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Monetary Policy Transmission Mechanisms and Inflation in the Slovak Republic

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Abstract

This paper presents the results of an empirical analysis into monetary policy transmission mechanisms and inflation in the Slovak Republic. The estimated vector autoregression (VAR) model suggests that inflation is determined by changes in foreign prices, the exchange rate, and wage costs, with a modest effect of aggregate demand, in line with theory for small, open economies. Monetary policy is shown to affect inflation via these channels. Changes in money supply seem to have a modest but rapid impact on prices. The measured effect of interest rate changes is modest and gradual, although it appears to have become more important in recent years.

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I. Introduction

Against the backdrop of a move to more flexible exchange rates and inflation-oriented monetary policy in advanced transition countries including the Slovak Republic, it has become more important to have an insight into the transmission channels of monetary policy. The understanding about these transmission mechanisms is well established for mature economies—the interest rate affects aggregate demand and expectations, whereas in small, open economies the exchange rate channel is added. However, for emerging market countries the mechanism is less straightforward, since the impact of interest rate changes is thought to be weak in those countries (see Box 1).

Empirical studies on advanced transition countries suggest that there is indeed limited *direct* impact of monetary policy on domestic inflation—from either monetary aggregates or interest rates—but they find a sizable impact of foreign prices, the exchange rate, and labor costs, and, in some countries, an effect of aggregate demand.[2] In light of these findings, the estimation procedure should treat the exchange rate, wages, and aggregate demand as endogenous and should be able to capture the *indirect* effect of monetary policy on prices via those variables.

The vector auto regression (VAR) technique is well suited for the empirical analysis of the behavior of a set of endogenous variables. Most VAR models are estimated without imposing restrictions on the relationships between variables. However, in transition economies, the short time series and abundance of structural changes reduce the likelihood of finding meaningful relationships based purely on data. A structural VAR estimation assesses whether relationships suggested by theory can be found in the data. For instance, Golinelli and Rovelli (2000) fruitfully applied a structural VAR on transmission mechanisms in the case of Hungary, and they found that "...the transmission of monetary policy impulses to macro variables is characterized in a fashion similar to that of advanced open industrial countries...the interest channel on aggregate demand and the exchange rate channel work together..."

This paper analyses the transmission of monetary policy impulses in Slovakia through the use of a structural VAR. As in the Golinelli and Rovelli paper, the approach is consistent with Svensson's model for small, open economies where the exchange rate is key (see Box 1). Svensson's model, though, is meant to represent a mature market economy, and thus relies on the interest rate as the only instrument of monetary policy. This approach needs to be qualified for a transition economy such as Slovakia. Until recently the framework of monetary policy in Slovakia was based on controlling monetary aggregates rather than setting interest rates. Moreover, previous empirical studies suggest that the impact of interest rate changes is still rather weak, while some studies suggest a sizable and more rapid impact of changes in broad money (see also Box 1). Therefore, the model and its estimation do not specify the channels and instruments in advance, and broad money turns out to play an important role.

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[2] See Doyle (2001) on Poland; Tzanninis (2000) on the Czech Republic; and Griffiths and Woo (1997) and Kuijs (2000) on the Slovak Republic.

Box 1. Monetary Policy Transmission Mechanisms in Small, Open Transition Countries

In mature market economies, the stance of monetary policy is typically represented by the policy interest rate. In a relatively closed economy, the main channels through which monetary policy affects inflation are aggregate demand and expectations. In an open economy, additional channels are (in the order of speed) (i) a (very fast) direct exchange rate channel for the transmission of monetary policy to inflation via the price of imports; (ii) a real exchange rate effect on aggregate demand via the relative prices of foreign and domestic goods; and (iii) the impact of the exchange rate on the price of domestically produced goods, via the price of imported intermediate inputs and wages. In addition, a more open economy will be affected to a greater extent by (i) possible wealth effects through the exchange rate as an asset price, and (ii) foreign shocks (Svensson,1998).

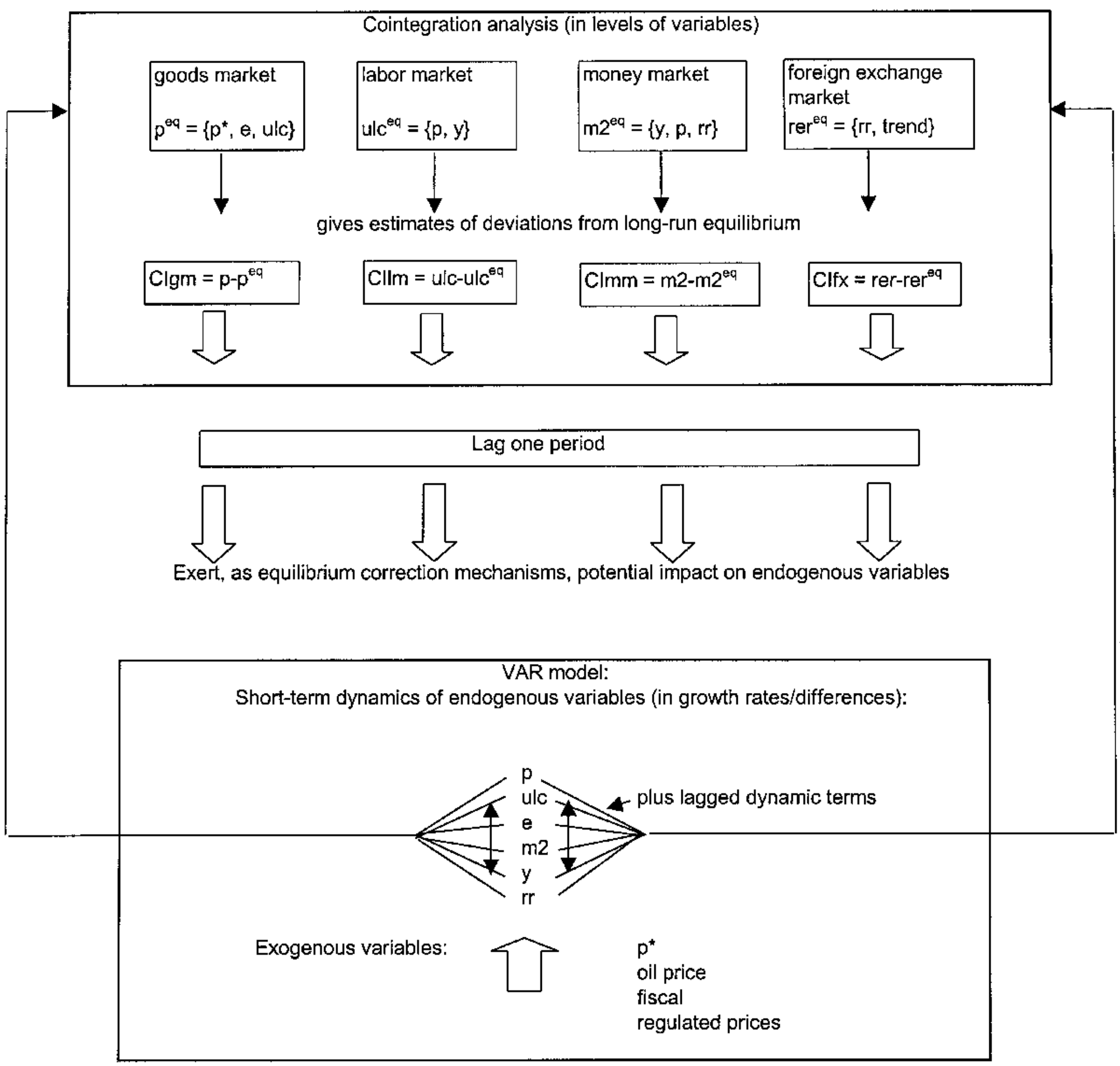
In emerging markets and transition countries, the pass-through from the exchange rate to inflation is generally higher than in more developed countries (Calvo and Reinhart, 2000). At the same time, the policy channels relied on by central banks in mature market economies can be rendered less effective in emerging markets by corporate and bank balance sheet problems, and underdeveloped financial markets. The lack of maturity and depth of the financial system has been shown to impede the smooth transition of monetary policy impulses (Cottarelli and Kourelis, 1994). In particular, in transition countries the impact of interest rate changes on credit has been found to be weak, owing to highly interest inelastic lending policies of banks burdened by nonperforming loans, undeveloped financial markets, and strong capital inflows (see Schaechter, Stone, and Zelmer, 2001).

