into the market-oriented economy. During the first years of transition the radical changes took place in the economic structure – the public sector was separated from the productive one, and afterwards, the productive enterprises were successively privatized. The policy makers pursued the economic reforms putting an equal weight to halt the process of economic decline and to maintain a minimum level of political and social stability. Structural economic reforms were gradually followed by the institutional transformation. The responsibility for fiscal policy was shifted towards the Ministry of Finance and the role of the budget was redefined from being an appendix of the central plan to an active tool of economic planning to ensure credibility (and hence stability) of the economy. Between 1990 and 1993 it meant maintaining social stability under declining output and near-hyperinflation. Despite tax reforms (corporate and personal income taxes (1990), VAT and excise tax (1993) were introduced), declining budget revenues forced the NBP to finance costs of the fiscal policy (i.e. the budget deficit in 80% in 1991 and 65% in 1993).

During the next five years (1994-1998) fiscal policy was lax[11] but relatively stable. A fast GDP growth resulting in an increase in revenues allowed for some reductions in tax rates. However, the privatisation process was slowed-down. The Russian crisis which broke out in

[11] As a result, monetary policy had to be more restrictive what resulted in an inefficient policy mix.

1998 decelerated Polish GDP growth. All these factors induced a shrink in the tax base. The inertia of public expenditure resulted in a significant growth of deficit in the next years. Unsustainable level of budget deficit induced changes in the fiscal policy in the next period.

In 1999 four great institutional reforms were started. They embraced following areas: local-government, health care, pension system and education system. The first two reforms shifted a part (about 12%) of the total public expenditure from the state budget to the local ones and to the National Health Fund. The case of the pension reform was different: a gradual transition from the pay-as-you-go system to the capital system without reduction of existing pensions led to huge deficiency of social security contributions which have had to be continuously covered by the state budget. In fact, the state budget deficit grew from 2.4% in 1998 to 7.1% in 2004[12].

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Modern economic history of Poland started in 1990, however the period up to 1998 was mostly devoted to implementing market mechanisms which made significant structural changes that in turn induced still changing reactions of the economy to policy instruments. Over this period the transmission mechanism was undergoing many changes that made it impossible to define stable macroeconomic relations. Our earlier research on the Polish monetary transmission mechanism (Kokoszczyński et.al.(1999) shows that before 1999 interest rate did not significantly affect either inflation or aggregate demand and that exchange rate was the main transmission channel. Up to 1998 monetary policy in Poland underwent many modifications with respect to its instruments (M0, interest rates), as well as much more profound adjustments of the exchange rate regime (increasing flexibility). Since 1999 Poland has a stable monetary policy framework (IT), and the economy seems to react as stylised facts would suggest: interest rate shocks induce lower inflation and reduce the aggregate demand. Besides monetary and fiscal policies there were also other factors that after 1999 tended to change the MTM. Namely, a near perspective of the EU accession changed the attitude of foreign investors as well as of exporters and as a result, the role of the exchange rate in the monetary transmission. It seems that it affects real sector less than before, while there are no visible changes in inflation reaction to the exchange rate.

All that has so far been said about changes that monetary and fiscal policies underwent and accompanying adjustments of the monetary transmission mechanism, leads us to the problem

[12] National data

of model uncertainty. Thus, if there is a substantial uncertainty about the "true" model of the developed market economies, it is probably even more so for economies in transition. There is also a problem of expectations formation. McCallum and Nelson (2000) note that "*it seems implausible that private agents could immediately begin forming their expectation consistent with any new policy regime, following a regime change (...)*" and conclude that "*the basic rational expectations approach requires that policy regime has been in effect long enough for private agents to understand that and believe in its continuation.*" Thus, a short life time of any policy regime and perspective of future policy variations and modifications have probably made private agents' expectations look predominantly backwards and limited the number of variables considered by the agents as worth observing taking into account the cost of information acquisition and its processing. Research on inflation expectations based on consumer surveys (Łyziak, forthcoming) leads to the conclusion that even if the adoption of inflation targeting in Poland in 1998 and the commitment of monetary authorities to reach price stability, decreased substantially the level of expected inflation, only very weak signs of consumer inflation expectations in Poland becoming more macroeconomically efficient and forward-looking appear in the most recent period.

4. Small scale inflation forecasting model: an outline

In this section we briefly present a small scale highly aggregated model that was developed at the NBP in 2001 and served for inflation forecasting (NSA, see Kłos et al., 2005) up to the end of 2005. The model was designed to capture inflation dynamics only. It was built on the standard assumptions of sticky prices and wages and described the transmission mechanism in the spirit of the New Keynesian School. Basic macroeconomic relationships included: the aggregate demand curve[13], uncovered interest parity (UIP) and the Phillips curve. The model had a few forward-looking features:

- a measure of inflationary expectations (equation 6) was constructed in such a way that θ=0.9, i.e.expected prices are in 10 percent forward-looking and in 90 percent backward-looking,
- there was an *ex ante* real interest rate in the IS curve,

[13] Output gap obtained from the HP filter (with the smoothing parameter λ=1600 standard for quarterly estimates).

- the exchange rate equation (UIP condition) was supplemented by the interest rate term structure which shows expected changes of the interest rate.

The model was estimated equation by equation, on a quarterly sample beginning in 1998.

Below we present equations of the NSA model (thereafter labelled as benchmark model):

(1) $\hat{y}_t = c_{\hat{y}} + \alpha_1 \hat{y}_{t-1} + \alpha_2 i^r_{t-1} + \alpha_3 e^r_{t-2} + \alpha_4 \Delta\left(\Delta_4 y^{EU}_t\right) \qquad \alpha_2, \alpha_3 < 0$

(2) $\pi_t = w^C_t \pi^C_t + w^F_t \pi^F_t + w^P_t \pi^P_t$

(3) $\pi^C_t = c_{\pi^C} + \beta_1 \pi^e_t + \beta_2 \hat{y}_{t-3} + \beta_3 e^r_{t-1} \qquad \beta_3 < 0$

(4) $\pi^F_t = c_{\pi^F} + \gamma_1 \pi_t + \gamma_2 \pi^F_{t-1} + \gamma_3 \left(p^F_{t-1} - p_{t-1}\right) \qquad \gamma_3 < 0$

(5) $\pi^P_t = \pi^O_t$ or: $\pi^P_t = \lambda_1 \pi^O_t + \lambda_2 \pi_{t-1} + \lambda_3 \Delta \hat{y}_t$

where: $\pi^O_t = \Delta b^{USD}_t - \Delta e^{USD/PLN}_t$

(6) $\pi^e_t = \theta_1 \pi_{t-1} + \left(1-\theta_1\right)\pi_{t+1}$

(7) $e^{USD/PLN}_t = c_{e^{USD/PLN}} + \varphi_1 e^{USD/PLN}_{t-1} + \varphi_2 \left(i_t - i^f_t\right) + \varphi_3 \left(i_t - i^{WIBOR1M}_t\right) + \varphi_4 dg_t + \varphi_5 fg_t + \varphi_6 e^{EUR/USD}_t + \varepsilon^{e^{USD/PLN}}_t$

(8) $e^n_t = e^{USD/PLN}_t + w^{EUR}_t \cdot e^{EUR/USD}_t$

(9) $i_t = 0.5 \hat{y}_t + 1.5\left(\pi_t - \pi^*_t\right)$ or: $i_t = \pi^e_t + 0.8 i_{t-1} + 0.2\left[0.5\left(\pi_{t+1} - \pi^*_{t+1}\right) + 0.5 \hat{y}_t\right]$

The following symbols have been used:

$\hat{y}$ – output gap;

Δy^{EU} – real GDP growth rate in the euro zone;

i – WIBOR 3M interbank market rate in nominal terms;

$i^{WIBOR1M}$ – WIBOR 1M interbank market rate in nominal terms;

i^r – WIBOR 3M interbank market rate in real terms;

i^f – LIBOR 3M foreign interbank market rate in nominal terms;

e^n – nominal effective exchange rate (in logs);

e^r – real effective exchange rate (in logs);

$e^{USD/PLN}$ – USD/PLN exchange rate (in logs);

$e^{EUR/USD}$ – EUR/USD exchange rate (in logs);

w^{EUR} – euro weight used for the determination of the nominal effective exchange rate – recently equal to 70%;

π^{C} – rate of growth of CPI, except for food and fuel prices (net inflation), quarter on quarter;

π^{F} – rate of growth of food prices, quarter on quarter;

π^{P} – rate of growth of fuel prices, quarter on quarter;

w^{C} – $w^{C} = 1 - w^{F} - w^{P}$;

w^{F} – weight of food in the CPI basket;

w^{P} – weight of fuels in the CPI basket;

b^{USD} – oil price per barrel on world markets (USD, in logs);

dg – domestic financing of the budget deficit;

fg – foreign financing of the budget deficit;

π – inflation, quarter on quarter;

π^{*} – central bank inflation target;

p^{F} – food price level;

p – consumer price level (goods and services);

π^{e} – consumers' inflation expectations (for the next quarter);

Equation (1) is the aggregate demand curve in an open economy. The output gap in this equation depends on its lagged value, the ex-ante real interest rate, the real effective exchange rate and the variable representing external demand.

The growth of prices of food, fuels and the remaining consumer goods and services — are modelled by separate equations. According to the identity (2), inflation as measured by the rate of growth in consumer price index (CPI) is a weighted average of price increases of the three components of the consumer basket. In the Phillips curve (equation (3), the explained variable is net inflation. Output gap, the real effective exchange rate and households' inflation expectations (quantified direct measure based on survey data) are the explanatory variables. Equation (4),[14] which is used for simulation purposes only,[15] makes the quarterly increase in

[14] Using identity (2) the general form of equation (4):

food prices dependent on its lagged value, net inflation, the increase in fuel prices and the relative food price in the earlier period. The increase in oil prices is described by equation (5). Fuel price changes depend on the price of a barrel of oil in domestic currency, the lagged inflation and changes in the output gap.

The USD/PLN exchange rate is modelled within the concept of the UIP (equation (7)). The empirical version of the exchange rate rule is the adaptive one (the so-called UIP+). The explanatory variables of the USD/PLN exchange rate are the lagged value of this variable, the interest rate disparity, the term structure of interest rates, the EUR/USD cross rate and risk factors. The list of risk factors includes budget deficit, net exports, foreign direct investment, etc. The nominal effective exchange rate is determined — in line with the arbitrage condition — as a function of the USD/PLN exchange rate and the EUR/USD cross rate (exogenous variable) — equation (8).

Monetary policy rule (9) is used for simulations only. One version of the rule is derived from the traditional Taylor rule: the nominal interest rate responds to the deviation of inflation from the inflation target and the deviation of the GDP from its potential value. In the other, there is interest rate smoothing and the rule is forecast-based.

Dynamic properties of the model are shown in Table 11 of the Appendix.

5. Modification of the benchmark model and design of the experiment

The benchmark version of the model performed quite well up to the end of 2004. Since then it started to underpredict aggregate demand and seemed to overestimate the impact of the exchange rate on the output gap. One may suspect that these phenomena occurred as a result of the increasing role of inflation expectations after IT adoption (we have observed that inflation expectations became slightly forward looking) and the EU entry. Since 2001, when the date of the entry was established, agents could start to adapt their behaviour to the expected fiercer competition. Accession to the EU in the mid-2004 could even accelerate these processes. Basing on these hypotheses and assuming the general theoretical concept of

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[a] $$\pi_t^F = \alpha_0 + \alpha_1 \cdot \pi_t + \alpha_2 \cdot \pi_{t-1}^F + \alpha_3 \cdot \left(\log\left(p_{t-1}^F\right) - \log\left(p_{t-1}\right) \right)$$

may be transformed into:

[b] $$\pi_t^F = \frac{\alpha_0}{1-\alpha_1 \cdot w_t^F} + \frac{\alpha_1 \cdot w_t^O}{1-\alpha_1 \cdot w_t^F} \cdot \pi_t^O + \frac{\alpha_1 \cdot w_t^C}{1-\alpha_1 \cdot w_t^F} \cdot \pi_t^C + \frac{\alpha_2}{1-\alpha_1 \cdot w_t^F} \cdot \pi_{t-1}^F + \frac{\alpha_3}{1-\alpha_1 \cdot w_t^F} \cdot \left(\log\left(p_{t-1}^F\right) - \log\left(p_{t-1}\right) \right)$$

[15] In forecasts based on the presented model, the increase in food prices is subject to expert assumptions.

the benchmark model is still valid, one could expect that incorporating expectations into the model should improve its performance and would allow us to do an exercise on robustness of monetary policy rules.

