

Dibooglu, Selahattin; Kutan, Ali M.

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## Sources of inflation and output fluctuations in Poland and Hungary: Implications for full membership in the European Union

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Zentrum für Europäische Integrationsforschung  
Center for European Integration Studies  
Rheinische Friedrich-Wilhelms-Universität Bonn



Selahattin Dibooglu and Ali M. Kutan

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**Sources of Inflation and Output Fluctuations in Poland and Hungary:**

**Implications for Full Membership in the European Union**

by

**Selahattin Dibooglu\* and Ali M. Kutan\*\***

\* Corresponding author. Department of Economics, University of Illinois at Urbana-Champaign, and Southern Illinois University. Mailing address: Department of Economics, Southern Illinois University at Carbondale, Carbondale, IL 62901-4515, USA. Phone: 618 453 5075; Fax: 618 453 2717; e-mail: dibo@siu.edu

\*\* Department of Economics and Finance, Southern Illinois University at Edwardsville, Edwardsville, IL 62026-1102, USA, and Center for European Integration Studies (ZEI), University of Bonn, Germany.

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## **ABSTRACT**

This paper examines the sources of fluctuations in inflation and output in two leading transition-economy candidates for admission to the European Union (EU), Poland and Hungary. Using a rational expectations, dynamic open economy aggregate supply- aggregate demand model, we consider real oil price, supply, balance of payments, demand, and monetary disturbances incorporating important features of transition economies such as balance of payments disturbances and finite capital mobility. Evidence indicates that supply shocks explain a sizable portion of price level movements in Hungary while demand shocks are dominant in price level movements in Poland. Monetary shocks are an important source of output fluctuations in the short run in Hungary suggesting nominal inertia. In Poland, real demand shocks affect output in the short run (up to one year), while monetary shocks are negligible. Estimates of “core inflation” based on historical realizations of the shocks suggest that a major component of inflation has been demand driven, “core” inflation. Finally, policy implications of these findings regarding EU membership are evaluated.

**JEL Classification Codes:** E3, P2, O5, C5

**Keywords:** Business Cycles, Inflation, Transition Economies, Time Series Models

## 1. Introduction

A significant economic and political challenge facing the transition economies of central and eastern Europe is to join the European Monetary System (EMS) and thus achieve full membership in the European Union (EU). The successful accession to membership in the EU by the current transition-economy applicants, the Czech Republic, Hungary, the Slovak Republic, Slovenia and Poland, will depend to a large extent on their ability to align themselves with the macroeconomic policies of the EU. Thus, an important task for the policymakers in the accession countries is to lower the inflation rate and, at the same time, to raise output per capita to a level approaching EU average. Although all transition economies have made a substantial progress in lowering inflation over time, their current inflation levels can be best described as “moderate”, ranging between 10 to 20 percent, still well above the average EU level. On the other hand, the output growth rate in the candidate countries has been somewhat faster than that of the EU, but these economies need to exceed the average EU growth level by a large amount for a sustained period of time if their living standards are to approach EU standards.

The purpose of this paper is to investigate the sources of movements in inflation and output in two leading transition- economy candidate countries, Hungary and Poland.<sup>1</sup> Understanding the forces underlying inflation and output growth can help policymakers become better prepared for full membership in the EU and also allow them to design credible policies before they establish any formal link to the Euro. Among the performance measures that most observers would view as important markers of credibility for joining the EMS are inflation and output growth. In addition, some transition economies, such as the Czech Republic and Poland have been pursuing a policy of inflation targeting to better control and reduce inflation. Therefore,

an empirical analysis of inflation rate movements is useful for monetary authorities in these countries, and their experience may provide important lessons for other transition economies.

Price stability has been an important policy goal for all transition policymakers since the beginning of transition efforts in early 1990s. Inflation is often blamed for major distortions in the economy, lack of foreign direct investment, appreciation of the real exchange rate, and worsening of the income distribution. Hence, it is particularly important to better understand the extent to which inflation is a demand driven, core inflation phenomenon. In this paper, we also construct a measure of core inflation for Poland and Hungary. If a substantial portion of total inflation is demand driven or core inflation, then there is room for policies aimed at limiting discretionary demand to bring down inflation and stabilize the economy. Looking forward, our results suggest that a major component of inflation in the two countries has been demand driven.

Brada (1998) and Desai (1997, 1998) argue that different initial conditions and different starting times of stabilization programs result in different paths for macroeconomic variables, such as output, prices, and real exchange rates. Different approaches to monetary policy may also lead to different behavior in these variables. Hungary began implementing stabilization programs much earlier than Poland and these two countries have also adapted different monetary policy stance and had different initial conditions. Dibooglu and Kutan (2001) provide empirical evidence that real exchange movements in Poland and Hungary during 1990-99 were affected by different factors. In this paper, we also test the validity of arguments made by Brada (1998) and Desai (1997, 1998) about the behavior of prices and output by providing evidence from Poland and Hungary.

The rest of the paper is organized as follows. In the next section, we provide an overview

of macroeconomic policy in Hungary and Poland. Section 3 describes our methodology. In section 4, we describe data employed and present our empirical results. Section 5 discusses policy implications of our findings and concludes.

## **2. An Overview of Macroeconomic Policy in Hungary and Poland**

### **2.1. Hungary**

Initially, at the beginning of the 1990's, Hungary followed a gradualist macroeconomic policy as the authorities sought to balance the desire for reducing inflation with the need to control the government deficit and to service a large external debt. Too large a reduction in inflation would have reduced government revenues and increased expenditures on the social safety net, thus increasing the government's need to borrow abroad. The official exchange rate was tied to a currency basket consisting of 50 percent U.S. dollar and 50 percent German mark weights until May 1994, when the weights for the reference basket changed to 70 percent ECU and 30 percent U.S. dollar. Monetary policy included active exchange rate management based on a currency peg with a narrow band of permitted fluctuations (Kutan and Brada, 2000).

The initial exchange rate policy, which aimed at a real appreciation of the forint to help combat domestic inflation, was found to be too costly because of the declining competitiveness of Hungarian exports and sluggish growth. Moreover, it failed to provide a nominal exchange rate anchor to reduce inflationary expectations. These costs began to appear in 1993, when the current account deficit reached 9% of GDP and then increased to 9.4 % the following year. At the same time, the government's budget deficit remained unacceptably high (Table 1). The fact that the foreign debt was also growing steadily put Hungary at risk of insolvency. This macroeconomic situation was certainly not sustainable.

During the 1990 to 1994 period, a loose fiscal policy led to growing budget deficits and a high level of foreign debt. Financing this deficit required monetary expansion as well as high interest rates so that commercial banks would find government securities attractive, thus fueling the inflation that the strong forint policy had sought to reduce. The disinflation policy combined with a fixed exchange rate resulted in continuous real appreciation, causing a loss of competitiveness and high current account deficits. The persistence of these twin deficits (Table 1) created uncertainty among Hungary's foreign creditors as well as concerns about the stability of the forint.

The two conflicting priorities of the government, control of inflation and improving international competitiveness, led to speculation against the forint, which undermined the credibility of the exchange rate regime. Liberalization of foreign exchange operations and the continuous real appreciation of the forint, resulting in significant capital inflows, gradually narrowed the ability of the monetary authorities to control the money supply. Moreover, during this period, there was no coordination between monetary and fiscal policy (Nemenyi, 1997).

The 1994 Mexican crisis further worsened Hungary's ability to borrow in international markets as the risk premium increased for emerging markets. The government realized that it could not sustain the dual objectives of controlling inflation and improving international competitiveness at the same time and, as a result, announced a major fiscal adjustment program in March 1995 [Szapary and Jakab (1998)]. Fiscal policy was tightened to reduce the twin deficits through lower government expenditures, higher import tariffs, and reduced government borrowing. Price stability was declared the key goal of monetary policy in the long run.

The March 1995 measures included a major change in the nominal exchange rate regime



that was intended to create credibility for economic policy and reduce the uncertainty associated with future policy measures so as to restore investors' confidence in the system (Nemenyi, 1997). Following a 9 percent devaluation of the official exchange rate, a preannounced crawling band exchange rate system was introduced in March 1995. The band of permitted fluctuations was set at 2.25 percent on either side of the parity, and thus has been maintained until recently. The rate of crawl was set according to an inflation target. The initial monthly rate was 1.9 percent and it was gradually reduced to 0.3 percent in April 2000. The official currency basket was changed to 70 percent DM and 30 percent U.S. dollar in January 1997 and the DM was replaced by the euro in January 1998. In January 2000, the exchange rate was completely tied to the euro. Table 2 provides a summary of the exchange rate measures in Hungary during the 1990-2000 period.

In sum, the post-1995 exchange rate regime in Hungary focused on the stability of the nominal exchange rate as a tool of disinflation and on preventing significant real appreciation of the forint in order to sustain the current account balance and to control capital inflows (Orlowski, 2000). In addition, Hungary experienced some shock therapy, e.g. the bankruptcy legislation introduced in the early 1990s. It received a significant amount of foreign direct investment. As a result, supply shocks should play a key role in output and price movements. The 1995 Bokros package also contained elements of shock therapy, including drastic cuts in budget spending, devaluation of the forint, change to a crawling peg and the introduction of import surcharges. Thus, we also expect that aggregate demand shocks in a broader sense to affect inflation and output growth during our sample period.

## **2.2. Poland**

The stabilization of the Polish economy began under much less favorable conditions than those found in Hungary. In 1989, inflation peaked at 54.8% per month, the government deficit was nearly 8% of GDP and both loss-making Polish firms and the government deficit were financed by rapid expansion of money and credit. Although the government began to deal with the crisis in late 1989, the major stabilization program began on January 1, 1990 with the Balcerowicz Plan. The zloty (zl) was devalued from 5,560 zl/US\$ to 9,500 zl/US\$ and pegged at the latter rate. Monetary and fiscal policies were tightened, enabling the government to achieve a surplus equivalent to 2.8 % of GDP in 1990 (Table 3) and credit creation was sharply curtailed (Brada and Kutan, 1999). The consequences of stabilization and liberalization were sufficiently virulent, both in the upsurge in prices and in the decline in production, to lead to an easing of macroeconomic policy late in 1990. However, the effects of this policy change were felt more in an acceleration of inflation than in real output growth (Wellisz, 1997) and the government soon abandoned this effort. As the recession deepened in 1991, the fiscal deficit reappeared and high inflation reduced the competitiveness of Polish exports. The zloty was devalued by 17 % in May 1991, and its peg was shifted to a basket of currencies.

Policy priorities gradually shifted from stabilization to stimulating growth (Krzak, 1996). Although the fiscal deficit was cut from 4.9 % of GDP in 1992 to 2.7 % in 1993 (Table 3), a level around which it has fluctuated since, monetary policy was relatively expansionary. While real interest rates remained positive, money supply and credit growth consistently outpaced the targets set by the National Bank of Poland (NBP). The zloty's peg was abandoned in October of 1991, replaced by a crawling peg in the same month with a preannounced devaluation of 1.8% per month against a basket of currencies (Nutti, 2000). Over time, the rate of depreciation has been

reduced and there have also been one-off devaluations and revaluations to accommodate exogenous shocks. In 1995, the band within which the zloty could fluctuate was widened to  $\pm 7\%$ . Poland's exchange rate policy was sufficiently credible to foreign investors that short-term capital inflows began to be a problem for the NBP by 1995 when, even with some NBP sterilization, capital inflows accounted for 59% of the growth of the money supply (Krzak, 1996). As a result, controlling the money supply became more difficult for the monetary authorities. We thus expect that balance of payments and monetary shocks have played a significant role in inflation and output movements during our sample period. Table 4 provides a summary of exchange rate policy regimes in Poland during 1990-1999.