In Slovakia, the current interest-rate-based monetary policy is a relatively new phenomenon. The interbank money market was introduced in 1995. Prior to October 1998, monetary policy was to a large extent based on maintaining an exchange rate peg and controlling monetary aggregates. Moreover, bank restructuring and bouts of financial turbulence have meant that banks' lending to the private sector has often been constrained by factors other than the monetary policy stance.

Nevertheless, recent empirical work on Slovakia suggests that plausible transmission channels can be quantified. Gavura, 2001—using Granger causality tests and bi-variate VARs—finds a very strong impact of the exchange rate on prices, some impact from monetary aggregates and wages, although "virtually no effect" from interest rates. In addition, a relatively stable money demand function can be found (see Kuijs, 2000) and, more comprehensively, Alquist, 2001). Finally, Chuda and Ševčovic, 2000 find that Slovakia's financial system transmits the interest rate increases of the National Bank of Slovakia (NBS) to other interest rates, and that interest rates have some impact on credit creation.

The period covered in this study is 1993–2000, and monthly data are used, to maximize the number of observations. Figure 1 depicts the basic scheme of empirical analysis. The empirical analysis in this paper finds that the main direct determinants of consumer prices are foreign prices, the exchange rate, and labor costs, with some additional impact from aggregate demand. Policy can affect inflation through those channels, and the empirical results suggest that monetary policy has significant (indirect) effects via all these channels. Changes in monetary aggregates appear to have a modest but rapid impact on prices. The impact of interest rate

Figure 1. The Basic Scheme of Empirical Analysis.



changes on prices are modest and gradual. At the same time, though, the results indicate that the interest rate channel has become more important in recent years.

The paper is structured as follows. In Section II, long-run equilibriums are specified for the markets for goods, labor, money, and foreign exchange, in line with economic theory. Section III describes the estimation of those long-run equilibriums as cointegration relationships. In Section IV, a dynamic VAR model is estimated with six endogenous variables that are assumed to be affected by the equilibrium correction mechanisms (ECMs) from the four long-run relationships and additional dynamic effects. In section V, the implications of the model are illustrated by impulse response analyses.

Box 2. Brief Overview of Inflation and Monetary Policy (1993–2000)

Slovakia's relatively good inflation performance during transition reflected forceful monetary policy and moderate wage pressures, facilitated by high unemployment and tripartite consensus between business, employees, and the government. Postponement of administered price increases further moderated price pressures. After inflation of 25 percent in 1993 (the first year as an independent country) on the heels of the introduction of the VAT and a 10 percent devaluation, inflation fell gradually to some 7 percent at end 1995, and remained at about this level until mid-1999, despite considerable turmoil in the foreign exchange market. With three years of current account deficits at 10 percent of GDP during 1996–98—partly reflecting a lax fiscal stance—capital flows variability led to a stepwise widening of the fluctuation bands for the peg to a deutsche mark/U.S. dollar basket. Persistent pressure on the foreign exchange market led to the floating of the koruna in 1998, despite a very tight monetary stance. Under the float, which remains in place today, monetary policy has increasingly been geared toward inflation goals. Although the National Bank of Slovakia views a stable, competitive exchange rate as important for the very open Slovak economy, it has adopted a policy of only intervening on the foreign exchange market to avoid sharp oscillations of the exchange rate—indeed, it has abstained from intervention since January 2001. In 1999–2000, administered prices were raised in the context of tightening the fiscal stance, temporarily boosting headline inflation; but with the domestic economy weak, core inflation remained subdued at 5–6 percent, subsequently falling below 4 percent in 2001, despite a recovery of domestic demand. Current account pressures resurfaced during 2001, and could pose dilemmas for the policy mix in the period ahead.

II. Long-Run Relationships in Four Markets

In line with economic theory, four long-term relationships are identified describing equilibrium on the markets for goods, labor, money, and foreign exchange.

On the ***goods market***, in the long run, the consumer price is expected to be determined by a weighted average of import prices (tradables) and domestic unit labor costs (nontradables).

$$P = f(P^{*} * E,\ ULC,\ other?), \tag{1}$$

where P denotes the core CPI index, P^* is the German CPI index (adjusted for the impact of Slovak import tariffs), and E is the DM exchange rate. *ULC* denotes whole economy unit labor costs, for which data are constructed in the absence of ULC data for nontradables.[3]

On the **labor market**, a Phillips curve type of labor market implies that in the long run the real wage is a function of labor productivity, adjusted for the degree of overheating. Thus:

$$W / P = f\,(labor\ productivity,\ output\ gap) \rightarrow$$

$$ULC = W / labor\ productivity = f\,(P,\ output\ gap), \tag{2}$$

Where W is the wage rate. Using the core CPI index in equation (2) as well reduces the number of necessary variables in the estimation—which is a key consideration. It is also justified from an economic point of view. The movement of the headline CPI has started to diverge from that of the core CPI only recently, owing to large administered price increases, on which there was consensus that they had to be absorbed by households as a real wage decline.

On the **money market**, a standard money demand function is assumed, in line with previous work discussed in Section I.

$$M2 = f\,(GDP,\ P,\ RR), \tag{3}$$

Where RR is the real interest rate, constructed by deflating the one-month interbank rate.

On the **foreign exchange market** (the balance of payments), a relationship is postulated for the real exchange rate, in terms of consumer prices, vis-à-vis Germany, and adjusted for Slovak import tariffs: $RER = P / (P^* * E)$. In a mature market economy without capital mobility, purchasing power parity would suggest that the *RER* be stationary, or constant in the long run. In an emerging transition country, with rapid productivity growth in the tradables sector, the presence of Balassa-Samuelson effects would suggest a trend appreciation of the *RER*, with the coefficient of the trend bearing a relationship to the tradables productivity differential between the host country and its trading partners.[4] Moreover, portfolio (and other capital market) effects suggest the inclusion of the real interest rate.

$$RER = f\,(RR,\ trend) \tag{4}$$

Table 1 lists all the variables and data sources. Figures 2 and 3 chart the variables of interest.

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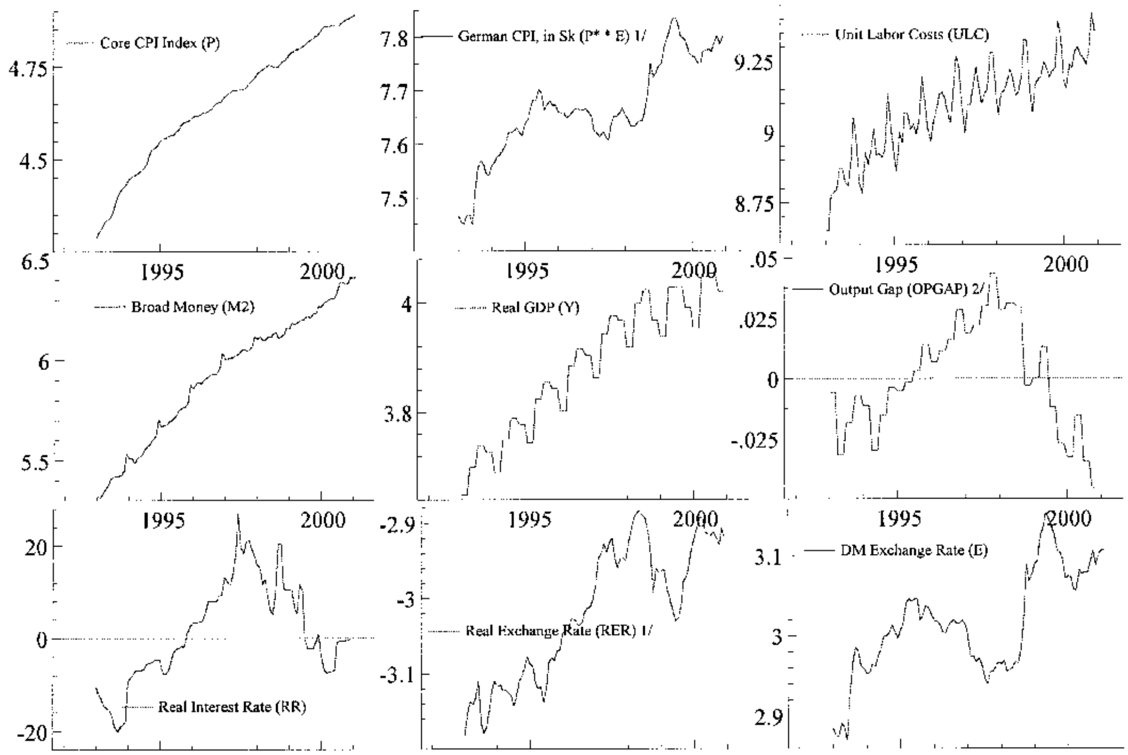
[3] Monthly data for industry wages are used to approximate whole economy wages, justified by the strong correlation between the two on an annual basis. There is no such correlation for labor productivity. Monthly data for whole economy productivity are obtained by interpolation.