Thus, three core equations of the benchmark model: aggregate demand, UIP condition and the Phillips curve were modified in the following way[16]:

$$(10)\ \hat{y}_t = c_{\hat{y}} + \alpha_1((1-k)\hat{y}_{t-1} + k\hat{y}_{t+1}) + \alpha_2 i^r_{t-1} + \alpha_3 e^r_{t-2} + \alpha_4 \Delta\left(\Delta_4 y^{EU}_t\right) + \alpha_5 \Delta g_t + \varepsilon^{\hat{y}}_t$$

$\alpha_2, \alpha_3 < 0$

$0 \le k \le 1$

where:

$\varepsilon^{\hat{y}}$ – exogenous disturbance term (white noise shock with standard deviation $\sigma_{\hat{y}}$)

Δg - dynamics of the budget deficit;

$g = dg + fg$ and
$$dg_t = q_g + q_1 dg_{t-1} + q_2 fg_t$$
$$fg_t = q_f + q_3 fg_{t-1} + q_4 dg_t$$

q – estimated parameters

k – degree of forward lookingness

$$(11)\ \begin{aligned} e^{USD/PLN}_t &= c_{e^{USD/PLN}} + \varphi_1((1-k)e^{USD/PLN}_{t-1} + ke^{USD/PLN}_{t+1}) + \varphi_2\left(i_t - i^f_t\right) + \varphi_3\left(i_t - i^{WIBOR1M}_t\right) + \\ &+ \varphi_4 dg_t + \varphi_5 fg_t + \varphi_6 e^{EUR/USD}_t + \varepsilon^{e^{USD/PLN}}_t \end{aligned}$$

where

$\varepsilon^{e^{USD/PLN}}$ – exogenous disturbance term (white noise shock with standard deviation $\sigma_{e^{USD/PLN}}$)

$$(12)\quad \pi^C_t = c_{\pi^C} + \beta_1 \pi^e_t + \beta_2 \hat{y}_{t-2} + \beta_3 e^r_{t-1} + \beta_4 \varepsilon^{\pi^C} \qquad \beta_3 < 0$$

where $\pi^e_t = 0.9\pi_{t-1} + 0.1\pi_{t+1}$ (as explained earlier in the text; see equation 6)

ε^{π} – exogenous disturbance term (white noise shock with standard deviation σ_{π})

For *k=0.0* to *k=1* with a step equal to 0.1, monetary policy rules were tested in three forms:

$$(13)\quad i_{t,k} = \psi_\pi(\pi_{t,k} - \pi^*) + \psi_{\hat{y}}\hat{y}_{t,k} + \varepsilon^i_t$$

[16] Notation as in the benchmark model.

and

(14) $i_{t,k} = \psi_{\pi}(\pi_{t,k} - \pi^{*}) + \psi_{\hat{y}}\hat{y}_{t,k} + \psi_{e^{USD/PLN}}\Delta e_{t,k}^{USD/PLN} + \varepsilon_{t}^{i}$

(15) $i_{t,k} = \theta_{k} i_{t-1,k} + \psi_{\pi}(\pi_{t,k} - \pi^{*}) + \psi_{\hat{y}}\hat{y}_{t,k} + \varepsilon_{t}^{i}$

The second form of the monetary policy rule arises from the Poland's striving for the membership in the euro zone, what implies necessity to stabilize both the variance of inflation and variance of dynamics of the nominal exchange rate. That does not necessarily lead to optimisation of variance of the output gap, or the output gap itself.

To check which monetary rule performs better in the economy described by the benchmark model and its modifications, two types of the loss functions have been defined:

1) We have assumed that the policy maker tends to minimize simultaneously variance of inflation and exchange rate (external requirement) and the variance of output gap. Thus, for each *k*, the following loss function has been compared[17]:

$$L_{t,k} = \mathrm{var}(\pi_{t,k}) + \mathrm{var}(\hat{y}_{t,k}) + \mathrm{var}(\Delta e_{t,k}^{USD/PLN})$$

2) In the second type of the loss function we have assumed that the policy maker tends to minimize variance of inflation and variance of output gap:

$$L_{t,k} = \mathrm{var}(\pi_{t,k}) + \mathrm{var}(\hat{y}_{t,k})$$

In the section 3 we have shown changes that underwent Poland over the last 15 years, from centrally planned with predominant state ownership to the market economy and the EU membership. Thus, when it comes to modelling, one must cope with a number of problems: relatively short time series that could be perceived as homogenous, poor data quality (mainly at the beginning of the transformation process) and necessary changes in statistics (adjusting definitions to the international standards). Non homogeneity of series results from structural changes, comprising privatisation process, liberalisation of prices (including the exchange rate) and markets as well as of capital flows together with frequent changes in monetary policy. All these factors make short series even shorter. Keeping in mind problems with data scarcity, changing definitions and with parameters non-constancy we decided to apply Bayesian estimation instead of classical econometric estimation. Some suggestions how to

[17] See e.g. Levin, Wieland and Williams (2003).

tackle that problem can be found in Charemza (2002), where drawing parameters from iteratively changing distributions with the straightforward objective function was presented as a realistic alternative to the econometric estimation. Choosing the Bayesian estimation under presented circumstances, we have to note the necessity of adaptation of the model to the Bayesian procedure and explaining the role of setting up prior distributions. Thus, three core equations of the benchmark model and the policy rule were separated and took the form presented at the beginning of this section. To close the model, all exogenous variables of the benchmark model were endogenized. They were approximated by the AR processes or the processes similar to the AR or by equations which are the linear combination of the AR process and variables explained within the core model. All variables, but exchange rates and interest rates, representing levels were replaced by their stationary or stationary-like approximations.

The problem of setting up prior distributions of parameters seems to be crucial if there is data scarcity. Prior distribution should reflect up-to-date state of our knowledge. To convert our knowledge into a distribution several techniques can be used. We have applied a combination of expert and conjunction approach. In the case of the former approach, prior is naturally based on expert's knowledge, whereas in the latter – one must find such a prior that when used in conjunction with the likelihood, it gives an easy form for posterior distributions. These types of priors are called conjugate priors and depend on the form of likelihood, e.g.:

Distribution of likelihood	*Parameter*	*Distribution of prior/posterior*
normal	mean (μ)	normal
normal	variance (σ^2)	inverse gamma

In the whole exercise the normal distributions of the likelihood were accepted. Then, having estimated parameters of the econometric version of the benchmark model we assumed that they incorporate our pre-experiment knowledge on the Polish economy. Hence values of these parameters were set up as means in the normal distribution of the respective parameters. Variances of the distribution were determined bearing in mind that if the prior variance is large, then the prior can be uninformative (a flat line in the distribution chart). Although improper priors are difficult to interpret literally, since in any case there are upper and/or lower bounds which limit possible values of the unknown parameter, they can be viewed useful as long as one considers that the posterior is well-defined. However, because of its flatness, the posterior is dominated by the likelihood, and it is only in the range in which the likelihood is large that the prior makes any practical difference - truncating the prior well outside this range will not substantially change the posterior.

In economic problems, it can be sometimes useful to set up a flat or uninformative prior so that the data can “speak for itself". The prior thus has a hypothetical, or “what if" status: if one was indifferent to parameter values in the range in which the likelihood is large, then his opinion after observing the data would be expressed as the posterior (see tables 1-4).

6. Results

We have performed estimates with various degrees of forward lookingness and for three time periods (1998-2005, 1998-2001, 2001-2005) for *k=0.0*[18] to *k=0.5* with a step equal to 0.1[19]. We have adopted the lead-lag structure similar to Orphanides and Williams (2004), even though some authors suggest that the forward-looking factor in the New Keynesian Phillips Curve (NKPC) is dominant[20]. Our decision to adopt such a lead-lag structure can be justified by a set of reasons. First, as we have shown, frequent changes in the monetary policy in Poland did not support development of forward-lookingness of economic agents. Second, we do our exercise not on a single equation but using the whole model, which involves also other than expected inflation forward-looking variables. Third, this lead-lag structure is frequently used in empirical works since it appeals to Fuhrer and Moore (1995) who built a model of contracting in the labour market that results in such a lead-lag structure and to Christiano, Eichenbaum and Evans (2001) who modify the Calvo model by introduction of indexation and derive a specification of the NKPC yielding a parameter at the lagged inflation larger than 0.5.

The model turned out to be unsolvable for the period 1998-2001. After analysing possible reasons, we have tentatively concluded that providing that it was not due to changes in definitions of variables, a plausible explanation is that over this period Polish economy did not work as the model would suggest.

[18] It should be remembered that even with *k=0* there is some forward-lookingness in the model (real ex ante interest rate, term structure in the UIP condition and 10 per cent inflation expectations in the Phillips curve are also forward-looking).

[19] As the first approximation we have chosen such a step just to limit the number of model versions, but as it will be clear, it was too big in some case and therefore we have make simulations with a smaller step, at least in the neighborhood of 0.0 and 0.2.

[20] The most influential work in this field is Gali, Gertler (1999). The results raised critiques see for example: Rudd, Whelan (2005), Linde (2005).

Estimations obtained from Bayesian estimates and from the traditional econometric method for the whole period 1998-2005 were significantly different in two important cases. Namely, Bayesian estimates gave a puzzling, positive sign of the parameter at the real interest rate in the IS curve (as expected, in the estimated version the sign was negative) and a stunningly high parameter at inflation expectations in the Phillips curve (see tables 5-7 in the Appendix). A simple inspection of graphs presenting response of annual inflation to selected impulses (table 12) shows that inflation response to the interest rate shock is counter-intuitive exhibiting a clear puzzle. Moreover, if one considers steady state solution obtained for this period it will be clear that the figures are not acceptable (e.g. enormously big positive output gap instead of being equal to zero, with both very high short-term interest rate and core inflation, see table 8 in the Appendix). The steady state solution should produce values of macroeconomic variables that would be sustainable in the long-run. One can imagine a long-run equilibrium that will be different from the steady state (e.g. the case of Japan – long term negative output gap and deflation). In our opinion the obtained results did not look as long-run sustainable solution and therefore we have to reject this solution. From this point of view, the results for the shorter period, 2001-2005 look much more reasonable, especially these for *k=0*, i.e. with backward looking expectations. They are, however, still somewhat biased by the short data span. In particular, once again output gap is positive (but now it is much smaller that in the previous case), and interest rate can be considered as a bit too high. On the other hand, inflation is close to the target of 2.5%. Response functions presented in table 13 of the Appendix confirm that the obtained results are reasonable: both inflation and output gap decrease after the interest rate shocks, whereas exchange rate appreciates (table 18). It should be noted, that these results are robust both for a two-factor simple rule and three factor rule including exchange rate (see table 4 in the Appendix). It is worth noting that the steady state solution for *k=0.2* is close to the previous one, reaction functions are acceptable, but the parameter for the output gap seems to exhibit too high persistence (it is greater than one). Steady state solutions and parameters estimates for *k=0.1*, *k=0.3* and *k=0.4*, as well as the reaction functions in these cases unfortunately do not look reasonable. As far as the steady state is concerned, either interest rate or output gap are unrealistically high or inflation is too high or on the contrary, it is almost equal to zero. It is a bit strange that we have to reject the solution for *k=0.*1, whereas these for *k=0.0* and *k=0.2* seem to be acceptable. In the further research we shall check whether the solutions for the neighbourhood of the point 0.2 could be also acceptable. Plausibility of results for *k=0* and *k=0.2* is reflected in the respective monetary policy rules. Both for the simple and the three factor rule the factor weights are similar. However, for the three factor rule the results exhibit a clear preference of the Monetary Policy Council for output stabilisation in the period 2001-2005 (see table 9 in the Appendix). The factor weights for the simple rule are more balanced. It is an amazing result, bearing in mind goals explicitly declared by the MPC (at least over the period starting from the last quarter of 1999 to the end of 2003). These results seem to be distorted by the high variability of output over this period: recession at its beginning and strong recovery in 2004, the latter supported by the Poland's EU entry (huge growth of domestic demand as a result of expected higher inflation after the accession). Considering a simple loss function it seems to be clear, that focusing monetary policy on the output gap stabilisation yields a bigger loss than it is the case when policy is focused on inflation and even when three factors but symmetrically distributed (output, inflation, exchange rate) are taken into account (see table 9 and 10). The results obtained for two and three factor loss function are quite similar (slightly better results are for the simple rule), what leads to the conclusion that exchange rate can be omitted in the monetary policy rule. To compare our results with other papers we have also estimated the model with the standard Taylor rule, i.e. with equal weights of inflation and output gap (for *k=0*). The loss function is significantly smaller, but the steady state inflation rate turns out to be lower by a half percentage point than the target (2.5%).