Although Poland has had a higher rate of inflation than Hungary over the decade of the 1990s, it has also had a faster rate of growth of real GDP (Table 3). Relatively higher growth in Poland may be due as much to an earlier start in implementing economic reforms as to better economic policy. Analogously, Poland's higher rate of inflation may reflect its more severe initial macroeconomic disequilibrium rather than an inability to restrain the growth of the money supply. Recently, output growth has slowed somewhat due to a fall in exports to Russia and the Ukraine caused by the financial crises in those countries. As inflation has slackened and as the nominal anchor of the crawling peg has decreased in importance with a further widening of the bands, Poland has adopted inflation targeting (Brada and Kutan, 1999). In 1998, the Monetary Policy Council set a goal of lowering Polish inflation to 6.8-7.8% in 1999 and 4% as measured by the CPI by the year 2003. As shown in Table 3, the inflation rate for 1999 was 9.8 %, which is much higher than the estimates made by the Council for 1999. In addition, the preliminary estimates of inflation rate was 8.5 % in 2000, suggesting that the inflation targeting policy has not been very

effective so far in Poland.

In summary, Poland moved gradually from a rigid fixed exchange rate targeting regime to a more flexible system with wide bands over time. Monetary policy in Hungary was geared to nominal exchange rate stability and radical measures were taken that generated substantial real shocks to the economy. Hence one may expect a higher incidence of monetary shocks and a smaller role for real shocks in Poland than in Hungary and vice versa.

### **3. The Dynamic Effects of the Shocks: An Illustrative Model**

This section presents a dynamic aggregate supply, aggregate demand model that incorporates some important elements of an economy in transition, namely balance of payments problems and finite capital mobility. The model is consistent with a vertical long-run Phillips curve, and represents a middle ground between market clearing approaches and models based on short run nominal inertia and nominal rigidities. Models of this nature have been applied extensively to explain macroeconomic fluctuations (e.g., Shapiro and Watson, 1988; Blanchard and Quah, 1989; Gali, 1992; Karras, 1994; Ahmed and Park, 1994) and real exchange rate fluctuations (Clarida and Gali, 1994; Weber, 1997). Moreover, Quah and Vahey (1995) propose a technique for measuring core inflation based on aggregate demand neutrality: Core inflation is defined as that component of measured inflation that has no long-run impact on real output, a notion consistent with the vertical long-run Phillips curve. Recently, Wehinger (2000) use this aggregate demand neutrality to derive core inflation for the G7 countries and we follow a similar strategy in this paper.

In order to motivate the restrictions embedded in the structural VAR model, consider a dynamic open economy aggregate supply- aggregate demand model with finite capital mobility:

$$h_t = h_{t-1} + \epsilon_t^h \quad \text{Oil price} \quad (1)$$

$$y_t^s = \check{y}_t - \theta h_t \quad \text{Aggregate supply} \quad (2)$$

$$\check{y}_t = \check{y}_{t-1} + \epsilon_t^s \quad \text{Evolution of capacity output} \quad (3)$$

$$k [i_t - i_t^* + (E_t s_{t+1} - s_t) - \rho_t] + \eta_1 (s_t - p_t) - \eta_2 y_t + b_t = 0 \quad \text{Balance of Payments (BOP)} \quad (4)$$

$$i_t = (E_t s_{t+1} - s_t) - (\eta_1/k) (s_t - p_t) + (\eta_2/k) y_t + [i_t^* + \rho_t - (1/k)b_t] \quad (4')$$

$$z_t = [i_t^* + \rho_t - (1/k)b_t] \quad (5')$$

$$z_t = z_{t-1} + \epsilon_t^z \quad \text{"BOP" shock} \quad (5)$$

$$y_t^d = d_t - \gamma [i_t - E_t (p_{t+1} - p_t)] + \eta_1 (s_t - p_t) - \eta_2 y_t \quad \text{Aggregate demand/IS} \quad (6)$$

$$d_t = d_{t-1} + \epsilon_t^d \quad \text{Aggregate demand shock} \quad (7)$$

$$m_t^d = p_t + y_t - \lambda i_t - \mu z_t \quad \text{Money demand} \quad (8)$$

$$m_t^s = m_{t-1}^s + \epsilon_t^m \quad \text{Money supply} \quad (9)$$

$$y_t^s = y_t^d = y_t \quad \text{Goods market equilibrium} \quad (10)$$

$$m_t^s = m_t^d = m_t \quad \text{Money market equilibrium} \quad (11)$$

where  $h$  is the real world oil price,  $y$  is domestic output,  $\check{y}$  is capacity output,  $i$  is domestic nominal interest rate,  $i^*$  is the foreign interest rate,  $s$  is the exchange rate expressed as the domestic currency price of foreign currency,  $p$  is the domestic price level,  $m$  is the money stock,  $d$  is autonomous aggregate demand,  $\rho$  is a risk premium on domestic currency investments,  $b$  represents an exogenous shift in net exports due to e.g., a change in competitiveness,  $z$  represents exogenous elements in the balance of payments equation,  $E_t$  is the expectations operator

conditional on information available at time  $t$ , all variables except interest rates are in logarithms, and all parameters are assumed positive.

Equation (1) is the evolution of the world oil price, which is assumed to be exogenous. Equation (2) is an aggregate supply equation, where aggregate supply depends on capacity output and world oil price. Capacity output in equation (3) is a function of the productive capacity of the economy (e.g., capital stock and employment), and for simplicity, it is assumed to be a random walk process.

A distinguishing feature of the model is that, due to risk premiums and fads, uncovered interest parity does not hold. Capital inflows are a function of the net domestic rate of return adjusted for a risk premium. Note that the parameter  $k$  represents the degree of capital mobility and large values of  $k$  indicate higher levels of capital mobility. The trade balance is a function of the real exchange rate<sup>2</sup> ( $s_t - p_t$ ) and domestic income. Moreover, due to exogenous changes in terms of trade,  $b_t$  represents exogenous increases in net exports. Although equation (4) may seem to impose a zero balance of payments, the existence of the shift term  $b_t$  provides a more general specification. For example, one can view  $b_t$  as an exogenous level for the balance of payments. Equation (4') rewrites equation (4) in terms of the domestic nominal interest rate while equation (5') pools all the exogenous elements in the balance of payments equation to define  $z_t$ . Equation (5) specifies the evolution of  $z_t$  as a non-stationary stochastic process<sup>3</sup>.

Equation (6) is an aggregate demand (IS) equation where aggregate spending depends on the expected real interest rate and net exports. The autonomous portion of aggregate demand,  $d_t$ , is assumed to follow a random walk in equation (7). Equation (8) is a conventional money demand equation with a unitary income elasticity. Money demand is also a function of the

exogenous elements in the balance of payments. This specification allows for reductions in money demand when there are exogenous shifts in the balance of payments that necessitate a depreciation of domestic currency. The exogenous BOP shock in money demand is meant to allow for currency substitution. It is known that currency substitution is prevalent in inflationary environments. Moreover, when there is a risk premium associated with domestic currency or there exist self-fulfilling fads in exchange rate expectations,  $z_t$  will be positive. In such cases, money demand is reduced by  $\mu z_t$ .

Equation (9) is the evolution of money supply, which for simplicity, is assumed to follow a random walk<sup>4</sup>. Finally we close the model by postulating goods and money market equilibrium relationships (equations 10 and 11) and proceed to solve the model for the rational expectations equilibrium.

In order to solve the model, we eliminate the interest rate from equations (6) and (8) using equation (4') to obtain the following system:

$$\begin{vmatrix} \lambda(1+\frac{\eta_1}{k}) & 1-\frac{\lambda\eta_1}{k} \\ \gamma(1+\frac{\eta_1}{k})+\eta_1 & -\gamma(1+\frac{\eta_1}{k})-\eta_1 \end{vmatrix} \begin{vmatrix} s_t \\ p_t \end{vmatrix} = \begin{vmatrix} \lambda & 0 \\ \gamma & -\gamma \end{vmatrix} \begin{vmatrix} E_t s_{t+1} \\ E_t p_{t+1} \end{vmatrix} + \begin{vmatrix} m_t - (\frac{\lambda\eta_2}{k} - 1)y_t + (\mu - \lambda)z_t \\ (1 + \eta_2 + \frac{\eta_2\gamma}{k})y_t - d_t - \gamma z_t \end{vmatrix} \quad (12)$$

The system can be written compactly as  $AY_t = B E_t Y_{t+1} + W_t$ , or  $Y_t = \Pi E_t Y_{t+1} + CW_t$  where  $C = A^{-1}$  and  $\Pi = A^{-1}B$ . The eigenvalues of the matrix  $\Pi$  are  $\{1/(1+\lambda); \gamma k / (\gamma k + \gamma \eta_1 + \eta_1 k)\}$ . The eigenvalues are both within the unit circle for finite values of the parameters, hence the forward looking solution is convergent. The forward looking solution to the system in (12) is

$$E_t Y_{t+1} = C \sum_{i=1}^{\infty} \Pi^i E_t W_{t+i+1} \quad (13)$$

Given the stochastic processes for the exogenous variables, it is evident that  $E_t W_{t+i} = W_t$  for  $i = 1, 2, \dots$ . Then the solutions for the real exchange rate, real money balances, and the price level in terms of the exogenous variables are:

$$s_t - p_t = \left[ \frac{k}{n_1(\gamma+k)} + \frac{\eta_2}{n_1} \right] y_t - \frac{\gamma k}{n_1(\gamma+k)} z_t - \frac{k}{n_1(\gamma+k)} d_t \quad (14)$$

$$m_t - p_t = c_1 y_t + c_2 z_t + c_3 d_t \quad (15)$$

$$c_1 \equiv \frac{2\lambda\eta_2 + \lambda k}{k(\gamma+k)} - 1; \quad c_2 \equiv \frac{\lambda k}{\gamma+k} - \mu; \quad c_3 \equiv -\frac{\lambda}{\gamma+k};$$

$$p_t = m_t - c_1 y_t - c_2 z_t - c_3 d_t \quad (16)$$

The observed movements in the vector of variables  $X_t = [h_t \ y_t \ (m_t - p_t) \ (s_t - p_t) \ p_t]'$  are due to five mutually uncorrelated “structural” shocks with finite variances,  $\epsilon_t = [\epsilon_t^h \ \epsilon_t^s \ \epsilon_t^z \ \epsilon_t^d \ \epsilon_t^m]$ . These are oil price shocks,  $\epsilon_t^h$ ; aggregate supply shocks,  $\epsilon_t^s$ ; BOP shocks,  $\epsilon_t^z$ ; aggregate demand shocks,  $\epsilon_t^d$ ; and money supply shocks<sup>5</sup>,  $\epsilon_t^m$ .

It can be shown that the long run impact of the structural shocks on the endogenous variables has a specific structure. In order to show the long run effect of structural shocks,  $\epsilon_t$ , on  $X_t$  we express the solution to the model in first differences:

$$\Delta h_t = \epsilon_t^h \quad (17)$$



$$\Delta y_t = -\theta \epsilon_t^h + \epsilon_t^s \quad (18)$$

$$\Delta(m_t - p_t) = c_1 (\epsilon_t^s - \theta \epsilon_t^h) + c_2 \epsilon_t^z + c_3 \epsilon_t^d \quad (19)$$

$$\Delta(s_t - p_t) = \left[ \frac{k}{\eta_1(\gamma+k)} + \frac{\eta_2}{\eta_1} \right] (\epsilon_t^s - \theta \epsilon_t^h) - \frac{\gamma k}{\eta_1(\gamma+k)} \epsilon_t^z - \frac{k}{\eta_1(\gamma+k)} \epsilon_t^d \quad (20)$$

$$\Delta p_t = c_1 \theta \epsilon_t^h - c_1 \epsilon_t^s - c_2 \epsilon_t^z - c_3 \epsilon_t^d + \epsilon_t^m \quad (21)$$

Note from equations (15) and (21) that the long run effect of a BOP shock on the price level depends on the degree of capital mobility and on the magnitude of the semi-interest elasticity of money,  $\lambda$ , relative to the elasticity of money demand with respect to a BOP deterioration,  $\mu$ . Assuming  $k$  is sufficiently large, the coefficient  $c_2$  in equation (21) reduces to  $\lambda - \mu$ . When  $\mu < \lambda$  ( $\mu > \lambda$ ), the predicted effect of a BOP shock on the price level is positive (negative). Consequently, the long run effect of a BOP shock on the price level is an empirical question. Similarly the long run effect of a supply shock on the price level can be of either sign. Notice that although all endogenous variables are unit root stochastic processes, the vector  $X_t$  is difference stationary. Finally, the long run impact of the structural shocks on the endogenous variables is “near-triangular”, which we show in the next section.

