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# The Design of Monetary Policy in a Small Transitional Economy: The Case of Tajikistan

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***Abstract:*** Using the Structural Vector Autoregression (SVAR) method this paper surveys the effect of monetary and exchange rate policies on Tajikistan's economy for the period 1996 to 2004. A number of restrictions are imposed and the contemporaneous and long-run restrictions model are used to identify the dynamic response of inflation and output to the monetary and exchange rate innovations. As a result these shocks are used to generate the structural impulse response and forecast error variance decomposition functions for assessing the dynamic impacts of monetary and exchange rate policies on country's real sector variables.

***Keywords:*** monetary and exchange rate policies, inflation, output and structural vector autoregression (SVAR)

***JEL Classification:*** E31, E42, E52, E58, E60.

## Introduction

After the collapse of Soviet Union the inflation and exchange rate have become the most discussed economic indicators in Tajikistan. The public follows their changes with enormous attention. The particularly high attention to real output and inflation arises from constant changes in domestic production and price expectations. In fact during the first few years of independence, when the country faced civil war (1992-1997), real GDP fell up to 30 per cent and inflation rate rose above 1000 per cent annually (State Committee on Statistics of the Republic of Tajikistan, 2000). It seems that a methodical understanding of the dynamics of GDP, inflation, the money supply (M1), nominal interest rates and local-currency depreciation is important, especially in terms of the correct directions for economic policy during transition. Hence, this paper analyses the impact of monetary and exchange rate innovations to price and output and their relative importance in determining price levels and the growth rate. The natural framework to investigate the role of innovations on the

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economy and their possible determination is a Structural Vector Autoregression (SVAR)[2] model.

The purpose of this paper is: 1) to evaluate inflation targeting in the specific context of a small transition economy, such as Tajikistan; and 2) to examine the short run and long run effects of the National Bank of Tajikistan's (NBT) monetary and exchange rate policies on the country's economy, in particular on the level of prices and real output during the transition period 1996-2004. Using monthly macroeconomic data, a system of five equations for the SVAR model is constructed. These variables are real GDP, the price level, nominal money supply (M1), nominal interest rate and the change in the nominal exchange rate, or local currency depreciation. It should be noted that, given short history of the country without a central planning structure, the construction of such a model is difficult. However, in view of the fact that the Tajik economy needs urgent stabilization and higher growth, the need for such a model is pressing.

In the model specification part of this study, at least ten restrictions are imposed to completely identify the structural model. Following previous studies, such as Shapiro and Watson (1988), Blanchard and Quah (1989), and Maliszewski (2000, 2003) and taking into account the transitional situation of Tajikistan's economy, several assumptions are made and a number of restrictions are imposed to differentiate the structural models of this study. Assuming that monetary and exchange rate policies have contemporaneous effects on the inflation rate, necessary restrictions for the first model can be identified. In the second model, the long-run restrictions have been assumed for real GDP and price responses to monetary innovations. Hence monetary shocks have been used to generate the impulse response and forecast error variance decomposition functions to assess the dynamic impacts on the different economic variables.

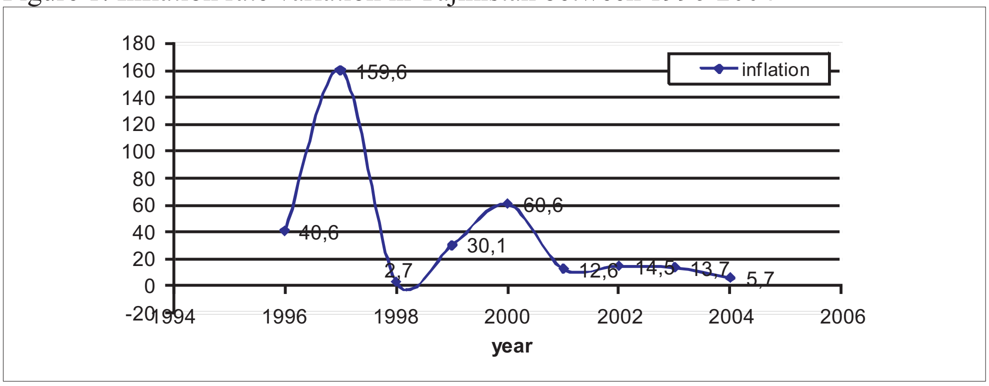
The estimated results show that monetary policy innovations do contain an important cause of inflation variability in the short-run restriction model rather than the long-run. However the nominal exchange rate and price shocks account for the major predictive power of price variability in the short-run and long-run restriction models. On the other hand the importance of monetary and exchange rate innovations as causes of real output variability increases in the long-run restriction model. Nevertheless, monetary and exchange rate innovations contribute substantially to variability of price level and real output during the transition periods. Overall the analyses suggests that a better performance of implementing monetary and exchange rate policies, in particular money supply, interest rate and nominal exchange rate, are the key instruments for any transitional developing economy to attain lower inflation.

This paper is organized as follows. Section 2 describes the role of monetary policy and inflation targeting in Tajikistan. Section 3 presents' methodology and model specifications for structural VAR. Section 4 provides the data, variables, and discusses the estimation results. Section 5 concludes the paper.

## Monetary Policy and Inflation declining in Tajikistan

Following the fall of the Soviet Union in 1991, Tajikistan's economy went through several high inflation phases, caused by the country's economic and political instability; civil war, enormous budget deficits, price shocks and weak monetary policies. As a result of these disturbances consumer prices in some periods rose to 20-50 per cent per month and annual real GDP fell about 20-30 per cent. The balance of payments crisis was one of the main factors that caused high inflation and other problems in the monetary system of the country. Throughout 1991-95, the inflation rate accelerated due a sharp devaluation of the Russian ruble.[3] Tajikistan was the last former USSR republic that was operating with the Russian ruble as the national currency, until May 1995. This brought about high levels of fluctuation in key macroeconomic variables, in particular prices and real output. In addition, there was a large expansion in the total credit value in the economy, mostly in the industrial and agriculture sectors that led significantly to persistence of high levels of inflation.

Figure 1: Inflation rate variation in Tajikistan between 1996-2004




The country's civil war, a decrease in output and employment, fast depreciation of the domestic currency, balance of payments errors and monetarisation of budget deficits were the major causes of high inflation and economic crisis. From mid 1996 a liberalisation and stabilisation program with International Monetary Fund (IMF) and World Bank (WB) assistance was introduced. The main targets of the program were the reduction of the inflation rate, increased growth of GDP and price liberalisation. However as a result of the introduction of these policies, inflation became the key concern of the economy. Thus maintaining price stability became the primary target of the NBT that had earlier aimed at maintaining economic development.

After facing a period of hyperinflation, the first years of the program (1996-1997) were not very successful in terms of achieving economic growth or lower inflation. Temporary fixing of the Tajik ruble against the US dollar was one of the more straightforward ways to reduce the high level of inflation which, on the other hand, counts as one of the purposes of stabilization policies for transition economies. The National Bank of Tajikistan (NBT) also reduced the amount of credit extended to the public sector. At the early stage of transition, the NBT controlled money supply through credit ceilings, however in the late 1990s the NBT turned to implementing indirect monetary policy instruments.

