

Monetary Policy in Transition Economies

Wojciech S. Maliszewski

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London School of Economics and Political Science
University of London

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ABSTRACT

These essays look at determinants of inflation and policies to control it at different stages of transition. It attempts to determine what factors have shaped the inflationary process, how successful were the policies adopted to control inflation, and what policy conclusions can be drawn from the experience of transitional economies. The first paper analyzes central bank independence in transitional economies, regarded as key for a successful monetary policy making. The results show that the central bank independence started to influence inflation only after the initial transitional shocks.

The next two papers analyze monetary transmission mechanisms in less advanced economies, choosing Georgia and Romania as examples. The papers estimate structural models of inflation. The results show that, in the case of Romania, inflation was driven by a monetary expansion. Interactions between real and monetary developments were limited when inflation was high. In Georgia, where the dichotomy between the real and monetary sectors is also evident in the data, the tight control over the exchange rate was crucial for maintaining a low-inflation equilibrium.

The third paper focuses on inflation in advanced transitional economies, analyzing transmission mechanisms and assessing the implementation of inflation targeting in the Czech Republic and Poland. The results show that the exchange rate has played a significant role in the transmission mechanism, suggesting that the behavior of this variable should be carefully watched even under an inflation targeting regime.

The last paper in the thesis analyzes the credibility of inflation targets, which is the main factor affecting the costs of disinflation under the inflation targeting framework. The paper attempts to identify to what extent inflationary expectations in Poland were guided by announcements of the targets. The results show that the credibility of the targets increased after the introduction of inflation targeting, but dropped quickly after the target was missed.

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1 INTRODUCTION

Controlling inflation has proved to be a difficult task for many transitional economies in Central and Eastern Europe. The end of central planning was associated with severe macroeconomic disequilibria, which led to an outburst of inflation after price liberalization. The effects of the initial shock lasted longer than expected, and when the high inflation finally declined, it still remained well above the level consistent with price stability. The process of reducing inflation from moderate to low levels was long and costly even in the most successful economies.

While the shock related to price liberalization was a unique feature of the transition environment, inflation in subsequent years is more amenable to standard macroeconomic policy analysis. High inflations were usually associated with excessive monetary expansion. Persistent moderate inflations were often linked to stubborn inflationary expectations. The standard features of the problem called for typical solutions, such as monetary tightening and various policies to break the inertia in expectations.

These essays look at determinants of inflation and policies to control it at different stages of transition. I attempt to determine what factors have shaped the inflationary process, how successful were the policies adopted to control inflation, and what policy conclusions can be drawn from the experience of transitional economies.

The first paper¹ sets the stage for the analysis by determining what institutional and political features have played a role in explaining inflation and how such influences varied over time. If inflation was driven largely by exogenous shocks and pre-transitional disequilibria, a standard monetary policy analysis—even with certain modifications as pursued later in the essays—would be inadequate. Defining the time when monetary policy started exerting influence on inflation is important to avoid misspecification in the subsequent analysis.

The paper concentrates on central bank independence, regarded as key for successful monetary policy making, but also considers other elements characteristic for

¹ Published in Economics of Transition (Maliszewski, 2000)

the transitional environment. Overall progress in transition, the fiscal position, and the adoption of a stabilization program supported by multinational organizations are considered as determinants of inflation. Testing for the effect of central bank independence together with these variables is interesting on its own and comparable to several studies conducted on other sets of countries. Given the fact that independent central banks are also likely to pursue a more restrictive monetary policy, these tests can also be regarded as a way to determine when this policy started playing an independent role in shaping inflation in addition to early transitional shocks, fiscal policy and external commitments.

This paper was one of the first attempts to analyze the institutional and political determinants of inflation, controlling for more elements than its predecessors and fully exploiting time-series and cross-sections variability in the data. The latter improvement is particularly important given the likely changes in the role of monetary policy over the period.

The results show that central bank independence, and therefore monetary policy as well, started to influence inflation after the initial transitional shocks; subsequent chapters in the thesis analyze the mechanism of this relationship. Again differentiating between the determinants of inflation at various stages of transition, the next two papers analyze the monetary transmission mechanism in less advanced economies, choosing Georgia and Romania as examples. The following two papers² turn to the problems faced by the relatively more advanced economies, illustrated by the Czech Republic and Poland.

In the two cases of the less advanced transition economies, the countries faced different initial conditions and chose different policies in their quest for price stability. Romania inherited a fully centralized planned economy, with politicians mistrusting the market and society exhausted by the previous policy of restraining domestic demand to fully repay the country's foreign debt. These conditions led to a slow path of reforms, loose fiscal and monetary policy, subsidization of state owned enterprises, and

² The paper on Romania is based on the joint paper with Nina Budina, Georges de Menil and Geomina Turlea, issued as DELTA Working Paper 2002/15 and forthcoming in Journal of International Money and Finance. The paper on Georgia was issued as IMF Working Paper WP/03/212 and invited for resubmission to the published in Applied Economics.

consequently persistently high inflation. Georgia faced a break up of trade links with other Soviet Union countries, a hike in previously subsidized energy prices, civil wars, severe depression, and consequently a burst of hyperinflation. The hyperinflation was brought to a halt by exchange rate based stabilization combined with fiscal tightening.

Despite the inferior initial conditions, Georgia managed to achieve a lower and a more stable inflation quicker than Romania. What drove inflation in these two countries and why did Georgia manage to stabilize faster?

The papers search for answers by estimating structural models of inflation based on money demand and exchange rate equations and carefully analyzing the exogeneity status of key variables. Given the extensive monetary financing of fiscal deficits and direct credits to state-owned enterprises, it is likely that monetary expansion from these sources was driving the persistent inflation in Romania. Exchange rate policy was accommodative, keeping the real exchange rate stable. To account for these features of the Romanian economy, the model focuses on imbalances between money demand and supply as a primary determinant of inflation and tests for the exogeneity of money. In Georgia, the design and implementation of the stabilization program suggests a dominant role of the exchange rate in inflation developments, with fiscal policy subservient to maintain exchange rate stable. The model takes this feature into account by explicitly analyzing the role of the exchange rate, and the exogeneity status of both the exchange rate and money. To keep the model simple, given the small available sample, output is assumed to be exogenous in this case.

Both models use standard econometric techniques, but their value added lies in the choice of countries and in their careful specification. In both cases the papers present the first thorough analysis of inflation in countries representative of large groups of similar transition economies. The specification is tailored to their different characteristics and utilizes prior knowledge about the behaviour of the economies. This prior knowledge, which singles out the main characteristics of these economies, helps to find a balance between the limited sample size and the scale of the model. From a methodological standpoint, the model analyzing inflation in Georgia is also based on firmer economic foundations than similar models estimated for other transition economies.

The results show that in both cases inflation has been consistent with priors. In the case of Romania inflation was driven by monetary expansion, and interactions between

the real sector and monetary developments were limited when inflation was high. In Georgia, where the dichotomy between the real and monetary sectors is also evident in the data, tight control over the exchange rate was crucial for maintaining low-inflation equilibrium.

Contrary to these examples, in more advanced transitional economies with lower inflation the links between the real and monetary sectors are likely to be stronger and a further disinflation may be costly. In addition, interactions between monetary and exchange rate policies become more complicated when transition progresses, with capital movements reducing the scope for independent monetary policy.

The next two papers turn to an analysis of inflation in the more advanced transition economies, replacing systems of controlled exchange rates by a new policy framework of inflation targeting. The new framework has been employed to reduce the costs of disinflation and to maintain control over inflation, while lowering the probability of exchange rate misalignments and related sudden changes. Inflation targeting seems to be an attractive alternative to other policy regimes. In addition to the benefits of a more flexible exchange rate, it does not rely on the behaviour of monetary aggregates, which is difficult to model when inflation declines to a low level and a rapid remonetization takes place. However, inflation targeting requires a thorough knowledge of the monetary transmission mechanism, which remains weak because of structural changes and a short history of monetary policy under the floating exchange rate system. Was inflation targeting successful given the limited knowledge about the monetary transmission mechanism? How can our understanding of the transmission mechanism be improved?

The first paper³ on inflation in advanced transitional economies attempts to deepen our understanding of the transmission mechanism and to assess the implementation of inflation targeting in these countries. The paper focuses on the experience of the Czech Republic and Poland. These economies again had diverse initial conditions and so followed different policies. Imbalances inherited from the planning system were lower in the Czech Republic, and the country quickly achieved exemplary macroeconomic stability and low inflation under the fixed exchange rate. However,

³ Earlier version of the paper was issued as CASE (Centre for Social and Economic Research) Studies and Analyses 246.

structural weaknesses, combined with the inflexibility of the exchange rate system, led to a currency crisis, followed by depression and a pickup in inflation. The inflation targeting system introduced soon after was associated with a faster than expected decline in inflation and a mediocre growth performance. Poland, facing relatively weaker initial conditions and higher initial inflation, moved from the fixed exchange rate arrangement to the crawling peg with a gradually widening band. The less restrictive exchange rate arrangement facilitated a smooth transition to a fully floating system, but limited progress in disinflation. The subsequent reduction in inflation from a moderate to low levels, conducted within the inflation targeting framework, brought about an economic slowdown.

The paper utilizes modern Bayesian methods, not previously applied to transitional countries data, to estimate the model of the transmission mechanism. The applied VAR model utilizes information from both the fixed and the floating exchange rate periods, increasing the number of degrees of freedom in the model, while keeping the crucial distinction between the two policy regimes. While the previous studies applied similar VAR specifications, they did not properly account for the policy change. This distinction enables me to estimate monetary transmission mechanisms under different regimes more precisely. It also allows for counterfactual simulations, replacing the policy reaction function estimated under the inflation targeting framework with the reaction function from the controlled exchange rate period. These simulations make possible an assessment of the inflation targeting performance against the previous regimes.

The results show that the exchange rate has played a significant role in the transmission mechanism, suggesting that the behaviour of this variable should be carefully watched even under an inflation targeting regime. Strict control over the exchange rate would be costly and difficult to sustain as shown by the simulations for the Czech Republic. But adjusting interest rates to smooth exchange rate paths could be beneficial, as suggested by simulations for Poland, which show higher volatility for both the exchange rate and inflation driven by changes in the interest rate under the inflation targeting regime.

The results also point to a significant impact of monetary policy on the real sector. The expected reduction in the cost of disinflation, due to a faster adjustment of expectations than under conventional policies, convinced policymakers to adopt the

inflation targeting framework in transition economies. However, the strong relation between the real sector and monetary developments, and the sharp slowdown in economic activity associated with inflation reduction in Poland, show that the full benefits of the inflation targeting framework did not materialize.

The last paper in the thesis analyses the credibility of the targets, which is the main factor affecting the costs of disinflation under the inflation targeting framework. The concept of credibility, which is particularly relevant in the inflation targeting framework, is the marginal credibility, defined as policymakers' ability to influence public expectations by the announcement of a target. The paper attempts to identify to what extent inflationary expectations in Poland were guided by such announcements and whether the marginal credibility of announcements increased after the introduction of the inflation targeting framework.

The paper applies an original Bayesian methodology, efficiently blending information from public announcements, a survey of inflationary expectations and actual data in order to assess the marginal credibility. Agents in the model are assumed to use past data and announcements to form their expectations. A higher weight attached to the announcement corresponds to higher marginal credibility.

The results show that the marginal credibility of the targets increased after the introduction of inflation targeting, but dropped quickly after the target was missed. The virtuous circle of a high marginal credibility influencing expectations, facilitating the achievement of the target, and further boosting credibility was broken. This virtuous circle could help circumnavigate the problems related to the limited understanding of the transmission mechanism. Without this shortcut, central bankers in advanced transition economies must face a painful process of a slow learning about the behaviour of their economies.

2 CENTRAL BANK INDEPENDENCE IN TRANSITION ECONOMIES⁴

2.1 Introduction

Monetary expansion driven by political factors is potentially one of the main causes of high and persistent inflation at the initial stage of transition from plan to market.⁵ Severe fiscal imbalances and narrow financial markets inevitably lead to monetary deficit financing. Institutional devices, such as an independent central bank, can impose necessary financial discipline on policy makers and restrict them from short-sighted monetary expansion. Economic theory and empirical evidence give strong support for delegating monetary policy to independent central bankers. Although the newly established central banks (CB) were generally provided with a considerable degree of statutory independence, the legal framework varies considerably from country to country and over time. In particular, weak constraints on the amount of credit granted to the government significantly reduce central banks' ability to conduct independent monetary policy. Moreover, the law protection does not always shield central bank from political pressure. The legal provisions may be ineffective because observance of the law, the main public good in developed society, has been destroyed under the communist rule. The new institutions "transported in the suitcases of Western advisors into largely insolvent and administratively weak states" (Semler (1994)) may not be able to withstand the political pressure of transition period. Macroeconomic imbalances, credit-hungry governments and underdeveloped financial system produce an environment in which the CB independence is thoroughly tested.

The aim of this paper is to examine legal independence of central banks and its influence on inflation in East European countries and former Soviet republics. Adjusting the methodology proposed by Grilli *et al.* (1991), the paper constructs the indices of political and economic independence. It also analyzes changes in the laws and proposes some explanations for recent upgrades of the central bank independence. Finally, the paper tests for the relationship between central bank independence and inflation in

⁴ Published in Economics of Transition (Maliszewski, 2000)

⁵ Next chapters investigate the relationship between monetary expansion and inflation for selected transition economies.

transition economies. The paper provides a sensitivity analysis to earlier empirical results, in particular to the findings reported in Cukierman *et al.* (2002), by using a different measure of independence, extending the analysis by accounting for recent changes in the laws, further exploring the time dimension of the CBI-inflation relationship, and controlling for additional explanatory variables in the econometric analysis.

The paper is organized as follows. First, possible motives for monetary expansion, its influence on inflation and the role of central bank in reducing inflationary bias are presented. Next section analyses various aspects of independence in transition countries. Previous empirical works are also discussed here. Next, indices of political and economic independence are presented. Section 2.6 analyses changes in the laws and section 2.7 tests the relation between independence and inflation. Last section concludes.

2.2 Central bank independence: theory and empirical evidence

There is a general consensus among economists that delegating monetary authority to the central bank that is highly averse to inflation may reduce "inflationary bias", i.e. persistent and higher than socially optimal price growth. The bias arises from government incentives for monetary expansion, classified by Cukierman (1992) into four categories, covering employment, revenue, balance of payment and financial stability motives.

The employment motive is based on the widely accepted "expectations augmented" Phillips curve, i.e. a positive relationship between deviations of unemployment from its equilibrium level and unanticipated shocks to inflation. The relation was given numerous theoretical explanations; some of them establish an exploitable trade-off between inflation and unemployment.⁶ Inflation depreciates the real value of money and allows the government to collect seigniorage revenue (Barro, 1983). It also cuts down the value of interest bearing debt fixed in nominal terms, reducing real expenditures on interest and repayment of principal (Barro and Gordon, 1983). The nominalistic features of tax and transfer systems provide further considerable gains from

⁶ The relation may be derived either from the Lucas (1973) "surprise" supply function or from the overlapping contracts models developed in Fischer (1977), Phelps and Taylor (1977) and Taylor (1979)

inflation to the government (Persson *et al.*, 1996). The government is tempted to use the inflationary financing if other taxes are difficult to collect or politically expensive to impose, and when it faces constraints on borrowing from private agents.

The concern about the balance of payment may lead to higher inflation through the effects of nominal devaluations (Cukierman, 1992), which, in the presence of nominal contracts, reduce real wages and increase output. Hence, more resources are available for export or for import substitution and the current account position temporarily improves.

Finally, the stability of the financial system may also be inconsistent with the low inflation objective (Cukierman (1990), (1992)). The banking system is vulnerable to surprise increases in interest rate since in the short run it affects the costs of (mostly short-term) borrowing more quickly than the revenues from (mostly long-term) loans. If the central bank cares about the profits of the banking sector, it may avoid raising interest rate when it is needed for suppressing inflationary pressure.

The motives for monetary expansion lead to a dynamic inconsistency problem, which arises when optimal policy before the private agents' contracts are set is different from optimal policy afterwards. For instance, when policy makers are ready to trade off more employment for higher inflation, they have incentive to inflate after the contracts have been set. Kydland and Prescott (1977) showed that, if expectations are rational, the resulting equilibrium is sub-optimal: unemployment is unchanged while inflation is higher. This result, popularized by Barro and Gordon (1983), can be extended to other motives for monetary expansion by adding additional elements to the government loss function.

Rogoff (1985) showed that the time inconsistency problem can be mitigated by delegating monetary policy to the central banker who attaches relatively greater weight than the policy makers to inflation vs. output stabilization. As a result, the conservative and independent central bank delivers lower mean and variance of inflation than the government would produce.⁷ The successful anti-inflationary policy of the German and Swiss central banks provides empirical support for this idea.

⁷ However, since the bank is more concerned about inflation, its responses to supply shocks are not optimal for output stabilization. Several extensions of the Rogoff (1985) model have been proposed, alleviating this trade off between flexibility and credibility of
(continued)

Formal tests of this theory require some judgment about unobservable central bank independence. Researchers usually concentrate on legal aspects of independence, assuming that the formal arrangements provide a reasonable proxy for the actual autonomy. The legal CB independence in industrial countries was analyzed by Bade and Parkin (1988), Alesina (1988), (1989), Grilli *et al.* (1991), Alesina and Summers (1990) and Ejffinger and Schaling (1993). Cukierman (1992) and Cukierman *et al.* (1992) extend the analysis to less developed economies and present the behavioural indices of CBI—the average turnover of the governor and the index based on the questionnaire sent to the CB staff. Most authors find an inverse relationship between their measures of independence and the average inflation, although only behavioural characteristics turn out to be significant in explaining inflation for less developed countries. Cukierman (1996) surveys theoretical and empirical literature on central bank independence.

2.3 Economic theory and transition reality

The employment motive for monetary expansion—a standard theoretical determinant of inflationary bias—seems to have only limited influence in the transition environment. High or very high inflation rates reduce the length of nominal contracts and bring various mechanisms of indexation, reducing potential gains from inflationary surprises. Moreover, a negative relationship between high inflation and economic growth, found in cross-country studies by Barro (1995) and Bruno and Easterly (1995), seems to be present in transition data. Fischer *et al.* (1996) claim that positive growth in post-communist economies resumes within two years of inflation falling below 50 percent. Ghosh (1997) estimates that per capita GDP growth rate above 2 percent is unlikely to occur as long as inflation stays above the 10 percent threshold. Finally, although Berg *et al.* (1999) do not find any robust negative relationship between inflation level and growth, they confirm that an increase in inflation deters output growth in the private sector. Their econometric evidence, however, suggests that increasing inflation had a stimulating effect on the public sector. The last result probably reflects the effects of slow restructuring in the

monetary policy. For relevant results see Flood *et al.* (1988), Lohmann (1992) and Walsh (1995)

subsidized public sector, which resulted in the smaller initial output losses but was often supported by inflationary means.

The revenue motive is undoubtedly the most important source of money creation in the countries under investigation. Inefficient welfare state, loss-making state-owned enterprises and tax base erosion produced substantial pressure on the budgets. Narrow domestic financial markets and limited access to foreign financing inevitably lead to the monetary deficit financing, at least at the initial stage of the systemic transformation.

Maintaining stability of the financial system, strongly related to quasi-fiscal operations of the government, also played a role in fuelling inflation. Banking systems in transition economies inherited considerable amount of non-performing loans. The bad debts were concentrated in state-owned banks and the government exerted pressure on these institutions to provide further loans to the insolvent state sector enterprises. Moreover, financial regulations were usually lax and newly developed private financial institutions were fragile and unstable. Central banks, legally responsible for financial stability, were forced to bail out insolvent banks in order to avoid financial crisis and to provide quasi fiscal subsidies to the public sector. Higher inflation was the imminent price for the rescue operations.

Similarly, a concern about the balance of payment deficit had considerable inflationary consequences. Transition countries quickly opened up their economies, running large deficits financed by borrowing from international institutions and, when they regained confidence, at financial markets. High deficits, combined with low level of international reserves and fragility of domestic financial systems make them highly vulnerable to balance of payments crises. Although the roots of the problem are elsewhere, a political pressure on competitive devaluation remains strong.

The pressures on central banks in transition environment make an appropriate legal framework potentially more important than in developed countries, but specific features of transition countries may distort the influence of legal provisions on inflation performance (Cukierman, 1996). The initial stage of economic transformation was characterized by severe macroeconomic imbalances. Price liberalization and devaluation of the currency, combined with initial monetary overhang, produced substantial shocks to inflation. Strong incentives for inflationary financing of the fiscal and quasi-fiscal deficits fuelled inflationary expectations. Containing inflationary pressure in this environment

was a formidable task for monetary policy. The evidence from post World War II monetary reforms, resembling the situation after the collapse of communism most closely, proves that even drastic measures might not be sufficient to hold inflationary pressure at bay in the presence of excess liquidity and entrenched inflationary expectations. Moreover, the norm of general adherence to the law has been destroyed under the communist rule (Triska, 1994). In the presence of strong political pressure and the above-mentioned shocks, there was a temptation to bend the law. In this case, the legal provisions may be insufficient to protect CBI, but the degree of legal independence is still an important indicator of the policy makers' willingness to "tie their hands" and construct institutional framework capable to provide price stability.

2.4 Empirical research on CBI in transition economies

Early attempts to explore the question of CBI in post-communist started from descriptive studies by Hinton-Braaten (1994), Hochreiter (1994) and Hochreiter and Riesinger (1995). The same approach was followed by Sundararajan *et al.* (1997), who discuss central banking reforms in former Soviet Union and Radzynger and Riesinger (1997), who present an extensive review of central bank legal independence in the Czech and Slovak Republics, Hungary, Poland and Slovenia.

The first index of legal independence for Czech Republic, Hungary, Poland and Slovak Republic was built by Siklos (1994). The index is based on the Cukierman *et al.* (1992) methodology, but introduces some additional elements specific to transition economies, such as a choice of exchange rate system, enterprise arrears, maturity of the financial system, foreign debt burden, absence of the deposit insurance system, structure of the CB board and the degree of monetary overhang. Most of the additional elements account for the effects of initial conditions on the CB policy, introducing behavioural elements to the legal index, but unfortunately blurring a distinction between the level of independence and the motives for monetary expansion. The new CB laws of Czech Republic, Hungary and Poland were also investigated by Eijffinger and Van Keulen (1995), who present several indices of political independence for a broader group of eleven countries.

Loungani and Sheets (1997) examine central bank independence in twelve post-communist countries. They derive two indices of CBI: the first covers goal, economic and

political independence and the second assesses similarity between the analyzed law and the Bundesbank statute. In the regression analysis, a strong negative correlation between the measures of independence and inflation emerges, even after controlling for fiscal performance and the overall reform progress.

Lybek (1999) focuses on CBI in the former Soviet Union economies, building a new index that incorporates standard elements present in the previous studies, but also covers accountability of the bank and takes into account the IMF guidelines provided to transition countries. The index consists of 21 graded characteristics. The empirical results reveal negative correlation between this measure and the average 1995-1997 inflation in the group of 15 former Soviet republics analyzed in the paper.

Finally, Cukierman *et al.* (2002) (CMN) present the most comprehensive study on CBI in transition economies to date. The authors construct CB independence index based on Cukierman *et al.* (1992) methodology for 26 post-communist economies, accounting for some recent changes in the laws. The first sixteen components of the index are the same as in Cukierman *et al.* (1992) and are grouped in four categories: position of the chief executive officer, policy formulation, central bank objectives and limitations on lending. All variables are given numerical values from 0 to 1 and are initially aggregated into eight legal variables (five concerning limitations on lending) and finally into unweighted (LVAU) and weighted (LVAW) indices. The next four variables are from Neyapti (2001) and cover financial independence of the CB (in setting its budget and salaries), CB supervisory authority and provision of emergency credit to private banks. The main finding of the Cukierman *et al.* (2002) study is that CBI is negatively related to inflation only at the sufficiently high and sustained level of economic liberalization. Thus, the CBI cannot protect from inflationary consequences of the powerful inflationary shocks experienced at the early stage of transformation.

2.5 The index of CBI and comparison with previous studies

An assessment of legal provisions for CBI has twofold purpose. The CBI is a proxy for actual independence and—by relating it to the inflation performance—one can empirically test the theoretical predictions in a group of transition countries. Furthermore, the question of great practical importance is how the institutional settings affect monetary policy and inflation in post-communist economies.

The sample covers twenty countries and includes all Central European countries except Bosnia and Yugoslavia (Albania, Bulgaria, Croatia, Czech Republic, FYR Macedonia, Hungary, Poland, Romania, Slovak Republic and Slovenia) and ten out of fifteen former Soviet republics (Armenia, Belarus, Estonia, Georgia, Kyrgyz Republic, Latvia, Lithuania, Moldova, Russia and Ukraine). The choice was dictated by data availability, but the group covers almost all post-communist economies except post-Soviet Central Asian countries (Azerbaijan, Kazakhstan, Tajikistan and Turkmenistan) and Mongolia. Only the laws enacted after the introduction of the two-tier banking systems are considered: the legal position of the central bank in the system of mono-bank system central planning is irrelevant for this study.

Main characteristics of the CB legislation are coded into indices similar to those proposed by Grilli *et al.* (1991) (GMT). In GMT the CBI is divided into two components: political and economic independence. The political independence is defined by three elements: the relationship between the government and the bank in formulation of the monetary policy, the procedure for appointing the board and the formal goal of the bank with respect to monetary policy. The elements are evaluated using eight criteria: appointment procedure for high officials of the bank (the governor and the board), length of their term in office, participation of the government representative in the board, government approval of monetary policy, legal provision strengthening the bank's position against the government in case of conflict and statutory obligations to maintain price stability. Economic independence is affected by legal constraint on the central bank's lending to the government and the location of banking supervision. The bank is assumed to be more economically independent if the direct credit facility is of limited amount, not automatic, temporary and at the market rate. In addition more independent bank sets the discount rate, does not participate in the primary market for public debt and is not engaged in the commercial banks' supervision.

While most of these criteria are self-explanatory, the location of the banking supervision requires more attention. Cukierman (1996) argues that placing the banking supervision under CB authority makes the bank more vulnerable to political pressure. In the presence of bank failures there is a high risk that bad debts will be monetized and placing the supervision outside CB makes the costs of rescue operations more transparent. On the other hand, the personnel needed for supervision and conducting monetary policy

is complementary and the central bank may use precise information on the banking system to improve its monetary policy. The use of this criterion is thus ambiguous, but—as discussed above—in the transition environment the banking system is often used as a channel for quasi-fiscal activities and placing banking supervision in the CB may reduce its independence.

The interpretation of two other GMT criteria requires further explanation. The government approval of monetary policy is interpreted as a prior approval of the monetary policy guidelines by the government or the parliament. The legal provision strengthening the bank's position against the government in case of conflict is interpreted as any provision explicitly stating independence of the CB from the executive.

There are two differences between the original GMT index and the methodology applied here. Firstly, it is assumed that the bank is more politically independent if the provisions for governor's dismissal, as stated in the law, are non-political only (e.g. loss of ability to perform his duties or sentence for criminal act). Consequently, the new variable is added to the political index. Secondly, in the index of economic independence, the government borrowing from CB is assumed to be less harmful if all direct credit is securitized. As noticed by Cottarelli (1993), securitization provides the bank with a stock of government papers, increasing flexibility of monetary policy.

Figure 2-1 presents GMT indices of political and economic independence based on the latest available CB laws. The laws were changing and the year attached to each country is the date of the latest enactment or amendment. The components of all indices, also those derived from older laws, are listed in Table 2-7 in Appendix 2.9. Other tables in the appendix give more detailed information on the most recent laws in the sample.

Table 2-1 Aggregate indices of political (PI), economic (EI) and overall (OI) independence.

	PI	EI	OI (PI + EI)
Bulgaria 97	8	7	15
Lithuania 96	8	7	15
Kyrgyz Republic 97	8	7	15
Poland 97	7	7	14
Armenia 96	7	7	14
Macedonia 96	8	6	14
Georgia 96	7	6	13
Moldova 95	8	5	13
Estonia 93	6	7	13
Czech Republic 92	8	5	13
Albania 96	6	6	12
Latvia 92	9	3	12
Croatia 92	7	4	11
Russia 95	5	6	11
Slovak Republic 92	5	6	11
Slovenia 91	7	4	11
Belarus 92	5	6	11
Hungary 97	3	7	10
Romania 91	4	3	7
Ukraine 91	3	2	5

Source: National legislations

In all countries the laws contain at least basic provisions for CBI, and the average level of independence is high. For instance, six countries in the group have higher legal independence than the Bundesbank with its 13 points in the original GMT index and one additional point for non-political provisions for governor's dismissal. Next section discusses changes to the laws in more detail, but it is immediately clear that the countries on the top of the list have the laws enacted or amended recently and that the older laws give less independence to the banks. Political independence is high in Latvia, Bulgaria, the Czech Republic, the Kyrgyz Republic, Lithuania, Macedonia, Moldova and the lowest in Hungary and Ukraine. Economic independence is high in countries that adopted currency board arrangements: in Bulgaria, Lithuania and Estonia. But it is equally high, according to the EI index, in Armenia, Hungary, the Kyrgyz Republic and Poland, where the laws have been recently upgraded. In Latvia, Romania and Ukraine it is the lowest. It seems that the political consensus on imposing the limits on the government borrowing from the bank—the main element of economic independence—is more difficult to attain than the political independence. The new laws only recently improved CB economic independence in the group. The measure of an overall independence is obtained by summing two indices. Bulgaria, Lithuania and Kyrgyz Republic receive the highest score in this ranking, closely followed by Poland, Armenia and Macedonia. Romania and Ukraine have the least independent central banks in the sample.

Several arguments are presented above for and against placing banking supervision in the central bank structure. In the sample under investigation only two countries (Hungary and the Slovak Republic) have their banking supervision outside central banks. Thus, the supervision seems to be perceived as a traditional role of the central bank. It is interesting to note that in the conflict between the governor of the National Bank of Poland and the Ministry of Finance in 1994 the governor strongly opposed delegating the banking supervision to an external body, expressing her concerns about the impact of such a step on independence of the bank (although this opposition may reveal reluctance to accept a restriction on administrative power of the governor rather than a true concern about CB independence).

It is useful to compare the constructed GMT index with existing CBI measures for the same group of countries. The indices cover broadly the same aspects of legal independence, although do not exactly overlap (e.g., CMN index does not cover a position of the CB board). The GMT index is not as precise as the methodology in CMN but this is not a serious limitation. Constructing a coarser index requires relatively less information and, since the laws of central bank differ in their degree of detail, may reduce arbitrariness in assessing the independence. Moreover, the more detailed index (with sub-characteristics for each variable) must be supported by a weighting system and a subjective judgment is involved in choosing the characterization of variables and weights in the aggregation.

Table 2-2 presents rankings of the CBI according to three indices: GMT built for the purpose of this paper, CMN and Lybek (1999). Since the Lybek's study covers only FSU countries, the FSU and the Central European banks are compared separately. In the FSU group the new law on the Bank of Kyrgyzstan is given the highest rank both by the GMT and by the Lybek index. Georgia, Lithuania, Armenia, Estonia and Moldova also score high in two indices, and the same group of countries appears on the top of the CMN index together with Belarus. The law on the Ukrainian National Bank and the old laws of Armenia and Moldova give the lowest independence to the respective central banks. Note that the law on the National Bank of Georgia in the Lybek's index is different from the law in the GMT index: in my interpretation the amendment of May 1996 reduced bank's ability to formulate policy independently and consequently its position according to the GMT index is lower. In the Lybek's index the bank scores high even after the

amendments. The Czech National Bank is the most independent among banks in Central Europe (before recent amendments to laws in other countries) according to both GMT and CMN indices. The Bulgarian National Bank is ranked second in the GMT index, while the National Bank of Hungary is placed second according to the CMN index. The banks of the Slovak Republic and Slovenia are on the next two positions and the National Bank of Romania is the least independent according to both indices.

The comparison reveals some similarities in the independence ranking, at least in the evaluation of the laws that grant the highest and the lowest CBI. Differences in construction make the exact comparison between them difficult, but a rough comparison between the measures reveal that the differences in ranking come mainly from the choice of variables and the adopted weighting system, rather than from substantial differences in the interpretation of the law. Correlation of the GMT index with two other measures, measured by Spearman's rank correlation coefficient, is high for the group of the Former Soviet Union countries, and relatively lower for Central European countries. The latter result comes mainly from different evaluation of the independence granted to central banks in Hungary and Croatia: a weak position of the bank's board reduces CBI in Hungary and the strong board's position boosts independence in Croatia according to the GMT index. The CMN index does not cover the position of the board.

Table 2-2 CBI ranking: Comparison of indices

Former Soviet Union			Central Europe	
GMT	Lybek (1999)	CMN	GMT	CMN
Kyrgyz Rep. 97	Kyrgyz Rep. 97	Lithuania 96	Czech Rep. 92	Czech Rep. 92
Lithuania 96	Georgia 96	Estonia 93	Bulgaria 91	Hungary 91
Armenia 96	Estonia 93	Armenia 96	Slovak Rep. 92	Slovak Rep. 92
Georgia 95	Moldova 95	Georgia 95	Slovenia 91	Slovenia 91
Estonia 93	Lithuania 96	Belarus 92	Croatia 92	Bulgaria 91
Moldova 95	Armenia 96	Moldova 95	Poland 92	Albania 92
Georgia 96	Latvia 92	Kyrgyz Rep. 92	Hungary 91	Poland 92
Latvia 92	Russia 95	Latvia 92	Albania 92	Croatia 92
Russia 95	Belarus 92	Russia 95	Romania 91	Romania 91
Belarus 92	Ukraine 91	Moldova 91		
Moldova 91		Armenia 93		
Kyrgyz Rep. 92		Lithuania 91		
Armenia 93				
Lithuania 91				
Ukraine 91				
<i>Spearman's rank correlation with GMT:</i>				
1	0.7636	0.8566	1	0.4583

Source: National legislations, Cukierman *et al.* (1998), Lybek (1999)

2.6 Changes in central bank laws

This section considers a reverse causality from past inflation to CBI, as well as some other factors shaping central bank position in the economy. In most of transition countries, central bank laws have been recently changed and lessons can be drawn from these episodes. In the midst of inflationary crisis, strengthening CB independence may boost confidence in the stabilization policy and contribute to its success. If this line of reasoning is correct, changes in CB laws reflect policy makers' pre-commitment to a low inflation regime and should complement stabilization attempts. Cukierman (1996), however, argues that CB independence functions well as a preventive, but not as a remedial device. He presents a historical example of the Reichsbank during hyperinflation in mid-1922, where independence from the government—augmented by increasing the fraction of non-government members in the board—resulted in a different distribution of seigniorage revenues (partly channelled to the private sector by discounting commercial papers), but not in lower inflation. Even after the changes, however, the corporate credit from the Reichsbank constituted not more than a third of total discounted bills and money creation was still largely determined by the government borrowing requirements. Strengthening position of the bank after the establishment of the Rentenbank put a halt on

the inflationary deficit financing and stabilized the economy. Other hyperinflations in the 20's in Austria, Hungary and Poland were stopped after similar measures (Sargent, 1986).

How the historical episodes match the recent experience of transition countries? Table 2-3 presents maximum inflation rates experienced in transition economies, dates of stabilization attempts⁸, dates of IMF standby agreements, introduction of national currencies by the FSU countries and changes in the central bank laws.

Five Central European countries (Czech Republic, Hungary, Poland, Slovak Republic and Slovenia) stabilized their economies at the start of reform process. The mixture of good policies and favourable initial conditions⁹ contributed to their relative successes. In this group, the CB laws were amended in Hungary and Poland, the two countries experiencing relatively high and persistent inflation. The CB independence is also one of the preconditions for joining the EMU, and, since the two countries are on the fast track to join the EU, they upgraded their laws to meet the Maastricht criteria.

In Albania, the new law on central bank was introduced as a part of the 1992 stabilization package, just few months before the program backed by the IMF started (IMF technical assistance seemed to contribute to the enactment of the new law).

Two former Yugoslav Republics: Croatia and FYR Macedonia were involved in military conflicts and experienced higher inflation than other Central European economies. Croatia achieved macroeconomic stabilization without institutional changes and, at least initially, without IMF backing. The law granting independence to the National Bank of Macedonia was legislated in the year when inflation was the highest and the CB position was further upgraded two years after the initial program.

⁸ The paper follows Fischer *et al.* (1996) in defining the dates of stabilization, with exception of Bulgaria and Romania, where the dates are for the most recent stabilization programs.

⁹ For extensive study on the effects of initial conditions on macroeconomic performance in transition, see De Melo *et al.* (1997).

Table 2-3 Inflation, timing of stabilization, and changes in central bank laws.

