RELATIONSHIP BETWEEN MONEY AND INTEREST RATE IN UKRAINE: IN SEARCH OF THE LIQUIDITY EFFECT[†]

Prepared by Olena Bilan[*]

Institute for Economic Research and Policy Consulting

Kyiv, Ukraine

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Abstract

This paper questions the plausibility of negative interest rate reaction to exogenous monetary expansion - the concept known as the liquidity effect - in the Ukrainian context. A semi-structural vector autoregression model (SVAR) is constructed to monitor the dynamic response of the interbank interest rate to shocks in monetary policy variable. The SVAR system of equations consists of macroeconomic block, which represents the information set of the central bank, and monetary policy block, which describes relationship between major monetary policy indicators. Parameters of the SVAR system are estimated by means of a structural model of the market for bank reserves expressed in innovation form. Shape of the impulse response function supports hypothesis of the liquidity effect dominance. The results are robust to the lag structure used in the VAR model as well as to the variations in the structural parameter that determines the fraction of the demand shock in total reserves offset by the National Bank of Ukraine. By presenting strong evidence of the liquidity effect in Ukraine, this paper provides grounds for monetary policymakers to believe that money expansion is likely to propagate into real sector through channels of monetary transmission that include interest rate reaction as an important part and contributes to the sparse scientific literature in the realm of monetary transmission in Ukraine.

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1 INTRODUCTION

The ultimate effect of money on the real economy has always been of great concern to economists and monetary policymakers. However, the *transmission mechanism*, or channels through which changes in monetary aggregates affect real economic variables, is an issue of even greater importance. Channels of monetary transmission determine strength, duration, and direction of the effects brought into real economy by policy actions. As was perspicaciously noticed by Mishkin (1995) in his introduction to the symposium on monetary transmission mechanism "Monetary policy is a powerful tool, but one that sometimes has unexpected or unwanted consequences." Thus, the ability of central bank authorities to conduct monetary policy successfully depends substantially on the depth of their awareness of channels through which monetary shocks are transmitted into economy.

If we refer to monetary policy in transition economies, such as Ukraine, it is even more important for policymakers to be able to predict the consequences of their activity as precisely as possible. Under circumstances of unstable economic environment, undeveloped financial markets, and newly established institutional settings, any careless action may lead to very harmful results. Therefore, understanding of the mechanism through which changes in monetary policy pervade into real economy is crucial for Ukrainian policymakers.

The monetary transmission mechanism embraces a varied range of channels. A notion of a negative relationship between money and interest rates – the liquidity effect – is an important part of many of them. The liquidity effect is the first stage of monetary transmission through traditional interest rate, exchange rate and credit channels. The notion of the liquidity effect emanates from the conventional Keynesian theory of money with a vertical supply curve and downward sloping demand curve. According to this framework, increases in money supply leads to (at least) short-run declines of interest rates. Although the theoretical concept of the liquidity effect is quite old and simple, the empirical evidence is still puzzling. The econometric technique used to estimate the liquidity effect in the latest studies is much more sophisticated than it was four decades ago, when the first attempt to evaluate the money-interest rate relation was made. Nevertheless, there are still doubts among economists about the direction and persistence of the interest rate response to monetary expansion.

The inability of empirical studies to support the underlying theoretical concept suggests that the relation between money and interest rates is much more complex than a conventional economic textbook states. Simple models presented in textbooks are not able to explain how and through which channels the economy responds to policymakers' actions; thus, more advanced investigations are necessary to reveal the true picture of how the economy works. By investigating the relation between money and the interest rate in Ukraine this study is intended to fill up one of the picture blanks.

The rest of the paper proceeds as follows. Chapter 2 addresses the definition of the liquidity effect and basic theoretical concepts underlying this notion. Chapter 3 provides a review of previous empirical studies. It emphasizes the main problems faced by previous researchers and points out ways and methods that were adopted to overcome them. Chapter 4 is devoted to empirical modeling of the money-interest rate relation. First, plausibility of different variables with respect to money endogeneity and interest rate choice problems, as well as applicability of different econometric techniques are discussed. Then, the semi-structural two-block vector autoregression model is built and estimated. The results of the model presented in Chapter 5 suggest that reaction of interest rate to monetary policy shock is strictly negative. The results are quite robust to the lag structure and to the value of model parameter. Chapter 6 concludes and suggests directions for further investigation.

2 THEORETICAL FRAMEWORK

The traditional definition of the liquidity effect is based on the partial equilibrium Keynesian model of money market with a downward sloping demand curve and vertical supply curve (Mishkin 2001). In this simple framework an increase in money supply (*everything else remaining equal*) leads to a decline in interest rate (see Figure 1.A). This immediate (short-run) interest rate response to the monetary expansion was called the *liquidity effect*. However, over time the effect of monetary expansion extends on other economic factors, which in turn influence interest rate. These "non-liquidity" factors can be classified as following:

1. *Income Effect*. Expansionary monetary policy leads to increase in national income and wealth, which affect the demand for money. As a result, the demand curve shifts to the right and interest rate increases (see Figure 1.B).
2. *Price-level Effect*. Increase in money supply may lead to overall increase in prices. Since according to the Keynesian framework people care about cash they hold only in real terms, when prices increase, more money is needed to leave the purchasing power at the sufficient level. As with income effect, demand curve shifts to the right and drives interest rate up (see Figure 1.B).

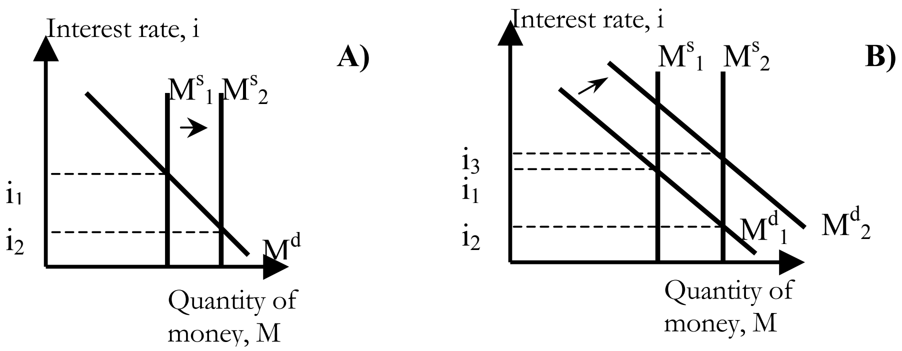

Figure 1. Interest rate response to increase in money supply
A - liquidity effect; B - non-liquidity effects.
Source: Mishkin 2001

3. *Expected-inflation Effect (or Fisher effect).* Increase in money supply may affect people's expectations about future level of inflation, which in turn leads to increase in interest rate. The expected-inflation effect works through financial assets, such as government bonds or bank deposits. When expected inflation increases the return on real assets also goes up, making bank deposits less desirable relative to real assets. The decreased demand for bank deposits drives the interest rate on them up. Two important points should be mentioned here:

(i) expected-inflation effect persists as long as the price level continues to rise;

(ii) expected-inflation effect may operate rapidly, even at the same time when the liquidity effect comes into force.

Strength and persistence of monetary expansion effects are determined by current situation in the economy. Thus, the ultimate result of increase in money supply is ambiguous. Three typical scenarios of interest rate movements are possible (Figure 2):

- liquidity effect dominates all other effects;
- liquidity effect is weak, expected-inflation effect comes into force later;
- liquidity effect is weak, expected-inflation effect comes into force immediately.

Therefore, identifying which effect dominates has important implications for policymakers, since monetary expansion may lead to unexpected, or opposite to expected, consequences.

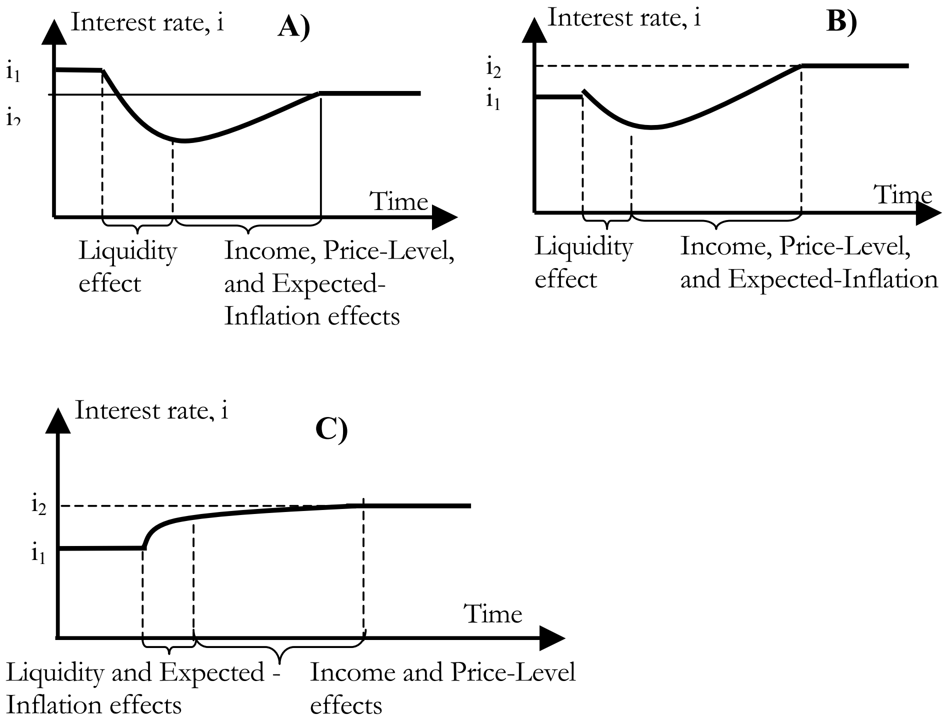

Figure 2. Ultimate interest rate response to increase in money supply
A – liquidity effect is strong; B – liquidity effect is weak; C – expected inflation effect comes into force immediately.
Source: Mishkin (2001)

3 REVIEW OF PREVIOUS EMPIRICAL STUDIES

Though the relationship between money and the interest rate is straightforward in theory, empirical evidence of the liquidity effect has been puzzling since the earliest empirical research, and it is today. Historically, the theoretical explanation of the liquidity effect was treated as a plausible concept. In the earliest empirical studies the existence of a negative short-run relation between money and interest rate was taken for granted. As a general rule, researchers focused on the strength and persistence of interest rate decline in response to the money stock growth.