All these results were obtained for the monetary policy rule with no interest rate smoothing. To check how interest rate smoothing affects the loss function, we have estimated the model for various degrees of forward-lookingness. We got the solutions only for *k=0*, *k=0.1*, *k=0.2*. The obtained scale of interest rate smoothing varied from 0.7 to 0.9 respectively. These results seem to confirm the more forward-looking the model, the higher is the smoothing parameter. The loss function with interest rate smoothing tends to be smaller than the one with no smoothing and smaller than the three factor monetary policy rule. Exclusion of the exchange rate from the loss function shows that the interest rate smoothing minimizes potential loss of inflation and output gap (with no effect on the exchange rate) We think that even such a small degree of forward-lookingness that is incorporated into our model justifies interest rate smoothing.

7. Conclusions

Contrary to our expectations the results seem not to confirm the hypothesis that expectations formation has changed and that they became more forward-looking. The best version of the model tested here is the version with a small degree of forward-lookingness. This outcome is a very nasty surprise and, if it is true, it may be a problem for the monetary policy. As we know, disinflation with backward-looking agents tends to cost more. A separate question is whether our results may be interpreted as a failure of inflation targeting as a strategy affecting significantly behaviour of the public. Here, the answer is to be given with more qualifications. One is, that the period our research covers was not a friendly environment for this kind of strategy induced changes. Another concerns the very limited success of the IT strategy when perceived by numerous deviations from the target.

The question of how advanced is forward-looking behaviour in the Polish economy seems again to persecute us when seeking for the best rule. Interest rate smoothing comes with strength usual for more forward-looking models than the one presented here (see Adalid, Coenen, McAdam, Siviero (2004). So, there arises a question what forward-lookingness means in the real world and how to reconcile these results with the literature. This is the most important question for our future research.

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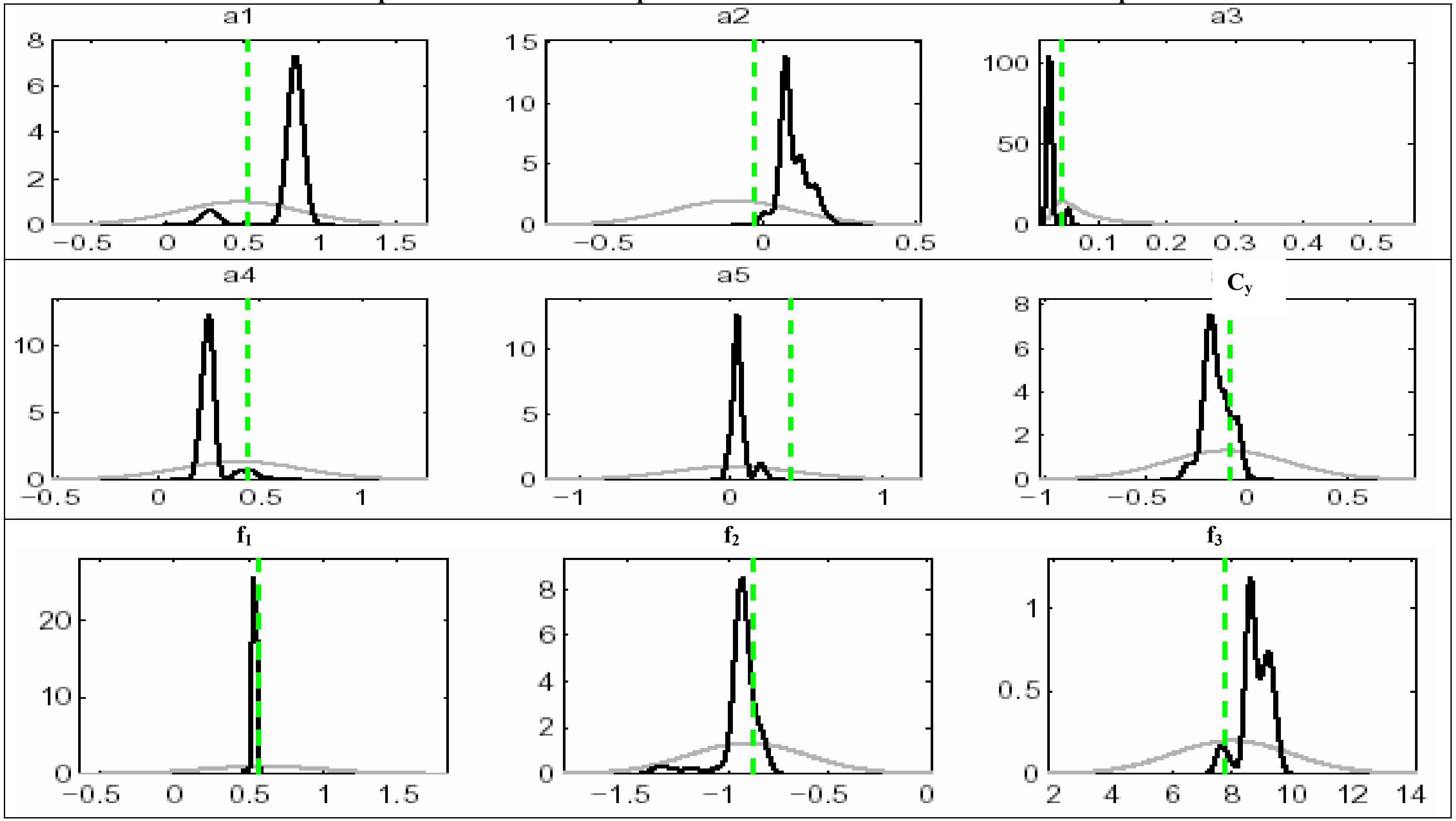
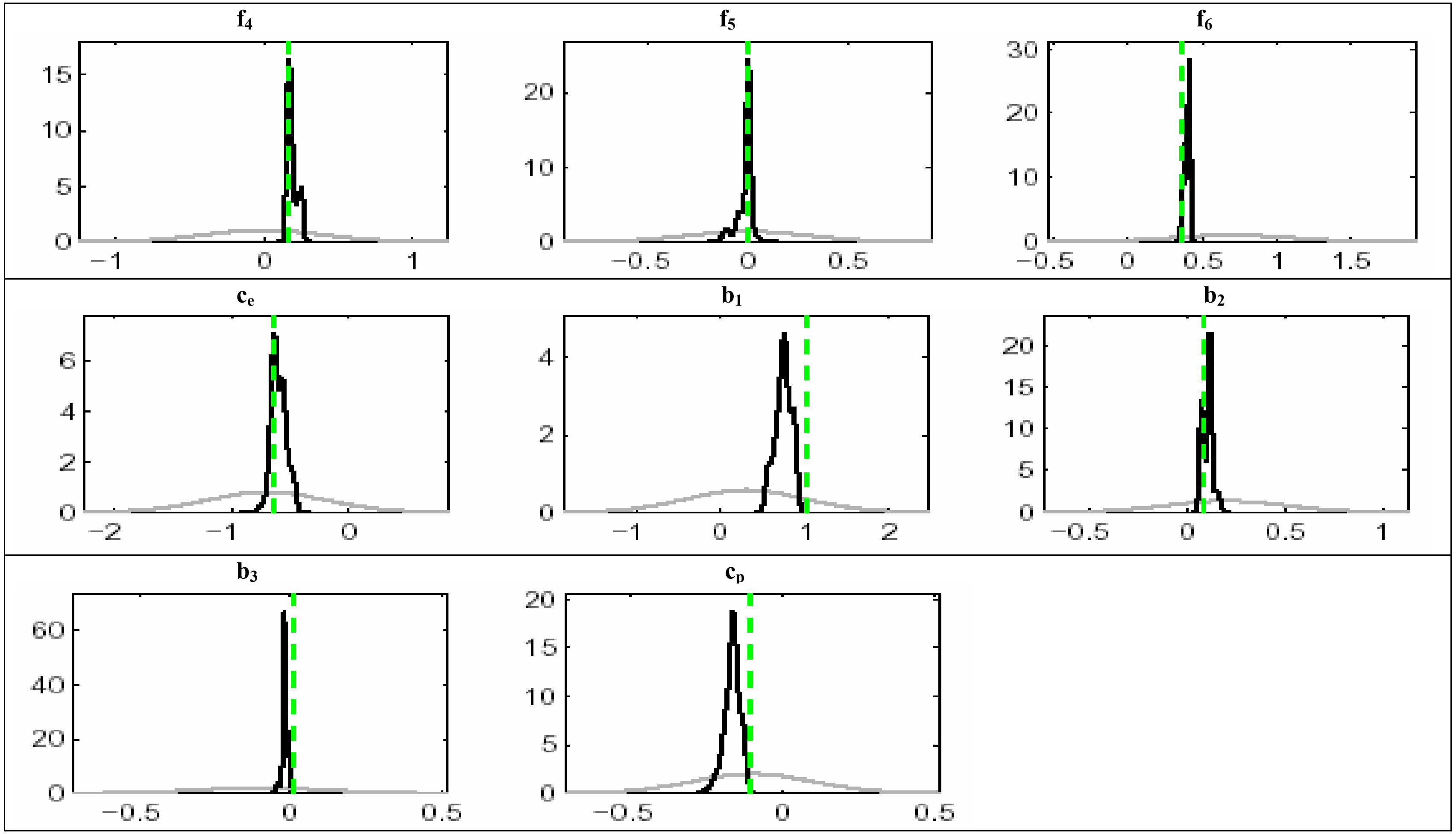
Appendix

Table 1.

Prior and posterior distribution of parameters for *k*=0 and 1998-2000 estimation period.