[4] For a discussion of Balassa-Samuelson effects, see Froot and Rogoff (1995).

Figure 2. Key Variables, 1993–2000
(in logs)



Sources: Slovak Statistical Office; National Bank of Slovakia; and IMF staff estimates.
1/ Adjusted for Slovak import tariffs.
2/ See Table 1 on calculation of output gap.

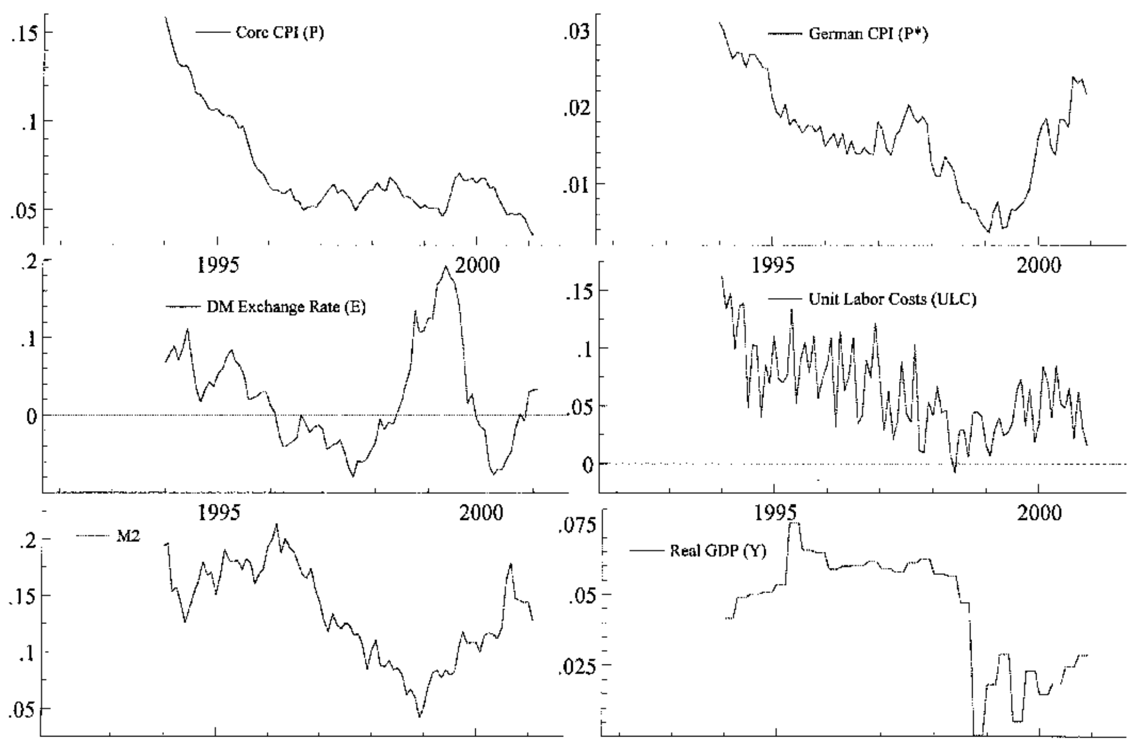
III. Estimation of Cointegration Relationships

Individual time series properties of the data were tested using Dickey-Fuller (unit roots) tests. As Table 2 shows, these suggested that all variables, including the real interest rate (*RR*), are nonstationary, but could be made stationary by taking first differences—hence, they are I(1), rather than I(0) or (I(2). The presence of long-run equilibrium relationships as postulated in section II was initially tested with the Johansen procedure.[5] Rank testing suggested that there were up to four long-run relationships among the set of six variables $\{P, (P^* * E), ULC, M2, Y, RR\}$ (see Appendix I). Attempts were made to identify a system of four long-run relationships as close as possible to the priors discussed in Section II by imposing (statistically accepted) restrictions based on the priors. However, the coefficients of identified systems (see Appendix I) were deemed not close enough to the theoretical priors.

[5] See Johansen, S. (1988).

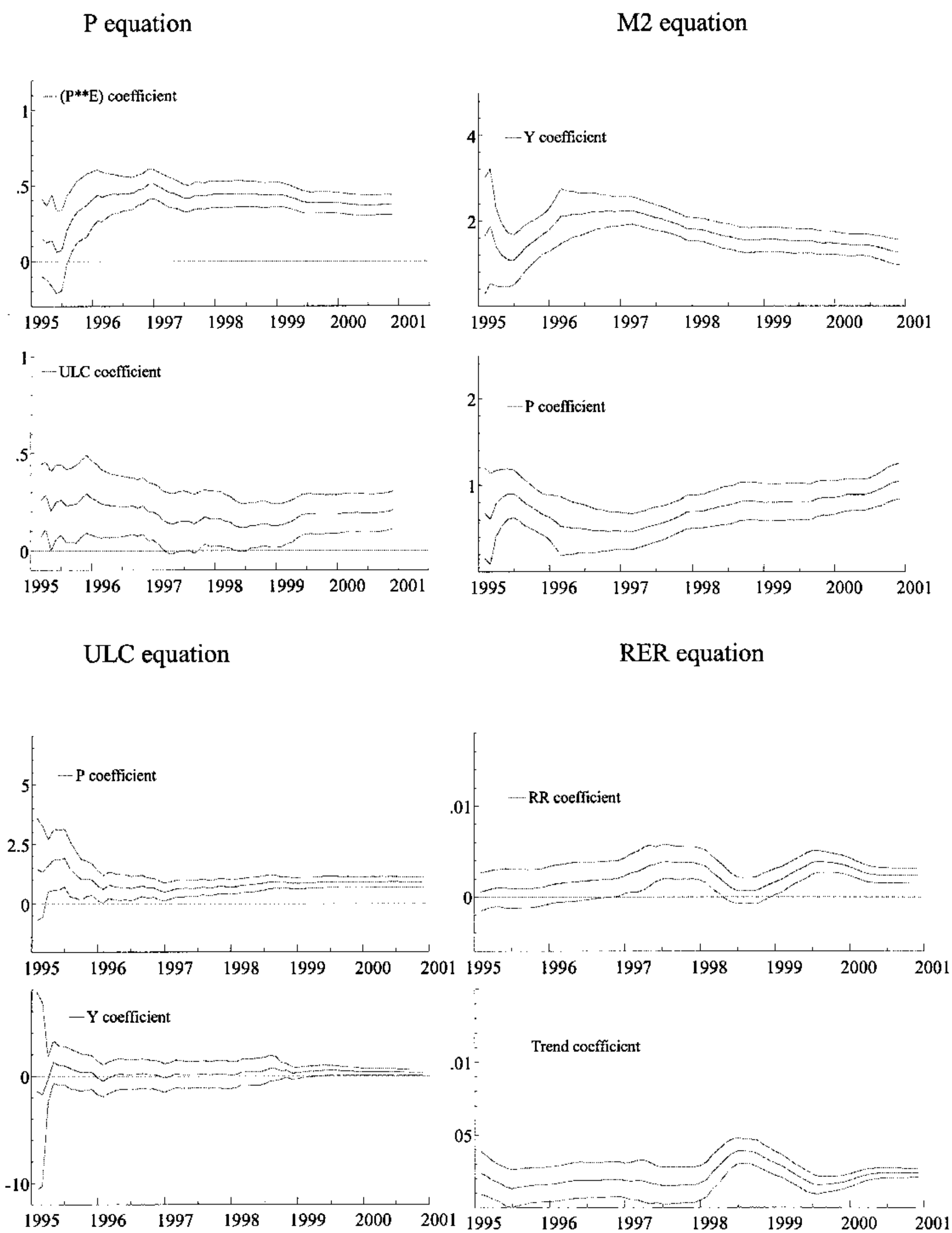
Instead, the estimation proceeded using a two-stage method: first estimating separately the four long-run relationships, then including them as ECMs in a dynamic model for the endogenous variables. The technical drawback of this approach is that it is (statistically) a less efficient procedure than the Johansen approach. The economic advantage is that—in this case—it allowed for the identification of long-run relationships with coefficients closer in line with the priors. Given the short time series and structural changes during the 1990s, the economic advantage was considered more important than the technical drawback. The single equation results are listed below as equations 5–8, with t-statistics in parentheses. The ECMs were shown to be all stationary (Table 2), which strengthened the legitimacy of the approach. The test results are shown in Appendix I). Figure 4 shows estimates of the parameter constancy of the equations, obtained after recursive estimation. Although some of the parameters vary over time, they do not move outside the initial error bands.