For example, Cagan and Gandolfi (1969) investigate the time pattern of the monetary effect on interest rates for monthly data spanning the period 1910-65. The equation presented in first differences relates the change in commercial paper rate during period *t* to M2 growth rates in period *t* and previous periods back to *t-n*. They find that, as theory predicts, the interest rate declines immediately after the increase in M2 growth rate and begins to rise later. To be precise, a 1% increase in M2 growth rate leads to a maximum 2.6% decline in commercial paper rate. In terms of the theoretical concepts outlined above, Cagan and Gandolfi have shown that the commercial paper rate behaves according to the second scenario presented in Figure 2.B: it reaches a trough seven month after an increase in money growth and then rises above its initial position.

Absolutely different results are obtained by Melvin (1983). He provides similar analysis for data drawn from the 1970s and finds that liquidity effect disappears during a month after the increase in money growth rate. In other words, Melvin's results conform to the last scenario (Figure 2.C): the liquidity effect is immediately offset by other economic factors that drive interest rate up. Melvin himself infers that it is an anticipated inflation effect that dominates the liquidity effect in 1970s. Melvin's "vanishing liquidity effect" contributes to the development of monetary business cycle models that imply that persistent exogenous increase in money growth leads to a *rise* in the nominal interest rate. However, Cochrane (1989), using a spectral band pass filter technique, finds that the liquidity effect reemerges in 1979-82.

These earlier studies use a common, very simple technique – a distributed lag model - which implicitly assumes that no other variable affects the relation between money and interest rate. Because of this limitation, it is impossible to test which variable except money is responsible for the interest rate movements. In order to explore this possibility Gordon and Leeper (1992) estimate a four-variable vector autoregression (VAR) model that includes money growth rates, interest rates, CPI and industrial production. They assume that the endogenous component of the monetary base is small; with this assumption they use monetary base to model the exogenous innovations in monetary policy. They find that relation between monetary base and federal funds rate is never negative; that is, there is again no liquidity effect.

Subsequent empirical studies were revolutionary in the realm of monetary policy modeling. Christiano and Eichenbaum (1992) use the cross-correlation between the federal funds rate and different monetary aggregates to show that broad monetary aggregates such as monetary base (M0), M1 or M2 are inappropriate measures of exogenous monetary shock. They point out that correlation between M0 and *current and future* values of the interest rate is *positive*, whereas correlation between M0 and *past* values of the interest rate is negative. At the same time, the non-borrowed reserves (NBR) held by commercial banks are *negatively* related to the *past and future* values of the interest rate. Christiano and Eichenbaum (1992) argue that it is an understatement of the endogenous component in broad monetary aggregates by previous researchers that has led to poor empirical evidence of the liquidity effect. In reality, monetary aggregates are largely influenced by shocks that come from the demand for money. Thus, M0 or M1 contains large endogenous component and cannot serve as good measure of monetary policy shocks. On the contrary, the level of NBR is directly controlled by the Federal Open Market Committee (FOMC) through open market operations. Therefore, monetary policy shock can be measured by changes in the level of NBR. Christiano and Eichenbaum (1992) construct VAR model to support their cross-correlation analysis. When NBR is used as a measure of monetary shock the fed funds rate exhibits a sharp, persistent decline. This result is robust to the sample choice as well as to the identification assumption. Strongin (1995) uses somewhat different measure of exogenous monetary shock - the mix of borrowed and non-borrowed reserves. Performing two sets of VAR models for subsamples similar to those used by Gordon and Leeper (1992), he finds that the liquidity effect is highly significant and persistent in all cases.

Definitely VAR modeling opens a wider horizon for research than the lag distributed regressions do; however, it is also subject to criticism. Bernanke and Mihov (1998) summarize three common pitfalls of VAR: (i) failure to allow the instability in structure or parameters, (ii) uncertainty about the choice of policy indicators, and (iii) non-robustness of identification assumption. Bernanke and Mihov (1998) eliminate some of the pitfalls by constructing semi-structural VAR model and by using other specific methods, however new approach to model the liquidity effect has been suggested recently. Hamilton (1997) pioneers the techniques of identifying the liquidity effect on the daily basis. "Rather than try to identify the effect of monetary policy over an entire month as earlier researchers have done", he investigates "the instantaneous consequences of an open-market purchase". His main argument against previous methods is that in most cases Federal Reserve changes its policy in response to changes in the level of output, inflation, exchange rate and other economic indicators. In other words, identifying the liquidity effect on monthly basis, previous researchers did include endogenous component induced by Fed's forecasting procedure. Hamilton simulates the errors that Fed makes in forecasting the demand for reserves. He argues that these errors are responsible for fluctuations in bank reserves and, as a consequence, in fluctuations in the fed funds rate. Building quite complicated model of market for reserves, Hamilton finds the liquidity effect is present and significant, but only on the last two days of the maintenance period. Hamilton's methodology is criticized by Thornton (2001). Thornton shows that when Hamilton's model is applied to other data samples, there is no significant evidence of liquidity effect. He also suggests alternative model based on the Fed's operating procedure, however, this model doesn't give reliable results. Thornton concludes that the liquidity effect cannot be identified at daily frequency.

Researchers in other countries were also involved in solving the "liquidity puzzle". Fung and Gupta (1994) use structural VAR to investigate the response of output, interest rate, and exchange rate to shocks in monetary policy for Canadian economy. They find that positive monetary shocks measured by increases in excess cash reserves lead to declines in the interest rate, increases in output, and deprecation of the Canadian dollar. Hayashi (2000) builds an elaborated econometric model of market for reserves to verify the existence of the liquidity effect in the Japanese interbank market for overnight loans.

Recently Ukrainian researchers have also become active in investigating the effects of monetary expansion on various economic variables. For example, Shevchuk (2001) employs a vector error correction model to reveal the relationship between money (measured by broad monetary aggregate M2), industrial production, inflation, and real exchange rate in Ukraine for 1994-2000. There are also some examples of successful and fruitful empirical research in the realm of monetary transmission for Ukrainian data (Kryshko 2000, Bolgarin, Mahadeva, and Sterne 2000). However, these studies neither investigate the interest rate response to monetary shock nor address the question of money endogeneity. To my present knowledge, the reaction of the interest rate to monetary policy shock has not yet been investigated in Ukraine. The present study is a first step toward filling the gap. It will contribute to the growing economic literature on monetary policy in Ukraine in two ways: by providing a deeper analysis of interest rate and its response to monetary policy shocks, and by attempting to solve the problem of money endogeneity discussed in Chapter 4 for Ukrainian data.

4 ECONOMETRIC MODELING

4.1 Preliminary notes

As could be seen from Chapter 3, empirical studies of the liquidity effect vary in many dimensions. There are especially heated debates among applied economists as to the appropriate measure of monetary policy shock. The challenge economists confront in attempt to investigate monetary policy is that policy actions reflect two types of shocks: policymakers' response to current development of the economy - endogenous component - and "pure" policy shocks - exogenous component (Christiano 1996). Thus, policymakers' actions can be expressed as a function (*feedback rule*) of a state of the economy. Policy actions result in changes of economic variables. The changes are induced partially by policymakers' actions and partially by previous situation in the economy. To evaluate the pure policy effect, one needs to identify only those changes that were not reactive to other variables - to separate exogenous and endogenous components of change in variables. The procedure of separating exogenous component is referred to as making an *identification assumption.* The analysis of monetary policy shock depends crucially on the plausibility of identification assumption.

Two general strategies for isolating monetary policy shock are exploited in empirical literature (Bernanke and Mihov 1998, Christiano, Eichenbaum and Evans 1998).

The first approach is nonparametric and grounds on policy makers' announcements about future stance of monetary policy. The judgment is rather subjective and reveals only the date and direction of policy change, but does not provide information about quantitative characteristics. On the other hand, it does not require any modeling, making the measure of policy stance independent of model parameters.

The second approach involves econometric modeling. It requires making reliable assumptions in order to assess the feedback rule. The set of assumptions includes functional form of feedback rule, assumptions about variables that policy makers look at when deciding about the direction of future policy (information set), and assumptions about operating instruments that central bank uses in achieving its policy goals. In addition, one should assume the nature of interaction between policy shock and information set. The most widely used assumption is that policy shock is orthogonal to the information set (recursiveness assumption). More formally this strategy can be implemented by estimating the following equation:

$$P = f(\Omega) + v^S \quad (1)$$

where P is an operating instrument (policy variable), Ω is a central bank information set, and v^S is an exogenous ("pure") policy shock. Equation (1) is incorporated in the econometric model, described below.

While functional form and information set assumptions do not evoke disagreements among researchers, the choice of operating instrument (P), which would reflect all changes in policy stance, is quite controversial. Figure 3 shows why it may be inappropriate to use money supply measured by M1 or a broader monetary aggregate as a policy variable for investigating the liquidity effect. The key reason is that changes in M1 reflect both demand shocks and supply shocks – phenomenon known as **money endogeneity problem**.

Let's assume that initially the money market is in equilibrium (M^*_1, i^*_1). Then a positive shock to money demand, induced, for instance, by changes in expectations, raises the demand for money from M^d_1 to M^d_2, and drives the interest rate up. Suppose also that policy-makers immediately observe these changes in the demand for money, and for some reason they are unhappy with high interest rate. The natural way to drive interest rate down to the initial position is to increase the money supply from M^s_1 to M^s_2 as in Figure 3.A. Since shifts in demand and supply take place almost simultaneously, we will observe increase in M1 over time and no change in interest rate, provided policymakers were correct in their predictions of increase in money demand and calculations of necessary change of money supply. However, if increase in money demand was underestimated, we will see that monetary expansion drives the interest rate *up* as shown in Figure 3.B.

