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Zavkidjon Zavkiev
The Australian National University
The National Bank of Tajikistan

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Estimating a Model of Inflation in Tajikistan

Zavkidjon Zavkiev[1]
The Australian National University, Canberra
The National Bank of Tajikistan, Dushanbe

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ABSTRACT

This paper attempts to estimate a model of inflation in Tajikistan using the Johanson cointegration approach and single equation error correction model. It also develops a methodology for creating monthly real output series. The paper investigates both the short run dynamic behaviour of inflation and the long run relationship of prices with their determinants. There is evidence that in the long run prices are determined by exchange rate, money, real output and interest rates, and in the short run by past values of money growth and inflation, and current and past values of output growth and interest rate changes. The speed of adjustment of prices to their long run equilibria is determined. The results suggest controlling excessive money growth and stabilizing excessive exchange rate fluctuations should be the key ingredients of monetary policy in controlling inflation of the country.

Keywords: Inflation, Price Level, Cointegration, Error Correction Model, Tajikistan

JEL Classification: E31, C32, O53

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[1] PhD Scholar, Division of Economics, Research School of Pacific and Asian Studies, The Australian National University, ACT 0200, Australia. Tel: [61] (2) 6125 6216, Fax: [61] (2) 6125 3700,
E-mail: zavkijon.zavkiev@anu.edu.au

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1. Introduction

During the Soviet era prior to 1991 prices were set administratively in Tajikistan by the central planner. The State Committee for Prices planned, controlled and monitored the prices. The country did not have an independent monetary policy and there was instead a republican branch of the Soviet Union Central Bank operating under guidelines of the Soviet Union Central Bank. The republican branch of the Soviet Union Central Bank conducted monetary policy through direct instruments, mainly by directly financing and lending specific sectors of the economy or the government. Monetary policy targets were aimed solely at supporting 5 year production plans. Because prices were controlled and an independent monetary policy was absent, price stability was not an issue for Tajikistan's republican branch of the Soviet Union Central Bank.

Following independence in 1991, Tajikistan adopted a program to transit from a planned based to a market-oriented economy. Considerable structural change, reform and liberalization of major policies occurred, particularly price liberalization. Prices of most goods and services were determined through market forces rather than by administrative means. The republican branch of the Soviet Union Central Bank was transformed to the National Bank of Tajikistan (NBT) acting as the country's central bank since 1991. As the country used the old Soviet Union Ruble until January 1994 and the Russian Ruble after, the NBT did not have enough independence. On May 10, 1995 the NBT achieved a significant independence when a national currency called the Tajik Ruble[2] was introduced. The adoption of a new Law in 1996, by which the NBT became responsible to parliament rather than government, made the NBT even more independent.

In contrast to the Soviet era, price stability became the key focus for the monetary authorities in the transition period. The NBT determined price stability as its ultimate goal. To achieve this the NBT has continuously paid attention to restricting money growth under a macroeconomic stabilization program and International Monetary Fund (IMF) supported program. In doing so, it brought annual inflation down from the high level of 2131.9 percent in 1995 to 13.7 percent by 2003. Such a development makes it

[2] A new national currency called the Somoni replaced the Tajik Ruble on October 30, 2000.

interesting to model inflation in Tajikistan using a money market approach[3], which explains inflation as a result of excess money supply over real money demand. As the country has a small open and highly dollarized economy incorporating a purchasing power parity approach is also important in modeling inflation.

This paper attempts to estimate a model of inflation in Tajikistan using the Johanson cointegration approach and single equation error correction model. The paper investigates both the short run dynamic behaviour of inflation and the long run relationships of prices with their determinants. There is evidence that in the long run prices are determined by exchange rate, money, real output and interest rates, and in the short run by past values of money growth and inflation, and current and past values of output growth and interest rate changes. The speed of adjustment of prices to their long run equilibria is determined.

As the existing empirical literature has not paid attention to modeling the inflation of Tajikistan, the paper makes a contribution to the literature. To the best of the author's knowledge, the NBT has not yet modeled inflation and uses an ad-hoc approach to forecast inflation. In this respect, the estimated model in this paper can be useful for the NBT. The paper makes another contribution in showing the methodology for creating monthly real gross domestic product (GDP) series, which can also be applied to other transition countries. The results can be used in implementing monetary policy for Tajikistan and other transition countries.

The rest of the paper is structured as follows. Section 2 provides a theoretical framework for modeling inflation. Section 3 briefly describes the related empirical literature. Section 4 gives the description and creation of data. Section 5 presents identifying trends, the cointegrating vector and exogeneity of variables. Section 6 describes the structure of a short run model of inflation and long run model of prices. Section 7 provides the estimated results of a short run model of inflation and long run model of prices. Section 8 discusses policy implications. Section 9 concludes with the key findings.

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[3] Throughout the paper a money market refers to an interaction of supply of and demand for monetary aggregates, namely M2 (a sum of currency, demand and time deposits including foreign currency deposits).

2. A theoretical framework of the model

The money market and purchasing power parity approaches have been extensively used in the literature to model the inflationary process in developing and transition countries (see Durevall 1998 and other studies reviewed in Section 3 of this paper). The money market approach explains inflation as a result of excess money supply over real money demand. The approach, due to Milton Friedman (1956), is based on the quantity theory of money and relies on three assumptions: (a) velocity and hence demand for money is stable; (b) in the short run growth of money affects real output, but in the long run real output is determined by real factors such as employment, technology and capital; and (c) supply of money given exogenously can be controlled independently of demand for money that is determined by a different set of factors.

The purchasing power parity approach argues that inflation is an international phenomenon, according to which exchange rates equalize the inflation of two countries. That is the equation $\pi^d = e + \pi^f$ holds, where π^d is domestic inflation, e is exchange rate changes defined as domestic currency per foreign currency (increase means depreciation) and π^f is foreign inflation.