	Highest inflation 1990-1998 (year)	Stabilisation program	IMF standby agreements	National currency adopted (sole legal tender)	New CB laws and major amendments (U) - CBI upgraded, (D) - CBI reduced
Albania	237 ('92)	Aug 92	Aug 92		Apr 92, Feb 96 (U)
Armenia	10896 ('93)	Dec 94	Jun 95	Nov 93 (Nov 93)	Aug 92, Apr 93, Jun 96 (U)
Belarus	1996 ('93)	Nov 94	Sep 95	May 92 (May 94)	Dec 90, Dec 92 (U)
Bulgaria	578 ('97)	Jul 97	Mar 91, Apr 92, Apr 94, Jul 96, Apr 97		Jun 91, Apr 96 (D), Jun 97 (U)
Croatia	1149 ('93)	Oct 93	Oct 94		'92
Czech Rep.	52 ('91)	Jan 91	Mar 93		Dec 92
Estonia	954 ('92)	Jun 92	Sep 92, Oct 93	Jun 92 (Jun 92)	Mar 90, May 93 (U)
FYR Macedonia	1935 ('92)	Jan 94	May 95		Apr 92, Apr 96 (U)
Georgia	7488 ('93)	Sep 94	Jun 95	Apr 93 (Aug 93)	Aug 91, Jun 95 (U), May 96 (D)
Hungary	33 ('90)	Mar 90	Mar 90, Sep 93		Oct 91, Jan 1997 (U)
Kyrgyz Rep.	1363 ('93)	May 93	Jan 94	May 93 (May 93)	Jun 91, Dec 92, Apr 94 (U), Jul 97 (U)
Latvia	959 ('92)	Jun 92	Sep 92, Dec 93	May 92 (Jul 92)	Mar 90, May 92 (U)
Lithuania	1161 ('92)	Jun 92	Oct 92, Oct 93	May 92 (Oct 92)	Feb 90, Mar 96 (U)
Moldova	2198 ('92)	Sep 93	Dec 93, Mar 95	Jun 92 (Jul 93)	Jun 91, Jul 1995 (U)
Poland	249 ('90)	Jan 90	Feb 90, Mar 93, Aug 94		Jan 89, Feb 92 (U), Aug 97(U)
Romania	296 ('93)	Feb 97	Apr 91, May 92, May 94, Apr 97		Mar 91
Russia	2506 ('92)	Apr 95	Aug 92, Apr 95	Jul 93 (Jul 93)	Dec 90, Apr 95 (U)
Slovak Rep.	58 ('91)	Jan 91	Jul 94		Dec 92 (D)
Slovenia	247 ('91)	Feb 92			Jun 91
Ukraine	10155 ('93)	Nov 94	Apr 95, May 96, Aug 97	Nov 92 (Nov 92)	Mar 91

Source: National legislations, Fisher *et al.* (1996), Havrylyshyn (2000), EBRD (1997), EBRD (1999).

There were recurrent inflationary episodes and several stabilization attempts in Bulgaria and Romania. The first country was on the verge of hyperinflation in late 1996 and

quickly deteriorating macroeconomic situation called for radical policy actions. The Bulgarian government successfully introduced the currency board system in mid 1997. The implementation of the new system was monitored by the IMF. Romania introduced changes to the CB law in 1998, as a part of the new government reform program. The new law restricted government borrowing from the bank by setting market interest rate on advances to the budget. The IMF standby agreement was signed less than a year before this amendment.

The CB independence in the FSU was initially restricted by the existence of the ruble area. The central banks participating in the monetary arrangement competed for seigniorage and tried to stimulate growth in their jurisdictions. As a result, the growth of credit was uncontrolled and inflation spilled over the rouble zone (see Balino *et al.*, 1997). The Baltic countries introduced their national currencies first and left the monetary union, launching stabilization programs under IMF conditionality. In Latvia the new CB law was enacted one month before the program started. Estonia introduced the currency board system in less than one year from the start of the stabilization program and the new IMF standby agreement was arranged soon after. Inflation in Lithuania stayed close to the level experienced by the Baltic neighbours, but the currency board was introduced three years after reducing inflation to two-digit level. Other countries of the FSU subsequently introduced the national currencies. Moldova, one of the first countries to follow Baltics, managed to reduce inflation quickly after the implementation of the IMF program. The CB law was upgraded only two years later, and again the timing of enactment coincided with the new IMF standby agreement. The Kyrgyz Republic also successfully stabilized the economy after leaving the ruble area. The IMF standby agreement was signed few months after the stabilization program had been launched, and changes in the law strengthening CB independence followed. Drastic eradication of hyperinflation occurred in Armenia and Georgia, two countries involved in the military conflicts. Six months after its start, the Armenian program was backed by the IMF agreement and the new central bank law was enacted one year later. In Georgia, the sequence of events was similar, but CB independence was upgraded simultaneously with the IMF agreement. In Belarus, Russia and Ukraine stabilization started later. Russia introduced its program simultaneously with signing the IMF standby agreement and upgrading CBI. Belarus and Ukraine concluded their agreements with the IMF few months after launching the

programs. CBI in Belarus was relatively high after introduction of the national currency. Ukraine did not upgrade CB independence after stabilization.

In four cases (Bulgaria, Georgia, Latvia and Russia) changes to the laws were introduced simultaneously with stabilization plans or, in case of Latvia, soon before it started. The CBI was used as an instrument to improve credibility of the new policy. Although the role of external conditionality and expertise might have been significant, the changes in the laws required strong domestic political consensus on the new policy. In six other countries the amendments were passed within a year from the IMF stabilization package. Since institutional changes were introduced only with lags, the external conditionality had probably a greater role in establishing the initial confidence in policy changes. Subsequent amendments to the law sanctioned the restrictions imposed by the IMF conditionality and the anti-inflationary consensus was established when the benefits from lower inflation became evident. In the first stage of stabilization the IMF played a "scapegoat" function: policy makers blamed external conditionality for the unpopular decisions they had to implement.¹⁰

In all cases discussed above changes in the CB law were motivated by policy makers' increasing aversion to inflation and their attempts to establish anti-inflationary credibility. Fiscal policy, however, was the main factor behind the inflationary episodes and the consistency of fiscal and monetary adjustments determined the success of stabilization. Constraints on government borrowing from financial markets require more painful fiscal adjustments and the narrower these markets are, the less willingly policy makers restrict their ability to borrow from the central bank (Cukierman, 1996). The scope for the non-monetary budget deficit financing, however, does not seem to affect decisions regarding the CBI.¹¹ When fiscal adjustments were not sufficient, the deficit was financed by external borrowing and by crowding out credits to the private sector. The CBI was thoroughly tested when the government hits the borrowing limit. The Russian

¹⁰ See James (1998) for a discussion on the changing role of IMF conditionality.

¹¹ The correlation between CB independence established by the most recent law and measures of banking reform and securities markets from the 1997 EBRD transition report is close to zero.

crisis clearly illustrates this problem¹², although in this case policy makers bypassed the “unpleasant monetarist arithmetic” by defaulting on the debt.

2.7 Central bank independence and inflation performance

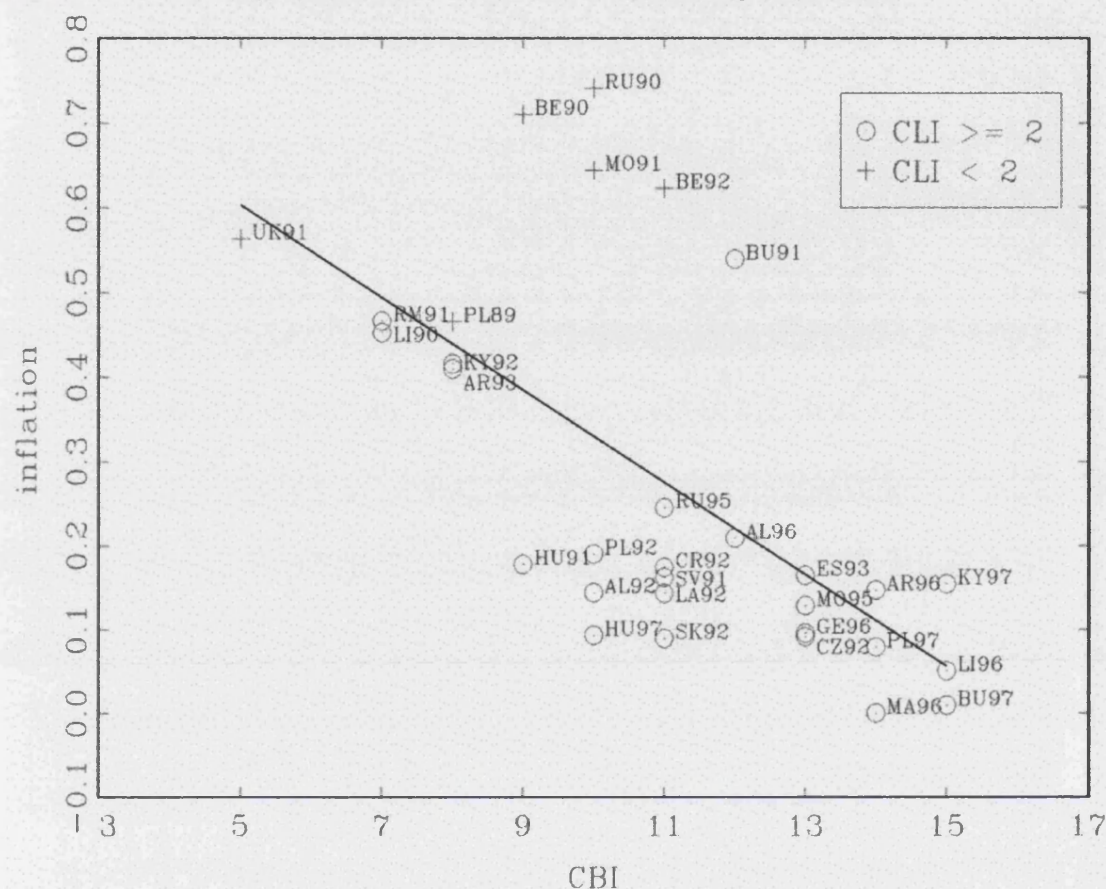
Historical episodes of stopping hyperinflations tend to suggest that the CB independence may be a powerful device for achieving price stability. Empirical cross-country studies show a negative correlation between the independence and inflation level for various groups of countries. The sample of transition economies is unique in a sense that it provides both cross-section and time series data on the CBI and inflation rates. To assess how well the CBI performs its anti-inflationary task, the paper tests for the relationship between the independence and inflation focusing on both characteristics of the data.

Figure 2-1 plots average inflation in the period starting next year after enactment of the CB law against CB independence measured by GMT index. Following CMN, inflation is characterized by the depreciation in the real value of money $\pi/(1+\pi)$, where π is inflation rate. Data on end-year inflation is obtained from 1997 EBRD Transition Report and 1999 EBRD Transition Update. Countries on the graph are divided into two groups according to their progress in transition to market economy. The progress is measured by the cumulative liberalisation indicator (CLI) taken from De Melo et al. (1996) (for 1989-1994) and updated by using indicators from EBRD Transition Reports (for 1995-1998).¹³ Following CMN, the threshold between fast and slow reformers is set to 2.

¹² The Central Bank of Russian Federation evaded legal provisions prohibiting credit to the government by redeeming maturing treasury bills from the market. Foreign currency credits were provided through lending via the Vneshekonombank.

¹³ De Melo et al. liberalisation index is the weighted average (with weights of 0.3, 0.3., and 0.4 respectively) of indices of liberalisation in internal markets (I), external markets (E) and private sector entry (P). The first two correspond respectively to the price liberalisation indicator and the trade and foreign exchange system indicator of the EBRD. The private sector entry index is the average of the small-scale and large-scale privatisation indicators and the banking system reform indicator. The EBRD indicators are rescaled to the 0-1 range and De Melo et al. index is updated by adding the changes in the EBRD index to the 1994 value.

Figure 2-1 Inflation (depreciation in the real value of money) and independence (OI).



AL-Albania, AR-Armenia, BE-Belarus, BU-Bulgaria, CR-Croatia, CZ-Czech Rep., ES-Estonia, MA-FYR Macedonia, GE-Georgia, HU-Hungary, KY-Kyrgyzstan, LA-Latvia, LI-Lithuania, MO-Moldova, PL-Poland, RM-Romania, RU-Russia, SK-Slovak Rep., SV-Slovenia, UK-Ukraine

Source: Table 2-1, EBRD (1997) and EBRD (1999)

The inverse relation between central bank independence and inflation seems to be present in the sample. Belarus (1990 and 1992 laws), Bulgaria (1991), Moldova (1991) and Russia (1990) are the most prominent outliers. The laws in Belarus, Moldova and Russia were enacted when the countries only began the process of price liberalisation and when the rouble zone arrangement restricted their monetary independence. Deviations from the negative CBI-inflation relationship reflect a degree of initial monetary overhang and the lack of restrictions on credit creation in the rouble zone. Moreover, the strong position of the president in the Belarusian political system may reduce the actual independence of the bank, even if the legal independence is relatively high. For this reason Belarus remains an outlier even after the first law had been amended in 1992. Bulgaria encountered a fiscal

crisis and a systemic banking crisis in 1996/1997 and the position on the graph reflects a near-hyperinflation experienced in this period.

The relationship between independence and inflation is statistically tested in the first set of equations reported in Table 2-4, where inflation in the post-enactment period is regressed on GMT measures of political independence, economic independence and the sum of the two. Since countries under investigation vary in the degree of macroeconomic imbalances inherited from past and the progress of market reforms and the CBI may be a proxy for a general soundness of policy, it has become a standard to include an overall indicator of transition progress in the regression testing the relation between the CBI and inflation.

Table 2-4 Relationship between average depreciation in the real value of money ($\pi/(1+\pi)$) in the post-enactment period and CBI

Dependent variable: $\pi/(1+\pi)$			
Regressors:			
Political independence, lagged (PI_{t-1})		-0.0207* (0.0118)	
Economic Independence, lagged (EI_{t-1})		-0.0119 (0.0140)	
Overall Independence, lagged ($OI_{t-1} = PI_{t-1} + EI_{t-1}$)	-0.0174* (0.0082)		0.0040 (0.0066)
Overall Independence when $CLI > 2$			-0.0264** (0.0065)
Cumulative Liberalization Index (CLI)	-0.0839** (0.0167)	-0.0859** (0.0167)	-0.0460** (0.0147)
CONSTANT	0.8010** (0.0539)	0.8006** (0.0540)	0.6602** (0.0628)
R-squared:	0.737	0.739	0.840
Adjusted R-squared:	0.718	0.71	0.822
Number of observations:	31	31	31

Notes:

Numbers in parenthesis are significance levels.

** and * denotes significance at 5% and 10% levels respectively

The relationship between CB independence on inflation is statistically significant. The results in the first column indicate that the effect of the combined index of overall independence (sum of the political and economic independence) on inflation is negative and significantly different from zero. The second column shows that the coefficient of political independence is close to the coefficient of overall independence and significant, while the coefficient of economic independence is still negative, but lower in absolute value and not significant. These findings are consistent with Loungani and Sheets (1997),

who also find more significant influence of political independence in their sample. One possible explanation for this result is that more politically independent central banks manage to sterilise government's borrowing even if they are not strong enough to enforce full adherence to the law and keep credit to the government within the legal limits. CMN find some evidence of a moderating effect of limitations on lending on inflation in their study. This result, however, is obtained without conditioning on the cumulative liberalisation index. In the sample under investigation, the regression of inflation on two measures of independence alone (not reported) gives the coefficient of economic independence that is highly significant and higher in absolute value than the coefficient of political independence. This result suggests that more advanced transition countries tend to have stricter limitations on lending and that the coefficient of economic independence may be biased if the CLI is not included in the model.

The last column repeats the experiment reported by CMN, who consider different impact of independence on inflation at different stages of transition. They found a significant and negative relationship between these two **only** at the high level of economic transformation. This conclusion is tested here in a similar way: a new variable, which is equal to OI_{t-1} at the high level of transition (measured by the CLI) and is zero otherwise, is added to the regression. The threshold, which is chosen by maximising R-squared, is equal to 2 and is the same as in CMN. The new variable is negative, significant at 1 percent significance level and higher in absolute value than the independence index alone in the previous regression. The coefficient of the overall independence measure becomes positive and loses its significance (the positive relation between independence and inflation at low level of liberalisation is driven by four outliers, as is evident from Figure 2-1). The result is similar to that obtained by Cukierman et al., although, contrary to results presented here, they do not discover any significant relationship between inflation and independence without the new variable.

Equations in Table 2-5 and Table 2-6 explore the time series dimension of the sample, using annual data instead of aggregating them to the pre- and post-enactment averages. The panel estimation has numerous advantages: it gives more degrees of freedom, properly takes into account different number of observations for different countries and laws, and allows for conditioning on other potentially significant variables. In particular, a step dummy that is one in the year of signing the IMF standby agreement

and after, and zero otherwise, is added to regressors. This variable accounts for the effect of the external conditionality on policy performance and is constructed from the dates of IMF agreements in Havrylyshyn *et al.* (2000). To test for the significance of government deficit financing, the general government budget deficit is also added to regressions (the series is constructed from the data in 1997 EBRD Transition Report and 1999 EBRD Transition Update). Finally, a step dummy for countries participating in the rouble zone is added: the dummy is one before a country adopts its own currency and zero afterwards. For non-FSU countries the dummy is always zero. Dates of adopting national currencies, reported in table 3, are from Lybek (1999).

Since results from the panel data are sensitive to adopted estimation methods, for each equation the tables report coefficients obtained from regressions with fixed and random effects, including only individual effects and both individual and time effects. The significance of individual and time effects is tested by F-tests on corresponding dummy variables and by Breusch-Pagan (1980) Lagrange Multiplier (LM) tests. The null hypotheses in both tests are that individual and time effects do not exist. The correlation between regressors and unobserved effects is tested by Hausman's (1978) test. In presence of such correlation, random effects method gives inconsistent and biased estimates, while the estimates from fixed effects method are still consistent and unbiased, and thus preferred. Otherwise, the random effects estimator is more efficient. The fixed effects method eliminates variation between countries, so that estimates are based on variation over time only. The random effects method takes into account both sources of variation in the data.

Table 2-5 Relationship between annual depreciation in the real value of money ($\pi/(1+\pi)$) in post-enactment period and CBI.

Dependent variable: $\pi/(1+\pi)$

Maximum estimation period: 1990 - 1998

Specification: $y_{it} = \alpha + X_{it}'\beta + u_{it}$

$u_{it} = \mu_i + v_{it}$ (individual effects only)

$u_{it} = \mu_i + \lambda_t + v_{it}$ (time & individual effects)

$\mu_i \sim \text{IID}(0, \sigma_\mu)$, $\lambda_t \sim \text{IID}(0, \sigma_\lambda)$, $v_{it} \sim \text{IID}(0, \sigma_v)$

	Individual effects only		Time & individual effects		Individual effects only		Time & individual effects	
Regressors:	Fixed effects	Random effects	Fixed effects	Random effects	Fixed effects	Random effects	Fixed effects	Random effects
OI _{t-1}	-0.0171 (0.0150)	-0.016422 (0.0128)	-0.0306* (0.0138)	-0.0298* (0.0131)	0.0189 (0.0145)	0.0191 (0.0110)	-0.0021 (0.0159)	0.0071 (0.0138)
CLI	-0.0853** (0.0142)	-0.0881** (0.0133)	0.1624** (0.061)	0.0152 (0.0392)	-0.0452** (0.0142)	-0.0491** (0.0129)	0.0812 (0.0633)	-0.0283 (0.0268)
OI _{t-1} when CLI > 2					-0.0343** (0.0060)	-0.0360** (0.0058)	-0.0232** (0.0072)	-0.0299** (0.0063)
CONSTANT		0.7964** (0.1272)		0.5966* -0.2317		0.5920** (0.0966)		0.5814** (0.1611)
R-squared:	0.613	0.595	0.716	0.176	0.710	0.677	0.744	0.433
Adjusted R-sq	0.532	0.588	0.63	0.162	0.646	0.668	0.664	0.419
Durbin-Watson:	1.052		1.3		1.313		1.347	
Number of obs:	122	122	122	122	122	122	122	122
Hausman's	0.4035 (0.817)		9.995 (0.007)		2.256 (0.521)		3.698 (0.296)	
Chi-squared statistic								
LM (H0: σ _μ = 0)	0.876 (0.349)				1.104 (0.293)			
LM (H0: σ _λ = 0)	2.288 (0.130)				0.349 (0.555)			
LM (H0: σ _μ = σ _λ = 0)	3.164 (0.206)				1.453 (0.484)			
F-statistic for equality of dummy variables:								
time dummies:	F(7,93) = 4.78 (0.00)				F(7,92) = 1.769 (0.103)			
group dummies:	F(19,93) = 2.606 (0.00)				F(19,92) = 1.685 (0.053)			

Notes:

OI_{t-1} - Overall Independence, lagged one period

CLI - Cumulative Liberalisation Index

** and * denotes significance at 1% and 5% levels respectively. Numbers in parenthesis under coefficients are standard errors¹⁴. Numbers in parenthesis reported with the tests are marginal significance levels. Variance components for random effects model with individual and time effects are estimated as suggested by Wansbeek and Kapteyn (1989). Variance components for random effects model with individual effects only is estimated as suggested by Swamy and Arora (1972) (see Baltagi (1995) p. 153).

¹⁴ In order to account for possible autocorrelation in the error term, autocorrelation and heteroscedasticity consistent standard errors for (artificially balanced) panel data model with fixed effects are estimated as suggested by Arellano (1987). These standard errors were close to standard errors estimated under classical assumptions and thus the latter are reported for the (unbalanced) panel data model presented in the paper.

Table 2-6 Relationship between annual depreciation in the real value of money ($\pi/(1+\pi)$) in post-enactment period and CBI.

Dependent variable: $\pi/(1+\pi)$

Maximum estimation period: 1990 - 1998

Specification: $y_{it} = \alpha + X_{it}'\beta + u_{it}$

$u_{it} = \mu_i + v_{it}$ (individual effects only)

$u_{it} = \mu_i + \lambda_t + v_{it}$ (time & individual effects)

$\mu_i \sim \text{IID}(0, \sigma_\mu)$, $\lambda_t \sim \text{IID}(0, \sigma_\lambda)$, $v_{it} \sim \text{IID}(0, \sigma_v)$

	Individual effects only		Time & individual effects		Individual effects only		Time & individual effects	
Regressors:	Fixed effects	Random effects	Fixed effects	Random effects	Fixed effects	Random effects	Fixed effects	Random effects
OI_{t-1}	-0.0010 (0.0116)	-0.0102 (0.0102)	-0.0179 (0.0122)	-0.015479 (0.0104)	0.0100 (0.0120)	0.0109 (0.0100)	0.0036 (0.0138)	0.0080 (0.0095)
CLI	-0.0455** (0.0121)	-0.0494** (0.0114)	0.034376 (0.0564)	-0.0466* (0.0197)	-0.0282* (0.0122)	-0.0322** (0.0112)	-0.0225 (0.0575)	-0.0462* (0.0198)
OI_{t-1} when CLI > 2					-0.0203** (0.0053)	-0.0225** (0.0052)	-0.0185** (0.0063)	-0.0220** (0.0053)
DEF_{t-1}	-0.0108** (0.0030)	-0.0099** (0.0028)	-0.0093** (0.0032)	-0.0091** (0.0028)	-0.0090** (0.0029)	-0.0076** (0.0025)	-0.0082** (0.0032)	-0.0060** (0.0023)
IMF_{t-1}	-0.2060** (0.0603)	-0.1904** (0.0541)	-0.1769** (0.0630)	-0.1791** (0.0556)	-0.1780** (0.0569)	-0.1519** (0.0479)	-0.1747** (0.0605)	-0.1352** (0.0469)
RUBEL	0.3036** (0.0768)	0.3125** (0.0741)	0.2542** (0.0916)	0.2960** (0.0838)	0.2424** (0.0737)	0.2467** (0.0701)	0.2368** (0.0882)	0.2572** (0.0834)
CONSTANT		0.6624** (0.1168)		0.7071** (0.1383)		0.5614** (0.1024)		0.6485** (0.1092)
R-squared:	0.782	0.759	0.799	0.584	0.811	0.781	0.816	0.741
Adjusted R-sq	0.728	0.749	0.729	0.566	0.761	0.769	0.750	0.728
Durbin-Watson:	1.551		1.55		1.612		1.592	
Number of obs:	122	122	122	122	122	122	122	122
Hausman's Chi-squared statistic	4.831	(0.437)	5.360	(0.374)	7.627	(0.267)	7.751	(0.257)
LM (H0: $\sigma_\mu = 0$)		14.448	(0.000)			11.931	(0.001)	
LM (H0: $\sigma_\lambda = 0$)		0.083	(0.773)			1.439	(0.230)	
LM (H0: $\sigma_\mu = \sigma_\lambda = 0$)		14.531	(0.001)			13.370	(0.001)	
F-statistic for equality of dummy variables (marginal significance level):								
time dummies:		F(7,90) = 1.074	(0.387)			F(7,89) = 0.390	(0.906)	
group dummies:		F(19,90) = 3.398	(0.00)			F(19,89) = 2.810	(0.001)	

Notes:

OI_{t-1} - Overall Independence, lagged one period

CLI - Cumulative Liberalisation Index

** and * denotes significance at 1% and 5% levels respectively. Numbers in parenthesis under coefficients are standard errors¹⁵. Numbers in parenthesis reported with the tests are marginal significance levels. Variance components for random effects model with individual and time effects are estimated as suggested by Wansbeek and Kapteyn (1989). Variance components for random effects model with individual effects only is estimated as suggested by Swamy and Arora (1972) (see Baltagi (1995) p. 153).

Table 2-5 repeats the earlier regression between inflation and CBI for the panel. The results support negative relationship between independence and inflation, even after controlling for the cumulative liberalisation. Coefficients of the overall independence

¹⁵ See previous footnote.

(OI) in the model with individual effects are close to those obtained from the time aggregated data. Standard errors of these estimates are, however, larger and the OI is not significantly different from zero. The effect of independence in the advanced stage of transformation is highly significant and larger in absolute value than estimated from the time aggregated data. The coefficient of the cumulative liberalisation index is negative and significant. In models with both individual and time effects (preferred on the basis of F statistics for time and individual dummies, although not on the basis of LM tests) the coefficient of the independence index is negative, significant and larger in absolute value than in earlier regression. A model with both effects, but allowing for a different impact of CBI in the advanced transformation stage, strongly supports the conclusion from the time aggregated data and indicates that the relationship between CBI and inflation is stronger at the higher level of liberalisation.

Regressions in Table 2-6 introduce the rouble zone dummy, IMF conditionality and budget deficits. The last two variables are lagged one period to allow for a delay between a policy change and inflation and to avoid endogeneity problems, particularly in case of the budget deficit. The three new variables are significant and have expected signs: inflation drops after introducing IMF programs and after adopting own currency, increases with higher in absolute value general government budget deficit. Regressions without time effects are now preferred over models with both effects on the basis of F statistics for time dummies and LM tests, but all models produce similar results. The coefficient of the overall independence is much smaller in absolute value than in models estimated from time aggregated data or from the panel with only one conditional variable and not statistically significant. The coefficient of independence at the high level of liberalisation is smaller in absolute value than in earlier regressions, but is still negative and highly significant.

Thus, the panel regressions conditional on additional variables support the conclusion that the negative relationship between inflation and independence is present in the data, but only at the advanced stage of economic transformation. The significance of CBI in models without the additional variables does **not** arise from the correlation between policy adjustments and changes in the law.

2.8 Conclusions

Almost all transition economies passed through the period of very high inflation. Economic theory suggests that an independent central bank can protect an economy from excessive monetary expansion, facilitating the stabilisation process and protecting society from inflationary bias. However, in a period of severe macroeconomic imbalances, this institutional arrangement may not be effective enough to stabilise the economy.

How effective is central bank independence in protecting price stability? The results reported in the text indicate that, although the fiscal policy stance and external conditionality are important elements of the stabilisation process, changes in the CB laws are highly significant in explaining the annual inflation rates over time. The CB independence, however, is not a substitute for other elements of stabilisation programs and exerts a downward pressure on inflation only at the high level of liberalisation, after the initial price liberalisation shock had been contained. Moreover, in most cases analysed here the new CB laws were enacted after the stabilisation program had been introduced. The two results: statistical significance of the CB independence at the high level of liberalisation, as well as the timing of stabilisation attempts and reforms of CB laws, suggest that the independence is a powerful device for protecting price stability, but not for stabilising the price level.

It still may be true that monetary institutions do not really matter for inflation performance, even after the initial stabilisation. The significance of CBI could mean that independence is a proxy for inflation aversion in the society and among policy makers. Granting legal independence to the central bank is a signal that the anti-inflationary consensus has been achieved when the costs of inflation exceed political gains from excessive monetary expansion. A lower inflation merely reflects the policy change and not the institutional changes.

Obviously, the legal framework is only one element of overall central bank independence. In the study by Cottarelli et al. (1998), who analyse a panel of transition and industrial countries, the CB independence is evaluated by IMF country economists in a questionnaire.¹⁶ Cottarelli et al. (1998) find significant effects of CB independence

¹⁶ The questionnaire asks IMF desk economists to evaluate CB independence in the scale from 1 (independent) to 10 (subordinate).

evaluated in this way on inflation. Similar conclusions thus follow from a more behavioural approach to measuring independence and undermine the critics expressed above. Further research, based on other behavioural measures, would be useful to check the robustness of the results. Some measures already proposed in the literature could be applied here: average turnover of the governor, political vulnerability of the governor (fraction of political transitions followed by a replacement of the governor) and an index based on a questionnaire sent to the CB staff.

2.9 Appendix: Construction of indices of Central Bank Independence

Table 2-7 Elements of political (PI) and economic (EI) CB independence. OI = EI+PI.

	G1	G2	G3	B4	B5	R6	R7	C8	C9	PI	D10	D11	D12	D13	D14	D15	M16	M17	EI	OI
Albania 92	*	*	*			*		*		5	*	*	*		*	*			5	10
Albania 96	*	*	*		*	*		*		6	*	*	*	*	*	*	*		6	12
Armenia 93	*	*				*		*	*	5	*		*			*			3	8
Armenia 96	*	*	*	*		*		*	*	7	*	*	*	*	*	*	*		7	14
Belarus 90	*	*		*		*			*	5	*	*	*	*	*	*			4	9
Belarus 92	*				*	*		*	*	5	*	*	*	*	*	*	*		6	11
Bulgaria 91	*		*	*		*	*	*	*	7	*	*	*	*	*	*	*		5	12
Bulgaria 96	*		*	*		*	*	*	*	6	*	*	*	*	*	*	*		5	11
Bulgaria 97	*	*		*	*	*	*	*	*	8	*	*	*	*	*	*	*		7	15
Croatia 92	*	*		*		*	*	*	*	7	*	*	*	*		*			4	11
Czech Rep 92	*	*	*	*	*		*	*	*	8	*	*	*	*	*	*	*		5	13
Estonia 93	*		*	*			*	*	*	6	*	*	*	*	*	*	*		7	13
Georgia 95	*	*	*	*	*	*	*	*	*	8	*	*	*	*		*	*		6	14
Georgia 96	*	*	*	*	*	*		*		7	*	*	*	*	*	*	*		6	13
Hungary 91		*	*					*		3	*	*	*	*		*	*		6	9
Hungary 97		*	*					*		3	*	*	*	*	*	*	*		7	10
Kyrgyz Rep 92	*		*					*		3	*	*	*	*	*	*	*		5	8
Kyrgyz Rep 97	*	*	*	*	*		*	*	*	8	*	*	*	*	*	*	*		7	15
Latvia 92	*	*	*	*	*	*	*	*	*	9	*		*		*		*		3	12
Lithuania 91	*			*	*	*		*		5			*		*		*		2	7
Lithuania 96	*		*	*	*	*	*	*	*	8	*	*	*	*	*	*	*		7	15
Macedonia 96	*	*	*	*	*	*	*	*	*	8	*	*	*	*	*	*	*		6	14
Moldova 91	*	*	*	*	*	*	*	*	*	8	*				*		*		2	10
Moldova 95	*	*	*	*	*	*	*	*	*	8	*	*		*	*	*	*		5	13
Poland 89	*			*		*		*		4	*		*		*	*	*		4	8
Poland 92	*	*	*	*		*		*		6	*		*		*	*	*		4	10
Poland 97	*	*	*	*	*	*	*	*	*	7	*	*	*	*	*	*	*		7	14
Romania 91		*			*	*		*		4	*		*		*		*		3	7
Russia 90	*			*		*		*	*	5	*		*	*	*	*	*		5	10
Russia 95	*		*	*		*		*	*	5	*	*	*	*	*	*	*		6	11
Slovak Rep 92		*	*			*	*	*	*	5	*	*	*	*	*	*	*		6	11
Slovenia 91	*	*		*	*	*	*	*	*	7	*	*	*		*		*		4	11
Ukraine 91	*			*		*				3	*				*		*		2	5

Source: National legislation

G1: Governor not appointed by the government

G2: Governor appointed for more than 5 years

G3: Provisions for governor's dismissal non-political only

B4: None of the board appointed by the government

B5: Board appointed for more than 5 years

R6: No mandatory government representative in the board

R7: Government approval of monetary policy is not required

C8: Statutory responsibility to pursue monetary stability

C9: Presence of legal provision supporting bank in conflicts with the government

D10: Direct credit facility is not automatic

D11: Direct credit facility is at the market interest rate

D12: Direct credit facility is temporary

D13: Direct credit facility is of limited amount

D14: CB does not participate in the primary market

D15: All direct credit is securitized

M16: Discount rate is set by the central bank

M17: Supervision of commercial banks is not entrusted to CB (**) or not entrusted to CB alone (*)

Table 2-8 Central bank governor

Country	Governor appointed by	Term (years)	Reappointment	Provisions for dismissal
Albania 96	President (proposal of the Central Bank Board)	7	Yes	Non-political
Armenia 96	Parliament (proposal of the President)	7	?	Non-political
Belarus 96	Parliament (proposal of the President)	6	-	-
Bulgaria 97	Parliament	6	Two terms	Non-political and action or inaction resulting in a failure to fulfil any task of the Bank
Croatia 92	Parliament	6	-	-
Czech Rep. 92	President	6	-	Non-political
Estonia 93	President (proposal of the Board Chairman)	5	-	Non-political
Georgia 96	Parliament (proposal of the President)	7	Yes	Disagreement on a current monetary policy between the Central Bank and the Parliament (or President)
Hungary 97	President (proposal of the Prime Minister)	6	Yes	Non-political
Kyrgyzstan	President (approval of the Parliament)	7	Three terms	Non-political
Latvia 92	Parliament	6	Yes	Non-political
Lithuania 91	Parliament (proposal of the President)	5	-	Non-political
Macedonia 96	Parliament (proposal of the President)	7	Two terms	Non-political
Moldova 95	Parliament	7	-	Non-political
Poland 97	Parliament (proposal of the President)	6	Two terms	Non-political
Romania 91	Parliament (proposal of the Prime Minister)	8	Yes	Unconditional
Russia 95	Parliament (proposal of the President)	4	-	Non-political
Slovak Rep. 92	President on Government's proposal	6	Two terms	Non-political
Slovenia 91	Parliament (proposal of the President)	6	Yes	-
Ukraine 91	Parliament	4	-	-

Sources: National legislations. For Armenia: Cukierman et al. (1998) and Bank of Armenia WWW page.

Table 2-9 Central bank board

Country	Board appointed by	Members	Term (years)	Reappointment	Government representative
Albania 96	Parliament: 3 members, President: 1 member, Council of Ministers: 2 members, Minister of Finance: 1 member, Central Bank Board: 1 member, Governor: 1 member	9	7	Yes	No
Armenia 96	Parliament (proposal of the President): V-Governor, President: 5 other members	7	7 (V-Governor), 5 (other members)	-	No
Belarus 96	Parliament: 1 member, Council of Ministers: 1 member, Parliament (proposal of the Governor): other members	-	6	-	No
Bulgaria 97	Parliament (proposal of the Governor): 3 V-Governors, President: 3 other members	7	6	-	No
Croatia 92	Parliament (proposal of the Governor): Deputy Governor and V-Governors, Parliament: other members	9-15	6 (Deputy Governor and V-Governors)	-	No
Czech Rep. 92	President	7	6	-	Yes (advisory)
Estonia 93	Parliament (proposal of the President): Chairman, Parliament (proposal of the Chairman): other members	-	5	-	Yes (Minister of Finance)
Georgia 96	Parliament (proposal of the President)	9	7	Yes	No
Hungary 97	President (proposal of the Governor, agreed with and presented by the Prime Minister): Deputy Governors, President (proposal of the Prime Minister consulted with the Governor): other members	Max 11	6 (Deputy Governors), 3 (other members)	-	Yes (advisory)
Kyrgyzstan	President (proposal of the Governor)	9	7	Three terms	No
Latvia 92	Parliament (proposal of the Governor)	8	6	Yes	Minister of Finance (advisory and suspensive right)
Lithuania 91	President (proposal of the Governor)	14	9	-	No
Macedonia 96	Parliament (proposal of the Governor): Deputy Governor and V-Governors, Parliament: other members	9	7	Two terms (Deputy Governor), No (other members)	No
Moldova 95	Parliament (proposal of the Governor)	5	7	-	Yes (advisory)
Poland 97	President: 3 members, Parliament: 6 six members	9	6	No	Yes (advisory)
Romania 91	Parliament (proposal of the Prime Minister)	9	8	Yes	No
Russia 95	Parliament (proposal of the Governor after consultation with the President)	13	4	-	Minister of Finance Minister of Economy (advisory)
Slovak Rep. 92	President (proposal of the Government with the consent of the Parliament): 2 V-Governors Government (proposal of the Governor): 2 Executive Directors and 3 other members	8	6 (V-Governors and Executive Directors), 4 (other members)	Two terms	Yes (advisory)
Slovenia 91	Parliament (proposal of the Governor): Deputy Governor and 3 V-Governors, Parliament (proposal of the President): 6 other members	11	6	-	No
Ukraine 91	Parliament (proposal of the Governor)	-	4	-	No

Sources: National legislations. For Armenia: Cukierman et al. (1998) and Bank of Armenia WWW page.