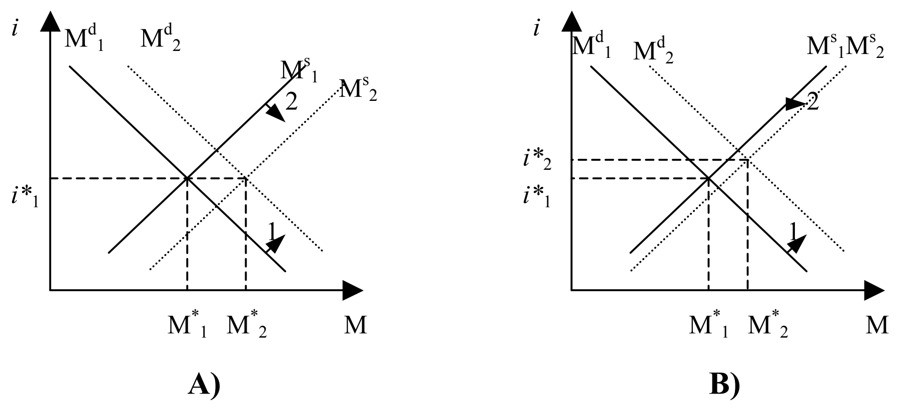

Figure 3. Interest rate reaction to endogenous monetary expansion.

Since economists agreed that broad monetary aggregates include a large endogenous component and both demand and supply shocks, several ideas about new policy variable have arisen. For example, Christiano and Eichenbaum (1992) argue that the quantity of nonborrowed reserves serves as the best indicator of the policy stance; Bernanke and Blinder (1992) suggest that the Fed (central bank of the United States) closely watches the fed funds rate and conclude that changes in the fed funds rate can be used as measure of policy shock; Strongin (1992) proposes using the proportion of nonborrowed reserve growth that is orthogonal to total reserve growth as policy measure. In any case, making a reliable identification assumption about policy instruments requires thorough knowledge of the central bank's operating procedure. From the analysis of the operation procedure of the National Bank of Ukraine[1] it follows that throughout sub-periods of the period of investigation the NBU used different instruments of monetary policy. However, all of them are common in a sense that any action with these instruments affects quantity of total reserves held by the banking system. Therefore, quantity of total bank reserves is likely to reflect a lot of exogenous actions of the NBU and innovation in total reserves will be a plausible measure of policy shock in this research.

The next problem that appears in studies of the liquidity effect is the problem of interest rate choice. Three interest rates were analyzed in the paper: the interest rate on loans to real sector, the interest rate on deposits, and the interbank interest rate. The lag robust Granger causality test shows that the interbank interest rate Granger causes interest rate on loans to private sector, but "causality" between the interbank interest rate and the interest rate on deposits is not clear. Another test for responsiveness to monetary policy actions (namely, to changes in the discount rate and reserve requirements ratio) shows that the interbank interest rate is more reactive to monetary policy actions compared to interest rate on loans and deposits. Results of two tests suggest[2] that the interbank interest rate contains unique information about monetary policy stance, and, therefore, is the best choice for econometric research in the realm of monetary policy.

Finally, the choice of econometric technique should be addressed. Econometric techniques most frequently used to investigate the liquidity effect (apart from recent works using daily data) fall into three major categories: (i) autodistributed lag (ADL) models, (ii)

[1] For the inquisitive reader description and analysis of the operation procedure of the National bank of Ukraine is provided in Appendix A.

[2] Results of both tests are available upon request.

vector autoregression (VAR) models, and (iii) structural/semi-structural vector autoregression (SVAR) models. The latter approach combines advantages of structural equation models and simple VARs. In SVAR models the relationships between variables ground on theoretical concepts, while dynamic nature of a model allows one to monitor the response of interest rate to monetary policy shock by means of impulse response function. For this reason semi-structural model is used in this research[3].

4.2 Model

In this study I basically follow the general strategy of Bernanke and Blinder (1992), developed further by Bernanke and Mihov (1995), and applied by Bernanke and Mihov (1998) to investigate the liquidity effect. To be precise, I construct semi-structural four variable VAR model, that comprises two blocks: non-policy (macroeconomic) block and monetary policy block:

$$\mathbf{Y}_t = \sum_{i=0}^{p} \mathbf{B}_i \mathbf{Y}_{t-i} + \sum_{i=0}^{p} \mathbf{C}_i \mathbf{P}_{t-i} + \mathbf{A}^E \mathbf{v}_t^E \tag{2}$$

$$\mathbf{P}_t = \sum_{i=0}^{p} \mathbf{D}_i \mathbf{Y}_{t-i} + \sum_{i=0}^{p} \mathbf{G}_i \mathbf{P}_{t-i} + \mathbf{A}^M \mathbf{v}_t^M \tag{3}$$

Equations (2) and (3) describe an unrestricted linear dynamic macroeconomic model. Sticking to the notations of Bernanke and Mihov, boldface letters are used to indicate vectors or matrices of variables or coefficients. In particular, **Y** is a vector of non-policy variables; **P** is a set (vector) of policy indicators. Thus, equation (3) may be interpreted as a policy block that defines relationships between primary indicators of monetary policy, whereas equation (2) is a non-policy block that describes a set of relationships in the rest of the economy. Vectors $\mathbf{v}^E$ and $\mathbf{v}^M$ are mutually uncorrelated "structural" error terms. Premultiplying them by matrices $\mathbf{A}^E$ and $\mathbf{A}^M$ respectively allows each shock to enter more than one equation in its block. Thus the assumption that elements of $\mathbf{v}^E$ or $\mathbf{v}^M$ are uncorrelated is unrestrictive. It is also assumed that one component of $\mathbf{v}^M$, say v^s, represents "pure" policy shock. Note that each equation in the model contains *current* and lagged (up to lag *p*) values of all variables. Therefore, system (2)-(3) is not econometrically identified, i.e. it cannot be transformed into the standard VAR form with only lagged variables in the right-hand side, unless one imposes some specific structural

[3] The well-known works on structural VAR include Gordon and Leeper (1994), Bernanke and Mihov (1995), Bernanke and Mihov (1998)

restrictions. Bernake and Blinder (1992) show that in general case to transform the model into reduced form it is sufficient to assume that policy variables do not affect the rest of the economy within the given period, i.e. that $\mathbf{C}_0=\mathbf{0}$. Under this assumption system (2)-(3) reduces to

$$\mathbf{Y}_t = \sum_{i=1}^{p} \mathbf{H}_i^E \mathbf{Y}_{t-i} + \sum_{i=1}^{p} \mathbf{H}_i^M \mathbf{P}_{t-i} + \mathbf{u}_t^E \tag{4}$$

$$\mathbf{P}_t = \sum_{i=1}^{p} \mathbf{J}_i^E \mathbf{Y}_{t-i} + \sum_{i=1}^{p} \mathbf{J}_i^M \mathbf{P}_{t-i} + [\mathbf{N}\mathbf{u}_t^E + \mathbf{u}_t^M] \tag{5}$$

The relationship between observable VAR residuals $\mathbf{u}^E$ and $\mathbf{u}^M$ and unobservable structural disturbances $\mathbf{v}^E$ and $\mathbf{v}^M$ is:

$$\mathbf{u}_t^E = (\mathbf{I} - \mathbf{B}_0)^{-1} \mathbf{A}^E \mathbf{v}^E = \tilde{\mathbf{H}} \mathbf{v}^E \tag{6}$$

$$\mathbf{u}_t^M = (\mathbf{I} - \mathbf{G}_0)^{-1} \mathbf{A}^M \mathbf{v}_t^M = \tilde{\mathbf{J}} \mathbf{v}_t^M \tag{7}$$

Therefore, provided matrix $\tilde{\mathbf{J}}$ of equation (7) is known, the dynamic response of all variables in the system to a policy shock can be measured by the impulse response function[4].

The components of matrix $\tilde{\mathbf{J}}$ can be estimated by means of simple model of the market for bank reserves expressed in innovation form. At this point I divert from the Bernanke and Mihov's strategy and construct a system of equation that incorporate features of the Ukrainian market for reserves. The system looks as follows:

$$u_{TR}^d = -\alpha u_{IIR} + v^d \tag{8}$$

$$u_{TR}^s = \varphi v^d + v^s \tag{9}$$

Equation (8) describes the commercial banks' demand for reserves, expressed in innovation form. It states that innovation in demand for reserves depends negatively on the innovation in the interbank interest rate (opportunity cost of holding reserves) and on an exogenous demand disturbance v^d. Equation (9) describes the behavior of the National bank of Ukraine (the NBU). It is assumed here that central bank observes and responds to the exogenous disturbance in demand for reserves. The strength of the response is given by coefficient φ. The assumption that the NBU observes the demand for reserves is quite

[4] The technical details of the model are available upon request.

reasonable, since the NBU and its branches closely monitor banks on a daily basis. Whether the NBU responds to the shocks in demand for reserves is an open question that will be discussed below. The second item in the supply equation is a disturbance term v^s - the policy shock I am interested in.

To solve system (8)-(9) one should impose condition of supply and demand equilibrium in the market for reserves. Solving the system in terms of innovation gives following expression:

$$\begin{bmatrix} u_{IIR} \\ u_{TR} \end{bmatrix} = \begin{bmatrix} \frac{1-\varphi}{\alpha} & -\frac{1}{\alpha} \\ \varphi & 1 \end{bmatrix} \begin{bmatrix} v^d \\ v^s \end{bmatrix} = \widetilde{\mathbf{J}} \begin{bmatrix} v^d \\ v^s \end{bmatrix} \tag{10}$$

To calculate the impulse response function of the policy shock v^s four variables should be estimated: parameters α and φ of matrix $\widetilde{\mathbf{J}}$ plus two variances of structural shocks, σ_d^2 and σ_s^2 ($cov(v^d,v^s)=0$ by assumption). Now it is apparent that system (10) is under-identified by one restriction. If additional restriction is imposed on some of the parameters, the system becomes exactly identified. It seems reasonable to make some assumptions of the NBU's willingness or ability to offset shocks in demand for total reserves and thus to restrict coefficient φ of the supply equation (9).