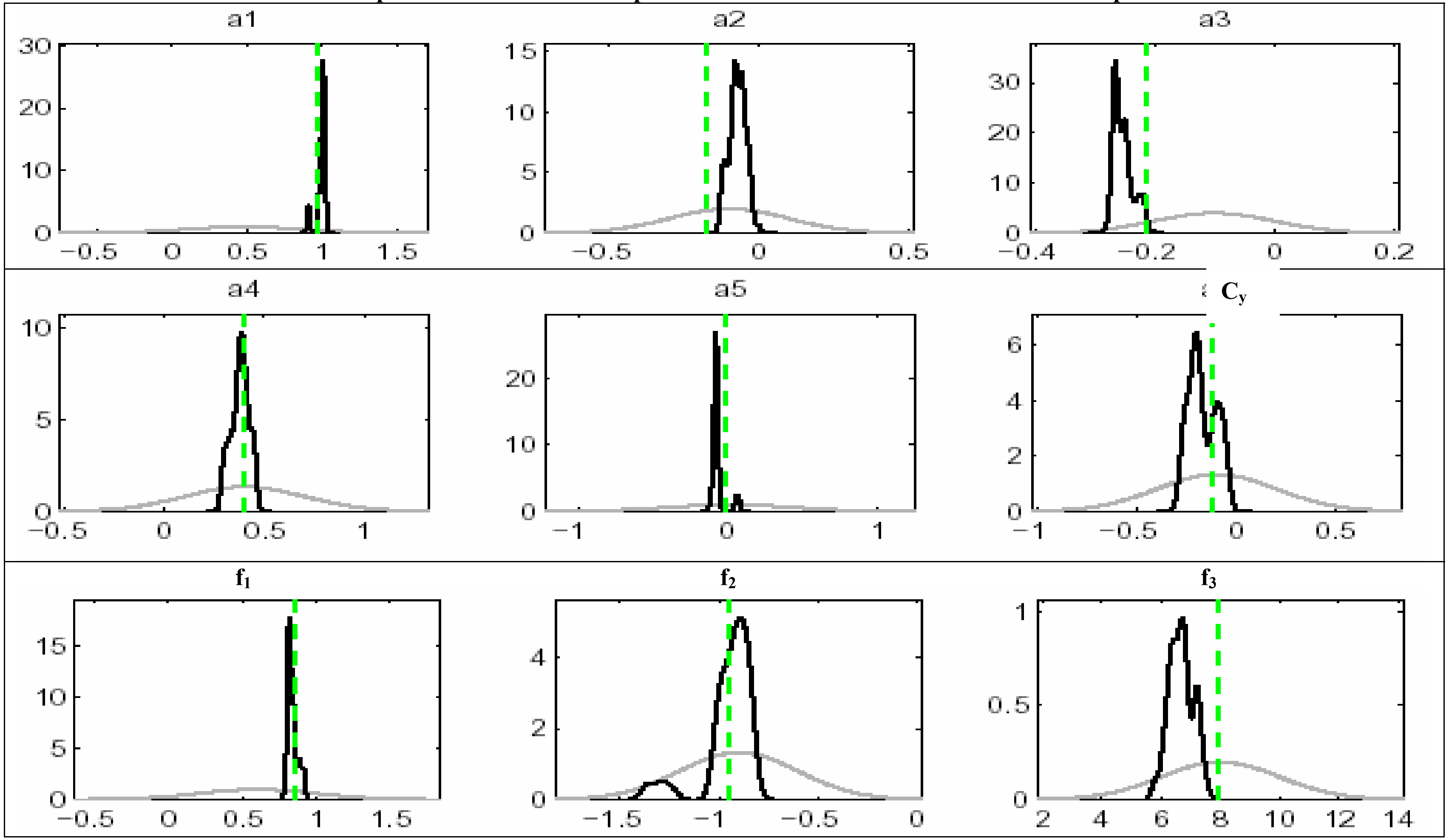


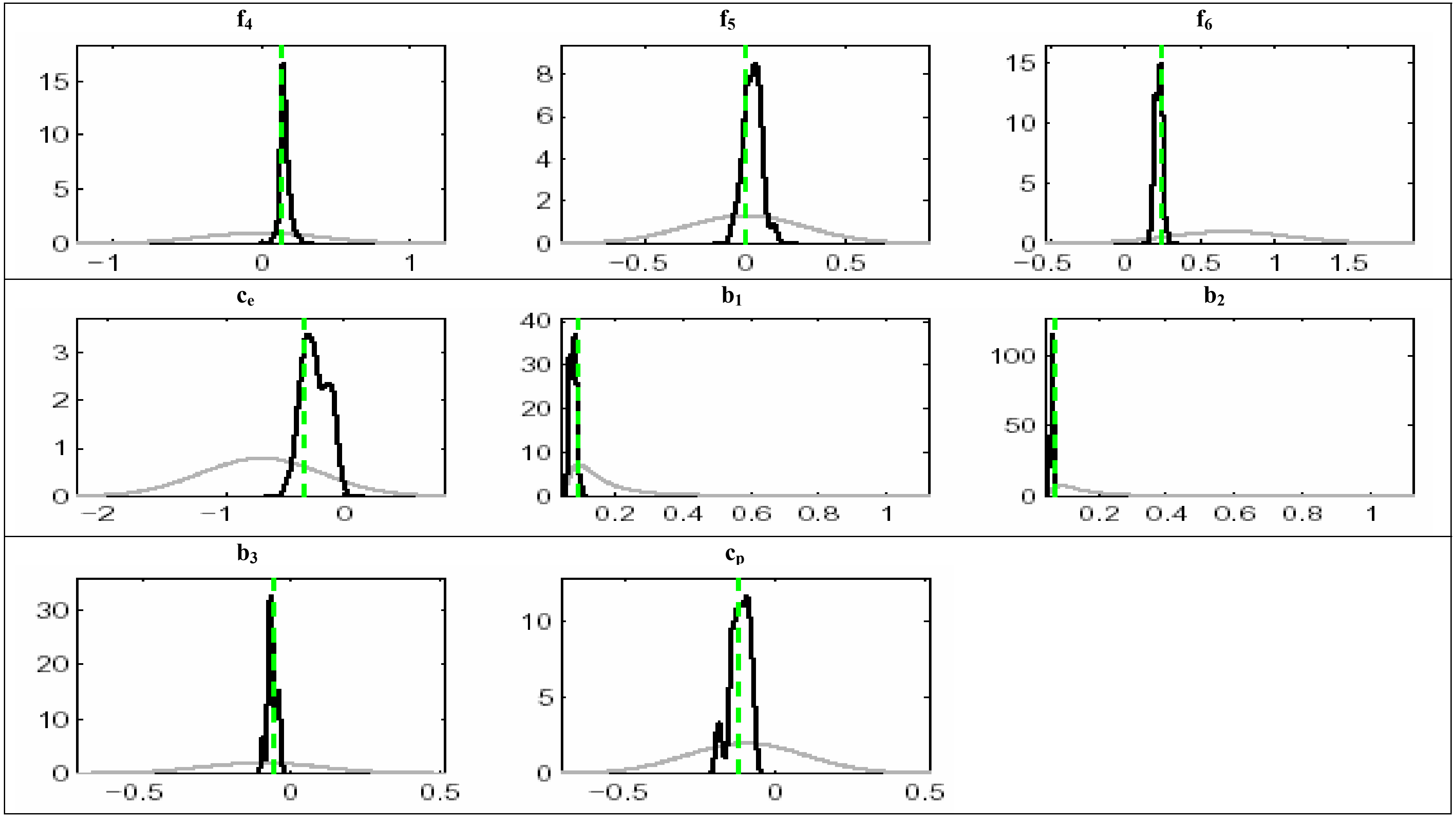


f4
f5
f6
ce
b1
b2
b3
cp

Table 2.

Prior and posterior distribution of parameters for *k*=0 and 2001-2005 estimation period.

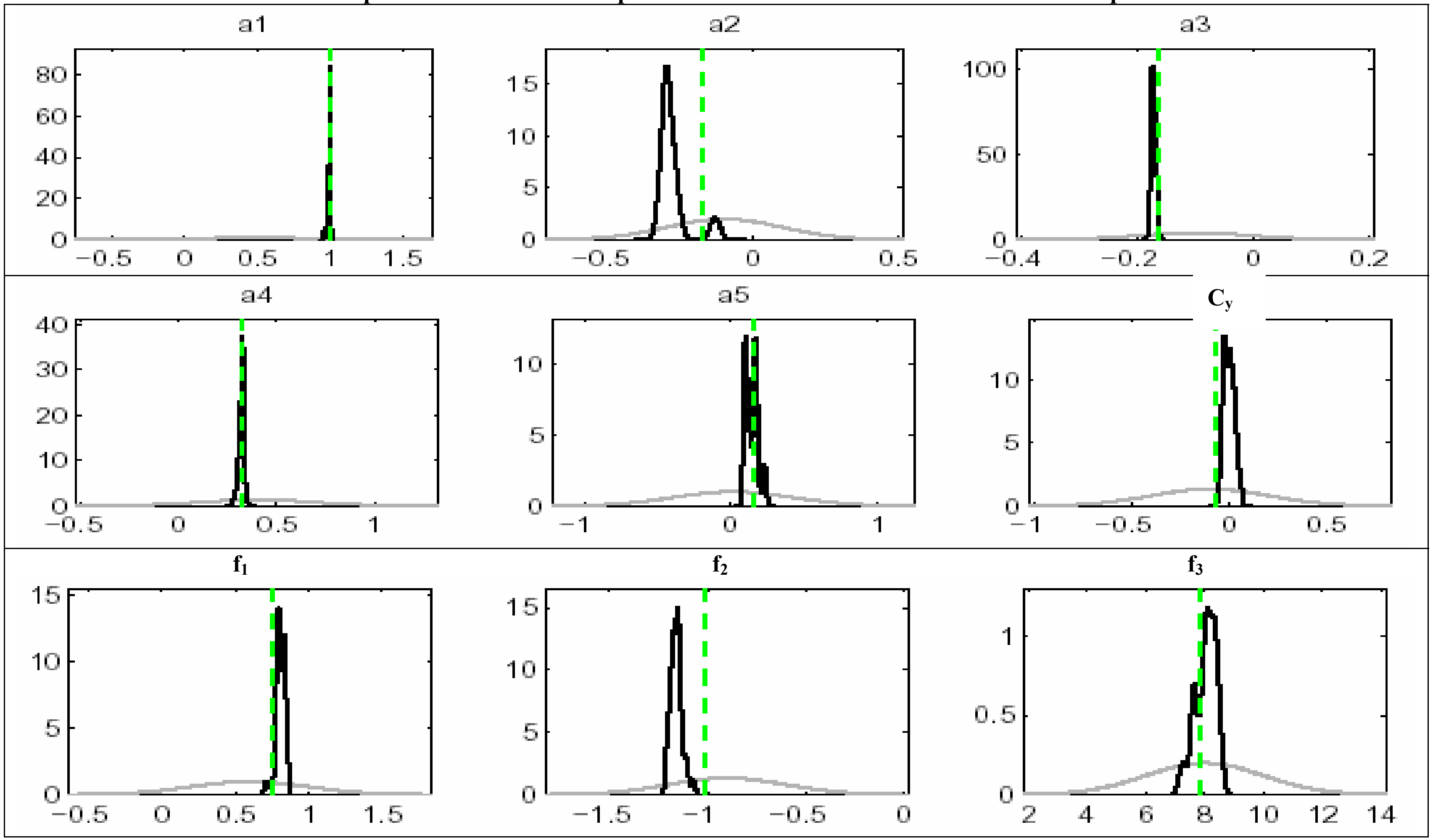




f_4
f_5
f_6
c_e
b_1
b_2
b_3
c_p

Table 3.

Prior and posterior distribution of parameters for *k*=0.1 and 2001-2005 estimation period.



