MATERIAŁY I STUDIA

Paper no 26

Monetary transmission mechanism in Poland The strenght and delays

Tomasz Łyziak

Warsaw, December 2002

Design:

Oliwka s.c.

Layout and print:

NBP Printshop

Published by:

National Bank of Poland
Department of Information and Public Relations
00-919 Warszawa, 11/21 Świętokrzyska Street
phone: (22) 653 23 35, fax (22) 653 13 21

http://www.nbp.pl

Contents

List of figures

Monetary transmission in Poland
The strength and delays[1]

Tomasz Łyziak[2]

Abstract

Monetary transmission mechanism is in the core of central banking. Its understanding however seems to be especially important within direct inflation targeting strategy. In particular, it facilitates the adequate setting of headline interest rates, consistent with declared objectives of the monetary policy. This paper looks into the strength of the monetary transmission mechanism in Poland as well as the delays in this process. It does so by using a new version of the small structural model of monetary transmission mechanism in Poland. There are three major differences between the new version of the model and the previous one, discussed in detail in Łyziak (2001). Firstly, in the version of the model presented in this paper, the interest rate channel and the bank-lending channel are modelled jointly. Secondly, due to the use of more adequate measures of the real exchange rate and a change of the sample period, both direct and indirect (demand) effects of the exchange rate channel are captured. Thirdly, in the new version of the model price behaviour of selected items of the consumer basket – i.e. foodstuffs, oil and remaining items – is modelled separately. Based on the model simulations, the paper confirms that the effectiveness of the monetary transmission mechanism in Poland has increased. It is reflected in a relatively stronger impact of interest rate impulses on inflation relative to the conclusions from the previous version of the model.

[1] This paper has benefited from helpful discussions with Dr Ryszard Kokoszczyński, Dr Lavan Mahadeva, Bojan Markovic and Ewa Wróbel. Any remaining errors are the responsibility of the author. The views expressed in this paper are those of the author and do not necessarily reflect those of the National Bank of Poland.

[2] Bureau of Macroeconomic Research, National Bank of Poland, Tomasz.Lyziak@mail.nbp.pl.

1

1 Small structural model of monetary transmission mechanism in Poland

The small structural model of monetary transmission mechanism in Poland is grounded on three fundamental relationships suggested by the theory of macroeconomics, which are treated as key elements of models describing the monetary transmission mechanism. They contain the aggregate demand curve, uncovered interest rate parity condition and the Phillips curve[3]. The complete set of the model's equations is as follows (standard errors in parentheses)[4]:

$$\left(\log(y_t)-\log(y_t^*)\right) = -0.07 + \underset{(0.15)}{0.41}\cdot\left(\log(y_{t-1})-\log(y_{t-1}^*)\right) - \underset{(0.15)}{0.32}\cdot i_{t-2}^r - \underset{(0.02)}{0.09}\cdot\log(e_{t-1}^r) \qquad [1]$$

$$\pi_t^C = -0.02 + \overline{\pi_t^e} + \underset{(0.12)}{0.34}\cdot\left(\log(y_{t-3})-\log(y_{t-3}^*)\right) - \underset{(0.00)}{0.02}\cdot\log(e_{t-1}^r) + \underset{(0.00)}{0.01}\cdot s^{(1)} \qquad [2]$$

$$\pi_t^F = -0.02 + \underset{(0.09)}{1.48}\cdot\pi_t - \underset{(0.09)}{0.48}\cdot\pi_{t-1}^F - \underset{(0.05)}{0.11}\cdot\left(\log(p_{t-1}^F)-\log(p_{t-1})\right) \qquad [3]$$

$$\pi_t^O = \log(b_t^{USD}) - \log(b_{t-1}^{USD}) - \log(e_t^{USD/PLN}) + \log(e_{t-1}^{USD/PLN}) \qquad [4]$$

$$\pi_t = w_t^C\cdot\pi_t^C + w_t^F\cdot\pi_t^F + w_t^O\cdot\pi_t^O \qquad [5]$$

$$\pi_t^e = \underset{(0.05)}{0.82}\cdot\pi_{t-1}^e + \underset{(0.05)}{0.13}\cdot\pi_t \qquad [6]$$

$$\overline{\pi_t^e} = 0.72\cdot\pi_t^e \qquad [7]$$

$$\log(e_t^r) - \log(e_{t+1}^r) = i_t^r - i_t^{r(f)} \qquad [8]$$

$$\log(e_t^{USD/PLN}) = \log(e_t^n) - w_t^{EUR}\cdot\log(e^{EUR/USD}) \qquad [9]$$

$$i_t = 0.5\cdot\left(\log(y_t)-\log(y_t^*)\right) + 1.5\cdot(\pi_t - \pi_t^*) \qquad [10]$$

where:

y – real GDP (a measure of aggregate demand);

y^* – potential GDP (measured with the Hodrick-Prescott filter);

i – one-month interbank interest rate (WIBOR1M) in nominal terms;

[3] M. Woodford (2002), p. 11.
[4] Detailed estimation results in the Appendix 2.

i^r – one-month interbank interest rate (WIBOR1M) in real terms;

$i^{r(f)}$ – foreign interest rate in real terms;

e^n – nominal effective exchange rate[5];

e^r – real effective exchange rate;

$e^{USD/PLN}$ – nominal USD/PLN exchange rate;

$e^{EUR/USD}$ – nominal EUR/USD exchange rate;

w^{EUR} – weight of euro used in the calculation of the nominal effective exchange rate;

π^C – quarterly dynamics of consumer prices excluding foodstuffs and oil (core inflation);

π^F – quarterly dynamics of foodstuffs prices;

π^O – quarterly dynamics of oil prices;

w^C – weight of items excluding foodstuffs and oil in the CPI basket;

w^F – weight of foodstuffs in the CPI basket;

w^O – weight of oil in the CPI basket;

b^{USD} – price of oil in international markets (USD per barrel);

π – quarterly inflation;

π^* – inflation target;

P^F – foodstuffs' price level;

P – price level;

π^e – individuals' inflationary expectations in quarterly terms;

$\overline{\pi^e}$ – adjusted measure of individuals' inflationary expectations in quarterly terms, which approaches actual inflation in a long-run[6];

$s^{(i)}$ – seasonal dummy, equal to 1 in the quarter i $\left(i = \{1,2,3,4\}\right)$.

Equation [1] is the aggregate demand curve, in which the output gap depends upon its lagged value, the real interest rate and the real effective exchange rate. Its analytical formula is similar to IS curves used in McCallum and Nelson (1997) and Svensson (1998) models, which have microfoundations in dynamic general equilibrium models with price stickiness. The only exception from those specifications is that in the aggregate demand curve of the small structural model of monetary transmission mechanism in Poland the expected future output gap, which is a relevant argument in theoretical fully forward-looking IS curves, is suppressed and instead the lag is used for simplicity. Such a modification is implemented in a number of empirical works[7] – for instance in Batini and Haldane (1999), Muinhos (2001) as well as de Freitas and Muinhos (2001) models.