Table 2-10 Monetary policy

Country	Relation with Government	Relation with Parliament	Monetary stability objective	Provisions in case of disagreement Central Bank vs. Government
Albania 96	Consultation	Bank submits semi-annual policy statements (assessment of the monetary policy in the proceeding six month and the monetary policy that will be followed in the next six months)	Yes	No
Belarus 96	Advisory	Bank submits quarterly reports and monetary policy guidelines for the next year. Parliament issues recommendations regarding monetary policy guidelines	Yes	Yes
Bulgaria 97	Advisory	Bank submits annual and semi-annual reports	Yes	Yes
Croatia 92	-	Bank submit reports at least twice a year and on demand	Yes	Yes
Czech Rep. 92	Advisory	Bank submit reports at least twice a year	Yes	Yes
Estonia 93	Advisory	Bank submits annual reports	Yes	Yes
Georgia 96	Advisory	Bank submits annual reports. Parliament issues directives regarding monetary policy guidelines.	Yes	Independence from the Government. Board dismissal in case of disagreement on Parliament directives regarding monetary policy
Hungary 97	Co-operation	Bank submits annual reports and monetary policy guidelines	Yes	No
Kyrgyzstan	Co-operation if price stability not endangered	Bank submits annual reports and semi-annual reports on monetary policy developments. Parliament approves annual reports.	Yes	Yes
Latvia 92	Advisory	Bank submits annual reports	Yes	Minister of Finance has a right to postpone a decision of the Board for ten days. The decision is executed if the Board does not change it during this period.
Lithuania 91	Advisory	Bank submits semi-annual reports	Yes	Yes
Macedonia 96	-	Bank submits semi-annual and annual reports	Yes	No
Moldova 95	Co-operation	Bank submits annual reports	Yes	No
Poland 97	Co-operation	Bank submits monetary policy guidelines and annual reports	Yes	No
Romania 91	-	Annual report	Yes	No
Russia 95	Co-operation	Bank submits annual reports and presents monetary policy guidelines. Parliament issues statements regarding reports and monetary policy guidelines of the Bank.	Yes	Yes
Slovak Rep. 92	Advisory	Bank submits semi-annual reports	Yes	Yes
Slovenia 91	-	Bank submit reports at least twice a year	Yes	No
Ukraine 91	-	Bank submit annual reports and monetary policy guidelines. Parliament approves monetary policy guidelines.	No	No

Sources: National legislations.

Table 2-11 Constraints on central bank credit to the government

Country	Instrument	Maturity	Quantitative Ceiling	Interest rate
Albania 96	Direct loans	one year	10% (1996), 6% (1997) and 2%(1998) of the budget revenue in the preceding year	Not lower than the market rate on treasury bills
	Securities (P)	U	4% of the budget revenue in the preceding year	-
	Securities (S)	U	U	-
Belarus 92	Direct loans	Less than six months	5% of the GDP in the current financial year	-
	Securities (P)	P	P	-
	Securities (S)	U	U	-
Bulgaria 97	Direct loans	P	-	-
	Securities (P)	P	-	-
	Securities (S)	P	-	-
Croatia 92	Direct loans	Repayable not later than the end of the budgetary year	5 percent of the budget	Discount rate
	Securities (P)	U	U	-
	Securities (S)	U	U	-
Czech Rep. 92	Direct loans	Less than three months	5 percent of the budget revenue in the previous year	-
	Securities (P)	U	U	-
	Securities (S)	U	U	-
Estonia 93	Direct loans	P	P	-
	Securities (P)	P	P	-
	Securities (S)	P	P	-
Georgia 96	Direct loans	Less than six months	5 percent (in special circumstances 8 percent if it is consistent with monetary policy of the Bank) of the average budget revenue in the last three financial years	Market rate
	Securities (P)		The above conditions applies to purchases of securities but may be relax if securities are purchased for conducting monetary policy on the secondary market	
	Securities (S)			
Hungary 97	Direct loans	Up to 15 days and repayable before the end of the budgetary year	2% of the planned budget revenues	Basic rate
	Securities (P)	P	P	P
	Securities (S)	U	U	U
Kyrgystan 97	Direct loans	P	P	-
	Securities (P)	P	P	-
	Securities (S)	U	U	-
Latvia 92	Direct loans	U	1/12th of the planned revenue	-
	Securities (P)	U	U	-
	Securities (S)	U	U	-
Lithuania 96	Direct loans	P	P	-
	Securities (P)	P	P	-
	Securities (S)	U	U	-
Macedonia 96	Direct loans	Repayable not later than the end of the budgetary year	5 percent of the planned budget	Market
	Securities (P)	U	U	-
	Securities (S)	U	U	-

Sources: National legislations.

Table 2-11 (contd). Constraints on central bank credit to the government

Country	Instrument	Maturity	Quantitative Ceiling	Interest rate
Moldova 95	Direct loans	U	U	Market
	Securities (P)	P	P	P
	Securities (S)	Less than 6 months	U	-
Poland 97	Direct loans	P	P	-
	Securities (P)	P	P	-
	Securities (S)	U	U	-
Romania 91	Direct loans	U	10 percent of the planned budget and twice the sum of the capital and reserve fund of the Bank	-
	Securities (P)	U	U	U
	Securities (S)	U	U	U
Russia 95	Direct loans	-	Prohibited, unless stated otherwise in the budget law	-
	Securities (P)	-		-
	Securities (S)	U	U	-
Slovak Rep. 92	Direct loans	Less than three months	Prohibited 5 percent of the budget revenues in the previous year None	U
	Securities (P)	P	P	-
	Securities (S)	Less than one year	U	-
Slovenia 91	Direct loans	Repayable not later than the end of the budgetary year	5 percent of the budget and 20 percent of the planned budget deficit	U
	Securities (P)	U	U	-
	Securities (S)	U	U	-
Ukraine 91	Direct loans	U	Subject to decision of the Parliament	-
	Securities (P)	U	U	-
	Securities (S)	U	U	-

Sources: National legislations.

3 MONEY, INFLATION AND OUTPUT IN ROMANIA, 1992-2000¹⁷

3.1 Introduction

The end of central planning in Europe—whether it came as a result of slow decay or of rapid collapse—was frequently accompanied by bursts of high inflation. Though the causes of that inflation have been and remain a subject of debate, statistical tests of alternative hypotheses have not been frequent.¹⁸ One of the central questions is the extent to which these early periods of high inflation were caused by excess monetary creation versus other factors. This paper addresses that question in the case of Romania, a weakly reformed, high inflation, transition economy.

High inflation can not persist unless it is caused or validated by excessive money creation. The objective of this paper is to provide an empirical estimate of the relationship between inflation and money creation in Romania, and to test statistically the extent to which money creation is cause or effect.

Romania is an interesting case in its own right, but also because liberalization in this country was delayed and drawn out, and the dynamics of high inflation can be observed over a period of several years. This paper specifies and estimates a demand function for real money in Romania. This is done with monthly data from January 1992, the earliest date for which all of the necessary series are available, to December 2000, when the rate of inflation first durably declined below 35% per year at an annual rate. Augmented ADF tests suggest strongly that the principal variables are integrated of order one. In this context, the search for a real money demand function is a search for a co-integrating, equilibrium relationship; and an important question is whether, and to what degree, the observed high inflation is influenced by divergence between actual money supply and equilibrium money demand.

The estimation of equilibrium real money demand functions has been one of the central focuses of the empirical literature on applied co-integration analysis. Ever since the path breaking studies of Johansen and Juselius (1990) and Juselius (1992),

¹⁷ This chapter is based on the joint paper with Nina Budina, Georges de Menil and Geomina Turlea, forthcoming in Journal of International Money and Finance.

¹⁸ One of the obstacles to statistical inference is the short duration of the initial burst of high inflation in most transition countries.

cointegrating real money demand equations have been identified and estimated in many different countries and contexts. Lutkepohl and Wolters (1998) edit the proceedings of a workshop motivated by the run-up to European Monetary Union, in which co-integration estimates of money demand are presented for the United Kingdom, Finland, Norway, Germany, Spain, Greece and Switzerland.¹⁹ Ericsson et al. (1998) discuss the structural analysis of co-integrating relationships in their introduction to a series of studies in which this method is applied to money demand in the United Kingdom, Denmark, Turkey, Brazil and Australia.²⁰

Though the general principles of money demand analysis apply to all non-centrally planned economies, European transition economies present certain characteristic traits, which call for a distinctive approach. These are: high inflation; large amounts of directed, non-market credits; periods when the exchange rate is significantly over-valued; and pervasive price controls. The paper argues that these call for modeling money demand with an extended version of the Cagan (1956) specification.

Single equation co-integration methods have been used to estimate long-run, Cagan money demand functions for transition economies by Aarle and Budina (1995). Measures of the difference between money supply and such money demand functions have been used as part of an error correction mechanism to explain inflation in Russia by Choudry (1998).²¹ This paper can be viewed as an extension to another incompletely reformed economy of the approach of Choudry.²²

¹⁹ See Hendry and Mizon (1998), Ripatti (1998), Eitrheim (1998), Scharnagl (1998), Lutkepohl and Wolters (1998), Vega (1998), Ericsson (1998), Ericsson and Sharma (1998), Peytrignet and Stahel (1998), and Juselius (1998).

²⁰ The studies, in a special section of the *Journal of Business and Economic Statistics*, are Harbo et al. (1998), Juselius (1998), Metin (1998), Durevall (1998) and de Brouwer and Ericsson (1998). See also, earlier work by Hendry and Doornik (1994).

²¹ See also the study of inflation in Ukraine by Banaian et al. (1998).

²² The special characteristics of the Cagan money demand function in Romania have been studied by Dobrescu (1994). Co-integration techniques are used to estimate a complete model of the monetary mechanism in Pelinescu and Scutaru (2000).

The rejection the weak exogeneity of inflation and the finding that excess money supply affects the course of inflation confirms Choudry's result. The specification and conclusions differ from those reached in a related analysis in IMF (2001).

Section 3.2 reviews the context of transition in Romania and presents the data. Section 3.3 discusses the distinguishing characteristics of money demand and inflation in European transition countries. Section 3.4 tests for the stationarity of the variables studied. Section 3.5 uses the Johansen (1998) technique to identify and estimate a co-integrating relationship and test for weak exogeneity. Section 3.6 estimates the implied error correction models and uses them to compute out-of-sample forecasts. The economic implications of these results are interpreted in Section 3.7.

3.2 Romania: A Decade of Delayed Liberalization and High Inflation

3.2.1 Political transformations²³

Under Ceausescu, Romania experienced one of the most draconian and repressive regimes in the Communist Europe. After he was overthrown in December 1989, power remained in the hands of the successor to the Communist Party, which eventually became the PDSR (Partidul Democrat Social Roman).

The PDSR introduced partial political and economic reforms, but resisted full liberalization. On at least two occasions, steps toward liberalization were either thwarted, or offset by increased distortions elsewhere. The unification of exchange rates in November 1991 was accompanied by a large devaluation, but the authorities stopped short of either adopting external convertibility, or freeing domestic prices. The exchange rate remained controlled, and was soon again overvalued. It remained overvalued until early 1997.

In June 1993, the share of consumer prices subject to controls was reduced from over 50% to about 40%, and, in October of the same year, real interest rates on credits from the state-owned banking system (which had been as low as -230%) were increased to positive levels. By the spring of the following year, massive directed credits to state owned enterprises and political affiliates had resumed. Between 1994 and 1996, the

²³ The political economy of Romania's first ten years of transition is discussed in De Menil (2003).

economy grew, but the distortions resulting from subsidized and uneconomical credits, the overvalued exchange rate, and price controls accumulated. Between 1991 and 1996, the IMF had signed, and then interrupted three Stand-By agreements, for lack of compliance with commitments to convertibility and price liberalization.²⁴

In elections in November and December 1996, opposition forces led by a coalition of historical parties won a majority of the National Assembly, and defeated the incumbent president. The new Government began its term with a comprehensive program of liberalization and stabilization. In February and March 1997, with the support of the IMF, it devalued the exchange rate, guaranteed its convertibility, and eliminated remaining price controls on all but 10% of consumer goods.²⁵ Energy and public utility prices were raised to international levels. The burst of inflation, which immediately resulted, was to be contained by strict budgetary and monetary policies. Implicit subsidies were eliminated, and the explicit, consolidated, cash budget deficit was limited to 5%. Subsidized, directed credits were stopped, but political pressures delayed the closure of major state banks, which had been rendered insolvent by their previous bad loans. For two years, these banks were bailed out by special credits from the central bank, which eventually found their way into increased money supply. Inflation remained high. Output fell as a result of domestic uncertainty and adverse external shocks.

Four years later, in the elections of November and December 2000, the PDSR – renamed the PSD (Partidul Social Democrat) – won back the majority of the legislature and the presidency. Though it temporarily halted privatization and social security reform, it maintained most of the other major reforms enacted between 1997 and 2000.

²⁴ Notwithstanding the above, trade was substantially liberalized, notably after the signature of an Association Agreement with the EU in February 1993, and exports and imports were reoriented towards the West. Also, small and medium sized enterprises were privatized, and 10 foreign banks (6 of them branches) were licensed between 1990 and 1996.

²⁵ The IMF supported the new Government's program with a Standby Credit, and the World Bank with Sectoral Adjustment Loans. The IMF loan was interrupted when a major Government reshuffle was accompanied by delays in the program in 1998.

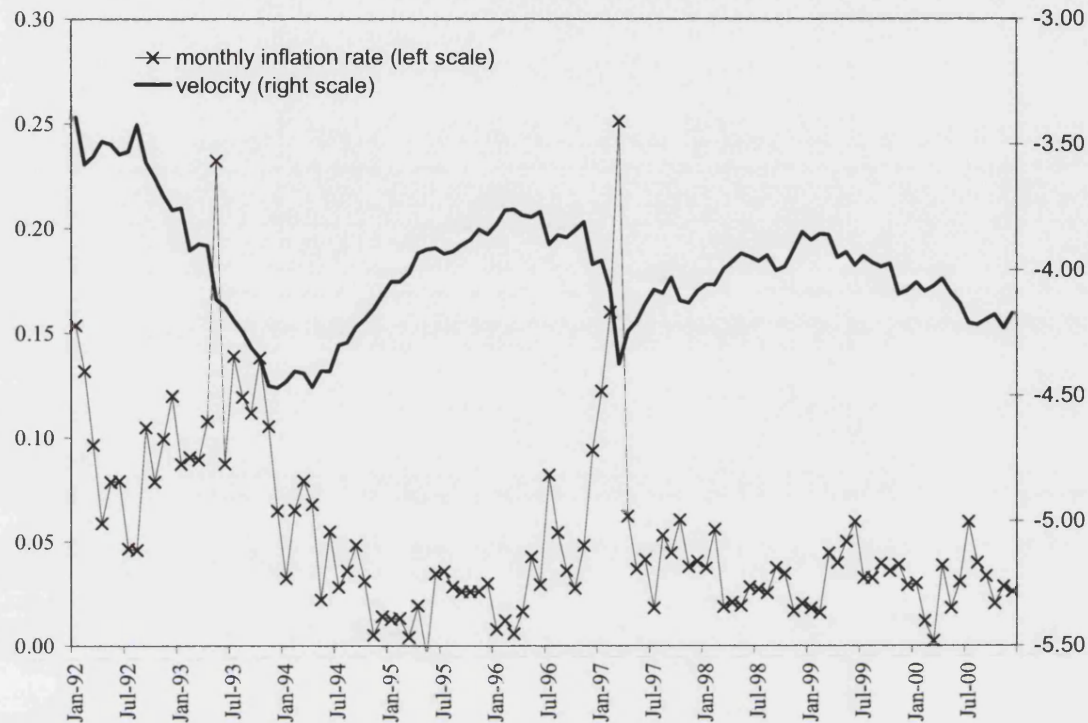
3.2.2 Economic Evolution

Figures 1 and 2 describe the evolution of inflation, output and money during the period of this study. Prices are measured by the consumer price index – P ; output by the real industrial production index – Y^{26} ; and money by domestic M2 – M^{27} . The data are monthly, seasonally adjusted, and they span January 1992 through December 2000. We eliminate common nominal trends, by focusing in the usual manner on the rate of change of prices (Δp), the natural logarithm of real industrial production (y), and the natural logarithm of real money balances ($m-p$), where lower case letters represent the logarithms of upper case letters.

²⁶ The paper uses real industrial production: the broadest activity variable available on a monthly basis. The velocity of M relative to the nominal value of reported industrial production will also be affected by the evolution of the share of informal to total output. Since informal output is not directly measurable, the effect of changes in its share is captured in the coefficients of the other factors influencing reported velocity. This approach is also taken by Dobrescu (1994,1998).

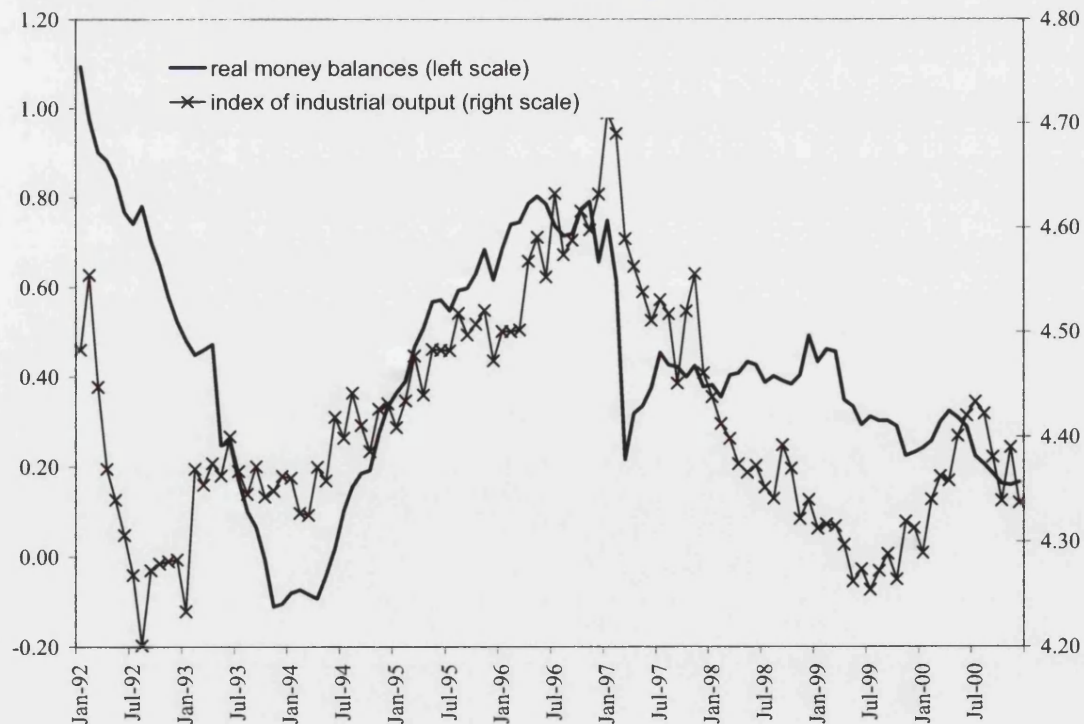
²⁷ In the studies of money demand in Romania cited in the previous footnote, Dobrescu advocates focusing on total M2, inclusive of foreign currency deposits, to which he adds estimates of economy-wide net arrears, and estimates of the value in Lei of foreign currency held outside the banking system. Foreign currency is excluded, both because domestic money is a less costly medium of exchange (as opposed to a store of value) in a less than hyperinflationary context, and because no direct measurements are available for foreign currency in circulation. Arrears are treated as a form of credit, rather than an alternative medium of exchange. In the estimates reported below, inflation and other explanatory variables capture the effect on M -velocity of variations in the intensity of the use of both foreign currency and arrears.

Figure 3-1 Romania: Trends in Velocity of Domestic Broad Money and Inflation



Source: National Bank of Romania

Figure 3-2 Romania: Trends in Real Money Balances and Output



Source: National Bank of Romania

Figure 3-1 shows inflation starting at a high level. The first observations of Δp in January and February 1992 are 18% and 12%. These come after a year of similarly high inflation. The average monthly rate during 1991 (not shown in the Figure) was 10%; the more customary January 1991 to January 1992 measure was 236%. The average monthly rate remains high in 1992 (9%) and 1993 (11%). 1993 was marked by an episode of partial liberalization in May 1993, when consumer prices rose 27%. The average monthly rate declines in 1994 (4%) and 1995 (2%), but starts to rise again after July 1996. Liberalization at the beginning of 1997 leads to a renewed bout of high inflation, 13% in January 1997, 17% in February, and 27% in March. The monthly rate then declines slowly. It averages 2% in 1999 and 4% in 2000. At no point in the period do price increases reach the level of hyperinflation (defined as 50% per month), but they are, throughout the period, well above the norm in Western Europe or the United States, and remain, at the end of the period, the highest in the region.

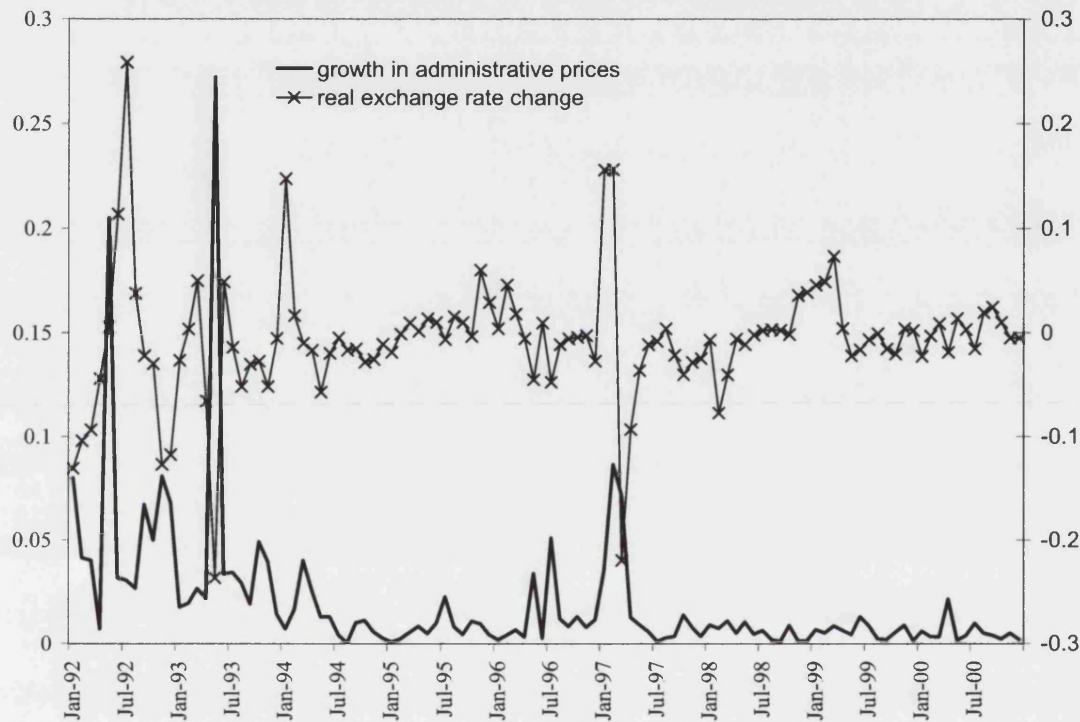
In January 1992, Romania was in the middle of its first transition recession, and industrial production was still declining. (Figure 3-2). However, output stabilizes in 1993, and grows steadily in 1994, 1995 and 1996. Between December 1993 and December 1996, the average annual rate of growth of industrial production is 13%. The OECD has described this as a period of real growth with weak structural change.²⁸ The second transition recession, beginning in early 1997, leads to a renewed decline of industrial production. Output stabilizes at the end of 1999, and is growing slowly during the last year of our period.

The wide swings which characterize the movement of real money balances between 1992 and 2000 (Figure 3-2) are suggestive of a positive relationship with real output and negative one with inflation. Between January 1992 and January 1994, real domestic M2 declines 69%. Between January 1994 and November 1996, it rises 139%. During the major liberalization episode of 1997, real M2 falls 41% in four months, and remains low for most of the rest of the period. Figure 1 presents the underlying relationship, central to this study, between velocity ($m - p - y$) and inflation.

²⁸ See OECD (1998) and OECD (2002).

Figure 3-3 represents two additional variables, whose movements are important characteristics of the inflation process in Romania: the monthly rate of change of the real leu/dollar exchange rate ($\Delta(e-p-p^*)$), and the monthly rate of change of administered prices (Δp^{adm}).²⁹

Figure 3-3 Romania: Growth in Administrative Prices and Real Exchange Rate Changes



Source: National Bank of Romania

Before 1997, the Leu was not freely convertible, except for brief intervals. Between episodes of devaluation, the authorities adjusted the official nominal exchange rate in a manner which resulted in a moderately rising trend of its real value.³⁰ In January and February 1997, the Leu was allowed to float, and it depreciated sharply. At the end of February, the currency became convertible on current account, but not on capital account.

²⁹ $\Delta(e-p-p^*)$ is the monthly rate of change of the official Leu/dollar exchange rate, minus the difference between the monthly rate of change of the US CPI and the Romanian CPI.

³⁰ Data on the black market premium suggest that the Leu was overvalued throughout this period. See de Menil (2003).

The National Bank of Romania intervened regularly, using reserves to smooth its movements. In the spring of 1999, when a combination of a peak in foreign debt service and delays in the renegotiations of an IMF Stand-By Agreement generated the expectation of a high probability of external default, the Bank again let the real value of the Leu slide. Otherwise, the period after February 1997 was characterised by a moderate appreciation of the real rate of exchange with the US dollar. Statistically the dynamics of real appreciation/depreciation appear similar before and after the 1997 liberalization.

The persistence of price controls over large segments of consumer goods implied that the economy was subjected to shocks at irregular intervals, when the authorities raised the prices still subject to administration.³¹ Figure 3-3 depicts the impact effect of these increases. The two largest shocks coincided with the liberalizations of May 1993 and February and March 1997. In those months, prices still under control rose respectively 57%, 24% and 44%. In the Figure, as in estimations, the increases in administered prices are weighted by the remaining share of controlled prices in the consumer price index. Since this share declined at each liberalization, the peaks of the weighted impact number in the Figure also decline. The construction of the administered price index, P^{adm} , and its weight, are described in appendix 3.9.

Figure 3-1 through Figure 3-3 do not include any interest rate measures. Until 1997, many of the largest state banks, which dominated the Romanian banking sector, were heavily engaged in extending directed credits at subsidized rates. The official measure of average deposit rates implies negative real rates through all of 1993, most of 1995, and all of 1996. After the liberalisation of 1997, these real interest rates fluctuate around zero. At the same time, the Treasury Bill market, which was almost non-existent before 1997, remained essentially the narrow preserve of these same banks after 1997. Given the limited and political nature of financial alternatives to holding money, interest rates are not included in estimates of the demand for money.

³¹ Practitioners in these economies often go so far as to argue that administrative price increases completely determine the overall course of inflation, while they are working their way through the economy. Estimates below will support the view that they alter the short-run dynamics of what is, in the long run, fundamentally a monetary phenomenon.

3.3 Modelling Money Demand in Transition

High rates of inflation and poorly developed financial markets have characterized European transition countries in their early years. Romania lived with both for longer than most. Under both conditions, the rate of inflation is a better measure of the opportunity cost of holding money than available interest rates. This points to the following extended Cagan (1956) form for the choice of a model of money demand:

$$m_t - p_t = \beta_0 + \beta_1(p_t^e - p_{t-1}) + \beta_2 y_t \quad (5.1)$$

As before, lower case letters are the natural logs of upper case letters. The second term is the expected inflation rate. We follow Aarle and Budina (1995), Banaian et al.(1998), Choudry (1998) and others in basing our analysis of money demand in transition on this simple form.

Choudry (1998) adds the rate of depreciation of the nominal exchange rate to (5.1) in the case of Russia. If the rate of change of the Leu/USD rate had diverged in an irregular manner from the domestic inflation rate for significant periods of time, adding $e - e_{-1}$ to (5.1) (where e is the logarithm of that exchange rate) would be beneficial. However, as pointed out above, in Romania, controls before 1997 and the managed float after 1997 resulted in relative constancy (with the exceptions mentioned) of the real exchange rate. Therefore, $e - e_{-1}$ does not have sufficiently independent variation to be an additional determinant of the long-run real demand for money. The transitory influence of variations in the real exchange rate is tested below.

One of the paradoxes of money demand and the inflation process in less than fully liberalized transition economies is that neither the prevalence of price controls nor their removal appears fundamentally to distort the form of the demand for money. High rates of inflation have been observed even when countries had pervasive price controls.³² It will be shown below that Romania is not an exception to this paradox.

³² In Ukraine in 1993, for instance, extensive controls did not stop price increases from reaching hyperinflationary levels. See de Menil(1996). Some of the controls were administered rates of profit margin, and others—in absolute level form—were rapidly adjusted, increasingly frequently, by the bureaucracy.

The liberalization of February and March 1997 merits particular attention. Did the freeing of most remaining controlled prices, the passage from an overvalued to a mostly market determined exchange rate, and the termination of years of massive directed credits, constitute such important structural changes that they led to a regime change in the monetary mechanism and the inflationary process? Tests for a structural break in long-run money demand, and in price dynamics are presented below. The answer is that, though our equations include short-run responses to these shocks, there does not seem to be evidence of a structural break.

3.4 Choice of Variables and Tests for Stationarity

Stochastic character of the seasonality in the series is tested using two different methods: the Dickey, Hasza, Fuller (1984) method modified by Osborn (1988) and the method developed by Franses (1991) as an extension of Hylleberg, Engle, Granger and Yoo (1990) test for monthly data. Both tests reject in all cases the null hypothesis of stochastic seasonality. The rejection of non-stationary, stochastic seasonality justifies our maintained, simplifying assumption that seasonality is deterministic. Seasonally adjusted data are used for all variables except p^{adm} .³³

Table 3-4 in Appendix 3.10 presents augmented Dickey-Fuller (ADF) unit root tests for all the variables. Following the strategy proposed by Dickey and Pantula (1987),

³³ In order to remove the deterministic seasonality present in our series we used the X-12-ARIMA program of Census Bureau of the U.S. Department of Commerce. Ericsson, Hendry, and Tran (1994) show that the linear seasonal filter approximating earlier version of the Census procedure (X-11) may affect inferences about cointegration and alter dynamics and exogeneity status of variables in the model. Siklos, Ghysels and Granger (1995) show that the X-11 procedure exhibits strong non-linear characteristics, and that these characteristics may lead to incorrect inference about the number of cointegrating vectors in series simulated from linear models. However, empirical series may exhibit certain non-linear features and the impact of X-11 adjustment on more complicated process has not yet been fully researched. If the periodic component of data-generating-process exhibit non-linear characteristics, and if seasonality is treated as a noise contaminating the true relationship between the series, application of the X-11 procedure may perform better than using seasonally unadjusted data. This is likely the case for transition data, where seasonal patterns are likely to be more complicated and volatile than in developed economies.

the sequence of tests starts from the null hypothesis of two unit roots in the series. The lag structure in ADF equations is determined by sequential reduction starting from 6 lags, based on F-statistics, Schwarz information criterion and tests for remaining autocorrelation in the residuals. The tests are conducted with constant and trend for the null hypothesis of a single unit root, and with constant only for testing the hypothesis of two unit roots. The estimation period runs from January 1992 to December 2000. The tests suggest that the log of real money ($m-p$), inflation Δp and the log of real industrial production y are all integrated of order one. The rate of change of the real exchange rate $\Delta(e-p+p^*)$ appears to be stationary. The evidence is borderline for the rate of change of administered prices Δp^{adm} , which is assumed to be stationary.

To check robustness of the model, the cointegrating and error correction relations are also estimated for a shorter sample period (June 1993 to November 1996), beginning after the first and ending before the second liberalization shock. The ADF tests for the shorter sample period are reported in Table 3-5. They provide additional support for the inferences based on Table 3-4. In the shorter sample period, there is strong rejection of a unit root for the rate of change of administered prices.

3.5 Johansen's tests for cointegration and weak exogeneity

We begin our analysis of the dynamics of money, price and output with the formulation of an unrestricted VAR system with three endogenous variables: ($m-p$), Δp and y . The multivariate approach is more efficient than single equation modelling if there is a failure of weak exogeneity³⁴ or if variables under investigation form more than one cointegrating relation. Since both of these conditions may be present in our data, we apply the Johansen (1988) procedure based on the system estimation to determine the number of cointegration vectors and to test for weak exogeneity.

The analysis starts from the unrestricted VAR system (UVAR) of the following form:

³⁴ In the cointegration framework the variable is weakly exogenous if it is not influenced by deviations from the long-run relationships. The concept of weak exogeneity is discussed in Engle et al. (1983). Weak exogeneity in the cointegration framework is discussed in Ericsson et al. (1998).

$$x_t = \sum_{j=1}^k A_j x_{t-j} + \gamma D_t + \varepsilon_t \quad (5.2)$$

where x_t contains all endogenous variables ($m-p$, Δp , y) and D_t contains exogenous variables. Finally, ε_t is a vector of normally distributed error terms. The system can also be presented in the equivalent VECM (vector error correction) form:

$$\Delta x_t = \sum_{j=1}^{k-1} \Pi_j \Delta x_{t-j} + \Pi x_{t-1} + \gamma D_t + \varepsilon_t \quad (5.3)$$

where $\Pi = (\sum_{i=1}^k A_i - I)$ and $\Pi_j = (-\sum_{i=j+1}^k A_i)$ for $j = 1, 2, \dots, (k-1)$. The Π matrix can be decomposed to $\alpha\beta'$, where α represents the speed of adjustment to equilibrium and β the long-run coefficients. The rank of the Π matrix, which is equivalent to the number of cointegrating vectors, is tested by the Johansen (1988) procedure.

The first step in empirical UVAR modelling is to set the appropriate lag structure and select the set of exogenous variables on which we are conditioning the system.

After experimenting with different sets of exogenous variables, the preferred set includes a constant term, an impulse dummy for January 1997 (more flexible exchange rate regime), an impulse dummy for March 1997 (price liberalisation), the current second difference of the log of the administered price index scaled by the weight of administered prices in CPI, and lags of the first difference of the real Leu/dollar exchange rate. The two 1997 dummy variables reflect general characteristics of the liberalization of that winter, not captured by the other two exogenous variables. The same specification is also run with, in addition, a time trend.^{35 36}

³⁵ The results were similar to those described below, except that the estimated semi-elasticity of inflation in the long-run demand was more than half again higher. With the trend present, acceptance of the weak exogeneity of output, and rejection of the weak exogeneity of inflation and real money were even clearer than they are below. The results without the trend produce more economically reasonable estimated value of the semi-elasticity of inflation.

³⁶ Two of the variables which were included in our original set of exogenous variables, but were not retained because they were not significant were Δw and $\Delta(w - p)$, where w is the average wage rate in industry.

Both the rate of change of administered prices and the rate of change the real exchange rate are treated as measures of exogenous, supply shocks, expected to have an impact effect on the overall price level, and therefore on the supply of real money.

The analysis starts with six lags of the endogenous variables, the two dummies mentioned above, the current, scaled, second difference of the log of administered prices, and six lags of the first difference of the real exchange rate. After sequential reduction, UVAR with four lags of each endogenous variable, four lags of the first difference of the real exchange rate, the two dummies and our measure of administered prices is chosen for further analysis³⁷, and the Johansen's (1988) trace (λ_{trace}) and maximum eigenvalue (λ_{max}) tests are used to determine the rank of Π matrix. Asymptotic critical values for these tests are given in Johansen (1988) and Osterwald-Lenum (1992). Reimers (1992) proposed small sample correction by replacing T by $T-nk$ in both tests, and results from this test are also reported. It is important to note that the critical values of these tests are only indicative if we condition on exogenous variables other than constant and seasonal dummies. Therefore, in order to draw more decisive conclusions on the number of cointegrating vectors, test results from the specification without exogenous variables in the system are also reported.³⁸

³⁷ The final lag structure is determined by VAR order selection criteria SC (Schwarz's information criterion) and AIC (Akaike's information criterion), together with F-statistics associated with sequential reduction. The results on specification search are available on request.

³⁸ Harbo et al. (1998) and MacKinnon et al. (1999) account fully for the inclusion of exogenous variables. The strength of results indicates that they are robust to adjustments in the critical values.