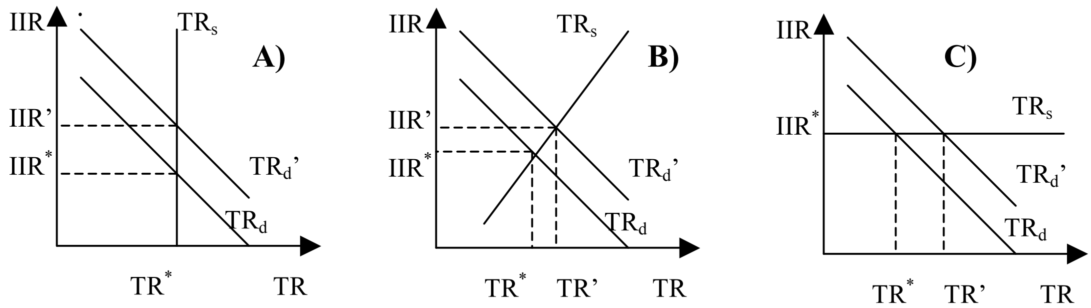

Figure 4. Supply and demand in the market for reserves.

<u>Case1.</u> As an extreme case I assume that the NBU does not offset any disturbances in the demand for total reserves, which implies $\varphi=0$. In this situation demand shock does not affect the quantity of reserves, i.e. supply of reserves is perfectly inelastic with respect to interest rate as shown in Figure 4.A. This case resembles real situation when the National Bank of Ukraine was conducting such policy some period of time after the Ukrainian government had defaulted on government bonds in August 1998. After the default the NBU was deprived of possibility to implement open-market operations, other open-market-like instruments were not yet in use, and the amount of discount loans also didn't change much in

spite of a sharp increase in the demand for reserves[5]. So, the NBU simply had no instrument to respond to the increased demand.

Case 2. Here I assume that the NBU offsets some fraction, namely one half, of demand shock. In this case the supply curve is positively sloped (Figure 4.B) and structural demand disturbances change the equilibrium level of reserves. The assumption corresponds to situation before the default or to the later period when open-market-like instruments were actively used by the NBU.

Case3. To make the picture complete I should assume that φ is equal to 1, i.e. the supply curve is perfectly elastic as shown in Figure 4.C. This is possible when central bank targets the interbank interest rate.

4.3 Econometric specification and estimation

Standard form VAR model (4)-(5) has an alternative plausible interpretation. Components of vector **Y** can be regarded as variables of the central bank's information set or as a set of monetary policy targets. Thus, equation (4) describes relationships between monetary policy targets, while equation (5) describes behavior of policy variables as before. With this interpretation in mind one can proceed to the estimation procedure that consists of several steps.

First step is to estimate the reduced form VAR model (4)-(5). Four variables are used in the analysis. While choice of some of them has already been substantiated above, here I provide more extensive explanation why exactly these variables are chosen.

Monetary policy block (equation (5))

In order to investigate the liquidity effect at least two variables should be included in the structural block: interest rate and policy variable that reflects exogenous monetary policy shocks. As was mentioned above, the econometric analysis suggests that the interbank interest rate contains unique information about monetary policy and helps to explain movements in other interest rates in Ukraine. From the analysis of the operation procedure of the National Bank of Ukraine (Appendix A) it follows that monetary policy tools, used by the NBU, directly affect amount of total reserves of commercial banks; therefore, total reserves contain significant exogenous component of policy actions. Thus, the best candidates for this block are:

[5] Refer to Appendix A for a detailed description of monetary policy instruments of the NBU.

- interbank interest rate (I) and
- total reserves held by commercial banks (R).

Macroeconomic block / Information set (equation (4))

From the description of the operation procedure of the National Bank of Ukraine provided in Appendix A it follows that the set of forecasted macroeconomic variables includes: (i) real GDP growth rate, (ii) government budget deficit and (iii) level of inflation. Grounding on the forecast, the NBU determines intermediate targets of monetary policy: (a) money supply (level and growth), (b) monetary base, and (c) amount of loans to real sector. Ideally, macroeconomic block should include all these variables to grasp as much information about central bank's activity as possible. However, taking into account small sample size of data at my disposal, I cannot afford including more than two variables in this block. It seems reasonable to take one variable from the forecasted set and the other from the set of intermediate targets.

Among forecasted variables, inflation seems to be the most appropriate one. According to the Constitution of Ukraine and to the Law of the National bank of Ukraine the officially established long-run goal of the NBU is the national currency stability, with low level of inflation as an essential component of stabilization. Furthermore, theoretical model described above predicts that the speed of inflation is responsible for existence or absence of the liquidity effect in the short-run. Therefore, among the forecasted indicators, inflation is the most important for study of the liquidity effect.

As to the intermediate targets, monetary base would be the best choice, since requirements to the monetary base is one of the IMF efficiency criteria that the NBU was for a long time obliged to fulfill. However, monetary base is simply the sum of currency in circulation and total bank reserves and, therefore, is highly correlated with variable already included in the monetary policy block of the model. Hence, some measure of money supply would be an appropriate candidate for inclusion in the macroeconomic block. For this purpose I take monetary aggregate M1, which represents supply of "narrow" money, or money for transactions.

Thus, information set of the NBU is represented by:

- level of inflation (P) and
- money supply measured by monetary aggregate M1 (M).

All data are monthly, spanning the period January 1997 – September 2001 (57 observations) The results of Phillips – Perron test for unit root, shown in Table B1 in Appendix B, suggest that all series are integrated of order one. To obtain correct estimators one should look for cointegrating equations and construct vector error correction (VEC) models. VAR models are also characterized by the ambiguity in number of lags included. To avoid misspecification due to lag structure and, at the same time, to save for the degrees of freedom I include up to 3 lags in the model. Table 1 presents results of Johansen cointegration test – the number of cointegrating equations for each lag structure. Estimation output of VEC models is provided in Appendix B.

Table 1. Cointegration rank test

Number of lags in VEC model	1	2	3
Number of cointegrating equations revealed by the Johansen cointegration test	3	1	1

Next step in the estimation procedure is calculation of the impulse response function. The dynamic response of variables to VAR residuals is of little importance. The reaction to one standard deviation increase in *policy shock* is a prime objective of this research. Under additional restrictions imposed on parameter φ the variance-covariance matrix of policy disturbances can be calculated using the formula:

$$\begin{bmatrix} s_d^2 & 0 \\ 0 & s_S^2 \end{bmatrix} = \tilde{\mathbf{J}}^{-1}\Omega_M(\tilde{\mathbf{J}}^{-1})' \tag{11}$$

where Ω_M is a variance-covariance matrix of policy block VAR residuals $\mathbf{u}^M$:

$$\Omega_M = \begin{bmatrix} \sigma_I^2 & \sigma_{I,R} \\ \sigma_{I,R} & \sigma_R^2 \end{bmatrix}$$

Now impulse response function can be estimated by setting $v^s = s_S$ and all other structural shock equal to zero. In VAR models impulse responses are often supplemented by decomposition of forecast variance. In the present context, however, calculation of variance decomposition requires additional restrictions on components of matrix $\tilde{\mathbf{H}}$, for which economic explanation hardly exists. Therefore, I confine myself to the analysis of impulse responses for different values of parameter φ and for different lag structure that are provided in the next chapter.

5 RESULTS AND ROBUSTNESS OF THE MODEL

5.1 Results

Table 2 reports the estimates of the slope coefficient of the demand for total reserves, α, and the standard deviation of structural disturbance v^S for different values of the offset parameter, φ, and for different lag structure. Positive sign of estimated α indicates that the estimated demand curve is (correctly) downward sloping.

Table 2. Estimates of parameter α and standard deviation of v^S

	1 lag		2 lags		3 lags	
	α	s_S	α	s_S	α	s_S
φ=0	2 280.00	240.34	35 850.00	219.01	8 429.00	223.48
φ=1/2	243.42	178.79	217.31	155.33	258.82	160.43
φ=1	25.99	25.66	1.32	1.33	7.95	6.86

The impulse responses of the interbank interest rate (I) to one standard deviation policy shock grouped by different values of parameter φ are presented in Figure 5. Panel A shows the dynamic response under assumption that the NBU does not offset the demand shock in bank reserves (φ=0). While quantitative results are somewhat sensitive to the number of lags included in specification, qualitatively we observe that interest rate reduces immediately after policy shock, reaches minimum and then increases slightly. The conformity to the first scenario described above is apparent.

Change in the responsiveness parameter does not affect the dynamic response substantially. As Panel B of Figure 5 shows, under assumption that the NBU offsets some part of the demand shock, φ=1/2, the pattern of the interbank interest rate response is extremely robust to the number of lags used in specification. Again the behavior of the interbank interest rate is similar to Scenario 1: it sharply decreases immediately after positive policy shock, reaches minimum point two months later, and eventually rises to the long-run (negative) level.

Panel C of Figure 5 depicts dynamic reaction of interbank interest rate when φ=1, i.e. under assumption of interest rate targeting. While with only 1 lag included, we observe a picture similar to Scenario 2: interest rate eventually rises to the level higher than the initial position, specifications with 2 and 3 lags give results similar to Scenario 1. Again the minimum level is reached two or three months after the policy shock.