In the recent version of the model, price behaviour of selected items of the consumer basket – namely: foodstuffs, oil and remaining groups – is modelled separately. Equation [2] explains quarterly dynamics of prices of CPI basket items excluding food and oil (i.e. the core inflation) with the output gap, the real effective exchange rate and individuals' inflationary expectations as explanatory variables. It should be noted that in the Phillips curve adjusted measures of individuals'

[5] According to a convention applied, the exchange rate is defined as a number of units of foreign currency equivalent to one unit of domestic currency. Hence the rise in the exchange rate is the appreciation of the domestic currency. The way, in which the nominal and real effective exchange rates are calculated, is described in detail in the Appendix 1.
[6] Remarks on the measurement of individual's inflationary expecytations and their use in the Phillips curve are presented in the next paragraph.
[7] Razzak (2002) characterizes the aggregate demand curve without forward-looking component as the empirical version of the IS curve.
See: W. A. Razzak (2002), p. 26.

1

inflationary expectations are used. Those measures – defined in the equation [7] – according to a long-run solution of the equation [6], gradually approach actual inflation.

The specification of equation [3] refers to error correction mechanism (ECM). Slightly modified form of this relationship[8] relates the quarterly dynamics of foodstuffs prices to the core inflation, quarterly dynamics of the oil price, lagged change of food prices as well as the relative price of food in the previous period.

Oil price setting is defined in the equation [4]. It is assumed that changes in the oil price in international markets (denominated in USD) as well as PLN/USD exchange rate movements are fully passed into changes of the oil price denominated in domestic currency.

According to the identity [5], inflation, measured by the consumer price index (CPI), is a weighted average of price changes of analysed items of the basket. Nowadays the proportion of foodstuffs in the CPI basket accounts for 29.73% and the weight of oil for 3.71%.[9]

The exchange rate in the small structural model of monetary transmission mechanism in Poland is driven by the uncovered interest rate parity (UIP) condition, expressed in the equation [8]. It is formulated in terms of the real effective exchange rate and real interest rates, which – as far as a measure of the real exchange rate used in the model is concerned – is equivalent to the analogous rule expressed in nominal terms. Uncovered interest rate parity is often rejected in studies of exchange rate movements, although there is little consensus on why it fails. However, Meredith and Chinn (1998) using G-7 countries data show that the perverse relationship between interest rates and exchange rates is a feature of the short-horizon data. They point out that in the short-run, the failure of uncovered interest rate parity condition results from risk premium shocks, but in the long-run exchange rate movements are driven by the "fundamentals", leading to a relationship between interest rates and exchange rates consistent with UIP. A recent paper by Bekaert, Wei and Xing (2002) concludes that deviations from uncovered interest rate parity are less pronounced than previously documented and seem to be connected rather with currencies taken into account than with the horizon.

There are two nominal exchange rates appearing in the small structural model of monetary transmission mechanism in Poland: the nominal effective exchange rate and the USD/PLN exchange rate. The arbitrage condition leads to the relationship [9], which relates the USD/PLN exchange rate to the nominal effective exchange rate and the EUR/USD exchange rate, treated as exogenous variable in the model.[10]

The equation [10] is the monetary policy reaction function, based on the conventional Taylor rule. The nominal interest rate depends on the difference between the model-consistent inflation forecasts and the inflation target as well as on the output gap.

The scheme below (Scheme 1) presents basic interactions considered in the small structural model of monetary transmission mechanism in Poland.

---

[8] Using the condition [5], the general form of the equation [3]:

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

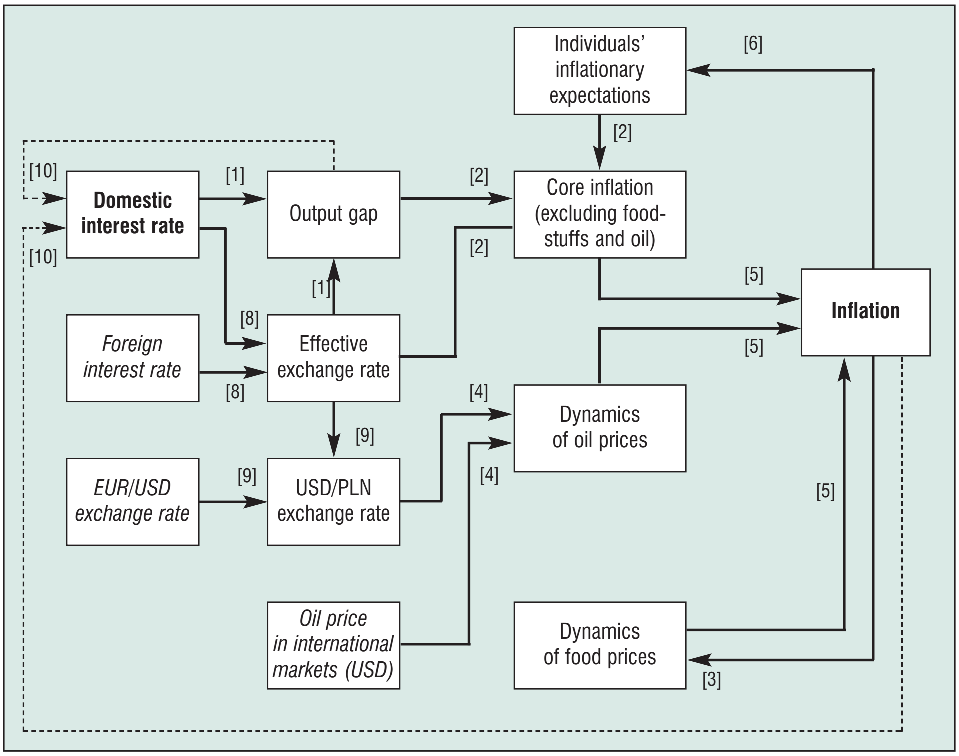
can be transformed into a following relationship:

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

[9] In previous years the weight of foodstuffs in the CPI basket was equal to: 39.23% in 1995, 39.60% in 1996, 36.85% in 1997, 36.27% in 1998, 31.62% in 1999, 30.45% in 2000 and 30.10% in 2001, while the weight of oil was equal to: 2.68% in 1995, 2.50% in 1996, 2.61% in 1997, 2.50% in 1998, 2.43% in 1999, 2.79% in 2000 and 3.48% in 2001.

[10] The equation [9] is derived and discussed in the Appendix 1.

Scheme 1. Small structural model of monetary transmission mechanism in Poland



2
Individuals' inflationary expectations in the small structural model of monetary transmission mechanism in Poland

Individuals' inflationary expectations play an important role in the small structural model of monetary transmission mechanism in Poland. The relationship given by the equation [6] attempts to explain their character, while the Phillips curve (equation [2]) enlightens how those measures influence inflation.