Table 3-1 Romania: Cointegration statistics

Model 1: UVAR with four lags Jan 1992 – Dec 2000, conditional model

Rank	λ_{\max}	λ_{\max} using T - nk	95%	λ_{trace}	λ_{trace} using T - nk	95%
0	28.68**	25.49*	22.0	44.33**	39.4*	34.9
1	11.47	10.19	15.7	15.65	13.91	20.0
2	4.18	3.72	9.2	4.18	3.72	9.2

Model 2: UVAR with four lags Jan 1992 – Dec 2000, no exogenous variables

Rank	λ_{\max}	λ_{\max} using T - nk	95%	λ_{trace}	λ_{trace} using T - nk	95%
0	30.57**	27.18**	22.0	44.4**	39.46**	34.9
1	9.80	8.17	15.7	13.82	12.29	20.0
2	4.02	3.58	9.2	4.02	3.58	9.2

Model 3: UVAR with four lags Jun 1993 – Nov 1996, conditional model

Rank	λ_{\max}	λ_{\max} using T - nk	95%	λ_{trace}	λ_{trace} using T - nk	95%
0	25.95*	18.54	22.0	41.76**	29.83	34.9
1	9.25	6.61	15.7	15.81	11.29	20.0
2	6.56	4.69	9.2	6.56	4.69	9.2

Notes:

** denotes rejection at 1% critical value

* denotes rejection at 5% critical value

Table 3-2 Romania: Tests for restrictions in the conditional model

Weak exogeneity tests (cointegrating rank = 1 imposed)

Variable	Jan 1992 – Dec 2000	Jun 1993 – Nov 1996
LDMR	$\chi^2(1) = 17.061 [0.0000]$ **	$\chi^2(2) = 16.662 [0.0000]$ **
Δ LCPI	$\chi^2(1) = 6.6331 [0.0100]$ **	$\chi^2(2) = 6.5678 [0.0104]$ *
LIIP	$\chi^2(1) = 1.2261 [0.2682]$	$\chi^2(2) = 0.39088 [0.5318]$

Long-run coefficients β' with weak exogeneity of LIIP imposed (standard errors in parentheses)

LDMR	Δ LCPI	LIIP	Constant
Jan 1992 – Dec 2000			
1.000	13.696	-2.225	8.865
-	(3.555)	(0.779)	(3.418)
Jun 1993 – Nov 1996			
1.000	16.069	-1.587	5.818
-	(4.076)	(0.803)	(3.746)

Adjustment coefficients α with weak exogeneity of LIIP imposed (standard errors in parentheses)

	Jan 1992 – Dec 2000	Jun 1993 – Nov 1996
LDMR	-0.05427 (0.0106)	-0.1274 (0.0279)
Δ LCPI	0.01522 (0.0053)	0.04797 (0.0194)
LIIP	-	-

Notes:

** denotes rejection at 1% critical value

* denotes rejection at 5% critical value

The results in Table 3-1 suggest that there is only one linear combination of the variables, which is stationary. After imposing this restriction and normalising the parameter of the log of real money to unity, the cointegrating vector is recognisable as an augmented Cagan (1956) money demand function.³⁹

³⁹ Unitary elasticity of real money demand to output is not imposed, both because there are institutional reasons to expect velocity to increase, other things being equal, during
(continued)

Tests for the weak exogeneity of industrial production, inflation and real money in the conditional system, and estimates of the coefficients with imposed restrictions are reported in Table 3-2. Since the hypotheses being tested are linear in $I(0)$ variables⁴⁰, the test statistic used is the likelihood ratio test with limiting χ^2 distribution and a number of degrees of freedom equal to the number of independent restrictions to be tested.

Weak exogeneity of industrial production can not be rejected in any configuration. Economically, this implies that there is no long-run feedback from excess real money to industrial production. Interpretation of this result is proposed in section 3.7. In contrast, weak exogeneity of both real money and the rate of inflation are decisively rejected at the 1% level. This rejection constitutes the underlying rationale for the estimation of error-correction mechanisms for the short-run dynamics of real money and inflation.

The identified equilibrium money demand function (using conditional UVAR with imposed weak exogeneity of production) has the following form (with standard errors under estimated coefficients):

$$\begin{aligned} m - p = & - 8.865 - 13.696 p + 2.225 y \\ & (3.418) \quad (3.555) \quad (0.779) \end{aligned} \tag{5.4}$$

The robustness of these results is checked by repeating the tests on a shorter sample, which excludes the two major price liberalization episodes of 1993 and 1997. In the longer period tests, it could be argued that the estimated sensitivity of inflation to excess real money is mainly a reflection of spurts of pent-up inflation released at the time of liberalization. The results for the shorter sample period, reported in Table 3-1 and Table 3-2, are qualitatively and quantitatively similar to the full-sample period results.⁴¹

the period, and because the only available monthly measure of output is industrial production, and not GDP.

⁴⁰ x_t is $I(1)$ but Δx_t and $\beta'x_t$ are $I(0)$ because there is cointegration between elements of x_t .

⁴¹ The trace and maximum eigenvalue pass the Johansen (1988) test for one cointegrating vector, but not the Reimers (1992) test, because of the shortness of the sample. Nevertheless, conditional on there being one cointegrating vector, weak exogeneity of inflation and real money are rejected, and weak exogeneity of output is not. The cointegrating vector is recognizable as a Cagan money demand, with coefficients similar to those obtained for the longer sample.

The short sample period results thus support the conclusion that excess supply of real money is a recurrent determinant of inflation, whose influence is not limited to episodes of liberalization.

3.6 Error correction model

In the next step of the analysis the unrestricted UVAR system is mapped to a vector error correction system by restricting the Π matrix, as suggested by cointegration analysis, and by reducing the number of the short run parameters to be estimated. Defining ECM_t as a deviation from the long run money demand equation, we can map the whole system from $I(1)$ to $I(0)$ as follows:

$$\Delta x_t = \sum_{j=1}^{k-1} \Pi_j \Delta x_{t-j} + \alpha ECM_{t-1} + \gamma D_t + \varepsilon_t \quad (5.5)$$

The analysis of the vector error correction representation starts with estimation of the system of two equations with three lags of each dependent variable, the ECM term, and exogenous variables retained from the UVAR representation. The system is reduced by imposing zero restrictions on short run parameters with significance level lower than 10 percent as indicated by t-statistics. Since the hypothesis of weak exogeneity of industrial production was not rejected and parameter reduction reveals that this variable is not Granger-caused by real money and inflation, industrial production is strongly exogenous with respect to the remaining two endogenous variables. Consequently, the production equation is not analyzed. Estimates of the error correction model conditional on this variable are reported in Table 3-3. Validity of the last stage of reduction is tested and accepted by calculating the likelihood ratio of the model reported in the table versus an error correction model similarly conditioned on exogenous production, but including the subsequently dropped variables.⁴²

⁴² The test is $\chi^2(24)=18.123[0.797]$. The final model cannot be tested versus the original cointegrated UVAR reported in Table 3-1, because industrial production is treated as endogenous in Table 3-1 and exogenous in Table 3-3. However, that simplification was itself previously validated by the test for the exogeneity of production, reported above.

Diagnostic tests for ninth order serial correlation, ninth order conditional heteroscedasticity and non-normality did not reveal any problems with the specification of the model.^{43 44}

The constancy of the system is checked through recursive estimation. Recursive residuals⁴⁵ and recursive Chow tests⁴⁶ for the complete system show reasonable constancy of all equations (Figure 3-4). They notably do not suggest the presence of a structural break at the beginning of 1997.

⁴³ The tests were run in PcFiml econometric package. See Doornik and Hansen (1993) for a description of the tests.

⁴⁴ Against the charge that, given the shortness of our sample, these estimates constitute data mining, one may cite Hoover and Perez (1999), and subsequent discussion in Campos and Ericsson (1999) and Hendry (2000, Chapter 20).

⁴⁵ 1-step ahead residuals and their confidence intervals, for estimation ending successively in December 1995 (the first end date chosen by the procedure) through December 2000.

⁴⁶ 1-step Chow tests scaled by their critical values at 1% level are shown in the left diagram. N-decreasing Chow tests for stability between t and December 2000 are shown in the right diagram.

Table 3-3 Romania: Error correction model: FIML estimates

Estimated coefficients (standard errors in parentheses) :

$$\Delta LDMR = -0.0462 \text{ ECM}_{-1} - 0.3628 \Delta LDMR_{-1} + 0.2893 \Delta LDMR_{-3} - 0.5309 \Delta \Delta LCPI_{-1}$$

(0.0084) (0.0910) (0.0764) (0.1623)

$$-0.6172 \Delta \Delta LCPI_{-2} - 0.3975 \omega \Delta \Delta LADM + \text{dummies}$$

(0.1540) (0.0935)

$$\Delta \Delta LCPI = 0.0139 \text{ ECM}_{-1} + 0.2748 \Delta LDMR_{-1} - 0.1021 \Delta LDMR_{-2} - 0.2361 \Delta \Delta LCPI_{-1}$$

(0.0037) (0.0470) (0.0367) (0.0825)

$$+ 0.0700 \Delta LIIP_{-3} + 0.0855 \Delta REXR_{-1} + 0.0358 \Delta REXR_{-2}$$

(0.0395) (0.0292) (0.0134)

$$+ 0.2850 \omega \Delta \Delta LADM + \text{dummies}$$

(0.0493)

Sample: Jan 1992 – Dec 2000

Diagnostic statistics:

Individual equations:

$\Delta LDMR$:

Normality $\chi^2(2)$ = 1.4963 [0.4732]

ARCH 9 F(9,36) = 1.2847 [0.2611]

AR 1-9 F(9,45) = 1.7569 [0.0902]

$\Delta \Delta LCPI$:

Normality $\chi^2(2)$ = 2.2736 [0.3208]

ARCH 9 F(9,36) = 0.56493 [0.8210]

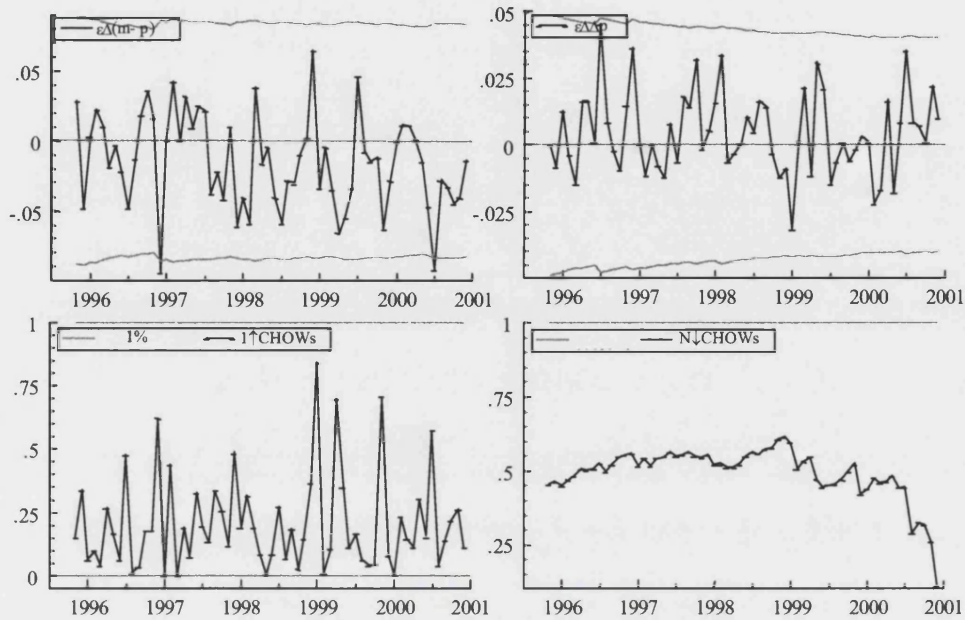
AR 1-9 F(9,45) = 2.3453 [0.0213]*

System:

Vector AR 1-9 F(36,160) = 0.99663 [0.4831]

Vector normality $\chi^2(4)$ = 2.2683 [0.6866]

Figure 3-4 Romania: Recursive Residuals and Chow Statistics for the Conditional ECM Model



3.7 Economic interpretation

The tests reported in Table 3-2 do not reject weak exogeneity of output, but reject weak exogeneity of both real money and inflation. In economic terms, in equilibrium, both the price level and real money are determined by the interaction of the supply and demand for money, whereas output is not. One possible interpretation is that output is supply determined.⁴⁷ This interpretation is not inconsistent with the emphasis on restructuring and reallocation in some analyses of the macroeconomics of transition. (See Blanchard (1997) and the literature cited there).

The result that the dynamics of inflation depend on the supply and demand for money is one of the principal findings of this study. Month-to-month movements in the rate of inflation are satisfactorily explained by an error correction mechanism in which the disequilibrium difference between supply and demand of money plays a significant role. Changes in administered prices and changes in the real exchange rate have transitory effects on the monthly movements of inflation.

⁴⁷ Popa (1998) presents evidence against the existence in Romania of a Phillips-like trade-off (working through demand channels) between inflation and output.

The results differ in emphasis from those reported in IMF (2001). The authors of that study focus on the levels of p, y, e, m and a measure of unit labour costs.⁴⁸ They take all five variables to be $I(1)$ ⁴⁹, find evidence for at least one cointegrating vector, and report that, in their preferred specification, nominal money does not appear significantly in the long-term, cointegrating relationship. Focusing on the relationship between p, e , and unit labour cost, they find a stable cointegrating relationship between the levels of those three variables, which they interpret as a price equation. They conclude that “unit labour costs, and to a lesser extent the exchange rate (...) are the leading proximate determinants of inflation,” and that “the role of money and credit growth, (though) also important, (has been) harder to demonstrate empirically.”⁵⁰ This paper finds strong evidence of a cointegrating relationship between real money, inflation and industrial production, and provides an estimate of a stable inflation equation in which excess money plays a significant role. The presented analysis suggests that focusing on the levels of nominal values is misleading, and the evidence strongly suggests that those variables are $I(2)$. The resulting misspecification is responsible for the implausible rejection of a long-run cointegrating relationship, which can be interpreted as a money demand equation in the IMF study.⁵¹

Findings presented here agree, on the other hand, with the results for Russia in Choudry (1998). The rejection in these studies of the weak exogeneity of inflation in Russia and Romania contrasts with the acceptance of that weak exogeneity in many cointegration studies of money demand and inflation in developed, market economies. In the workshop on “Money Demand in Europe” cited in the introduction, weak exogeneity of prices was rejected in only one case, that of Switzerland.⁵² In other cases,

⁴⁸ The period spanned by their data is January 1991 through March 2000.

⁴⁹ The authors acknowledge that many of the tests reported in their Appendix I could be interpreted as supporting a conclusion that the variables are $I(2)$.

⁵⁰ IMF (2001), pp. 2 and 3.

⁵¹ Table AII.3 of the study reports several estimates of cointegrating relationships in which monetary variables are highly significant. See models 4a, 5a and 6a.

⁵² See Petriguet and Stahel (1998).

the proximate causes of inflation were implicitly or explicitly seen to be cost-push or excess demand variables. Additional country studies are needed to ascertain whether or not the direct influence of excess money supply on inflation found here is a characteristic of high inflation, transition economies.

The fact that real money is endogenous implies that nominal money is itself endogenous. In principle, the endogeneity of real money could reflect exclusively the endogeneity of the price level. But, in that case, the $\Delta(m-p)$ equation would be a simple transformation of the $\Delta\Delta p$ equation (Table 4). It can be readily shown that this is not the case. Interpretation of the endogeneity of real money is beyond the scope of this paper. If M2 were directly controlled by the authorities, one could argue that its endogeneity suggests that monetary policy was partially accommodating.

3.8 Conclusions

This paper uses cointegration techniques to examine the equilibrium relations between real money, output and inflation in Romania, between 1992 and 2000. The three variables are found to be linked by a cointegrating relation that can be interpreted as an expanded Cagan (1956) money demand function. Output is shown to be strongly exogenous. But the dynamics of inflation and real money are satisfactorily described by error correction mechanisms, which include significant short-run effects of monetary disequilibria. The coefficients of those dynamic equations are stable, and do not show signs of structural break during the liberalization of 1997. The results imply that inflation was largely a monetary phenomenon, in Romania between 1992 and 2000.

3.9 Appendix: Construction of the administered price index

The administered price index is constructed from disaggregated data on consumer prices and their weights in the CPI, provided by the Romanian Statistical Office and published in the Price Statistical Bulletin. The list of administered prices was taken from the succession of laws and ordinances, provided by the National Bank of Romania. Since we do not have information about the weights used in constructing the 1993 CPI index, the figure for 1993 is based on regulations in 1993 and product weights in 1994.

The estimated share of the average consumer basket subject to controls evolved as follows:

<u>Period</u>	<u>Share of Consumer Prices Controlled</u>
1992.01 – 1993.04	0.52
1993.05 – 1996.12	0.33
1997.01 – 1997.02	0.37
1997.03 – 1998.08	0.15
1998.09 – 1998.12	0.10
1999.01 – 1999.12	0.12
2000.01 – 2000.12	0.15

Reductions in the share mainly result from the freeing of previously controlled items. Some of the variability reflects changes in the weights of controlled items in the basket. The shares are higher than officially reported by the Romanian authorities prior to 1997, but close to the estimates reported in IMF (2001).

3.10 Appendix: Unit Root Tests

Table 3-4 Romania: ADF unit root tests on the SA data—long sample: 1.1992 – 12.2000

Variable	Two roots		One root			
			Constant and trend		Constant	
	Lag	Test statistic	Lag	Test statistic	Lag	Test statistic
LDMR	4	-3.6694**	4	-2.6317	4	-2.8203
ΔLCPI	4	-6.8111**	4	-2.8751	4	-2.5050
LIIP	4	-4.9507**	4	-1.5757	4	-1.5772
ΔLADM	4	-9.3518**	4	-3.5692*	4	-2.5974
ΔLREXR	4	-8.7797**	4	-6.7454**	4	-6.7563**

Notes:

** denotes rejection at 1% critical value

* denotes rejection at 5% critical value

Table 3-5 Romania: ADF unit root tests on the SA data—short sample: 4.1993 – 11.1996

Variable	Two roots		One root			
			Constant and trend		Constant	
	Lag	Test statistic	Lag	Test statistic	Lag	Test statistic
LDMR	1	-3.7527**	4	-2.5485	4	-1.0021
ΔLCPI	3	-5.0742**	4	-1.0994	4	-3.0908*
LIIP	4	-3.6099**	4	-3.2600	4	0.11889
ΔLADM	4	-12.690**	4	-5.7587**	4	-8.1583**
ΔLREXR	4	-4.6040**	4	-3.9457*	4	-4.2036**

Notes:

** denotes rejection at 1% critical value

* denotes rejection at 5% critical value

4 MODELLING INFLATION IN GEORGIA⁵³

4.1 Introduction

Georgia has achieved an impressive success in stabilizing its economy after a hyperinflationary episode in 1993-1994. Inflation dropped from 15607 percent in 1994 to 163 percent in 1995 and reached a single-digit level in 1997. Devaluation of the Lari after the Russian financial crises raised the price level but did not have any lasting effect on inflation. In the same time National Bank of Georgia has faced difficulties in conducting its monetary policy: the economy has been highly dollarized, monetization has been low, and the money demand has fluctuated widely. This paper attempts to throw some light on the behaviour of inflation in Georgia and construct an inflation model suitable for policy formulation and evaluation. It tests for the presence of economically interpretable long-run relationships between prices, money and exchange rate, estimates a short-run inflation equation, and tests for its robustness and stability.

The model points to a dominant role of exchange rate in the behaviour of inflation and shows a low persistence of inflation in Georgia. Both factors contributed to the observed behavior of inflation after the Russian crises: after the depreciation, inflation increased sharply but quickly subdued, when the authorities managed to maintain the exchange rate at a higher, but stable level.

The model does not attempt to explain the behaviour of inflation during the hyperinflation and stabilization periods. For an analytical and empirical analysis of these episodes, the reader is referred to Wang (1999). Jirny and Jarocinski (1998) discuss and model the behaviour of money demand in Georgia following the stabilization.

The rest of the paper is organized as follows. Section 4.2 describes developments in monetary and exchange rate policy in the post-stabilization period. Section 4.3 lays down theoretical background for the model, describes statistical properties of the data and presents estimates of the long- and short-run models. The last section offers policy conclusions.

⁵³ Published as IMF Working Paper WP/03/212. Invited resubmission to Applied Economics.

4.2 Macroeconomic Developments in Georgia

Georgia experienced one of the highest inflation rates among the former Soviet Union countries after the creation of a national currency—the *coupon*—in April 1993. A stabilization program in mid-1994 brought an end to hyperinflation, and introduction in October 1995 of a new currency (the *lari*) replacing the coupon boosted demand for money. Since then, the National Bank of Georgia (NBG) has conducted a prudent monetary policy, focusing on maintaining price stability. The lari was pegged de facto to the U.S. dollar between October 1995 and December 1998 and price stability helped to remonetize the economy somewhat, although monetization has remained low and dollarization high (Table 4-1).

To keep the exchange rate stable, the NBG intervened in the foreign exchange market, sterilizing the liquidity impact of direct central bank credit to the government. Other monetary policy instruments included interventions in the inter-bank credit auctions. At the end of 1996 – in an attempt to lower interest rates – the NBG started providing liquidity to the banking sector through the auctions, but the strategy had an adverse effect on NBG foreign reserves targets and was abandoned in the second half of 1997.

In the final months of 1998, the onset of the Russian crisis and widespread public concern regarding domestic budgetary problems led to a sharp decline in the demand for lari (broad money declined by 25 percent in nominal terms from August to November) and growing pressure on the pegged exchange rate. To defend the lari, the NBG intervened heavily in the foreign exchange market (Figure 4-1), increased banks' reserve requirements, withdrew liquidity through interbank auctions, and suspended automatic intra-month budget financing. The attempt was unsuccessful, and after running foreign reserves down to the equivalent of 3 weeks of imports, the NBG allowed the lari to float on December 7, 1998. The lari/dollar exchange rate immediately dropped by 20 percent and monthly inflation soared to 12 percent (Figure 4-2).

After the depreciation, the NBG further tightened monetary policy by limiting credit to the government, but the continued weakness of the fiscal position forced an increase in direct financing in the last months of 1999 and in the first half of 2000. This once again exerted downward pressure on the currency. As the fiscal position improved in the second part of 2000, the NBG was able to restrain the growth in net domestic assets.

Moreover, it controlled reserve money growth sufficiently to offset a rebuilding of foreign reserves at the end of the year, which was permitted by favourable balance of payments developments. When the exchange rate began to appreciate at the end of 2002, the NBG intervened by stepping up foreign exchange purchases. Aside from these episodes, the exchange rate has remained largely stable, inflation low, and monetization has been increasing throughout the post-crisis period. The crisis, however, has raised dollarization of the economy (which increased from 73 percent at the end of 1998 to 86 percent at the end of 1999⁵⁴), indicating that policy credibility has remained low.

⁵⁴ Measured as a ratio of foreign to total deposits.

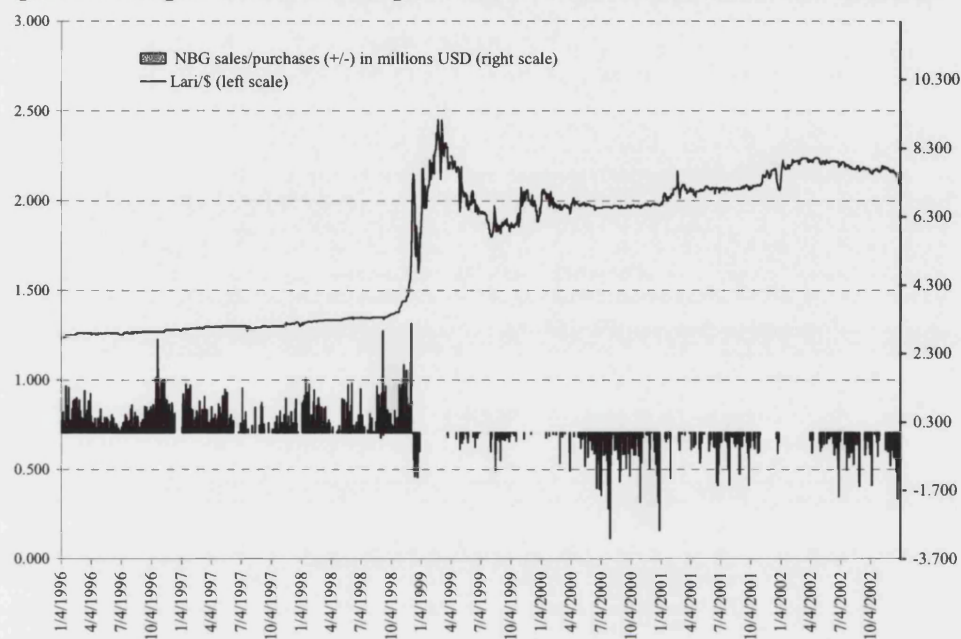
Table 4-1 Georgia: Selected Macroeconomic Indicators, 1995-2002

	1995	1996	1997	1998	1999	2000	2001	2002
(Annual percent change)								
Real sector								
GDP volume	2.6	10.5	10.6	2.9	3.0	1.9	4.7	5.6
Consumer prices								
Period average	162.7	39.4	7.0	3.6	19.1	4.0	4.7	5.6
End-of-period	57.4	13.7	7.2	10.7	10.9	4.6	3.4	5.4
(Percent of GDP)								
Government finances								
Revenue and grants	10.6	14.1	14.4	15.6	15.4	15.2	16.3	15.8
Of which: revenue	7.7	12.2	14.1	14.7	14.6	14.9	15.6	15.6
Expenditure and net lending	18.7	21.5	21.2	21.8	22.1	19.2	18.3	17.8
Balance (commitments)	-8.1	-7.4	-6.8	-6.1	-6.7	-4.0	-2.0	-2.0
Balance (cash)	-7.0	-7.2	-6.1	-4.9	-5.0	-2.6	-1.6	-1.9
(Percent change, end-of-period)								
Broad money 1/								
Including foreign currency deposits	135.2	41.9	45.5	-1.2	20.7	39.0	18.5	17.9
Excluding foreign currency deposits	319.7	38.2	35.4	-11.5	9.6	33.5	5.7	14.5
(Millions of USD)								
External Sector								
Exports (goods)	362.6	417.0	493.5	478.3	477.0	527.7	473.0	468.6
Imports (goods)	-700.1	-767.9	-1,052.4	-1,163.7	-1,013.0	-937.0	-934.8	-944.1
Trade balance	-337.4	-350.9	-558.9	-685.4	-536.0	-409.2	-461.8	-475.6
Current account (including transfers)	-404.8	-415.4	-364.1	-370.3	-217.5	-175.6	-179.2	-202.5
Official reserves, end-of-period								
(In millions of U.S. dollars)	156.7	158.0	173.3	118.4	132.4	109.4	161.1	197.7
(In months of imports)	2.7	2.5	1.5	1.0	1.3	1.0	1.4	1.8
(Lari/USD)								
Exchange rate								
Period average	1.29	1.26	1.30	1.39	2.02	1.98	2.07	2.20
End-of-period	1.23	1.27	1.30	1.79	1.96	1.98	2.06	2.09

Sources: Georgian authorities; and IMF estimates.

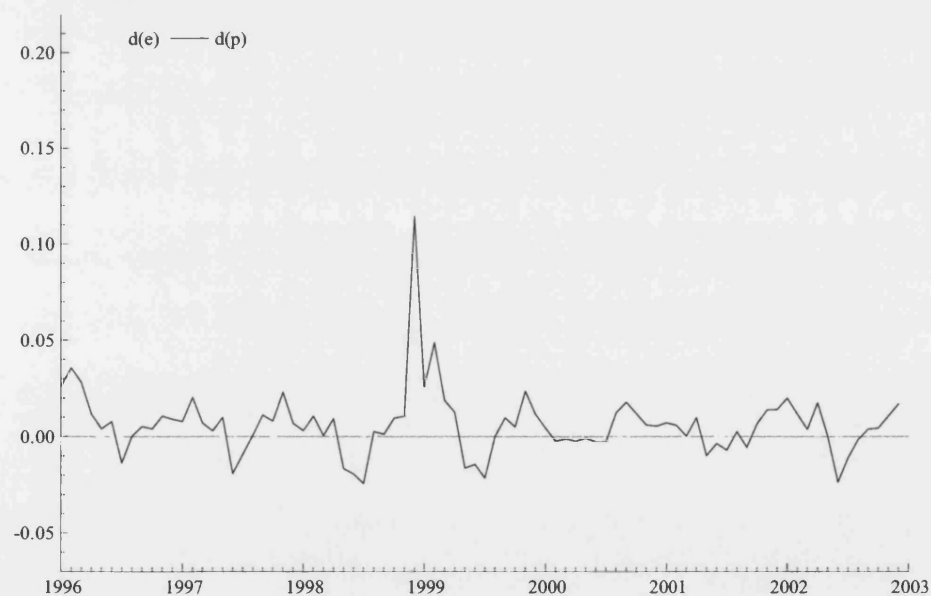
1/ Valued at end-of-period actual exchange rates.

Figure 4-1 Georgia: Lari/USD exchange rate and NBG interventions at the TICEX market



Source: Georgian authorities.

Figure 4-2 Georgia: Inflation and percentage changes in Lari/USD exchange rate.



Source: Georgian authorities.

4.3 Model Specification

This section provides theoretical underpinnings for the long-term (co-integrating) relationship estimated in the empirical part of the paper. Long-term price level (P) behaviour is assumed to be governed by the balance between aggregate demand (Y^D) and supply (Y^S) of domestic goods and services. The aggregate demand for domestic goods and services is a function of real money supply (M/P) and the real exchange rate (E/P). In log-linear form (denoted by lower-case letters), the aggregate demand is written as:

$$y^D = \alpha_1(m - p) + \alpha_2(e - p) \quad (6.1)$$

The aggregate supply is exogenously given and in equilibrium is equal to aggregate demand and real income (Y):

$$y = y^S = y^D \quad (6.2)$$

It is assumed that the domestic goods market is always in equilibrium and therefore equation (6.2) always holds.

Flow demand for foreign exchange (current account deficit) is assumed to be a function of real exchange rate and real income. Real income is fixed at the level of aggregate supply, the available foreign financing is exogenously given, and the real exchange rate tends to equilibrate the foreign currency market. Money demand is assumed to be a function of real income. Similarly, since real income—the only variable entering the real money demand function—is exogenous, real money balances tend to equilibrate the money market. Since the domestic goods market is, by assumption, in equilibrium, equilibrium in the foreign currency market implies equilibrium in the money market (and vice versa) by application of the Walras law.

If the markets are in equilibrium, the simple model determines two real variables ($m-p$ and $e-p$), leaving one degree of freedom for determination of nominal variables (m , e and p). Fixing one of the nominal variables determines the other two, providing a nominal anchor for the system. Empirically, if the markets are on average in equilibrium, it is likely that two unique long-run co-integrating vectors emerge between non-stationary nominal variables in equation (6.1) (treating y as exogenous). The two co-integrating vectors describe equilibria in any two of the three markets and the equilibrium in the

omitted market is described by a linear combination of the two unique co-integrating vectors, again by the application of the Walras law.

It is also possible that the money and foreign exchange markets are persistently out of equilibrium (adjustments towards equilibrium may be very slow or non-linear) and that the goods market—by assumption—quickly adjusts to equilibrium. Empirically, even though the equilibrium in the foreign exchange and money markets is ultimately restored, the persistence of the disequilibrium can preclude finding two co-integrating vectors among the series in a short sample. Only the vector corresponding to the equilibrium in the goods market—described by equation (6.1)—can be discovered in this case.⁵⁵ The model is misspecified by omitting one of the co-integrating vectors, but it can still provide a good approximation to the data generating process.

From a policy perspective, fixing one of the nominal variables no longer provides a nominal anchor for the system. Fixing any two still determines a third one by equation 1, although it is possible that the variables are persistently fixed at the level inconsistent with a long-run equilibrium. It follows that, though monetary and exchange rate policies need to be ultimately consistent, for a prolonged time the two can be conducted independently to set the price level.

The persistent pressure on exchange rate before the Russian crisis—discussed in section 4.2 above—may be an example of disequilibrium of this type in one of the markets. The disequilibrium in the foreign exchange market in this period would imply that the money market was also out of equilibrium. The shift in real money holdings during the crisis gives some support to this hypothesis.

If only goods market adjusts to equilibrium quickly enough in the sample, substituting (6.2) into (6.1) and solving for p gives the price level:

$$p = \alpha_1 / (\alpha_1 + \alpha_2) m + \alpha_2 / (\alpha_1 + \alpha_2) e - 1 / (\alpha_1 + \alpha_2) y \quad (6.3)$$

Equation (6.3), similar to the price equation developed by Bruno (1993), describes an observable relationship between prices, exchange rate, money and real income, suitable

⁵⁵ Another implication is that, even if it is possible to successfully find one co-integrating vector corresponding to equation (6.1), a stable money demand function cannot be estimated from the data.

for estimation and testing in the co-integration framework even if money and foreign exchange markets are persistently out of equilibrium. The equation exhibits a neo-classical dichotomy: y^s is fixed and equi-proportional changes in nominal variables leave the two real variables (m-p and e-p) unaltered. Testing for the neo-classical dichotomy is equivalent to testing that coefficients of money and exchange rate sum up to one.

The equilibrium real money demand discussed above is a function of real income only. A standard money demand formulation for high-inflation economies incorporates expected inflation ($E(p-p_1)$) or expected exchange rate depreciation ($E(e-e_1)$) into the function. If inflation or exchange rate depreciation series contain a unit root, and if one is interested in estimating a co-integrating relationship describing money demand or behaviour of prices, it is necessary to incorporate these variables into the long-run equation (see Budina et al., 2002 or Choudhry, 1998). Visual inspection suggests that time series properties of prices and exchange rate in Georgia changed after eradication of hyperinflation and introduction of the Lari. Tests for stationarity of the series—discussed below—suggest that after 1996 inflation and exchange rate depreciation became integrated of order zero, while real money balances remained integrated of order one. This result leaves only the real income as a potential argument in the co-integrating relationship describing the real money demand.

Short-run dynamics of prices and other endogenous variables in the system is modelled as an error-correction mechanism. The exact form of the short run relationship (lag structure) is determined by application of the general-to-specific methodology as discussed below.

4.4 Sources, Transformations and Statistical Properties of the Data

The model is estimated on monthly data for the post-stabilization period (January 1996-February 2003). Domestic CPI and GDP (a measure of income) are available from the Georgian State Department of Statistics (SDS). The available quarterly GDP series has been interpolated under the assumption that a monthly series follows a unit root process.⁵⁶ The exchange rate is measured by average lari/U.S. dollar exchange rate, and money is

⁵⁶ The code for the Kalman filter interpolation - written in Ox (Doornik 1999) with the SSFPack package (Koopman et al. 1999) - is available on request.

measured by M2, both available from the NBG.⁵⁷ Fruit and vegetable prices are obtained from disaggregated CPI data and are divided by the total CPI to obtain relative values. Average oil prices are from the IMF's WEO database. All series are in logs and are seasonally adjusted using a version of the X-12 procedure.⁵⁸

Statistical tests confirm that time series properties of the inflation series has changed after macroeconomic stabilization and introduction of the Lari. The Augmented Dickey-Fuller (ADF) test conducted on the Jan 1991 – Dec 1995 sample cannot reject the null hypothesis of non-stationarity. The result is reversed when the test is performed on the post-stabilization sample Jan 1996 – Feb 2003, when logs of CPI, M2, and the lari/U.S. dollar exchange rate are all integrated of order one (Table 4-8 in the appendix).⁵⁹ Modelling the regime change is beyond the scope of the paper and the model estimation period starts in January 1996, a few months after introduction of the lari to insulate estimates from the pre-lari regime

4.5 Testing and Estimation of Co-integrating Vectors

The Johansen (1988) procedure is used to test for the number of co-integrating vectors, estimate their coefficients and test for weak exogeneity of the variables. The weak exogeneity of system variables has important econometric consequences and a clear

⁵⁷ Estimation of the model using M3 instead of M2 yields very similar results.

⁵⁸ As implemented in GiveWin. Ericsson, Hendry, and Tran (1994) show that the linear seasonal filter approximating earlier version of the Census procedure (X-11) may affect inferences about co-integration and alter dynamics and exogeneity status of variables in the model. Siklos, Ghysels and Granger (1995) show that the X-11 procedure exhibits strong non-linear characteristics, and that these characteristics may lead to incorrect inference about the number of co-integrating vectors in series simulated from linear models. However, the exchange rate dynamics in Georgia exhibits a pronounced seasonal component in the post-1998-depreciation period, which does not exist in the pre-crisis period. Accounting for this effect in a model with seasonally unadjusted data would be difficult. Seasonally adjusting the exchange rate series for the post-crisis period only (and other variables for the whole period) is a more straightforward strategy, which is applied in the paper. More generally, empirical series may exhibit certain non-linear features and the impact of adjustment procedures on more complicated process has not yet been fully researched.

⁵⁹ The log of real GDP is interpolated under the assumption that the series follows a unit root process.

economic interpretation. From the econometric standpoint, it justifies conditioning on weakly exogenous variables, allowing for simplification of the system. Economically, weak exogeneity implies that there is no feedback from deviations from long-run equilibria to certain variables.

The procedure starts by selecting a set of endogenous and exogenous variables and choosing an appropriate lag structure for the endogenous variables. Prices, the exchange rate and money are modelled as endogenous variables. Real GDP is determined outside the system and restricted to enter only the co-integration space. Allowing output to enter the system endogenously and adding some proxies for potential output—such as deterministic trend—would allow for testing the assumptions of output exogeneity and continuous equilibrium in the goods market. The alternative approach is not followed given the small sample size, already a large number of parameters, and difficulties with modelling the supply side of the economy in the midst of structural changes. Two other exogenous variables are added to the list of variables affecting the short run dynamics of inflation: percentage changes in relative prices of fruits and vegetables, and percentage changes in oil prices. The two variables proxy for supply shocks stemming from agriculture sector and from input prices. The variables are assumed to be exogenous and only their current values enter the short-run equation. In addition, two dummy variables are used: for December 1998, the month of a *de facto* regime change when lari started floating against the dollar, and for September 1998, the first month after the Russian crises. The VAR is estimated with 6 lags of each endogenous variable, which is a compromise between an attempt to correctly capture potentially rich dynamics of monthly data and to preserve degrees of freedom.⁶⁰

⁶⁰ Sequential testing starting from the highest order of six allows for reduction of the lag length to four. Given high uncertainty surrounding the correct lag length I opt for the over-parameterized model. Monte Carlo studies in Gonzalo (1994) show that efficiency loss from choosing a too long lag structure is small, while a too short lag structure has a severe impact on maximum likelihood estimates. Estimates of co-integrating vector obtained from the four-lag model are almost identical to those obtained from the six-lag specification.

Results of the tests suggest that there is only one co-integrating vector between prices, money, the exchange rate and output (Table 4-2).⁶¹ After normalizing the parameter of the log of price level to unity, a hypothesis that coefficients of money and exchange rate sum up to one (homogeneity restriction) is tested, together with exogeneity restrictions (Table 4-3). The homogeneity restriction, the weak exogeneity of the exchange rate, and the weak exogeneity of money are not rejected at 5 percent significance level. The weak exogeneity of prices is strongly rejected. Testing joint hypotheses leads to the same conclusions about the homogeneity and exogeneity status of the variables. Exogeneity of the exchange rate implies that prices—rather than exchange rate—adjust to bring about changes in the real exchange rate necessary to restore equilibrium in the goods market. This hypothesis is reasonable a priori, given that the nominal exchange rate was heavily managed, even in the post-Russian-crisis period. Similarly, weak exogeneity of money means that prices adjust to generate changes in real money balances necessary to restore equilibrium in the goods market.