Purchasing power parity is not a short run hypothesis and even in the long run it is questionable whether it holds (see, for example, Pakko and Pollard 1996). If this hypothesis does hold then under a fixed exchange rate regime domestic inflation equalizes foreign inflation and under a flexible exchange rate regime exchange rate adjusts to equalize the purchasing power parity condition. However, in practice, even under a fixed exchange rate regime, domestic inflation does not fully equalize with foreign inflation because of country specific risks, transaction costs, tariffs quotas and other trade restrictions. For small open economies with a flexible exchange rate regime the speed at which the effects of exchange rates transmit to prices is high. In this case, exchange rate depreciation raises the prices of imported goods converted into domestic currency, even if the prices of imported goods in foreign currencies remain unchanged.

In modeling inflation for Tajikistan the money market approach, incorporating the purchasing power parity condition has been used for the following reasons.

First, Tajikistan had hyperinflation at the beginning of introducing its national currency in 1995 and high inflation later. The inflation rate in 1995, 1996, 1997, 1999 and 2000 was 2131.9 percent, 40.6 percent, 163.6 percent, 30.1 percent and 60.6 percent, respectively (IMF 1998 for 1995 and the NBT on request for 1996-2000). Negative economic growth rates of 12.5 percent in 1995 and 4.4 percent in 1996 were transformed into positive economic growth of 1.7 percent in 1997, 3.7 percent in 1999 and 8.3 percent in 2000 (IMF 1998, 2003 for 1995-1996, SSCT 2003 for 1997-2000). Comparing hyperinflation and high inflation with the economic recession and recovery over this period, it seems prices rose many times higher than real output fell and increased. As Cagan (1956) pointed out, this means in the case of high inflation and not deep recession high prices can be explained with monetary phenomena.

Second, since financial markets, namely government securities markets, are underdeveloped in Tajikistan (up until now there is no secondary market for government securities in the country and even the function of a primary market for government securities was stopped since the government abandoned the issuance of treasury bills in 2001), money supply through the credit channel is important for the country's economy. The NBT imposes restrictions on money growth under stabilization and structural arrangement programs agreed with the IMF. As stated in the IMF country study report "Following a rapid monetary expansion after the introduction of Tajik ruble, the monthly inflation rate reached nearly 50 percent in the second half of 1995" (IMF 1998:33). From the NBT's policy and also this quote, it appears both the NBT and the IMF explain excessive growth of money supply as one of the key factors determining inflation in Tajikistan and thus are in a favor of the money market approach.

Third, the county has a small open and highly dollarized economy. For example, in 2000, the ratio of imports to GDP was 101.5 percent (Source: the author's calculation using SSCT 2003) and in 2001, the dollarization ratio defined as the ratio of foreign currency deposits to broad money was 43.0 percent (Source: the author's calculation using the NBT's data).

Equation (1) has been used for modeling inflation in Tajikistan. This is very common in economic theory and empirical studies (see, for example, Callen and Chang 1999). In equation (1) P_N and P_T represent prices of non-traded and traded goods, respectively, α and $1-\alpha$ represent the price shares of non-traded and traded goods to overall prices, respectively, and $0 \prec \alpha \prec 1$. Equation (1) means overall prices are combined average weighted prices of non-traded and traded goods and services.

$$P = f(P_N, P_T) = P_N^{\alpha} \times P_T^{1-\alpha} \tag{1}$$

The money market approach is specified in equation (1a). According to this, whenever there is an excess nominal supply of money (M) over real money demand (m^D) the prices of non-traded goods must rise to adjust goods market disequilibria. "Individuals cannot change the nominal amount of money in circulation, but according to the quantity theory of money they can influence the real value of their cash balances by attempting to reduce or increase their balances. In this attempt they bid the prices of goods and services up and down…" Cagan (1956:29).

$$P_N = \left(\frac{M}{m^D}\right)^{\lambda} \tag{1a}$$

In equation (1a) m^D equals nominal money demand divided by price levels $\left(\frac{M^D}{P_N} = m^D\right)$ and λ is a scaling factor representing the relationship between aggregate demand and demand for non-tradable goods. Equation (1a) was initially derived from the money market equilibrium condition, i.e. $M = M^D$. Dividing both sides by P_N implies $\frac{M}{P_N} = m^D$. By solving the last condition for P_N equation (1a) can be obtained.

Equation (1a) can be explained graphically using Figures 1a and 1b. In Figure 1a the money market is presented where the initial money market equilibrium (E_0) is attained when the initial money supply curve (M_0^S) intersects the initial real money demand curve (m_0^D). This corresponds to the initial goods market equilibrium (E_0) in Figure 1b, at which the initial short run supply curve (S_0^{SR}), initial demand curve (D_0) and initial long run supply curve (S_0^{LR}) intersect. When a central bank increases money supply this shifts out the money supply curve to (M_1^S) in Figure 1a and the goods demand curve to (D_1) in Figure 1b. To analyze the effect of such a policy on the economy in this model consider two cases.