Individuals' inflationary expectations indices are quantified on the basis of Ipsos-Demoskop survey with the use of adjusted Carlson and Parkin (1975) probability method. The survey question concerning inflationary expectations is designed in a qualitative way, i.e. the respondents do not give precise quantitative answers regarding inflation in future, but declare the expected direction of change, comparing their foresights with current price movements. They respond to the following question: "*Given what is currently happening, do you believe that prices over next 12 months: (1) will increase faster; (2) will increase at the same rate; (3) will increase at a slower rate; (4) will be stable; (5) will fall; (6) I do not know*". The adjusted Carlson and Parkin (1975) quantification procedure assumes that individuals' inflationary expectations are normally distributed as well as that among respondents who choose point answers, i.e. options (2) and (4), there are agents whose expectations fall within sensibility intervals centred on the current rate of inflation and a zero rate of price changes respectively[11].

Before substituting inflationary expectations' measures into the Phillips curve of the small structural model of monetary transmission mechanism in Poland, they are subject to an additional correction. Starting from a general form of the equation [6], which can be written as:

$$\pi_t^e = \varpi_1 \cdot \pi_{t-1}^e + \varpi_2 \cdot \pi_t \qquad [11]$$

adjusted indices of inflationary expectations, $\overline{\pi^e}$, which approach the actual inflation in a long-run, are derived. This concept presupposes that even if expectations can be biased in a short-run, a kind of learning process leads to a fulfilment of the rational expectations hypothesis in a long-run[12].

A long-run solution of the equation [11] can be written in the following manner:

$$\pi^e = \frac{\varpi_2}{1-\varpi_1} \cdot \pi \qquad [12]$$

The assumption that economic agents learn so that in a long-run their expectations gradually approach actual inflation figures means that the coefficient $\frac{\varpi_2}{1-\varpi_1}$ in the above written equation

[11] Detailed description of this approach can be found in: T. Łyziak (2000).

[12] A frequent assumption made in macroeconomics models is that inflationary expectations are rational, which means that economic agents fully exploit all available information and do not make systematic forecast errors. In other words, their expectations are unbiased and efficient predictors of current inflation: actual inflation is equal to expected inflation on average and equal to expected inflation plus a random forecast error period by period. Empirical studies show that Polish individuals' inflationary expectations do not fulfil rational expectations hypothesis.
See: T. Łyziak (2001), pp. 15-18; M. Brzoza-Brzezina. B. Kłos, A. Kot., T. Łyziak (2002), pp. 33-36.

should be equal to 1. The estimation of the equation [6] on Polish data does not produce such a value (parameters ϖ_1 and ϖ_2 are equal, respectively, to: 0.82 and 0.13).

Assuming that the adjusted measures of individuals' inflationary expectations, which meet the rational expectations hypothesis in a long-run, are proportional to indices obtained from the quantification procedure:

$$\overline{\pi_t^e} = \delta \cdot \pi_t^e \qquad [13]$$

2

the equation [12] can be transformed in the following way:

$$\overline{\pi^e} = \frac{\varpi_2}{(1-\varpi_1)\cdot\delta} \cdot \pi \qquad [14]$$

Since the adjusted measure of individuals' inflationary expectation is supposed to approach actual inflation in a long-run, the coefficient δ should be equal to $\frac{\varpi_2}{1-\varpi_1}$, i.e. 0.72.

There are two major reasons for adjusting individuals' inflationary expectations in the above presented manner. The first one refers to a theoretical assumption that the inflation-output trade-off appears only in a short time, while in a long-run the Phillips curve is vertical, i.e. there is no long-run relationship between the output gap and inflation. This feature imposes so-called dynamic homogeneity restriction on the right hand side of the Phillips curve, which means that coefficients on all nominal variables (price indices, expectations, exchange rate) should sum to one[13]. Adjusted measures of Polish individuals' inflationary expectations make the dynamic homogeneity property accepted more easily relative to unadjusted ones. Another reason implying the need of such an adjustment refers to a notion that not only the character of individuals' inflationary expectations, but also measurement errors may lead to a conclusion that the rational expectations hypothesis is not fulfilled even in a long-run[14]. There are two types of measurement errors, namely quantification errors and survey errors. The first category refers to the procedure of quantification implemented, namely to errors generated by assumptions of the adjusted Carlson and Parkin (1975) method. The second category contains errors covering the extent, to which the sample of respondents is statistically not fully representative as well as those resulting from possible misunderstanding of the survey question and options of answer. For instance, it seems that some of respondents' opinions reflect rather the scenario they are afraid of than the one which in their view is the most probable, therefore the measure of expectations obtained from the quantification procedure may be biased.

The concept of inflationary expectations approaching actual inflation in a long-run is pictured below (Figure 1). It is assumed that at the starting point inflationary expectations are 1 percentage point above the actual inflation and in successive periods they follow a rule:

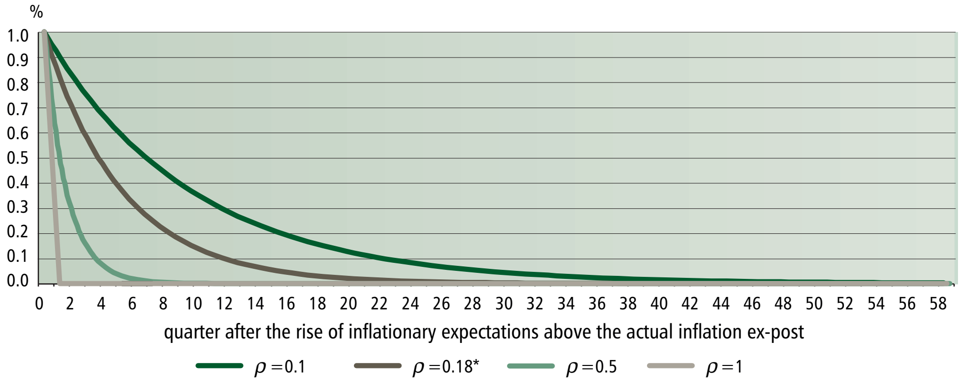
$$\pi_t^e = (1-\rho)\cdot\pi_{t-1}^e + \rho\cdot\pi_t \qquad [15]$$

The sum of coefficients on the right hand side of the equation [15] is equal to 1, thus in a long-run inflationary expectations reach the level of actual inflation. The speed of adjustment depends on the coefficient ρ : the higher is ρ , the quicker is the learning process.

13 See: Bank of England (1999), pp. 77-82; 99.

14 It should be noted that majority of international studies on survey measures of inflationary expectations conclude that those expectations are not rational. References to studies on the character of survey measures of inflationary expectations are listed in: T. Łyziak (2001), p. 18.