The equation with imposed restrictions of homogeneity and weak exogeneity of money and exchange rate (Table 4-4) is chosen for further analysis. The exchange rate coefficient is higher than that of money, but they are both close to one-half. Real income coefficient is negative, as predicted by equation (6.3). Less restricted estimates are also recognizable as the price equation (6.3), with positive coefficients of money and exchange rate and a negative coefficient of output. Recursive estimates of parameters, plotted on Figure 4-3, show that coefficients are stable over time. Figure 4-4 plots the co-integrating vector and components of the long-run relationship. The largest deviation from equilibrium appears after the post-Russian-crisis devaluation. Since prices did not fully adjust to the new exchange rate level, the disequilibrium was exhorting an upward pressure on inflation in this period.

Since the weak exogeneity of the exchange rate and money is not rejected, it is valid to condition on these two variables in a single-equation inflation model. The behaviour of money in Georgia between 1996 and 2002 was volatile, with a break in

⁶¹ Estimating the model with a trend added to the co-integrating space does not change the number of co-integrating vectors, but results in very high standard errors of the trend and real output coefficients.

remonetization coinciding with the Russian crisis. The crisis has also led to a change in the exchange rate regime. Given the breaks, the behaviour of money and the exchange rate is difficult to model. Conditioning on these two variables is therefore a convenient strategy in modelling the dynamics of inflation, which is of primary interest. In order to check for the robustness of this specification, the model is also estimated by instrumental variables method, using past changes in money and exchange rate as instruments.

Table 4-2 Georgia: Tests for the number of cointegrating vectors between p, m, e and y.

Rank	λ_{\max}		λ_{\max}		λ_{trace}		λ_{trace}	
			using				using	
			T - nk				T - nk	
0	39.25	[0.003]**	28.38	[0.003]**	30.53	[0.041]*	22.07	[0.035]*
1	10.87	[0.223]	9.09	[0.285]	8.46	[0.425]	7.07	[0.489]
2	1.78	[0.182]	1.78	[0.182]	1.38	[0.239]	1.38	[0.239]

Notes: Variables are defined in the text. The ADF test for co-integration has the null hypothesis that residuals from reported equations contain unit roots against an alternative of a stationary root. The number of lags in the test was chosen based on F-tests for a joint significance of lags and Akaike information criterion, starting from 6 lags for each equation. Test equations are estimated with a constant and seasonals for the PPP relationship and seasonals only for the money demand residuals. * and ** denote significance at the 5 percent and 1 percent level, respectively. All results reported in the paper are obtained from PcGive econometric package (Hendry and Doornik 2001).

Table 4-3 Georgia: Tests for weak exogeneity and restrictions on long-run coefficients.

Homogeneity restriction:

(sum of coefficients of money and exchange rate in the cointegrating vector = 1)

$$\chi^2(1) = 2.8404 [0.0919]$$

Weak exogeneity tests: 1/

a. No other restrictions imposed

	e_t^{USD}	m_t	p_t
p_t	$\chi^2(2) = 17.868 [0.0001]**$	$\chi^2(2) = 19.670 [0.0001]**$	$\chi^2(1) = 17.606 [0.0000]**$
m_t	$\chi^2(2) = 3.1609 [0.2059]$	$\chi^2(1) = 3.0294 [0.0818]$	
e_t^{USD}	$\chi^2(1) = 0.2559 [0.6130]$		

b. With homogeneity restriction imposed

	e_t^{USD}	m_t	p_t
p_t	$\chi^2(3) = 19.273 [0.0002]**$	$\chi^2(3) = 24.458 [0.0000]**$	$\chi^2(2) = 22.616 [0.0000]**$
m_t	$\chi^2(3) = 6.8798 [0.0758]$	$\chi^2(2) = 6.7213 [0.0347]*$	
e_t^{USD}	$\chi^2(2) = 4.3538 [0.1134]$		

1/ Numbers along diagonal are test statistics for a simple hypothesis that a variable in a given column (or, likewise, in a row) is weakly exogenous. Numbers outside diagonal are test statistics for a joint hypothesis that variables in a given column and a row are weakly exogenous.

Table 4-4 Georgia: Coefficients of cointegrating vectors β and adjustment coefficients α .

	A	B	C
Restriction	Number of cointegrating vectors = 1		
		Sum of coefficients of money and exchange rate =1	
			Weak exogeneity of money and exchange rate
β:			
p_t	1.0000 (0.0000)	1.0000 (0.0000)	1.0000 (0.0000)
m_t	-0.2530 (0.0457)	-0.4309 (0.0650)	-0.3759 (0.0736)
e^{USD}_t	-0.5213 (0.0314)	-0.5691 (0.0000)	-0.6241 (0.0000)
y_t	0.4418 (0.1478)	1.2833 (0.1101)	1.2659 (0.1247)
α:			
p_t	-0.1561 (0.0394)	-0.0706 (0.0190)	-0.0744 (0.0171)
m_t	0.3271 (0.2015)	0.1741 (0.0951)	
e^{USD}_t	-0.0451 (0.0888)	-0.0487 (0.0418)	

Notes: The system has a form $\Delta x_t = \sum_{j=1}^{k-1} \Pi_j \Delta x_{t-j} + \alpha \beta' x_{t-1} + \gamma D_t + \varepsilon_t$, where x_t is a vector of endogenous variables and D_t is a vector of exogenous variables. The rank of the $\alpha \beta'$ matrix determines the number of cointegrating vectors. The matrix can be decomposed to the matrix of adjustment coefficients α and the matrix of long-run coefficients β . Standard errors reported in parentheses.

Figure 4-3 Georgia: Recursive Estimates of Long-Run Coefficients of the Price Equation

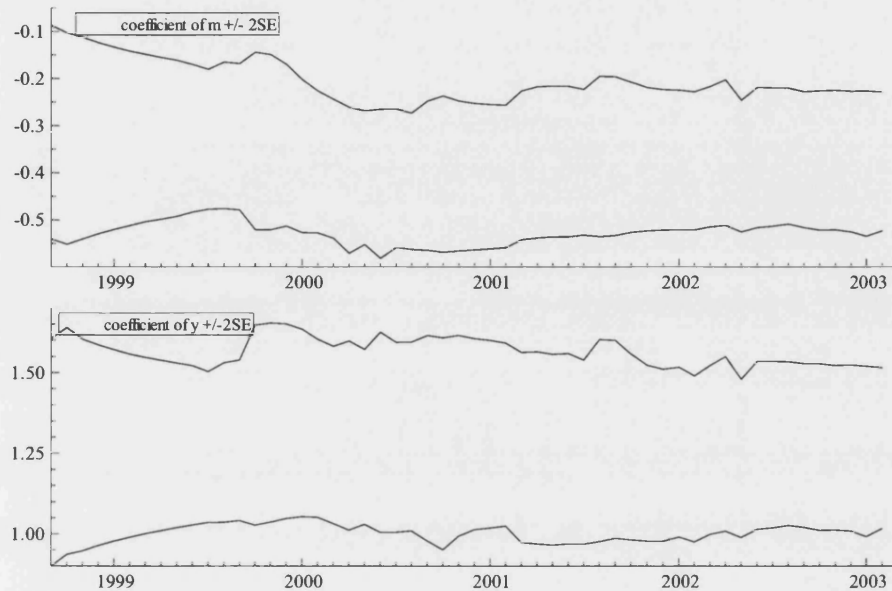
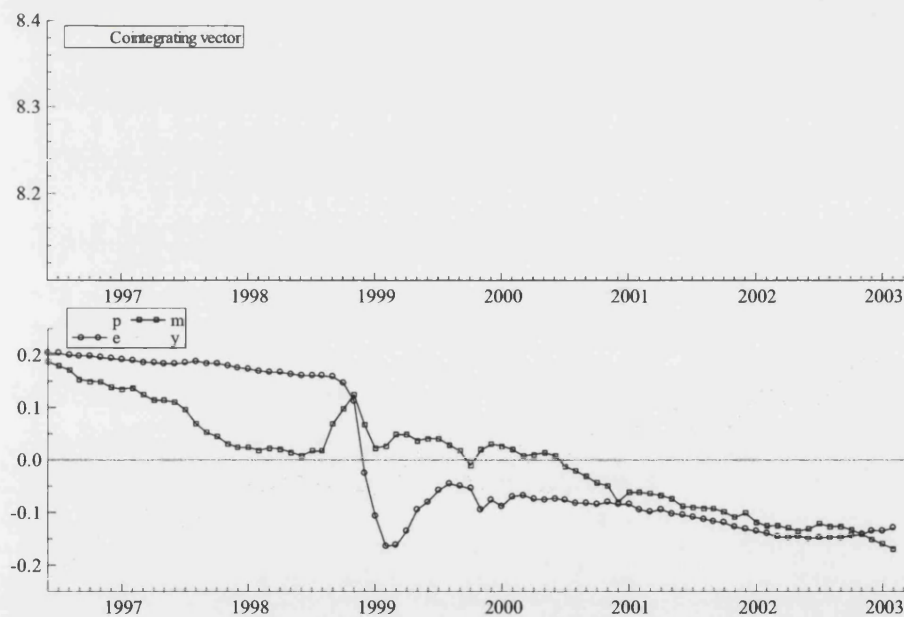


Figure 4-4 Georgia: Cointegrating Vector and Components of the Long-Run Relations.



4.6 Error-Correction Model for Inflation

The “general-to-specific” methodology is followed in searching for the final form of the short-run dynamic inflation equation. The specification search begins from estimation of a relatively unrestricted model. The unrestricted inflation equation includes five lags of

inflation; five lagged and current values of changes in the log of money and in the log of the exchange rate; the lagged error-correction term from the long-run price equation; changes in oil prices and in relative prices of fruits and vegetables; and the dummy variables discussed above. The search is guided by information criteria and the imposed restrictions are tested against unrestricted alternatives.⁶²

Restrictions imposed on the general specification leading to the final equation reported in Table 4-5 cannot be statistically rejected and improve information criteria. Figure 4-5 shows actual and fitted values, together with residuals. The equation shows that inflation is strongly affected by exchange rate changes and that the pass-through is fast. Changes in money also have a significant impact on inflation, but this effect takes longer to work its way through the economy than exchange rate changes. The adjustment of prices is also affected by the error-correction term, which is highly significant but low. This suggests that the price level slowly adjusts to its long-run equilibrium, which is a function of the levels of money, exchange rate and output. Supply shocks originating in agriculture have a high and significant short-term impact on inflation. Changes in oil import prices have a smaller, but also significant impact.

The final inflation equation easily passes all specification tests (Table 4-6). One-step ahead residuals are within a 2 standard deviations band, indicating that the estimated parameters are stable (Figure 4-6). One-step ahead and break-point Chow tests do not reject stability of the parameters at 1 percent level (Figure 4-6). Since the behaviour of inflation is visibly different in the period immediately preceding the exchange rate devaluation of December 1998 than in the rest of the sample, the model is re-estimated on the shorter sample from June 1999 to February 2003 as a further check for stability of the coefficients (column B in Table 4-7). The results are remarkably close to the full sample estimates.⁶³

The assumption that conditioning on contemporaneous changes in exchange rate and money is valid is checked by estimating the equation by the instrumental variables

⁶² F-tests have been used to test the restrictions. Akaike, Schwarz, Hannan-Quinn and the Final Prediction Error criteria have been used for judging adequacy of the reductions.

⁶³ Standard errors of some coefficients are higher, but this is not surprising, given that the new estimates are based on a shorter and therefore less informative sample.

(IV) method. The results of IV estimation, using lagged changes of exchange rate and lagged moving average of money changes as instruments, are reported in column C of Table 4-7. The estimates are close to the OLS results, although coefficient of the moving average of changes in money is lower than the OLS counterpart.

Table 4-5 Georgia: Parsimonious error-correction equations for inflation and money demand.

$$\begin{aligned} \Delta p_t = & 0.4450 + 0.0952 \Delta e^{\text{USD}}_t + 0.0961 \frac{1}{3} (\Delta m_t + \Delta m_{t-1} + \Delta m_{t-2}) - 0.0534 \text{ECM}_{t-1} \\ & (0.1037) \quad (0.0274) \quad (0.0253) \quad (0.0125) \\ & + 0.1325 \Delta(p_t^{\text{food}} - p_t) + 0.0285 \Delta p_t^{\text{oil}} + 0.0862 \text{D1298} \\ & (0.0225) \quad (0.0076) \quad (0.0081) \end{aligned}$$

$R^2 = 0.8582$

Equation standard error: 0.0055

DW = 2.19

Sample: 1996.6 – 2003.2

Number of observations: 81

Notes: Δ indicates first difference. D0998 is one for September 1998, zero otherwise, and D1298 is one for December 1998, zero otherwise. Standard errors reported in parentheses.

Table 4-6 Georgia: Diagnostic statistics for the single-equation inflation model.

AR 1-5 test:	F(5,69) =	1.4581	[0.2149]
ARCH 1-5 test:	F(5,64) =	0.2341	[0.9461]
Normality test:	$\chi^2(2)$ =	1.4100	[0.4941]
hetero test:	F(11,62) =	0.8282	[0.6127]
hetero-X test:	F(21,52) =	0.5846	[0.9108]
RESET test:	F(1,73) =	0.8634	[0.3558]

Notes: AR 1- n tests for autocorrelation up to n th lag, performed through an auxiliary regression of residuals on original variables and lagged residuals. *Normality test* has a null hypothesis that distribution of residuals has skewness and kurtosis corresponding to the normal distribution. ARCH 1- n tests for autoregressive conditional heteroscedasticity up to n th lag in the residuals through auxiliary regression of squared residuals on a constant and lagged squared residuals. See Hendry and Doornik (2001) for a description of the tests. Probabilities are reported in parentheses and * and ** denote significance at the 5 percent and 1 percent level, respectively.

Table 4-7 Georgia: Robustness check for the single-equation inflation model.

	Dependent variable: Δp_t		
<i>Estimation method:</i>	A <i>OLS</i>	B <i>OLS</i>	C <i>IV</i>
<i>Sample:</i>	96.6 – 03.02	99.6 – 03.02	96.6 – 03.02
Constant	0.4450 (0.1037)	0.4332 (0.1729)	0.4806 (0.1076)
Δe^{USD}_t	0.0952 (0.0274)	0.1064 (0.0552)	0.0712 (0.0407)
$\frac{1}{3}(\Delta m_t + \Delta m_{t-1} + \Delta m_{t-2})$	0.0961 (0.0253)	0.1311 (0.0622)	0.0646 (0.0360)
ECM_{t-1}	-0.0534 (0.0125)	-0.0520 (0.0208)	-0.0577 (0.0130)
$\Delta(p_t^{\text{food}} - p_t)$	0.1325 (0.0225)	0.1277 (0.0293)	0.1326 (0.0231)
Δp_t^{oil}	0.0285 (0.0076)	0.0320 (0.0095)	0.0270 (0.0079)
D1298	0.0862 (0.0081)		0.0910 (0.0104)

Notes: Standard errors reported in parentheses.

Figure 4-5 Georgia: Δp actual values, fitted values and residuals from the error-correction model.

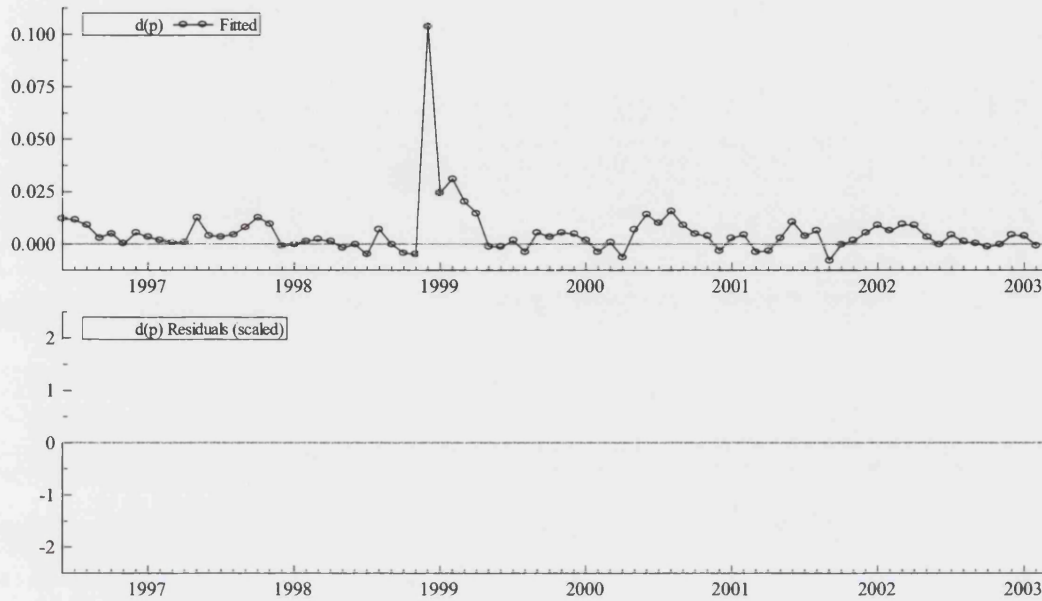
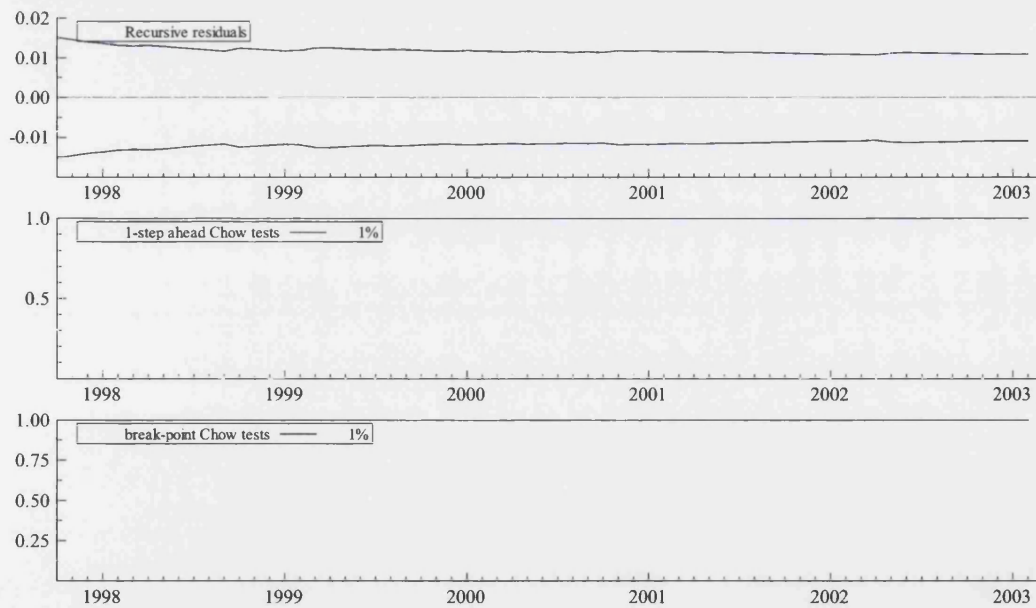


Figure 4-6 Georgia: Δp recursive residuals, 1-step ahead Chow tests and break-point Chow tests.



4.7 Conclusions

The econometric results show that it is feasible to estimate robust price and inflation equations for Georgia. The long-run price equation expresses prices as a function of money, the exchange rate, and real income, and may be interpreted as portraying

equilibrium in the goods market. Short-run dynamics of inflation are strongly affected by current exchange rate changes, money growth, and changes in relative prices of foodstuffs and in prices of oil. The estimated long- and short-run relationships are stable, and may be useful as a tool for policy formulation and evaluation. Estimation of a separate money demand equation turns out to be more difficult, pointing to a longer and more complicated adjustment mechanism governing the behaviour of real money balances.

The results suggest that the NBG faces serious challenges when conducting monetary policy. Public memory of hyperinflation is still fresh, and any external or internal shock quickly exerts strong pressure on the exchange rate. Because the stock of foreign exchange reserves remains small, the NBG has no scope for leaning against downward pressure on the Lari, especially when budget financing needs complicate monetary tightening. Yet even when faced with these challenges, the NBG has enjoyed substantial success in keeping inflation low and relatively stable. Looking ahead, further accumulation of foreign reserves and development of indirect monetary control instruments, such as a deeper treasury bill market, would increase the capacity of the NBG to respond to shocks.

4.8 Appendix: Tests for Stationarity

Table 4-8 Georgia: Unit Root Augmented Dickey-Fuller Test Statistics 1996.1 – 2003.2

	Level		First Difference	
	Lag	Test statistic	Lag	Test statistic
Seasonally adjusted series				
P	2	-2.951	1	-3.873**
M	1	-3.180	1	-6.250**
e ^{USD}	3	-1.628	2	-5.172**
Unadjusted series				
P	2	-2.732	4	-4.344**
M	1	-3.181	1	-6.596**
e ^{USD}	3	-1.750	2	-4.854**

Notes: The null hypothesis is that a series contains a unit root against a stationary alternative. For each variable the augmented Dickey-Fuller test statistic and the number of lags used in the test are reported. The number of lags was chosen based on F-tests for a joint significance of lags and Akaike information criterion, starting from 6 lags for each equation. Equations for levels of unadjusted series are estimated with a constant, seasonals and a linear trend. Equations for levels of seasonally adjusted series are estimated with a constant and a linear trend. Since first differences do not appear to be trended, the trend is not included in estimated equations for first differences of the series. Inclusion of trend into these equations does not change the results. * and ** denote significance at the 5 percent and 1 percent level, respectively.

5 MONETARY POLICY IN ADVANCED TRANSITION ECONOMIES

5.1 Introduction

Choosing exchange rate and monetary regimes for transition economies has been a difficult task. Exchange rate anchors proved popular at the beginning of reforms, as fixing the exchange rate was relatively easy to implement and effective in taming inflationary expectations in the midst of structural changes. These anchors became difficult to sustain by advanced reformers, gradually more integrated with the world economy and subject to booms and bursts in financial flows, complicating monetary management, especially when combined with inflexible fiscal policy responses. The advanced transition economies started looking for alternative monetary regimes. Unstable relationship between the growth of money supply and inflation in the past led to a disillusion with monetary targeting (Horvath and Jonas, 1998). A “just-do-it” approach without specifying a nominal anchor lacked credibility, especially in countries which abandoned the peg in a crisis situation. A hard peg regime would eliminate monetary policy from the set of policy tools. Given the drawbacks of alternative regimes, some countries embraced the growingly popular inflation targeting.⁶⁴

This paper evaluates the experience of two advanced transition economies, Poland and the Czech Republic, which at the end of the decade conducted their monetary policies in the framework of direct inflation targeting with a floating exchange rate.⁶⁵ The two countries—facing many of the above mentioned difficulties—exemplify the experience of advanced transition economies that recently introduced inflation targeting. They also represent different strategies for introducing the new framework, with a much faster implementation in the Czech Republic after the currency crisis, and a more gradual approach taken by Poland.

Performance under inflation targeting is compared with a counterfactual scenario of the past, more restrictive exchange rate regime. While the fixed exchange rate lessened

⁶⁴ See Jonáš and Mishkin (2003) for a fuller discussion of alternative monetary regimes for transition economies.

⁶⁵ Another advanced transition country, Hungary, introduced inflation targeting only in 2001, moving to a more flexible exchange rate arrangement much slower than the Czech Republic and Poland.

control over domestic monetary conditions, the exchange rate channel may still be a powerful tool to control inflation, and exchange rate stabilization may play a role even under the inflation targeting regime. Incentives to use the relatively well-documented exchange rate channel may be particularly strong in transition economies, where the relationship between monetary policy instruments and inflation remains highly uncertain (Christoffersen *et al.*, 2001, and Gottschalk and Moore, 2001). On the other hand, limiting exchange rate fluctuations may lead to confusion about the final goal of monetary policy. For instance, exchange rate smoothing may be compelling for emerging markets, where—due to typically high degree of dollarization—exchange rate movements may have adverse effects on the financial sector balance sheet (Mishkin, 2004).⁶⁶ There is a consensus in the literature that inflation targeting central banks should not pursue exchange rate stabilization for its own sake, but only as a tool to achieve a given inflation target. However, theoretical recommendations how far the central bank should go in stabilizing exchange rate fluctuations vary.

Early theoretical literature indicates that exchange rate smoothing may be an important element of the inflation targeting strategy. Svensson (1998) considers alternative targeting rules for a small open economy: strict inflation targeting (where central bank minimizes only inflation variability) and flexible inflation targeting (where output gap variability and interest rate smoothing are added to the loss function), both applied to domestic and CPI inflation.⁶⁷ He shows that the flexible CPI inflation targeting reduces the volatility of output to the low level achieved under the domestic inflation targeting, and stabilizes real interest and exchange rates more than other regimes.⁶⁸

⁶⁶ Large and abrupt depreciations may increase the burden of dollar-denominated debt, produce a massive deterioration of balance sheets, and increase the risks of a financial crisis as discussed in Mishkin (1996).

⁶⁷ While the model used by Svensson (1998) is not fully micro-founded, it contains a realistic lag structure resembling policy models commonly used in central banks for policy analysis.

⁶⁸ In simulations, domestic inflation targeting is successful in stabilizing domestic inflation and—particularly in case of the flexible targeting—output gap. However, it generates high volatility in real exchange rate and the CPI inflation, driven by interest rate changes to produce desired adjustments in aggregate demand. The strict CPI inflation allows for a near-perfect stabilization of the CPI inflation, but exacerbates real exchange

(continued)

Svensson (1998) concludes that the flexible CPI inflation targeting regime, which requires a certain degree of exchange rate smoothing, “appears as an attractive alternative (...) in a situation with weight on stabilization to both inflation and real variables”.

Evaluation of alternative policy rules in fully micro-founded models and using consumers’ welfare as a criterion produces less clear-cut results, but supports exchange rate smoothing in some specifications.⁶⁹ Galí and Monacelli (2002) and Clarida *et al.* (2001) confirms that the CPI inflation targeting implies a smoother exchange rate than domestic inflation targeting, but find that the latter dominates the former from a welfare viewpoint.⁷⁰ The exchange rate smoothness, combined with price stickiness, slows the response of the real exchange rate to productivity shocks, leading to inefficient allocation of resources. The result is challenged in models assuming imperfect exchange rate pass-through.⁷¹ Smets and Wouters (2002) show that minimizing distortions from staggered price setting in the imported goods sector—consistent with welfare maximization—gives an explicit reason for the stabilization of the nominal exchange rate in response to certain shocks.

The counterfactual simulations empirically investigate potential costs and benefits of limiting exchange rate fluctuations. Using the past regime as a benchmark has certain advantages over comparing the current implementation of inflation targeting with hypothetical optimal policies. Firstly, devising an optimal policy requires a fully structural model immune to *unknown* policy changes. While the method applied in this paper is not exempt from the Lucas critique, the stability of equations describing the behaviour of the private sector across the two *actual* regimes can be tested. Secondly, the comparison with the past exchange rate regime is relevant in the context of adopting the

rate volatility and introduces high output volatility, as it requires an aggressive use of the direct exchange rate channel to cancel the effect of domestic inflation on the CPI inflation.

⁶⁹ Only a snapshot of the rich literature is discussed here. See Lane (2001) for a survey.

⁷⁰ Several extensions of the model confirm this finding: Benigno and Benigno (2001) (two countries); Benigno (2001) (incomplete financial markets); and Senay and Sutherland (2005) (endogenous changes in price flexibility).

⁷¹ See Choudhri and Hakura (2001), Yetman and Devereux (2003) and Gagnon and Ihrig (2004) for empirical evidence of imperfect pass-through.

Euro, as the process of accession to the Eurozone will require a period of limiting exchange rate fluctuations under the ERMII system, similar to past exchange rate bands (although less adjustable).

The paper contributes to the literature on monetary transmission mechanisms in the two economies by explicitly modelling the change in the monetary policy regime. The applied methodology is a version of the structural VAR proposed by Sims and Zha (2002), allowing for changes in some parameters of the model across regimes. The changes are restricted to parameters of the policy reaction functions, but more general specifications allowing for changes in all coefficients of the model are also tested. The preferred specification captures well policy changes and it is parsimonious enough to produce reasonable results in small samples under investigation. Identification of shocks follows the scheme proposed by Cushman and Zha (1997) and Kim and Roubini (2000) for open economy models, but extends their frameworks by exploiting the effects of fluctuations in emerging bond markets on capital flows to transition economies. Most of estimating structural VAR for transition economies applies a simple recursive identification scheme (e.g. Christoffersen *et al.*, 2001, and Gottschalk and Moore, 2001, Wrobel 2001). A notable exception is Dibogloo and Kutan (2000), who estimate structural VARs for Poland and Hungary with long-run identification restrictions. Changes in the exchange rate regime are not addressed in any of the existing papers.

The remainder of the paper is organized as follows: the next section describes monetary and exchange rate policies in Poland and the Czech Republic, focusing on the timing of the regime change and the implementation of inflation targeting. Section 5.3 discusses identification and section 5.4 describes estimation strategy and results. Section 5.5 shows counterfactual policy simulations and interprets the results. Section six checks the robustness of results. A description of data sources and technical details of the estimation strategy are relegated to appendices.

5.2 Monetary and exchange rate policy in Poland and the Czech Republic

5.2.1 The Czech Republic

In Czechoslovakia, a macroeconomic disequilibrium inherited from the Soviet-style system was less severe than in Poland and price liberalization produced a smaller effect on inflation. The koruna was initially pegged to the basket of five currencies and

since 1993 to the basket of DM and USD. Inflation was falling, approaching a single digit level by 1994.

Since 1994, the fixed exchange rate regime—combined with liberalization of the foreign exchange market, improved rating of the Czech Republic and the privatization process – led to a massive capital inflow, a pressure on real appreciation and a growing current account deficit. In 1997, the growing external disequilibrium changed market sentiments towards koruna. A speculative attack, triggered by the Asian crisis, led to abandoning the peg in May 1997. The CNB adopted measures to avoid a sharp drop in the domestic currency value. The koruna was well inside the band when exit from the previous exchange rate regime was announced, leaving some scope for depreciation even within the previous, narrow band. The CNB maintained a tight liquidity control after the devaluation, driving up money market rates and preventing excessive depreciation. Pressure on koruna eased after June 1997 and the central bank was gradually reducing the rates, closely monitoring developments on the foreign exchange market. Real interest rates converged to the pre-crisis level in August 1997, completing the process of interest landing after the hike triggered by the crisis (Smidkova et al. 1999).

Figure 5-1 (upper panel) plots daily percentage deviations of the pre-crisis exchange rate basket from central parity.

Inflation targeting, a new regime in the Czech monetary policy, was introduced at the beginning of 1998. The CNB initially targeted net inflation rate (excluding changes in administrative prices and direct taxes). Economic slowdown, brought about by the currency crisis and the tight monetary policy in its aftermath, exerted downward pressure on inflation. The 1998 target was missed by a large margin: the net inflation was 1.7 percent against the 6 ± 2 per cent target range. In mid-1998 the CNB started reducing interest rates and, in a series of cuts, the rate was lowered from 15 percent at the beginning of 1998 to 5.25 percent in November 1999. Policy relaxation did not prevent the net inflation rate to drop below the 4.5 ± 0.5 percent target in 1999. Interest rates remained stable in 2000, and were falling at a slower rate in 2001, reaching 4.75 percent at the end of the year. Low interest rates induced portfolio outflows, but capital inflows related to foreign direct investments put a pressure on koruna appreciation and in 2000 the currency appreciated in nominal terms. The net inflation in 2000 was again below the target (4.5 ± 1 percent), and fluctuated in the lower range of the target band (3 ± 1

percent) in 2001. In 2001, the CNB announced the target band for headline inflation, declining from 3-5 percent in January 2002 to 2-4 percent in December 2005. Despite record-low interest rates (falling to 2 percent in August 2003) and interventions in the foreign exchange market, further appreciation of koruna kept monetary conditions tight and hampered implementation of the inflation targeting framework. The rate of inflation was 2 percentage points below the target in 2002, and 1.5 percentage points lower in 2003. Inflation returned to the centre of the CNB's target band in 2004, fuelled by the past policy relaxation, and increases in food, oil prices, and indirect taxes after the EU accession.

5.2.2 Poland

Poland experienced a period of near-hyperinflation after price liberalization in 1989-90. As a part of the stabilization package, the zloty was temporarily fixed against the dollar. The inflation was quickly reduced, but remained at a two-digit level and exchange rate appreciated in real terms. In 1991 the exchange rate was devalued, the dollar was replaced by a basket of five currencies, and subsequently a crawling peg system replaced the peg. In the 1991-94 post-stabilization period, despite large fiscal deficit financing, real interest rates of the National Bank of Poland (NBP) remained at a positive level and inflation was declining in line with the crawling peg.

In 1995 a capital inflow to the country – driven by increasing credibility of economic reforms and privatization process – became a source of excessive monetary expansion. In order to increase the risk faced by portfolio investors and tame the inflow, the crawling peg system was replaced by a ± 7 percent band in May 1995. The zloty appreciated after introduction of the new system, but the new regime did not bring any significant increase in volatility since exchange rate was persistently close to the strong bound of the zone (Figure 5-1 plots daily percentage deviations of the basket from central parity after introduction of the target zone). The capital inflow slowed down only after interest rate cuts and revaluation of the parity at the end of 1995. The volatility was still limited, with the NBP keeping percentage deviations of the exchange rate basket from parity within an implicit ± 2.5 percent zone.

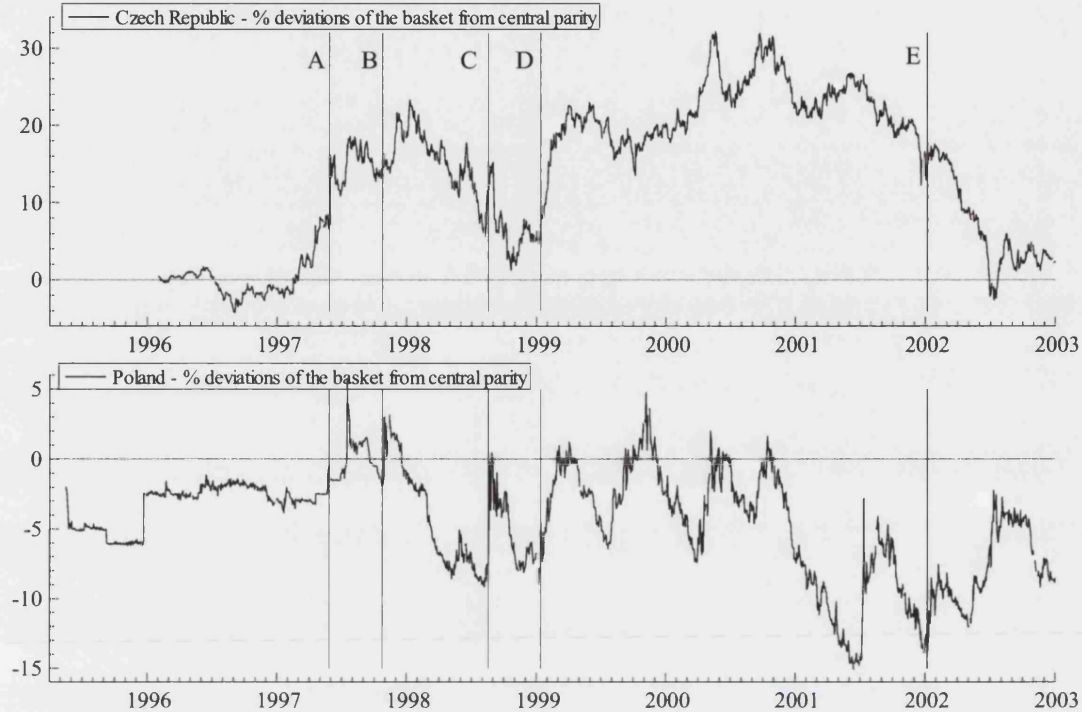
In January 1998, a newly established Monetary Policy Council (MPC) adopted inflation targeting as a monetary policy strategy. The MPC considered a break from the

previous exchange rate policy as a necessary step in implementation of the inflation targeting framework (NBP, 1998). In February 1998 the exchange rate band was widened to ± 10 per cent and the exchange rate was allowed to move more freely within the zone. In October 1998 the target zone was widened to ± 12.5 per cent, in March 1999 it was further widened to ± 15 per cent, and in April 2000 zloty started floating.

At the end of 1996 and in 1997 NBP interest rates were increasing after a rapid growth in domestic credit in 1996, but throughout 1998 the reference rate was reduced from 24 percent in February to 15.5 percent in December. The sharp reduction was a response to economic slowdown, a decline in the 12-month inflation from 13 percent in 1997 to 8.4 in 1998, and large portfolio capital inflows. Central bank interest rates remained at a stable level for the first half of 1999 but higher inflation—overshooting the 6.6-7.8 percent target for 1999—prompted monetary authorities to reverse the cuts starting from the second half of 1999. In 2000 interest rates were further increased but the inflation rate remained above the 5.4-6.8 percent target for this year. A period of interest rate cuts started only from the beginning of 2001, when inflation was declining and economic activity plunged into recession. Despite the policy relaxation (the reference rate dropped by 8.5 percentage points in 2001 and by nearly 5 additional points in 2002), the end-year inflation was below the 7 ± 1 target in 2001 and dropped to 0.8 percent in 2002, well below the 5 ± 1 target⁷². The policy relaxation pushed inflation towards the lower band of the target range (3 ± 1) at the end of 2003. A modest policy tightening started in 2004, when inflation oscillated above the upper band of the range (2.5 ± 1) at the end of the year.