Gradually, with the help of the IMF and WB, monetary and budgetary regulation has been restored and domestic prices have stabilized compared to previous periods. Open market operations have become one of the policy instruments since their introduction by the joint efforts of the NBT and the Ministry of Finance in 1998. At the end of 1998 the effect of the Russian financial crisis and the devaluation of the local currency brought some new inflationary tendencies, however the NBT applied measures to avoid a quick fall in the domestic currency. The exchange rate was considered as the main instruments for the promotion of exports and macroeconomic stability. Thus the NBT switched from a fixed to a managed floating exchange rate system in order to improve competitiveness of the national currency. At the same time the NBT maintained tight liquidity management, holding up money market rates in order to prevent serious depreciation of the national currency.

The macroeconomic stabilization program introduced inflation targeting in the monetary policy of Tajikistan. As a result of the stabilization program inflation declined more sharply than targeted. For instance, the rate of change of consumer prices declined from 159 per cent during 1997 to 2.7 percent in 1998 (NBT, 1998, 1999 and IMF, 2000). The main reasons for the significant decline in inflation were the high interest rates and lower real wages that brought domestic demand under control. Despite the maintenance of a tight monetary policy in early 1999 to depress the effects of the exchange rate depreciation of late 1998, inflation continued to be sensitive and started to rise between 1999 to 2000 due to extended credits to the private sector and public borrowing to finance the deficits. The high and continuing inflation has affected the economy negatively, deteriorating income distribution and holding constant the low level of investment from abroad.

As regards monetary policy, despite the fact that reserve money remained close to the targets, net domestic assets were significantly higher than expected as net credits to the government exceeded the predicted targets. Monetary authorities implicitly started to use exchange rate as part of a disinflation program by holding higher interest rates on domestic assets and a lower depreciation rate for rising investment. However, note that since 1999 the NBT has gradually reduced interest rates by strictly monitoring developments on the foreign exchange market. The NBT has also practically started extending all credit through the credit auction mechanism.

In June 1998, the government of Tajikistan adopted a new medium-term economic adjustment and reform program for the period 1999-2002, supported by the World Bank's Structural Adjustment Credits, in order to combine the gains in financial stabilization and intensify structural reforms. The key medium-term macroeconomic objectives of the program were to: 1) decrease the inflation rate to 7 per cent; 2) increase real GDP growth to 6-7 per cent a year; and 3) increase foreign exchange reserves of the NBT to about 3.5 months of imports by the end of 2002. To achieve the inflation and foreign reserve aims, the program was based on appropriate tight monetary and fiscal policies.

The new Tajik currency 'somoni' which replaced the Tajik ruble was introduced on October 30, 2000, with the equivalent of one somoni to 1000 Tajik rubles. This currency reform was assessed as positive as: 1) it was the first currency reform that did not cause losses to the country population; 2) the introduction of the new currency was based on improvement of the economic and banking systems; and 3) it maintained the link to historical traditions (Government of Tajikistan, 2000, and NBT 2000). In commenting on Tajikistan's currency reform, Eduardo Aninat, IMF Deputy Managing Director, said: 'currency reform is an important element of Tajikistan's economic program, which calls for prudent monetary policy by the central bank, continued fiscal consolidation, and accelerated structural reforms, to improve the investment environment in the country' (IMF News Brief, 2000).

As a result of the tight monetary policy framework, Tajikistan has achieved strong macroeconomic performance over the past three years (2002-04) as growth has been sustained at a relatively high rate, while inflation has declined as well. Real GDP expanded by 9,5 per cent in 2002, over 10,0 per cent in 2003 and about 10,6 per cent in 2004. Meanwhile, inflation was less than 14,5 per cent in 2002, about 13,7 per cent in 2003 and only 5,7 per cent in 2004 (NBT, 2001-2004; State Committee on Statistics of the Republic of Tajikistan, 2005). The exchange rate remained stable till November 2001, but weakened after that, reflecting an expansion of liquidity and political instabilities over the situation in neighboring Afghanistan. Despite some depreciation in the exchange rate, the nominal exchange rate has remained mostly stable over the last two years.

While the implementation of various stabilization programs since 1997 lowered the level of inflation, it was only temporary, and, as was shown above, inflation remains a key dilemma for the development of the Tajik economy. The possible reasons of today's high inflation rates in Tajikistan are: 1) inflationary influences of raising exchange rates through prices of imported goods; 2) increases in world prices of major imported inputs (such as oil, gas, wheat); 3) regional political instability (Afghanistan, Russia and Central Asia) and, to some extent, the existing high public sector budget deficits and their miniaturization; and 4) the rise in the prices of public sector products that are used by the domestic private sector. There is also the question related to independence of the NBT. It is not easy for the NBT to carry out its obligations independently from the government or parliament, which contradicts it in resolving some targeting tasks.

To ensure the successful implementation of monetary policy, the NBT has improved its short-term liquidity control and developed its tools for indirect monetary management. Thus as a result, a stable monetary setting could have substantially increased foreign investment and domestic savings in 2005. Further depreciation of the local currency, despite high interest rates and interventions in the foreign exchange market, has kept the monetary setting tight and improved performance of the monetary and exchange rate targeting framework, or, in other words, overall the monetary and exchange rate policies have aimed at following inflation targeting. However one of the requirements for inflation targeting is price stability in the economy. Hence one of the primary goals of the NBT is to achieve and maintain price stability through careful implementation of monetary policy instruments that can assist unemployment and growth policies of the government in attaining economic development.

## Methodology and Model Specification of Structural VAR

### *Methodology and Model Specification*

The structural VAR is an appropriate methodology to bring multiple time-series analysis and economic theory together to determine the dynamic response of estimated variables to various shocks that take place in the economy. This paper is based on the Sims model (1980, 1982, 1986) and the general model of SVAR put forward by Giannini (1992), Amisano and Giannini (1997).

Following previous studies we consider a system of simultaneous equations implied in vector form as:

$$By_t = \gamma_0 + A(L)y_{t-1} + M\varepsilon_t \tag{1}$$

Where $y_t$ is a vector of endogenous variables, $\gamma_0$ is the fixed constant, $y_{t-1}$ is a vector of their lagged values, $\varepsilon_t$ is a vector of random error of the disturbance terms for every variable which captures any exogenous factors in the model, B is the square matrix of dimension *nxn*, where *n* is a number of variables, and contains the structural parameters of the contemporaneous endogenous variables, A(L) is a matrix polynomial in the lag operator L of length p, and M is the square *nxn* matrix, which contains the contemporaneous response of the variables to the innovations (disturbances).

The first stage of structural VAR analysis is the estimation of the reduced form. As the coefficients in the matrices of (1) are unknown and the variables have temporary effects on each other the model in this form cannot be completely identified. But, it is likely to transform (1) into a reduced-form model by multiplying both sides of the equation by the inverse matrices of B, which brings about the standard VAR representation as:

$$Y_t = \alpha_0 + D(L) y_{t-1} + e_t \qquad (2)$$

where $\alpha_0 = B^{-1}\gamma_0$, $D(L) = B^{-1}A(L)$ and $e_t = B^{-1}M\varepsilon_t$.