Figure 1. Inflationary expectations approaching the actual inflation ex-post in the long run



* – value of parameter ρ in Poland.

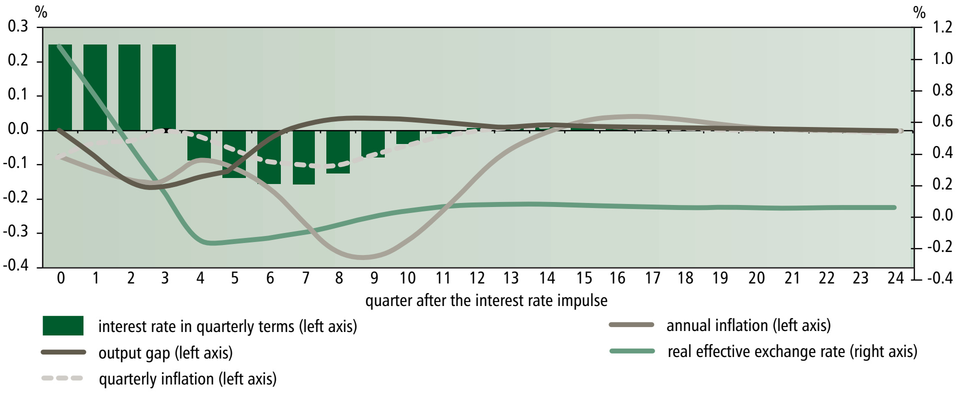
According to response functions presented above, if the coefficient ρ is equal to 1, inflationary expectations, after a temporary shock pushing them above the actual inflation ex-post, adjust immediately in the next quarter. If the value of the coefficient ρ amounts to 0.5, the learning process takes approximately 6 periods, while when it is equal to 0.18 (like in the Polish case[15]), inflationary expectations approach actual inflation after 5 years. If ρ oscillates around 0.1, the adjustment process takes as many as 9 years.

[15] According to the equation [14], the coefficient ρ in Poland is equal to $\frac{\varpi_2}{\delta}$, i.e. 0.18.

3
Monetary transmission mechanism in Poland – new empirical findings

In order to characterize the strength and the speed of monetary transmission mechanism in Poland, a simulation describing the pass-through of the interest rate impulse is run[16]. It is assumed that there is an unexpected rise in the short-term interest rate controlled by the central bank, which lasts four quarters. Within this period the monetary policy reaction function is fixed, while in subsequent quarters monetary authorities follow the Taylor rule. The figure below (Figure 2) presents the impulse responses of selected variables to such an impulse.

Figure 2. Response functions of selected variables to the interest rate impulse



The real effective exchange rate reacts immediately after the interest rate impulse. Its appreciation amounts to more than 1% in the quarter, when the interest rate impulse is imposed and then gradually disappears. The maximum fall in the output gap, equal to 0.2 percentage point, takes place in the second and the third quarter after the interest rate impulse. According to response functions presented above, after four quarters of the monetary policy tightening, interest rates are reduced below their benchmark level along with the Taylor rule.

Response functions of quarterly and annual price dynamics are double-dip-shaped. The first fall in inflation reflects direct effects of the exchange rate channel (a reduction of import prices expressed in domestic currency), while the second one is caused by a joint operation of the interest rate channel and the bank–lending channel, amplified by indirect effects of the exchange rate channel. The influence of the monetary policy impulse on quarterly inflation reaches its momentum in the seventh and eighth quarter after the impulse, when the quarterly inflation is reduced by 0.1 percentage point relative to the benchmark path. The maximum fall in annual inflation is equal to 0.35-0.4 percentage point and takes place in the eighth and ninth quarter after the interest rate impulse.

Successive figures (Figure 3, Figure 4) present how price indices of selected items of consumer basket, i.e. foodstuffs, oil and remaining items, react to the interest rate impulse. As it can be noted, prices of oil and food respond immediately to the monetary policy impulse. According to the equation [4], oil price dynamics is linked directly to the PLN/USD exchange rate, thus it is obvious that its adjustment to interest rate changes is very quick. As far as food price changes are concerned, the equation [3] suggests that they react rapidly to price movements of

[16] Winsolve 3.50.5 software was used.

remaining consumer basket items, including oil prices. This link substitutes – at least to some extent – another relationship, which is not included explicitly in the small structural model of monetary transmission mechanism in Poland, namely the impact of exchange rate movements on food prices. Previous studies have shown that this impact is fairly strong[17]. Price indices of remaining items of the consumer basket, respond to the interest rate impulse both through the impact of exchange rate changes on import prices denominated in the domestic currency as well as due to a reduction in the demand pressure in the economy.

Figure 3. Response functions of quarterly dynamics of food prices, oil price and remaining items of the CPI basket to the interest rate impulse

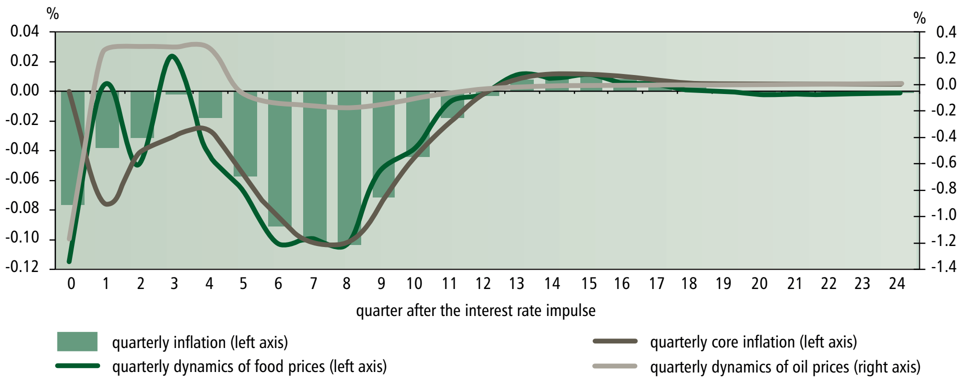
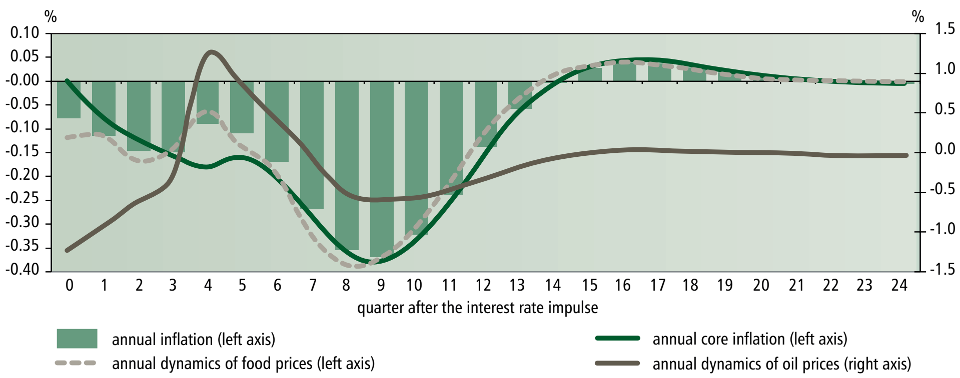


Figure 4. Response functions of annual dynamics of food prices, oil price and remaining items of the CPI basket to the interest rate impulse



[17] See: R. Kokoszczyński [ed.] (1999), p. 41.