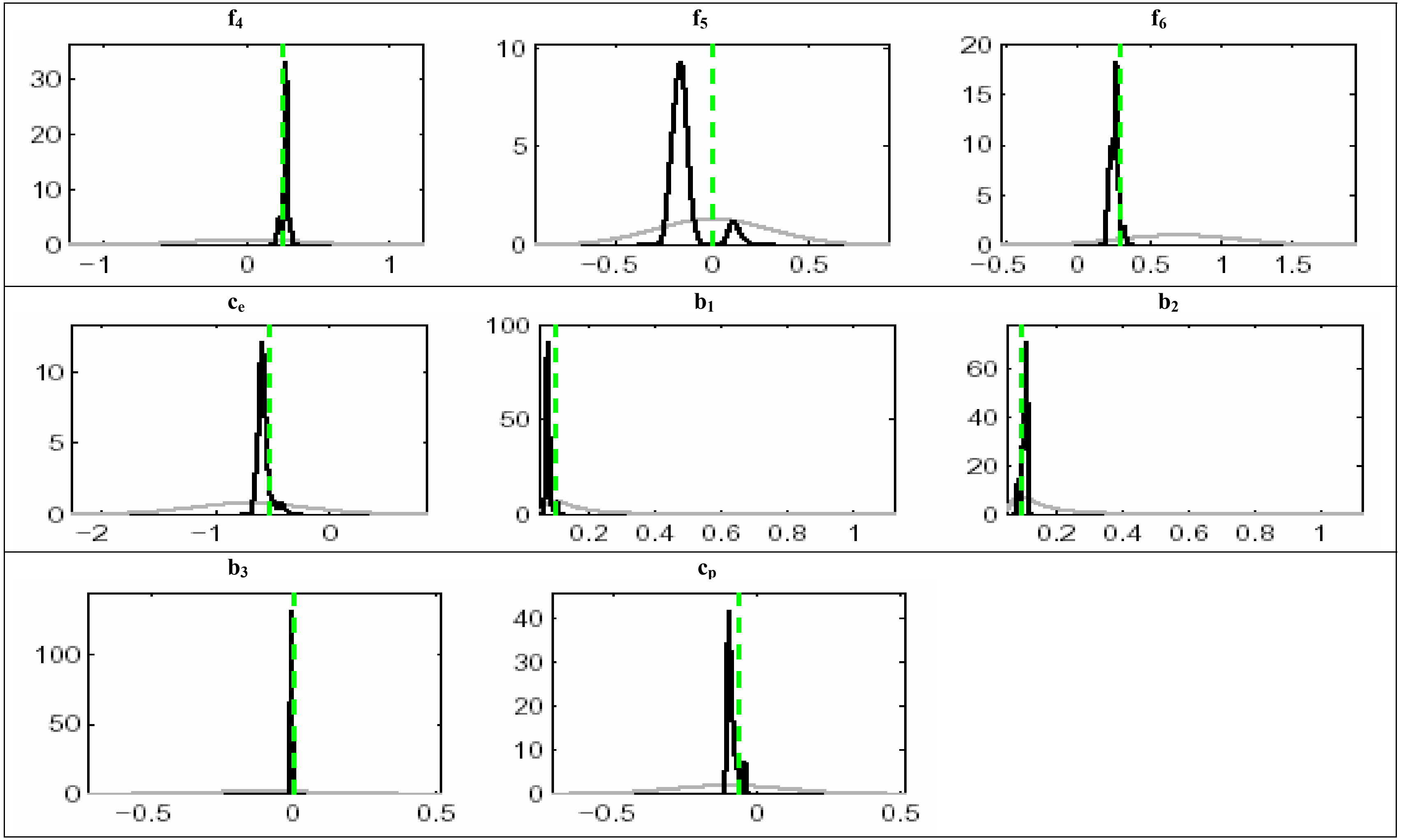
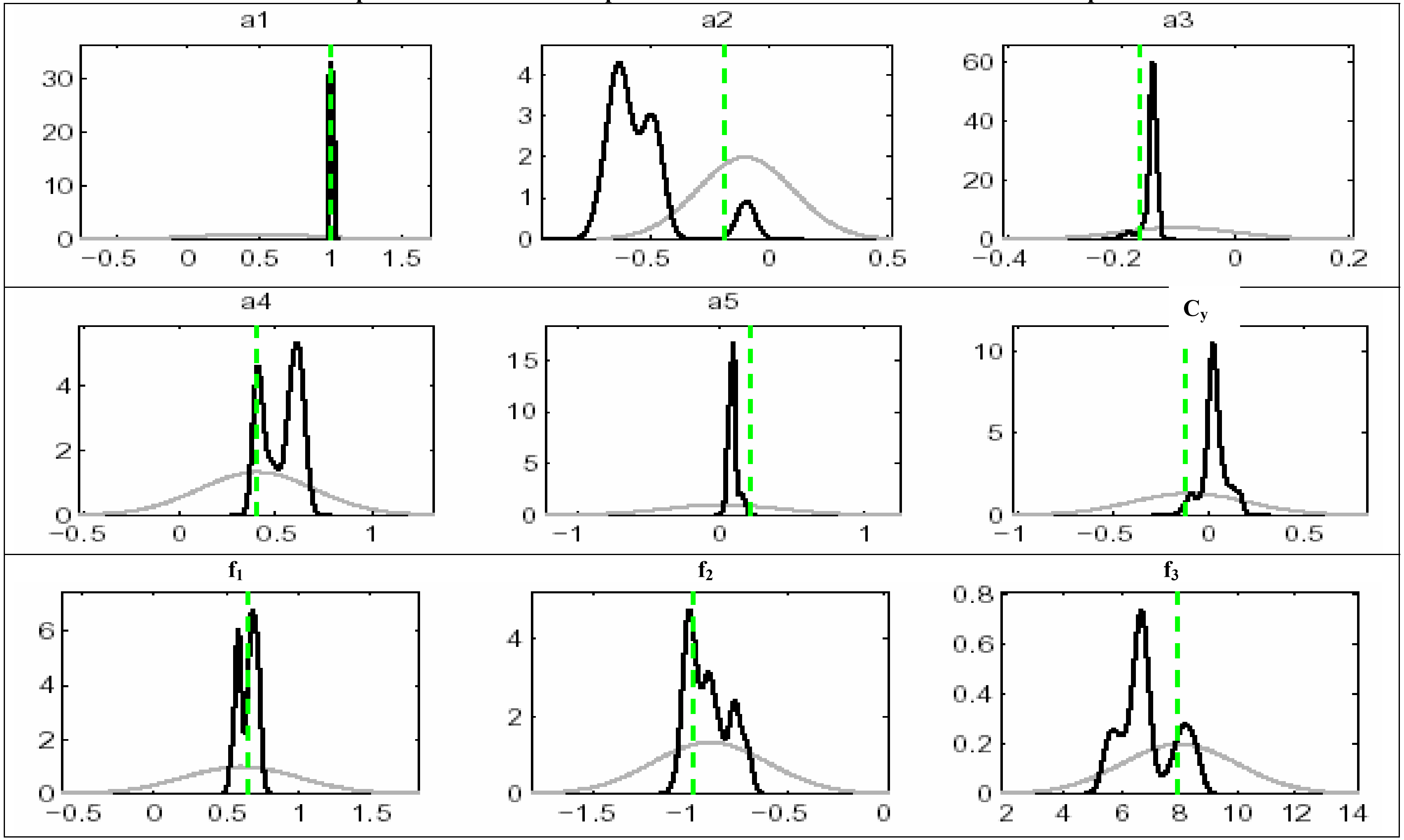
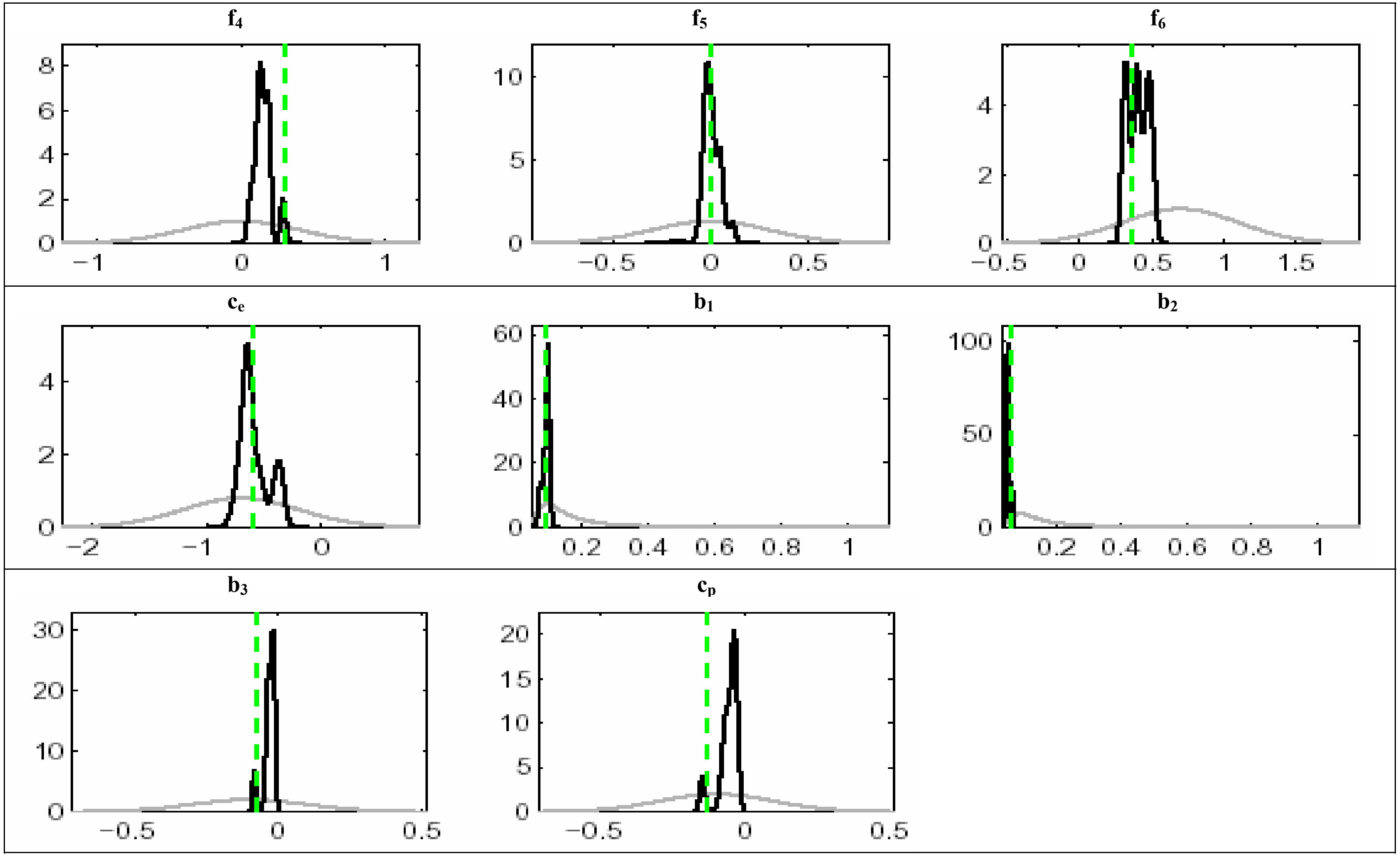

f4
f5
f6
ce
b1
b2
b3
cp

Table 4.

Prior and posterior distribution of parameters for *k*=0.2 and 2001-2005 estimation period.





f4
f5
f6
ce
b1
b2
b3
cp

Table 5.
Aggregate demand:

$$\hat{y}_t = c_{\hat{y}} + \alpha_1((1-k)\hat{y}_{t-1} + k\hat{y}_{t+1}) + \alpha_2 i^r_{t-1} + \alpha_3 e^r_{t-2} + \alpha_4 \Delta\left(\Delta_4 y_t^{EU}\right) + \alpha_5 \Delta g_t + \varepsilon_t^{\hat{y}}$$

	c_y	a_1	a_2	a_3	a_4	a_5
estimated	-0.067	0,477	-0,104	-0,058	0,375	
k=0 1998-2005	-0.149	0.586	0.092	-0.042	0.347	0.140
k=0 2001-2005	-0,151	0,958	-0,097	-0,230	0,361	-0,016
k=0.1	-0.062	0.987	-0.203	-0.170	0.311	0.175
k=0.2	0.004	1.011	-0.310	-0.152	0.465	0.121
k=0.3	-0.110	0.989	-0.022	0.107	0.354	0.433
k=0.4	-0.235	0.976	0.056	0.123	0.468	-0.029

Table 6.
UIP

$$e_t^{USD/PLN} = c_{e^{USD/PLN}} + \varphi_1((1-k)e_{t-1}^{USD/PLN} + ke_{t+1}^{USD/PLN}) + \varphi_2\left(i_t - i_t^f\right) + \varphi_3\left(i_t - i_t^{WIBOR1M}\right) + \varphi_4 dg_t + \varphi_5 fg_t + \varphi_6 e_t^{EUR/USD} + \varepsilon_t^{e^{USD/PLN}}$$

	c_e	f_1	f_2	f_3	f_4	f_5	f_6
estimated	-0.715	0.589	-0.955	6.959	0.017	0.051	0.673
k=0 1998-2005	-0.525	0.529	-1.004	8.218	0.169	-0.001	0.398
k=0 2001-2005	-0.231	0.839	-1.000	6.916	0.128	0.053	0.251
k=0.1	-0.475	0.778	-1.115	8.057	0.244	0.003	0.272
k=0.2	-0.630	0.684	-0.838	7.480	0.208	0.013	0.342
k=0.3	-0.502	0.783	-0.999	6.993	0.083	-0.108	0.326
k=0.4	-0.179	0.845	-0.329	8.401	0.015	0.079	0.128

Table 7.
Phillips curve

$$\pi_t^C = c_{\pi^C} + \beta_1 \pi_t^e + \beta_2 \hat{y}_{t-2} + \beta_3 e_{t-1}^r + \varepsilon^{\pi^C}$$

	c_p	b_1	b_2	b_3
estimated	-0.053	0.283	0.211	-0.063
k=0 1998-2005	-0.198	0.769	0.132	-0.030
k=0 2001-2005	-0.138	0.075	0.058	-0.069
k=0.1	-0.064	0.079	0.096	-0.005
k=0.2	-0.097	0.098	0.057	-0.053
k=0.3	-0.098	0.451	0.030	-0.022
k=0.4	-0.106	-0.245	0.038	-0.114

Table 8.
Steady state (in %)
Monetary policy rules with: inflation, output gap, exchange rate.

Monetary policy rules with: inflation, output gap, exchange rate.							k=0 2001-2005 (two monetary policy factors: inflation and output gap)	k=0 2001-2005 (two monetary policy factors – Taylor rule)
	k=0 1998-2005	k=0 2001-2005	k=0.1	k=0.2	k=0.3	k=0.4		
Output gap	14.75	1.35	6.81	1.91	11.38	9.24	1.30	0.21
PLN/USD	3.49	3.72	3.63	3.83	2.87	3.34	3.71	3.63
Inflation	6.25	2.37	0.79	2.59	6.27	5.81	2.14	2.03
Net inflation	12.06	1.61	3.11	1.67	2.11	10.65	1.38	1.87
Interest rate 3M	13.99	6.79	6.99	7.03	17.26	14.56	6.62	7.01
Monetary policy rules with inflation and output gap and estimated interest rate smoothing i_{t-1}								
		k=0 2001-2005 i_{t-1}=0.71	k=0.1 2001-2005 i_{t-1}=0.79	k=0.2 2001-2005 i_{t-1}=0.94	k=0.3 2001-2005	k=0.4 2001-2005		
Output gap		1.05	1.14	0.19				
PLN/USD		3.52	3.52	3.34				
Inflation		2.62	2.72	2.52	none	none		
Net inflation		2.36	2.44	2.61				
Interest rate 3M		6.77	6.98	10.66				

Table 9.
Monetary policy rules – factor weights (in%).