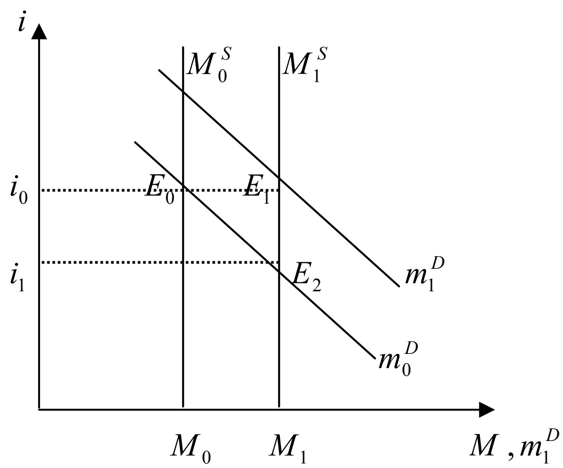

Figure 1a. Money market

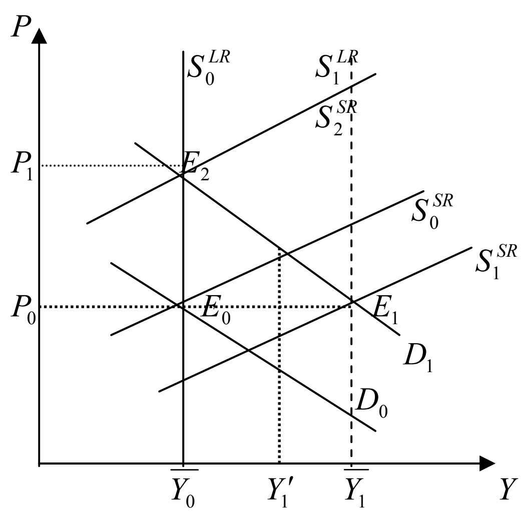

Figure 1b. Goods market

Case 1 assumes no price change. In terms of equation (1a) this means prices are constant, that is $\overline{P_N} = \frac{M}{m^D}$. In this case when money supply increases prices cannot adjust and hence real money demand must adjust to restore a new equilibrium. To restore equilibrium real money demand increases and this shifts the real money demand curve out to m_1^D. A new money market equilibrium is attained at point E_1 in Figure 1a that corresponds to a new goods market equilibrium at E_1 in Figure 1b. A new goods market equilibrium at E_1 in Figure 1b can be achieved through the following mechanism. Given the assumption of no price change, real money demand must adjust. This implies some changes in the real side of an economy should occur in order to change real money demand. This can be the expansion of real output and hence, the long run output capacity of an economy. This shifts both short run and long run supply curves out to S_1^{SR} and S_1^{LR}, respectively (Figure 1b). As a result, prices remain unchanged at P_0. In short, case 1 means any monetary expansion consistent with the production capacity of an economy or productivity growth does not produce inflation.

Case 2 assumes prices change proportional to the money supply change so that real money demand remains unchanged. In terms of equation (1a) this means real money demand is constant, that is $P_N = \frac{M}{\overline{m^D}}$. In this case when money supply increases real money demand cannot adjust and hence prices must adjust to restore a new equilibrium. To restore equilibrium at point E_2 prices rise and a movement occurs along the initial real money demand curve (m_0^D) in Figure 1a. This new money market equilibrium corresponds to a new goods market equilibrium at point E_2 in Figure 1b. The new equilibrium in the goods market can be attained as a result of the following process. First, the goods demand curve shifts out in response to an increase in money supply as explained earlier. Second, a short run supply curve shifts inward in response to upward production costs pressure because of higher inflationary expectations. Finally, a new equilibrium is attained at intersection point (E_2) of a new short run supply curve (S_2^{SR}), new demand curve (D_1) and initial long run supply curve (S_0^{LR}) shown in Figure 1b. As a result, the economy ends up with higher prices ($P_1 \succ P_0$) and nominal wages, and no change in real output. This is consistent with the views of monetarists and Keynesians that money affects real variables in the short run, but in the long run only affects nominal variables leaving the real economy unaffected.

The real money demand equation is a very standard one commonly used in the literature (see, for example, Wells 1995). Demand for real money is a positive[4] function of real GDP (Y) and a negative[5] function of interest rate (i). In equation (1a) β_0 is a constant, β_1 is an income elasticity of money demand and β_2 is an interest rate semi-elasticity of money demand.

$$m^D = \beta_0 \times Y^{\beta_1} \times \exp(i^{-\beta_2}) \tag{1b}$$

Substituting (1b) into (1a) equation (1c) can be obtained.

$$P_N = \left(\frac{M}{\beta_0 \times Y^{\beta_1} \times \exp(i^{-\beta_2})} \right)^{\lambda} \tag{1c}$$

Returning to the prices of traded goods and services, it can be seen in equation (1d) that they are determined in the world market. Prices of traded goods are equal to foreign prices of traded goods (P_F) converted into the domestic currency by using the exchange rate (E). This is a standard purchasing power parity condition mentioned earlier. Parameters θ_1 and θ_2 in equation (1d) are the exchange rate elasticity of traded goods prices and foreign prices elasticity of traded goods prices, respectively.

$$P_T = \mathrm{E}^{\theta_1} \times P_F^{\theta_2} \tag{1d}$$

Substitute (1c) and (1d) into (1) implies the following:

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[4] This comes from transaction and precautionary motives of money.
[5] This comes from speculation motives of money.

$$P = \left[\left(\frac{M}{\beta_0 \times Y^{\beta_1} \times \exp(i^{-\beta_2})} \right)^{\lambda} \right]^{\alpha} \times \left[\mathrm{E}^{\theta_1} \times P_F^{\theta_2} \right]^{1-\alpha} \tag{2}$$

Taking a natural logarithm (Ln) of both sides leads to equation (3).

$$LnP = \alpha\lambda(LnM - Ln\beta_0 - \beta_1 LnY + \beta_2 i) + (1-\alpha)[\theta_1 LnE + \theta_2 LnP_F] \tag{3}$$

Setting $\lambda = 1$ (since it is assumed that demand for non-tradable goods is the same as aggregate demand) and $P_F = 1$ (since foreign inflation is relatively very small) equation (3) can be rearranged as follows:

$$LnP = -\alpha Ln\beta_0 + \alpha LnM - \alpha\beta_1 LnY + \alpha\beta_2 i + (1-\alpha)\theta_1 LnE \tag{4}$$

For estimation purposes equation (4) has been transformed to a stochastic equation with time subscripts and unobservable terms (ε_t) that are assumed to be normally distributed. As a result equation (5) has been obtained, where the lower case letters represent the natural logarithm of corresponding upper case letters.

$$p_t = \gamma_0 + \gamma_1 m_t + \gamma_2 y_t + \gamma_3 i_t + \gamma_4 e_t + \varepsilon_t \tag{5}$$

where $\gamma_0 = -\alpha Ln\beta_0 \prec 0, \gamma_1 = \alpha \succ 0, \gamma_2 = -\alpha\beta_1 \prec 0, \gamma_3 = \alpha\beta_2 \succ 0$ and $\gamma_4 = (1-\alpha)\theta_1 \succ 0$

In the reduced form of inflation model in equation (5) money supply is positively related to prices. This is because excess money supply pushes the prices of non-traded goods up leading to an overall price rise. The negative sign of real GDP means that as people's income increase they demand more money and under a given money supply this creates excess demand for money, resulting in lower prices.