The error terms $e_t$ are linear combinations of the orthogonalized shocks ($\varepsilon_t$), such that each individual error term is serially uncorrelated with a zero mean and a constant variance. While different from the disturbance terms $\varepsilon_t$, the error terms in $e_t$ are correlated with each other. Hence, this raises a dilemma in recovering the underlying structural disturbances from the estimated VAR.

In VAR analysis the only source of variation of $y_t$ variables is random disturbances that in the reduced form are indicated by a vector of white noise $e_t$, usually called a vector of innovations (Amisano and Giannini, 1997). This study employs the models used in the applied SVAR studies, such as, the short-term SVAR models; the long-run effect; the impulse-response function (IRF); and the forecast error variance of decomposition (FEVD).[4]

The empirical work applied in this study is in the form of a small, open-economy structural vector autoregression (SVAR). This SVAR model is composed of a system of five equations, depicting the relationship between the main macroeconomic indicators of Tajikistan, the growth rate of real GDP, the inflation rate, the growth rate of nominal money supply (M1), the nominal interest rate, and the local currency depreciation.

The above equation (1) is called a structural VAR as it is assumed to be determined by some underlying economic theory. Thus the structural model of this study is described by the following dynamic system of simultaneous equations (1.1-1.5):

$$er_t = a_{10} - b_{12}ir_t - b_{13}m_t - b_{14}g_t - b_{15}p_t + \sum_{i=1}^{p} a_{11}^{i} er_{t-1} + \sum_{i=1}^{p} a_{12}^{i} ir_{t-1} + \sum_{i=1}^{p} a_{13}^{i} m_{t-1} + \sum_{i=1}^{p} a_{14}^{i} g_{t-1} + \sum_{i=1}^{p} a_{15}^{i} p_{t-1} + \varepsilon_t^{er}, \qquad (1.1)$$

$$ir_t = a_{20} - b_{21}er_t - b_{23}m_t - b_{24}g_t - b_{25}p_t + \sum_{i=1}^{p} a_{21}^{i} er_{t-1} + \sum_{i=1}^{p} a_{22}^{i} ir_{t-1} + \sum_{i=1}^{p} a_{23}^{i} m_{t-1} + \sum_{i=1}^{p} a_{24}^{i} g_{t-1} + \sum_{i=1}^{p} a_{25}^{i} p_{t-1} + \varepsilon_t^{ir}, \qquad (1.2)$$

$$ir_t = a_{20} - b_{21}er_t - b_{23}m_t - b_{24}g_t - b_{25}p_t + \sum_{i=1}^{p} a_{21}^i er_{t-1} + \sum_{i=1}^{p} a_{22}^i ir_{t-1} + \sum_{i=1}^{p} a_{23}^i m_{t-1} + \sum_{i=1}^{p} a_{24}^i g_{t-1} + \sum_{i=1}^{p} a_{25}^i p_{t-1} + \varepsilon_t^{ir}\ , \quad (1.2)$$

$$m_t = a_{30} - b_{31}er_t - b_{32}ir_t - b_{34}g_t - b_{35}p_t + \sum_{i=1}^{p} a_{31}^i er_{t-1} + \sum_{i=1}^{p} a_{32}^i ir_{t-1} + \sum_{i=1}^{p} a_{33}^i m_{t-1} + \sum_{i=1}^{p} a_{34}^i g_{t-1} + \sum_{i=1}^{p} a_{35}^i p_{t-1} + \varepsilon_t^{m}\ , \quad (1.3)$$

$$g_t = a_{40} - b_{41}er_t - b_{42}ir_t - b_{43}m_t - b_{45}p_t + \sum_{i=1}^{p} a_{41}^i er_{t-1} + \sum_{i=1}^{p} a_{42}^i ir_{t-1} + \sum_{i=1}^{p} a_{43}^i m_{t-1} + \sum_{i=1}^{p} a_{44}^i g_{t-1} + \sum_{i=1}^{p} a_{45}^i p_{t-1} + \varepsilon_t^{g}\ , \quad (1.4)$$

$$p_t = a_{50} - b_{51}er_t - b_{52}ir_t - b_{53}m_t - b_{54}g_t + \sum_{i=1}^{p} a_{51}^i er_{t-1} + \sum_{i=1}^{p} a_{52}^i ir_{t-1} + \sum_{i=1}^{p} a_{53}^i m_{t-1} + \sum_{i=1}^{p} a_{54}^i g_{t-1} + \sum_{i=1}^{p} a_{55}^i p_{t-1} + \varepsilon_t^{p}\ , \quad (1.5)$$

$$\text{where} \quad \begin{pmatrix} \varepsilon_t^{er} \\ \varepsilon_t^{ir} \\ \varepsilon_t^{m} \\ \varepsilon_t^{g} \\ \varepsilon_t^{p} \end{pmatrix} \sim \text{i.i.d.} \left( \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{er}^2 & 0 & 0 & 0 & 0 \\ 0 & \sigma_{ir}^2 & 0 & 0 & 0 \\ 0 & 0 & \sigma_m^2 & 0 & 0 \\ 0 & 0 & 0 & \sigma_g^2 & 0 \\ 0 & 0 & 0 & 0 & \sigma_p^2 \end{pmatrix} \right) \quad (1.b)$$

where $er_t$, $ir_t$, $m_t$, $g_t$, and $p_t$ are endogenous variables [$er_t$ is the log of the growth rate of nominal exchange rate, $ir_t$ is the log of the nominal interest rate of NBT, $m_t$, the log of the growth rate of nominal money supply (M1), $g_t$ is the log of real GDP growth, $p_t$ denotes the log of the growth rate of consumer price indices,]. Here the exogenous error terms $\varepsilon_t^{er}$, $\varepsilon_t^{ir}$, $\varepsilon_t^{m}$, $\varepsilon_t^{g}$, $\varepsilon_t^{p}$ are independent and are interpreted as structural innovations. For simplicity the seasonal dummy variables are omitted in the equations here but they are included in the estimation process. The realisation of each structural innovation is known as capturing unexpected shocks to its dependent variable (respectively), which are uncorrelated with the other unexpected shocks ($\varepsilon_t$). In (1.1- 1.5), the endogeneity of $e_{rt}$, $ir_t$, $m_t$, $g_t$, and $p_t$ is determined by the values of coefficients of b.

The model (1.1 – 1.5) can be written in matrix form as:

$$\begin{bmatrix} 1 & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & 1 & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & 1 & b_{34} & b_{35} \\ b_{41} & b_{42} & b_{43} & 1 & b_{45} \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 \end{bmatrix} \begin{bmatrix} er_t \\ ir_t \\ m_t \\ g_t \\ p_t \end{bmatrix} = \begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \\ a_{40} \\ a_{50} \end{bmatrix} + \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} \end{bmatrix} \begin{bmatrix} er_{t-i} \\ ir_{t-i} \\ m_{t-i} \\ g_{t-i} \\ p_{t-i} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^{er} \\ \varepsilon_t^{ir} \\ \varepsilon_t^{m} \\ \varepsilon_t^{g} \\ \varepsilon_t^{p} \end{bmatrix} \quad (1.c)$$

where i=1,2,….,n.

*Identification of Restrictions*

Without imposing a number of restrictions, the parameters in the SVAR model (1.1 – 1.5) cannot be identified. To identify a monetary and exchange rate policy shock in Tajikistan the short and long run parameter restrictions are applied. Identification of shocks in the system described by equations (1.1-1.5) and (1.b) requires imposing at least *n(n-1)/2* sufficient restrictions.