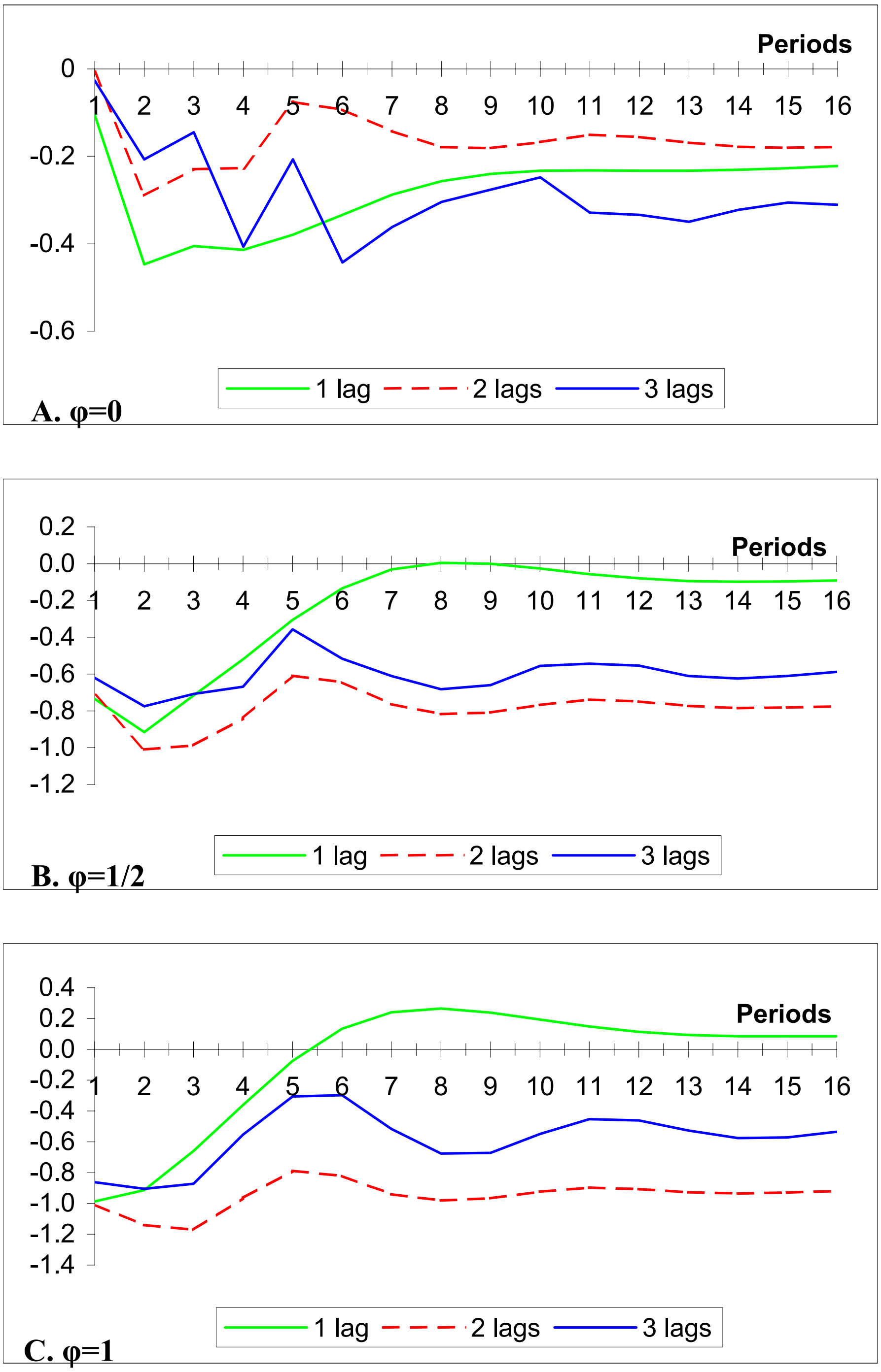

Figure 5. Impulse responses of interbank interest rate (I) to one standard deviation policy shock grouped by variations in the responsiveness parameter φ

5.2 Robustness of the model and possible drawbacks

The robustness of the results to the number of lags included in the specification has been already verified. In order to check whether change in some variables would affect the results, I estimated several different versions. To make comparison easier, I will refer to the specification described in the previous chapter as the benchmark case.

First, specification with both M1 and total reserves *logged* was estimated in the same manner as the benchmark model. In the log-linear case main findings are not affected. Namely, estimates of parameter α are positive (ensuring that the demand for reserves is downward-sloping) and behavior of the interbank interest rate resembles scenario 1 with minimum value reached 2 months after the policy shock. Further, I tried to use *growth rates* of M1 and total reserves instead of levels. This exercise was not so successful as the previous one: occasionally negative values of α were obtained. This should not be very surprising taking into account that structural model of the market for reserves (8)–(9) loses its convenient economic interpretation when model is estimated in growth rates. Nevertheless, the impulse responses are again shaped according to the scenario 1.

Second, one may reasonably object that since monetary aggregate M1 contains only quickly adjustable checkable deposits, the process of multiple (checkable) deposit creation is quite fast and changes in total bank reserves may induce changes in M1 even within a month. So, assumption that policy indicators do not affect information set in the current period does not hold. To respond to the objections of this type, M1 was substituted by broader monetary aggregate M2, which includes more sluggish time deposits, and new specification was estimated in levels and in logs as before. The estimates of α and impulse responses are very similar to those obtained from the benchmark specification and, hence, consistent with the hypothesis of liquidity effect.

Finally, seasonally adjusted real GDP was introduced in the model instead of M1. But here results appear to be inconclusive to some extent: I again obtained negative estimates of α, although impulse responses resemble mainly Scenario 1. It is worthwhile to note that there is no official statistics of real GDP on monthly basis, since only quarterly figures of GDP deflator are reported by the State Statistics Committee of Ukraine. In this study widespread proxy of monthly real GDP was used: real figures were calculated as nominal values divided by CPI. Therefore, implausible estimates of parameters may be caused by shortcomings of data set.

While rather strong empirical evidence of the liquidity effect is presented here, the promising findings may be undermined by several drawbacks of the model. Among them could be:

- Assumption that variables from the information set affect policy indicators within the current period. In other words, I implicitly assume that policymakers of the National Bank observe current developments of the economy and immediately respond to them. This assumption may be subject to some critique, since not all information becomes available to policymakers quickly enough and their response may be delayed due to, for example, bureaucratic impediments.
- In some specifications residuals of the interest rate equation are not normal. Non-normality is likely to be caused by small sample size and abnormally high values of the interbank interest rate in crisis periods.
- Total bank reserves may not be the best possible measure of monetary policy shock. While choice of proper policy variable has been grounded on the analysis of operation procedure of the National Bank of Ukraine, it is still subject to some subjective judgment. Alternative measure may give more robust results.
- The model does not allow me to examine which "non-liquidity" factors are responsible for increase in interest rate after the liquidity effect has slackened. This question leaves space for additional detailed examination.

Notwithstanding listed limitations, I can conclude that data and chosen econometric technique have succeeded in proving hypothesis of the liquidity effect in the Ukrainian interbank market.

6 CONCLUSION

This study has been devoted to the investigation of money-interest rate relationship in Ukraine. In particular, it has questioned the plausibility of the concept of the the liquidity effect - negative interest rate reaction to exogenous monetary expansion - in the Ukrainian context. From the simple theoretical model of money market, described in the first place, it appears that the interest rate response to the expansionary monetary shock may follow three typical scenarios depending on the current situation in the economy.

The macroeconomic evidence of the liquidity effect presented in this study is based on a semi-structural four variable VAR model, that consists of a macroeconomic block, representing the information set of the National Bank, and structural monetary policy block, describing the relationship between monetary policy indicators. To test the robustness of results to the lag structure of VAR model, different specifications with 1 to 3 lags were estimated. In all cases the impulse response of the interbank interest rate to a one standard deviation policy shock was strongly negative. Qualitatively the result is robust to the lag structure used in VAR model as well as to the variations in the responsiveness parameter, while quantitatively some sensitivity is observed. Nevertheless, in the majority of cases interbank interest rate exhibits typical behavior: it decreases immediately after the policy shock, reaches a trough approximately two months later, then increases slightly, and, finally, settles down to a new steady state, which is lower than the initial position. Therefore, the main finding of this research is that the behavior of the interbank interest rate is consistent with the hypothesis of dominance of the liquidity effect over other "non-liquidity factors" that affect interest rate after innovation in monetary policy. Albeit, the question of the very factor responsible for interest rate increase requires additional examination.

By providing empirical support to the first link in a chain of monetary transmission, this study signals that money expansion is likely to propagate into real economy through the channels that include interest rate reaction as an important part. Wide horizon for further research in the realm monetary transmission in Ukraine is opened. Especially important would be to explore the next link: behavior of those interest rates that are essential for real sector agents. This would allow policymakers of the National Bank to assess the effect of monetary policy actions not only on performance of interbank market, but also on the real sector.

WORKS CITED

Bernanke, Ben S., and Alan S. Blinder. 1992. The federal funds rate and the channels of monetary transmission. *The American Economic Review*, Vol. 82, Issue 4 (September):901-921

_______, and Ilian Mihov. 1995. Measuring monetary policy. *NBER Working Paper 5145* (June)

_______, and ______. 1998. The liquidity effect and long-run neutrality. *NBER Working Paper 6608* (June)

Bolgarin, I., Mahadeva L., and G. Sterne. 2000. Some methodological aspects of building and exploiting model of monetary transmission mechanism in Ukraine. *Visnyk NBU* #11 (November): 4-6 (Деякі методологічні аспекти побудови та використання моделі механізму монетарної трансмісії в Україні, *Вісник НБУ*, №11, 2000)

Cagan, P., and A. Gandolfi. 1969. The lag in monetary policy as implied by the time pattern of monetary effects on interest rates. *The American Economic Review* (May):27-84

Christiano, Lawrence J. 1996. Identification and the liquidity effect: A case study. Federal Reserve Bank of Chicago. *Economic Perspectives*(May):2-13

_________, and Martin Eichenbaum. 1992. Identification and the liquidity effect of a monetary policy shock. In *Business Cycles, Growth and Political Economy*, edited by L. Hercowitz and L. Leiderman, Cambridge (MA):MIT Press. Quoted in Lawrence J. Christiano. Identification and the liquidity effect: A case study. Federal Reserve Bank of Chicago *Economic Perspectives* (May 1996):2-13

_________, _________, and Charles L. Evans. 1998. Monetray policy shock: What have we learned and to want end? *NBER Working Paper 6400* (February)

Cochrane J. H. 1989. The return of the liquidity effect: A study of the short-run relation between money growth and interest rates. *Journal of Business and Economic Statistics 7* (January):75-83

Dzoblyuk, O. 2000. Peculiarities of implementation of discount rate policy as an instrument of regulation of monetary relationships. *Banking #3*: 39-42 (Особливості застосування політики облікової ставки як інструмента управління грошово-кредитними відносинами, *Банківська справа,* №3, 2000)

Eremenko, I. 2001 Reserve requirements and implicit taxation of commercial banks in Ukraine. In *Fostering Sustainable Economic Growth in Ukraine*, edited by Cramon-Taubadel, Stephan von and Iryna Akimova, Heidelberg - Berlin – New-York: Physica-Verlag.