With regard to interest rates, when interest rates rise people try to reduce their demand for money holdings and, again, under fixed money supply this creates excess money supply ending in higher prices. An increase in nominal exchange rate raises the foreign prices of traded goods measured in domestic currency leading to an overall price rise.

3. The related empirical literature

There is a vast literature on modeling inflation for developed and developing countries. However, empirical study is limited on modeling inflation in countries transitioning from a planned to a market oriented economy. In the literature, a model of inflation for some transition countries such as Tajikistan is not yet estimated. This section reviews empirical work on estimating models of inflation in transition and developing countries with greater focus on the money market and purchasing power parity approaches. In order to compare with the results of the paper, the numerical results of the empirical studies reviewed in this section are provided later in section 7.

Maliszewski (2003) applied the aggregate demand aggregate supply (demand-pull) approach to model inflation in Georgia using monthly series. According to Maliszewski (2003) the exchange rate is the dominant factor in determining inflation, with money supply the second main determinant.

Lissovolik (2003) estimated a model of inflation for Ukraine using monthly data. He tested two approaches-*a* combined money market and purchasing power parity model, and a mark-up model[6]. The combined money market and purchasing power parity approach did not work well. He explained this as being due to poor data, existence of seasonality and a poor measure of money supply (M2), which does not include dollar cash transactions. Alternatively, he estimated a mark-up model of inflation and found this approach to perform better for Ukraine.

Kim and Pirttila (2004) analyzed the relationship between money, barter and inflation in Russia using money market and purchasing power parity approaches. The estimated

[6] According to a mark-up approach price level is a mark-up over total unit costs, where prices rise in response to increases in unit costs.

results showed the significance and importance of money and exchange rate in the inflationary process of Russia.

Nicolic (2000) modeled inflation in Russia using the quantity theory of money method that is the root of the money market approach. The author estimated the autoregressive distributed lag model of inflation with lags of money supply, including seasonal and policy shift dummies. The result was that money growth appears to have the strongest correspondence to contemporary inflation in Russia.

Ohnsorge and Oomes (2003) applied a mark-up approach and a mixture of both mark-up and money market approaches to model inflation for Russia. In the mark-up model they found nominal effective depreciation, unit labor cost and utility prices were important sources of inflation. In the mixture of both mark-up and money market approaches they found inflation responded to an excess supply of effective broad money defined as ruble broad money plus foreign currency in circulation. Inflation accelerated by 3.7 percent when the effective broad money exceeded money demand by one percent.

Pelipas (2005) modeled inflation for Belarus using a money market approach. The results showed the significance of money, the exchange rate and interest rates in determining inflation. Monetary gap (the difference between money supply and money demand) had a significant impact on inflation in both the short and long run.

Inoue (2005) estimated a model of inflation applying a panel data for 20 transition countries. The model included exogenous variables, namely policy framework (inflation targeting and exchange rate targeting used as dummy variables), money supply growth (M2), indices of economic liberalization and central bank independence. The coefficient of money supply was positive and significant.

Coorey, Mecagni and Offerdal (1997) used a pooled sample of 21 transition countries to estimate a model of inflation. The country of interest here-Tajikistan was not in the sample. The approach used exogenous variables, namely lagged inflation, money growth, real exchange rate growth, nominal wage growth and two indicators of relative price variability (variance and skewness of relative prices). One of the key results of the paper was that money growth played a dominant role in explaining inflation for 21 transition countries. Nominal wage growth and relative price variability were also important. The authors suggested that regardless of its source controlling money growth is essential for achieving disinflation.

Callen and Chang (1999) modeled and forecasted inflation in India using the wholesale price index. They applied two approaches- combined money market and purchasing power parity, and output gap with quarterly series. Both approaches were generally consistent. Since some coefficients had the opposite sign in the output gap approach, the money market approach performed better. Money supply, foreign inflation and exchange rate all had good predicting power in explaining inflation.

Hasan (1999) modeled a money market approach of inflation in China incorporating aggregate demand and aggregate supply factors, such as output gap, wages, productivity and industrial productivity. While aggregate demand and aggregate supply factors were important, monetary forces had a predictable influence on the behaviour of prices. Hence, the author suggested the use of broad money (M3) as an intermediate target for monetary policy.

Price and Nasim (1999) estimated a model of inflation in Pakistan applying a combined money market and purchasing power parity approach. The estimated results showed that conditions of the money market and purchasing power parity are important for predicting inflation. Money and exchange rate were key determinants of inflation.

Ubide (1997) applied a combined money market and purchasing power parity approach to model inflation in Mozambique. The ordinary least squares (OLS) estimated results with monthly data indicated that both money and exchange rate had significant impacts on inflation. The exchange rate had both contemporaneous and lagged effects, whereas money had only lagged effects. The author concluded tight monetary policy and stabilized exchange rate policy should be pursued for controlling inflation in Mozambique.

Welfe (2000) applied mark-up and price-wage-spiral approaches to model inflation in Poland. The results supported price-wage-spiral hypothesis and also showed a cost-push approach is the most adequate in explaining the inflationary process in Poland. There was also evidence of the Phillips curve's relevance.