Figure 3. Key Variables, 1993–2000
(year-on-year growth)



Sources: Slovak Statistical Office; National Bank of Slovakia; and IMF staff estimates.

Figure 4. Long-Run Equations: Parameter Constancy, 1995–2000



On the ***goods market***:

$$LP = 0.37*L(P^{*}*E) + 0.21*LULC - 0.0006*FLOAT + 0.0044*trend - 0.37 + seasonality \quad (5)$$
$$\quad (11.2) \qquad (4.4) \qquad (-9.0) \qquad (16.2) \qquad (-1.0)$$

The equation suggests a strong impact on consumer prices of import prices, and a significant impact of wage costs. Initial results suggested a structural break coinciding with the shift in October 1998 from an exchange rate peg to a floating exchange rate regime.[6] The variable *FLOAT* (the product of a dummy for the period from October 1998 onwards and a trend) is capturing the structural break. The trend is included to pick up "other" influences.

On the ***money market***:

$$LM2 = 1.27 * LY + 1.04 * LP - 3.80 + seasonality \quad (6)$$
$$\quad (8.6) \qquad (10.1) \qquad (-27.1)$$

This equation suggests, consistent with previous results,[7] that the coefficients for prices and real output are relatively close to 1 (although the coefficient of real output is statistically significantly higher than 1) and there is no significant impact from (real) interest rates. The residual of this long-run relationship shows the difference between money supply (M2) and money demand measured by income and prices, i.e., the monetary policy stance.[8]

On the ***labor market***:

$$LULC = 0.92 * LP + 0.33 * LY - 0.00156 * trend + 3.72 + seasonality \quad (7)$$
$$\quad (8.7) \qquad (2.6) \qquad (-2.7) \qquad (7.9)$$

This equation is specified using output (LY), rather than the output gap (OPGAP), as in equation 2. However, the two specifications are interchangeable.[9] Theory would suggest a coefficient on P of 1, but this is rejected statistically. The coefficient on *P* being lower than 1 implies that so far during transition, real wages have increased somewhat less than productivity. The results suggest that, in the long run, *real* unit labor costs are predominantly a function of the output gap, with a

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[6] Changes in coefficients after the introduction of an inflation-based, rather than an exchange-rate-based, monetary policy regime have also been observed in other countries. See Schaechter, Stone, and Zelmer, (2000).

[7] See Kuijs (2000) and Alquist (2001).

[8] Strictly speaking, this is true only in the absence of structural changes.

[9] Equation 7 can be rewritten, using the results of regressing *LY* on a trend (and seasonal dummies) to obtain the output gap. This regression suggested a coefficient for the trend of 0.00393. Equation 7 would than be: $LULC=0.92*LP+0.33*OPGAP-0.00026*trend+seasonality$.

relatively small residual impact (-0.3 percent per year) picked up by the trend. Figure 4 suggests that the coefficient on output was very small up to 1997, but has recently increased. This suggests that wage costs have become increasingly sensitive to the business cycle—a characteristic associated with more mature market economies.

On the ***foreign exchange market:***

$$LRER = 0.0024 * RR + 0.0024 * Trend - 3.17 \quad (8)$$
$$\quad\quad (6.2) \quad\quad\quad (15.7) \quad\quad\quad (-329.1)$$

This equation suggests that, in long-run equilibrium, a 1 percent increase in the real interest rate is associated with a 0.24 percent more appreciated real exchange rate, while Balassa-Samuelson type factors would allow for a trend appreciation of the CPI-based real exchange rate of (12*0.24=) 3.6 percent per year. The strong correlation between wage growth in the tradables and nontradables sectors (see footnote 3) is consistent with B-S type of appreciation. Figure 4 suggests that the coefficient of the real interest rate has increased over time, but that the trend was disturbed during the exchange market turmoil of 1998–99.

The residuals of the cointegration relationships—which represent estimates of deviations from the long-run equilibria—are shown in Figure 5. Unit root tests suggest they are stationary, although those for the money and foreign exchange markets only at the 5 percent level (see Table 2). The residuals will be used as ECMs in the subsequent specification of dynamic equations for the endogenous variables.

IV. Dynamic Model

The dynamic model consists of six equations for the endogenous variables $\{P, E, ULC, M2, LY,$ and $RR\}$. Their first differences were regressed on the four (one period lagged) ECM terms derived above, the (one period) lagged differences of all endogenous variables, and the exogenous variables.[10] The exogenous variables are the oil price, denominated in koruna (*POIL*), German consumer prices (P^*), a fiscal variable (*FISC*), and regulated prices (*PREGUL*). The dynamic model was estimated as a VAR, over the period March 1993–December 2000. Table 3 shows the results from a more parsimonious specification after eliminating insignificant variables.[11] The dynamic equations are interpreted as follows:

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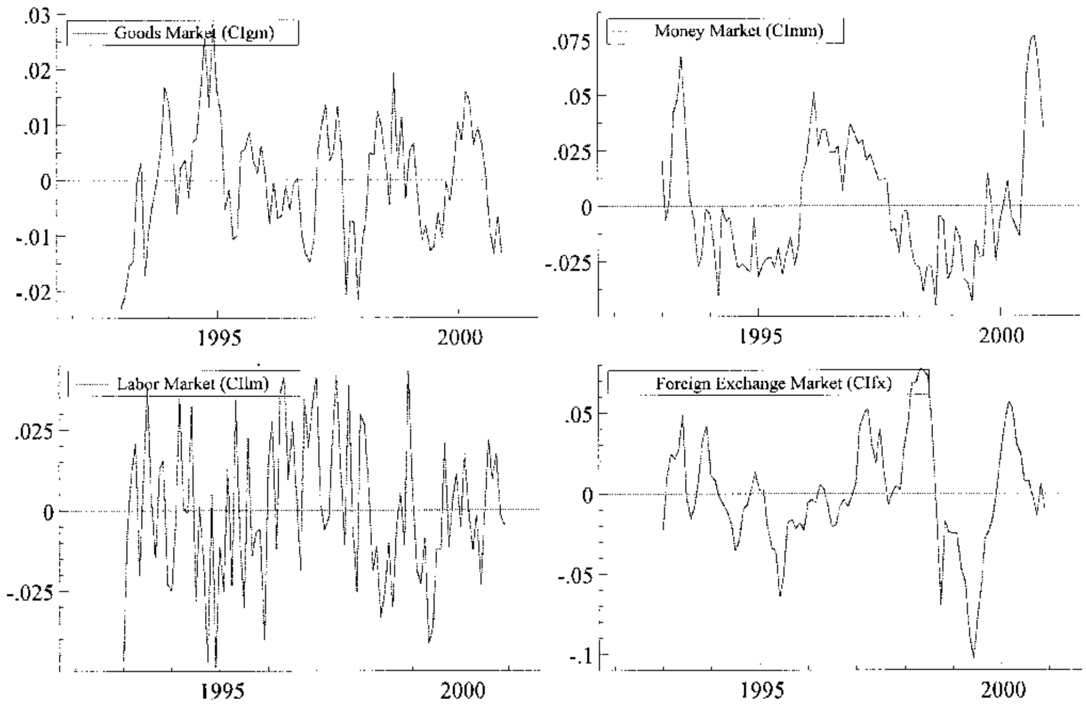
[10] The results suggested that including only one lag implies virtually no loss of information, compared with including two lags.

[11] A few dynamic effects that appeared strongly at odds with theory were considered spurious and were also removed.

Figure 5. Cointegration Relationships, 1995–2000



Sources: Slovak Statistical Office; National Bank of Slovakia; and IMF staff estimates.

The price level (*P*). The only significant ECM is that of the goods market. Its coefficient indicates that if the price level is different from its equilibrium as defined by the long-run relationship, 9 percent of the gap would be undone every month. Additional dynamic effects are found only from the exchange rate and aggregate demand. These results mean that in terms of *direct* effects, prices are determined by foreign prices, the exchange rate, unit labor costs, and aggregate demand. With no direct effect of monetary policy (the monetary ECM, or "excess money"), its impact will have to come via the direct determinants of the price level.

The exchange rate (*E*).[12] The foreign exchange ECM is the only significant ECM. The equation suggests that if the real exchange rate is more appreciated than its equilibrium the koruna depreciates against the DM, reversing 9 percent of the disequilibrium every month. The dynamic effect from aggregate demand (*Y*) suggests that higher aggregate demand in itself (i.e., abstracting from the impact via policy responses) exerts depreciation pressure. A plausible explanation for this effect would be via higher imports and a weaker current account.