#### *Identification of the Shocks*

Since the vector  $\Delta X_t$  is covariance stationary, it can be written as an infinite moving average process in the structural shocks:

$$\Delta X_t = \sum A_i \epsilon_{t-i} = A(L) \epsilon_t \quad (22)$$

where  $A(L)$  is a matrix whose elements are polynomials in the lag operator  $L$ . Denote the elements of  $A(L)$  by  $a_{ij}(L)$ . The time path of the effects of a shock in  $\epsilon_j$  on variable  $i$  after  $k$  periods can be denoted  $\omega_{ij}(k)$ . We also adopt the notation such that  $A(1)$  is the matrix of long run effects whose elements are denoted  $a_{ij}(1)$ ; each element gives the cumulative effect of a shock in  $\epsilon_j$  on variable  $i$  over time. Similarly,  $A_0$  is the matrix of the contemporaneous impact effects and consists of  $\omega_{ij}(0)$ . The objective of identification is to discern the 25 elements of  $A_0$ . Given the model structure above, the long run effects of the shocks on the endogenous variables are given by

$$\begin{array}{c|c} \begin{array}{c} \Delta h_t \\ \Delta y_t \\ \Delta(m_t - p_t) \\ \Delta(s_t - p_t) \\ \Delta p_t \end{array} & \begin{array}{c} a_{11}(1) \quad 0 \quad 0 \quad 0 \quad 0 \\ a_{21}(1) \quad a_{22}(1) \quad 0 \quad 0 \quad 0 \\ a_{31}(1) \quad a_{32}(1) \quad a_{33}(1) \quad a_{34}(1) \quad 0 \\ a_{41}(1) \quad a_{42}(1) \quad a_{43}(1) \quad a_{44}(1) \quad 0 \\ a_{51}(1) \quad a_{52}(1) \quad a_{53}(1) \quad a_{54}(1) \quad a_{55}(1) \end{array} \end{array} \begin{array}{c} \epsilon_t^h \\ \epsilon_t^s \\ \epsilon_t^z \\ \epsilon_t^d \\ \epsilon_t^m \end{array} \quad (23)$$

Note that the matrix of long run effects is lower triangular except that  $a_{34}(1)$  is not zero. The system in (23) provides 9 restrictions toward identification. Given the 15 restrictions embedded in the variance covariance matrix, an additional restriction is needed to identify the shocks.

For a sufficiently high level of capital mobility, aggregate demand shocks have no long run effect on real money balances. An aggregate demand shock in this case has no effect on real interest rates and any autonomous changes in aggregate demand have to be offset by a nominal and real appreciation of domestic currency. As a result, net exports decline and aggregate demand shocks have no long run effect on prices or real money balances under perfect capital mobility. Perfect capital mobility implies that the coefficient  $c_3 = -\lambda/(\gamma+k)$  in equations (15) and (19) and

the long run response  $a_{34}(1)$  in equation (23) is zero. In the empirical model, it is fairly straightforward to re-estimate the model for non-zero values of  $a_{34}(1)$  corresponding to limited capital mobility. This enables us to assess the sensitivity of the results to varying degrees of capital mobility.

#### 4. Empirical Results

Our benchmark model consists of the system in (23) with “high capital mobility” where  $a_{34}(1) = 0$ . After estimating the model, we perform variance decompositions and impulse response analyses to study the dynamic effects of real oil price, aggregate supply, balance of payments, real demand, and monetary shocks on the price level and output. We then use simulations based on historical realizations of the orthogonal shocks to construct estimates of “core” inflation. The data are monthly from January 1990 through April 2000. The measures of the variables are:  $h_t$  = real domestic price of crude oil (West Texas crude oil converted to domestic currency using period average exchange rate and deflated by the producer price index),  $y_t$  = industrial production index,  $q_t$  = real effective exchange rate,  $p_t$  = consumer price index,  $m_t$  = M3 for Hungary, and M2 for Poland. Most series are from CD ROM edition of the *International Financial Statistics*, except the following: Industrial Production in Poland is taken from Plan Econ Inc.; West Texas crude oil price is from the Federal Reserve Bank of St Louis FRED® database; M3 in Hungary is from the National Bank of Hungary. All data are seasonally adjusted using the Census X-11 additive method.

In order to properly specify the VAR, variables ought to be tested for unit roots. Augmented Dickey-Fuller (ADF) tests for the levels and first differences of the variables are

given in Table 5. The ADF test statistics seem to be sensitive to the lag length, hence we present sample autocorrelation coefficients for the variables as well. The sample ADF test statistics indicate that all variables are stationary in the first differences at the 5 percent significance level. However, the real exchange rate and the price level in Poland appear stationary. Moreover, real money balances in Poland and the real exchange rate and the price level in Hungary seem on the borderline of a unit root process. Sample autocorrelation coefficients for price levels and real exchange rates clearly suggest a unit root process in real exchange rates and prices in both countries. Moreover an AR(1) coefficient of 0.98 and a slowly decaying autocorrelation function in the real money balances in Poland point to a unit root process. For the empirical model, we proceed with the assumption that all variables are unit root processes in levels, and stationary in first differences<sup>6</sup>.

We then let  $\Delta X_t = [\Delta h_t \Delta y_t \Delta(m_t-p_t) \Delta(s_t-p_t) \Delta p_t]$  and estimate the VAR for Poland and Hungary. Starting with a maximum lag of 8, we pare down the model depending on the joint significance of maximum lag coefficients. Likelihood ratio tests indicate that the model can be pared down to 4 lags for Hungary and 6 lags for Poland. In order to preserve symmetry and capture possible dynamics, we estimate the VAR with six lags for both countries. The transition process by its very nature involves structural change. Moreover, both countries introduced major stabilization programs in 1995. In order to test for structural change, we divide the sample into two sub-periods: 1990.2-1994.12 and 1995.1-2000.4. We then test for structural change using a multivariate version of the Chow test. The estimated test statistic yields  $\chi^2(155) = 428.14$  for Hungary and  $\chi^2(155) = 434.22$  for Poland. Both statistics strongly reject the null hypothesis of no structural change. In order to account for the structural change, we include a dummy variable for

both countries ( $d = 1$  for  $t \geq 1995:1$  and zero otherwise) in the VAR. We then implement the identification strategy outlined above, and proceed with innovation accounting analysis typical of VARs.

### *Impulse Response Functions*

Figure 1 presents responses of the price level to each shock (real oil price, supply, balance of payments, demand, and monetary) for Poland and Hungary. We present both median responses and a 90 percent confidence band based on bootstrapping with 1000 draws for the impulse response functions. The figure indicates that the response of the price level to a real oil price shock is insignificant in both countries. The effect of a supply shock on prices is similar to a closed economy case where prices fall in response to an aggregate supply shock in both Poland and Hungary. The effect of a BOP shock is negative but mostly insignificant in Poland. This indicates that a BOP shock has a demand deflating effect.

The effect of an aggregate demand shock on prices is positive and significant in both countries. Prices gradually rise in response to a monetary shock suggesting some nominal inertia in both Poland and Hungary. Prices level off after a year in both countries.

The response of output to various shocks is given in Figure 2. Output falls slightly in response to an oil price shock and then rises in both countries although the response is mostly statistically insignificant. Output effects of supply shocks are positive and significant as expected. As in the price level, a BOP shock has some demand deflating effect, and output mostly falls in response to a BOP deterioration. However, the response is statistically insignificant. A real demand shock is expansionary in both countries even though the response is not significant in Hungary. Similarly, monetary shocks seem to have output expansionary effects. Although the

effect is mostly insignificant in Poland, there is a pronounced and significant impact effect of a monetary shock in Hungary. Overall, the results are broadly consistent with the implications of the aggregate supply - aggregate demand model.

#### *Variance Decompositions*

Table 6 presents variance decompositions of the price level and output under the assumption of perfect capital mobility. At short term forecasting horizons, real demand shocks play an important role in explaining the price level in Poland, followed by supply and BOP shocks. In Hungary, supply shocks seem to play the dominant role in price level movements although real demand shocks are still important in the short run. These findings are consistent with our prior expectations as discussed in Section 2.

For both countries, monetary shocks are negligible in explaining price level movements in the short run. In the long run, aggregate demand, supply, and monetary shocks play almost equally in price level movements in Poland while supply shocks seem to dominate the price level in Hungary. Notice the absence of any major role for real oil price shocks in influencing price level movements in both countries. Moreover, although monetary shocks do not play a major role in price level movements in the long run, they seem to explain a moderate proportion of price level movements in Poland. This may be attributed to the exchange rate based stabilization programs which tend to limit monetary discretion that have been implemented in both countries.

Variance decompositions of output reveal interesting patterns. First, in both countries supply shocks explain a sizable proportion of output movements in both countries. Second, balance of payments and real oil price shocks are negligible in both countries. On the other hand, aggregate demand shocks in the broad sense (real demand vs. monetary shocks) seem to play a

different role in explaining output movements in each country. This finding supports the arguments made by Brada (1998) and Desai (1997, 1998) that different initial conditions and macroeconomic policy between the two countries are likely to yield different outcomes for the behavior of output and other key macroeconomic variables.

While both types of demand shocks are constrained to have no long run effect on output, the short run effect can be substantial. Indeed, monetary shocks seem to dominate output movements in Hungary in the short run while real demand shocks appear to be modest. In Poland, real demand shocks play a moderate to important role in output movements in the short run while monetary shocks are negligible. Overall, aggregate demand policies in the broad sense seem to have a significant role in the short run in both countries.

#### *Imperfect capital mobility and alternative specifications*

For transition economies, it may not be reasonable to assume perfect capital mobility particularly in the initial stages of transition since institutional infrastructure was in its infancy and there was more currency as well as political risk. However, the leading transition economies today possess almost perfect capital mobility as currency convertibility in both current and capital accounts is introduced.

In this section, we assess the sensitivity of the results to the degree of capital mobility. To that end, we estimate the model with limited capital mobility corresponding to non-zero values of the coefficient  $c_3$ . Recall that the parameter  $k$  measures the degree of capital mobility so  $c_3 = -\lambda/(\gamma+k)$  determines the long run effect of aggregate demand impulses on real money balances. We gauge the effect of limited capital mobility by estimating the model for a finite  $k$ . We set the long run effect of aggregate demand shocks on the demand for real money balances at  $a_{34}(1) = -$

0.009 standard deviations for Hungary and Poland<sup>7</sup>. Variance decompositions from this model are summarized in Table 7.

Limited capital mobility evidently has no bearing on the relative importance of real oil price, supply, or monetary shocks in explaining the price level or output. The effects of limited capital mobility can be summarized as follows: The importance of real demand shocks in explaining the price level in Hungary increases in the long run. In Poland, there is a reverse tendency: the effect of real demand shocks on the price level is somewhat diminished. As for output, real demand (BOP) shocks explain a higher proportion of output movements in Hungary (Poland) under limited capital mobility. These results are more consistent with our prior expectations about the importance of monetary and real shocks in affecting prices and output as discussed in Section 2.

Overall, the assumption regarding capital mobility does not seem to alter the results substantially for Hungary. However the results are somewhat sensitive to capital mobility in Poland in that the role of real demand and BOP shocks change depending on capital mobility<sup>8</sup>.