4. Description and creation of data

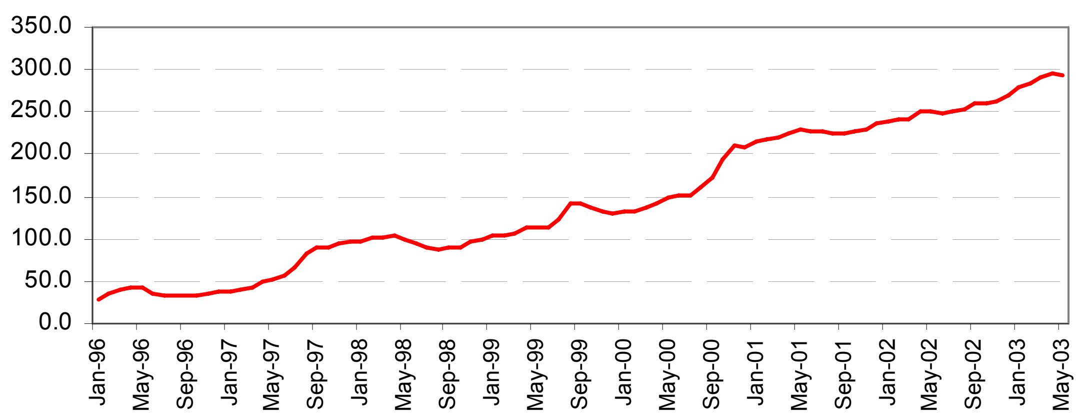
Data for all variables are monthly time series for the period 1996:01-2003:05. All variables are measured in Somoni and seasonally unadjusted. Data on prices, nominal GDP and real GDP come indirectly from the State Statistical Committee of Tajikistan (SSCT) through the NBT. This is because the SSCT does not have a web page and the data are only available in hard copies and published monthly/quarterly/annually in Tajik and Russian. It is sometimes difficult to find monthly data continuously from these publications. In order to avoid discontinuity, the majority of data have been obtained from the NBT on request. Data for recent years can now be found from the NBT's web page. Some data that did not meet modeling requirements have been transformed or constructed. The monthly real GDP series in money terms are not published and, hence, have been created in the paper.

Prices

Prices are consumer price index (CPI). Monthly CPI data are published by the SSCT, but have been obtained from the NBT on request. Price levels have then been constructed using series of CPI. For constructing the price levels December 1998 has been chosen as a base period. This was necessary for comparability and consistency of base period between price levels, the created real GDP and nominal exchange rate index explained later in this section. The constructed series of price levels are diagrammed in Figure 2.

There are three different kinds of price measures available in Tajikistan: CPI, producers price index (PPI) and GDP deflator. After reducing, the CPI contains 333 goods and services because of homogeneity of some goods and services (before reducing it contained 703 goods and services). The commodity and services structure of the CPI is as follows: 100 (218) food, 174 (369) non-food and 59 (116) services. In terms of percentages, its structure is 31.0 percent food, 52.5 percent non-food and 16.5 percent services. The CPI has both domestic and foreign goods, but their proportion has not been found from official statistical publications.

Figure 2. CPI price level (P) (Dec. 1998=100)



Another price measure is PPI and monthly PPI data are published by the SSCT. It includes only manufacturing products and does not include all manufacturing goods, but covers only 60-80 kinds of manufacturing products. PPI is not measured in market prices.

A third price measure is the GDP deflator that includes all domestically produced goods and services. Since data on GDP deflator are published annually by the SSCT, they are not available monthly. The annual GDP deflator is determined implicitly, but not explicitly.

The comparison of these 3 different measures of prices suggests the CPI is best for modeling inflation, for the following reasons: (a) it has a wider coverage of goods and services compared to the PPI, (b) it includes prices of both non-traded and traded goods and services, (c) it is available monthly, (d) it is better understood by the Tajikistan public, (e) it is used for wage indexations and transforming other variables from nominal into real terms, (f) it better reflects the cost of living and consumers' expectations since it is measured in market prices.

Real GDP

Data on monthly real GDP in money terms are never published officially and therefore had to be created. Nominal GDP and growth rates of real GDP are published by the SSCT with monthly frequencies, but both are with cumulative effects. Throughout this paper, nominal GDP and real GDP growth with cumulative effects were named period to period nominal GDP and period to period real GDP growth, respectively. As period to period nominal GDP and period to period real GDP growth rates have cumulative effects they do not represent pure monthly effects. For example, if period to period real GDP growth as of 31 May 2003 is 6.0 percent it means real GDP grew by 6.0 percent during the first five months of 2003 compared with the same period in 2002. Therefore, the main task of this subsection is to create monthly real GDP series using the available data on period to period nominal GDP and period to period real GDP growth rates. For creating monthly real GDP series the following methodology has been applied.

Step 1. Data for monthly nominal GDP (Y_t^N) (Figure 2) has been calculated using the following formula:

$$Y_t^N = G_t - G_{t-1}$$

where G_t is period to period nominal GDP, t and $t-1$ represent current and previous month of a year, respectively, $t = [1, 12]$ for each year, $G_{t-1} = 0$ for $t = 1$.

Step 2. The real GDP (Y_t) data in money terms (million Somoni) for twelve months of 1999 have been constructed using the CPI as a proxy for GDP deflator with this formula:

$$Y_t = \frac{Y_t^N}{GDP\ DEFLATOR_t} \times 100 \text{ where } t = [1, 12]$$

December 1998 has been chosen as the base period for constructing an implied GDP deflator. This is why the same base period applied to the price levels mentioned earlier. A base year of 1999 has been chosen for this purpose, because over the period 1991-2003 the gap between annual CPI inflation and annual GDP deflator inflation was smallest in this year. Because of this and because data on monthly GDP deflator are not available using the CPI as a proxy may serve as a good approach conditioning it is used to determine monthly real GDP for only 12 months of 1999.

Step 3. In this step monthly real GDP series in money term (million Somoni) have been created for the post 1999 period using real GDP series found in Step 2 and period to period growth rates of real GDP (g) that are published by the SSCT on a monthly basis. Monthly real GDP series in money terms for 12 months of 2000 have been created using the following formula:

$$Y_{Jan}^{2000} = \left(1 + g_{Jan}^{2000} / 100\right) \times Y_{Jan}^{1999}$$

$$Y_{Feb}^{2000} = \left(1 + g_{Feb}^{2000} / 100\right) \times \left(Y_{Jan}^{1999} + Y_{Feb}^{1999}\right) - Y_{Jan}^{2000}$$

$$Y_{Mar}^{2000} = \left(1 + g_{Mar}^{2000} / 100\right) \times \left(Y_{Jan}^{1999} + Y_{Feb}^{1999} + Y_{Mar}^{1999}\right) - (Y_{Jan}^{2000} + Y_{Feb}^{2000})$$

$$Y_{Dec}^{2000} = \left(1 + g_{Dec}^{2000} / 100\right) \times \left(Y_{Jan}^{1999} + \ldots + Y_{Dec}^{1999}\right) - (Y_{Jan}^{2000} + \ldots. + Y_{Nov}^{2000})$$

Step 3 has then been repeated for calculating the monthly real GDP series in million Somoni for 2001, 2002 and 2003.