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[12] Note that the nominal exchange rate is defined in terms of Sk/DM; a higher number means a depreciation, whereas, by convention, the real exchange rate is defined such that a higher number means an appreciation.

Unit labor costs (*ULC*). As expected, the labor market ECM has a very strong effect. The surprisingly significant effect of the money market ECM suggests that a loosening of the monetary policy stance tends to increase unit labor costs. With the ECMs explaining the behavior of ULC rather well, no additional dynamic effects are found to be significant.

M2. The money market ECM is found to be significant, with the expected sign. Less obviously, the labor market ECM is also found to be significant. This seems to imply that wage increases tend to increase demand for and supply of money. In addition, dynamic effects are found from the core CPI and the oil price. The fiscal variable (*FISC*) is also found to have an impact on *M2*: a higher budget deficit tends to increase *M2*. Although this effect is in a sense mechanical, the finding suggests that, in the 1990s, monetary policy accommodated fiscal policy to some extent.

Aggregate demand (*Y*). Two dummy variables were included to improve the fit.[13,14] Significant dynamic effects could be found from real interest rates (*RR*) and regulated prices. The real interest rate effect suggests a remarkably rapid impact on aggregate demand (in one month). However, the impact is very modest in size—a 1 percentage point increase in the real interest rate would result in a 0.04 percent fall in output—confirming previous findings and views.

The real interest rate (*RR*). The coefficient of the foreign exchange market ECM suggests that if the real exchange rate is 1 percent higher than its equilibrium value as defined by the long-run relationship the real interest rate will increase by 0.2 percentage point. The higher real interest rate is necessary to sustain a more overvalued real exchange rate. In addition, a dynamic effect from aggregate demand is found: a 1 percent higher (monthly) output growth would lead to a 0.7 percentage point increase in real interest rates. Both effects suggest that the real interest rate responds to macroeconomic imbalances by reducing them.

The Appendix I shows the test statistics for the six equations and Figure 6 shows actual and fitted values and residuals. The residuals of none of the equations—except for the unit labor cost equation—are distributed normally. This is due mainly to a few large outliers for all equations (see Figure 6). In general no attempt has been made to remove the outliers by including dummy variables. Experimentation with such removal suggested that, while this improved the fit, it had a negligible impact on the specification of the equations. The Portmanteau tests suggested no autocorrelation of the residuals. The ARCH tests suggested no heteroscedasticity, although the vector ARCH test found some evidence of heteroscedasticity at the 5 percent significance level.

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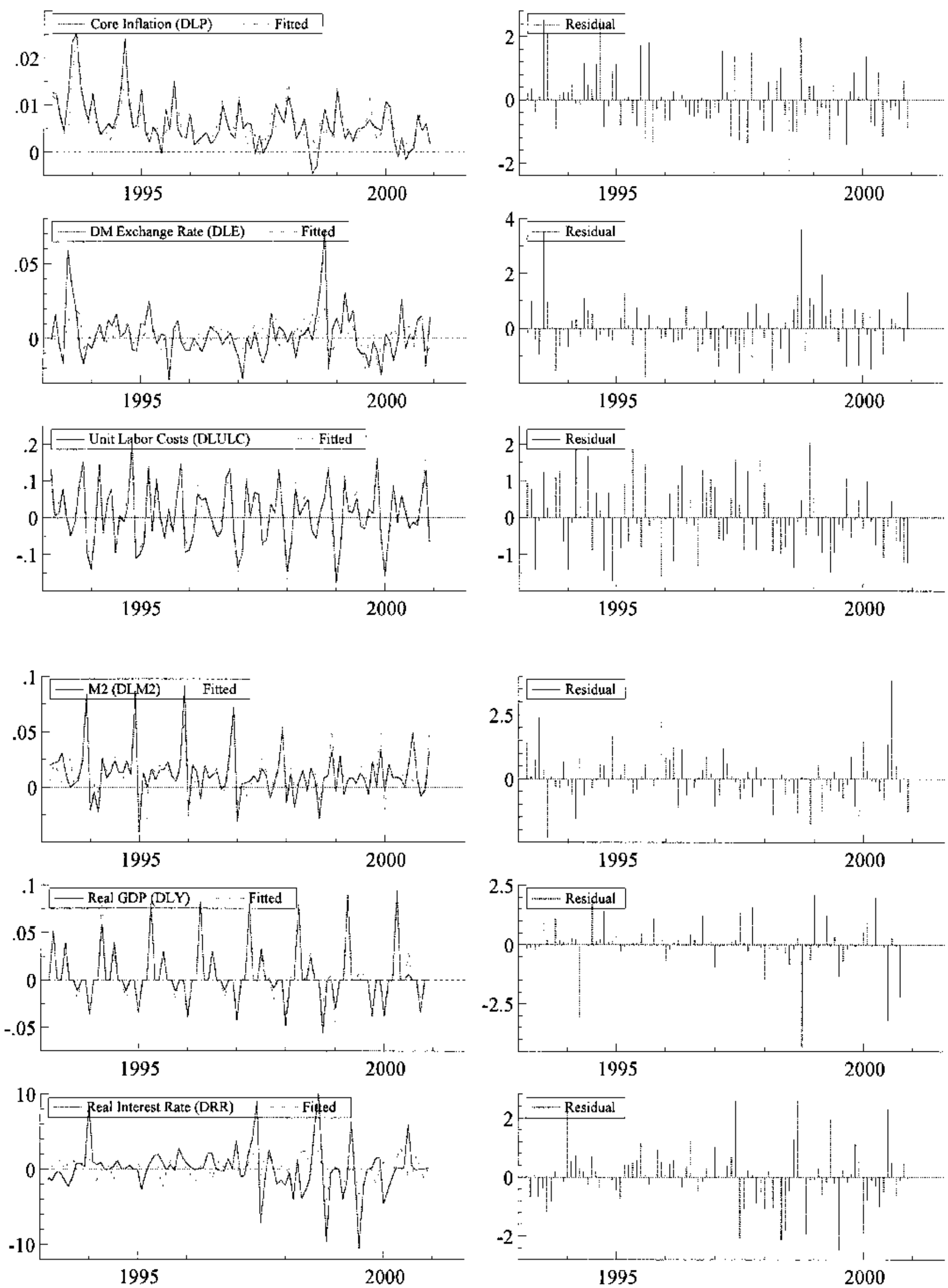
[13] For April 1993 and October 1999. These dummies have no obvious information content.

[14] The goods and labor market ECMs were found to be significant. However, these were difficult to justify conceptually. They were therefore considered spurious, and removed.

Figure 6. Dynamic Model, Actual and Fitted Values, and Residuals, 1995–2000



Sources: Slovak Statistical Office; National Bank of Slovakia; and IMF staff estimates.

The regression results can be summarized as follows. First, the main *direct* determinants of inflation are foreign prices, the exchange rate, and wage costs, with some additional impact from aggregate demand. Second, no *direct* impact of monetary policy on prices could be found (from either monetary aggregates or interest rates). Third, there is a statistically significant *indirect* impact of monetary policy on prices, via the impact of interest rates on the exchange rate and aggregate demand—which, in turn, is found to have a direct impact on prices, the exchange rate, and wage costs—and the impact of broad money on wage costs. Hence, the "standard" monetary policy transmission mechanisms on which central banks in more mature open market economies rely are present. Fourth, however, the size of the effects of broad money changes and interest rate changes on prices seems to be modest and, in the case of interest rate changes, gradual, particularly during the first part of the period under investigation.

In Section V, policy simulations are discussed to illustrate the behavior of the model formed by the six equations, allowing all the effects discussed above to operate simultaneously.