⁷² In June 2002, the MPC reduced the 2002 target to 3 ± 1 .

Figure 5-1 Percentage deviations from central parities for the Czech Republic and Poland.



Source: NBP, CNB, ING Bank

Remark : Central parities and baskets in the floating exchange rate period are the same as last parities and baskets in the target zone period.

- A – Czech crisis (devaluation)
- B – Asian crisis (stock exchange crash in Hong-Kong)
- C – Russian crisis (devaluation)
- D – Brazilian crisis (devaluation)
- E – Argentine crisis (devaluation)

5.3 Specification and identification of the model

The empirical model adopted in this study is a version of a small, open-economy structural vector autoregression (SVAR). Similar models have been successfully estimated for Canada by Cushman and Zha (1997) and for other OECD countries by Kim and Roubini (1995). Due to data limitations (short time series), the size of the model is kept at the minimum and consequently the adopted identification scheme is simpler than in the other studies. The basic model is described by the following system of simultaneous equations:

$$y_t' A_0 = x_t' A_+ + \varepsilon_t, t = 1 \dots T \quad (7.1)$$

where $y_t = [Y_t, P_t, I_t, E_t, S_t^*, I_t^*]$ is a $n \times 1$ vector of endogenous variables (Y_t is output, P_t denotes prices, I_t is short-term interest rate, E_t is exchange rate, S_t^* is spread on emerging market debt, and I_t^* is interest rate in industrialized countries), X_t is a $m \times 1$ vector of lagged endogenous variables and exogenous variables specified below, and ε_t is a $n \times 1$ vector of structural disturbances with the following distribution:

$$\varepsilon_t | y_t \sim N(0,1) \quad (7.2)$$

Five variables in the y_t vector can be grouped into two blocks: output and prices form a "real sector" block, and short-term interest rate, exchange rate, and measures of return on foreign assets (the spread and the interest rate) form a "financial sector" block. Identification of shocks in the system described by equations (7.1) and (7.2) requires imposing a sufficient number of restrictions on the A_0 matrix. Table 5-1 presents the imposed restrictions.

Table 5-1 Restrictions on coefficients of the A_0 matrix.

Real sector bloc			Financial sector bloc			
			Policy reaction function	Information equation	Emerging market spread	Foreign interest rate
P	a_0			a_5		
Y	a_1	a_2		a_6		
I			a_3	a_7		
E			a_4	a_8		
S^*				a_9	a_{10}	
I^*				$-a_7$		a_{11}

The first column of the table lists endogenous variables. The top rows divide the table into two blocs and—when economically interpretable—into behavioral equations defined by columns with non-empty cells.

Identification of shocks in the real sector block is achieved by assuming that financial sector variables affect real sector variables only with a lag. This restriction makes the A_0 matrix bloc triangular. The real sector bloc itself is assumed to be triangular, which is normalization. Shocks and equations in the real sector bloc are not

given any economic interpretation, and their normalization does not affect identification of shocks in the financial sector bloc (Zha, 1996).

Identification of shocks in the financial sector is achieved by assuming that a time-lag in data dissemination does not allow real sector variables to contemporaneously enter the policy reaction function, and that returns on foreign assets are exogenous and do not contemporaneously affect variables in the policy reaction function. The information equation includes all variables, but coefficients of domestic and foreign interest rate are restricted to have the same absolute value with opposite signs, giving this equation an interpretation of the uncovered interest parity condition. Restrictions identifying the financial sector bloc do not depend on any particular policy regime, and can be used under both pegged and floating exchange rate arrangements.

The policy reaction equation may be interpreted as a function describing the behaviour of an implicit monetary condition index—a linear combination of short term interest rate and exchange rate—by lagged endogenous and exogenous variables. This interpretation originates from Gerlach and Smets (1996) and Smets (1996), who show that it is optimal for monetary authorities targeting the monetary condition index not to react to foreign financial markets' shocks. Contemporaneous coefficients in the monetary policy reaction function can be normalized to sum up to one, and interpreted as weights in the monetary condition index. A successful identification should give a higher weight to exchange rate in the target zone regime, and a higher weight to interest rate in the floating regime.

The presence of the emerging market debt spread in the foreign sector block is innovative. The traditionally used interest rate in industrialized countries may not fully capture shocks affecting transitional economies. Advanced transition economies are regarded as emerging markets and—as depicted on figure 1—capital flows to these countries are driven by developments in other emerging markets to much larger extent than by changes in developed economies' interest rates (Habib, 2002). Changes in emerging market debt spread are likely to be exogenous with respect to the behaviour of

other variables in the model, given a relatively small size of the Czech Republic and Poland in international capital markets.⁷³

The change in the monetary policy strategy—a switch to inflation targeting—makes the fixed-coefficient VAR model potentially unsuitable for the analysis of the whole sample. To account for policy changes, the model allows for a limited time-variation in coefficients, following the methodology proposed by Sims and Zha (2002) and similar to Del Negro and Obols-Homs (2001). In the specification with time-varying coefficients, equation (7.1) is replaced by:

$$y_t' A_0(s_t) = x_t' A_+(s_t) + \varepsilon_t, t = 1 \dots T \quad (7.3)$$

where s_t is a state of the economy, which is assumed to be observable.

If all elements of matrices A_0 and A_+ vary across states, the number of parameters in the system described by equation (7.3) can be very large, making it unsuitable for short transition series. In what follows, time-variation in the system is restricted to parameters of the policy reaction function, both in the A_0 and in the A_+ matrix. The number of states is set to two, corresponding to the pegged and floating exchange rate regime. Testing this specification against a more flexible alternative shows that the policy break was the major change in the estimation period.

5.4 Estimation and results

In empirical specification, variables in the financial sector bloc are short term interest rates (1 month WIBOR for Poland and 1 month PRIBOR for the Czech Republic), exchange rate indices defined as a weighted average of USD and DM rates (domestic currency units per foreign currency unit, with a dollar weight of 35 percent for the Czech

⁷³ Since the EMBI+ index used in the study gives a small weight to Polish Eurobonds (3.7 percent), the assumption that returns on foreign assets measured by the index are exogenous with respect to domestic variables may be violated. Even if country's bonds are excluded, other bonds in the index may be affected by developments on domestic financial markets. In particular, the exogeneity assumption may be violated in case of the Czech Republic during the 1997 crisis. Developments in the Czech Republic and Poland do not seem to have any visible effect on the EMBI+ index, but robustness of results to this assumption is checked by estimating alternative specifications as discussed below.

Republic and 50 percent and Poland), spread on the JP Morgan EMBI+ index, and 1 month LIBOR. These interest rates are best proxies for short term policy rates in the sample. The dollar weight in the exchange rate index for the Czech Republic is the official basket weight in the March 1996–June 1997 period. For Poland, the weight is an approximation, since the official basket included four non-dollar currencies, later replaced by the Euro. The spread on the EMBI+ index and LIBOR measure returns on foreign assets. Real sector variables are consumer price index and interpolated real GDP.⁷⁴ Industrial production and consumer price indices are seasonally adjusted and in logs, exchange rate and EMBI+ indices are in logs, and money market rates are not transformed. A dummy equal to one in May and June 1997 and zero elsewhere is introduced in the information equation for the Czech Republic. Introduction of the dummy reflects the assumption that large shocks related to a sudden capital outflow in this period are not drawn from the same distribution as other shocks in the model. Following Begg (1998), it is assumed that the capital outflow was driven by a confidence crisis, which was contemporaneously exogenous to other variables in the model. It is assumed that the policy reaction to the shock was not different from policy responses to other disturbances in international financial markets. A description of variables is given in 5.7

Estimation period runs from May 1995 (introduction of the target zone) until September 2004 for Poland, and from March 1996 (introduction of the target zone) to December 2003 for the Czech Republic. The date of policy change is set to January 1998 for the Czech Republic (corresponding to introduction of the inflation targeting framework) and to February 1998 for Poland (corresponding to widening of the target zone to ± 10 percent by the Monetary Policy Council, after announcing a switch to inflation targeting). The discussion above and Figure 5-1 indicate that the dates mark a visible change in the exchange rate behaviour, consistent with a switch to a floating regime.

⁷⁴ GDP series are interpolated from quarterly values using related monthly series: index of industrial production, retail sale and construction activity for the Czech Republic; and the same set of variables augmented by the volume of cargo transport for Poland. State-space model used for interpolation is estimated through the Kalman filter as discussed in 5.9

Co-integration analysis is not conducted. Bayesian methods are used for the estimation, in which the inference is not affected by non-stationarity of the data. However, as discussed in Sims (1996), estimation of a VAR system conditional on initial conditions with flat priors attributes implausible explanatory power to initial conditions. This leads to the well-known bias toward stationarity in conventional estimates of such models. Sims' remedy to this problem is to formulate priors that reflect the prior implausibility of models dominated by initial conditions, pushing the model towards non-stationarity. In this paper, unit root priors are applied to the reduced-form VAR, but other priors advocated by Sims (1996) and Sims and Zha (2002) to reduce the reliance on initial conditions are not used. According to Sims (1996), the application of these priors should not be automatic, but should depend on investigator's prior knowledge about the behaviour of the system. The prolonged effect of powerful price liberalization shocks experienced at the beginning of transition gives a strong reason not to downplay the role of initial conditions in the system. The estimated model leans therefore toward a hypothesis that the gradual disinflation path experienced by transition economies could had been expected at the start of the process.

Additional restrictions are imposed on the reduced system and coefficients to tighten the inference. The reduced form systems are assumed to be non-explosive. Coefficients of exchange rate and interest rate in the monetary policy reaction function are restricted to have opposite signs ($-a_3^{(i)} / a_4^{(i)} > 0$), and the weight attached to exchange rate in the monetary condition index is restricted to be higher in the target zone regime ($-a_3^{(1)} / a_4^{(1)} < -a_3^{(2)} / a_4^{(2)}$). 5.8 discusses in details the Bayesian estimation technique.

The lag length in the VAR is set to six, which is a balance between limiting degrees of freedom and allowing for a reach dynamics in the system. All calculations are conducted in OX (Doornik, 1999) and programs replicating the results are available on request.

5.4.1 Model fit

Table 5-2 presents measures of fit for models with different treatment of structural breaks associated with monetary policy regime changes: Schwarz criteria and likelihood functions evaluated at the top of posterior density. Four specifications are considered: changes in all parameters of the model at the time of structural break; changes in

parameters of the monetary policy function; changes in contemporaneous coefficients of the monetary policy reaction function (weights of exchange and interest rates in the MCI); and constant parameters across policy regimes.

Table 5-2 Measures of fit.

	$\log(f(Y_T \hat{\theta}) \cdot \pi(\hat{\theta}))$	Schwarz
Czech Republic		
All parameters	2222.7	-34.494
Monetary policy	2133.5	-38.084
MCI weights	2130.1	-39.229
Nothing	2047.7	-37.555
Poland		
All parameters	2535.0	-33.999
Monetary policy	2471.9	-37.893
MCI weights	2461.2	-38.767
Nothing	2448.1	-38.615

Models allowing for changes in policy parameters are strictly favoured over specifications allowing for variation in all model parameters, providing evidence that structural equations other than monetary policy reaction function did not change at the time of regime change. A model forcing all coefficients to be constant across regimes is marginally better than the model allowing for changes in policy parameters for Poland, and worse for the Czech Republic.

Models allowing for changes in only contemporaneous coefficients of the policy reaction function (MCI weights) come first in the ranking.

Although measures of fit favour models with time-varying contemporaneous coefficients in the policy reaction function, the difference is small compared to models allowing for changes in all parameters of the function. Further analysis is therefore conducted using models with the fully time-varying policy reaction functions, given their more straightforward economic interpretation.

5.4.2 Coefficients of the A_0 matrix

Table 5-3 and Table 5-4 list modes, and 5th and 95th percentiles of posterior distributions of coefficients in A_0 matrices for two regimes for the Czech Republic and Poland.

Table 5-3 Coefficients of the A_0 matrix for the Czech Republic.

	5 th percentile	Mode	95 th percentile
a_0	153.30	173.88	195.05
a_1	-77.99	-29.82	26.99
a_2	274.94	308.07	344.17
$a_3^{(0)}$	17.25	26.53	36.69
$a_4^{(0)}$	-137.52	-108.55	-83.57
$a_3^{(1)}$	261.23	298.61	338.78
$a_4^{(1)}$	-18.57	-7.13	-1.12
a_5	3.13	28.59	55.89
a_6	-46.28	4.56	50.03
a_7	36.19	47.92	58.37
a_8	55.95	63.09	70.61
a_9	-37.45	-17.80	0.26
a_{10}	104.92	115.67	128.59
a_{11}	441.25	480.49	535.40
$ a_3(0) / (a_3(0) + a_4(0))$	0.14	0.20	0.26
$ a_3(1) / (a_3(1) + a_4(1))$	0.94	0.98	1.00

Table 5-4 Coefficients of the A_0 matrix for Poland.

	5 th percentile	Mode	95 th percentile
a_0	101.85	114.21	127.10
a_1	-83.20	-26.44	27.56
a_2	319.50	356.05	393.68
$a_3^{(0)}$	26.69	72.12	119.87
$a_4^{(0)}$	-151.06	-119.86	-90.95
$a_3^{(1)}$	63.75	112.71	142.82
$a_4^{(1)}$	-49.40	-33.84	-20.59
a_5	-25.67	-7.24	6.73
a_6	-67.45	-16.99	36.85
a_7	87.97	112.96	145.03
a_8	29.95	47.62	58.73
a_9	-54.42	-34.50	-9.80
a_{10}	109.96	120.23	132.19
a_{11}	468.76	513.82	562.51
$ a_3(0) / (a_3(0) + a_4(0))$	0.17	0.38	0.54
$ a_3(1) / (a_3(1) + a_4(1))$	0.57	0.78	0.87

Coefficients of the policy reaction function a_3 and a_4 are consistent with their interpretation as contemporaneous coefficients in the monetary policy reaction function. After normalization, these coefficients can be interpreted as weights of exchange rate and interest rate in the MCI, which are reported in bottom rows of the tables. Both for the Czech Republic and Poland, the weight attached to exchange rate in the MCI is much

higher than in the floating exchange rate regime. In both regimes the weights are precisely estimated. The difference between two policy regimes appears to be lower for Poland than for the Czech Republic.

Coefficients of financial variables in information equations are economically interpretable and in most cases precisely estimated. An increase in domestic interest rate or a decline in LIBOR appreciate domestic currency, while a higher spread on emerging market debt depreciates the currency. Coefficients of other variables in information equations are estimated less precisely.

Since the real sector block is not identified, no interpretation is given to coefficients in the first two equations of the model.

5.4.3 Dynamic responses to policy shocks in the two regimes

Responses of consumer price index, industrial production, money market rate and exchange rate to a monetary policy shock for the Czech Republic and Poland are plotted on Figure 5-2 and Figure 5-3. Graphs in left and right columns show posterior modes and 5th and 95th percentiles of the posterior distribution for the first and the second regime respectively.

Figure 5-2 Czech Republic: Impulse responses to a monetary policy shock in two regimes: 1996.3-1997.12 (left column) and 1998.1-2003.12 (right column) with 95% confidence interval.

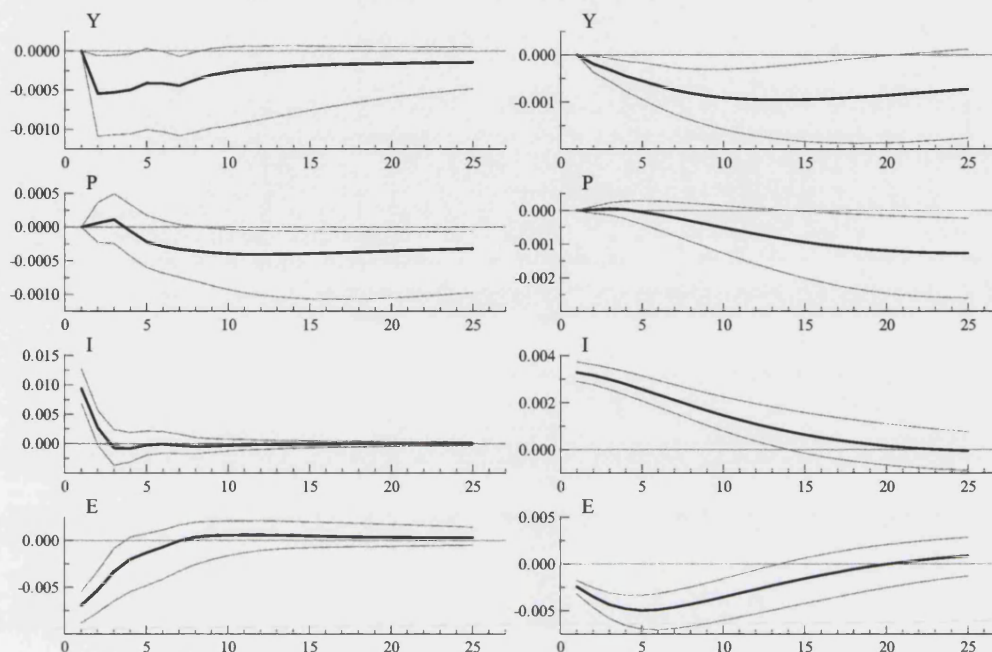
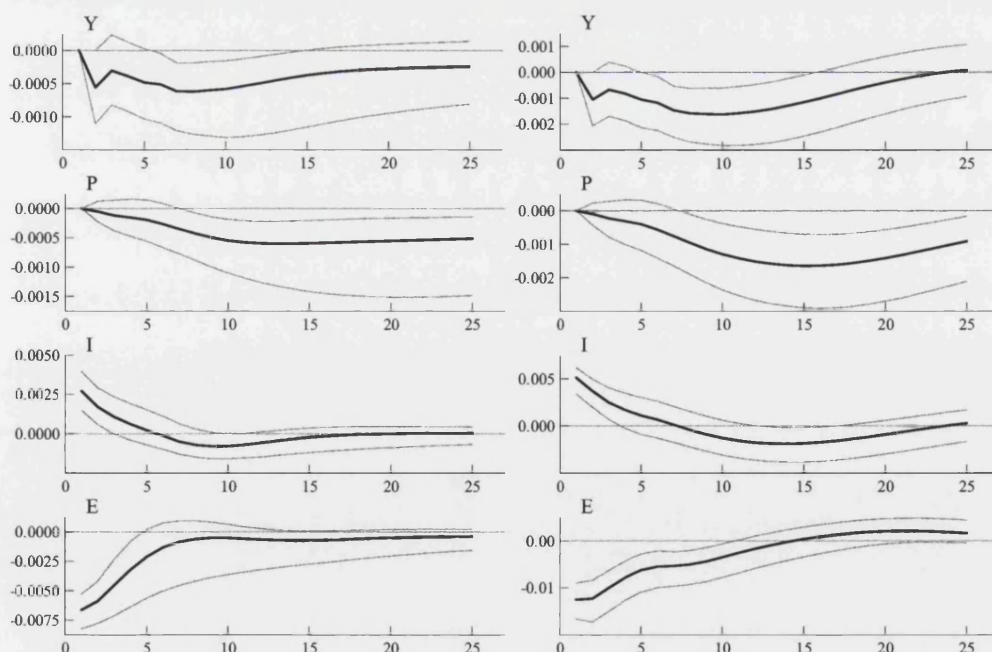


Figure 5-3 Poland: Impulse responses to a monetary policy shock in two regimes: 1995.5-1998.2 (left column) and 1998.3-2004.9 (right column) with 95% confidence interval.



In both regimes, a negative monetary policy shock leads to a simultaneous appreciation of exchange rate and an increase in interest rate, but the path of response is different,

reflecting changes in the operation of monetary policy in these periods. In the Czech Republic, the monetary policy shock in the first regime has a strong but short effect on both the interest rate and the exchange rate. In the floating exchange rate regime, interest rate and exchange rate responses are smaller, but more persistent. Responses of output and prices have a correct sign in both regimes, but are not precisely estimated. Both output and prices react faster in the first regime: output decline starts shortly after the shock and continues for a period of 7 months, and prices react fully to a monetary policy shock after about a year. Under the floating exchange rate, the maximum output decline occurs after 12 months, and prices fully react nearly two years after the shock. In Poland, responses of interest rate and exchange rate are both stronger and more persistent in the floating exchange rate regime, but the initial reaction to the shock is reversed after about 15 months. Output responses are estimated more precisely, with output falling to the lowest level three quarters after monetary tightening, and prices fully falling a year after the tightening. Output and price responses under the floating exchange rate regime are stronger than in the first regime, but partly reversed due to policy reversals indicated by the behaviour of interest and exchange rates.

5.5 Counterfactual Simulation of the 1998 Policy Change

This section attempts to estimate the effects of the 1998 change in policy framework on the behaviour of policy instruments, inflation and output for the Czech Republic and Poland. The aim of these simulations is to evaluate the implementation of inflation targeting combined with floating exchange rates in the two countries. Following Sims and Zha (2002), a counterfactual history is modelled as follows. For each draw from the parameters' density, a sequence of unit variance structural shocks is saved. In the next step—starting from December 1997 for the Czech Republic and February 1998 for Poland—a one-step to n-step ahead forecasts are created (where n is the last period of the simulation), using the saved structural shocks and parameters from the previous policy regime. The counterfactual paths for year-on-year changes in output, year-on-year changes in CPI, short-term interest rate and exchange rate index are plotted on Figure 5-4 and Figure 5-5 for the Czech Republic and Poland.

Figure 5-4 Czech Republic: Counterfactual simulation of a policy rule from the crawling peg regime operating in the floating exchange rate period.

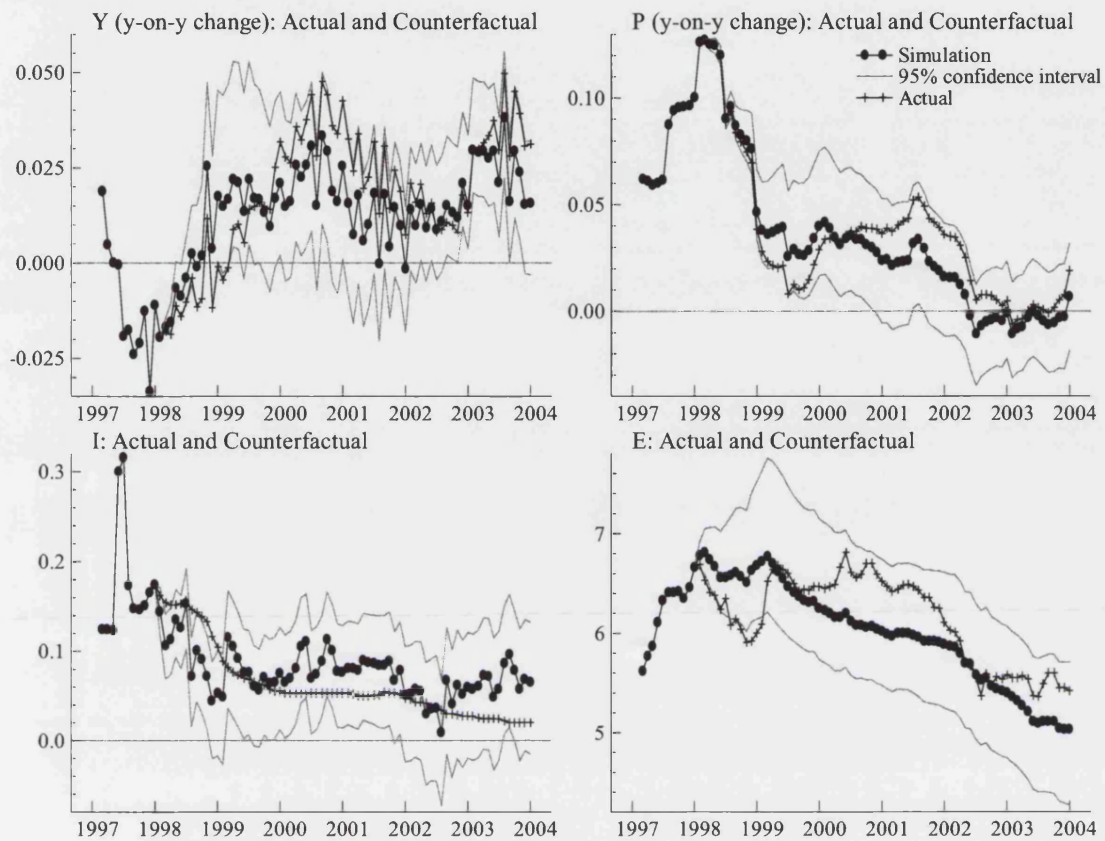
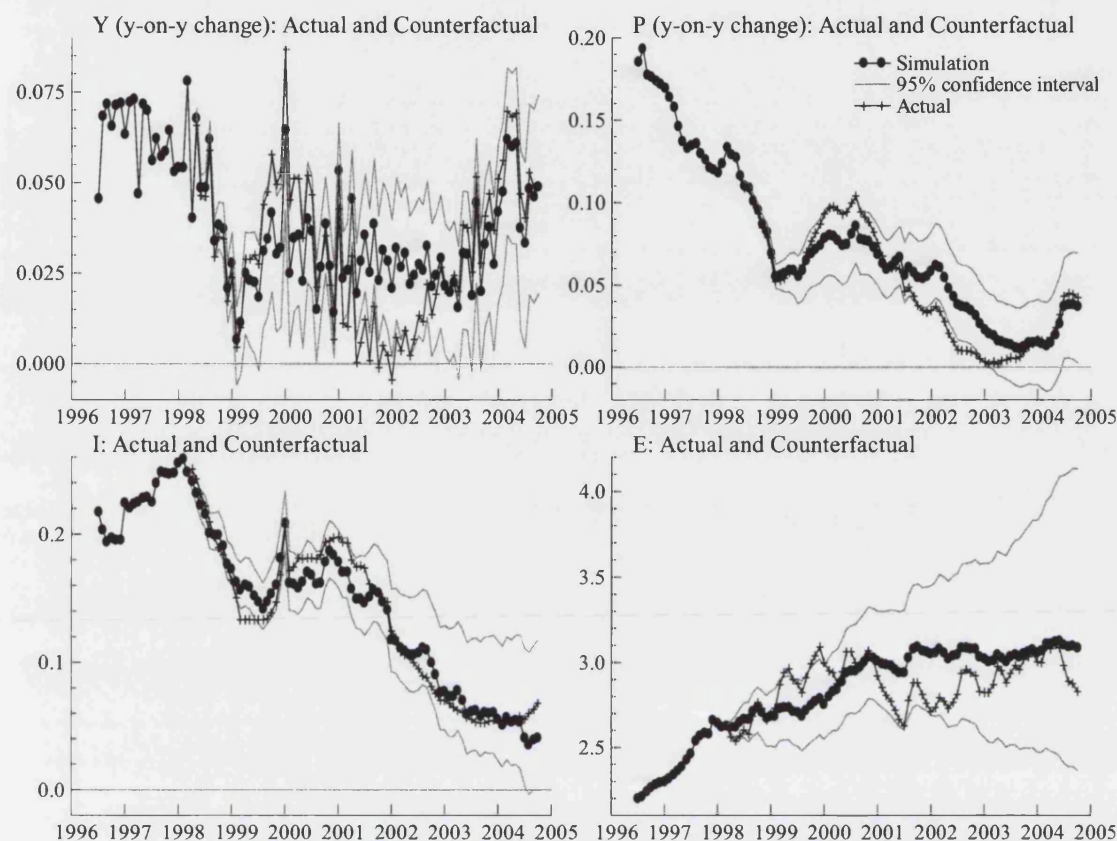


Figure 5-5 Poland: Counterfactual simulation of a policy rule from the crawling peg regime operating in the floating exchange rate period.



For both countries, the simulated exchange rate path is smoother, but contains a time-varying trend implying a real appreciation.⁷⁵ The estimated first regime restricts exchange rate fluctuations, but combines this policy with an adjustable speed of nominal depreciation. Throughout the simulation period, the counterfactual interest rate path exhibits more high-frequency volatility, responding—instead of exchange rate—to shocks originating from international financial markets.

For the Czech Republic, the simulated paths are significantly different from actual ones at the beginning of the simulation period. The results suggest that without the policy change, there would be a significantly faster relaxation of monetary policy after the crisis,

⁷⁵ In Poland, the depreciating nominal exchange rate is consistent with real appreciation due to relatively higher inflation. Nominal appreciation is necessary in case of the Czech Republic, when inflation is lower.

generating faster output recovery and initially higher inflation. Subsequently, in 2000 interest rates would need to be increased compared to the baseline in order to counteract exchange rate depreciation, reducing output and stabilizing inflation. The baseline paths are close to the 95 percent confidence interval for counterfactual simulations in this period. The simulated monetary policy appears too tight in the last 18 month of the analysis compared to the actual interest rate and exchange rate behaviour, although differences between the simulated and actual paths are not significant. The simulated policy strongly supports the exchange rate, which may be a reflection of the interest hike and its subsequent behaviour during and after the 1997 crisis, covered in the estimation period. This strong emphasis on the exchange rate generates a likely sub-optimal behaviour of interest rate at the end of the simulation.

For Poland, the counterfactual policy is not only often significantly different, but also seems to perform better than the actual one for most of the simulation period. The simulated interest rate path is more gradual. In particular, the policy relaxation in 1999, and a subsequent tightening are less pronounced. As a result, exchange rate depreciates less in 1999, and the strong appreciation in 2001 is avoided. This leads to smoother output and inflation paths.

The model is also estimated using alternative inflation measures. While policy targets in both countries are currently set for the headline inflation, the Czech Republic targeted net inflation after the introduction of the new framework. In Poland, MPC statements underline the role of the net inflation in policy decisions.⁷⁶ While it is unlikely that the policy under the previous monetary regime was fully guided by these measures of inflation, the policymakers might, to some extent, have taken into account a temporary nature of the shocks now excluded from the net inflation series. Estimating the system with the net inflation series allows for this possibility. Impulse responses produced from the re-estimated models are similar to the original specification. The interpretation of counterfactual simulations—presented on Figure 5-6 and Figure 5-7 is also broadly similar. The main exception is that the counterfactual path for the Czech inflation is now

⁷⁶ The net inflation for the Czech Republic excludes changes in administrative prices and direct taxes. In Poland, the net inflation excludes prices of food and oil products.

significantly lower than the actual at the end of the sample due to a strong increase in interest rate and exchange rate appreciation.

Figure 5-6 Czech Republic: Counterfactual simulation of a policy rule from the crawling peg regime operating in the floating exchange rate period using net inflation.

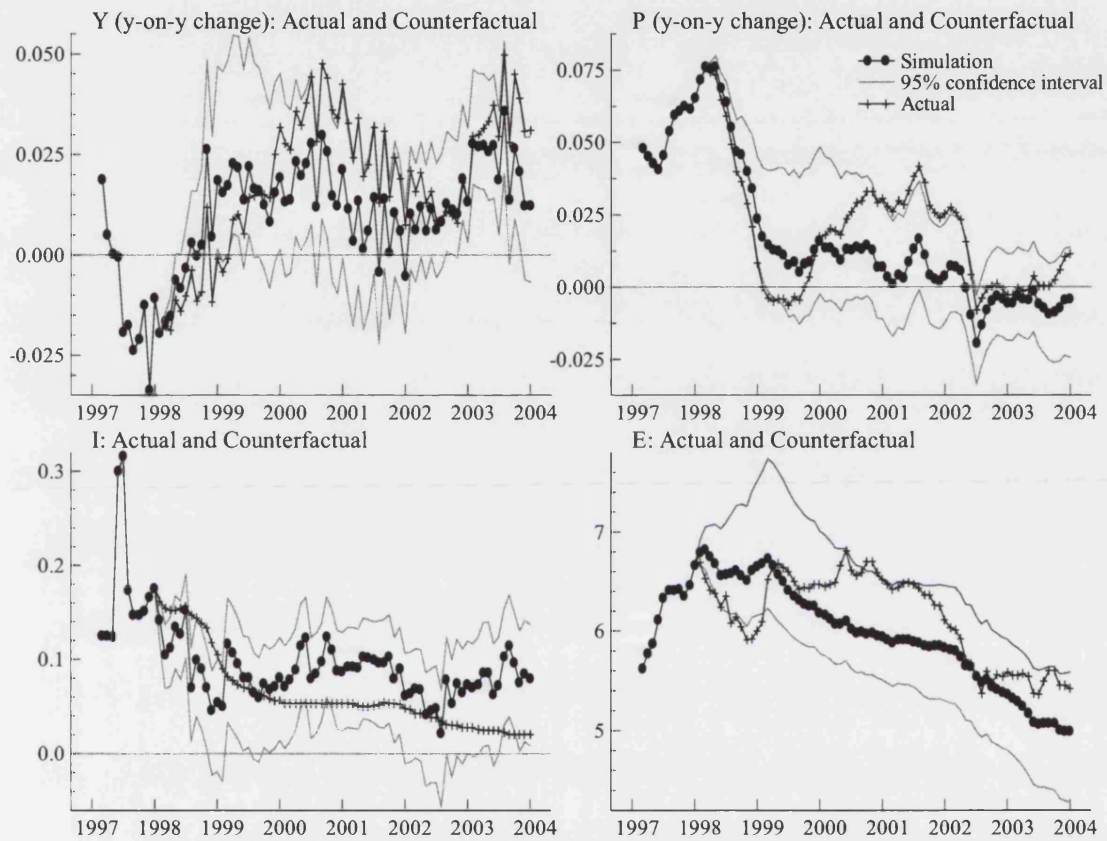
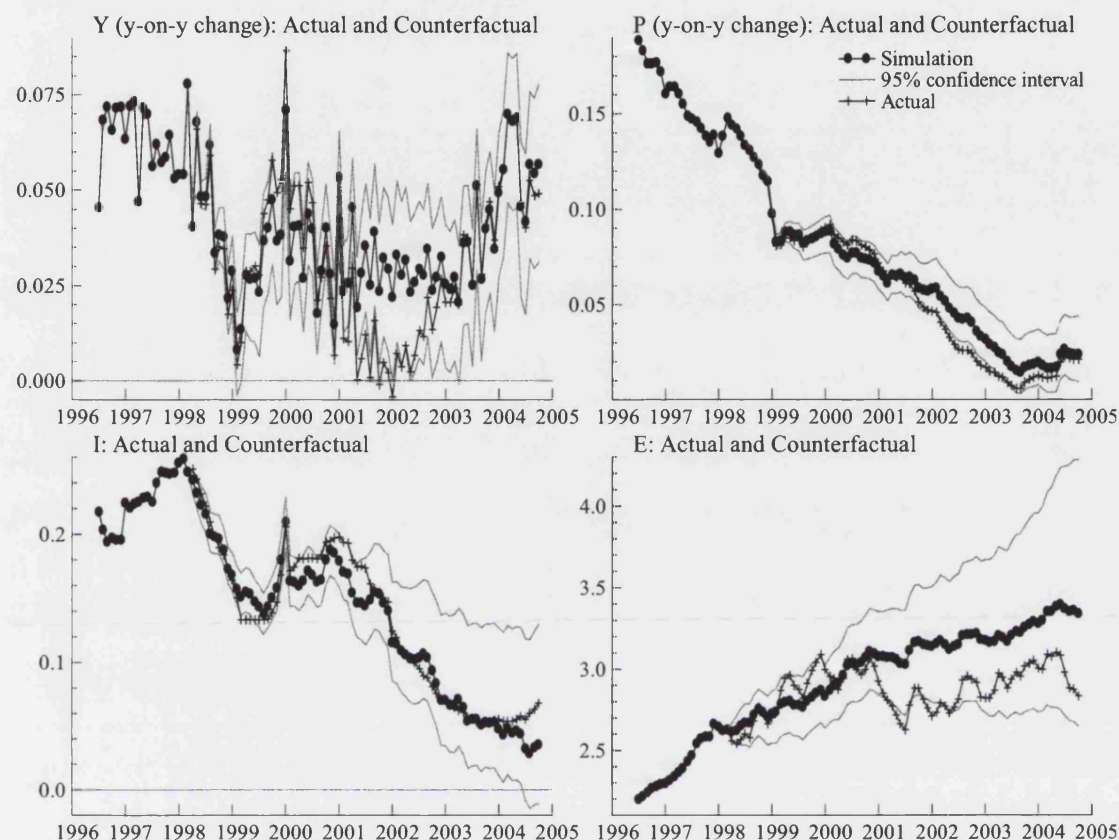


Figure 5-7 Poland: Counterfactual simulation of a policy rule from the crawling peg regime operating in the floating exchange rate period using net inflation.



Additional robustness checks included adding central bank foreign currency reserves as an exogenous variable affecting the behaviour of financial variables, adding fiscal primary balance to the system, and relaxing priors used in the presented specification. The addition of reserves, which proxy for central bank intervention at the exchange rate market, does not significantly change the results. Estimating the model either with primary balance or with weak priors did not produce economically interpretable results due to the large number of parameters in the systems. It is worth to note, however, that since variables in the real sector block are affected by fiscal policy, the estimated monetary policy indirectly reacts to fiscal variables even in the current specification.

5.6 Conclusions

This paper attempts to shed some light on the effects of monetary policy on output and inflation, and evaluate the effects of monetary policy changes in the Czech Republic and

Poland after the introduction of the inflation targeting framework in 1998. The six-variable structural VAR methodology adopted in the study is successful in identifying monetary policy shocks and their effects for the Czech and Polish economies. The time-varying model is capable of detecting changes in the policy reaction function consistent with the introduction of the floating exchange rate system and switching to short-term interest rates as the main policy instrument. Counterfactual simulations—in which the countries do not switch from target zones to the floating exchange rate system—facilitate the evaluation of the policy in the floating exchange rate period.