Fung, Ben, and Rohit Gupa. 1994. Searching the liquidity effect in Canada. *Bank of Canada Working Paper* #94-12

Gordon, David B., and Eric M. Leeper. 1992. In search of the liquidity effect. *Journal of Monetary Economics 29*: 341-370.

Grebenyk N. 1999. The Certificate of Deposit of the National Bank of Ukraine. *Visnyk NBU*, #12 (December):7 (Депозитний сертифікат Національного банку України, *Вісник НБУ*, №12, 1999)

Grebenyk N. 2000. Main target is the stability of national currency. *Visnyk NBU*, #6 (June):2-3 (Головна мета – стабільність національної валюти, *Вісник НБУ*, №6, 2000)

Gurski, Urban. 1999. Ukrainian interbank market. Preliminary results of research. (Украинский межбанковский рынок. Предварительные результаты исследований). *Studies and Analyses* #148 (January)

Hayashi, Fumio. 2000. Is there a liquidity effect in the Japanese interbank market? *Harvard Institute of Economic Research Discussion Paper* #1898 (May)

Kryshko, Maxim. 2001. Bank lending channels and monetary transmission mechanism in Ukraine. *EERC MA Thesis Paper*, NaUKMA

Kuznetsov, A. 2002. Strategic choice of NBU. *Newsletter of the Center for Monetary Policy within the NBU Council*, Vol.1: 3-10

Melvin, Michael. 1983. The vanishing liquidity effect of money on interest: Analysis and implications for policy. *Economic Inquiry*, Vol. XXI (April): 188-202

Melnyk, O. M. 2000. Legislative fundamentals and the most important parameters of monetary policy. *Finance of Ukraine*, *#7*: 34-44 (Законодавчі основи та найважливіші параметри грошово-кредитної політики, *Фінанси України,* №7, 2000)

Mishkin, Frederic S. 1995. Symposium on the monetary transmission mechanism. *The Journal of Economic Perspectives*, Vol. 9, Issue 4 (Autumn):3-10

Mishkin, Frederic S. 2001. *The Economics of Money, Banking and Financial Markets*. 6th ed. Boston, San Francisco, New-York: Addison-Wesley

Shevchuk V. 2001. The effect of monetary policy on industrial production, inflation and real exchange rate in Ukraine during 1994-2000. *Visnyk NBU*, #1 (January):12-15 (Вплив монетарної політики на промислове виробництво, інфляцію та реальний обмінний курс в Україні у 1994-2000 роках, *Вісник НБУ*, №1, 2001)

Stelmakh et al. 2000. *Monetary and credit policy in Ukraine*. (Грошово-кредитна політика в Україні), ed. Mischenko. Kyiv: Znannya

Strongin, Steven. 1995. The identification of monetary policy disturbances: Explaining the liquidity puzzle. *Journal of Monetary Economics 35* (August):463-97

Thornton, Daniel L. 2001. Identifying the liquidity effect at the daily frequency. *Federal Reserve Bank of St. Louis Review* (July-August):59-78

APPENDICIES

Appendix A. Operation procedure of the National Bank of Ukraine

The activity of the National Bank of Ukraine is regulated by the Constitution of Ukraine and the Law of Ukraine "On the National Bank of Ukraine". According to the Law, the NBU is responsible for carrying out following functions: it determines and conducts monetary and credit policy, issues domestic currency, acts as a lender of last resort, determines the order and form of payments (including interbank payments), exercises banking regulation and supervision, and carries out other functions defined by the Law (clause 7). Clause 99 of the Constitution of Ukraine states that the long-run objective of the National Bank of Ukraine is to provide stability of national monetary unit, hryvnia.

While the role of the NBU in monetary policy design and conduct is clearly stated officially, it is much more obscure in practice. Kuznetsov (2002) describes comprehensively the "hierarchy" of legal entities involved in the monetary policy conduct in Ukraine. In contrast to developed countries where money growth is determined by the growth of production and savings, in Ukraine as well as in other transition economies monetary actions undertaken by local authorities are strongly dependent on the schedule of state debt repayment to international financial organizations, especially to the IMF. The activity of the NBU is restricted by its obligation to fulfill the efficiency criteria established by the IMF, the most important of which are requirements to net foreign reserves, net domestic assets and monetary base. In addition, despite the officially proclaimed political independence of the NBU from the government (clause 4 of the Law), the NBU must bring its policy in accordance with the indexes of socio-economic development, defined by the Ministry of Economy and on the Issues of European Integration, and take account of activity of the main borrower and accumulator of the state financial resources – the Ministry of Finance. Thus, balancing between external and internal constraints the NBU designs directions and goals of monetary policy in a form of the official document "The Main Monetary Policy Guidelines". This document determines tentative levels of objectives and intermediate targets, as well as describes major instruments that NBU plans to employ in order to achieve the projected levels of targets.

The most important forecasted macroeconomic variables are (Grebenyk 2000):

- Real GDP growth rate
- Government budget deficit
- Level of inflation

Taking into account this forecast, the NBU determines corresponding intermediate targets of monetary policy:

- Money supply, level and growth rate
- Monetary base, level and growth rate
- Amount of loans to real sector

To achieve intermediate targets National Bank uses administrative (direct) and non-administrative (market) instruments. The major non-administrative instruments of monetary policy of the NBU can be classified as follows (Stelmakh et al. 2000):

- Required reserves
- Open-market operations
- Certificates of Deposit
- Discount rate policy

Since application of monetary policy instruments is the crucial part in the analysis of policy shock, the brief description of each instrument in Ukrainian context is provided below.

Reserve requirements

Reserve requirements policy is a powerful and administratively easily implemented instrument of monetary policy. Yet, frequent changes in reserve requirement policy as well as high reserve requirements ratio may appear very costly for banking sector and introduce distortions in interest rates formation (Eremenko 2001). For these reasons, and also due to availability of alternative instruments, central banks in developed countries use reserve requirements basically to support liquidity of commercial banks (Stelmakh et al. 2000) and continue to show a tendency toward reduction of reserve requirements ratio to zero level (Eremenko 2001, Melnyk 2000). In contrast, central banks of transition economies lack effective instruments of monetary policy and use reserve requirements as a key tool of money market regulation. This was also true for Ukrainian central bank throughout the period of investigation.

The National Bank of Ukraine used required reserves to guarantee the stability of banking sector, to regulate money turnover and to combat inflation (Stelmakh et al. 2000). In the end of 1996 the NBU took an important step toward establishing order and transparency in regulation of bank reserves - it adopted the Statute on accumulation of required reserves by the banking system of Ukraine. The Statute establishes a unified reserve requirements ratio and maintenance period for all types of deposits, describes the procedure of required reserves calculation, stipulates the possibility of government bonds and vault cash "covering", and institutes enforcement procedure and punitive sanctions[6]. Insufficient market reforms, lack of financial instruments, presence of structural and fiscal obstacles made reserve requirements the dominant instrument of monetary policy in Ukraine in 1997 – 1999. In the crisis periods of 1997, 1998, and 1999 the NBU actively used required reserves to slacken the pressure on foreign exchange market and to stabilize money market by increasing the reserve requirements ratio, shortening the maintenance period, and reducing or abolishing the amount of "covering" (Stelmakh et al. 2000).

Open-market operations

In Ukraine the market for government bonds began to function in March 1995 when the Ministry of Finance issued government bonds (OVDP) to finance budget deficit. The NBU was responsible for distribution, storage and settlements servicing of OVDPs, so it acted as a chief agent between the Ministry of Finance and market participants. In addition, the NBU was eligible to buy OVDPs at its own expenses in primary or secondary market and sell them in secondary market (Stelmakh et al. 2000).

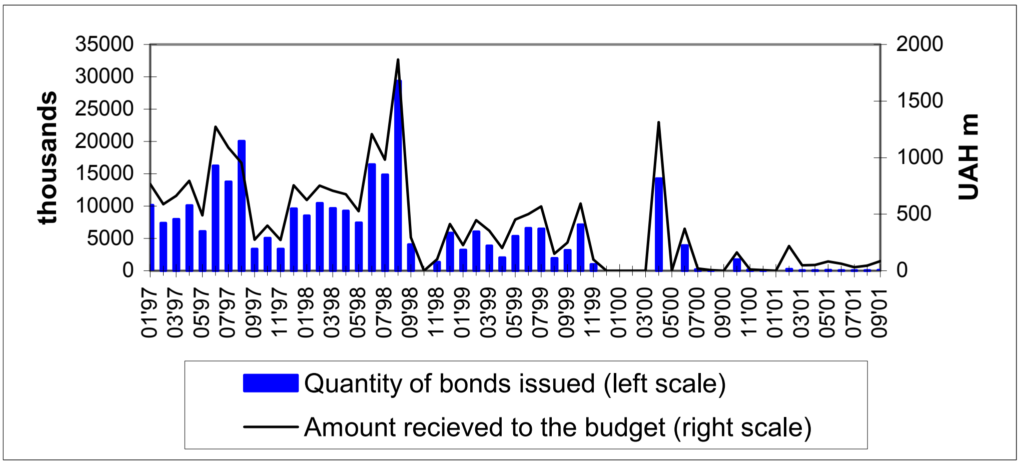

Figure A1. OVDP primary market in 1997 – 2001
Data source: Bulletin of the National Bank, various issues

[6] To enhance the enforcement procedure and make other changes new versions of the Statute were designed in 1999 and 2001.