Step 4. The series of monthly real GDP in money terms for the pre 1999 period have been created using the backward calculation of Step 3. Monthly real GDP series in money terms for 12 months of 1998 have been created using the following formula:

$$Y_{Jan}^{1998} = \frac{Y_{Jan}^{1999}}{(1 + g_{Jan}^{1999} / 100)}$$

$$Y_{Feb}^{1998} = \frac{Y_{Jan}^{1999} + Y_{Feb}^{1999}}{(1 + g_{Feb}^{1999} / 100)} - Y_{Jan}^{1998}$$

$$Y_{Dec}^{1998} = \frac{Y_{Jan}^{1999} + ... + Y_{Dec}^{1999}}{(1 + g_{Dec}^{1999} / 100)} - \left(Y_{Jan}^{1998} + ... + Y_{Nov}^{1998}\right)$$

Step 4 has then been repeated for calculating the monthly real GDP series in million Somoni for 1997 and 1996.

Panel (a) of Figure 5 shows the log of monthly real GDP series created in Steps 1 through 4 discussed earlier. The series have seasonal patterns. Comparison of Figures 3 and 4 reveals these seasonality patterns come mainly from the nominal GDP series rather than from price changes[7]. There are some explanations for the existence of such seasonality. High peaks in autumn are due to a boost in production of agricultural crops, namely cotton and electricity power[8]. Relatively smaller peaks in summer are due to crops of grain, fruits, vegetables and electricity power.

Troughs occur in winter because of a decline in production of agricultural products and also electricity power, since the latter reduces due to the decrease in water flows from the mountains. Visual analysis of Panel (a) in Figure 5 also explains the existence of time trend in the patterns, which means real GDP is growing over time.

In Panel (b) of Figure 5 the created real GDP series have been seasonally adjusted using the X11 seasonal adjustment method in E-Views. After seasonal patterns have been adjusted, the time trend of patterns looks much clearer in Panel (b) of Figure 5. However, even seasonally adjusted real GDP series have some significant seasonality patterns. The created monthly data on seasonally unadjusted and adjusted real GDP that are provided in Table1 of Appendix 1 might be useful for future researchers. The seasonally unadjusted series of real GDP were included in the model.

[7] The Figure 4 used here as a rough comparison instead of GDP deflator.

[8] Agricultural sector dominated other sectors with 26.7 percent of the economy in 2001, followed by manufacturing that accounted for 22.6 per cent in that year. In 2002, cotton and electricity accounted for 18.4 percent and 10.0 percent of total exports, respectively.

Figure 3. Constructed Monthly Nominal GDP (mln Somoni)

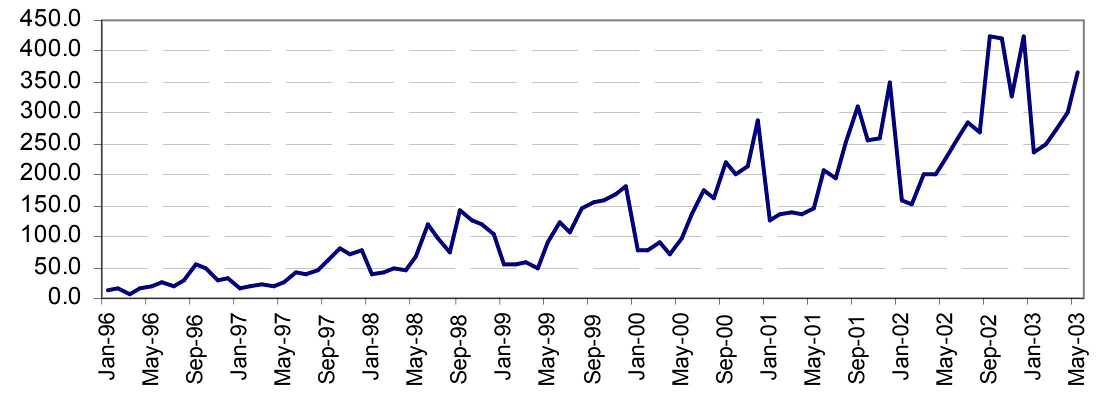


Figure 4. CPI inflation (%P)