Table 1 presents the imposed short-run parameter restrictions (B matrix). In the short-run version of the SVAR model, restrictions are required for specific identification. Restrictions can be imposed on the structure of the vector of error terms, ($e_t$), on the basis of economic theory. Each equation must hold an independent structural disturbance term.

Table 1: Restrictions on parameters of the B matrix

| | Monetary sector | | | Real sector | |
|---|---|---|---|---|---|
| variables | NER | NIR | M1 | GDP | PD |
| NER | 1 | 0 | 0 | 0 | 0 |
| NIR | 0 | 1 | 0 | 0 | 0 |
| M1 | $b_1$ | 0 | 1 | 0 | 0 |
| GDP | 0 | $b_3$ | $b_5$ | 1 | 0 |
| PD | $b_2$ | $b_4$ | $b_6$ | $b_7$ | 1 |

The identification of restrictions in the real sector (prices and real GDP) is obtained by assuming that monetary sector variables affect the real sector only with a lag (A matrix). The real sector variables have no effect in identification of shocks in the monetary sector. Assume that nominal exchange rate does not contemporaneously affect real GDP. Two more restriction are that the nominal variables have no contemporaneous effect on interest rate and the last two additional restrictions are that real output does not have a contemporaneous effect on prices, and change in the interest rate may not contemporaneously change M1. 'Despite NBT's high interest rate, the demand for borrowing money did not decline in the short-run as the expectation of high inflation was obvious. Thus a high nominal interest rate was less effective on contemporaneously variation of NER and M1. However change in the nominal exchange rate has a significant effect on variation of money supply' (Author's personal communication with Mr. Samikhon Kurbonov the head of the NBT's Monetary Policy Department, January 2001). Overall, in identifying the short-run restriction model I have only three overidentifying restrictions. Notice that the restrictions identifying the monetary sector do not rely on a particular policy regime. Also the advantage of the short-run SVAR model is that the impulse response functions can be applied to check whether the shocks have an effect on each endogenous variable as economic theory expects. In other words, the difference of this method from the Cholesky decomposition is that the IRF (Impulse Response Function) and FEVD (Forecast Error Variance Decomposition) effects from these short-run restrictions can present direct economic meaning from the analysis (Sims, 1980; Hamilton, 1994; Enders, 1995; and Amisano and Giannini, 1997).

Apart from identification of structural shocks by short-run parameter restrictions on A and B matrices there is an alternative approach of imposing restrictions on the long-run parameters for the structural disturbances. The method of long run structural VAR analysis introduced by Shapiro and Watson (1988), and Blanchard and Quah (1989) based on the hypothesis that the long-run effect of particular shocks on particular variables is restricted. This technique can be more attractive for macroeconomists, as the long-term properties of economic theory capture more understanding than the short-term. Table 2 presents the identifying long run parameter restrictions of C matrix for this study.

Table 2: Restrictions on long run parameters of C matrix

| | Monetary sector | Real sector | | | |
|---|---|---|---|---|---|
| Variables | NER | NIR | M1 | GDP | PD |
| NER | $c_0$ | 0 | 0 | 0 | 0 |
| NIR | $c_1$ | $c_5$ | 0 | 0 | 0 |
| M1 | $c_2$ | 0 | $c_8$ | 0 | 0 |
| GDP | $c_3$ | $c_6$ | $c_9$ | $c_{11}$ | 0 |
| PD | $c_4$ | $c_7$ | $c_{10}$ | $c_{12}$ | $c_{13}$ |

We assume that in the case of transitional economies (like Tajikistan) M1 and IR have a long run effect on prices and real GDP. The exchange rate shocks will change other economic and monetary variables in the long run. 'In the long-run a rapid growth rate was expected as prices became more stable consequently the nominal exchange rate innovations has been effecting to the variation of nominal interest rate and money supply' (Author's personal communication with Mr. Samikhon Kurbonov, the head of the NBT's Monetary Policy Department, January 2001). Thus in identifying the long-run model we have only one overidentifying restriction, which is shown by a likelihood ratio test value in which the long-run model is exactly identified as in the short run.

To summarize this section note that a structural VAR is a standard VAR where the restrictions required for identification of the structural model are given by economic theory. However the restrictions can be short-run or long-run, mostly reliant on economic theory, depending on whether the shocks are temporary or permanent.

## Estimation and Results

Monthly data between January 1996 and December 2004 are used to estimate the structural VAR model of this study. All the data, (the monthly growth rates of consumer price indexes, real GDP, nominal money supply (M1), nominal exchange rate (a weighted average of USD to domestic currency) and nominal interest rate (NBT interest rate)), are from the statistical department of the NBT. Following theory and in order to avoid any econometric problems in the estimation model, the natural log is taken for all variables. The time dummy variables are included for the possibility that shocks related to an unexpected change of variables in that period are not depicted as other shocks allocation in the model. The unit root tests result in Table 3 show that all the variables are I(0), that is stationary in levels. Since the NBT's nominal interest rate does not vary for some period of time (several months) and as well in order not to omit a large number of observations, the lag length is set to two, which is the optimal value according to the Akaike criterion.[5] Results are given in Table 4.

Table 3: Unit root tests of variables

| Variables | ADF test for I(0) | PP test for I(0) | Critical value at 1% | Critical value at 5% |
|---|---|---|---|---|
| NER | -10.82 | -10.76 | -3.52 | -2.89 |
| NIR | -6.68 | -7.11 | -3.52 | -2.89 |
| M1 | -11.16 | -11.13 | -3.52 | -2.89 |
| GDP | -11.15 | -11.12 | -3.52 | -2.89 |
| PD | -5.56 | -5.41 | -3.52 | -2.89 |

Source: Author's own calculation
Note: ADF and PP are Augmented Dickey Fuller and Phillips-Perron tests for stationary of the monthly data variables.

Initially reduced form results show that the inflation variation is from inflationary expectations as well as from monetary and exchange rate policy instruments. However it is likely that better predictions could be achieved only by applying the contemporaneous and long-run restriction models of structural VAR. Therefore short-run and the long-run restriction of SVAR models were used, to evaluate inflation targeting and the response of real sector (prices and GDP) to monetary and exchange rate innovations in the specific context of Tajikistan's economy. Hence these estimated shocks are used to generate the structural impulse response and forecast error variance of decomposition functions for assessing the dynamic impacts of monetary and exchange rate policy on real sector variables.

Table 4: Selection order criteria of VAR/SVAR model

| lag | LL | LR | FPE | AIC | HGIC | SBIC |
|---|---|---|---|---|---|---|
| 0 | 272.81 | | 2.8e-09 | -5.53 | -4.79 | -3.70 |
| 1 | 433.49 | 321.36 | 8.4e-11 | -9.05 | -8.02* | -6.46* |
| 2 | 468.74 | 70.501* | 6.7e-11* | -9.32* | -7.98 | -5.97 |

Source: Author's own calculation
Note: The asterisk shows the optimal lag length suggested by each criterion

*The Short-Run Restrictions Model*

After six months of inflation targeting, the inflation rate in 1998 dropped to 2.7 per cent (159.6 per cent in 1997) and growth rate rose to 5.3 per cent (1.7 per cent in 1997). Following good economic achievements during 1998, from January 1999 the NBT started to gradually decrease the nominal interest rate by focusing more on other instruments (policies) such as money supply and exchange rate.

