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Wojciech Maliszewski

VAR-ing Monetary Policy in Poland

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Abstract

The paper makes an attempt to estimate the effects of monetary policy shocks on the economy. We estimate four variables VAR system with industrial production, CPI, money market rate and exchange rate. Two policy indicators: money market interest rate and exchange rate are assumed to be contemporaneously influenced by monetary policy shocks. The identification of the shocks is obtained by assigning weights to these two variables in the short run monetary condition index. The response functions generated by the small VAR system have reasonable shapes and economic interpretations: monetary policy shock seems to affect inflation and output relatively quickly. Granger causality tests reveals that although money market rate has limited predictive power in forecasting industrial production and CPI, the predictive power of exchange rate is very significant for the CPI. Decomposition of variance of the forecasted variables is consistent with these results: monetary policy shocks have significant contribution to the forecast variance of CPI.

1. Introduction

Poland, one of the most successful reformers in the Central Europe, reduced inflation rate to the one digit level only nine years after achieving macroeconomic stabilisation. A possible explanation for the slow progress is that moderate inflation was perceived to be too costly to be reduced quickly [Krzak, 1998]. Consequently, Polish authorities followed a strategy of gradual disinflation, reducing potential output losses. Monetary policy, constrained by the crawling peg regime, was consistent with this strategy. The aim of this research is an empirical analysis of the role of monetary policy in reducing inflation, focusing on the effects of monetary policy shocks on the economy.

The research will proceed as follows: first, a brief descriptive analysis of the monetary and exchange rate policies is presented. Next section discusses various methods of measuring the effects of monetary policy shocks on the economy. The econometric methodology and the estimation method are described next. Next sections present some results and show some simulations based on the empirical model. Last section concludes.

2. Monetary Policy in Poland

The gradual disinflation strategy adopted by Polish authorities was based on a mixture of exchange rate and monetary targets. As the monetary policy was constrained by the exchange rate regime, these two policies should be analysed jointly. Due to structural, institutional and policy changes several distinct stages can be distinguished in the process of disinflation. Below we discuss the operation of the monetary and exchange rate policies in the changing environment.

2.1. Overview of Disinflation Strategy

Initial macroeconomic stabilisation was based on the exchange rate peg combined with credit rationing, positive real interest rates, balanced budget and restrictive income policy. The stabilisation stage was successful, but the inflationary impact of price liberalisation was stronger and more persistent than expected. Moreover, the real economy sharply contracted, bringing a subsequent easing of the policy in 1991. High

fiscal deficit, wage push and negative interest rate slowed down the disinflationary process. Weaker policy eroded competitiveness and undermined the exchange rate peg, leading to devaluation in May 1991 and a switch to a crawling peg in October 1991.

Inflation was persistent in 1992–1994, when the monetary expansion was fuelled by the fiscal deficit, financed mostly by the National Bank of Poland (NBP) and the banking system. The fiscal deficit in 1992 amounted to six percent of GDP and was financed in over 40 percent by the central bank. Significant fiscal adjustments were made in 1993, when the deficit was reduced to three percent of GDP but almost 40 percent of it was still financed by the NBP. In 1994 this proportion remained at a high, 35 percent level. Interest rates were low in real terms after substantial reductions at the beginning of 1993. The rate of crawl was set in line with the disinflation strategy but several step devaluations impaired the effectiveness of the exchange rate anchor. However, some progress in reducing inflation was achieved due to fiscal adjustment in 1993 and weak domestic demand [IMF, 1997].

In 1995 the role of budget deficit financing declined and the increasing net foreign reserves became the main source of monetary expansion (the capital inflow began when Poland gained favourable credit ratings from international agencies). In response to increasing net international reserves the exchange rate peg was replaced by the target zone system in May 1995. As anticipated, the zloty appreciated after an introduction of the new system but the reserves were still growing due to expectations of further appreciation. Initially, the target zone regime did not bring any significant increase in uncertainty to the exchange rate movements since the zloty was persistently close to the upper bound of the zone. The monetary authorities employed large-scale open market operations to sterilise the effects of growing foreign reserves. The capital inflow was slowed down by interest rate cuts at the end of 1995 and by further appreciation of the zloty in 1996 (in December 1996 the central rate of the band was revalued by 6 percent). The appreciation produced a strong anti-inflationary push. It not only affected the price setting behaviour of economic agents through a competitive pressure but also increased demand for real money balances. This increase was strong enough to absorb the monetary expansion created by growing net international reserves [Durjasz and Kokoszczynski, 1998].

From mid-1996 foreign capital inflow was reduced but low interest rates, necessary to restrain the rapid growth of reserves, contributed to the domestic credit expansion. Growing domestic demand became a new source of inflationary pressure and called for monetary tightening. Interest rates were increased several times since the end of 1996 and some other measures were taken by the NBP to contain the growing inflationary pressure (see below). These steps did not increase foreign capital inflows because of high

uncertainty after currency crises in emerging markets. Consequently, the monetary policy was successful in exerting downward pressure on inflation in 1997 and in 1998. Interest rates were subsequently lowered when inflation was reduced to one digit level and some adverse external shocks (Russian and Asian crises) hit the economy.