4
Supply shocks and the reaction of monetary policy

Understanding the monetary transmission mechanism, which in transition economies is subject to permanent changes, constitutes a crucial factor conditioning the effectiveness of monetary policy. However even a deep insight in monetary transmission channels and stages is not sufficient to make the central bank capable to meet pre-announced objectives of monetary policy. Polish experiences clearly show that supply shocks, such as unexpected changes of oil price in international markets or movements in food prices – given the composition of the consumer basket – may have a grave impact on inflation. Hence it is important to analyse the effects of supply shocks on price movements in the economy and to verify whether the monetary policy should react to temporary supply shocks to constrain their second-round effects (increase of inflationary expectations and of the pressure on wages).

In order to address those issues, supply shocks simulations are run on the basis of the small structural model of monetary transmission mechanism in Poland. In the food price shock it is assumed that the impulse is equal to 1 percentage point, uniformly distributed throughout subsequent four quarters. In the oil price shock it is supposed that within one quarter the prices of the oil barrel in international markets go up by 1% relative to the benchmark level. In those simulations two scenarios of the monetary policy response to a temporary supply shock are taken into account: monetary authorities either follow the Taylor rule, tightening the interest rate policy after the shock (monetary policy active) or do not react to the shock (monetary policy passive). Response functions of selected variables to supply shocks conditioned on the reaction of monetary policy are presented in figures below.

Figure 5. Response of the interest rate and the real exchange rate to a rise in food prices

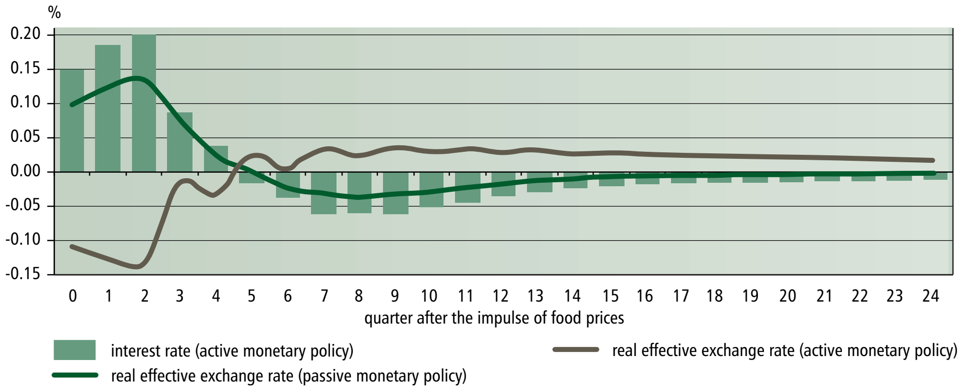


Figure 6. Response of the output gap to a rise in food prices

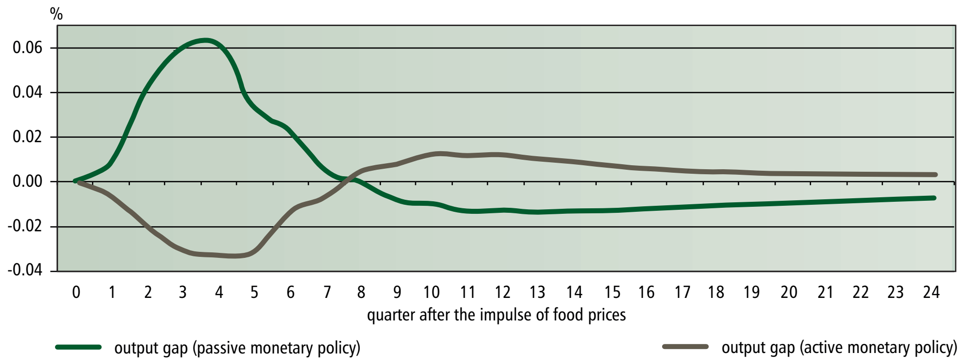


Figure 7. Response of annual inflation to a rise in food prices

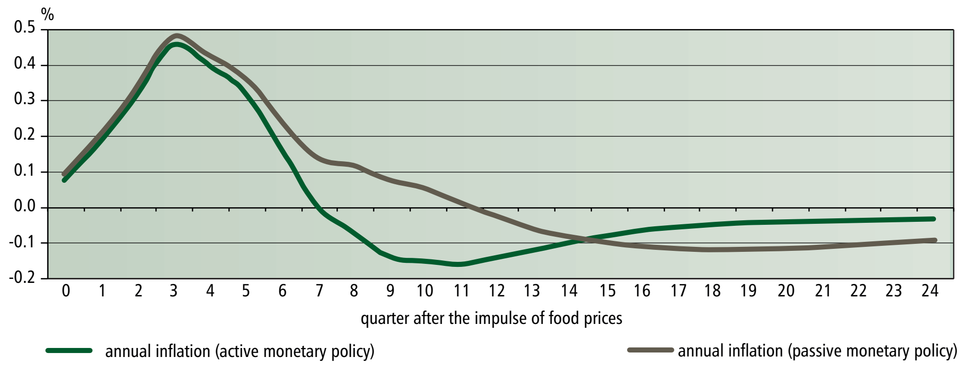


Figure 8. Response of the interest rate and the real exchange rate to a rise in the oil price