In order to assess the sensitivity of the results to different specifications of the VAR and sample periods, we estimated various models. First, we estimated the model with unit root inflation and output processes. The estimated impulse responses from this model did not conform to theoretical overidentification restrictions implied by the AS/AD model. Recall that a supply shock has a positive effect on the price level and money supply shock has a contractionary effect on output. We also estimated the model for 1992-2000 excluding the initial transition period. Results from this model show high standard errors in that most impulse responses are



insignificant, perhaps due to insufficient observations. Therefore we conclude that the benchmark model provides the most plausible representation of the data.

### *Core Inflation*

Following Quah and Vahey (1995), we construct “core inflation” by eliminating supply side influences (oil price shocks and supply shocks). The remaining “demand driven inflation” based on historical realizations of balance of payments shocks, real demand shocks, and monetary shocks gives an idea about the extent of policy induced inflation.<sup>9</sup> The deterministic part of the simulated inflation is included in the core inflation estimate. If a substantial portion of total inflation is demand driven or “core inflation”, there is room for policies aimed at limiting discretionary demand policies to bring down inflation and stabilize the economy. A decomposition of inflation based on historical realizations of the shocks is given in Figure 3. A core inflation measure higher than total inflation indicates that favorable supply side effects featured strongly to bring down inflation.

Figure 3 reveals several interesting features of the inflation period in Poland and Hungary. First, in both countries core inflation was never far below total inflation<sup>10</sup> during the entire sample period except at the beginning of the transition in Poland. As a matter of fact, in the second half of the 1990s there is a moderating effect of favorable supply shocks on total inflation. Inflation moderating favorable supply shocks show no particular pattern for Poland but are strongly visible in Hungary after 1995. One can conjecture that the upgrading of old technologies through foreign direct investment, increase in product quality and structure, decline in unit labor costs, and introduction of the post-95 measures have been some of the main driving forces of the observed increase in output and decline in inflation in Hungary.

Given the negligible non-core inflation and oftentimes moderating supply side influences on inflation, the historical decomposition of inflation has important policy implications. If we assume that core inflation is mostly induced by discretionary demand policies, commitment mechanisms that limit discretionary policies have a good chance of stabilizing the economy.

## **5. Conclusions**

Using a rational expectations, dynamic aggregate supply and aggregate demand model with limited capital mobility and structural VARs, we have attempted to decompose inflation and output movements into those attributable to real oil price, supply, balance of payments, real demand, and monetary shocks. Variance decompositions results have indicated that supply shocks explain a preponderance of price level movements in Hungary while demand shocks are dominant in price level movements in Poland. On the other hand, monetary shocks are an important source of output fluctuations in the short run in Hungary suggesting nominal inertia. In Poland, real demand shocks affect output in the short run (up to one year), while monetary shocks are negligible. We have found that these findings are not overly sensitive to the assumption regarding capital mobility. These results support the view that different initial conditions and different starting times of stabilization programs, as well as, different approaches to monetary and exchange rate policy in Poland and Hungary have resulted in different factors driving output and inflation [Brada (1998) and Desai (1997, 1998)].

Our results have suggested that aggregate demand policies in the broad sense have played a significant role in the short run in both countries. This may be related to the relative fixity of the exchange rate regimes that Poland and Hungary adopted in the 1990s. The relative effectiveness of real demand policies is compatible with the view that floating rates steepen the short run

Phillips curve trade-off (Dornbusch and Krugman 1976). Accordingly, even if demand policies are not stable, fixed rates provide a framework that stabilizes their effects. For example, an expansionary policy adopted in response to an imminent decline in economic activity under fixed exchange rates is more likely to raise output and employment rather than wages if it is not expected to persist (Alogoskoufis and Smith 1991; Eichengreen, 1993). Moreover, expansionary demand policies produce larger increases in output and employment under credible fixed exchange rates when inflation is not expected to persist, as compared to flexible exchange rates. In that regard, it is important for these countries to continue to have some form of fixed exchange rate regime before any formal peg to the Euro.

Empirical evidence has indicated that supply shocks have been a key determinant of output and prices in both short and long run in both countries. Therefore, it is important for both countries to put more emphasis on supply side policies that increase productivity over time. Estimates of core inflation based on historical realizations of the shocks have indicated a major component of inflation has been demand driven, core, inflation. Therefore, it is important that policymakers restrain discretionary demand policies to lower inflation.

Our results have important implications for full membership preparations of Hungary and Poland in the EU and lessons for other candidate countries. Based on our empirical findings, it appears that a combination of discretionary demand policies along with supply-side reforms that emphasize productivity enhancement and investment in new technology would be important factors to lower inflation and increase output growth in both countries, thus increasing their chances of full membership in the EU. In addition, unfavorable supply shocks would hurt the attempts of lowering inflation and achieving a sustainable output growth in both countries, perhaps significantly delaying the timing of full EU membership for the candidate countries.

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Table 1 – Hungary: Macroeconomic Indicators 1991 to 2000

|                                 | 1991  | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---------------------------------|-------|------|------|------|------|------|------|------|------|------|
| Real GDP growth (%)             | -11.9 | -3.1 | -0.6 | 2.9  | 1.5  | 1.4  | 4.6  | 4.9  | 4.2  | 5.2  |
| CPI rate of inflation (%)       | 34.2  | 23.0 | 22.5 | 18.9 | 28.3 | 23.5 | 18.3 | 14.3 | 10.0 | 9.8  |
| In % of GDP:                    |       |      |      |      |      |      |      |      |      |      |
| Current account balance         | 0.8   | 0.9  | -9.0 | -9.4 | -5.6 | -3.7 | -2.1 | -4.8 | -4.3 | -3.9 |
| Government deficit <sup>a</sup> | 3.0   | 7.0  | 6.5  | 8.4  | 6.7  | 3.1  | 4.9  | 4.8  | 3.7  | 3.8  |
| Public debt                     |       |      |      |      |      |      |      |      |      |      |
| Consolidated <sup>b</sup>       | 66.9  | 65.0 | 84.3 | 83.2 | 85.4 | 71.7 | 63.6 | 63.5 | 66.3 | 62.8 |
| Non-consolidated <sup>c</sup>   | 74.7  | 79.0 | 90.8 | 88.3 | 86.5 | 72.6 | 63.7 | 62.1 | 60.9 | 56.7 |

Note: Figures for 2000 are preliminary.

<sup>a</sup> Based on official data reported in Kiss and Szapary (Table 2, 2000), which includes transactions of the central government, the social security funds, the local authorities, and the extra-budgetary funds. For details, see Kiss and Szapary (2000).

<sup>b</sup> Government and National Bank of Hungary, excluding the sterilization instruments of the central bank, see Kiss and Szapary (Table 1, 2000)

<sup>c</sup> Non-consolidated with the National Bank of Hungary. For details, see Kiss and Szapary (Table 1, 2000)

Table 2 – Exchange rate policy measures in Hungary: 1990-2000

| Dates            | Currency basket   | Rate Adjustment    |
|------------------|---|--------------------|
| 32873            | Introduction of an adjustable fixed rate regime based on the currency composition of previous year's foreign trade until December 8, 1991 |                    |
| December 9, 1991 | 50% USD-50% ECU   | -                  |
| March 16, 1992   |   | 1.90               |
| June 24          |   | 1.60               |
| November 19      |   | 1.9                |
| 34011            |   | 1.9                |
| March 26         |   | 2.90               |
| June 7           |   | 1.90               |
| July 9           |   | 3.00               |
| August 2         | 50% US\$-50% DM   |                    |
| September 29     |   | 4.50               |
| 34336            |   | 1                  |
| February 16      |   | 2.60               |
| May 13           |   | 1.00               |
| May 16           | 70% ECU-30% US\$  |                    |
| June 10          |   | 1.20               |
| August 5         |   | 8.00               |
| October 11       |   | 1.10               |
| November 29      |   | 1.00               |
| 34701            |   | 1.4                |
| February 14      |   | 2.00               |
| 36962            | Introduction of preannounced crawling peg adjustments   | 9                  |
| March 16         |   | Daily devaluations |
| 36965            |   | 0.06               |
| July 1           |   | 0.042              |
| 35064            |   | 0.04               |
| 35430            | 70% DM-30% US\$   | -                  |
| April 1          |   | 0.036              |
| 37117            |   | 0.033              |
| January 1, 1998  |   | 0.030              |
| June 15          |   | 0.026              |
| 37164            |   | 0.023              |
| January 1, 1998  | 70% EURO-30% US\$   |                    |
| January 1        |   | 0.020              |
| July 1           |   | 0.016              |
| 37164            |   | 0.013              |
| 36525            | 100 % EURO  | 0.013              |
| 36981            |   | 0.01               |

Source: National Bank of Hungary, various annual and monthly Reports.

Table 3. Poland: Macroeconomic Indicators 1990 to 2000

|   | 1990  | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|-------|------|------|------|------|------|------|------|------|------|------|
| GDP real growth rate                    | -11.6 | -7.0 | 2.6  | 3.8  | 5.2  | 7.0  | 6.1  | 6.9  | 4.8  | 4.1  | 4.1  |
| CPI rate of inflation                   | 249   | 60.4 | 44.3 | 37.6 | 29.5 | 21.6 | 18.5 | 13.2 | 8.6  | 9.8  | 8.5  |
| In % of GDP:                            |       |      |      |      |      |      |      |      |      |      |      |
| Current Account balance                 | 5.2   | -2.8 | -3.7 | -2.7 | -1   | 4.3  | -0.9 | -3   | -4.3 | -7.5 | -6.1 |
| General government balance <sup>a</sup> | 2.8   | -1.8 | -4.9 | -2.3 | -2.7 | -2.6 | -2.5 | -1.3 | -2.4 | -2.0 | -2.2 |
| Public Debt                             | na    | na   | 147. | 108. | 69.0 | 59.0 | 53.6 | 49.4 | 43.0 | na   | 42.0 |
|   |       |      | 3    | 6    |      |      |      |      |      |      |      |

Notes:

<sup>a</sup>General government includes the state, municipalities and extra-budgetary funds. General government balance includes privatization receipts. Figures for 2000 are preliminary.

Sources: *EBRD Transition Report, various issues, EIU and national statistics*



Table 4. Exchange Rate Policy in Poland 1990-1999

| Date           | Regime   |
|----------------|--|
| January 1990   | Fixed exchange rate against the US \$ (After a 31.6% devaluation on January 1, 1990)   |
| May 1991       | Fixed rate against a basket of 5 currencies (after a 17% devaluation).<br>Currency basket: 45% US\$, 35% DM, 10% British Pounds, 5% French franc, 5% CHF |
| October 1991   | Crawling peg, pre-announced crawling devaluation at a monthly rate of 1.8%   |
| February 1992  | 10.7% Devaluation  |
| August 1993    | 7.4% Devaluation; monthly crawling rate 1.6%   |
| September 1994 | Monthly crawling rate 1.5%   |
| November 1994  | Monthly crawling rate 1.4%   |
| February 1995  | Monthly crawling rate 1.2%   |
| May 1995       | Crawling band, widened band (+/- 7%), same crawling rate   |
| December 1995  | 6% Revaluation   |
| January 1996   | Monthly crawling rate 1.0%   |
| February 1998  | Band widened to +/- 10%, monthly crawl 0.8%  |
| July 1998      | Monthly crawling rate 0.65%  |
| September 1998 | Monthly crawling rate 0.5%   |
| October 1998   | Band widened to +/- 12.5%  |
| January 1999   | New currency basket: 55% EURO, 45% US\$  |
| March 1999     | Band widened to +/- 15%, monthly crawling rate 0.3%.   |

Source: Adapted from Nuti (2000)