Table 5: The estimated coefficients of the short-run parameter restrictions

| | NER | NIR | M1 | GDP | PD |
|---|---|---|---|---|---|
| NER | 1 | 0 | 0 | 0 | 0 |
| NIR | 0 | 1 | 0 | 0 | 0 |
| M1 | .47 (1.99)** | 0 | 1 | 0 | 0 |
| GDP | 0 | .38 (1.48) | -5.96 (-2.11)** | 1 | 0 |
| PD | 8.62 (4.01)* | -.88 (-2.30)** | 2.62 (3.68)* | -.86 (-2.69)* | 1 |

Test for Over-identification Restrictions: Chi2 (3)=2.069 Prob>chi2=0.558
Note: The asterisks *, ** denote significant level at 1 and 5 per cent, respectively.
Source: Author's own calculation

Following Sims and Zha (2002) and Maliszewski (2003) for the estimation of short-run parameters a limited time-variation in coefficients of the model is used in order to observe changes in monetary policy design and inflation targeting. The subsequent sample for the short-run model is also analysed to see the level of inconsistency of coefficients. Table 5 presents estimated coefficients of the contemporaneous endogenous variables (matrix B). Note that the likelihood ratio (LR) test statistics for the null hypothesis of the overidentifying restrictions are 2.07. Under the null hypothesis this statistic have a chi square distribution with three degrees of freedom. Thus the identified restrictions cannot be rejected at any reasonable significance level.

The estimation results indicate that the sign and significance levels of the coefficients of the contemporaneous variables, for instance only a change in the exchange rate policy could contemporaneously change the inflation rate for the whole sample, while monetaryinnovations do affect the level of prices contemporaneously, but not as much as they affect exchange rate. The effects of money supply (M1) and nominal interest rate on prices are significant too. Overall, from the above estimated results, it can be concluded that in the short-run restriction model the exchange rate and monetary policy have more effects on the variation of prices than real output.

*The Long-Run Restrictions Model*

For measuring the permanent effects of monetary and exchange rate shocks on real sector variables in a transitional economy, I apply the long-run restriction SVAR model. Table 6 presents the result of the long-run structural VAR model (matrix c). The LR test statistic for the null hypothesis of the overidentifying restrictions is 2.26 and under the null hypothesis this statistic has a chi square distribution with one degree of freedom. Therefore the identified restrictions cannot be rejected at any level of significance.

The long-run SVAR model estimation shows the permanent effect of monetary and exchange rate policies on inflation, as well as the contribution of real output to price level. The obtained coefficients are statistically significant at estimated lags. When compared to the short run the real GDP in the long run provides a clear effect on prices and is relevant to the theory that increases in output growth will decrease prices in the long run. Despite having low coefficients the monetary policy instruments have contributed significantly to a changing inflation rate in the long-run model. However, the highest predictive influence for prices in the long run is the coefficient from the nominal exchange rate. With respect to the growth rate targeting the estimated long-run model revealed that monetary innovations has had more effects than exchange rate. The result shows that NBT interest rate and money supply (M1) have contributed substantially to output growth in the long run. Local currency depreciation has negatively influenced and diminished the growth of real GDP in the long-run restricted model. This implies that the NBT has been implementing better monetary policy instruments for inflation and growth rate targeting, and permitting a managed float for the exchange rate. Overall, the monetary and exchange rate shocks have influenced the real sector of the economy (price level and real output), but their contribution to variation of real output is high, which is different from the short-run restriction model.

Table 6: The estimated coefficients of the long-run parameter restrictions

| | NER | NIR | M1 | GDP | PD |
|---|---|---|---|---|---|
| NER | .096 (12.41)* | 0 | 0 | 0 | 0 |
| NIR | .652 (4.05)* | 1.33 (12.41)* | 0 | 0 | 0 |
| M1 | -013 (-2.47)** | 0 | .045 (12.41)* | 0 | 0 |
| GDP | -2.99 (-8.85)* | 1.09 (6.09)* | 1.13 (6.26)* | 1.37 (12.41)* | 0 |
| PD | .102 (8.82)* | -.052 (-7.60)* | .011 (2.02)** | -.019 (-3.71)* | .0432 (12.41)* |

Test for Over-identification Restrictions: Chi2 (1)=2.263 Prob>chi2=0.133
Note: *, ** denote significant level at 1 and 5 per cent, respectively.
Source: Author’s own calculation

*Stability and LM Tests*

For the condition of stability of the SVAR models the stability of models was measured to find out whether eigenvalues in this model lie within the unit circle and how SVAR model satisfies stability conditions. The results in Table 7 shows that all the eigenvalues of the short-run and long-run restrictions model lie inside the unit circle, which tells us that structural VAR satisfies stability conditions.

The Lagrange multiplier (LM) test is conducted to see that disturbances are not autocorrelated in post analysis of VAR and SVAR models (Johansen, 1995). One of the assumptions upon which inference and post analysis after VAR and SVAR are predicted is that the errors is not autocorrelated. The obtained LM statistics for residual autocorrelation after the structural VAR model show that there is no autocorrelation at tested lag order 1 or 2, since we cannot reject the null hypothesis, this test does not provide any hint of model misspecification. The above test results are summarized in Table 8.

Table 7: Eigenvalue stability condition

| Eigenvalue | Modulus |
|---|---|
| .8995443 + .03718112i | .900312 |
| .8995443 - .03718112i | .900312 |
| - .5182567 + .4519884i | .687665 |
| - .5182567 - .4519884i | .687665 |
| .6365048 | .636505 |
| - .4675131 | .467513 |
| .4661241 | .466124 |
| .102717 + .3241779i | .340062 |
| .102717 - .3241779i | .340062 |
| .241865 | .241865 |

Source: Author’s own calculation
* Lütkepohl (1993) and Hamilton (1994) show that if the modulus of each eigenvalue of the matrix A is strictly less than one, than estimated VAR (p) is stable. Since the modulus of each of the eigenvalues is strictly less than one, the above estimates satisfy the eigenvalue stability conditions.

Table 9: Lagrange-multiplier test

| lag | Chi2 | df | Prob>chi2 |
|---|---|---|---|
| 1 | 25.1434 | 25 | 0.45436 |
| 2 | 33.8585 | 25 | 0.11097 |

Ho: no autocorrelation at lag order.
Source: Author’s own calculation

*Impulse Response Analysis(IRF)*[6]

As we are estimating the short-run and long-run restrictions of the structural VAR model, apart from using orthogonalized IRF it is necessary to observe n (structural) impulse response functions for each independent shock for better analysing estimated models. The orthogonalized (Cholesky) and structural impulse response analyses only include results for model b and model c for 12 periods ahead of the real sector variables (prices and real GDP) and some monetary variables that normally allow for a sensible economic interpretation. The estimated orthogonalized and structural IRF for both short-run and long-run restrictions SVAR models is presented in Figure 2.