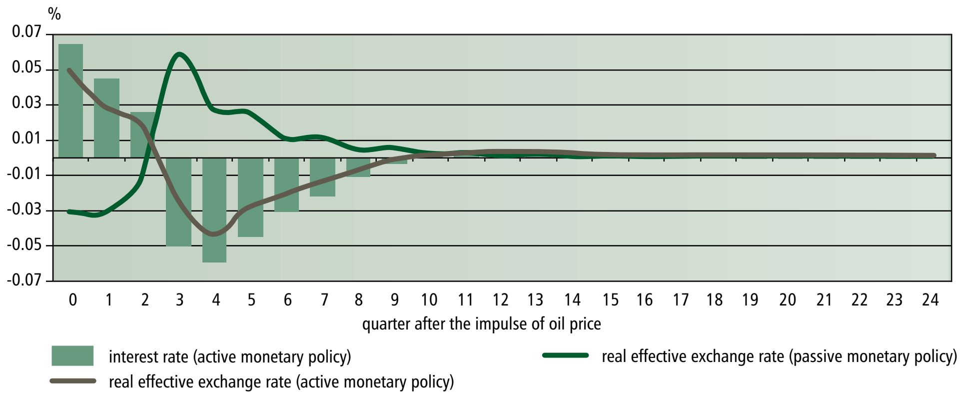


Figure 9. Response of the output gap to a rise in the oil price

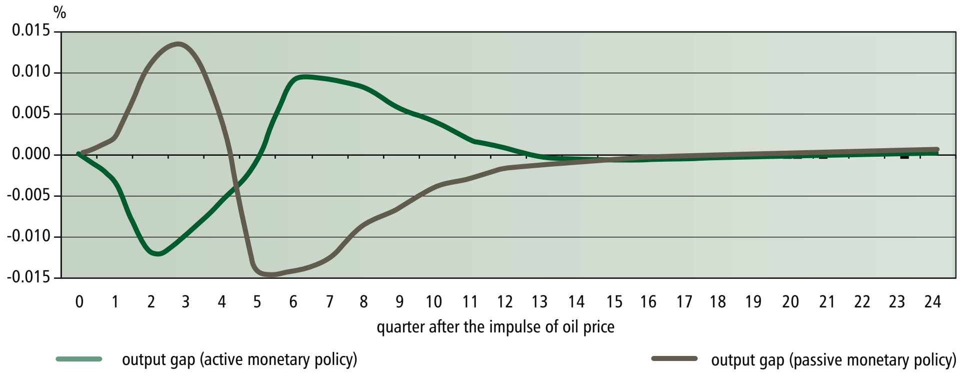
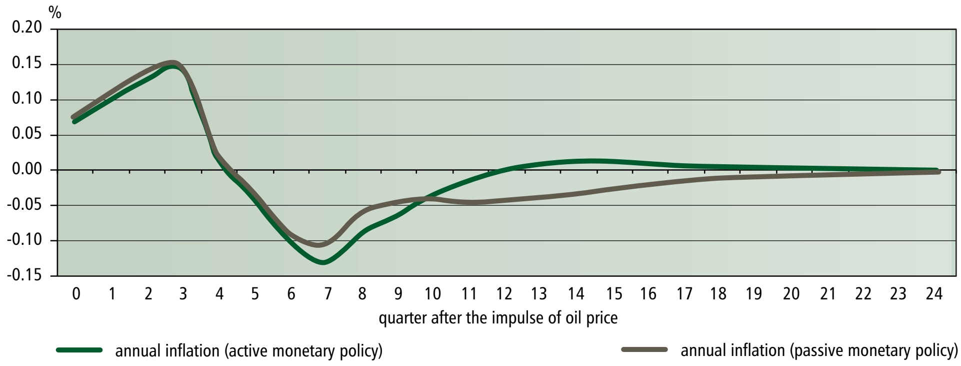


Figure 10. Response of annual inflation to a rise in the oil price



4

The maximum impact of the food price impulse on annual inflation appears in the third quarter after the impulse and amounts to 0.45-0.5 percentage point. The maximum reaction of annual inflation to the oil price shock takes place in the third quarter after the shock and amounts to 0.15 percentage point. It should be underlined that the maximum reaction of annual inflation to both supply shocks does not depend substantially upon the scenario of the monetary authorities' reaction. Given the delays in the Polish monetary transmission mechanism, differences between annual inflation impulse responses assuming active and passive monetary policy begin to be more evident (especially as far as the food price shock is concerned) after the seventh quarter after the impulse. Despite of the fact that in a shorter horizon the increase of interest rates in the active monetary policy scenario does not affect inflation considerably, it has adverse effects on the real sector of the economy, reflected in a fall in the output gap. In contradistinction to the active monetary policy scenario, in the passive one the real effective exchange rate depreciation, caused by a fall in real interest rates, pushes the output gap up.

Taking as a criterion the impact of monetary policy on price behaviour, it seems that the effectiveness of responding actively to temporary supply shocks is rather constrained. Obviously stronger reactions of the interest rate policy than those imposed by the Taylor rule could generate better effects, however they would be accompanied by a larger fall in the output below its potential level.

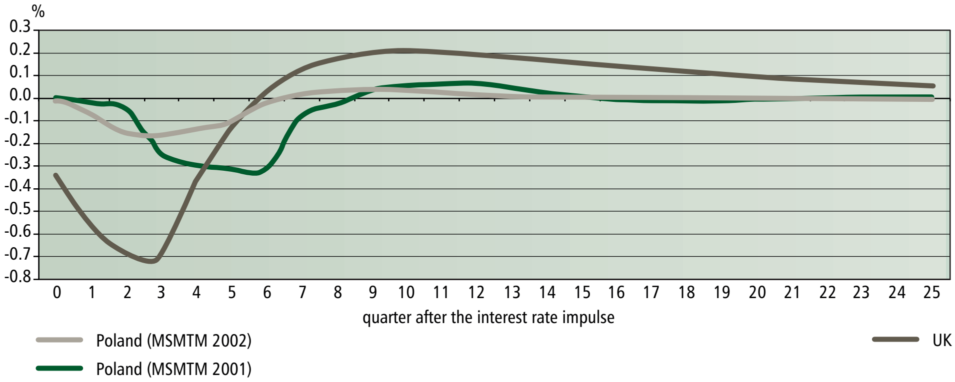
5
Conclusions

The version of the small structural model of monetary transmission mechanism in Poland presented in this paper was estimated on an updated and shortened sample period relative to the primary version of the model. Although the bank-lending channel, which constituted a focus point in the previous version of the model, is not addressed separately in the actual one, nevertheless the treatment of the exchange rate channel seems to be much more complete. Both its direct and indirect (demand) effects are explicitly captured. Moreover, in the recent version of the model, price dynamics of different items of the consumer basket is modelled disjointedly.

Due to vigorous structural, institutional and behavioural changes in the Polish economy, the monetary transmission mechanism is under ongoing evolution. Elasticities, lags and the character of different relationships within the chain of interactions between the nominal interest rate and inflation change instantaneously.

It seems that in the new version of the small structural model of monetary transmission mechanism in Poland the statistical significance of the output gap in fundamental relationships suggested by the theory of macroeconomics has increased. Response functions pictured below (Figure 11) suggest that the maximum reaction of the demand pressure in the economy to the interest rate impulse takes place earlier (in the third quarter after the interest rate impulse – like in the UK Batini and Haldane (1999) model[18]) than it resulted from previous studies (the sixth quarter after the impulse). On the other hand, the reaction of the output gap in the new version of the model seems to be smaller than in the primary one. However, it does not mean that the second stage of monetary transmission mechanism – i.e. the relationship between the interest rate and the aggregate demand – has become weaker. It rather reflects different measures of the output gap used in the primary version of the model and in the recent one[19].