2.2. Operation of the Monetary Policy

Operation of the monetary policy in Poland has been constrained by availability of policy instruments, exchange rate regime and fiscal policy. The constraints were changing with developments of the money and capital markets, and the evolution of the exchange rate system. The operational targets of the central bank were also changing in the period under investigation.

At the initial stage of macroeconomic stabilisation the monetary system was in the process of transformation from the monobank to the modern two-tier banking system. The National Bank of Poland faced difficult initial conditions at the beginning of the process. There was an excess liquidity in the banking system, excess reserves were subject to large fluctuations due to the inefficient payment system, money market did not exist and real interest rates were negative [Ugolini 1996, Balino et al., 1994]. In response to these unfavourable circumstances monetary authorities had to rely on the credit ceilings as the main policy instruments. The central bank was also reducing excess liquidity by issuing National Bank bills, replaced by the Treasury Bills in 1991. In addition, the refinancing policy was tightened, interest rates were increased to the positive real values and the reserve requirements were increased to the maximum legal limit (30 percent). In 1992 the NBP began first repo transactions with the National Bank Bills and Treasury Bills. The money market was operating and the interest rate term structure began to emerge. As a result of these developments, the credit ceilings were abolished at the end of the year. Since 1993 the open market operations – repo, reverse repo and outright sales – became the main monetary policy instrument. Liquidity management was facilitated by a reform of the payment system in 1993, and, in 1994, an introduction of the average system for required reserves and a possibility to use reserves for settlement purposes (these steps considerably reduced excess reserves of the banking system). After 1993 the required reserves remained the only non-market instruments used in the monetary policy. Another non-market measure was introduced temporarily in 1997: in order to sterilise the impact of credits to the government (taken for financing expenditure after the flooding), the central bank began collecting deposits from households. The action put pressure on the commercial bank to raise their deposit and credit interest rates [Durjasz and Kokoszczynski, 1997].

The National Bank of Poland monetary policy has been constrained by the exchange rate regime. The exchange rate was fixed until May 1995 (with step devaluation in May 1991). From October 1991 the crawling peg was introduced, with the rate of crawl set by the central bank and the ministry of finance. In May 1995 the system was replaced by a more flexible target zone arrangement. In the fixed or quasi-fixed exchange rate systems interest rate policy could not be fully independent but the degree of flexibility in the monetary policy seemed to be quite sizeable, at least in the first years of reforms. The increasing net international reserves became a problem for monetary authorities in 1994 and, as discussed above, was a serious challenge for conducting monetary policy in 1995. As indicated by IMF estimates [IMF, 1997], the sterilisation of capital inflow was effective but very expensive: offset coefficient was in the range of -0.57 to -0.62 (where -1 means totally ineffective sterilisation). Moreover, Gomulka (1997) estimates that the portfolio capital was not very sensitive to changes in the yield differentials. This result indicates that there was some room for an independent interest rate policy even in the period of fast growing net international reserves.

Budget deficit financing was an important element limiting independence of the monetary policy in the 1990–1994 period. The legal ceiling on the central bank credit to the government (3 percent of GDP) was suspended by the parliamentary act in this period. The dependence of the government on the monetary deficit financing was high due to underdevelopment of the capital market and inability to finance the deficit outside the banking sector. Development of the capital markets and the foreign portfolio investments have changed this situation. As a result, the deficit financing has not significant effect on monetary expansion from 1995 onwards.

The final objective of the National Bank of Poland is price stability. In practice, the final inflation objective is consistent with the annual inflation target set in the budget law. This annual target was met for the first time only in 1998. Although deviations between the targeted inflation and actual outcomes were diminishing over time, it seems that the monetary authorities did not attempt to strictly adhere to the target, "as long as inflation was kept broadly on a gradual downward path" [IMF, 1997]. The intermediate objective of the monetary policy has been broad money growth. However, the targets for M2 growth specified by the NBP in the annual assumptions for the monetary policy were never met and were adjusted to the developments in the money demand. The operational target of the central bank was changing between the money market rate (1993–1995) and the reserve money (1996–1997). In practice, the money market rate (T/N reverse repo rate) has always been regarded as an important instrument of the monetary policy [Opiela, 1998]. The scope for independent interest rate policy increased after introduction of the target zone system in May 1995. The use of interest rate as an instrument of monetary policy in the period of official reserve money targeting was

observed at the end of 1996. The role of the money market rate as a policy instrument increased in 1997 [Opiela, 1998] and in 1998 has been officially adopted as an intermediate target by the newly established Monetary Policy Council.