Table 5. Stationarity: Autocorrelation and ADF Statistics

|   | $q_t$ | $p_t$ | $m_t-p_t$ | $y_t$ | $h_t$ | $\Delta q_t$ | $\Delta p_t$ | $\Delta(m_t-p_t)$ | $\Delta y_t$ | $\Delta h_t$ |
|---|-------|-------|-----------|-------|-------|--------------|--------------|-------------------|--------------|--------------|
| POLAND  |       |       |           |       |       |              |              |                   |              |              |
| <i>Autocorrelations (<math>\rho_k</math>)</i> |       |       |           |       |       |              |              |                   |              |              |
| k = 1   | 0.91  | 0.97  | 0.98      | 0.94  | 0.92  | 0.22         | 0.65         | -0.11             | -0.4         | 0.29         |
| k = 6   | 0.66  | 0.82  | 0.87      | 0.86  | 0.55  | 0.08         | 0.44         | -0.01             | 0.22         | -0.11        |
| k = 12  | 0.42  | 0.67  | 0.73      | 0.75  | 0.12  | 0.02         | 0.35         | 0.26              | 0.61         | -0.1         |
| <i>ADF <math>\tau_\mu</math> Statistic</i>    |       |       |           |       |       |              |              |                   |              |              |
|   | -4.49 | -4.6  | -2.85     | 1.49  | -0.39 | -6.65        | -3.04        | -6.34             | -8.8         | -7.33        |
| Lags  | 1     | 2     | 1         | 1     | 3     | 1            | 3            | 1                 | 1            | 2            |
| HUNGARY                                       |       |       |           |       |       |              |              |                   |              |              |
| <i>Autocorrelations (<math>\rho_k</math>)</i> |       |       |           |       |       |              |              |                   |              |              |
| k = 1   | 0.95  | 0.98  | 0.98      | 0.84  | 0.97  | 0.16         | 0.23         | 0.14              | -0.4         | 0.05         |
| k = 6   | 0.72  | 0.86  | 0.81      | 0.66  | 0.81  | -0.15        | -0.1         | -0.06             | 0.35         | 0            |
| k = 12  | 0.5   | 0.72  | 0.54      | 0.6   | 0.66  | -0.12        | 0.51         | -0.01             | 0.59         | 0.23         |
| <i>ADF <math>\tau_\mu</math> Statistic</i>    |       |       |           |       |       |              |              |                   |              |              |
|   | -2.85 | -2.48 | -0.6      | -1.59 | 0     | -3.87        | -5.92        | -7.55             | -3.5         | -7.93        |
| Lags  | 7     | 2     | 1         | 3     | 2     | 6            | 1            | 1                 | 2            | 2            |

Notes: The critical value of the ADF  $\tau_\mu$  test at the 5 % significance level is -2.89. The maximum lag for the ADF test is selected by the Schwarz Criterion.

Table 6. Variance Decomposition of the Price Level and Output: High Capital Mobility

|          | Poland             |              |              |              |              | Hungary      |              |              |              |              |
|----------|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
|          | $\epsilon^h$       | $\epsilon^s$ | $\epsilon^z$ | $\epsilon^d$ | $\epsilon^m$ | $\epsilon^h$ | $\epsilon^s$ | $\epsilon^z$ | $\epsilon^d$ | $\epsilon^m$ |
| <i>k</i> | <i>Price level</i> |              |              |              |              |              |              |              |              |              |
| 1        | 4.0                | 26.1         | 23.9         | 41.9         | 4.0          | 15.0         | 50.1         | 6.1          | 28.4         | 0.4          |
| 6        | 4.8                | 31.7         | 12.1         | 34.5         | 16.8         | 8.1          | 58.8         | 6.5          | 20.8         | 5.9          |
| 12       | 1.8                | 29.7         | 8.8          | 37.0         | 22.7         | 2.4          | 66.0         | 7.9          | 10.2         | 13.4         |
| 18       | 1.6                | 29.8         | 8.8          | 36.2         | 23.6         | 1.9          | 63.8         | 11.0         | 8.3          | 15.0         |
| 24       | 1.7                | 30.2         | 8.9          | 35.3         | 23.9         | 2.8          | 61.0         | 13.2         | 6.9          | 16.0         |
| 30       | 1.9                | 30.6         | 9.0          | 34.6         | 24.0         | 3.7          | 58.7         | 14.9         | 6.3          | 16.3         |
| 36       | 2.0                | 30.9         | 9.0          | 34.1         | 24.0         | 4.5          | 57.1         | 16.0         | 5.9          | 16.5         |
| <i>k</i> | <i>Output</i>      |              |              |              |              |              |              |              |              |              |
| 1        | 0.9                | 58.5         | 1.7          | 32.2         | 6.7          | 0.1          | 24.4         | 8.5          | 12.8         | 54.2         |
| 6        | 12.6               | 63.8         | 0.6          | 14.7         | 8.2          | 11.7         | 36.3         | 8.9          | 6.9          | 36.3         |
| 12       | 9.8                | 76.8         | 0.8          | 7.8          | 4.7          | 15.5         | 53.6         | 7.4          | 3.8          | 19.7         |
| 18       | 8.3                | 82.9         | 0.6          | 5.1          | 3.1          | 14.1         | 66.7         | 5.2          | 2.2          | 11.7         |
| 24       | 7.0                | 86.5         | 0.5          | 3.7          | 2.3          | 11.6         | 75.3         | 3.6          | 1.5          | 8.0          |
| 30       | 6.2                | 88.8         | 0.4          | 2.8          | 1.8          | 9.6          | 80.5         | 2.7          | 1.2          | 6.1          |
| 36       | 5.5                | 90.4         | 0.3          | 2.3          | 1.4          | 8.2          | 83.7         | 2.2          | 1.0          | 5            |

Table 7. Variance Decomposition of the Price Level and Output: Low Capital Mobility

|          | Poland             |              |              |              |              | Hungary      |              |              |              |              |
|----------|--------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
|          | $\epsilon^h$       | $\epsilon^s$ | $\epsilon^z$ | $\epsilon^d$ | $\epsilon^m$ | $\epsilon^h$ | $\epsilon^s$ | $\epsilon^z$ | $\epsilon^d$ | $\epsilon^m$ |
| <i>k</i> | <i>Price level</i> |              |              |              |              |              |              |              |              |              |
| 1        | 4.0                | 26.2         | 15.0         | 50.8         | 4.0          | 15.0         | 50.1         | 6.4          | 28.0         | 0.4          |
| 6        | 4.8                | 31.7         | 15.8         | 30.8         | 16.8         | 8.1          | 58.8         | 3.7          | 23.5         | 5.9          |
| 12       | 1.8                | 29.7         | 19.0         | 26.7         | 22.7         | 2.4          | 66.0         | 1.0          | 17.1         | 13.4         |
| 18       | 1.6                | 29.8         | 18.3         | 26.7         | 23.6         | 1.9          | 63.8         | 0.6          | 18.7         | 15.0         |
| 24       | 1.7                | 30.2         | 17.6         | 26.6         | 23.9         | 2.8          | 61.0         | 0.8          | 19.4         | 16.0         |
| 30       | 1.9                | 30.6         | 17.1         | 26.4         | 24.0         | 3.7          | 58.7         | 0.9          | 20.3         | 16.3         |
| 36       | 2.0                | 31.0         | 16.7         | 26.3         | 24.0         | 4.5          | 57.1         | 1.1          | 20.9         | 16.5         |
| <i>k</i> | <i>Output</i>      |              |              |              |              |              |              |              |              |              |
| 1        | 0.9                | 58.6         | 32.6         | 1.3          | 6.7          | 0.1          | 24.5         | 0.8          | 20.6         | 54.0         |
| 6        | 12.6               | 63.9         | 13.1         | 2.1          | 8.2          | 11.6         | 36.4         | 1.5          | 14.2         | 36.2         |
| 12       | 9.8                | 76.8         | 6.4          | 2.2          | 4.7          | 15.4         | 53.7         | 1.5          | 9.7          | 19.7         |
| 18       | 8.3                | 82.9         | 4.1          | 1.6          | 3.1          | 14.1         | 66.8         | 1.4          | 6.0          | 11.7         |
| 24       | 7.0                | 86.6         | 2.9          | 1.2          | 2.3          | 11.6         | 75.3         | 1.0          | 4.1          | 7.9          |
| 30       | 6.2                | 88.9         | 2.3          | 0.9          | 1.8          | 9.5          | 80.5         | 0.8          | 3.1          | 6.0          |
| 36       | 5.5                | 90.4         | 1.8          | 0.8          | 1.4          | 8.2          | 83.7         | 0.6          | 2.5          | 4.9          |

## ENDNOTES

1. Other transition economies, including the Czech Republic, are not included due to insufficient observations for empirical analysis. For most transition economies, data start either in 1993 or 1994, which does not provide enough degrees of freedom to get reliable estimates using the structural VAR model. In a future study, we plan to include other transition economies and draw more general conclusions. In this sense, our paper is exploratory and provides an initial analysis of this issue.
2. For simplicity, foreign prices are normalized to unity. In the empirical analysis we will use real effective exchange rates, which does not assume unit foreign prices.
3. Although  $\epsilon_t^z$  is labeled a “balance of payments shock”, it is evident that it captures foreign interest rate shocks, risk premium shocks, and competitiveness shocks. Without further structure, it is impossible to disentangle  $\epsilon_t^z$  into its constituent parts. To keep the dimensions of the VAR tractable,  $\epsilon_t^z$  will be a composite shock of the above.
4. In the empirical model, we do not restrict “exogenous variables” to follow any particular process; the assumption of random walk is to illustrate identification restrictions.
5. If one assumes a stable money demand function,  $\epsilon_t^m$  can be interpreted as a money supply shock. However, if money demand is not stable,  $\epsilon_t^m$  will capture money supply shocks *net of* money demand shocks.
6. Even though some variables appear stationary in levels (e.g., real exchange rates, price levels, real money balances), an autoregressive coefficient near unity makes it impossible to invert the VAR in order to obtain the moving average representation. Hence, based on a slowly decaying ACF, we assume that these variables are unit root processes in levels.
7. A long run effect of 0.009 standard deviations is comparable in absolute value to an average long run effect of a shock presented in Figure 1. Moreover,  $a_{34}(1)$  coefficients in equation (23) that are higher than 0.009 in absolute value did not converge.
8. Strictly speaking, real demand shocks and BOP shocks are indistinguishable under limited capital mobility.
9. Demand driven inflation is only an approximation to policy induced inflation, as not all broadly defined demand shocks are policy related.
10. The fact that supply shocks explain a sizable proportion of the forecast of error variance in the price level is not inconsistent with a sizable core inflation. Variance decompositions give an idea about the effects of various shocks of the *same size* while historical decompositions simulate the series based on the historical incidence of the shocks.