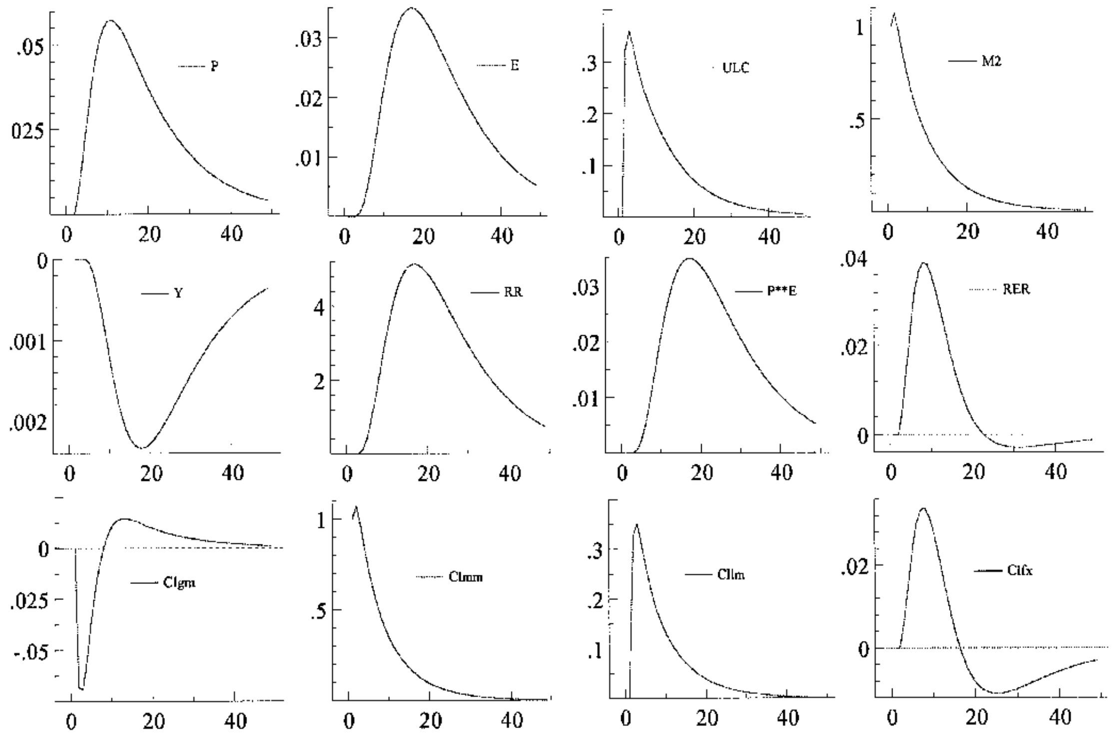
V. Impulse Response Functions

The simulation properties of the VAR model were assessed by conducting impulse response analysis with respect to innovations in M2, the real exchange rate, and the exchange rate.[15] The low correlation between the residuals of these variables (see Appendix I) allows for the analysis of innovations in isolation (without orthogonalization).

Shocking *M2* equation (Figure 7). As discussed in Section V, a higher level of broad money tends to lead to higher unit labor costs, and therefore higher prices. The impact takes time to feed through, and the maximum effect on prices—0.06 percent for an initial 1 percent increase in *M2*—takes place after around 10 months. The impact of higher broad money on output is very small, compared with its impact on prices. Remarkably, this effect on output is negative, owing to the response of real interest rates to the initial expansionary shock that brings the economy back to equilibrium. As the response of prices to the money shock is initially stronger than that of the exchange rate, the real exchange rate appreciates. This appears to be consistent with the negative effect on output. Eventually, the depreciation catches up with price increases, and the real exchange rate response peaks after less than 10 months. The real interest rate response is responsible for the eventual return of all variables to their baselines. With output returning to steady state in the long run, the model seems to exhibit the neutrality of money. In fact, with the impact on output very small (compared with its impact on prices), money could be said to be almost neutral in the short run.

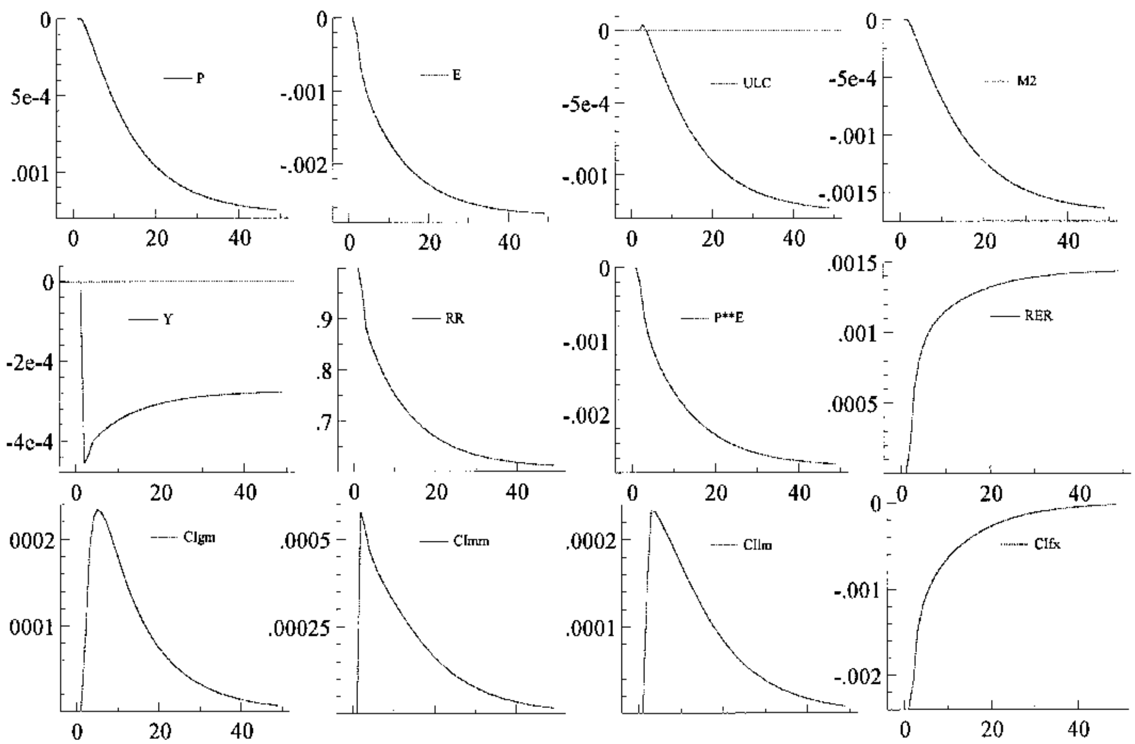
[15] In these analyses, the error term of one of the equations was given an impulse shock of 1 percent in the first period (for the real interest rate equation, the shock was 1 percentage point).

Figure 7. Impulse Response: Shock M2 Equation by 1 Percent



Source: IMF staff estimates.

Figure 8. Impulse Response: Shock Real Interest Rate (RR) Equation by 1 Percentage Point



Source: IMF staff estimates.

Shocking real interest rate (*RR*) equation (Figure 8). A 1 percentage point increase in real interest rates leads to an appreciation of the exchange rate and a (small) reduction in output, thus exerting downward pressure on prices and wage costs. The decline in prices is gradual, and it takes a long time before the price level stops falling.[16] After 10 months, the impact on the exchange rate is around 0.17 percent, and the effect on the core CPI only 0.05 percent. This result suggests that large changes in interest rates are required to affect inflation. The insensitivity of prices and output to real interest rate changes is illustrated by the large swings in the real interest rate shown in Figure 2. Although the interest rate does not enter the money demand equation, M2 decreases, due to the impact of the interest rate on output and prices.

Shocking the exchange rate (*E*) equation (Figure 9). A depreciation shock leads to higher prices, with the price level rapidly increasing by 0.4 percent for a 1 percent depreciation. Slightly higher output also results. This seems to be consistent with a better net trade position due to a more depreciated real exchange rate (with the price rise substantially less than the nominal depreciation). The initial depreciation shock depreciates the real exchange rate below equilibrium, because of which the nominal exchange rate moves back by appreciating, thereby also reducing the price increase. Higher nominal GDP leads to higher M2. The real interest rate can decrease, because a lower real exchange rate needs to be sustained (with the impact of higher output on the real interest rate offsetting slightly some of the impact).