3. Measuring Effects of Monetary Policy

Numerous studies have been devoted to measuring the stance of monetary policy and its impact on the economy. In a traditional approach changes in monetary aggregates were identified as a policy indicator, under an assumption that they reflect changes in money supply targeted by monetary authorities. This approach is not satisfactory, since the growth of monetary aggregates can depend on other, non-policy factors. If central bank accommodates money demand shocks the observable changes in money reflect both money supply and demand shocks. Recent empirical studies attempt to alleviate this problem by identifying changes in the policy directly, focusing on specific operating procedures of the central bank. Two main approaches can be distinguished in the recent empirical works: a "narrative" approach, based on the informal analysis of Central Bank documents, and an econometric analysis, based on the structural VAR modelling. Romer and Romer (1989) apply the first method, analysing the minutes of the Federal Open Market Committee. Some better known examples of the structural VAR methodology, adopted in this paper and discussed in detail below, include Bernanke and Blinder (1992), Sims (1992), Strongin (1995), and Bernanke and Mihov (1996).

The aim of the VAR methodology is to identify monetary shocks, and their effect on the economy, by imposing some minimal identifying assumptions on the unrestricted VAR system. As already mentioned, changes in monetary aggregates are simultaneously affected by demand and supply shocks. Thus, it is necessary to develop a statistical method capable to differentiate between these two kinds of disturbances. This is equivalent to an estimation of the money supply and demand curves, where shifts in the supply curve can be interpreted as the policy shocks. Typically, however, the same variables enter money demand and supply equations. In this case standard econometric inference is subject to a simultaneous equation bias: the estimated coefficients are averages of the demand and supply elasticity.

In the structural VAR methodology the identification of shocks is achieved by a variety of restrictions related to central bank operating procedures. An attempt is made to estimate the authorities' policy reaction function to some changes in non-policy variables. This predictable reaction to economic development is an endogenous element of the

monetary policy. Some part of the variation in the policy instruments, however, cannot be explained by the reaction function. These changes (residuals) are directly interpretable as policy shocks, i.e. some exogenous revisions of monetary policy. A dynamic response of the non-policy variables to such policy shocks (impulse response function) allows for tracking down the effects of policy changes on the economy.

The analysis usually starts from an unrestricted VAR system with two kinds of variables: non-policy variables affecting monetary policy (including some potential policy objectives) and variables reflecting the stance of policy. In the simplest case the policy vector is a single variable – central bank rate or reserves. The economy is thus described by the following system of equations:

$$Y_t = B_0 Y_t + \sum_{i=1}^k B_i Y_{t-i} + C_0 p_t + \sum_{i=1}^k C_i p_{t-i} + A^y v_t^y \quad (1)$$

$$P_t = D_0 Y_t + \sum_{i=1}^k D_i Y_{t-i} + G_0 p_t + \sum_{i=1}^k G_i p_{t-i} + v_t^p \quad (2)$$

where Y is a vector of non-policy variables, p is a policy variable and v^y and v^p are orthogonal, "primitive" shocks. The matrix A^y in the first equation allows the non-policy shocks to enter more than one non-policy equation. The system is not identified but identification of the policy shocks (v^p) can be achieved by imposing one of two restrictions: either contemporaneous policy variables are excluded from the first equation ($C_0 = 0$) or contemporaneous non-policy variables are excluded from the second equation ($D_0 = 0$). The first restriction assumes that the economy reacts to policy action only with a lag. The second restriction assumes that there is no immediate response of monetary authorities to economic shocks. The assumption is rationalised by the fact that some data on macroeconomic aggregates are available only with lags and policymakers do not react to shocks they cannot observe. Estimation of the system identified in this way starts from a reduced form VAR followed by a Cholesky decomposition of variance-covariance matrix of the reduced system. If the policy indicator is assumed to be independent from non-policy variables, it enters first in the system. Under the second assumption, the policy variable depends on all non-policy variables and thus enters last. The identifying assumptions are minimal: the method does not allow for identification of other shocks in the non-policy block.

The analysis becomes more complicated if the policy vector is not a single variable. In this case the structural system of equations become:

$$Y_t = B_0 Y_t + \sum_{i=1}^k B_i Y_{t-i} + C_0 P_t + \sum_{i=1}^k C_i P_{t-i} + A^y v_t^y \quad (3)$$

$$P_t = D_0 Y_t + \sum_{i=1}^k D_i Y_{t-i} + G_0 P_t + \sum_{i=1}^k G_i P_{t-i} + A^p v_t^p \quad (4)$$

where P is now a vector of policy variables and A^p allows shocks to policy variables to enter more than one policy equation. The elements of v^p and v^y are again assumed to be orthogonal. The identification scheme is similar to the case of a single policy indicator but the reduced form variance-covariance matrix is instead decomposed into orthogonal policy and non-policy blocks. The policy block, however, is a system of simultaneous equations itself, and some further identifying restrictions are necessary to retrieve the structural parameters and a pure policy shock. The identification is achieved by various assumptions about the operation of the money market and monetary authorities. Researchers typically focus on the interaction between the markets for borrowed and non-borrowed reserves [Bernanke and Mihov, 1996; Strongin, 1995]. The analysis allows for better identification of the policy shocks and for choosing among alternative policy indicators. The interpretation of the identified policy shocks and impulse responses is identical to the scalar case.