Figure 1. Response of the Price Level

a) Poland

b) Hungary

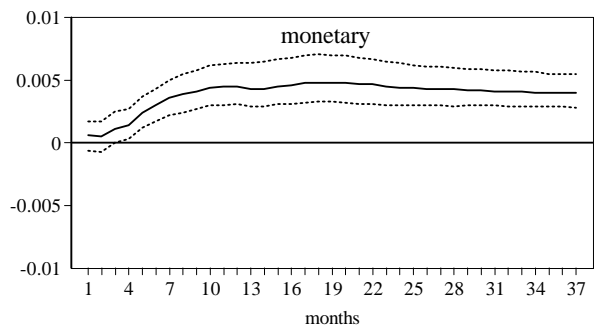
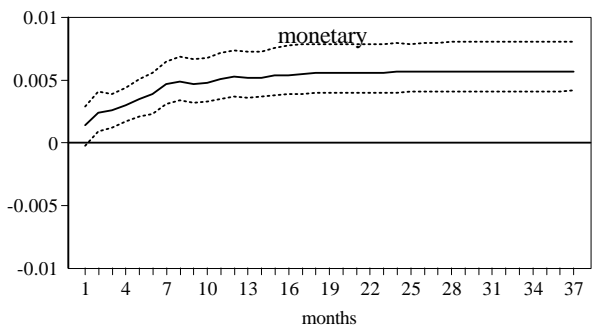
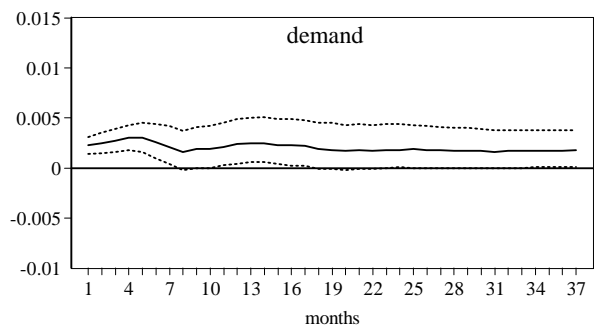
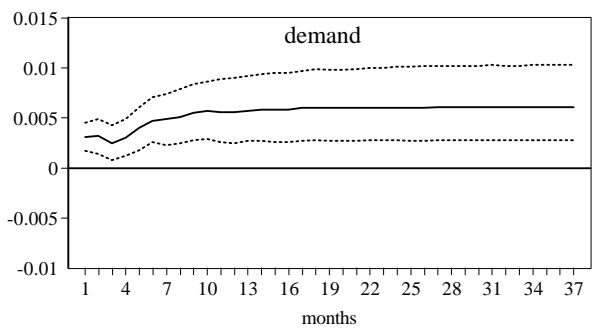
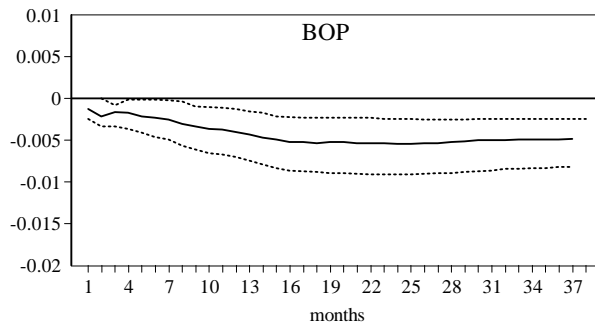
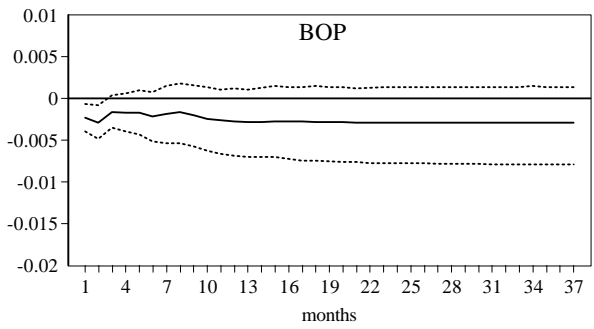
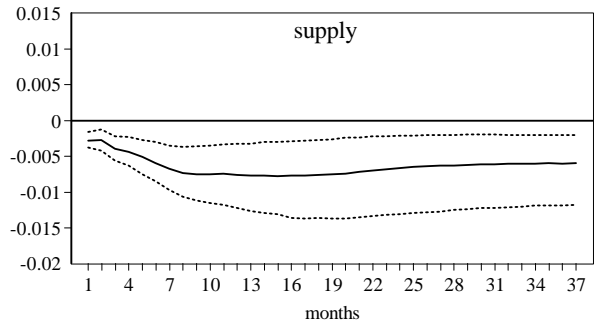
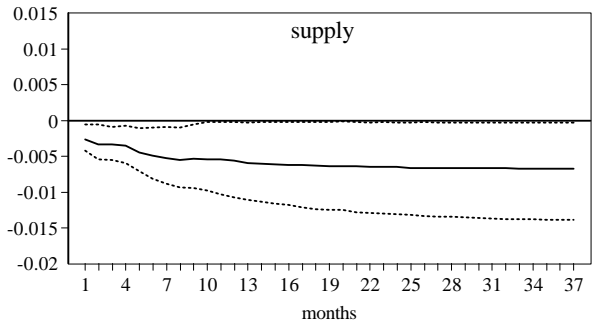
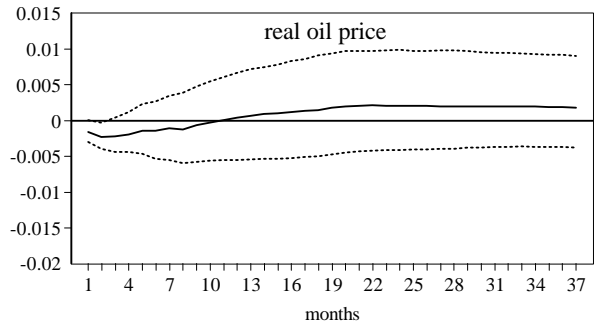
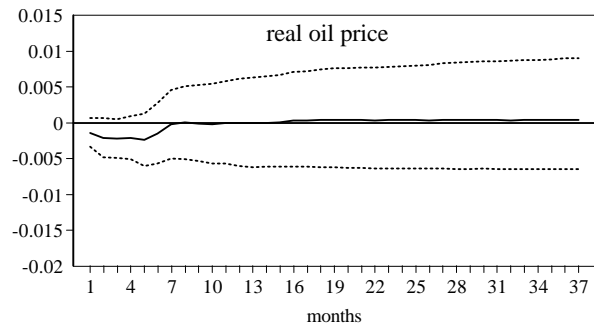


Figure 2. Responses of Output

a) Poland

b) Hungary

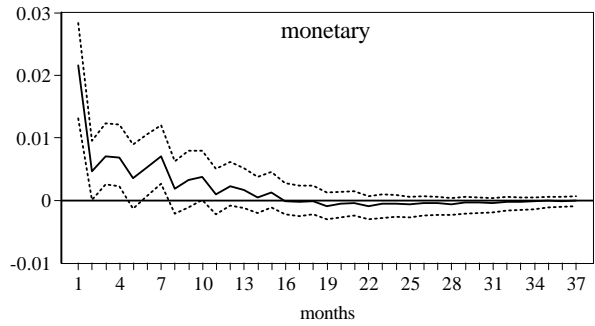
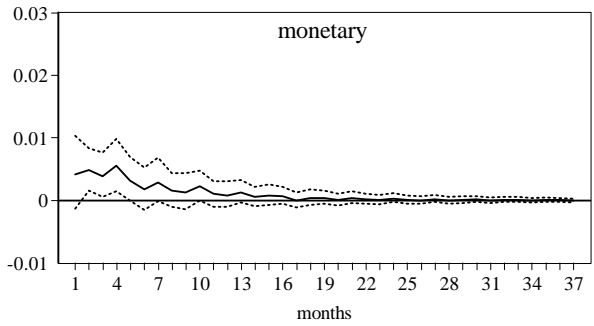
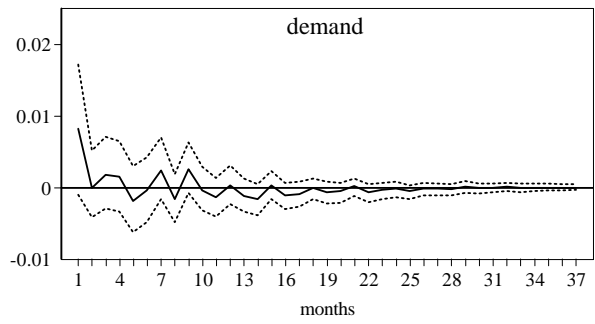
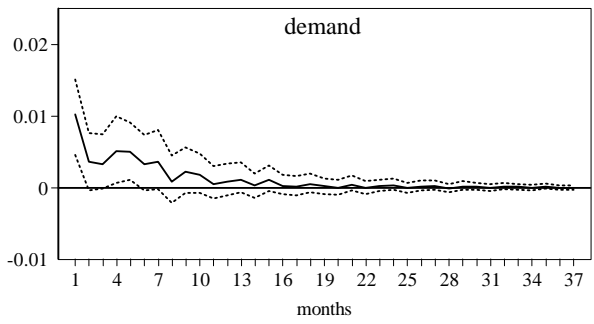
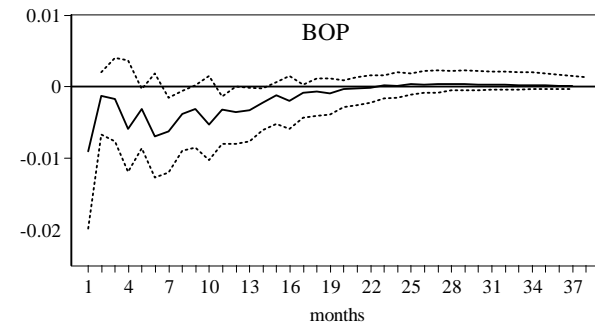
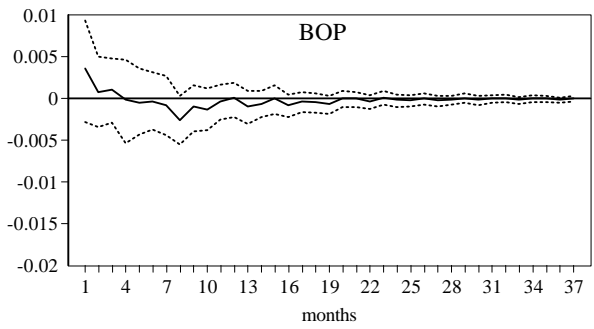
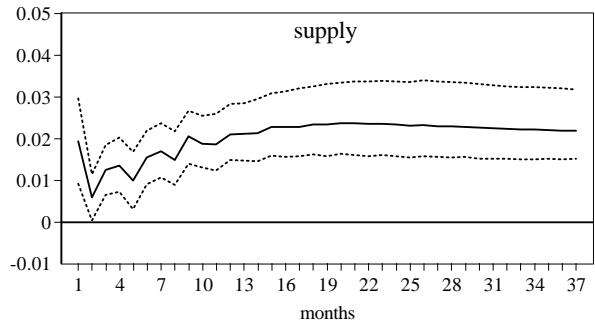
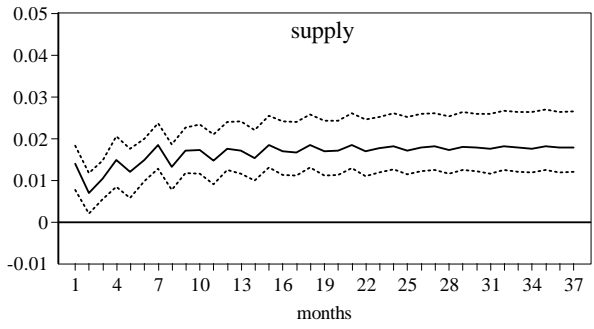
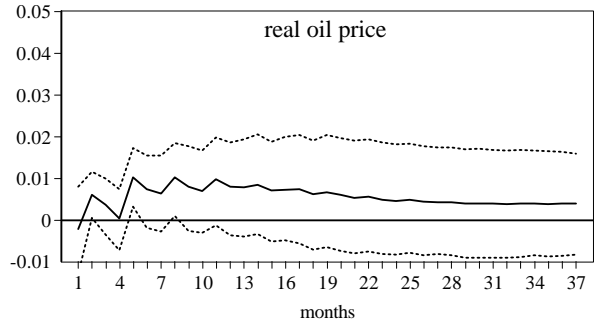
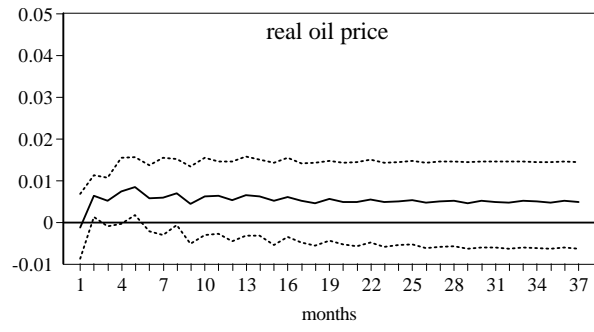
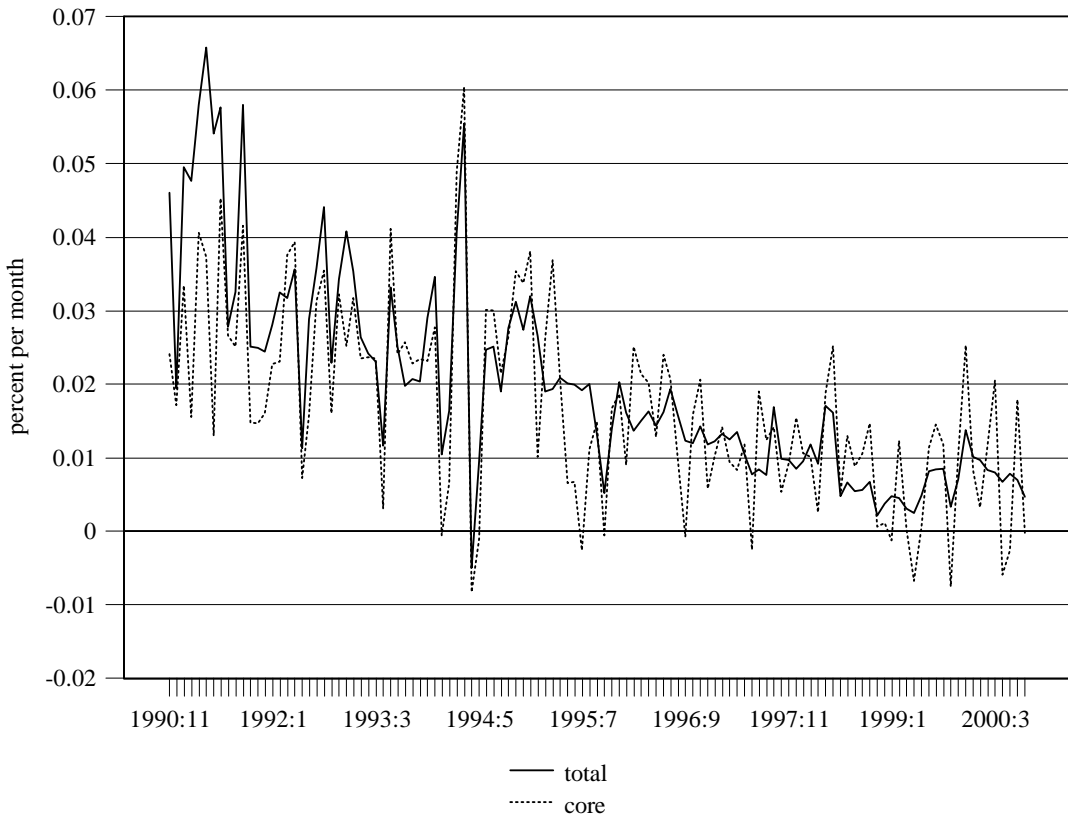
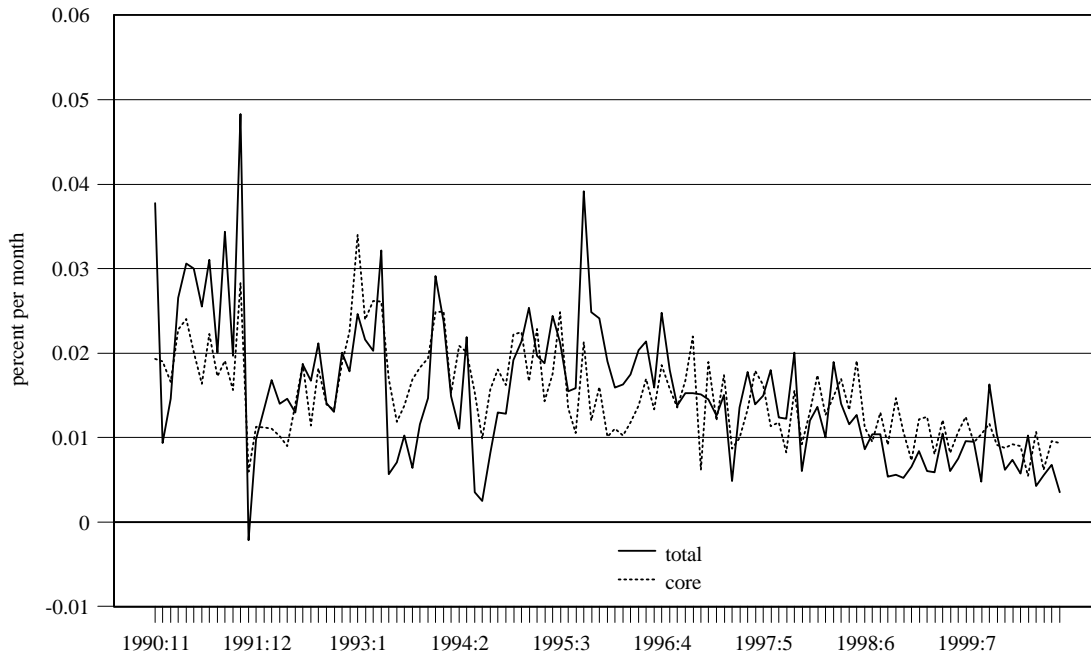