For both countries, a typical unexpected monetary tightening during the regime with restricted exchange rate fluctuations leads to a temporary appreciation of the exchange rate and a temporary increase in the short term interest rate. In the inflation targeting framework, monetary policy tightening is reflected in a persistent increase of short-term interest rates, leading to exchange rate appreciation. Responses of prices and output are consistent with macroeconomic theory and other VAR studies: both prices and output decline after the contractionary monetary policy shock and the response of output is faster than the response of prices.

In the Czech Republic, the weight of exchange rate in the monetary conditions index for the regime with restricted exchange rate fluctuations is much higher than the corresponding weight for Poland. This is likely a reflection of the behaviour of interest rate during and after the 1997 crisis, when monetary policy attempted to defend the peg. For this reason, the identified monetary policy function for the past regime may be of limited use to evaluate the behaviour of macro-variables when exchange rate fluctuations are constrained, but there are no unusually large shocks.

In Poland, a contractionary monetary policy shock under the floating exchange rate generates stronger interest rate and exchange rate responses than in the corresponding period for the Czech Republic. Moreover, the responses of exchange and interest rates to the shock are reversed after about 15 months, pointing to cyclicity in setting monetary policy instruments. In counterfactual simulations, the exchange rate and interest rate paths are smoother than actual, leading to a more stable inflation and output. The smoother simulated interest path suggests that reducing monetary policy volatility—which apparently increased in the floating exchange rate period—dominates the stronger effect of external shocks on interest rate when exchange rate fluctuations are restricted.

Gains from limiting exchange rate fluctuations in Poland would therefore originate mainly from reducing volatility in the monetary policy itself.⁷⁷ This has important implications for the EMU accession. Restricting exchange rate fluctuations in this process would reduce the discretion in monetary policy, and therefore its volatility. The model, however, cannot answer the question how the fixed and non-adjustable exchange rate would affect inflation behaviour in the presence of persistent real appreciation.

⁷⁷ Borghijs and Kuijs (2004) offer a similar conclusion.

5.7 Appendix: Data sources and transformations

Country	Variable	Description	Source
Czech Republic	E	$(\text{CZK/USD})^{0.35}(\text{CZK/DM})^{0.65}$ (in logs)	CNB
	I	1 month PRIBOR	CNB
	Y	Index of industrial production (X11 seasonally adjusted, in logs)	CNB
Poland	P	CPI (X11 seasonally adjusted, in logs)	CNB
	E	$(\text{PLN/USD})^{0.5}(\text{PLN/DM})^{0.5}$ (in logs)	NBP
	I	1 month WIBOR	Datastream
Financial markets	Y	Index of industrial production (X11 seasonally adjusted, in logs)	CSO
	P	CPI (X11 seasonally adjusted, in logs)	CSO
	I*	JP Morgan EMBI+ (in logs)	Datastream

CNB – Czech National Bank

NBP – National Bank of Poland

CSO – Central Statistical Office (Poland)

5.8 Appendix: Bayesian estimation

The estimation method for the multi-regime model in this paper is adapted from Sims and Zha (2002), simplified after assuming that dates of regime changes are known.

Following Sims and Zha, the model (7.1) is rewritten in the following way

$$y_t' A_0^{(k)} = x_t' [D^{(k)} + \bar{S} A_0^{(k)}] + \varepsilon_t' \quad (7.4)$$

where

$$\bar{S} = \begin{bmatrix} I_{n \times n} \\ 0_{(m-n) \times n} \end{bmatrix} \quad (7.5)$$

Priors for non-zero coefficients in A_0 (for regimes $k=1,2$) are specified assuming a joint Gaussian prior distribution with independent individual elements with mean zero and standard deviation set to $\lambda_0 / \hat{\delta}_i$ for the i 'th row of $A_0^{(k)}$, where λ_0 is a hyperparameter and $\hat{\delta}_i$ is a standard deviation from an estimated autoregressive process for the i 'th variable. For $D^{(k)}$, a joint Gaussian prior distribution is specified with independent individual elements with mean zero and standard deviation of the coefficient on lag l of variable j in each equation given by $\frac{\lambda_0 \lambda_1}{\hat{\delta}_j l^{\lambda_3}}$, where l , λ_1 , λ_3 are hyperparameters and $\hat{\delta}_j$ is a standard deviation from an estimated autoregressive process for the j 'th variable. This formulation of the prior is equivalent to specifying a random walk prior for reduced form VAR coefficients. In the baseline specification $l = 1$, $\lambda_0 = 1$, $\lambda_1 = .2$, $\lambda_3 = 1$. In addition, diffuse priors are assumed for deterministic and exogenous elements of the system.

Denoting the j 'th column of $A_0^{(k)}$ by $a_{0,j}^{(k)}$ and the j 'th column of $D^{(k)}$ by $d_j^{(k)}$ for $j = 1, \dots, n$ and $k = 1, 2$, the proposed prior distributions for elements of $A_0^{(k)}$ in equation j can be written as:

$$a_{0,j}^{(k)} \sim N(0, H_{0,j}), k = 1, 2, j = 1, \dots, n \quad (7.6)$$

$$d_{0,j}^{(k)} \sim N(0, H_{+,j}), k = 1, 2, j = 1, \dots, n \quad (7.7)$$

The model is further rewritten by stacking $a_{0,j}^{(k)}$ and $d_j^{(k)}$ for $k = 1, 2$ into:

$$a_{0,j} = \begin{bmatrix} a_{0,j}^{(1)} \\ a_{0,j}^{(2)} \end{bmatrix}, d_j = \begin{bmatrix} d_j^{(1)} \\ d_j^{(2)} \end{bmatrix} \quad (7.8)$$

In order to avoid over-parameterization of the model, the coefficients in a_j and d_j must be restricted. In the baseline specification only parameters of policy reaction functions are allowed to vary. Following Waggoner and Zha (2001), coefficients in $a_{0,j}$ and $d_{0,j}$ can be expressed in terms of “free” coefficients by writing the restrictions as:

$$Q_j a_{0,j} = 0, R_j d_j = 0, j = 1, \dots, n \quad (7.9)$$

where Q_j is a $n_k \times n_k$ matrix with rank q_j and R_j is a $m_k \times m_k$ matrix with rank r_j . Denoting by U_j a $n_k \times q_j$ matrix such that the columns of U_j form an orthonormal basis for the null space of Q_j and denoting by V_j a $m_k \times r_j$ matrix such that the columns of V_j form an orthonormal space for the null space of R_j , a_j and d_j can be expressed in terms of a $q_j \times n_k$ vector b_j and a $r_j \times m_k$ vector g_j satisfying the following relationships:

$$a_{0,j} = U_j b_j, d_j = V_j g_j, j = 1, \dots, n \quad (7.10)$$

Vectors b_j and g_j contain “free” parameters of the model. The original parameters in a_j and d_j can be recovered by linear transformations U_j and V_j .

The prior for coefficients in b_j and g_j are obtained by combining equations 7.6, 7.7, 7.8 and 7.10:

$$b_j \sim N(0, \overline{H}_{0j}), j = 1, \dots, n \quad (7.11)$$

$$g_j \sim N(0, \overline{H}_{+j}), j = 1, \dots, n \quad (7.12)$$

where

$$\overline{H}_{0j} = (U_j'(I \otimes H_{0j}^{-1})U_j)^{-1}, j = 1, \dots, n \quad (7.13)$$

$$\overline{H}_{+j} = (V_j'(I \otimes H_{0j}^{-1})V_j)^{-1}, j = 1, \dots, n \quad (7.14)$$

Introducing notation:

$$Y^{(k)} = \begin{bmatrix} y_{t_1^{(k)}}' \\ \vdots \\ y_{t_{T_k}^{(k)}}' \end{bmatrix}, X^{(k)} = \begin{bmatrix} x_{t_1^{(k)}}' \\ \vdots \\ x_{t_{T_k}^{(k)}}' \end{bmatrix}, k = 1, 2 \quad (7.15)$$

where T_k is the total number of observations in regime k ; and $t_1^{(k)}$ and $t_{T_k}^{(k)}$ are respectively the first and the last observation from regime k , the likelihood function expressed in terms of original parameters is proportional to:

$$\begin{aligned} L &\propto \prod_{k=1}^2 |\det(A_0^{(k)})|^{T_k} \prod_{k=1}^2 \exp \left\{ -\frac{1}{2} \text{trace}[Y^{(k)} A_0^{(k)} - X^{(k)} (D^{(k)} + \bar{S} A_0^{(k)})] [Y^{(k)} A_0^{(k)} - X^{(k)} (D^{(k)} + \bar{S} A_0^{(k)})] \right\} = \\ &\prod_{k=1}^2 |\det(A_0^{(k)})|^{T_k} \prod_{k=1}^2 \exp \left\{ -\frac{1}{2} [Y^{(k)} a_{0,j}^{(k)} - X^{(k)} (d_j^{(k)} + \bar{S} a_{0,j}^{(k)})]' [Y^{(k)} a_{0,j}^{(k)} - X^{(k)} (d_j^{(k)} + \bar{S} a_{0,j}^{(k)})] \right\} = \\ &\prod_{k=1}^2 |\det(A_0^{(k)})|^{T_k} \prod_{k=1}^2 \exp \left\{ -\frac{1}{2} [a_{0,j}^{(k)'} Y^{(k)'} Y^{(k)} a_{0,j}^{(k)} - 2(d_j^{(k)} + \bar{S} a_{0,j}^{(k)})' X^{(k)'} Y^{(k)} a_{0,j}^{(k)} + \right. \\ &\left. (d_j^{(k)} + \bar{S} a_{0,j}^{(k)})' X^{(k)'} X^{(k)} (d_j^{(k)} + \bar{S} a_{0,j}^{(k)})] \right\} \end{aligned}$$

The above expression can be simplified by introducing the following notation:

$$\begin{aligned} \tilde{\Delta}_0^{-1} &= \text{diag} \left\{ [Y^{(k)'} Y^{(k)} - 2\bar{S}' X^{(k)'} Y^{(k)} + \bar{S}' X^{(k)'} X^{(k)} \bar{S}]_{k=1}^2 \right\} \\ \tilde{\Delta}_{+0} &= \text{diag} \left\{ [X^{(k)'} Y^{(k)} - X^{(k)'} X^{(k)} \bar{S}]_{k=1}^2 \right\} \end{aligned} \quad (7.16)$$

$$\tilde{\Delta}_+^{-1} = \text{diag} \left\{ [X^{(k)'} X^{(k)}]_{k=1}^2 \right\} \quad (7.17)$$

where $\text{diag} \left\{ [X^{(k)'} X^{(k)}]_{k=1}^2 \right\}$ is a matrix with $X^{(1)'} X^{(1)}$ and $X^{(2)'} X^{(2)}$ on the diagonal. Using the newly introduced symbols, the likelihood function is proportional to:

$$L \propto \prod_{k=1}^2 |\det(A_0^{(k)})|^{T_k} \prod_{k=1}^2 \exp \left\{ -\frac{1}{2} [a_{0,j}' \tilde{\Delta}_0^{-1} a_{0,j} - 2d_j' \tilde{\Delta}_{+0} a_{0,j} + d_j' \tilde{\Delta}_+^{-1} d_j] \right\} \quad (7.18)$$

Equation (7.18) can be re-written in terms of free parameters b_j and g_j implicitly defined in equation (7.10):

$$L \propto \prod_{k=1}^2 |\det(A_0^{(k)})|^{T_k} \prod_{k=1}^2 \exp \left\{ -\frac{1}{2} [b_j' U_j' \tilde{\Delta}_0^{-1} U_j b_j - 2g_j' V_j' \tilde{\Delta}_{+0} U_j b_j + g_j' V_j' \tilde{\Delta}_+^{-1} V_j g_j] \right\} \quad (7.19)$$

Combining equation (7.19) with priors from equation (7.11) and (7.12), and completing the squares in g_j gives the following conditional posterior distribution for g_j and the marginal density kernel for b :

$$\pi(g_j | Y_T, b) = N(\tilde{g}_j, (V_j' \tilde{\Delta}_+^{-1} V_j + \overline{H}_{+j}^{-1})^{-1}) \quad (7.20)$$

$$\begin{aligned} & \pi(b | Y_t) \\ & \propto \prod_{k=1}^2 |\det(A_0^{(k)})|^{T_k} \prod_{k=1}^2 \exp \left\{ -\frac{1}{2} [b_j' (U_j' \tilde{\Delta}_0^{-1} U_j + \overline{H}_{0j}^{-1}) b_j - \right. \\ & \quad \left. b_j' (V_j' \tilde{\Delta}_{+0} U_j)' (V_j' \tilde{\Delta}_+^{-1} V_j + \overline{H}_{+j}^{-1})^{-1} (V_j' \tilde{\Delta}_{+0} U_j)] b_j \right\} \end{aligned} \quad (7.21)$$

where $\tilde{g}_j = (V_j' \tilde{\Delta}_+^{-1} V_j + \overline{H}_{+j}^{-1})^{-1} (V_j' \tilde{\Delta}_{+0} U_j) b_j$.

The posterior density of parameters of the model is estimated by Gibbs sampling, combining direct draws from distribution in equation (7.20) with Metropolis-Hastings step for drawing from distribution in equation (7.21). The results reported in the paper are based on 100.000 draws (with 10.000 initial draws discarded). To ensure that draws converge to a target distribution, several runs have been tried with random values of initial parameters. All runs converged to the same distribution. In addition, a numerical maximization of the marginal density in (7.21) gives the same values of bs as modes of bs obtained from the Gibbs algorithm. Other restrictions discussed in the text (slope of the monetary policy reaction function and non-explosiveness of the system) are imposed by eliminating draws violating the restrictions and replacing them with new draws, and by imposing the restrictions in the numerical maximization of (7.21).

5.9 Appendix: State-space model for GDP interpolation

A generic Gaussian state-space model consists of a transition and a measurement equation (Koopman *et al.* 1998):

$$\alpha_{t+1} = d_t + T_t \alpha_t + H_t \varepsilon_t, \quad \alpha_1 \sim N(a, P), \quad t = 1, \dots, n \quad (7.22)$$

$$y_t = c_t + Z_t \alpha_t + G_t \varepsilon_t, \quad \varepsilon_t \sim NID(0, I) \quad (7.23)$$

where $NID(\mu, \Psi)$ denotes an independent sequence of normally distributed random vectors with mean μ and variance matrix Ψ , and $N(\cdot, \cdot)$ is a normally distributed variable. The state equation (7.22) describes the behavior of unobservable stochastic processes contained in the $m \times 1$ state vector α_t . The measurement equation (7.23) links the state vector with a $n \times 1$ vector of observables y_t and the vector of disturbances ε_t .

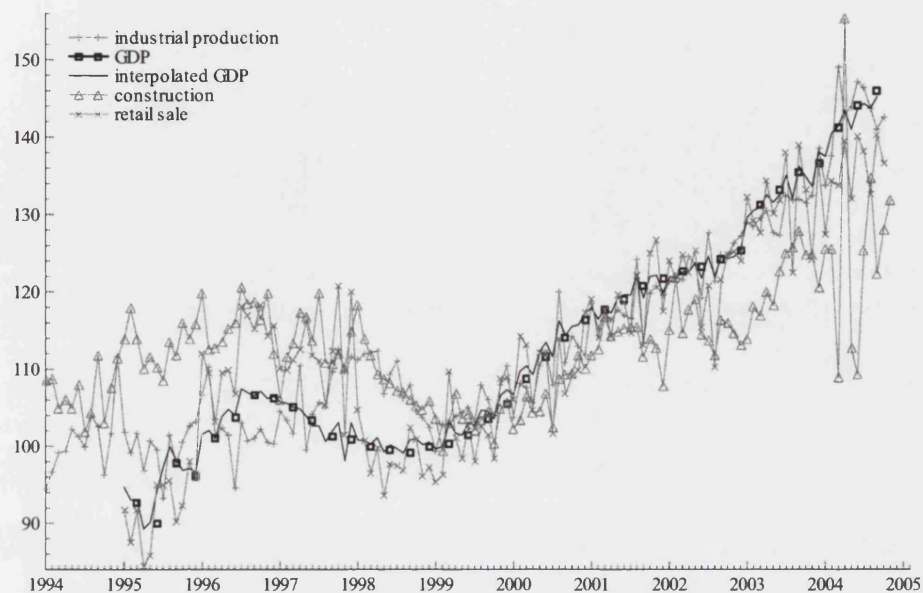
In the interpolation model for the Czech Republic, the unobservable monthly GDP (a state variable) is related to proxy variables observable at monthly frequency with coefficients t_1, t_2, t_3 (indices of industrial production, retail sale and construction activity), and an unobservable component, which is assumed to follow a random walk process with variance σ^2 . The unobservable monthly state variable is linked to the observable quarterly GDP via transition equation. Both the proxy variables and quarterly GDP series are seasonally adjusted. In terms of generic matrices above, the model takes the following form:

$$T_t = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ t_1 & t_2 & t_3 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix}, \quad Z_t = \begin{pmatrix} t_1 & t_2 & t_3 & 1 & 1 & 1 \end{pmatrix}, \quad \begin{pmatrix} H_t H_t' & H_t G_t' \\ G_t H_t' & G_t G_t' \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \sigma^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$P = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 10^6 & 0 & 0 \\ 0 & 0 & 0 & 0 & 10^6 & 0 \\ 0 & 0 & 0 & 0 & 0 & 10^6 \end{pmatrix}, \quad a = (x_0^1 \quad x_0^2 \quad x_0^3 \quad 0 \quad 0 \quad 0), \quad d_t = \begin{pmatrix} x_t^1 \\ x_t^2 \\ x_t^3 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \quad c_t = 0,$$

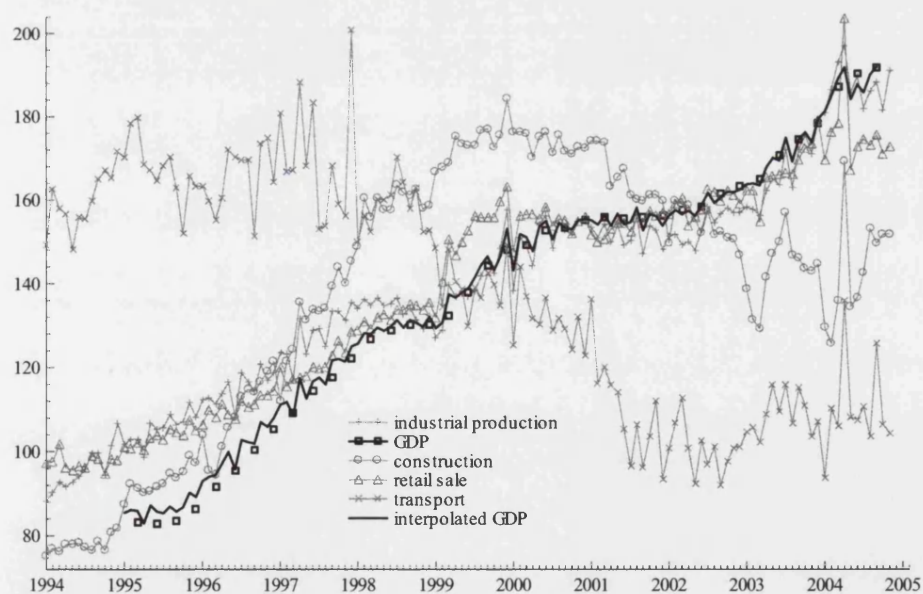
The model is estimated through the Kalman filter algorithm by maximum likelihood. Figure 5-8 plots proxy variables, quarterly GDP series, and interpolated monthly GDP series. The structure of the interpolation model for Poland is identical, with the set of proxy variables augmented by the volume of cargo transport. Figure 5-9 plots the series.

Figure 5-8 Czech Republic: Quarterly GDP, proxy monthly series, and interpolated GDP



Source: Czech Statistical Office and own calculations

Figure 5-9 Poland: Quarterly GDP, proxy monthly series, and interpolated GDP



Source: Polish Statistical Office and own calculations

6 CREDIBILITY OF INFLATION TARGETS IN POLAND

6.1 Introduction

Over the past decade, a number of countries adopted inflation targeting as a framework for conducting their monetary policy. The main features characterizing the new approach are 1) public announcement of medium-term numerical targets for inflation; 2) institutional commitment to price stability and to achievement of the inflation goal, combined with increased accountability of the central bank for attaining these objectives; 3) increased transparency of the monetary policy; 4) reduced role for intermediate targets (Mishkin, 1998). The first three of these elements aim at reducing uncertainty regarding monetary policy strategy, hence influencing inflationary expectations. The last element increases flexibility of central bank's operations in search for the most efficient way of controlling inflation. These two pillars of inflation targeting reinforce each other. Better monetary policy enhances credibility of the targets. The higher is the credibility, the easier it is for policymakers' to control inflation and to accommodate shocks without jeopardizing the price stability objective. The credibility factor is therefore critical for successful implementation of the framework.

The concept of credibility, which seems to be particularly relevant in the inflation targeting framework, is the marginal credibility, defined by Cukierman and Meltzer (1986) as policymakers' ability to influence public expectations by means of policy announcements.⁷⁸ This notion of credibility is especially important for countries in the process of inflation reduction: the costs of disinflation may be significantly reduced if authorities are able to successfully manipulate private sector's expectations.

This paper empirically investigates credibility of the targets, proposing an alternative way of estimating the credibility of policy announcements, closely resembling the Cukierman and Meltzer (1986) definition. The methodology is applied to the analysis of credibility of inflation targets in Poland, contributing to the discussion on merits of inflation targeting, particularly in the transition environment. Although inflation targeting in Poland attracted some attention, researchers focused mainly on feasibility and

⁷⁸More recently, the concept of marginal credibility has been investigated by Walsh (1999).

operational aspects of the new regime (Christoffersen *et al.*, 2001, Gottschalk and Moore, 2001), leaving aside credibility-related issues.

The proposed methodology collects three pieces of information: survey data on inflationary expectations, forecasts generated from past observations of inflation and other macroeconomic indicators, and central bank's inflation targets. The aim is to statistically assess the relative distance between the targets and survey-based expectations on the one hand, and between these expectations and data-based forecasts on the other. The closer are expectations to the targets relative to the data-based forecasts, the higher is the marginal credibility of the target (the public attaches greater weight to policy announcements than to past developments).

The two crucial elements in this methodology is a procedure to generate data-based forecasts and a testing procedure for assessing the effect of targets on expectations. The paper starts from summarizing inflation dynamics with an unconstrained VAR model, which is the data-based forecasting model. The central bank's target is regarded as an alternative model (a target model), which is used by the public for forecasting inflation. It is assumed that the public constructs their predictions of future inflation from a weighted average of forecasts from the data-based model and the target model. The estimated weight attached to the target model is interpreted as the marginal credibility of policymakers' announcements.

Intuitively, the paper attempts to identify to what extent inflationary expectations are driven by the targets, as opposed to past developments in the data. If parameters of central bank's loss function change over time in an unobservable way, and, as in Cukierman and Meltzer (1986), policy announcements partly reveal these changes, it is optimal for private agents to use both the past data and the announcements in forecasting inflation. Obviously, successful inflation targeting framework may modify dynamic interactions between macroeconomic variables and the data-based VAR model will adapt to these changes. In the limiting case of a credible strict inflation targeting with a constant low inflation target, the VAR forecast will eventually replicate the target, eliminating the difference between the data- and target- based forecasts. However, the adaptation of the VAR parameters will not be immediate, mimicking the learning process of economic agents after the switch to inflation targeting. In transition economies such as Poland, the learning process about the new policy regime may be lengthy due to protracted high

inflation history and there is a substantial uncertainty surrounding policymakers' commitment to the price stability objective.

The chapter starts from a discussion of the existing empirical literature on the credibility of policy announcements. Next section presents a descriptive analysis of monetary policy and inflation targeting in Poland, addressing the broader issue of inflation targeting in emerging market economies. Section 6.4 gives a more detailed description of the proposed methodology. Estimation results follow, and some technical details of the estimation strategy are relegated into the appendix.

6.2 Credibility of inflation targets in empirical literature

Empirical work on inflation targeting is already vast but the issue of credibility attracted relatively less attention than some operational problems related to the implementation of the new framework. The simplest approach to the empirical analysis of policy credibility compares inflation forecasts derived from financial instruments (Svensson, 1993) or from surveys of inflationary expectations (Johnson, 1998) to official targets. This approach, however, does not allow for the analysis of marginal credibility defined above, providing instead a measure of average credibility, defined by Cukierman and Meltzer (1986) as a difference between beliefs and targets.⁷⁹ In other words, the method does not distinguish between a growing trust in policy announcements, and a policy shift without any change in the *mechanism* generating private sector expectations. In the latter case, private sector's expectations may be in line with the government's target even if the public does not take into account the target in formulating their expectations, learning instead about the central bank's policy reaction function from past policy developments.

Bernanke *et al.* (1999) proposed and applied three related methods of analyzing the effects of targets on expectations. The first method is based on the comparison of sacrifice ratios before and after the adoption of inflation targeting. The lower sacrifice ratio is an indicator of economic benefits brought about by inflation targeting due to their effects on expectations. Bernanke *et al.* (1999) regressed the sacrifice ratio—estimated in

⁷⁹See Faust and Svensson (2001), (2002) for a more recent analysis of average credibility in an extension of the Cukierman and Meltzer (1986) model.

a sample of industrialized economies before the introduction of inflation targeting—on the initial level of inflation and the speed of disinflation. In the next step, they generated forecasts from this regression for the inflation targeting period. They found that the sacrifice ratio after the introduction of inflation targeting was not only higher than the average sacrifice ratios in previous disinflationary episodes, but also higher than the ratios forecasted from the regression. The results give strong evidence *against* the credibility bonus entertained by inflation targeters.

Since the comparison of sacrifice ratios does not take into account possible effects of supply shocks on inflation, Bernanke *et al.* (1999) estimated a Phillips-type inflation equation with lagged exchange rate and commodity prices as proxies for supply side factors. In the next step, they generated forecasts from the Phillips curve estimated on the sample before introduction of inflation targeting and compared these forecasts with the actual inflation rates in the inflation targeting period. With a notable exception of the United Kingdom, the comparison does not reveal any significant over-prediction of inflation by the model, confirming the results from the sacrifice ratio exercise: the credibility effects of inflation targeting do not seem to be present in the sample.

The last method applied in Bernanke *et al.* (1999) measures average credibility of the targets and is based on direct, survey-based observations of inflationary expectations. The comparison of inflation expectations with the announced targets reveals that expectations do not adjust momentarily to the targets: a learning process seems to be lengthy even for countries successful in meeting the inflation targets. The behaviour of expectations after the initial disinflation, however, seems to show that the targets are able to anchor the medium term expectations: after similar developments in inflationary expectations in Australia and New Zealand in the disinflation phase, expectations in Australia, which introduced inflation targeting later, were more prone to an upward drift than in New Zealand. The comparison of inflation targets with survey-based inflationary expectations and various tests for stability of the Phillips curve regression before and after introduction of inflation targeting have been applied in a number of other studies and usually led to similar conclusions.⁸⁰

⁸⁰See Hutchison and Walsh (1998) for opposite conclusions for New Zealand.

The methods applied by Bernanke *et al.* (1999) and widely followed in the literature have, however, several drawbacks. The comparison of sacrifice ratios does not take into account possible effects of supply shocks on inflation. Testing stability of the Phillips curve mixes up the effects of changes in the mechanism governing the formation of inflationary expectations with other possible changes in functioning of labour markets or non linearities in the model. Finally, the comparison of expectations with the target does not provide any insight into the marginal credibility of the target.

Kuttner and Posen (1999) propose another testing procedure for assessing the effects of targets on expectations. Noting that the introduction of inflation targeting tends to reduce inflation persistence, they test for a change in parameters governing inflation dynamics after implementation of the framework. There are, however, two regimes leading to a reduction in inflation persistence: the optimal state contingent rule⁸¹, which can be regarded as a successful implementation of inflation targeting based on trust in policy targets; and the regime attaching zero weight to output fluctuations in policymakers' loss function. Kuttner and Posen (1999) distinguished between the two regimes by identifying responses of long- and short-term interest rates to inflation shocks, interpreted as responses of expectations and policy instruments to supply shocks. Their results show a reduction in inflation persistence in the United Kingdom after the introduction of inflation targeting, combined with a milder response of the policy and expectations to macroeconomic shocks. Kuttner and Posen (1999) interpret this result as a shift towards a policy regime consistent with the optimal state contingent rule. Similar results are obtained for Canada, while the opposite conclusions are drawn for New Zealand, leading to a "chatty conservatism" interpretation of inflation targeting in this country, i.e. a regime where inflation targeting is only a dressing window for a more conservative stance in the monetary policy.

Another approach to the analysis of credibility in the inflation targeting framework is presented by Ruge-Murcia (2000), who estimated the inflation target zone model for Canada. Ruge-Murcia (2000) econometrically described inflation generating process, and derived forecasts consistent with this process and its implications for long

⁸¹The optimal state contingent rule is defined in King (1997) as a rule allowing the central bank to offset macroeconomic shocks but in the same time commit to hit its inflation target rate on average.

term interest rates under the rational expectations assumption. He used two forms of the inflation generating process: with fixed and stochastic bounds of the inflation target zone. The model with stochastic bounds indicates that the actual inflation target zone in Canada was significantly narrower than the official one. A potential drawback of this analysis, especially in applications to countries that adopted inflation targeting only recently, is that rational expectations assumption may be too strict at the initial stage of inflation targeting, when the learning process is not completed. More generally, the rational expectations framework does not allow for the analysis of credibility in the presence of asymmetric information between policymakers and the public.

The issue of marginal credibility of the targets has been taken up explicitly in earlier literature on credibility of policy announcements. For instance, Weber (1991) estimated the marginal credibility of policy announcements for the EMS. Expectations in his models are derived as a fitted value of a least-squares regression of the actual observable policy outcome on the announced targets and expected policy outcome conditional on past information. The main drawback of this analysis is that the estimated credibility (the coefficient of the announced targets) is constant over time. Another problem is a restrictive set of information used by the private sector in constructing their data-based forecasts (Weber (1991) uses univariate time series models). Nevertheless, the Weber (1991) approach is the closest to the methodology adopted in this paper.

6.3 Inflation targeting in Poland

6.3.1 Inflation targeting in emerging economies

Inflation targeting in emerging economies, defined as countries introducing market reforms and embarking a closer integration with the world economy, raises some specific issues. As reported above, there is some supporting evidence that inflation targets have been able to anchor medium term inflationary expectations in the developed economies. In the initial phase of inflation targeting the effects of announcements on expectations were, however, rather weak. Since these disinflation periods were either short or the targeting was introduced when the inflation rate reached a low, stationary value, the role of announcements in disinflation was not the main topic of research in the literature on inflation targeting in these countries. In many emerging economies macroeconomic stabilizations have been achieved only recently. The inflation rates remain in a moderate

range, making further disinflation more costly than the initial stabilization of the economy. In this context, the ability of targets to affect expectations and reduce the costs of disinflation is of a paramount importance. The attractiveness of inflation targeting also stems from relatively few other options for conducting monetary policy in a country increasingly integrated with the world financial markets. The influential proponents of polar exchange rate arrangements argue that only extreme forms of exchange rate fixing are sustainable, making the exchange rate anchor expensive in terms of policy responses to shocks. Floating exchange rate may be combined with money targets, but the speed of financial innovations and, in some cases, fresh memories of hyperinflationary episodes make the velocity of money hard to predict, rendering monetary targeting infeasible.

Given the potential benefits of inflation targeting for transition economies, it is not surprising that the history of targeting in this group of countries is as long as in the industrialized economies. Chile was the second country in the world adopting the framework, starting from the initial inflation rate of 29 percent in the last quarter of 1990 and reaching the rate of 3.8 percent in the first quarter of 1999. Israel adopted inflation targeting in 1992, with the initial inflation level of 18.9 percent in the last quarter of 1991, reduced to 1.9 percent in the last quarter of 1999. The credibility of targets attracted a considerable attention of researchers in these two countries. A description of Latin American experience with inflation targeting can be found in Corbo and Schmidt-Hebbel (2001), who studied the effects of targets on inflationary expectations in the case of Chile.⁸² They analyzed the credibility effect of the new regime by running counterfactual simulations from a small model of Chilean economy constructed in Corbo (1998), with an explicit modelling of inflationary expectations before and after the introduction of inflation targeting. The target is a significant factor in explaining the evolution of inflationary expectations after the introduction of the new framework. Simulations from the model with the inflationary expectation equation estimated before the regime change point to a substantial credibility bonus brought about by targeting. Inflation targeting in Israel is analyzed by Leiderman (1995), who assesses the effect of target announcements

⁸² Chilean experience with inflation targeting is also analysed in Landerretche *et al.* (2000) and Morande (2000). A discussion on inflation targeting in other emerging economies can be found in Mishkin (2000) and, in the broader framework of international experience with inflation targeting, in Mishkin and Schmidt-Hebbel (2001) and in Corbo *et al.* (2001)

on inflationary expectations by comparing expectations derived from financial instruments shortly before and after the announcement of a new target. The targets seem to affect inflationary expectations, although this effect is not tested statistically.

6.3.2 Disinflation and Inflation Targeting in Poland

Adopting a full-fledged inflation targeting regime in Poland was a gradual process, resembling the approach taken by other emerging economies, most notably Chile and Israel. The discussion on the implementation of the inflation targeting strategy in Poland starts from a brief description of monetary, exchange rate and fiscal policy developments since the initial stabilization program at the beginning of 1990.

The initial macroeconomic stabilization package, adopted simultaneously with price liberalization, was based on exchange rate peg, combined with fiscal and monetary tightening and some heterodox measures such as credit rationing and restrictive income policy. Stabilization stage was successful, but the inflationary impact of price liberalization was stronger and more persistent than expected. Moreover, the real economy sharply contracted, bringing a relaxation of the policy in 1991 and consequently a slowdown in the disinflationary process. More expansionary policy eroded competitiveness and undermined the exchange rate peg, leading to devaluation in May 1991 and a switch to crawling peg in October 1991. After two discretionary devaluations in February 1992 and August 1993 the rate of crawl was subsequently reduced in line with a disinflation strategy pursued by the National Bank of Poland (NBP).

Monetary expansion between 1992 and 1994 was fuelled by substantial fiscal deficits, financed mostly by the NBP and the banking system. While the National Bank of Poland enjoyed relatively high degree of statutory independence and the government borrowing from the NBP was formally restricted, the budget law regularly suspended the provisions of the central bank law, raising the borrowing limits. Despite the initially large monetary deficit financing and low real interest rates after 1993, some progress in reducing inflation was achieved due to later fiscal adjustments and a weak domestic demand.

The increasing net foreign reserves became the main source of monetary expansion since 1995, after the country gained favourable credit ratings from international agencies. Similarly to the strategy taken by Chile and Israel, a more flexible

exchange rate system was introduced as a response to the increased capital inflow. The exchange rate peg was replaced by the target zone system in May 1995. As anticipated, the zloty appreciated after the introduction of the new system, but capital inflow continued and the zloty was persistently close to the upper bound of the zone. The inflow slowed down after interest rate cuts at the end of 1995 and further appreciation in 1996 after the revaluation of the exchange rate band. The appreciation produced a strong anti-inflationary push. It not only affected the price setting behaviour of economic agents through competitive pressure, but also seemed to increase demand for real money balances. This increase was strong enough to absorb the monetary expansion created by growing international reserves (Durjasz and Kokoszczyński, 1998).

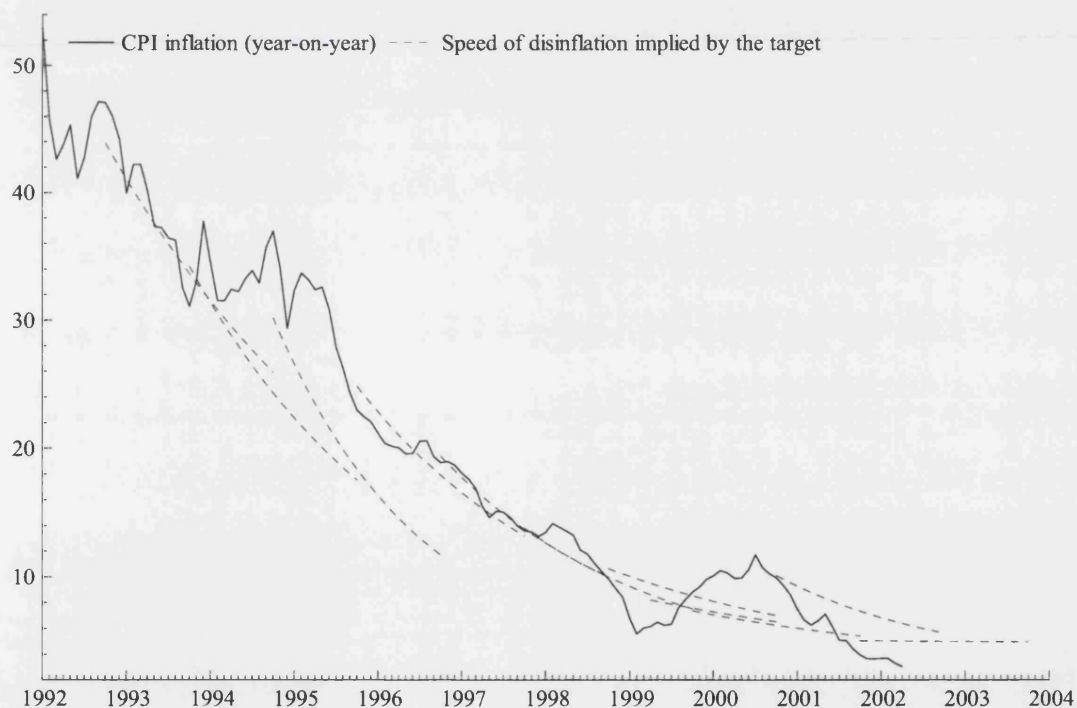
Greater exchange rate flexibility—combined with frequent policy changes and external shocks—increased the volatility of inflation. From mid-1996 foreign capital inflow abated, but low interest rates fuelled domestic credit expansion, calling for monetary tightening. The rates were increased several times since the end of 1996 and monetary policy was successful in exerting a downward pressure on inflation in 1997 and in 1998. The policy was loosened when inflation was reduced to one digit level and adverse external shocks (Russian and Asian crises) hit the economy. Central bank interest rates remained at a stable level for the first half of 1999 but higher inflation—overshooting the target for 1999—prompted monetary authorities to reverse the cuts starting from the second half of 1999. In 2000 interest rates were further increased but the inflation rate remained above the target for this year.