4. Econometric Methodology and Estimation Procedure

The main problem in modelling monetary policy is an appropriate choice of the policy variables. In the empirical part of the paper I apply the structural VAR methodology with two policy indicators: money market interest rate and exchange rate. As discussed above, the operating procedures of the National Bank of Poland were changing over time, but there is a strong evidence that the money market rate was closely monitored and, to some extent, influenced by the central bank even in the period of the official reserve money targeting. Until recently, the exchange rate was adjusted in the crawling peg and crawling band systems.

As discussed above, introduction of two policy variables requires some further identifying restrictions than simple orthogonality between the policy and non-policy blocks. Our approach follows Smets (1997), who analyses monetary policy in Germany, Italy and France, assuming that monetary authorities target a weighted average of exchange and interest rates. In this case the policy block P in equation (4) contains interest rate and exchange rate and the vector of (orthogonalised with respect to non-policy variables) errors $A^p v_t^p$ becomes:

$$A^p v_t^p = \begin{vmatrix} u_t^{MR} \\ u_t^{EXR} \end{vmatrix} = \begin{vmatrix} a_1 & a_2 \\ a_3 & a_4 \end{vmatrix} \begin{vmatrix} v_t^{pp} \\ v_t^{px} \end{vmatrix} \quad (5)$$

or

$$u_t^{MR} = a_1 v_t^{pp} + a_2 v_t^{px} \quad (6)$$

$$u_t^{EXR} = a_3 v_t^{pp} + a_4 v_t^{px} \quad (7)$$

Equations (5) and (6)–(7) say that errors in interest rate (u_t^{MR}) and exchange rate (u_t^{EXR}) equations are mixtures of policy shocks (v_t^{pp}) and exogenous shocks (v_t^{px}) due to adjustments in the risk premium, shifts in exchange rate expectations, foreign interest rate shocks etc. The system (6)–(7) is unidentified by one restriction to identify it. After solving (6)–(7) for the policy shock in terms of reduced form residuals and renormalising the policy shock such that the sum of the weights on the interest rate and exchange rate residuals sum to one we have:

$$v_t^{pp} = (1-w)u_t^{MR} + wu_t^{EXR} \quad (8)$$

Equation (8) may be interpreted as a short-term monetary condition index (MCI) and $(1-w)$, w as weights attached to interest rate and exchange rate by monetary authorities. The weights, if known, provide a sufficient identification restriction for the system (6)–(7). Smets (1997) estimates the weights by GMM, in our approach we impose them exogenously and check sensitivity of the model to various assumptions about their values.

Non-policy variables in our VAR system are consumer price index and industrial production index. These variables correspond to potential final objectives of the monetary policy. While the price stability is a statutory objective of the National Bank of Poland, the bank is obliged to support the economic policy of the government if it does not interfere with the former. Although broad money (M2) is a formal intermediate objective of the bank, this variable does not enter into the system. The money demand function in Poland seems to be unstable and, in practice, the monetary authorities adjust their targets to meet the more general objective of gradual disinflation (presumably with some weight given to output losses).

The effective estimation period starts only in 1993, when the modern payment system and the central bank open market operations became fully operational (monetary policy was based on non-market instruments, i.e. credit rationing before 1993). The model is estimated with monthly observations from January 1993 to April 1999. Industrial production index and consumer price index are seasonally adjusted and in logs, exchange rate (defined as average of USD/PLN and DM/PLN rates) is in log and money market rate is not transformed. The description of the variables is given in appendix.

The data are probably non-stationary but, as often in the VAR analysis, stationarity and cointegration analysis is skipped. We believe that limited sample does not allow for drawing precise conclusions about the long-run properties of the series and consequently we do not impose cointegration/no-cointegration restrictions. Similarly, we do not test for lag length in the VAR but instead we set it exogenously to six. The final specification and residual tests are presented in the appendix. Diagnostic tests do not indicate misspecification of the system. Stability tests (not reported) suggest that the reduced form VAR is relatively stable, although some problems with stability of the exchange rate equation are indicated (linear VAR model may not be well suited to model the discrete changes in exchange rate regime).

5. Results and Simulations

5.1. Impulse Responses to Policy Shocks

The estimated VAR is a reduced form of the structural equations (3) and (4). The orthogonalisation of the policy block residuals is achieved by assuming that there is no contemporaneous effect of the policy actions on the economy. Identification of the policy shock follows from the choice of MCI weights $(1-w)$ and w , as discussed above. The responses of industrial production, CPI, money market rate and exchange rate to monetary policy tightening are plotted on figures 1–3 under alternative assumptions about w ($w=0.25$, $w=0.5$, $w=1$).