Figure 3. Core and non-core inflation

a) Poland



b) Hungary





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Figure 1. Response of the Price Level

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b) Hungary

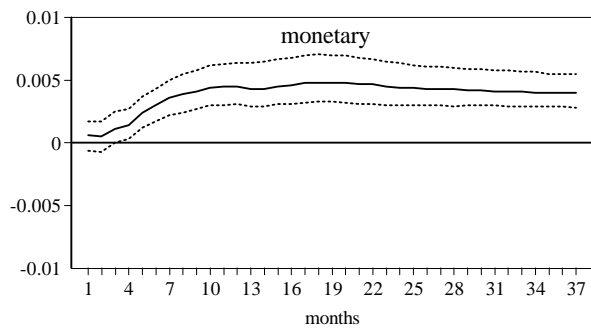
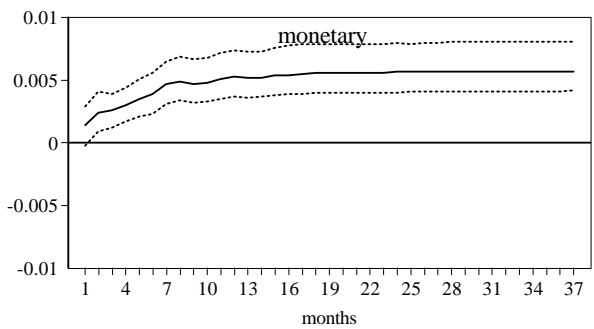
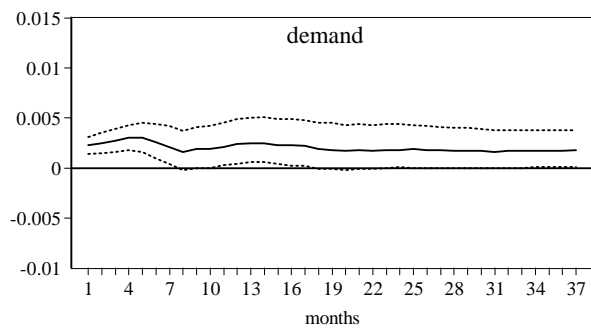
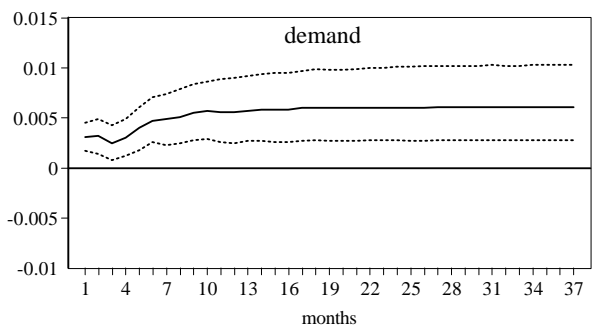
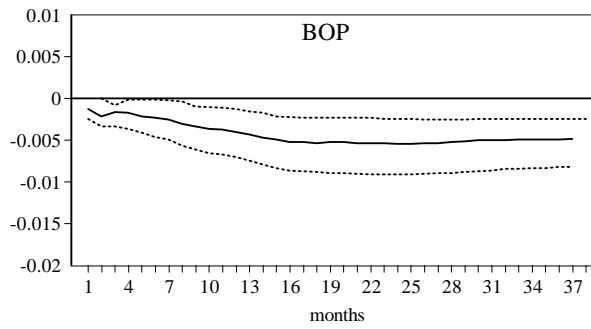
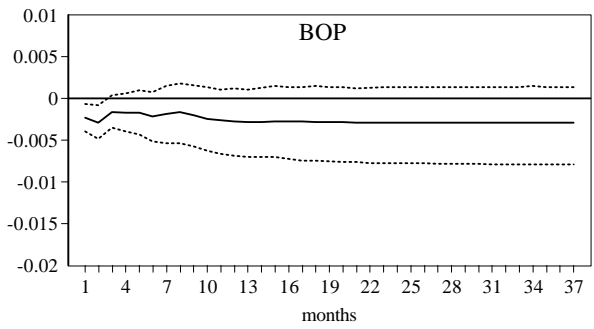
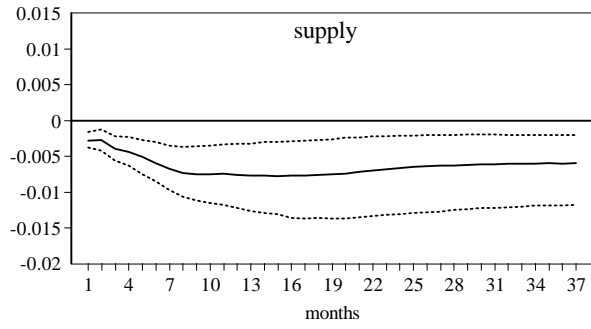
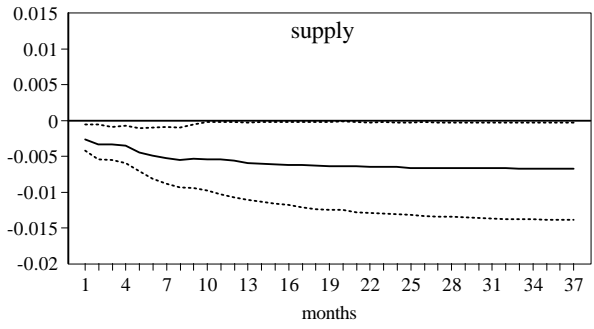
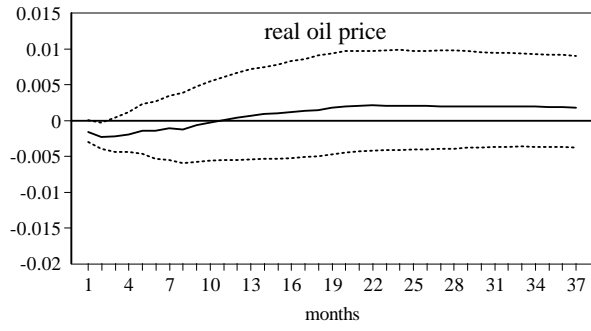
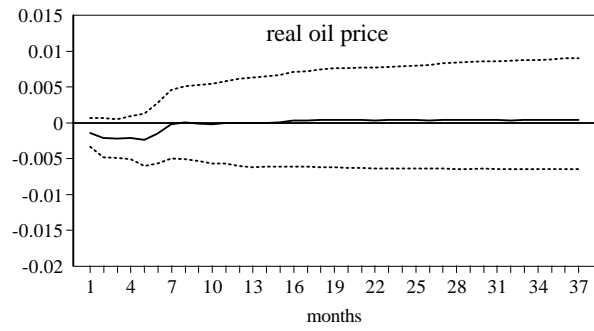