<table>
<tr><td colspan="7">Monetary policy rules: inflation, output gap, exchange rate.</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">1998-2005
k=0</td><td colspan="5">2001-2005</td></tr>
<tr><td>k=0</td><td>k=0.1</td><td>k=0.2</td><td>k=0.3</td><td>k=0.4</td></tr>
<tr><td>Inflation</td><td>29.05</td><td>4.78</td><td>74.13</td><td>4.14</td><td>3.79</td><td>5.72</td></tr>
<tr><td>Output gap</td><td>23.20</td><td>82.08</td><td>13.81</td><td>85.22</td><td>72.83</td><td>75.30</td></tr>
<tr><td>Exchange rate</td><td>47.75</td><td>13.14</td><td>12.06</td><td>10.64</td><td>23.38</td><td>18.98</td></tr>
<tr><td></td><td>Standard monetary policy rule</td><td colspan="5">Monetary policy rules with inflation and output gap and estimated interest rate smoothing</td></tr>
<tr><td rowspan="2"></td><td colspan="6">2001-2005</td></tr>
<tr><td>k=0</td><td>k=0</td><td>k=0.1</td><td>k=0.2</td><td colspan="2" rowspan="4"></td></tr>
<tr><td>Inflation</td><td>33.0</td><td>40.6</td><td>17.3</td><td>46.0</td></tr>
<tr><td>Output gap</td><td>67.0</td><td>59.4</td><td>82.7</td><td>54.0</td></tr>
<tr><td>Interest rate</td><td>0</td><td>0.71</td><td>0.79</td><td>0.94</td></tr>
</table>

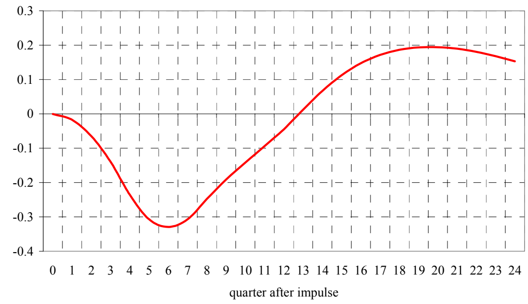
Table 10.
Loss function

	Three factor monetary policy rule (output gap, inflation, exchange rate)						Two factor monetary policy rule (output gap, inflation)				
	1998-2005	2001-2005					2001-2005				
							no smoothing		with interest rate smoothing		
	k=0	k=0	k=0.1	k=0.2	k=0.3	k=0.4	Taylor π & y weights 0.5; 0.5	k=0	k=0 i_{t-1}=0,71	k=0.1 i_{t-1}=0,79	k=0.2 i_{t-1}=0,94
Loss function = Σ(variance(output gap + inflation + exchange rate)); % of Taylor rule	45.3	258.3	132.8	347.9	533.7	305.7	**100.0**	238.7	144,1	133,7	38,4
Loss function = Σ(variance(output gap + inflation)); % of Taylor rule	12.2	139.0	141.9	242.8	404.1	269.9	**100.0**	130.1	52.2	52.6	1.7

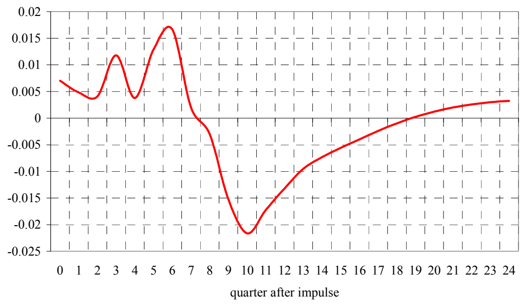
Table 11.

Benchmark model - response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

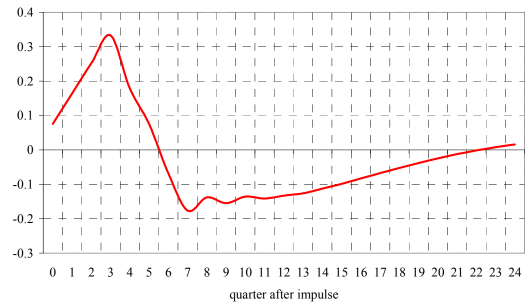
Interest rate impulse [a]



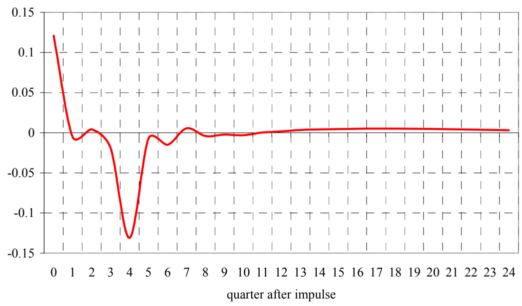
External demand impulse [b]



Food price impulse [c]



Oil price impulse [d]



[a] – a four-quarter increase in the nominal short-term interest rate by 1 pp from the baseline

[b] – a four-quarter increase in the annual GDP growth rate in the euro zone by 0,1 pp from the baseline

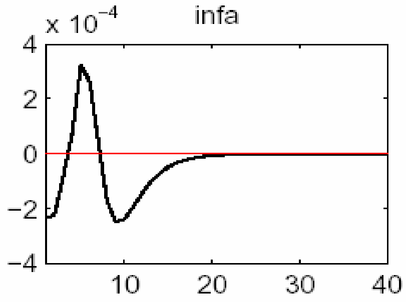
[c] – an increase in the annual ford price growth rate by 1 pp from the baseline, evenly distributed over four subsequent quarters

[d] – a one-quarter increase in the oil barrel price by 10% from the baseline

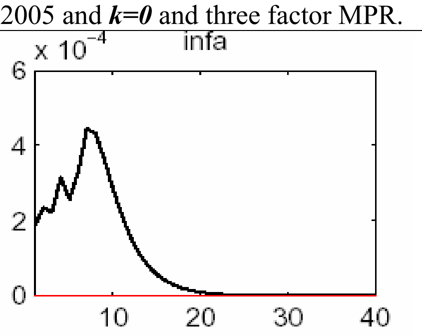
Table 12.

Response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

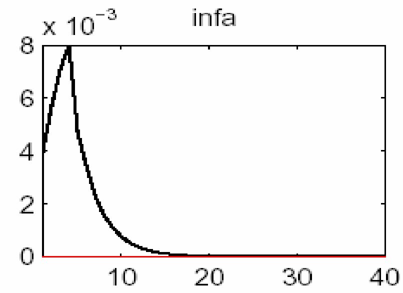
Bayesian estimated NSA model for 1998-2005 and ***k=0*** and three factor MPR.



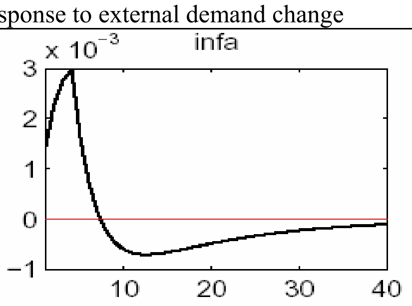
Response to short-term interest rate change



Response to external demand change



Response to food prices change

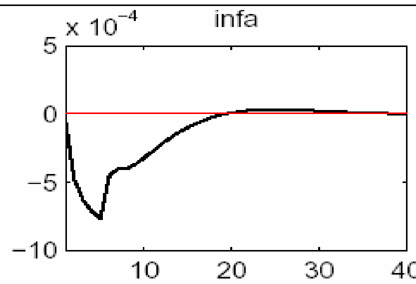


Response to oil price change

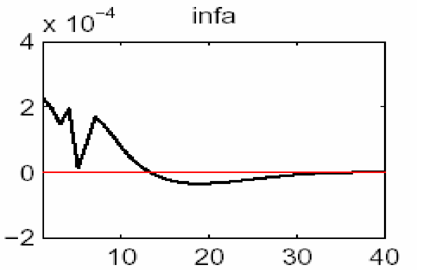
Table 13.

Response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

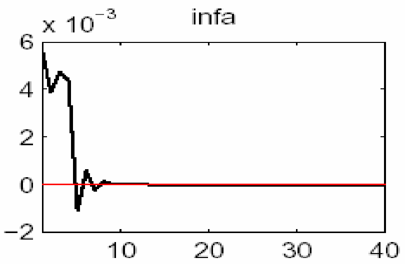
Bayesian estimated NSA model for 2001-2005 and ***k=0*** and three factor MPR.



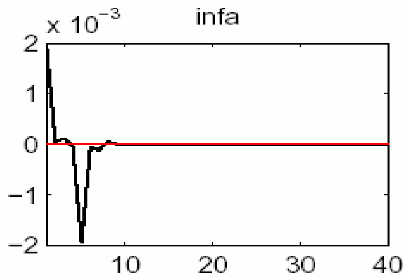
Response to short-term interest rate change



Response to external demand change



Response to food prices change

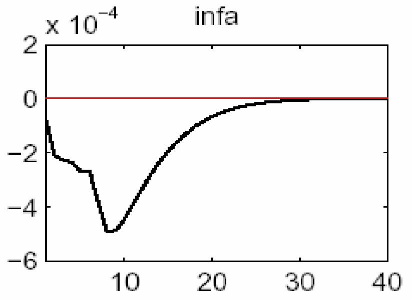


Response to oil price change

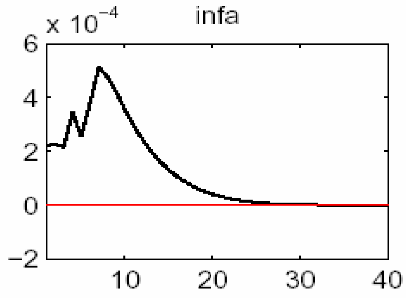
Table 14.

Response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

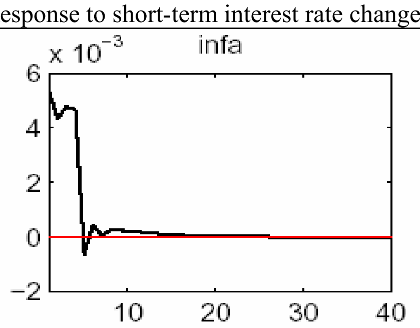
Bayesian estimated NSA model for 2001-2005 and ***k=0.1*** and three factor MPR.



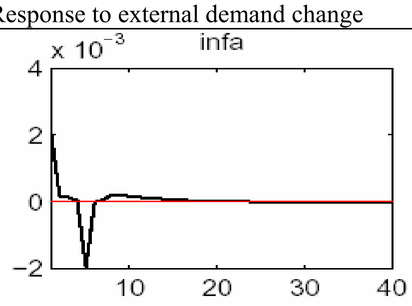
Response to short-term interest rate change



Response to external demand change



Response to food prices change

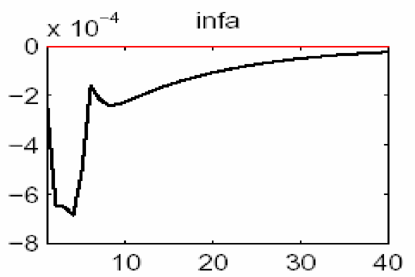


Response to oil price change

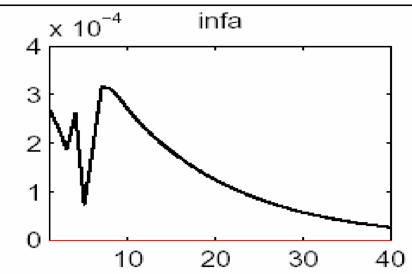
Table 15.

Response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

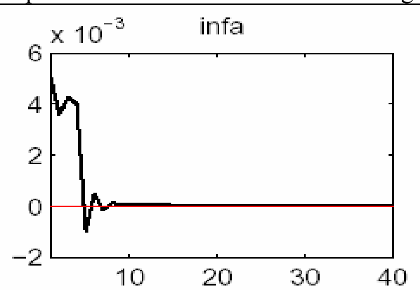
Bayesian estimated NSA model for 2001-2005 and ***k=0.2*** and three factor MPR.