The pattern of response is similar for $w=0.25$ and $w=0.5$. The results are consistent with the theoretical presumptions: both inflation and output decrease after a negative monetary shock. The shock is reflected in higher interest rate and exchange rate appreciation (since exchange rate is defined as foreign currency/zloty). The response of CPI is the highest about six to ten month after the shock and the effect of shock is persistent. Industrial production also drops to the lowest level six to ten month after the shock and recovers afterward. Alternative identification with $w=1$ (pure exchange rate targeting) gives implausible impulse responses for interest rate and inflation. In what follows we will use identification with $w=0.5$.

The pattern of response is similar for $w=0.25$ and $w=0.5$. The results are consistent with the theoretical presumptions: both inflation and output decrease after a negative monetary shock. The shock is reflected in higher interest rate and exchange rate appreciation (since exchange rate is defined as foreign currency/zloty). The response of CPI is the highest about six to ten

Figure 1. Impulse responses of industrial production (IIP), CPI, money market interest rate and exchange rate to monetary policy shock ($w = 0.25$)

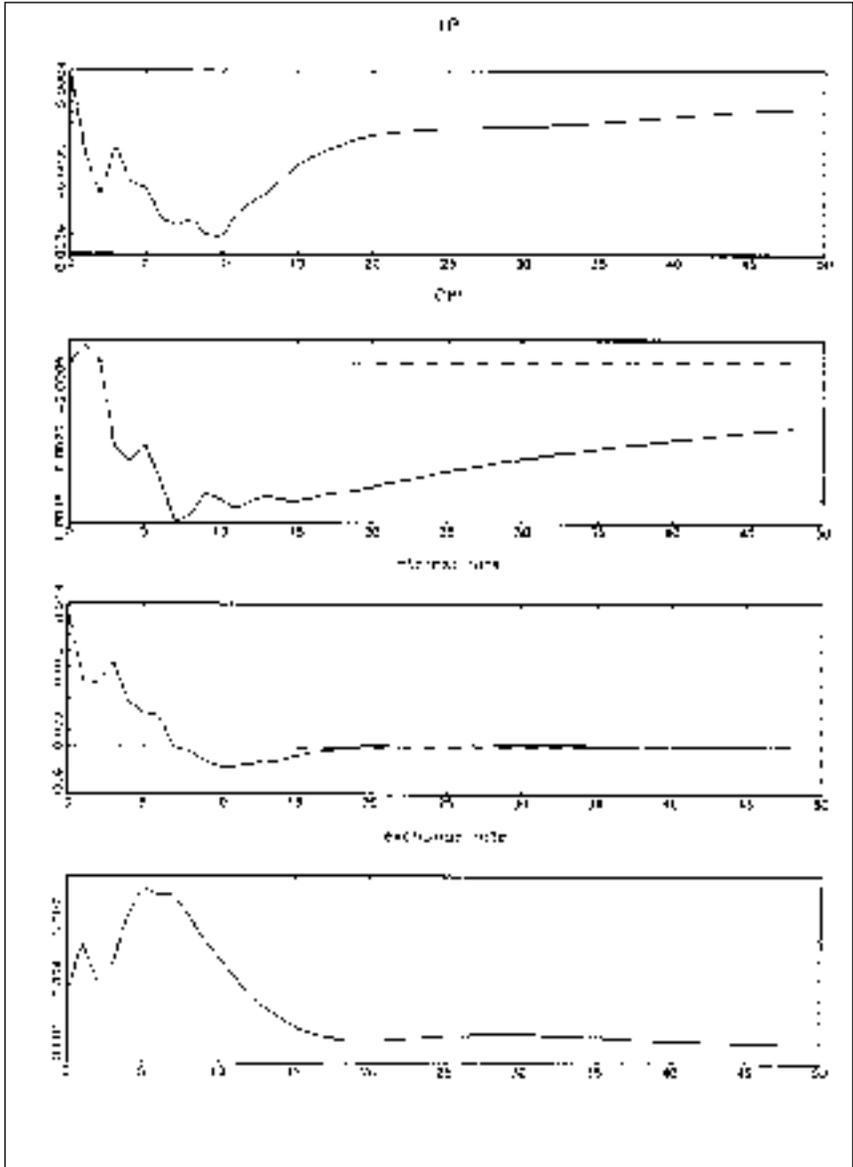


Figure 2. Impulse responses of industrial production (IIP), CPI, money market interest rate and exchange rate to monetary policy shock ($w = 0.5$)