Figure A1 depicts the dynamics of primary market for OVDPs. Till July 1997 domestic and foreign investors operated actively in the market since government bonds were highly profitable securities. This allowed Ukrainian government to increase number of bonds issued, thus, widening the market for government securities and raising sizeable amount of funds to the budget. Due to increased activity of traders and investors at that time, the NBU was able to conduct monetary policy through open-market operation successfully. However, the attitude of foreign investors toward financial markets of developing countries was negatively affected by consequences of the East Asian crisis at the end of 1997. As a result, large part of foreign portfolio investments was withdrawn from Ukrainian financial markets. Domestic investors (mainly commercial banks) followed this strategy and also reduced volumes of trade with government bonds. The NBU was deprived of possibility to implement open-market sales as effectively as before. In addition, it involuntary became the major participant in the OVDPs primary market (Stelmakh et al. 2000). The situation became even worse in August 1998, when Ukrainian government defaulted on OVDPs and frozen all its payments on bonds till 2001-2004. With the collapse of secondary markets the NBU entirely lost the most effective instrument of monetary policy. Furthermore, in 1998 – 1999 it almost fully financed budget expenses by purchasing bonds in the primary market (i.e. directly from the Ministry of Finance), which inevitably led to the rapid money supply growth (Stelmakh et al. 2000). In December 1999 the issue of government bonds was completely stopped. At the same time, according to the new version of the Law On the National Bank of Ukraine, the NBU became no longer eligible to buy government bonds in the primary market. Devoid of support of the central bank, Ukrainian government for a long time failed to restore confidence of commercial banks in government bonds. Thus, despite the promising start in April 2000, the revival of the government bonds market was far from success in 2000 - 2001.

Certificates of deposit

Inability to take advantage of open-market operations - the most efficient and quickly implemented monetary policy tool – compelled NBU officials to look for an alternative open-market-like instrument, that would substitute faithless government bonds. The search was crowned with success: in March 2000 the final version of the Statute On the Certificate of Deposits of the National Bank of Ukraine was adopted (Stelmakh et al. 2000). The Certificate of Deposits (here and thereafter CD) is a debt security of the National Bank that can be traded, exchanged, and used as a collateral only by commercial banks (Grebenyk 1999). CDs are short-term securities (with the period to maturity no longer than 180 days), they are issued in electronic form and distributed among banks on special auction sessions. The frequency of sessions, quantity of CDs issued each session, face value and interest payments are determined by the NBU depending on the current development of the money market (Stelmakh et al. 2000). Thus, the National Bank fully controls all aspects of CDs' circulation. The only thing beyond its control is the demand of commercial banks, which to great extent depends on the credibility of the issuer, the NBU. Despite this possible impediment, starting in January 2001 CDs became an actively used monetary policy tool (see Figure A2).

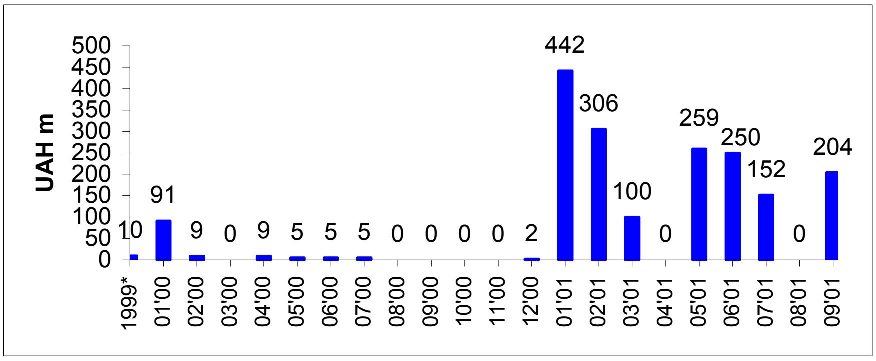

Figure A2. Certificates of Deposit issued by the NBU in 1999 – 2001
** during the whole year 1999. Data source: Bulletin of the National Bank, various issues*

Discount rate policy

Discount policy affects the money supply through the volume of discount loans supplied to the banking system. Change in the volume of discount loans affects monetary base and propagates further in money supply. Central bank regulates the volume of discount loans through the discount window or by setting the discount rate – interest rate that banks pay on funds borrowed from the central bank. When discount rate is low, compared to the market interest rate, commercial banks are ready to borrow from the central bank; therefore, the volume of discount loans increases. Analogously, when discount rate is high, the volume of discount loans decreases. Therefore, the simple logic predicts that, if the discount rate is an effective instrument of monetary policy, the volume of discount loans and the interest-rate spread (i.e. difference between the market interest rate and the discount rate) should be positively related. As Figure A3 shows, this does not hold true for Ukraine at least during 1997 - 2001.

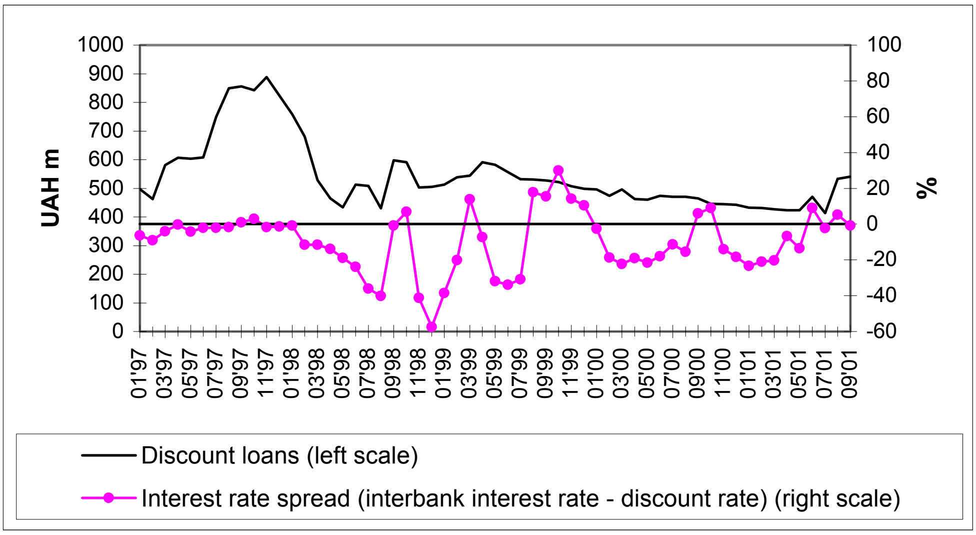

Figure A3. Interest rate spread and discount loans in 1997 – 2001
Data source: Bulletin of the National Bank, various issues; UEPLAC monthly update "Ukrainian Economic Trends", various issues

Several features of the discount rate policy can be inferred from Figure A3. First, most of the time during 1997 – 2001 the interest-rate spread was negative. Thus, with the interbank interest rate lower than the discount rate, it was less costly for commercial bank to borrow in the interbank market than from the NBU. Second, positive relationship between the interest rate spread and the amount of discount loans is observed in 1997 and to lesser extent in 1998. Since 1999 the volume of discount loans exhibits stable (slightly downward) trend despite the significant fluctuations in the interest-rate spread. These facts indicate that in 1999 - 2001 the discount rate was very weak and ineffective tool of monetary policy.

Several explanations are provided in economic literature. By interviewing Ukrainian commercial banks, Gurski (1999) finds out that banks are unwilling to borrow from the NBU due to complication and lack of transparency in the refinancing procedure. Banks complain that credit auctions, where discount loans are distributed, are held rarely and disorderly; furthermore, application process is usually prolonged and there is no guarantee that any reply will be received in time. There is no evidence that regulation concerning credit auctions changed much since 1999. If so, stable trend of volume of discount loans in 1999 – 2001 is readily explained. As to the earlier episode, Dzoblyuk (2000) points out that during the periods of rapid growth of market for government bonds banks were heavily engaged in speculative operations with OVDPs, so that relatively cheap discount loans might be easily reinvested in profitable government securities, rather than transmitted to the real sector. This observation explains why discount rate policy was hardly effective even in 1997 – 1998, when positive relationship between volumes of discount loans and interest-rate spread is detected. Under these circumstances, in 1997 - 2001 official discount rate functioned as an informative (or even declarative) index rather than the regulatory mechanism (Dzoblyuk 2000). Recall, that econometric test for the information content of the interbank interest rate also supports this conclusion implicitly.

Summary

Summarizing all above it can be concluded that during sub-periods of the period of investigation, January 1997 – September 2001, the leading place in money market regulations was attributed to different instruments: (i) reserve requirements, (ii) open market operations or (iii) certificates of deposit, whereas discount rate functioned mainly as an informative indicator. Two common features unite the first three instruments: first, they are under *direct* control and supervision of a *single* legal entity, the National Bank of Ukraine, and second, any action with these instruments is immediately reflected in the volume of total reserves held by commercial banks. These two features allow me to suggest that total reserves contain the major part of the exogenous policy shocks. Thus, taking total reserves as a policy variable is likely to be a plausible solution to money endogeneity problem described above.

Appendix B. Estimation input and output

Table B1. Descriptive statistic of variables used in modeling

	M	P	I	R
Mean	13235.72	1.282456	2.382368	2537.105
Median	11434	1	1.891667	2301
Maximum	25884	6.2	7.41	5209
Minimum	6433	-1.7	0.3	942
Std. Dev.	5402.964	1.478673	1.676651	1426.687
Skewness	0.757984	0.864594	1.262912	0.481816
Kurtosis	2.353237	4.06629	3.942204	1.775454
Jarque-Bera	6.451598	9.801772	17.2604	5.766735
Probability	0.039724	0.00744	0.000179	0.055946
Observations	57	57	57	57
Phillips-Perron test statistic for levels	5.796151 (-3.5478)*	-3.921985** (-3.5478)	-2.565851 (-3.5501)	-0.116551 (-3.5501)
Phillips-Perron test statistic for 1st differences	-7.864119 (-3.5478)	-12.88998 (-3.5478)	-46.14091 (-3.5523)	-9.265309 (-3.5523)

** 1% MacKinnon critical values for rejection of hypothesis of a unit root are in parentheses*

*** While Phillips-Perron test rejects the hypothesis of a unit root for inflation, ADF test statistics is very sensitive to the number of lags included. Taking into account small sample size, I am inclined to suspect that inflation is a non-stationary series.*

Eviews estimation output

Vector error correction model, 1 lag

Date: 03/26/02 Time: 14:26
Sample(adjusted): 1997:03 2001:09
Included observations: 55 after adjusting endpoints
Standard errors & t-statistics in parentheses