Figure 11. Response functions of the output gap to the interest rate impulse in Poland (primary and new version of the small structural model of monetary transmission mechanism: MSMTM 2001, MSMTM 2002) and in the UK

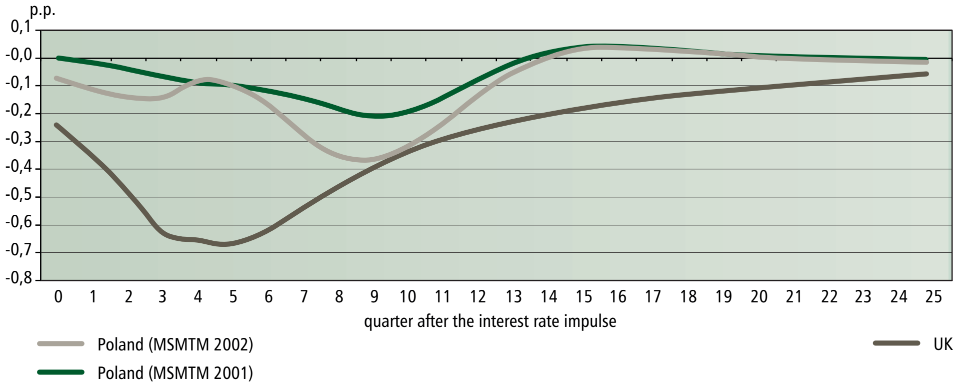


[18] See: L. Mahadeva, P. Sinclair [ed.] (2001).

[19] In the primary version of the model the output gap was estimated on the basis of GDP figures covering years 1992-1999, while in the recent one: 1994-2001. The recently used measure of the output gap is relatively less volatile, therefore the impact of analogous interest rates changes on it seems to be smaller, while its influence on inflation stronger than previously.

Taking into consideration the relationship between interest rates and inflation, it occurs that the monetary transmission mechanism gradually becomes stronger than in the past. The response function of annual inflation to the interest rate impulse obtained from the new version of the small structural model lies between the response function obtained from the primary version of the model and the impulse response from the UK Batini and Haldane (1999) model. Interpreting those results one should bear in mind that they probably reflect not exclusively the evolution of monetary transmission mechanism itself, but also changes in the model structure. Those changes, including the update of the sample period, could make data problems, affecting the model picture of the propagation of monetary impulses in Poland, less important than previously.

Figure 12. Response functions of annual inflation to the interest rate impulse in Poland (primary and new version of the small structural model of monetary transmission mechanism: MSMTM 2001, MSMTM 2002) and in the UK



The maximum fall in annual inflation resulting from the previous version of the small structural model of monetary transmission mechanism in Poland, was equal to 0.2 percentage point, while in the recent one it amounts to 0.35-0.4 percentage point. Though the maximum reaction of annual inflation in both versions of the model takes place in the ninth quarter after the interest rate impulse, it should be noted that also in a shorter horizon, i.e. until the fourth quarter after the impulse, the response of price dynamics obtained from the new version of the model is substantially stronger than in previous studies.

On the other hand the monetary transmission mechanism in Poland still seems to be relatively weak and slow relative to developed economies. The maximum reaction of annual inflation in Poland is twice lower and twice slower than in the United Kingdom. Simulations presented in this paper suggest that due to long lags in the monetary transmission mechanism in Poland, the monetary policy is rather inefficient in responding to temporary supply shocks.

5

6
Appendix 1: Measuring the nominal and real effective exchange rate

In the new version of the small structural model of monetary transmission mechanism in Poland a measure of the nominal effective exchange rate (e^n) based on EUR/PLN $(e^{EUR/PLN})$ and USD/PLN $(e^{EUR/PLN})$ exchange rates is used. According to a convention applied, the exchange rate is defined as a number of units of foreign currency per one unit of domestic currency. Hence the rise in the exchange rate is the appreciation of the domestic currency.

The nominal effective exchange rate is calculated as a weighted average of bilateral exchange rates. Ellis (2001) points out that even if the arithmetic average is more familiar, there are strong theoretical and statistical reasons to prefer the geometric average. In contradistinction to geometric averages, percentage movements in the arithmetic indices differ in magnitude depending on whether bilateral exchange rates are expressed as units of domestic currency per foreign currency unit or the other way around. In addition, the logarithm of a geometric average is the arithmetic average of logarithms of bilateral exchange rates. This is a particularly useful feature, which simplifies the modelling[20].

Therefore the nominal effective exchange rate used in the small structural model of monetary transmission mechanism in Poland is defined in the following way:

$$e^n = \left(e^{EUR/PLN}\right)^{w^{EUR}} \cdot \left(e^{USD/PLN}\right)^{w^{USD}} \qquad [16]$$

where w^{EUR} and w^{USD} denote arbitrarily chosen weights, reflecting a currency structure of international trade and summing to 1:

$$w^{EUR} + w^{USD} = 1 \qquad [17]$$

The equation [16] can be transformed into a logarithmic form. After substituting the condition [17] into [16], it can be written as:

$$\log\left(e^n\right) = w^{EUR} \cdot \log\left(e^{EUR/PLN}\right) + \left(1 - w^{EUR}\right) \cdot \log\left(e^{USD/PLN}\right) \qquad [18]$$

Defining the nominal effective exchange rate it is assumed that $w^{EUR} = 0.75$ and $w^{USD} = 0.25$

The real effective exchange rate is the nominal effective exchange rate adjusted for relative price levels:

$$e^r = e^n \cdot \frac{P}{P^*} \qquad [19]$$

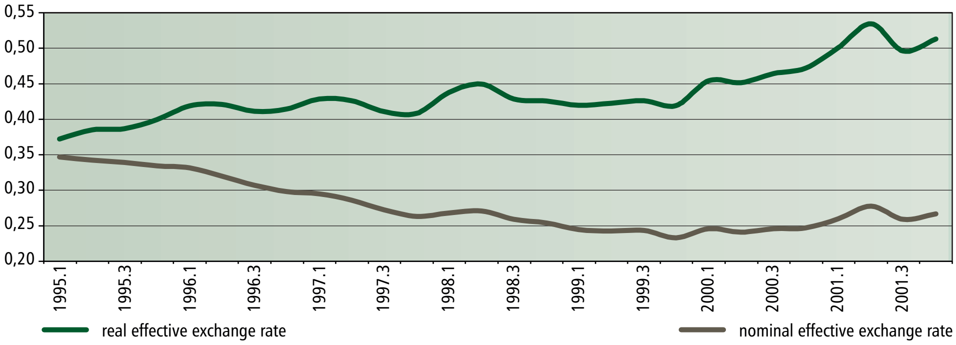
[20] L. Ellis (2001), pp. 3-4.

where P denotes the level of domestic prices while P^* the level of foreign prices, calculated as a weighted average of price levels in the Economic and Monetary Union and in the United States. Weights used to compute the foreign price level are exactly the same as those used while calculating the nominal effective exchange rate:

$$P^* = \left(P^{EUR}\right)^{w^{EUR}} \cdot \left(P^{USD}\right)^{w^{USD}} \quad [20]$$

The nominal effective exchange rate and the real effective exchange rate computed in a manner described above are presented below (Figure 13).