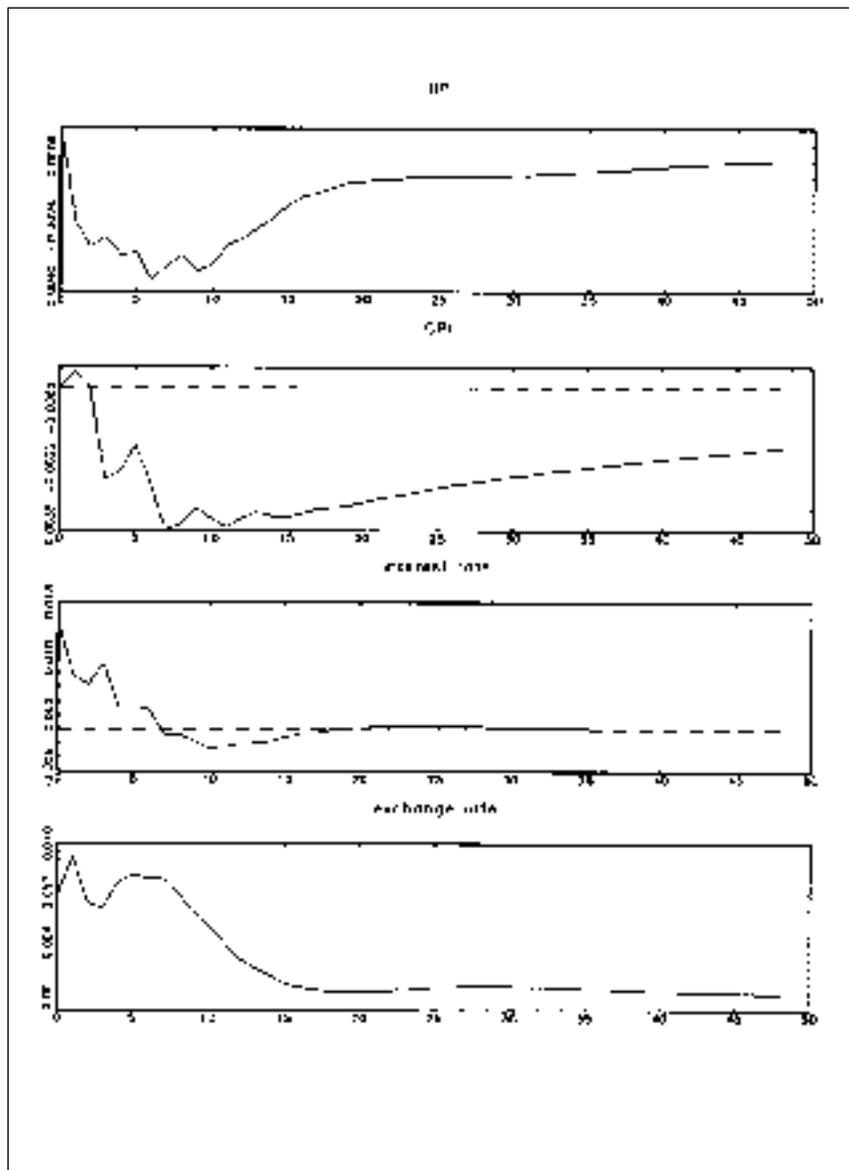
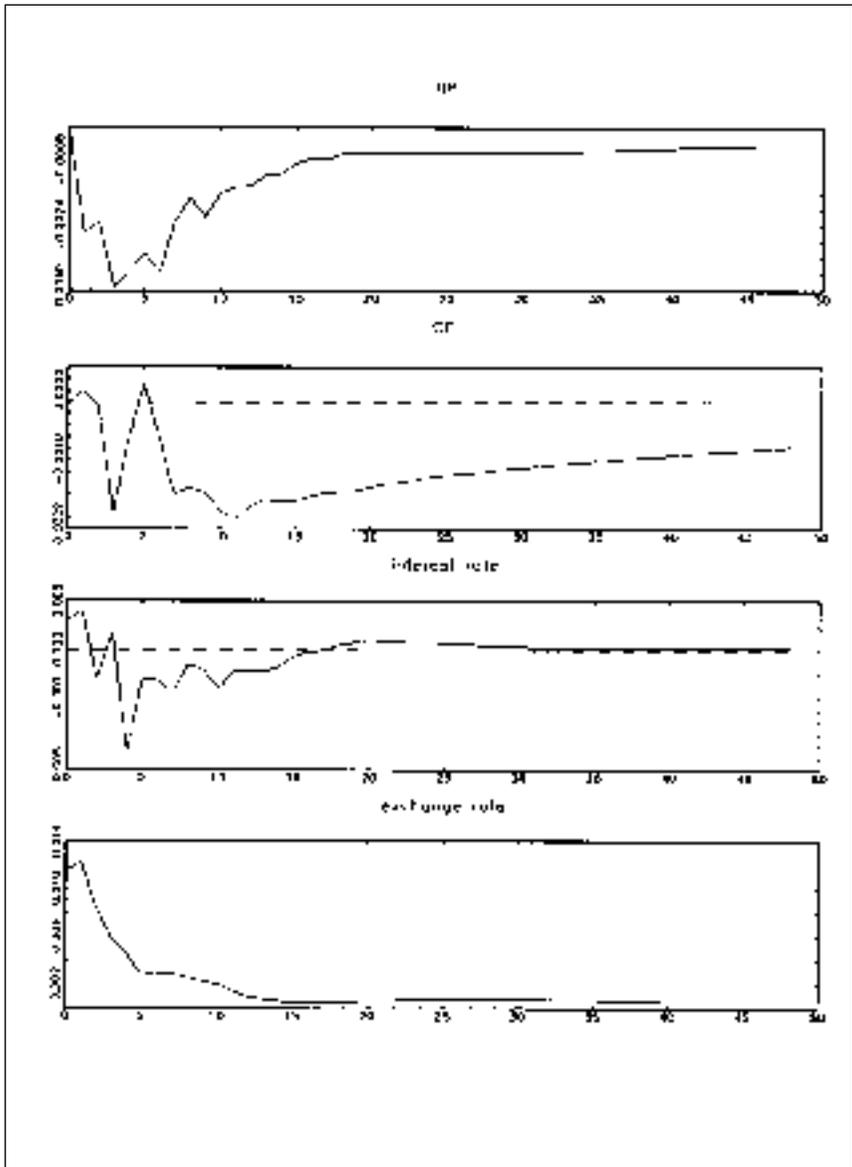