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	
M1(-1)	1.000000	0.000000	0.000000	
INFL(-1)	0.000000	1.000000	0.000000	
IIRM(-1)	0.000000	0.000000	1.000000	
TR(-1)	17.79161	0.002556	0.012017	
	(84.9013)	(0.01114)	(0.04720)	
	(0.20956)	(0.22941)	(0.25460)	
Error Correction:	**D(M1)**	**D(INFL)**	**D(IIRM)**	**D(TR)**
CointEq1	-0.010976	-0.000165	0.000137	-0.018090
	(0.02882)	(6.2E-05)	(6.0E-05)	(0.01368)
	(-0.38079)	(-2.66986)	(2.26847)	(-1.32200)
CointEq2	-38.12222	-0.854593	-0.269546	45.38579
	(74.9677)	(0.16115)	(0.15654)	(35.5883)
	(-0.50852)	(-5.30326)	(-1.72187)	(1.27530)
CointEq3	40.22717	0.493669	-0.174624	24.43021
	(61.0586)	(0.13125)	(0.12750)	(28.9855)
	(0.65883)	(3.76137)	(-1.36961)	(0.84284)
D(M1(-1))	-0.171799	6.26E-05	-0.000457	-0.029823
	(0.13662)	(0.00029)	(0.00029)	(0.06486)
	(-1.25749)	(0.21310)	(-1.60118)	(-0.45984)
D(INFL(-1))	-76.60723	0.221701	0.069648	-15.52223
	(68.0976)	(0.14638)	(0.14220)	(32.3270)
	(-1.12496)	(1.51458)	(0.48980)	(-0.48016)
D(IIRM(-1))	-59.07361	-0.253440	0.061735	10.52444
	(75.5604)	(0.16242)	(0.15778)	(35.8697)
	(-0.78181)	(-1.56041)	(0.39127)	(0.29341)
D(TR(-1))	0.395412	-0.000407	-0.001122	-0.438878
	(0.34625)	(0.00074)	(0.00072)	(0.16437)
	(1.14199)	(-0.54739)	(-1.55124)	(-2.67007)
R-squared	0.267987	0.404154	0.340848	0.187569
Adj. R-squared	0.176485	0.329674	0.258454	0.086016
Sum sq. resids	14348937	66.29876	62.56588	3233608
S.E. equation	546.7506	1.175255	1.141690	259.5512
Log likelihood	-421.0174	-83.17947	-81.58581	-380.0403
Akaike AIC	12.72640	0.441383	0.383432	11.23632
Schwarz SC	12.98188	0.696862	0.638911	11.49180
Mean dependent	352.4364	-0.014545	-0.017273	61.50909
S.D. dependent	602.4950	1.435453	1.325803	271.4899

Determinant Residual Covariance	1.72E+10
Log Likelihood	-850.2225
Akaike Information Criteria	23.92931
Schwarz Criteria	24.29428

Vector error correction model, 2 lags

Date: 03/26/02 Time: 14:29
Sample(adjusted): 1997:04 2001:09
Included observations: 54 after adjusting endpoints
Standard errors & t-statistics in parentheses

Cointegrating Eq:	CointEq1			
M1(-1)	1.000000			
INFL(-1)	36046.41 (3040768) (0.01185)			
IIRM(-1)	-10719.52 (830534.) (-0.01291)			
TR(-1)	411.0808 (35621.3) (0.01154)			
Error Correction:	**D(M1)**	**D(INFL)**	**D(IIRM)**	**D(TR)**
CointEq1	0.000448 (9.9E-05) (4.53465)	3.50E-08 (2.4E-07) (0.14357)	1.42E-07 (2.2E-07) (0.65909)	7.62E-05 (4.6E-05) (1.66450)
D(M1(-1))	-0.212013 (0.14020) (-1.51221)	-1.71E-05 (0.00035) (-0.04927)	-0.000605 (0.00031) (-1.97496)	0.010050 (0.06499) (0.15464)
D(M1(-2))	-0.235498 (0.13610) (-1.73033)	-0.000219 (0.00034) (-0.65288)	0.000120 (0.00030) (0.40432)	-0.006842 (0.06309) (-0.10845)
D(INFL(-1))	-101.7739 (55.4794) (-1.83444)	-0.247107 (0.13701) (-1.80356)	-0.221000 (0.12118) (-1.82366)	26.65044 (25.7172) (1.03629)
D(INFL(-2))	-61.41721 (57.9140) (-1.06049)	-0.511859 (0.14302) (-3.57887)	-0.459965 (0.12650) (-3.63601)	96.94317 (26.8457) (3.61113)
D(IIRM(-1))	-58.11566 (65.1173) (-0.89248)	0.100529 (0.16081) (0.62513)	0.131950 (0.14224) (0.92768)	8.167554 (30.1848) (0.27059)
D(IIRM(-2))	112.7215 (60.5417) (1.86188)	0.392624 (0.14951) (2.62604)	0.007660 (0.13224) (0.05792)	7.236072 (28.0638) (0.25784)
D(TR(-1))	0.318018 (0.32882) (0.96714)	0.000137 (0.00081) (0.16818)	-0.001351 (0.00072) (-1.88086)	-0.412471 (0.15242) (-2.70608)
D(TR(-2))	-0.135597 (0.35578) (-0.38113)	-0.000909 (0.00088) (-1.03489)	0.000232 (0.00078) (0.29824)	0.066670 (0.16492) (0.40425)
R-squared	0.363597	0.309257	0.373086	0.322858
Adj. R-squared	0.250458	0.186458	0.261635	0.202478
Sum sq. resids	12466275	76.02895	59.47987	2678672
S.E. equation	526.3348	1.299820	1.149685	243.9796
Log likelihood	-410.0604	-85.86000	-79.23215	-368.5424

Akaike AIC	12.68289	0.675463	0.429987	11.14518
Schwarz SC	13.01438	1.006961	0.761485	11.47668
Mean dependent	350.3148	0.005556	-0.013534	64.37037
S.D. dependent	607.9449	1.441097	1.337960	273.2008

Determinant Residual Covariance	1.51E+10
Log Likelihood	-831.3921
Akaike Information Criteria	23.81116
Schwarz Criteria	24.17949

Vector error correction model, 3 lags

Date: 03/26/02 Time: 14:31
Sample(adjusted): 1997:05 2001:09
Included observations: 53 after adjusting endpoints
Standard errors & t-statistics in parentheses

Cointegrating Eq:	CointEq1
M1(-1)	1.000000
INFL(-1)	-2529.564
	(5506.13)
	(-0.45941)
IIRM(-1)	-101.4437
	(2227.51)
	(-0.04554)
TR(-1)	-12.02154
	(11.2781)
	(-1.06592)

Error Correction:	D(M1)	D(INFL)	D(IIRM)	D(TR)
CointEq1	-0.028819	7.16E-06	3.16E-06	-0.004571
	(0.00617)	(1.5E-05)	(1.3E-05)	(0.00305)
	(-4.67368)	(0.47830)	(0.23969)	(-1.50082)
D(M1(-1))	-0.265540	-0.000154	-0.000312	-0.002109
	(0.14933)	(0.00036)	(0.00032)	(0.07375)
	(-1.77815)	(-0.42517)	(-0.97722)	(-0.02859)
D(M1(-2))	-0.183118	-0.000357	0.000214	-0.012930
	(0.14393)	(0.00035)	(0.00031)	(0.07108)
	(-1.27228)	(-1.02251)	(0.69363)	(-0.18190)
D(M1(-3))	-0.144130	0.000190	0.000314	-0.022914
	(0.13734)	(0.00033)	(0.00029)	(0.06783)
	(-1.04942)	(0.56948)	(1.06893)	(-0.33781)
D(INFL(-1))	-196.4328	-0.308125	-0.185095	7.950385
	(66.7543)	(0.16211)	(0.14283)	(32.9690)
	(-2.94263)	(-1.90069)	(-1.29594)	(0.24115)
D(INFL(-2))	-94.77535	-0.640599	-0.415293	84.87667
	(63.9230)	(0.15524)	(0.13677)	(31.5707)
	(-1.48265)	(-4.12661)	(-3.03645)	(2.68847)

D(INFL(-3))	-52.79991	-0.197599	-0.101262	-26.48238
	(78.9084)	(0.19163)	(0.16883)	(38.9718)
	(-0.66913)	(-1.03116)	(-0.59978)	(-0.67953)
D(IIRM(-1))	-24.43236	0.065731	0.042813	7.799968
	(70.4773)	(0.17115)	(0.15079)	(34.8078)
	(-0.34667)	(0.38404)	(0.28392)	(0.22409)
D(IIRM(-2))	66.37172	0.499976	-0.025152	4.727427
	(65.0086)	(0.15787)	(0.13909)	(32.1068)
	(1.02097)	(3.16696)	(-0.18083)	(0.14724)
D(IIRM(-3))	56.44422	0.291792	-0.227564	16.28124
	(69.4320)	(0.16861)	(0.14856)	(34.2915)
	(0.81294)	(1.73052)	(-1.53184)	(0.47479)
D(TR(-1))	0.179123	0.000526	-0.000765	-0.398577
	(0.36694)	(0.00089)	(0.00079)	(0.18123)
	(0.48815)	(0.58997)	(-0.97428)	(-2.19931)
D(TR(-2))	-0.363074	-0.000344	0.000317	0.061905
	(0.37311)	(0.00091)	(0.00080)	(0.18427)
	(-0.97310)	(-0.37913)	(0.39682)	(0.33594)
D(TR(-3))	-0.843596	0.001823	-0.001140	-0.062682
	(0.37172)	(0.00090)	(0.00080)	(0.18359)
	(-2.26942)	(2.01939)	(-1.43293)	(-0.34142)
R-squared	0.446092	0.416214	0.476559	0.329255
Adj. R-squared	0.279919	0.241079	0.319527	0.128031
Sum sq. resids	10846758	63.96946	49.65479	2645781
S.E. equation	520.7389	1.264609	1.114168	257.1858
Log likelihood	-399.2743	-80.18857	-73.47583	-361.8855
Akaike AIC	12.71965	0.678680	0.425369	11.30875
Schwarz SC	13.20293	1.161959	0.908648	11.79203
Mean dependent	351.8113	-0.007547	-0.015818	66.35849
S.D. dependent	613.6623	1.451637	1.350657	275.4206
Determinant Residual Covariance		8.57E+09		
Log Likelihood		-800.9139		
Akaike Information Criteria		23.39996		
Schwarz Criteria		23.92042		