The graphs reveal that the shapes of the functions are very similar over the two models. Further, graphs illuminate only one main differences over the two models. In model b, the estimated orthogonalized and structural IRF move alongside each other almost in all graphs. In model c there is a gap between orthogonalized and structural IRF, which means that short-run and long-run restrictions model of estimated SVAR could show different effects (impulse-response) of estimated variables. Notice that the shape of the orthogonalized IRF is the same in both models.

Figure 2(a-d): Orthogonalized and structural IRF for the short-run and long-run restriction models

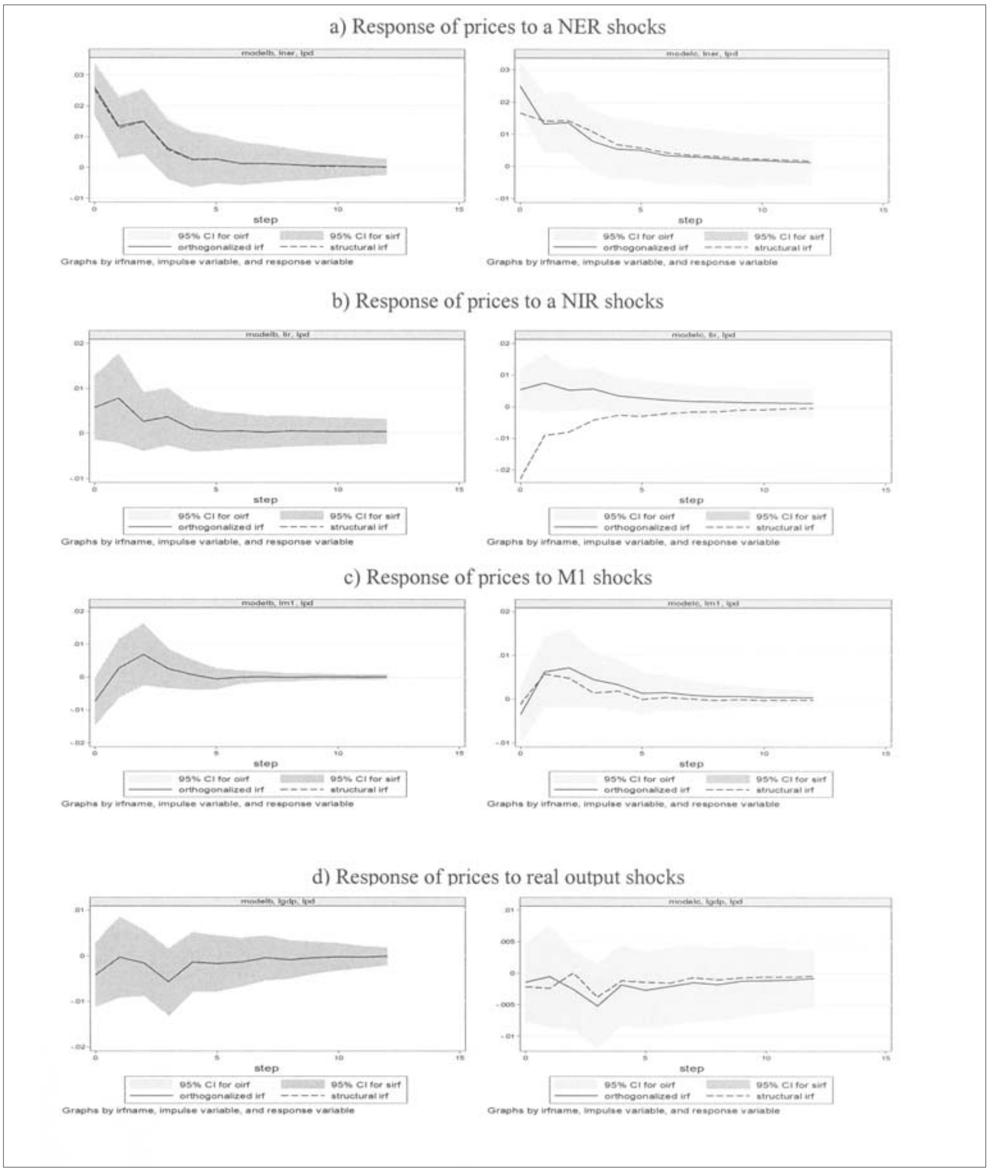


Figure 2(e-i): Orthogonalized and structural IRF for the short-run and long-run restriction models

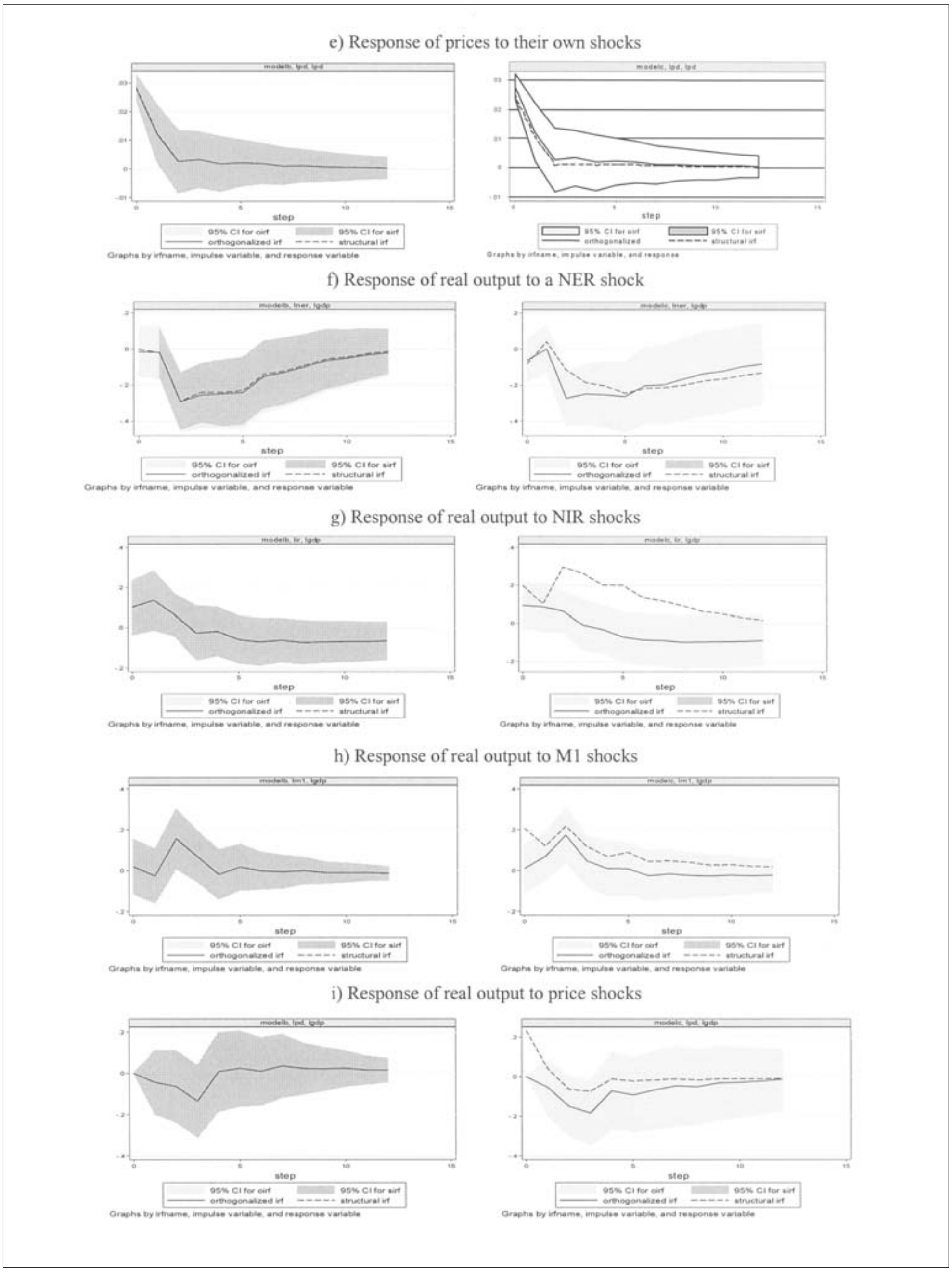
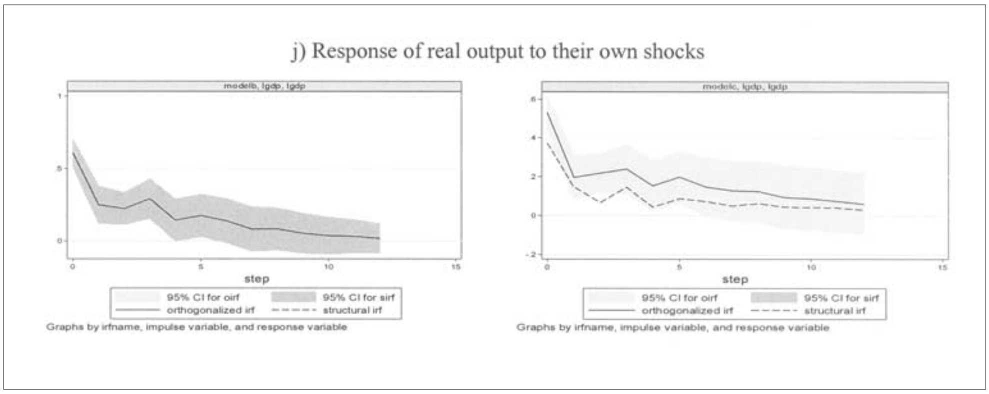