Figure 3. Impulse responses of industrial production (IIP), CPI, money market interest rate and exchange rate to monetary policy shock ($w = 1$)



month after the shock and the effect of shock is persistent. Industrial production also drops to the lowest level six to ten month after the shock and recovers afterward. Alternative identification with $w=1$ (pure exchange rate targeting) gives implausible impulse responses for interest rate and inflation. In what follows we will use identification with $w=0.5$.

5.2. Granger Causality Tests

To assess the strength of the relationship between the policy indicators and other variables in the system, we run Granger causality tests based on the estimated VAR systems. The tests detect if the variable of interest has any (statistically significant) predictive power in forecasting other variables in the model. As the test is very sensitive to the methods used to deal with potential non-stationarity of the series, we perform the tests for levels and differences with six lags of each variable. The marginal significance levels for the null hypothesis that all lags of the money market rate can be excluded from either the industrial production, CPI or exchange rate equations (in levels) are reported in the third column of Table I. The tests for predictive power of industrial production,

Table I. Marginal significance levels of variables for forecasting (levels, 6 lags)

	Explanatory variable			
	Industrial production	CPI	Money market rate	Exchange rate
<u>Forecasted variable:</u>				
Industrial Production		0.316	0.962	0.195
CPI	0.609		0.671	0.062
Money market rate	0.102	0.340		0.400
Exchange rate	0.792	0.606	0.051	

Table 2. Marginal significance levels of variables for forecasting (first difference, 6 lags)

	Explanatory variable			
	Industrial production	CPI	Money market rate	Exchange rate
<u>Forecasted variable:</u>				
Industrial Production		0.422	0.996	0.185
CPI	0.525		0.413	0.027
Money market rate	0.194	0.599		0.243
Exchange rate	0.727	0.643	0.710	

CPI and exchange rate are presented in remaining columns (F statistics are reported for all tests). The tests for first differences of variables are reported in Table 2.

Table 1 and 2 show that the money market rate has very limited predictive power in industrial production and CPI equations (the F-statistics do not reject the null hypothesis of no Granger causality, both for levels and changes). However, it has a significant predictive power in exchange rate equation estimated in levels. This effect disappears in equations re-estimated using first differences. The exchange rate has in turn a significant predictive power in CPI equation estimated in both ways. Obviously, the results should be interpreted with caution. The short sample under investigation does not allow for very strong statistical conclusions about the causality between variables. Moreover, channels of monetary transmission are changing continuously with institutional and systemic changes in the economy and the simple statistical model with fixed parameters may be inappropriate for modelling the varying relations. Thus, a weak predictive power of the money market rate in non-policy equations may result from misspecification of the test. Still, the causality from exchange rate to CPI is very strong and robust to different specifications.

The tests for predictive power of non-policy variables in the money market equation show some predictive power of industrial production in the money market rate equation. If the money market rate is a good measure of monetary policy, its endogeneity with respect to non-policy variable would mean that monetary authorities react to past developments in the economy in a pre-specified way. However, the relationship is weak, which is intuitive in a complicated transition environment with uncertain channels of monetary transmission. An alternative interpretation is that the central bank reacts to some other set of information about the economy rather than to the simple aggregates used in the test.

5.3. Variance Decomposition

Another measure of predictive power in the VAR system is contribution of alternative variables to the variance of forecasted variable. The decomposition is based on orthogonalised residuals and thus, as in the case of impulse response function, depends on the identification scheme. In this section we assume that $w=0.5$ and we adopt an additional identifying restriction by applying Cholesky decomposition to the covariance matrix of the non-policy block in equations (3)–(4). We assume that industrial production enters first and CPI second in the non-policy block, but our primary interest is in contribution of the identified policy shocks, which is not sensitive to the non-policy block identification. Table 3 reports decomposition of variance for all variables in the estimated VAR at a 12, 24 and 36-month horizon.