Figure 13. Nominal and real effective exchange rate in Poland (1995-2001)



There are two nominal exchange rates appearing in the small structural model of monetary transmission mechanism in Poland: the nominal effective exchange rate as well as the USD/PLN exchange rate. The arbitrage condition leads to the relationship [21]:

$$e^{EUR/PLN} = e^{EUR/USD} \cdot e^{USD/PLN} \quad [21]$$

which is equivalent to a condition as follows:

$$\log\left(e^{EUR/PLN}\right) = \log\left(e^{EUR/USD}\right) + \log\left(e^{USD/PLN}\right) \quad [22]$$

Substituting the equation [22] into the equation [18] one can derive the following relationship:

$$\log\left(e^{USD/PLN}\right) = \log\left(e^{n}\right) - w^{EUR} \cdot \log\left(e^{EUR/USD}\right) \quad [23]$$

The equation [23] is applied in the small structural model of monetary transmission in Poland to determine changes in the USD/PLN exchange rate reflecting movements in the nominal effective exchange rates, caused by exogenous disturbances or the operation of the uncovered interest rate parity condition.

7
Appendix 2: Basic diagnostics of the model's equations

Aggregate demand curve – equation [1]

$$\left(\log(y_t)-\log(y_t^*)\right)=-0.07+\underset{(0.15)}{0.41}\cdot\left(\log(y_{t-1})-\log(y_{t-1}^*)\right)-\underset{(0.15)}{0.32}\cdot i_{t-2}^r-\underset{(0.02)}{0.09}\cdot\log(e_{t-1}^r)$$

TSLS

Sample: 1997.1-2002.1
R^2: 0.82
R^2 adjusted: 0.78
DW: 2.10

Phillips curve – equation [2]

$$\pi_t^C=-0.02+\overline{\pi_t^e}+\underset{(0.12)}{0.34}\cdot\left(\log(y_{t-3})-\log(y_{t-3}^*)\right)-\underset{(0.00)}{0.02}\cdot\log(e_{t-1}^r)+\underset{(0.00)}{0.01}\cdot s^{(1)}$$

OLS

Sample: 1995.1-2001.4
R^2: 0.89
R^2 adjusted: 0.88
DW: 1.77

The value of intercept was imposed in order to make the sign of the coefficient on the real effective exchange rate consistent with the theory. To avoid excessive subjectivism, the choice of this value was done in two steps. In the first one, the Phillips curve was estimated without the real effective exchange rate. In the second step the equation [2] was estimated in its above written form with such a value of intercept, which made the coefficient on the output gap equal to that one from the estimation within the first step. Since the real effective exchange rate is used to capture direct effects of the exchange rate channel, its appearance in the Phillips curve should not change the output gap coefficient.

Food price dynamics – equation [3]

$$\pi_t^F=-0.02+\underset{(0.09)}{1.48}\cdot\pi_t-\underset{(0.09)}{0.48}\cdot\pi_{t-1}^F-\underset{(0.05)}{0.11}\cdot\left(\log(p_{t-1}^F)-\log(p_{t-1})\right)$$

OLS

Sample: 1997.1-2002.1
R^2: 0.76
R^2 adjusted: 0.74
DW: 2.02

Individuals' inflationary expectations – equation [6]

$$\pi_t^e=\underset{(0.05)}{0.82}\cdot\pi_{t-1}^e+\underset{(0.05)}{0.13}\cdot\pi_t$$

OLS

Sample: 1997.1-2001.4
R2: 0.95
R2 adjusted: 0.94
DW: 2.21

8
References

Bank of England (1999): *Economic models at the Bank of England*. London.

Batini N., Haldane A. (1999): *Forward-looking rules for monetary policy*. Bank of England Working Paper, No. 91, January.

Bekaert G., Wei M., Xing Y. (2002): *Uncovered interest rate parity and the term structure*. NBER Working Paper, No. 8795, February.

Bernanke B. S., Blinder A. S. (1988): *Credit, money and aggregate demand*. In: „American Economic Review", No. 78, May, pp. 435-439.

Brzoza-Brzezina M., Kłos B., Kot A., Łyziak T. (2002): *Hipoteza neutralności pieniądza [Money neutrality hypothesis]*. „Materiały i Studia", No. 142, National Bank of Poland.

Ehrmann M. (2000): *Comparing monetary policy transmission across European countries*. In: „Weltwirtschaftliches Archiv. Review of World Economics". Kiel Institute of World Economics, Tübingen.

Ellis L. (2001): *Measuring the real exchange rate: pitfalls and practicalities*. Research Discussion Paper 2001-04, Reserve Bank of Australia, August.

Freitas P. S., Muinhos M. K. (2001): *A simple model for inflation targeting in Brazil*. Working Paper Series, No. 18, Banco Central do Brasil, April.

Kokoszczyński R. [ed.] (1999): *Mechanizm transmisji impulsów polityki pieniężnej: przegląd głównych teorii oraz specyfikacja transmisji w Polsce [Monetary transmission mechanism in Poland. Review of principal theories and specification of the transmission in Poland]*. „Materiały i Studia", No. 91, National Bank of Poland.

Łyziak T. (2000): *Badanie oczekiwań inflacyjnych podmiotów indywidualnych na podstawie ankiet jakościowych [Examination of individuals' inflationary expectations on the basis of qualitative surveys]*. In: „Bank i Kredyt", No. 6, National Bank of Poland.

Łyziak T. (2001): *Monetary transmission mechanism in Poland. Theoretical concepts vs. evidence.* NBP Paper, No. 19, National Bank of Poland, March.

Mahadeva L., Sinclair P. (2001): *The transmission mechanism of monetary policy*. Material prepared for the Central Bank Governors' Symposium at the Bank of England on 8 June 2001, Centre for Central Banking Studies, typescript.

McCallum B., Nelson E. (1999): *An optimising IS-LM specification for monetary policy and business cycle analysis*. In: „Journal of Money, Credit and Banking", No. 31

Meredith G., Chinn M. D. (1998). *Long-horizon uncovered interest rate parity*. NBER Working Paper, No. 6797, November.

Muinhos M. K. (2001): *Inflation targeting in an open financially integrated emerging economy: the case of Brazil*. Working Paper Series, No. 26, Banco Central do Brasil, August.

Razzak W. A. (2002). *Monetary policy and forecasting inflation with and without the output gap*. DP2002/03, Reserve Bank of New Zealand, March.

Svensson L. E. O. (1998). *Open-economy inflation targeting*. „Journal of International Economics", No. 50 (2000), pp. 155-183.

Woodford M. (2002): *Interest and Prices*. Foundations of a Theory of Monetary Policy, Princeton University Press, forthcoming.