Figure 2(j): Orthogonalized and structural IRF for the short-run and long-run restriction models




According to Figure 2(a), model b indicates that a positive shock to nominal exchange rate causes an increase in prices and the effect decreases after 8 periods. In contrast to model b, in the model c graph the initial effect value is lower and it implies that price response to NER innovations is high in the short-run, which means that the NBT's floating-managed exchange rate policy has contributed significantly to falling inflation rates. In 2(b) the structural response of prices to NIR captures a positive and negative shock effect in model b and model c respectively. It implies that changes in NBT nominal interest rate contemporaneously has a positive effect on prices but in the long-run model price responds negatively. Figure 2(c) shows that M1 shocks in both models have almost the same effect and it is clear that prices are affected significantly only between the second and third periods. However, the effect slowly dies out. In Figure 2(d) prices respond contemporaneously to real output innovations, and a negative shock to real output causes prices to vary for about 8 periods with some significant points. Graph 2(e) is of the orthogonalized and structural impulse-response function from the shocks to prices and response prices. We see that the identification restrictions applied in model b and model c imply that a positive shock to prices causes prices to increase for a very short time and the effects slow for about 10 periods, after which the effect dissipates.

The real output growth targeting accounted as the key issues of Tajikistan's macroeconomic stability program, which was implemented by the IMF, WB and Government. Therefore in terms of real output responses to monetary and exchange rate innovations, as well as to price and its own disturbances, we examine Figure 2(f)-(j). Starting from Graph (f), nominal exchange rate shock does not have a contemporaneous effect on real output. Consequently initial value is equal to zero. However the effects changes gradually. Even a negative shock to NER in model b appears only after the first periods while it immediately appears in model c, and innovations have significant impact on real output growth, which implies that the NBTs exchange rate policy has contributed to real GDP growth during the period 1997 to 2004. Nevertheless the NBT's nominal interest rate, Figure 2(g), does have a contemporaneous effect on real output, and a positive shock to NIR in model b significantly persists only for the first two periods, though in model c a high positive shock affects real output significantly for about 10 periods. In 2(h), real output contemporaneously responds to money supply but only a positive shock has a significant effect between periods 2 and 3. But in the same graph (model c), a positive shock to M1 affects real output significantly for about 8 periods. A high positive shock effect of prices to real output shown in model c, Graph (i), which after 2 periods the effects became negative. While in the short run restrictions model output does not respond immediately to price shock. Similarly Graph 2(e) to 2(j) shows a structural impulse-response function from the innovations to output to itself. The main difference is that in model b the initial effect of structural shock is greater than in model c. It also implies that a positive shock to real output causes the country's real output to increase rapidly in the short run and the effects are only minimised in the long-run period.

Analysing the structural impulse response function for the above models of Tajikistan's economy we can conclude that the inflation targeting responses of prices to monetary and exchange rate innovations are different in the two models. First, the response of prices to the nominal interest rate shocks is positive in model b and negative in model c, which meant that rising NBT's nominal interest rate contemporaneously did not affect on rising prices but it has significant impact to decrease prices in the long run. Second, the effect of money supply innovations to price level is smaller in the long-run, while the effects in the short-run model are high. It imply that increasing of money supply (especially amount of credits giving to the private and public sector) has had effect on rising prices in the short-run, but had very slow effect in the long-run. As analyses show, and also based on the monetary and transitional situation of Tajik economy over the past years, most likely in the long-run M1 has more influence on the growth rate rather than prices. Finally, price responds strongly to the nominal exchange rate innovations in both the short-run and the long-run restriction models, which again proofs that fluctuation of prices during these years mostly related to variation on the nominal exchange rate and stability of national currency.

Overall, the structural impulse-response analyses show that the effect of monetary and exchange rate innovations is high in the contemporaneous model. These analyses suggest that better performing monetary and exchange rate policies, in particular money supply, interest rate and nominal exchange rate, are the best instruments for any transitional developing economy as it seeks to lower inflation.

*Forecast Error Variance Decomposition Analysis*[7]

The Forecast Error Variance Decomposition (FEVD) and structural FEVD for the short-run and long-run restricted parameter SVAR model of the real sector (prices and real GDP) and monetary variables are constructed, however, in order to save space they are not shown here[8]. They support the results implied by impulse response analysis. There is a significant difference between model b and model c of the structural forecast error variances (SFEVD), but a minor difference can be seen between the two models' forecast error variances (Cholesky's and the short-run restriction models).

In the present model the forecast error variance (FEVD/SFEVD) of the price depreciation series in the short-run restriction model is mainly determined by nominal exchange rate shock, its own shocks, and to some extent by interest rate, money supply and real output shocks. In other words, for model b at the 12 periods horizon, around 48 per cent of the variance in prices is accounted for by price shocks while around 42 per cent results from currency depreciation shocks. The interest rate, money supply and real output contain the remaining 10 per cent of predictive information about prices. However in the long-run restriction model, the predictive power of exchange rate, money supply, real output and its own innovations on prices are low, except for the structural fraction of mean squared error (mse) due to nominal interest rate. The predictive power of NER on prices declines to 36 per cent, while only 30 per cent of the variance in prices is captured by price shocks. In the long run restriction model the contribution of nominal interest rate innovations to price variation increases to 28 percent over 12 periods. The proportion of variance in prices attributable to money supply and real output innovations decreases further because most of the variation in prices is due to currency depreciation shocks.