Table 3. Variance decomposition of forecasted variables

	Contribution of:			
	Shocks to IIP	Shocks to CPI	Monetary policy shocks (v^{PP})	v^{PX}
Forecast horizon = 12				
Forecasted variable:				
IIP	75.9%	2.1%	18.0%	4.0%
CPI	15.9%	54.3%	27.9%	1.9%
Money market rate	15.9%	6.3%	48.9%	28.9%
Exchange rate	2.0%	13.9%	59.9%	24.2%
Forecast horizon = 24				
Forecasted variable:				
IIP	71.4%	2.2%	22.6%	3.8%
CPI	17.7%	37.6%	43.3%	1.3%
Money market rate	16.6%	7.5%	48.1%	27.8%
Exchange rate	2.9%	14.0%	60.0%	23.2%
Forecast horizon = 36				
Forecasted variable:				
IIP	69.6%	2.5%	24.2%	3.7%
CPI	18.0%	32.8%	48.1%	1.2%
Money market rate	16.6%	7.5%	48.2%	27.7%
Exchange rate	3.8%	14.0%	60.0%	22.3%

The decomposition of CPI variance shows that thirty percent of the variance can be explained by monetary policy shocks at a 12-month horizon, forty percent at a 24-month horizon and almost fifty percent at a 36-month horizon. Much smaller variance of industrial production can be attributed to the policy shocks: from 20 percent at the 12-month horizon to 24 percent at the 36-month horizon. Since part of exchange rate variation reflects monetary policy shocks, the results are consistent with the Granger causality tests reported above. Only small variance of the money market rate variation is explained by any of the non-policy variables, again suggesting that an endogenous component of monetary policy is hard to detect.

6. Conclusions

This paper makes an attempt to estimate the effects of monetary policy shocks on the economy. We estimate the four variables VAR system with industrial production, CPI, money market rate and exchange rate. Industrial production and CPI are likely to be affected by monetary policy shocks and should also influence central bank decisions on the monetary policy. Two policy indicators: money market interest rate and exchange rate are contemporaneously influenced by monetary policy shocks. The identification of these shocks is obtained by assuming weights given to these two variables in the short run monetary condition index. The estimation of the small VAR system allows for the analysis of the response of "non-policy" variables to exogenous policy shocks. The response functions generated by the model have reasonable shapes and direct economic interpretations. A monetary policy shock seems to affect inflation and output relatively quickly; their effects are the highest within six months from the shock for inflation and within ten month for industrial production.

However, Granger causality tests reveals that although money market rate has very limited predictive power in forecasting industrial production and CPI, the predictive power of exchange rate is very significant for CPI. Decomposition of variance of the forecasted variables is consistent with these results: monetary policy shocks have significant contribution to the forecast variance of CPI. On the other hand, a regular response of the monetary authorities to the developments in CPI and industrial production seems to be hard to detect.

We conclude that the results are well interpretable and consistent with economic theory. In particular, the exchange rate policy seems to have a powerful influence on other nominal variables. This result suggests that the crawling peg and crawling band systems significantly contributed to the persistent, moderate inflation in the period under investigation. Reduction of the rate of crawl should have a dramatic impact on inflation performance. However, the monetary transmission mechanisms are still not fully developed and the sample under investigation is probably too short to draw any decisive conclusions about the effects of monetary policy on the economy. Thus, the use of interest rate as an instrument of monetary policy may be much more difficult and the effects of changes in this instrument, if significant at all, will be difficult to predict.

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Appendix

Sources of the variables and transformations

Money market rate MMR (weighted average of the WIBOR rate with maturity up to 1 month) – NBP

Exchange rate EXR (constructed as $0.5 \cdot \text{USD/PLN} + 0.5 \cdot \text{DM/PLN}$) – NBP

Consumer Price Index CPI – Central Statistical Office

Index of Industrial Production IIP – Central Statistical Office

Diagnostic statistics (system with 6 lags, estimated over 1993.7 – 1999.4)

Statistic	ICPI	IIP	MRIM	IEXR_INV
AR 1- 5F(5, 40)	0.230118 [0.9471]	1.5973 [0.1830]	1.9736 [0.1036]	2.15 [0.0791]
Normality $\chi^2(2)$	7.7549 [0.0207] *	4.9513 [0.0841]	2.4467 [0.2942]	5.8727 [0.0531]
ARCH 5 F(5, 35)	1.1374 [0.3592]	0.411458 [0.8375]	0.483201 [0.7864]	0.480768 [0.7881]

The following tests are reported:

- Breusch-Godfrey LM test for serial autocorrelation, obtained by regressing the residuals from the original model on all regressors of that model and the lagged residuals;
- ARCH test for autoregressive conditional heteroscedasticity, obtained by regressing the squared residuals from the model on their five lags;
- Doornik and Hansen (1993) univariate test for normality.



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