Figure 2. Responses of Output

a) Poland

b) Hungary

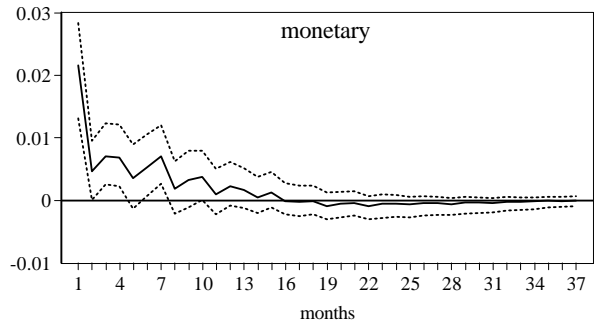
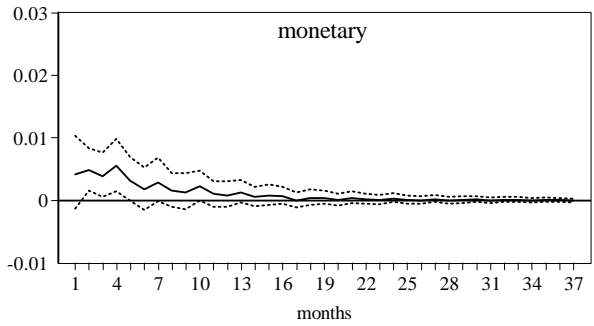
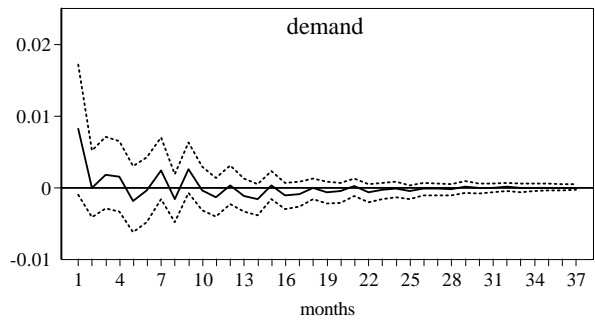
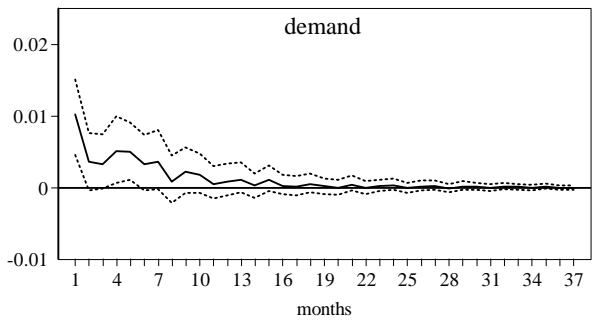
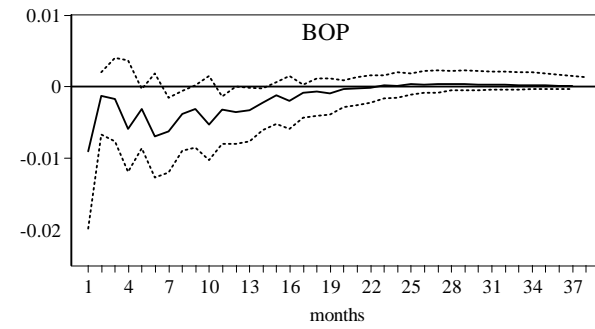
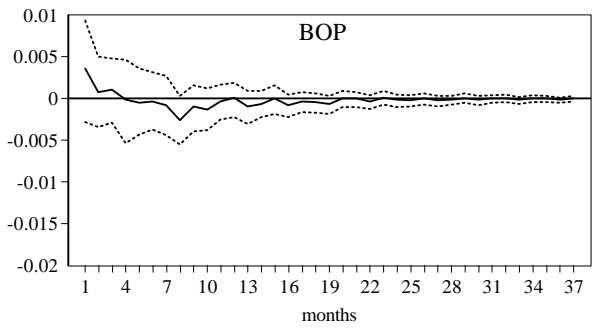
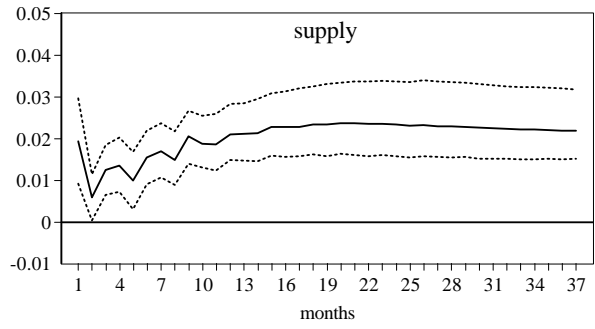
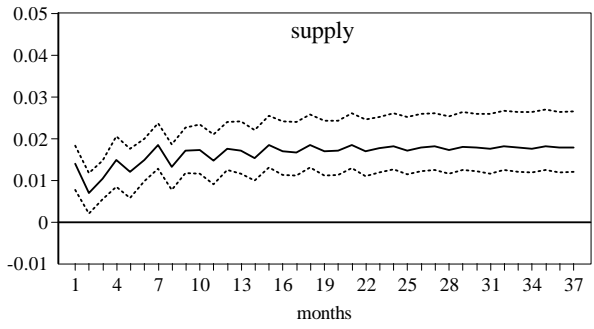
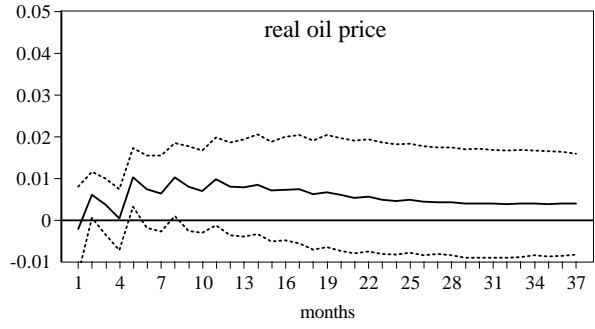
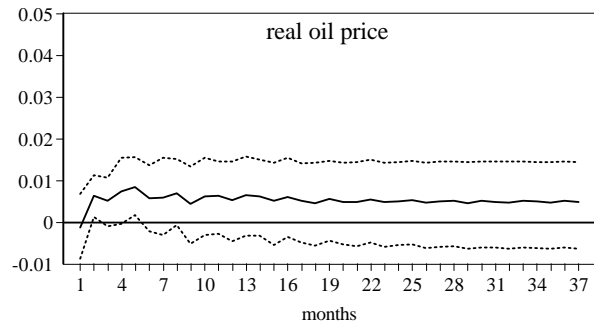
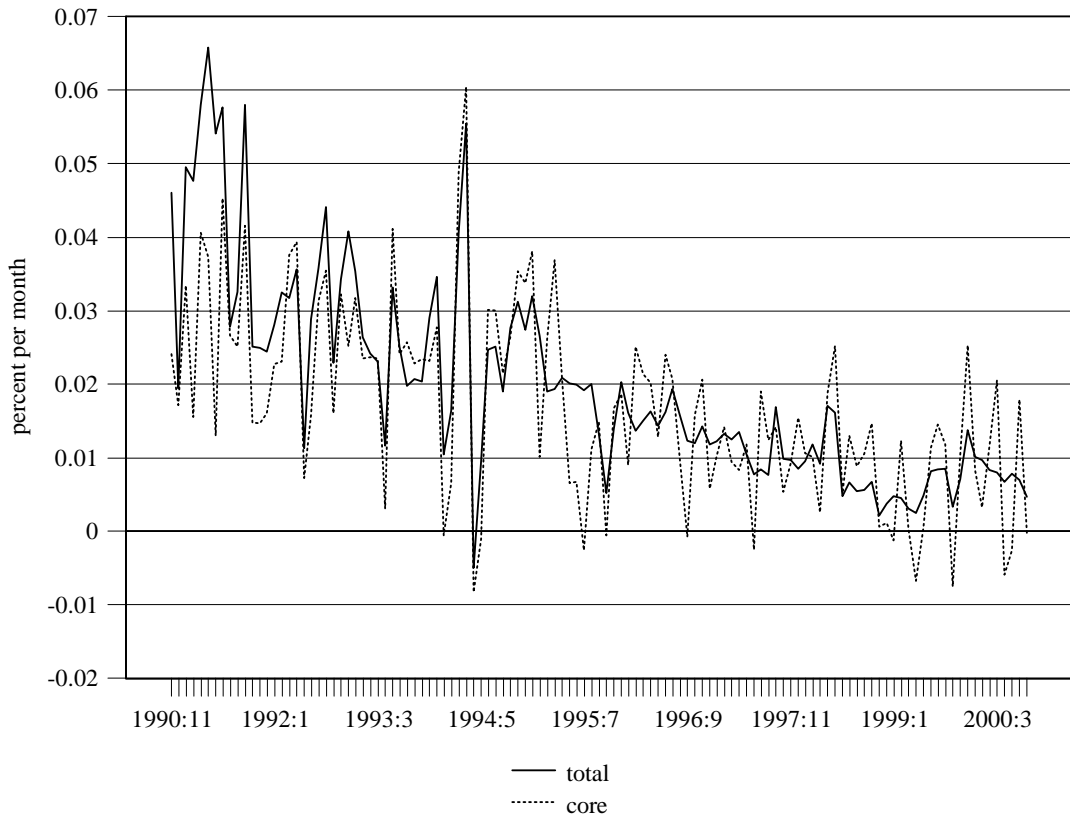


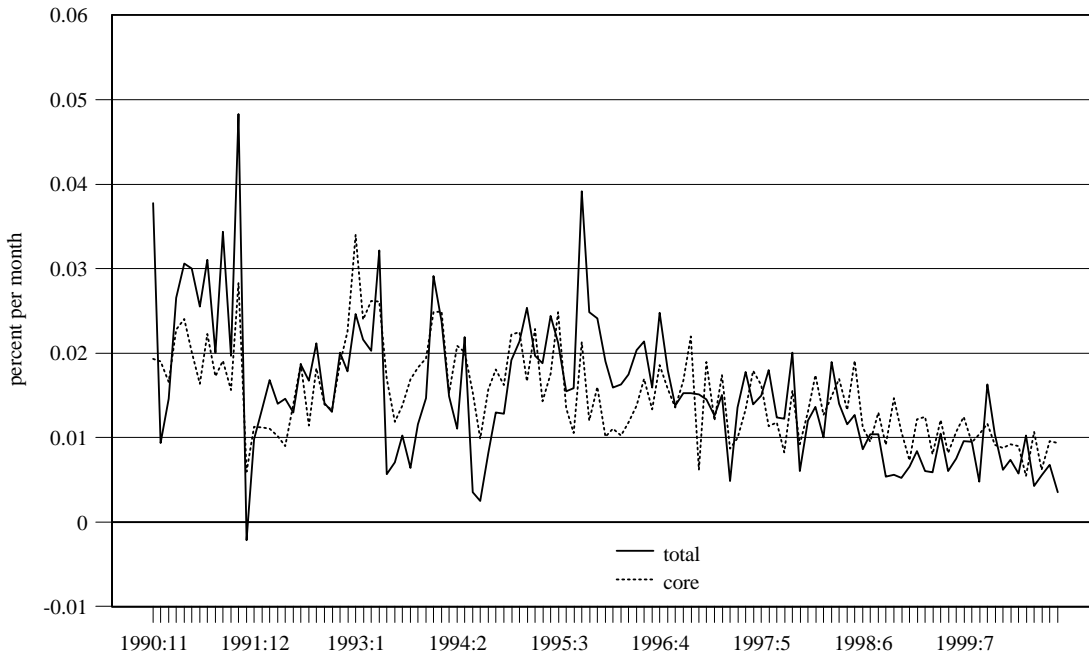


Figure 3. Core and non-core inflation

a) Poland



b) Hungary



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Zentrum für Europäische Integrationsforschung  
Center for European Integration Studies  
Rheinische Friedrich-Wilhelms-Universität Bonn

Walter-Flex-Strasse 3  
D-53113 Bonn  
Germany

Tel.: +49-228-73-1732  
Fax: +49-228-73-1809  
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