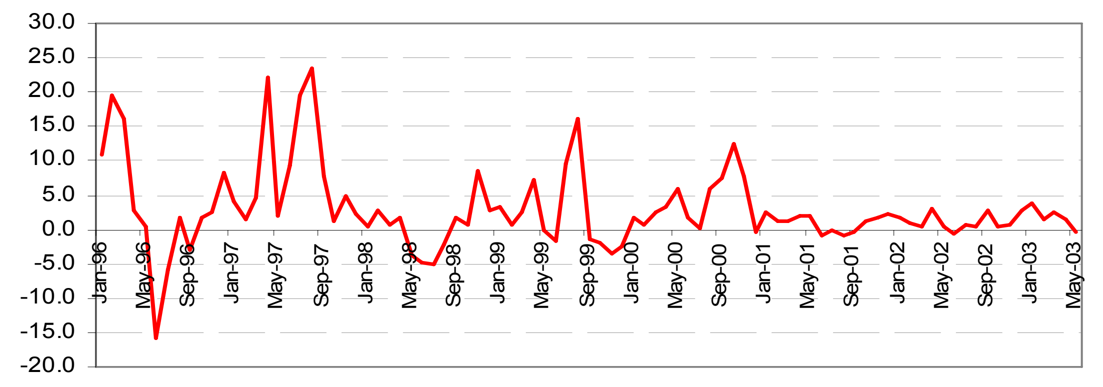
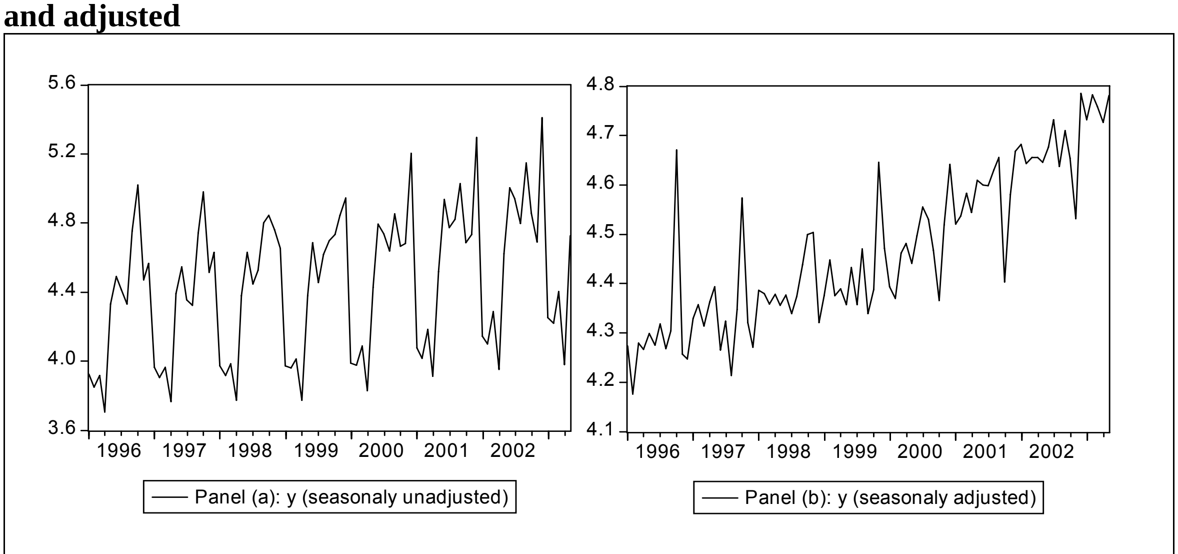
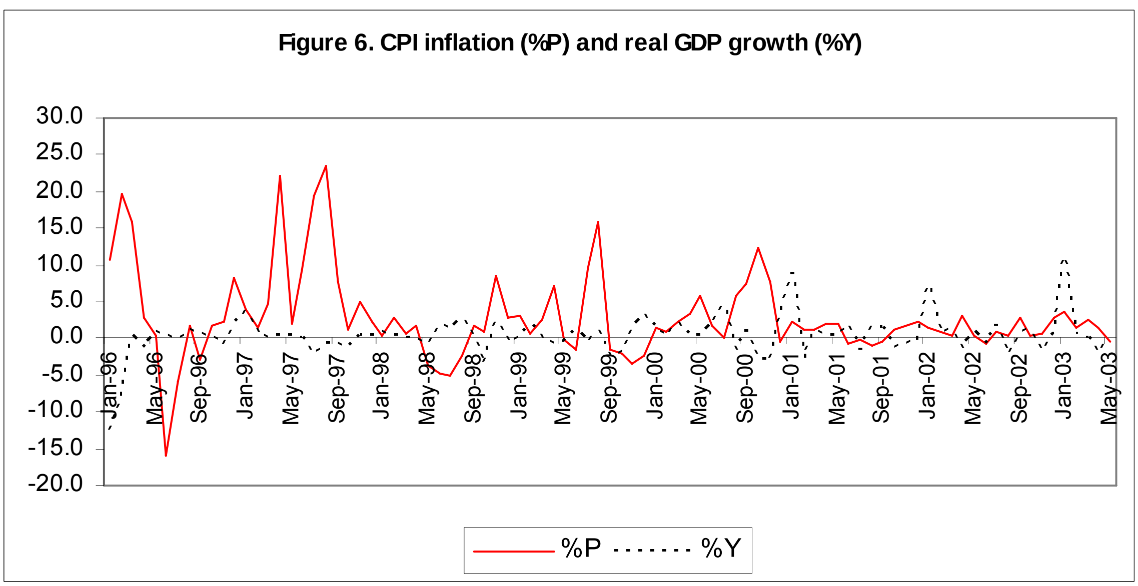


Figure 5. Log of the created real GDP series (mln. Somoni): seasonally unadjusted and adjusted



A consistency check has been conducted for the created monthly real GDP series. Monthly real GDP data have been summed up for each year and the implied annual data on real GDP obtained. Then using the implied annual real GDP series the implied annual growth rates of real GDP have been calculated. These implied annual growth rates of real GDP were exactly the same as the actual annual growth rates of real GDP published by the SSCT. This confirms the created monthly real GDP series in money terms is consistent with the real economy of Tajikistan.

In Figure 6, CPI inflation and real GDP growth have been plotted. Series on monthly real GDP growth ($\%Y$) (Figure 6) have been calculated from the created series of real GDP (Y_t) by applying the formula of $\%Y_t = \frac{Y_t - Y_{t-1}}{Y_t} \times 100$. The relatively higher inflation in the beginning of the sample coincides with the negative or lower real GDP growth and by the end of the sample higher real GDP growth coincides with the lower inflation. This may suggest the existence of a negative relationship between these two variables.



Money supply

Money supply data are a broad money indicator of M2 including foreign currency deposits and are in million Somoni. This better captures the ongoing foreign currency transactions made frequently in Tajikistan. Data on broad money has been acquired from the NBT. As shown in Figures 7 and 8, prices and money supply have strong co-movements, indicating a positive relationship. Hence, money supply may play a role in determining inflation.