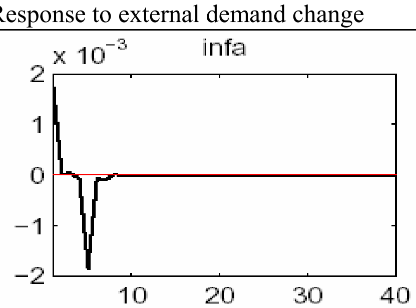
Response to short-term interest rate change



Response to external demand change



Response to food prices change

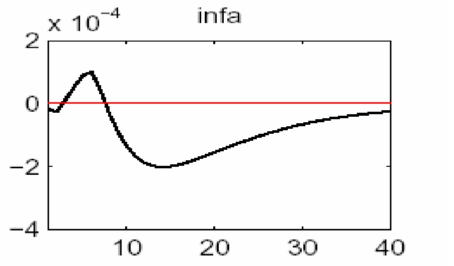


Response to oil price change

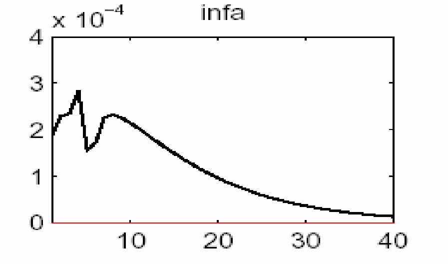
Table 16.

Response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

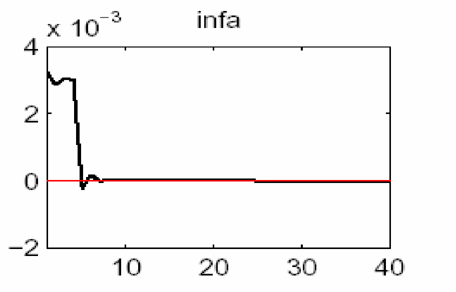
Bayesian estimated NSA model for 2001-2005 and ***k=0.3*** and three factor MPR.



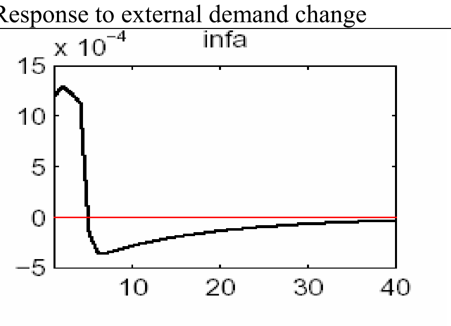
Response to short-term interest rate change



Response to external demand change



Response to food prices change

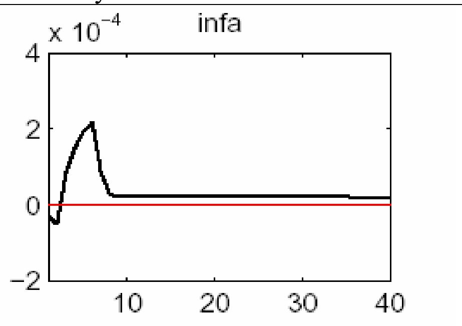


Response to oil price change

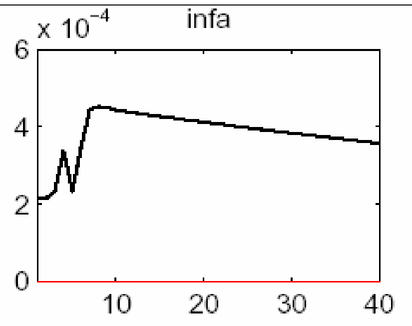
Table 17.

Response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

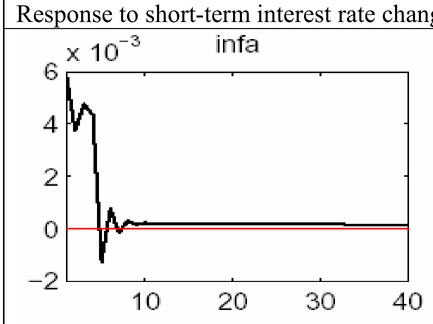
Bayesian estimated NSA model for 2001-2005 and ***k=0.4*** and three factor MPR.



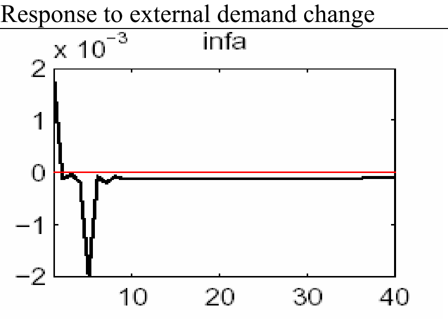
Response to short-term interest rate change



Response to external demand change



Response to food prices change

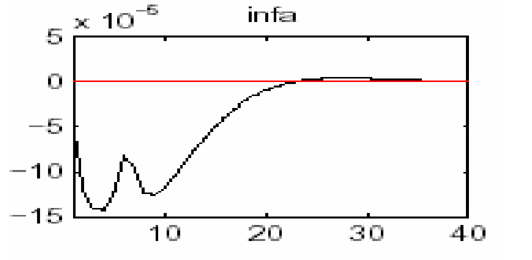


Response to oil price change

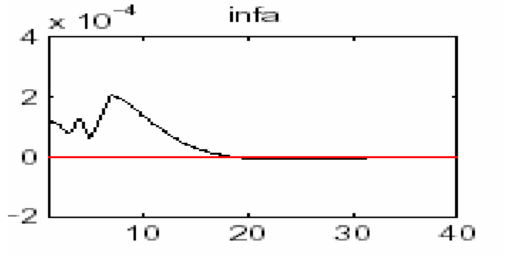
Table 18.

Response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

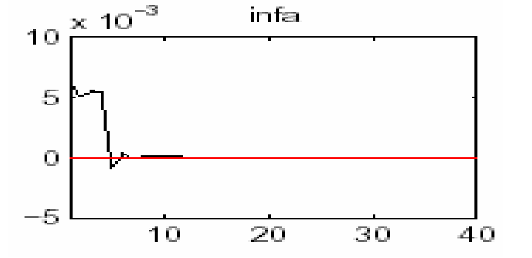
Bayesian estimated NSA model for 2001-2005 and ***k=0*** (Simple Taylor rule).



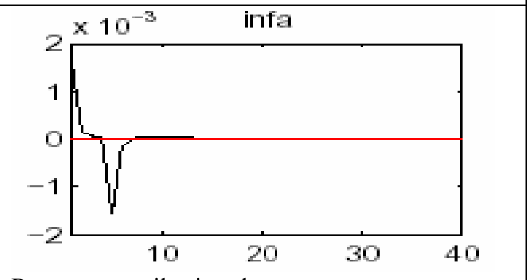
Response to short-term interest rate change



Response to external demand change



Response to food prices change

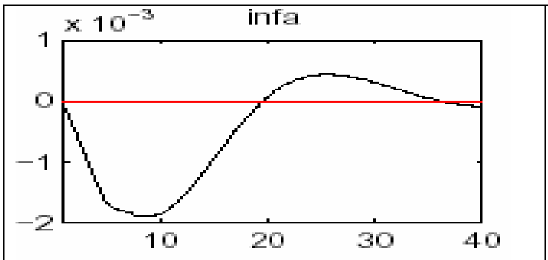


Response to oil price change

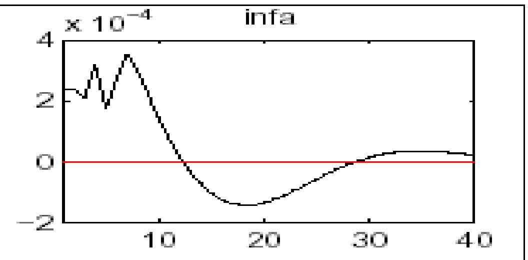
Table 19.

Response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

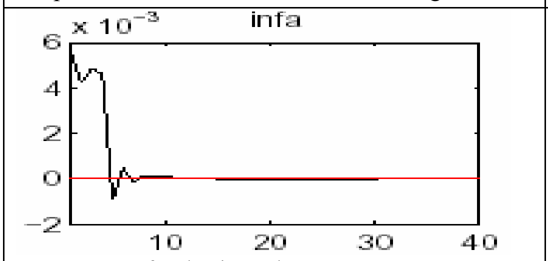
Bayesian estimated NSA model for 2001-2005 and ***k=0*** (estimated smoothing $\theta=0.71$).



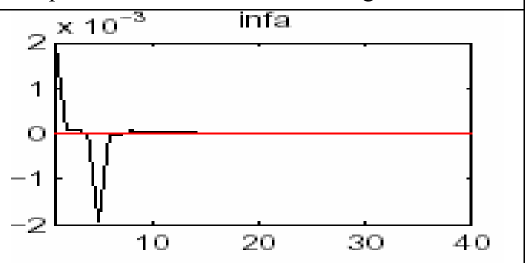
Response to short-term interest rate change



Response to external demand change



Response to food prices change

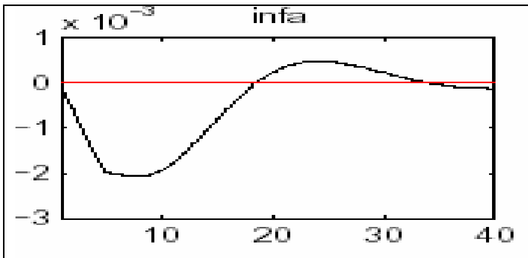


Response to oil price change

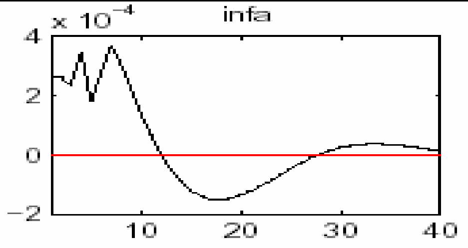
Table 20.

Response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

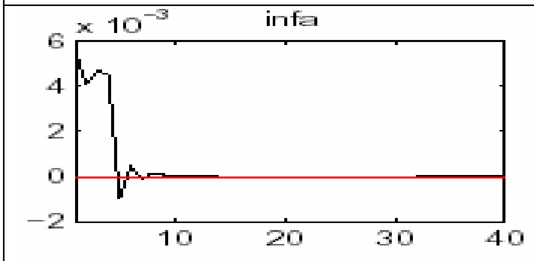
Bayesian estimated NSA model for 2001-2005 and ***k=0.1*** (estimated smoothing θ =*0.79*).



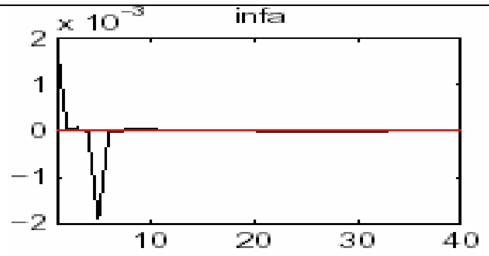
Response to short-term interest rate change



Response to external demand change



Response to food prices change

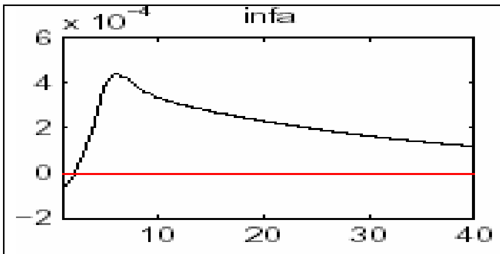


Response to oil price change

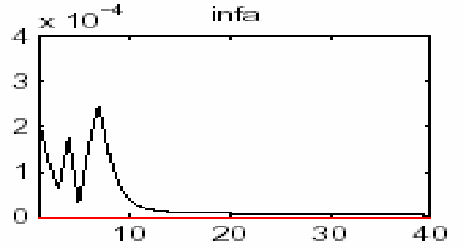
Table 21.

Response of annual inflation to selected impulses – deviations from the baseline (in percentage points)

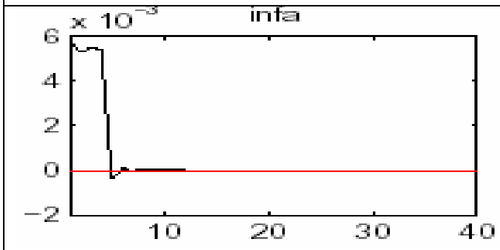
Bayesian estimated NSA model for 2001-2005 and ***k=0.2*** (estimated smoothing θ =*0.94*).