VI. Conclusions

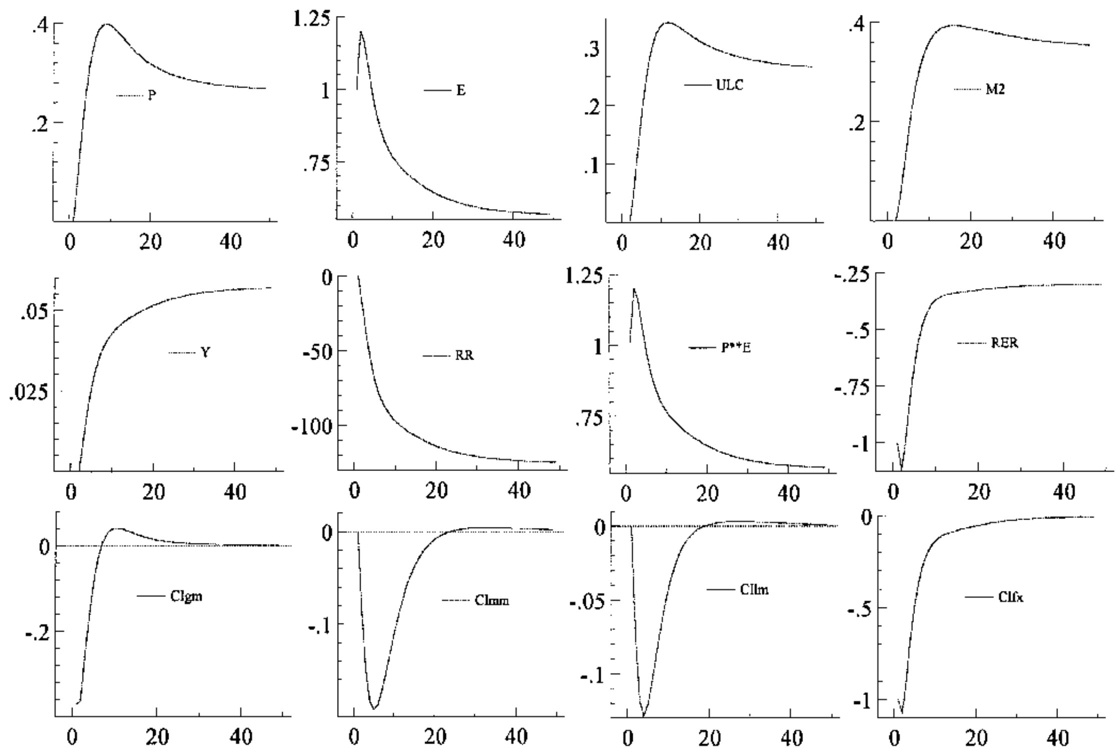
With monetary policy of the NBS increasingly conducted with inflation considerations in mind, it is important to understand the determinants of inflation and the impact of monetary policy on the economy. A structural VAR is estimated, using as ECMs estimated long-run relationships in line with economic theory. The results seem consistent with mainstream economic thinking on the monetary policy transmission mechanisms, inflation determination, the behavior of the exchange rate and aggregate demand, and the policy reaction function of the central bank in a small, open economy such as Slovakia.

The analysis shows that the main *direct* determinants of inflation are foreign prices, the exchange rate, and wage costs, with some additional impact from aggregate demand, but no *direct* impact of either monetary aggregates or interest rates. However, there is a statistically significant *indirect* impact of monetary policy on prices, via the impact of interest rates on the exchange rate and aggregate demand—which, in turn, is found to have a direct impact on prices, the exchange rate and wage costs—and the impact of broad money on wage costs.

[16] One difference compared with the simulation of M2 is that in this simulation the variables—including the real interest rate—eventually settle down at a new equilibrium, instead of eventually returning to the baseline.

The impact of broad money changes seems to be modest in size but rapid. The impact of interest rates on prices is found to be modest in size and gradual. The maximum impact of an initial 1 percent change in broad money on consumer prices is 0.06 percent, and occurs after around 10 months; at that time the impact of an initial 1 percentage point real interest increase would be around 0.05 percent. The latter result indicates that so far during transition the impact of interest rate changes has not been very strong. This is not surprising. The NBS' fully interest-rate-based monetary policy is a relatively new phenomenon, whereas bank restructuring and bouts of financial turbulence have meant that banks' lending to the private sector has often been constrained by factors other than the monetary policy stance. The relative insensitivity of prices to real interest rate changes suggests that, in current circumstances, it would be difficult for the NBS to commit itself to rigid formal inflation targeting. However, several effects contributing to the interest rate channel have recently become more significant, suggesting that the channel will become more important as financial deepening and convergence with the EU continue.

Figure 9. Impulse Response: Shock DM Exchange Rate (E) Equation by 1 Percent



Source: IMF staff estimates.

Table 1. Variable Definitions and Transformations

	Mnemonic	Definition
Endogenous		
	P	CORE CPI Index [constructed prior to 1997]
	E	DM exchange rate
	ULC	Unit labor costs, whole economy Calculated as WAGE/PRODWH
	M2	Broad money
	Y	Real GDP (1995 prices), Interpolated from quarterly data
	RR	Real interbank rate, 1 month 2/ Deflated with CPI inflation
	OPGAP 1/	Output gap Calculated as residual of regression of Y on Trend and seasonal dummies
Identity		
	RER	Real exchange rate, against Germany, adjusted for Slovak tariff Calculated as P/(P**E)
Exogenous/Policy		
	P*	German CPI Index, adjusted for Slovak import tariff Calculated as CPIG * (1+TIMP/100)
	POIL	Oil price (in koruny) [=Oil price, in dollars * Sk/$]
	PREG	Index of regulated prices
	FISC	Net credit to government Deflated with P, differenced, moving average
Auxiliary		
	CPIG	German CPI Index
	TIMP	Effective import tariff (calculated as revenue/import value)
	WAGE	Wage, whole economy Approximated by WAGEind
	WAGEind	Wage in industry
	PRODWH	Productivity, whole economy Interpolated from annual national accounts data, six months moving average
	CPI	Consumer Price Index (Jan. 1989=100)

Sources: Slovak Statistical Office; National Bank of Slovakia; IMF *World Economic Outlook;* and IMF staff estimates.

1/ The output gap is not used in the modeling, but is included for illustrative purposes.
2/ For 1993–94 (when the interbank market did not exist), the (nominal) rate is set equal to 6.91, the level in January 1995.

Table 2. (Augmented Dickey-Fuller) Unit Root Tests

Variable	Mnemonic	Logged	Level			Difference		
			ADF 1/	Significance 2/	k 3/	ADF 1/	Significance 2/	k 3/
Core CPI	P	yes	-2.72		1	-6.10	**	0
Deutsch mark exchange rate (Sk/DM)	E	yes	-1.36		0			
Unit labor costs, whole economy	ULC	yes	-1.59		5	-9.64	**	4
M2	M2	yes	-1.14		0	-12.08	**	0
Real GDP, in 1995 prices	Y	yes	-1.14		6	-8.83	**	5
Real interest rate	RR		-2.00		0	-8.36	**	1
Output gap	OPGAP		0.34		6	-9.29	**	0
German CPI, denominated in Koruna, and adjusted for Slovak import tariffs	P^{*}*E	yes	-1.46		0	-7.93	**	0
Oil price, denominated in Koruna	POIL	yes	-0.30		0	-8.87	**	0
Regulated Price Index	PREG	yes	1.23		6	-2.82		5
Net credit to the government, real, differenced, moving average	FISC		-1.44		4	-5.11	**	3
Goods market cointegration relationship	CIgm		-4.56	**	0			
Money market cointegration relationship	CImm		-2.90	*	0			
Labor market cointegration relationship	CIlm		-8.08	**	0			
Foreign exchange cointegration relationship	CIfx		-3.31	*	1			

1/ MacKinnon critical values for 1, 5, and 10 percent rejection of unit root hypothesis: '-3.62, -2.95, and -2.61 percent, for model with constant and without trend.
2/ * and ** indicate significance at 5 and 1 percent, respectively.
3/ Order of augmentation, or lag used to get t-value.

Table 3: Dynamic Equations 1/

1 DLP =	0.617 * DLP(-1)	+ 0.048 * DLE(-1)	+ 0.075 * DLY(-1)	- 0.09 * CIgm(-1)	+ 0.001		
	(8.5)	(2.0)	(1.7)	(-2.9)	(1.1)		
2 DLE =	0.296 * DLE(-1)	+ 0.409 * DLY(-1)	+ 0.093 * CIfx(-1)	- 0.001			
	(2.8)	(2.1)	(2.1)	(-0.1)			
3 DLULC =	0.326 * CImm(-1)	- 0.974 * CIlm(-1)	- 0.058				
	(3.8)	(-9.0)	(-7.5)				
4 DLM2 =	0.59 * DLP(-1)	+ 0.280 * DLM2(-1)	- 0.204 * CImm(-1)	+ 0.294 * CIlm(-1)	+ 0.033 * DLPOIL	+ 0.174 * DFISC	+ 0.052
	(2.1)	(2.6)	(-4.3)	(4.9)	(2.0)	(2.4)	(11.2)
5 DLY =	-0.001 * DRR(-1)	- 0.104 * DLPREG	- 0.028 * D934	- 0.019 * D9910	- 0		
	(-1.8)	(-3.2)		(-2.5)	(-0.0)		
6 DRR =	72.12 * DLY(-1)	+ 19.34 * CIfx(-1)	+ 0.283				
	(1.8)	(2.2)	(0.274)				

1/ L denotes logarithm; D934 is a dummy for April 1993, and D9910 is a dummy for October 1999.
t-values are in parentheses.
For test results, see Appendix I.
All equations also included 11 seasonal dummies.