The process of disinflation was guided by inflation objectives specified in annual monetary policy guidelines, consistent with budgetary projections. These widely publicized forecasts can be regarded as early inflation targets. Indeed, this initial form of inflation targeting was remarkably close to the experience of Chile and Israel, where inflation targets co-existed with exchange rate pegs. First announcements of inflation targets in Israel were similarly regarded as forecasts consistent with the peg rather than official targets (Leiderman, 1995). Institutional changes in 1998 indicated a further progress towards the introduction of the inflation targeting strategy. The new law on the National Bank of Poland, adopted in January 1998, granted the NBP a high degree of independence guaranteed in the Constitutional Law, and established the Monetary Policy Council (MPC), a body responsible for conducting the NBP monetary policy. The newly

formed MPC officially adopted inflation targeting as a monetary policy strategy in 1999 and published the Medium Term Financial Strategy, where the medium-term inflation target was set below the 4 percent level at the end of 2003.

Figure 6-1 explains the evolution of the disinflation strategy. Reported on the graph is the speed of disinflation implied by the Dec-to-Dec inflation targets, calculated under two assumptions: 1) the targeted inflation follows a smooth path, approximated by an AR1 process; 2) the targeted inflation asymptotically approaches a level consistent with price stability, here assumed to be 3 percent. Given these two assumptions it is straightforward to calibrate parameters of the autoregressive process consistent with the Dec-to-Dec inflation targets.⁸³

Figure 6-1 Poland: Speed of disinflation implied by the Dec-to-Dec inflation targets and actual year-on-year CPI inflation.



Source: NBP and own calculations.

⁸³ In all the calculations we use information sets currently available to the agents. Targets were usually announced in September. Agents knew July inflation rates at the time of announcement.

A notable feature of the implied speed of disinflation is that in most cases annual targets extrapolated two years ahead is consistent with subsequent annual targets. In other words, for several consecutive years monetary authorities targeted a certain disinflation path and, if deviations from a given path had been encountered, there was an attempt to correct them in the following year. The first multi-period disinflation path runs from the end of 1992 to the end of 1995. Inflationary developments in 1993 seemed to be consistent with the targeted speed of disinflation: a blip at the end of 1993 could have been regarded as a temporary shock, justifying the choice of the target consistent with the same path for 1994. The increase in inflation proved to be long-lasting and the 1994 target was exceeded by 6 per cent. Despite the growing evidence of a permanent change in the dynamics of inflation, the target for the following year again assumed a return to the disinflation paths implied by the previous targets and therefore an accelerated disinflation in 1995. The target was again missed by 4 percent, leading to an apparent revision of the disinflation strategy in the following years. The 1996 target implied a flatter disinflation path, accommodating the change in inflation dynamics observed in the previous years. Subsequently, the inflation targets proved to be easier to achieve in 1996-1998. The annual inflation rate was close to the target in 1996 and virtually hit the targets in 1997 and 1998.

In 1999, the first full year after the official adoption of inflation targeting, the target was again consistent with the 1996-1998 disinflation path. The Dec-to-Dec inflation at the end of this year, however, exceeded the upper bound of the target by 2 percent. Similarly, the 2000 target, still consistent with the previous disinflation path, was exceeded by 2 percent. The two subsequent failures led to a revision of the disinflation strategy and the target announced for 2001 implied an upward shift of the disinflation path. Moreover, at the end of 1999 monetary policy was drastically tightened. The tightening, together with some external shocks, forced inflation back to the track consistent with the 1996-2000 targets.

6.4 Data and Methodology

In order to assess the effect of announcements on inflationary expectations, the paper collects three pieces of information: survey-based expectations, announced targets, and forecasts of future inflation generated from past data. The last piece is an empirical

counterpart of private agents' forecasts conditional on past information excluding policy targets. If survey-based inflationary expectations are relatively closer to the target than to the forecast, the target has a strong effect on expectations. Otherwise, the marginal credibility of the target is low.

The analysis uses a survey of professional forecasters conducted by Reuters as a measure of inflationary expectations.⁸⁴ The survey covers between fourteen and twenty financial institutions from Oct 1994 to Nov 2001. For each month the survey reports expected Dec-to-Dec inflation at the end of the current year. From Jan 1996, the survey also collects data on expected year-on-year inflation twelve-month ahead or, after Nov 2000, eleven-month ahead.⁸⁵

Central bank's targets are regarded as an alternative model, which can be potentially used by the public for forecasting inflation (a target model). Inflation targets before 1998 are Dec-to-Dec inflation projections published in the budget law. After the official adoption of inflation targeting in 1998, the Monetary Policy Council switched to a target zone. Since policymakers cannot control inflation perfectly, the predictive density from the target model is assumed to be non-degenerate even before the official introduction of the target zone. Instead, a normal distribution is assumed with mean equal to point projections before 1998 and to middle points of the target zone from 1998 onwards. Standard deviation of this distribution is assumed to be an average percentage deviation of boundaries of the band from middle points for the post-1997 period.

Lastly, projections based on past economic developments are generated from an unconstrained VAR (data-based model). The VAR forecast corresponds to the third piece of information discussed above: it does not include any information about the future stance of monetary policy other than inferred from the past. Since the analysis of

⁸⁴ Inflationary expectations of other groups in the society are not analysed. Results from qualitative surveys suggest that households' inflationary expectations are largely backward looking (Lyziak, 2003). Households' expectations may derive from news reports on the views of professional forecasts (Carroll, 2003), so the effect of the target on these expectations may be delayed and indirect.

⁸⁵ Since the CPI data are released with a lag, the twelve-month ahead forecast was effectively a thirteen-month ahead starting from the previous month. After November 2000 the respondents were inquired about the twelve-month ahead forecast starting from the previous month.

credibility requires predictive densities rather than point forecasts, the VAR is estimated using Bayesian methods as in Kadiyala and Karlsson (1997). The basic system has four variables: CPI, average monthly exchange rate of PLN to the basket of DM and USD (with equal weights), M2 and the index of industrial production. All variables except interest rate are in logs and the model is estimated on 12-month differences.⁸⁶ The basic specification imposes relatively tight Minnesota-type priors on parameters, found to reduce the average inflation forecast RMSE compared to a non-Bayesian VAR. In order to check for the robustness of results, priors are relaxed and money is replaced by manufacturing wage index in alternative specifications. In all models, the estimation sample changes, mimicking information set available to the private sector. Since the CPI data are released with a lag of two months, in any given month forecasts are generated from models estimated on a sample ending two months earlier. Since the first observation from the survey of inflationary expectations is Oct 1994, the first estimation period for the VAR runs from Jan 1992 to Aug 1994.

Since the authorities set only Dec-to-Dec targets and the paper uses monthly data (the available annual series are too short), the marginal credibility of the target in analysed at different forecast horizons. Given the two-month lag in data availability, the longest forecast horizon is thirteen months, when the public forecasts Dec-to-Dec inflation using data until November of the previous year. The shortest forecast horizon is two months, when the public predicts Dec-to-Dec inflation using data until October of the same year.

In addition, the paper analyzes the credibility of twelve-month ahead⁸⁷ implicit inflation targets, where the implicit disinflation path is defined as in section 6.3.2. The standard deviation of the distribution around the target is assumed to be the same as of end-of-year target. This approach allows for a more meaningful analysis of month-by-month changes in credibility.

Professional forecasters aggregate information from predictive densities generated by the data-based and the target model. The baseline analysis assumes that each forecaster

⁸⁶ Estimating the model on levels with seasonal dummies produces similar results.

⁸⁷ After Nov 2000 the paper analyzes the credibility of eleven-month ahead implicit targets to be consistent with changes in the Reuters survey (see footnote 85).

randomly and independently picks point forecasts from the two predictive densities. This assumption reflects uncertainty about agents' loss functions and true models, and implies that diffuseness of forecasters' predictive density is fully reflected in the degree of disagreement among forecasters. Zarnowitz and Lambros (1987) provide some evidence against it—professional forecasters may have loss functions penalizing certain ranges of predictive densities, reflecting either their strategic behaviour or loss functions of their customers—but report that the degree of disagreement is nevertheless positively correlated with uncertainty surrounding the forecasts.⁸⁸ An alternative specification for checking the robustness of results assumes that forecasters choose points in the predictive density region between the 15th and 85th percentile. Finally, it is assumed that each agent's point forecast of inflation is a weighted average of the point forecasts from the data-based model and the target-model. The weight attached to the target-model forecast is interpreted as a marginal credibility of the target and is a parameter to be estimated. The paper uses Bayesian numerical methods to estimate these parameters for each year. The posterior distribution of weights $\varphi(\omega | inf_{survey}^e)$ is proportional to:

$$\varphi(\omega_t | inf_t^{survey}) \propto \varphi(\omega_t) \prod_{i=1}^n f(inf_{it}^{survey} | \omega_t) = \kappa(\omega_t | inf_t^{survey}) \quad (8.1)$$

where ω_t is the weight attached to inflation target at time t , $\varphi(\omega_t)$ is a prior distribution of ω_t , and $f(inf_{it}^{survey} | \omega_t)$ is the posterior predictive density of inflation conditional on ω_t evaluated at forecaster i 's survey expectations inf_{it}^{survey} . Since it is assumed that survey expectations are drawn independently from the same posterior predictive density, the likelihood function of $inf_t^{survey} = (inf_{1t}^{survey}, \dots, inf_{nt}^{survey})'$ is a product of predictive densities evaluated at individual expectations $\prod_{i=1}^n f(inf_{it}^{survey} | \omega_t)$. The posterior density of ω_t is proportional to the product of the likelihood function and the prior density for the weights. The analytical expression for the posterior predictive density of inflation conditional on ω_t (denoted by $f(inf^e | \omega_t)$) is not known. Instead, the

⁸⁸ See Ottaviani and Sorensen (2001) and references cited there for the analysis of strategic behaviour in forecasting.

function $f(\text{inf}^e | \omega_t)$ is simulated by drawing from $\omega_t * f_{\text{target}}(\text{inf}^e) + (1 - \omega_t) * f_{\text{VAR}}(\text{inf}^e)$, where $f_{\text{target}}(\text{inf}^e)$ is the predictive density of inflation from the target model and $f_{\text{VAR}}(\text{inf}^e)$ is the predictive density of inflation from the VAR model, and the resulting density is evaluated at $\text{inf}_{it}^{\text{survey}}$. Finally, the mode of ω_t is estimated by searching for a maximum of the posterior density kernel $\kappa(\omega_t | \text{inf}_t^{\text{survey}})$, and the 5th and 95th percentile of the distribution for ω_t by deterministic integration (using trapezoidal rule) of the posterior density. A non-informative prior for ω_t is used, so that the posterior density kernel is equal to the likelihood function treated as a function of ω_t .

The weights ω_t are estimated using all available information in the survey data. In particular, the analysis is not restricted to some moments, but uses all available information from the distribution of survey expectations. Similarly, information from the predictive density of inflation is fully used.

6.5 Estimation of the Credibility of Inflation Targets

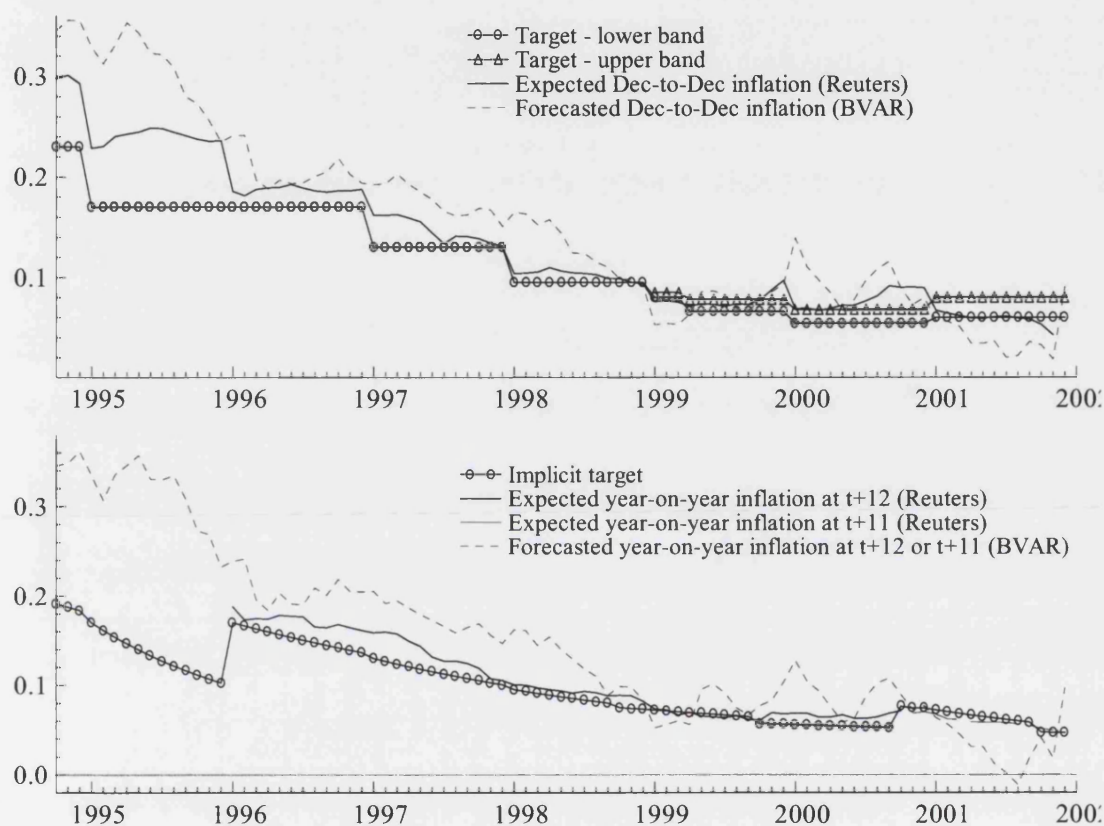
Figure 6-2 shows modes of survey-based inflationary expectations, modes of predictive densities of inflation, and inflation targets for both Dec-to-Dec and year-on-year inflation twelve and—after November 2000—eleven months ahead. Although, as pointed out in the previous section, the aim is to use all information available in the sample, the graphical analysis checks if there is an economically interpretable relationship among these series.

There seems to be some effect of the target on expectations at the initial stage of inflation targeting, reinforced by the fuller implementation of the strategy. The mode of the expected Dec-to-Dec inflation is far from the target in 1994 and 1995 (Figure 6-2, upper panel). In the first half of 1995 it seems, however, that the relative distance to the target is shorter than to the VAR forecasts, pointing to the marginal credibility effect even at the early stage of inflation targeting. Although the target in 1995 was not fully believed, it could have had some influence on expectations given the large uncertainty surrounding data-based forecasts at the beginning of the sample. The distance between the target and expectations diminishes in 1996. As discussed in section 6.3.2, there seemed to be a change in the disinflation strategy in 1996 and the target for this year

could have been regarded as more plausible by the private sector. Although the realization of the Dec-to-Dec inflation in 1996 was closer to the target than in previous years, expectations in 1997 were more in line with the data-based forecast than with the target. The 1997 target was missed only marginally, which could have had a positive effect on the credibility of the 1998 target. However, it is not apparent from the graph to what extent expectations were affected by the target. In 1999, the first full year after the official introduction of inflation targeting, the effect of the target on expectations seems to be strong: despite sudden changes in the inflation dynamics, the mode of survey expectations was fixed at the middle point of the target for most of the year. However, after a large deviation from the target at the end of the year, expectations for 2000 followed the data-based forecasts. In 2001 inflationary expectations were close to the target at the beginning of the year, despite a large deviation from the target in 2000. The target for 2001 was probably regarded as relatively easy to achieve: the disinflation path implied by the target accommodated an apparent change in inflation dynamics in 2000. Survey-based expectations diverged from the target later in 2001.

The relationship among the targets, expectations and forecasts over the approximately year-ahead horizon is less clear, but seems to follow a similar pattern to the relationship to the Dec-to-Dec series (Figure 6-2, lower panel). The effect of the target seems to be weak at the beginning of the sample, stronger after the change in disinflation strategy in 1996 and further enhanced by the official inflation targeting in 1999. However, differences between forecasting horizons are evident at the end of the sample, when the year-ahead expectations are closer to the targets than their Dec-to-Dec counterparts.

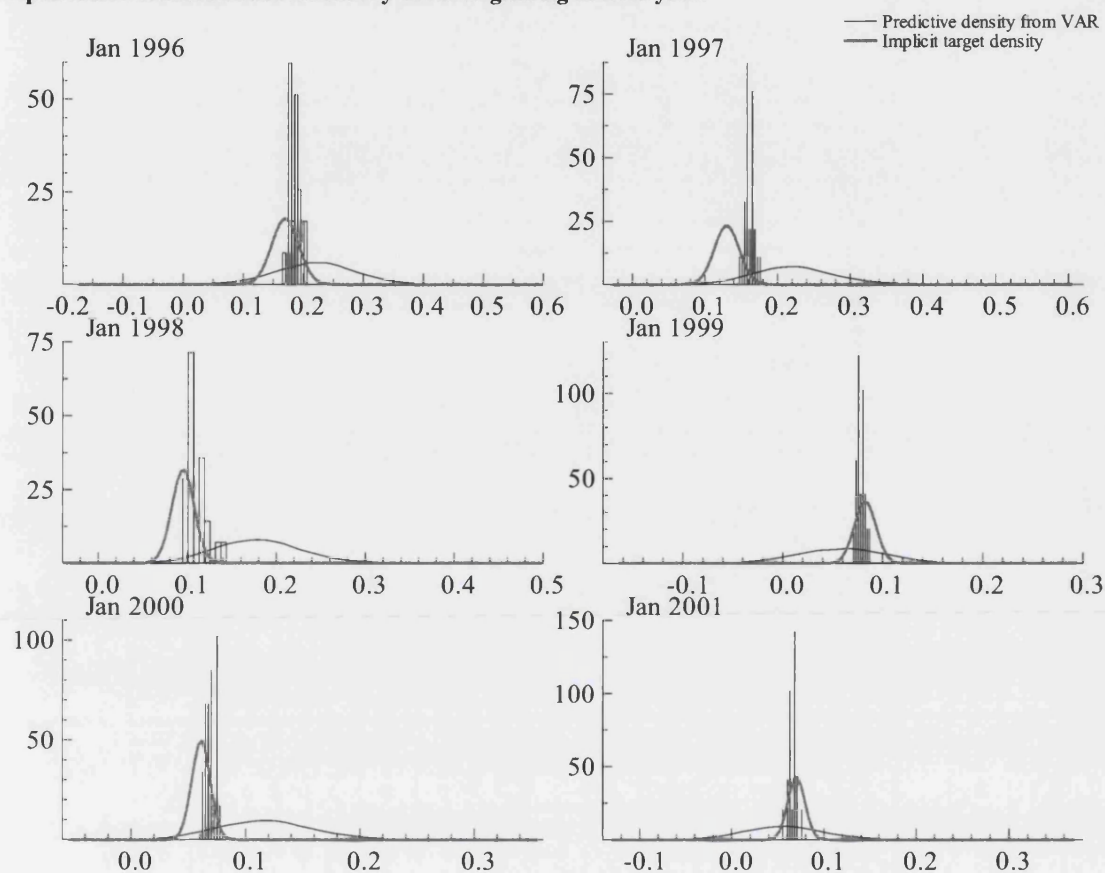
Figure 6-2 Poland: Expected Dec-to-Dec inflation from the Reuters survey, forecasted Dec-to-Dec inflation from the BVAR model, and inflation targets (upper panel), and expected year-on-year inflation one-year ahead from the Reuters survey, forecasted year-on-year inflation one-year ahead from the BVAR model and implicit targets (lower panel).



Source: NBP, Reuters and own calculations.

The analysis of distributions of the survey data, inflation forecasts and targets starts from a graphical inspection for selected months. Figure 6-3 shows the predictive densities of Dec-to-Dec inflation at the beginning of each year starting from 1996, implicit densities around inflation targets and histograms of inflationary expectations from the Reuters survey.

Figure 6-3 Poland: Predictive densities of Dec-to-Dec inflation from the BVAR model, implicit distributions around Dec-to-Dec inflation targets, and histogram of Dec-to-Dec inflationary expectations from the Reuters survey at the beginning of each year.



Source: NBP, Reuters and own calculations.

Before 1999, Dec-to-Dec inflationary expectations at the beginning of the year are located between the modes of the predictive densities from the data-model and the target-model. Peaks of the 1996 and 1998 histograms are situated close to the target predictive density; although in both cases the histograms are skewed to the left, pointing to a weaker effect of the target on some forecasters. 1997 expectations are equally far from the target and the BVAR forecast.

The distribution of inflationary expectations after the official introduction of inflation targeting is more concentrated and relatively closer to the targets. In January 1999 and in January 2001 there is a slight tendency for expectations to centre below the middle point of the target zone. Expectations are slightly above the target in Jan 2000.

Figure 6-4 Poland: Estimates of weights attached to targets in inflationary expectations from the Reuters survey.

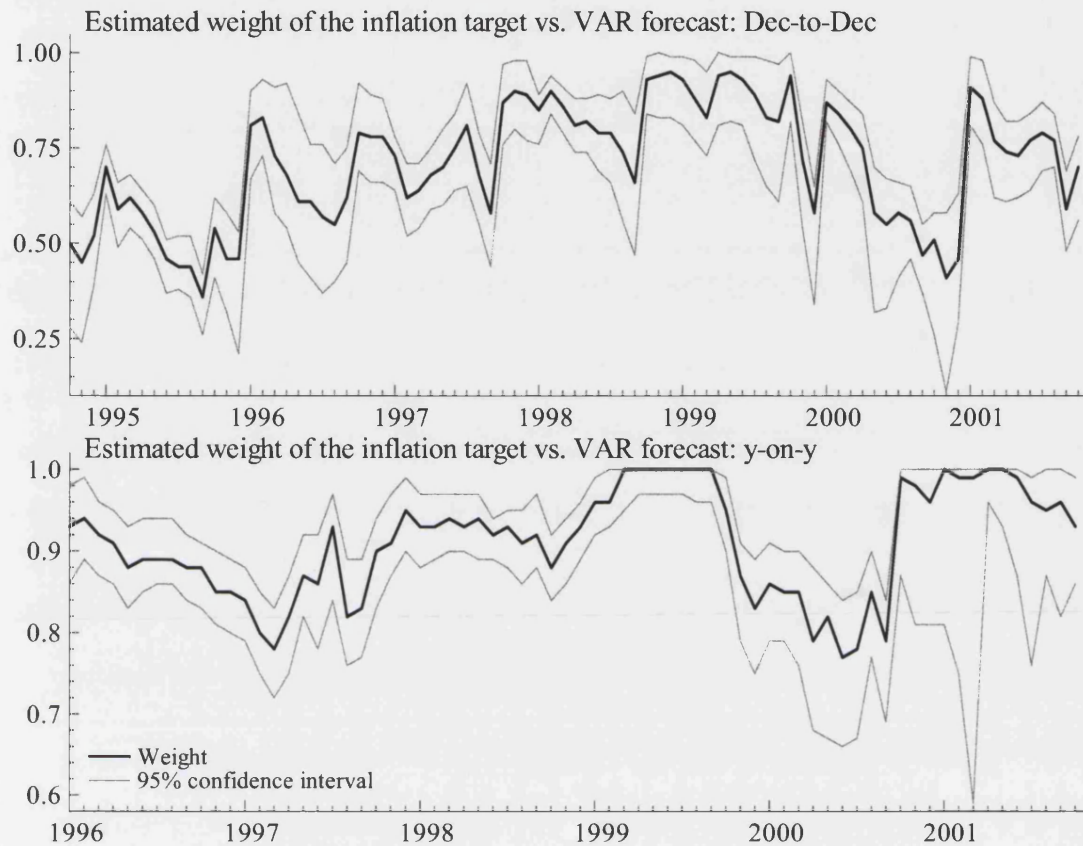


Figure 6-4 reports estimates of weights attached to targets in expectations estimated using the Bayesian method described above.

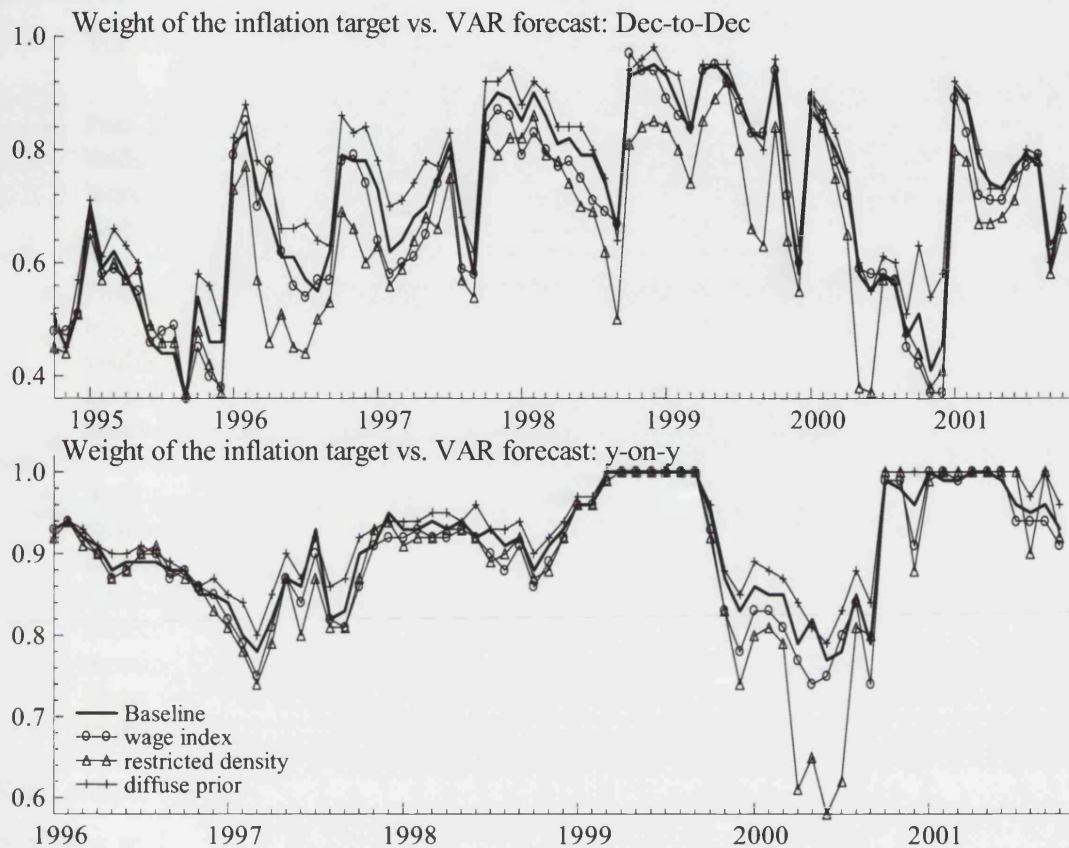
The econometric analysis confirms that the target credibility increased around the time of the introduction of inflation targeting in 1999. The interpretation of weights attached to Dec-to-Dec targets is difficult due to the time-varying forecast horizon—the effect of the target tends to fall towards the end of year, when inflation is clearly outside the control of monetary authorities. Taking into account this seasonal pattern, the credibility of the target seems to be relatively low at the beginning of 1995. There is a visible influence of the target on expectations for 1996, temporarily reversed at the beginning of 1997, when the weight attached to the data-based forecast is relatively higher. Credibility of the 1998 target was again high after monetary authorities had reached the 1997 target. The official introduction of inflation targeting in 1998, combined with hitting the target in this year, resulted in the record-high credibility of the 1999

target. Interestingly, the weight attached to the target was high until nearly the end of this year. A large deviation from the target in 1999 hindered credibility, increasing the weight attached to the data-based forecasts at the beginning of 2000. In 2001 the weight attached to the target was again high at the beginning of the year, reflecting a less ambitious character of the target for this year.

The relationship among the targets, expectations and forecasts over the one-year ahead horizon is more pronounced than suggested by the graphical analysis above, and the pattern of estimated weights is similar to the Dec-to-Dec series. The main difference is that average weight attached to inflation targets is higher, indicating a high credibility of the central bank's disinflation strategy, even when the short-term targets are likely to be missed. A difference in dynamics appears at the end of the sample, after the official introduction of inflation targeting. Dec-to-Dec inflationary expectations clearly diverge from the target when it becomes evident that it will be missed at the end of 2001. One-year ahead expectations are still close to the implicit disinflation path in this period. Therefore, the official inflation targeting and the public announcement of the medium-term disinflation path seem to have a moderating effect on expectations.

In order to check the sensitivity of results to different specifications of the model used for generating predictive densities, the estimation is repeated with predictive densities from the baseline specification restricted to a region between the 15th and 85th percentile; predictive densities from the BVAR model with very weak priors; and predictive densities from the model with money replaced by manufacturing wage index. Figure 6-5 shows results from the alternative specifications, together with the baseline series. The results are similar, the only significant difference being a much lower credibility of the implicit disinflation path in 2001 when using the model with restricted predictive density.

Figure 6-5 Sensitivity analysis for estimates of weights attached to targets in inflationary expectations from the Reuters survey.



6.6 Conclusions

The paper analyses the credibility of inflation targets in Poland, contributing to the literature on inflation targeting in emerging economies and, in particular, in the process of disinflation. The concept of credibility used in this paper is borrowed from Cukierman and Meltzer (1986), who emphasize a potential influence of the target on expectations. The marginal credibility is of a paramount importance in the process of disinflation, when credible targets can greatly reduce the costs of reducing inflation.

The proposed methodology combines survey data on inflationary expectations, predictive densities of inflation generated from a BVAR model, and implicit distributions around inflation targets. Intuitively, if the survey-based expectations are relatively closer to the target than to the data-based forecast, the marginal credibility of the target is high. The Bayesian approach to estimate weights attached to targets and data-based forecasts

make an efficient use of available information and it provides an intuitive, time-varying measure of the credibility of the target

The evolution of estimated weights seems to depend on:

- Past deviations from the target. Achieving targets in the past boosts reputation and leads private agents to revise their mechanism of forming expectation by increasing the weight attached to the target. In case of Poland, a negative effect of past deviations can be observable in 2000 and, to a lesser extent, in 1997.
- Plausibility of the targeted disinflation path. Overly ambitious targets are not believed by the public, reducing the weight attached to the target. This effect is visible after changes in the disinflation path implied by the 1996 target and initially in 2001, when the less ambitious target seemed to increase the weight attached to the target.
- Institutional reforms. In 1998 the National Bank of Poland officially adopted inflation targeting as a monetary policy framework. The influence of the target on expectations seems to be particularly strong in 1999, the first full year of official inflation targeting. There is also a visible change in the influence of the target on expectations at one-year horizon: in 2001 one-year ahead inflationary expectations remained close to the implicit target despite growing evidence that the Dec-to-Dec target would be missed. The market participants seemed to trust the NBP medium-term disinflation policy.

Short sample makes testing for the significance of each of these factors difficult, and also precludes analysis of some interesting issues related to credibility, such as a relationship between the marginal credibility and the costs of disinflation policy discussed above.

The main policy conclusion is that the targets had an effect on professional forecasters' expectations. The first two observations regarding the evolution of the weights are also important for policy-makers: there is a visible credibility effect after deviations from the targets and, perhaps less obvious, the plausibility of the target seems to have an effect on the marginal credibility. Although the paper does not provide firm arguments for the moderating effect of the official targeting regime on expectations, there is some evidence in the data pointing to this effect.

Although high credibility of the targets can reduce the costs of disinflation, there are also some potential dangers of the high marginal credibility for policy-making. Official press releases of the Monetary Policy Council put a lot of attention to the evolution of professional forecasters' inflationary expectations, suggesting that policy-makers' decisions are to some extent influenced by this piece of information. This is no different from the practice of advanced inflation targeters, such as United Kingdom and

New Zealand, where professional forecasters' inflationary expectations take an important place in inflation reports. But results on forecast-based policies reported by Bernanke and Woodford (1997) are important in this context. If monetary policy relies solely on inflationary expectations of outsiders, and if these expectations are in turn based only on announced inflation targets, the model investigated by Bernanke and Woodford (1997) exhibits indeterminacy, potentially leading to undesirable economic equilibria. In this context, Bernanke and Woodford (1997) stress the importance of structural models in monetary policy making. Structural econometric modelling is difficult in the transition environment, making the use of survey-based expectations more tempting for the central bank. It is, however, indispensable in a serious implementation of the inflation targeting regime and the analysis of survey expectations can only be a building block in constructing such a model.

6.7 Appendix: Bayesian VAR Model

Following description in Kadiyala and Karlsson (1997), the VAR system has the following form:

$$y_t = \sum_{i=1}^p y_{t-i} A_i + x_t C + u_t \quad (8.2)$$

where y_t is $1 \times m$ vector of endogenous variables and x_t is $1 \times q$ vector of exogenous variables at time t . A_i and C are respectively $m \times m$ and $q \times m$ parameter matrices.

Equation (8.2) can be written as:

$$y_t = z_t \Gamma + u_t \quad (8.3)$$

where $z_t = \{x_t, y_{t-1}, \dots, y_{t-p}\}$ and Γ is $k(= q - pm) \times m$ matrix given by $\{C', A_1', \dots, A_p'\}'$. Stacking the vectors y_t, z_t and u_t for $t = 1, \dots, T$ into Y, Z and U gives the multivariate regression model:

$$Y = Z\Gamma + U \quad (8.4)$$

Letting the subscript i denote the i th column vector, the equation for variable i is $y_i = Z\gamma_i + u_i$. Stacking the columns of Y, Γ and U into y, γ, u , the system can be written as:

$$y = (I \otimes Z)\gamma + u \quad (8.5)$$

Assuming that $u \sim N(0, \Psi \otimes I)$, the likelihood is proportional to:

$$\begin{aligned} L(\gamma, \Psi) &\propto |\Psi|^{-T/2} \exp\{-\text{tr}[(Y - Z\Gamma)' \Psi^{-1} (Y - Z\Gamma)]/2\} \\ &\propto N(\gamma | \hat{\gamma}, \Psi \otimes (Z'Z)^{-1}) \times iW(\Psi | (y - Z\hat{\Gamma})'(y - Z\hat{\Gamma}), T - k - m - 1) \end{aligned} \quad (8.6)$$

where $\hat{\Gamma}, \hat{\gamma}$ are OLS estimates of Γ, γ and iW denotes inverse Wishart density.

Assuming conjugate (Normal-Wishart) priors:

$$\gamma | \Psi \sim N(\tilde{\gamma}, \Psi \otimes \tilde{\Omega}), \Psi \sim iW(\tilde{\Psi}, \alpha) \quad (8.7)$$

the posterior distribution is given by:

$$\gamma | \Psi, y \sim N(\bar{\gamma}, \Psi \otimes \bar{\Omega}), \Psi | y \sim iW(\bar{\Psi}, T + \alpha) \quad (8.8)$$

where $\bar{\Omega} = (\tilde{\Omega}^{-1} + Z'Z)^{-1}$, $\bar{\Gamma} = \bar{\Omega}(\tilde{\Omega}^{-1}\tilde{\Gamma} + Z'Z\hat{\Gamma})$ and $\bar{\Psi} = \hat{\Gamma}'Z'Z\hat{\Gamma} + \tilde{\Gamma}'\tilde{\Omega}^{-1}\tilde{\Gamma} + \tilde{\Psi} + (Y - Z\hat{\Gamma})'(Y - Z\hat{\Gamma}) - \bar{\Gamma}'(\tilde{\Omega}^{-1} + Z'Z)\bar{\Gamma}$.

In the paper, prior means for parameters in Γ make each endogenous variable an AR1 process with autoregressive parameter α :

$$y_{it} = \alpha y_{i,t-1} + u_{it} \quad (8.9)$$

Other parameters of the Normal-Wishart prior are set so that elements of $\tilde{\Psi} \otimes \tilde{\Omega}$ coincide with elements of the variance-covariance matrix specified for parameters in equation i as:

$$\text{Var}(\gamma_i) = \begin{cases} \frac{\pi_1 \sigma_i^2}{k \sigma_j^2} & \text{for parameters on lags of variable } j \\ \pi_2 \sigma_i^2 & \text{for parameters on exogenous variables} \end{cases} \quad (8.10)$$

where k is the lag length and σ_i is a scale factor accounting for different variability in endogenous variables, set to the residual standard error from p -lag univariate autoregression for variable i .

Priors for the baseline forecasting model used in the paper are $\pi_1 = 0.1, \pi_2 = 10e5$ and $\alpha = .99$, resembling Minnesota priors, but assuming stationary

and persistent processes for all the series. Alternative specifications make this prior close to diffuse by setting $\pi_1 = 10e5$.

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