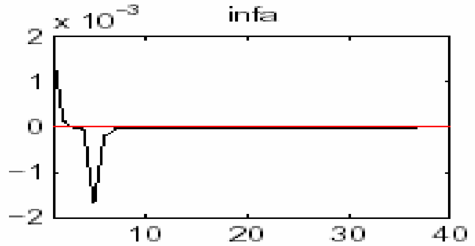
Response to short-term interest rate change



Response to external demand change



Response to food prices change



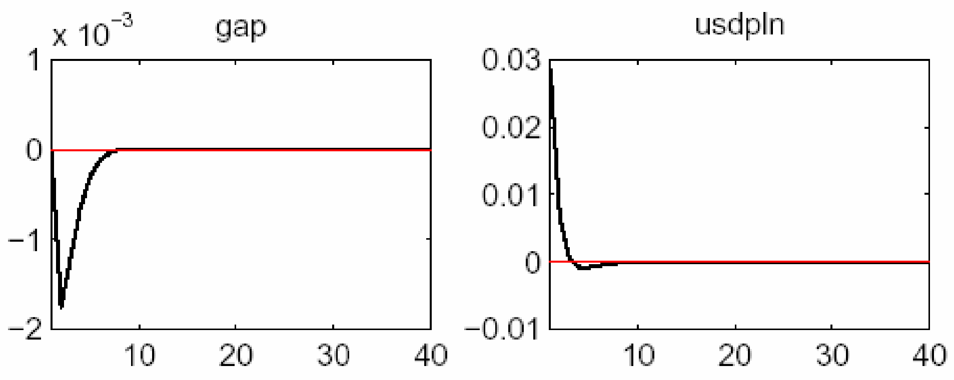
Response to oil price change

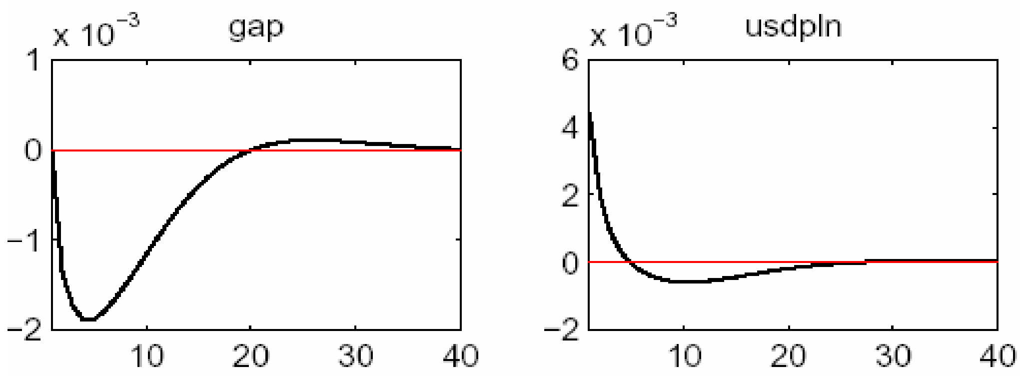
Table 22.

Response of output gap and USD/PLN exchange rate to short-term interest rate change – deviations from the baseline (in percentage points)

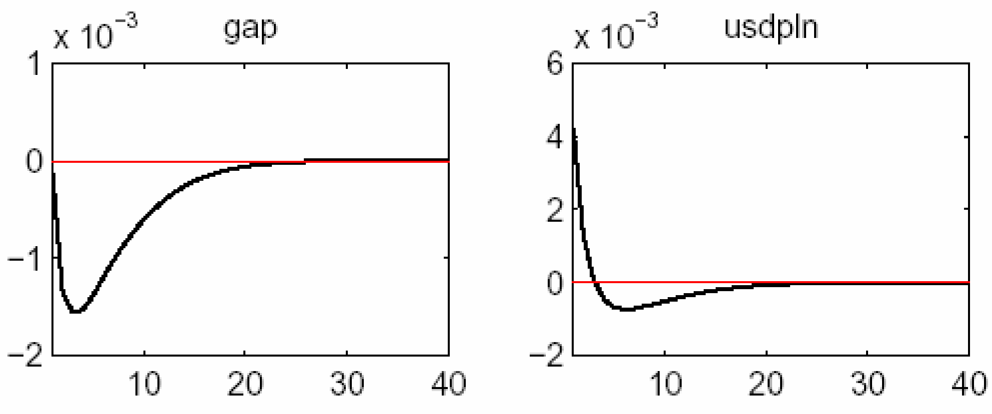
Bayesian estimated NSA models.

For 1998-2005 and ***k=0*** and three factor MPR.



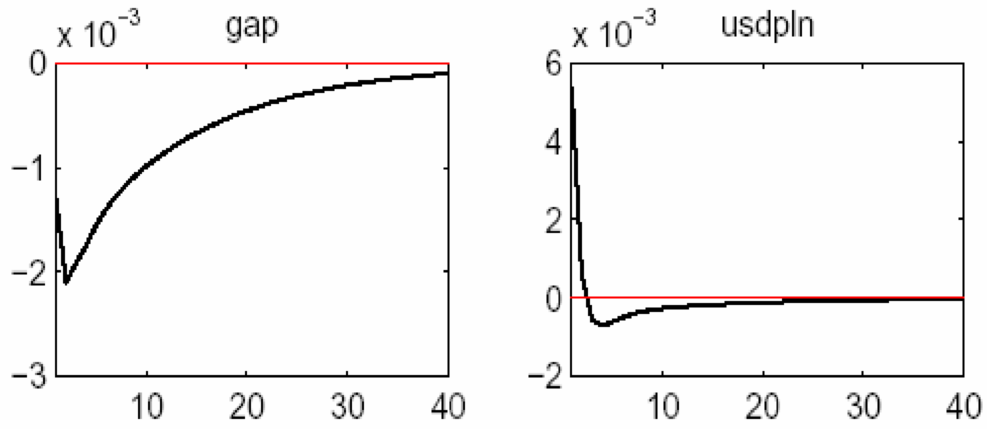


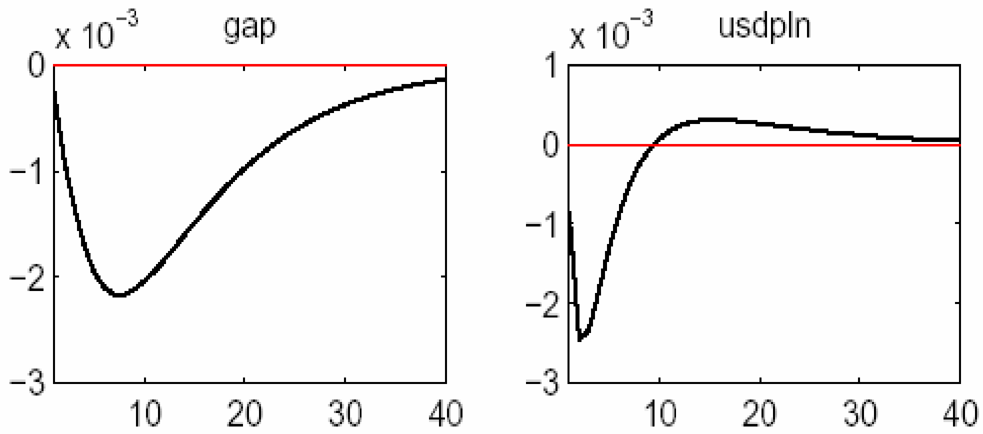
For 2001-2005 and ***k=0*** and three factor MPR.



For 2001-2005 and ***k=0.1*** and three factor MPR.

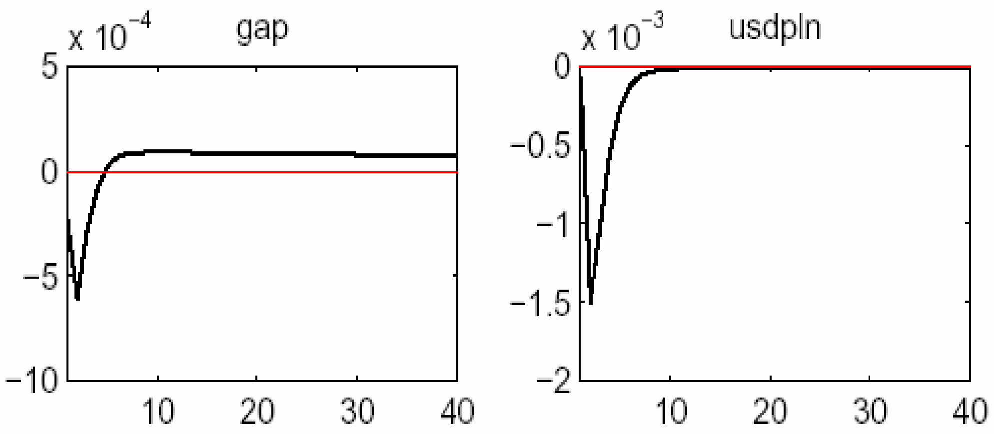
For 2001-2005 and ***k=0.2*** and three factor MPR.



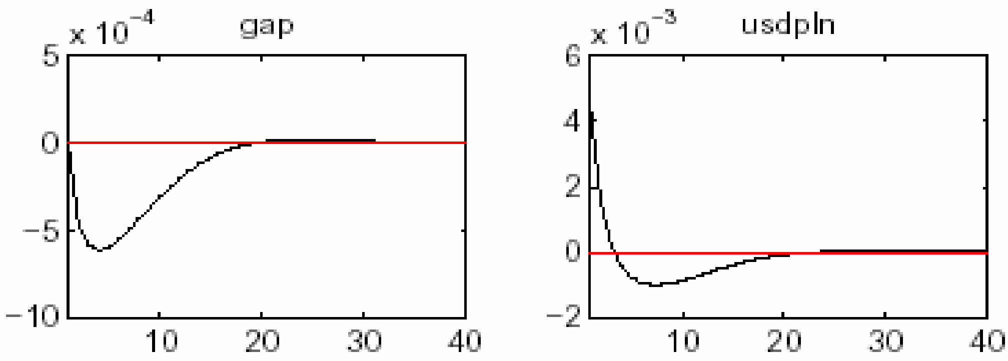


For 2001-2005 and ***k=0.3*** and three factor MPR.

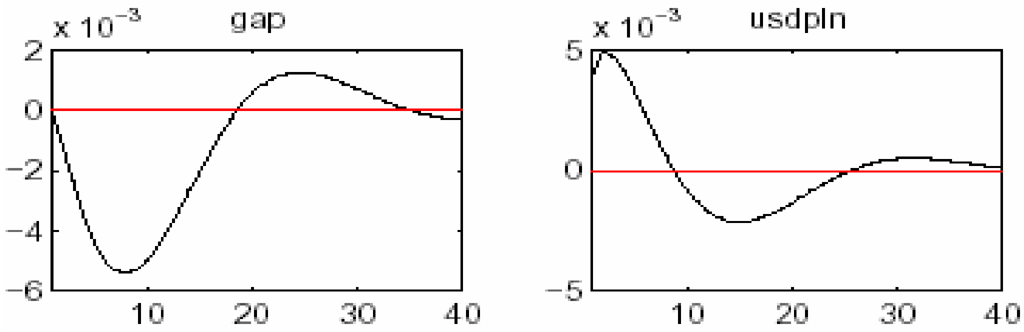
For 2001-2005 and ***k=0.4*** and three factor MPR.



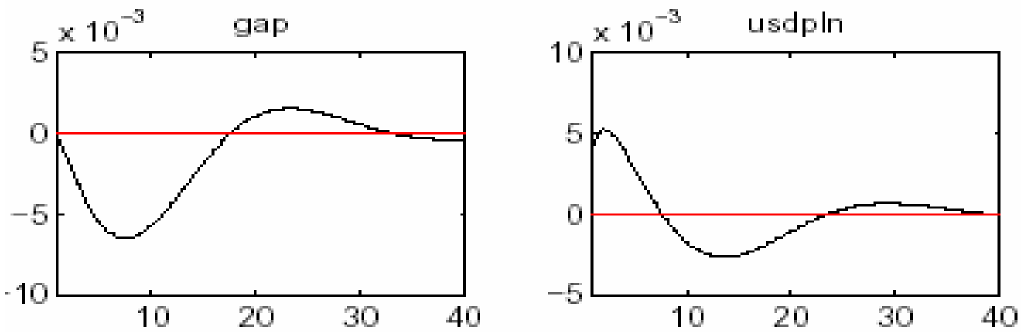
For 2001-2005 and ***k=0*** (simple Taylor rule).



For 2001-2005 and ***k=0*** (estimated smoothing *θ =0.71*).



For 2001-2005 and ***k=0.1*** (estimated smoothing *θ =0.79*).



2001-2005 and ***k=0.2*** (estimated smoothing *θ =0.94*).