Monetary and exchange rate innovations have predictive power on real output variances in these models. First, the Cholesky error variance decomposition (FEVD) for both models has the same shape and almost similar level of variances in real output. Although the structural FEVD are different between the two models they give further illumination on the relationships among the real sector (output, price) and monetary (money supply, interest rate and nominal exchange rate) variables. In model b, at all time horizons, exactly 60 per cent of the variance in real output is explained by its own innovations while nominal exchange rate explains about 28 per cent, nominal interest rate explains about 7 per cent and only 5 per cent of output variances is accounted for by money supply and price shocks. In the long-run restriction model, only 20 per cent of the variance in real output is accounted for by its own shocks, about 32 per cent is accounted for by NER, 30 per cent by NIR, 12 per cent by money supply and only 6 per cent by price innovations. These results are consistent with the evidence from the structural impulse response functions, showing that the link between prices and real output is not robust.

The SFEVD analysis suggests that exchange rate innovations account for price fluctuations in the short run more than monetary innovations, but in the long run restriction model the monetary innovations (in particular nominal interest rate) are more accountable for price variances. This implies that better management of monetary and exchange rate policies, in particular nominal exchange rate, interest rate and, to some extent, the money supply, are the best instruments for inflation and growth targeting for transitional developing countries.

## Conclusion

Tajikistan has experienced an enormous increase in its inflation rate and decline in real output growth over the last decades. However, as the results of the successful implementation monetary and exchange rate policies that had aim for obtaining low inflation and strengthening the balance of payments, in the late 1990s and the last years the inflation rate has dropped and real GDP growth has risen significantly. The NBT's stable monetary environment has had also support to increase domestic investment, which in turn was the key factor of rapid growth. This paper analyses the effect of monetary and exchanges rate policy innovations as a source of considerable change in inflation and real output in Tajikistan. Given these sharp changes in the macroeconomic performance of Tajikistan we need a framework to evaluate the conduct of macroeconomic policy. This research provides such a framework in the shape of a SVAR model and is the first to do so for Tajikistan. Our main interest have has been to investigate how certain shocks affect inflation targeting and to examine the effect of monetary and exchange rate policy innovations on the country's real sector economy, in particular on the change of prices and real output. Using monthly macroeconomic data, an SVAR model is constructed, which includes data for Tajikistan's transition period, between 1996 and 2004.

The reduced form VAR, followed by a short-run and long-run restriction SVAR model, allows identifying of monetary and exchange rates policy innovations with a consistent dynamic response of key macroeconomic variables. The dynamics of the estimation models are presented by analysis of structural impulse response functions and the structural forecast error variance decomposition.

The coefficients of the short-run restriction model reveal that exchange rate policy innovations are more effective than monetary policy innovations on the inflation targeting process in Tajikistan. The monetary and exchange rate innovations have influenced the real sector variables, in particular price level and real output in the long-run restriction model. Impulse response analysis for the above models show that the inflation targeting responses of prices to monetary and exchange rate shocks are different in the two models. The response of prices to the nominal interest rate shocks is positive in the short-run and negative in the long-run restriction models. The effect of money supply innovations on price level is high in the short run. The price response to nominal exchange rate innovations is high in both models. The SFEVD analysis suggests that exchange rate innovations account for price fluctuations in the short run (model b) more than monetary innovations. However in the long-run restriction model (model c) the monetary innovations (in particular nominal interest rate) account more for price variances.

Overall our estimations show that monetary policy innovations do contain a more important cause of inflation variability in the short run restriction model. However the nominal exchange rate and price shocks account for the major predictive power of inflation variability in the short-run and the long-run restriction models. On the other hand the importance of monetary and exchange rate innovations as causes of real output variability increases in the long-run restriction model. The main difference between the short-run and long-run restrictions of this model is that in the short-run monetary and exchange rate innovations have a greater impact on variation in inflation, while in the long-run these policy innovations are more effective in enhancing growth. Thus, the NBT's monetary and exchange rate policies have contributed significantly in attaining low inflation and high real output of Tajikistan's transitional economy between 1998 and 2004.

Illuminating the response of prices and real output to monetary and exchange rate innovations is certainly the key objective of this research. Hence the inclusion of monetary sector innovations into the structural VAR model and analysing short-run and long-run restrictions, as well as the dynamic analysis of SIRF and SFEVD, help us to understand the transmission process of Tajikistan's monetary and exchange rate policies.

## NOTES

[1] This paper is drawn from my Ph.D. dissertation at the Australian National University. I would like to thank Dr. Tom Kompas, Prof. Raghbendra Jha and Prof. Heather Anderson for their helpful comments and suggestions. The views expressed herein are those of the author and not necessary those of the National bank of Tajikistan.

[2] A structural VAR can be used to describe the dynamic effects of innovations in monetary policy on different macroeconomic variables and to estimate the effect of monetary policy innovations in accounting for particular macroeconomic events in previous times. This technique has been used by Sims (1982, 1986), Blanchard (1989), Bernanke and Blinder (1992) and Cristiano et al. (1994) and Giannini et al. (1995). Note that most of the empirical research in this area relates to the US, while some empirical studies refer to other economies as well, e.g., those of Sims (1992), Cushman and Zha (1997) and Christiano et al (1998). According to their studies, an unforeseen tightening of monetary policy in

the first phase reduces monetary aggregates and various economic activities and, in the next stage, the rate of inflation falls. An unforeseen tightening of monetary policy in a small open economy always leads to local-currency appreciation as it does in large economies. However the reaction of prices is faster in small economies because of the quicker response of the exchange rate to changes in monetary policy (Cushman and Zha, 1997).

[3] The first currency reform was in May 1995, switching from the Russian Ruble to the Tajik Ruble. As a result of this reform the population had considerable financial losses.

[4] In a short-term SVAR, A and B matrices model, all the information is about contemporaneous correlations. Psr identifies the structural impulse-response functions, and Psr itself is identified by the restrictions placed on the parameters in A and B.

[5] Since the number of observations is not large, we are interesting only on two key criteria, such as AIC and SBIC, to determine the optimal lag length of the VAR system in this study. See Enders (1995) for more detail on lag length and criteria's.

[6] According to Amisano and Giannini (1997) there is one key difference between long-run and short-run restrictions SVAR models. In the short-run model, the constraints are applied directly to the parameters in the A and B matrices. However, in the long-run model, the constraints are imposed on functions of the estimated VAR (p) parameters. Estimation and inference of the parameters in C is straightforward, obtaining the asymptotic standard errors of the SIRF needs untenable assumptions. For this reason, varif estimates only bootstrapped standard errors for the long-run SVAR model (Stata 8.2., 2004).

[7] Due to the same problems that arose with the SIRF, the asymptotic standard errors of the SFEVD are not available after the long-run SVAR models, but bootstrapped standard errors are given (the result is given in the Appendix).

[8] Please contact the author for FEVD and structural FEVD on mentioned variables.

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