TEST RESULTS

I. Attempting to Identify System with Johansen Approach [1]

eigenvalue	loglik for rank	
	1877.02	0
0.645051	1924.67	1
0.410466	1948.97	2
0.305815	1965.77	3
0.227802	1977.66	4
0.153202	1985.31	5
0.0518387	1987.75	6

Ho:rank=p	-Tlog(1-\mu)	using T-nm	95%	-T\Sum log(.)	using T-nm	95%
p == 0	95.29**	70.43**	44.0	221.5**	163.7**	114.9
p <= 1	48.61**	35.93	37.5	126.2**	93.26*	87.3
p <= 2	33.58*	24.82	31.5	77.56**	57.33	63.0
p <= 3	23.78	17.58	25.5	43.98*	32.51	42.4
p <= 4	15.3	11.31	19.0	20.2	14.93	25.3

SYS General cointegration test 1993 (3) to 2000 (12) [2] [3]

\beta'

LP	L(P*E)	LULC	LM2	LY	RR
1.0000	-0.16456	-1.2693	0.00000	0.00000	0.00000
-0.95547	0.00000	0.00000	1.0000	-1.3364	0.00017308
-0.82431	0.00000	1.0000	0.00000	0.00000	-0.0012794

Standard errors of beta'

LP	(LP*E)	LULC	LM2	LY	RR
0.00000	0.10156	0.076670	0.00000	0.00000	0.00000
0.22875	0.00000	0.00000	0.00000	0.32713	0.0010375
0.028702	0.00000	0.00000	0.00000	0.00000	0.00032058

[1] Two 2 lags were included. This implied virtually no loss of information, compared with including 3 lags.

[2] After the imposition of a rank of 4, the resulting system gave acceptable results in terms of coefficients. However, the inclusion of the trend in the system caused some technical problems, apparently caused by instability of the foreign exchange relationship. Therefore, instead, a rank of 3 was imposed, allowing for separate estimation of the long-run relationship for the foreign exchange market.

[3] Although the parameter signs are all correct, and the size of the coefficients broadly in line with expectations, the standard errors are rather high. The relatively high inaccuracy with which the relations are estimated also affects the estimation of the impact coefficients. Some important impact coefficients do not have the right sign (for instance the one in the first row, first column, denoting the impact of the goods market ECM on P). An additional problem with this system is the seemingly spurious appearance of the real interest rate in the relationship for the labor market. The restriction of putting its coefficient to zero was not accepted.

```
\alpha (standard errors in parenthesis)
 LP             0.0293 (0.014)    0.0000 (0.000)     0.0585 (0.027)
 L(P*E)         0.1248 (0.050)    0.0000 (0.000)     0.0000 (0.000)
 LULC           0.2124 (0.092)    0.3391 (0.091)    -0.8547 (0.184)
 LM2            0.0000 (0.000)   -0.1615 (0.0476)    0.1812 (0.081)
 LY             0.0000 (0.000)    0.0000 (0.000)     0.0000 (0.000)
 RR             44.705 (11.017)   0.0000 (0.000)     71.912 (21.579)

loglik = 2151.3912  -log|\Omega| = 45.77428  unrestr. loglik = 2159.9447
LR-test, rank=3: Chi^2(10) = 17.107 [0.0720]
```

II. Test Results Single Equation Estimation of Long-Run Relationships

```
EQ( 1) Modeling LP by RLS; 1993 (1) to 2000 (12)

R^2 = 0.995665  F(15,80) = 1225 [0.0000]  \sigma = 0.0115571  DW = 0.687
RSS = 0.01068531488 for 16 variables and 96 observations
AR 1- 6 F( 6, 74) =      9.6597 [0.0000] **
ARCH 6  F( 6, 68) =      1.3399 [0.2518]
Normality Chi^2(2)=     0.11341 [0.9449]
Xi^2    F(19, 60) =      1.1958 [0.2916]
RESET   F( 1, 79) =      65.845 [0.0000] **

EQ( 2) Modeling LULC by RLS; 1993 (1) to 2000 (12)

R^2 = 0.980874  F(14,81) = 296.72 [0.0000]  \sigma = 0.0245939  DW = 1.65
RSS = 0.04899379424 for 15 variables and 96 observations
AR 1- 6 F( 6, 75) =      1.2664 [0.2831]
ARCH 6  F( 6, 69) =     0.82306 [0.5560]
Normality Chi^2(2)=      1.2993 [0.5222]
Xi^2    F(17, 63) =      1.3351 [0.2014]
RESET   F( 1, 80) =      4.3134 [0.0410] *

EQ( 3) Modeling LM2 by RLS; 1993 (1) to 2000 (12)

R^2 = 0.991528  F(13,82) = 738.21 [0.0000]  \sigma = 0.0307013  DW = 0.347
RSS = 0.07729082798 for 14 variables and 96 observations
AR 1- 6 F( 6, 76) =      29.333 [0.0000] **
ARCH 6  F( 6, 70) =      10.718 [0.0000] **
Normality Chi^2(2)=      16.796 [0.0002] **
Xi^2    F(15, 66) =     0.89771 [0.5700]
RESET   F( 1, 81) =      2.9149 [0.0916]

EQ( 4) Modeling LRER by RLS; 1993 (1) to 2000 (12)

R^2 = 0.845871  F(2,93) = 255.2 [0.0000]  \sigma = 0.0354815  DW = 0.291
RSS = 0.1170810393 for 3 variables and 96 observations
AR 1- 6 F( 6, 87) =      44.444 [0.0000] **
ARCH 6  F( 6, 81) =      17.578 [0.0000] **
Normality Chi^2(2)=      2.4957 [0.2871]
Xi^2    F( 4, 88) =      2.3691 [0.0586]
Xi*Xj   F( 5, 87) =      6.1293 [0.0001] **
RESET   F( 1, 92) =     0.19485 [0.6599]
```

III. Test Results Dynamic Equations

```
Estimating the model by FIML, 1993-2000

Optimization result: Strong convergence
(eps1=0.0001, eps2=0.005)

loglik = 2141.7183  log|\Omega| = -45.5685  |\Omega| = 1.6213e-020  T = 94
LR test of over-identifying restrictions: Chi^2(165) = 261.353 [0.0000] **

correlation of residuals
                  DLCPIC        DLRXDM       DLULCWH          DLM2           DLY
 DLCPIC           1.0000
 DLRXDM          0.36132        1.0000
 DLULCWH        0.053507      0.042751        1.0000
 DLM2           0.048853     -0.086336      -0.10656        1.0000
 DLY            0.038791      -0.13137     -0.016693     -0.058967        1.0000
 DRIB1MR      -0.0069172      0.071755      0.043672      0.015480     -0.078000
                 DRIB1MR
 DRIB1MR          1.0000

DLCPIC  :Portmanteau 10 lags=   13.446
DLRXDM  :Portmanteau 10 lags=   5.4821
DLULCWH :Portmanteau 10 lags=   17.732
DLM2    :Portmanteau 10 lags=   8.5376
DLY     :Portmanteau 10 lags=   16.538
DRIB1MR :Portmanteau 10 lags=   10.907
DLCPIC  :Normality Chi^2(2)=     5.6303 [0.0599]
DLRXDM  :Normality Chi^2(2)=     15.969 [0.0003]  **
DLULCWH :Normality Chi^2(2)=     4.7698 [0.0921]
DLM2    :Normality Chi^2(2)=     14.798 [0.0006]  **
DLY     :Normality Chi^2(2)=     27.892 [0.0000]  **
DRIB1MR :Normality Chi^2(2)=     10.999 [0.0041]  **
DLCPIC  :ARCH 6  F( 6, 39) =     0.4396 [0.8478]
DLRXDM  :ARCH 6  F( 6, 39) =    0.33375 [0.9150]
DLULCWH :ARCH 6  F( 6, 39) =    0.93801 [0.4791]
DLM2    :ARCH 6  F( 6, 39) =    0.18461 [0.9794]
DLY     :ARCH 6  F( 6, 39) =    0.85306 [0.5375]
DRIB1MR :ARCH 6  F( 6, 39) =    0.56433 [0.7560]
Vector portmanteau 10 lags=   421.42
Vector AR 1-6  F(216,233) =     1.2909 [0.0280] *
Vector normality Chi^2(12)=    74.603 [0.0000] **

Note 1/ All equations also included 11 seasonal dummies.
```

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