Figure 7. Prices (p) and money supply (m)

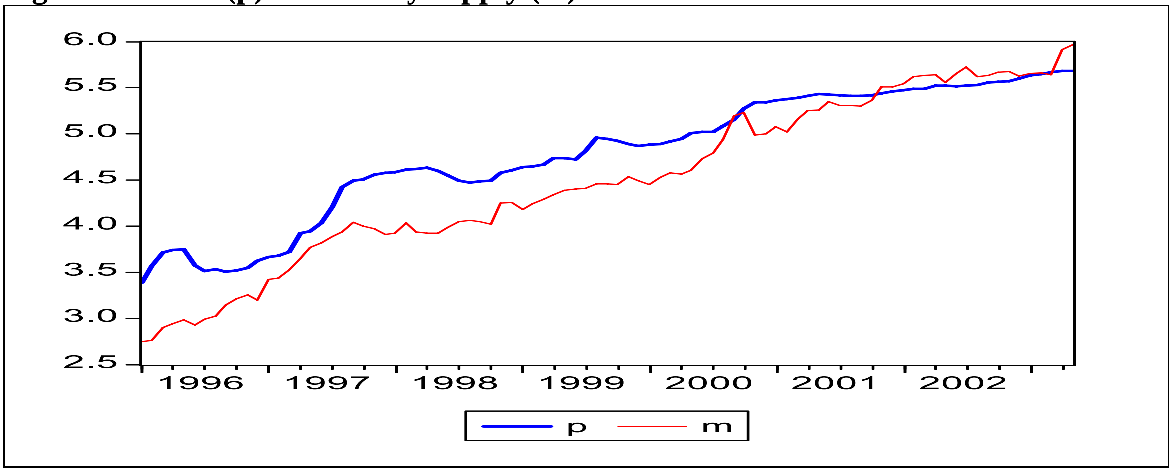
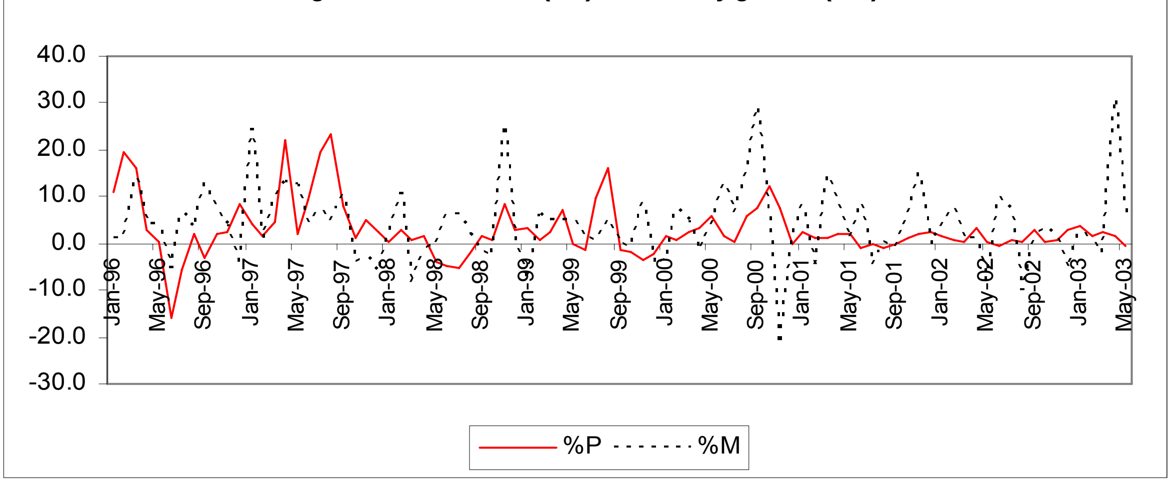


Figure 8. CPI inflation (%P) and money growth (%M)



Interest rates

Interest rates data come from the NBT's web page and are in monthly (not annual) percent. Banks' lending rates have been chosen to represent the interest rate. However, for the pre 1998 period data on banks' lending rates have not been found and therefore, the NBT's refinance rates for this period have been used instead.

From Figures 9 and 10 it can be seen there appears to be a negative relationship between prices and interest rates. Interest rates are higher for high inflation periods and lower for low inflation periods due to inflationary expectations through the Fisher effect. Therefore, interest rates may have some predicting power in determining inflation or there may be an inflation premium in interest rates.

Figure 9. Prices (p) and interest rates (i)

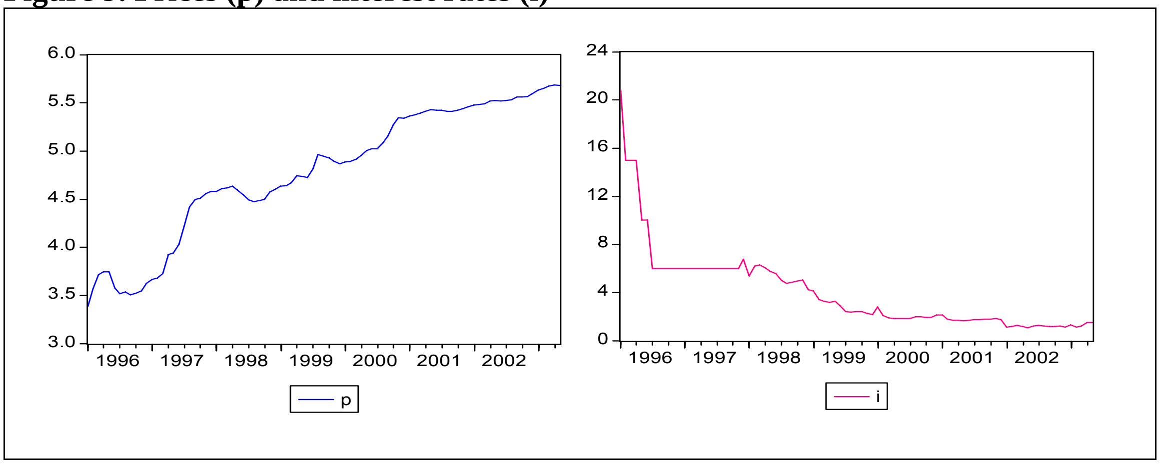
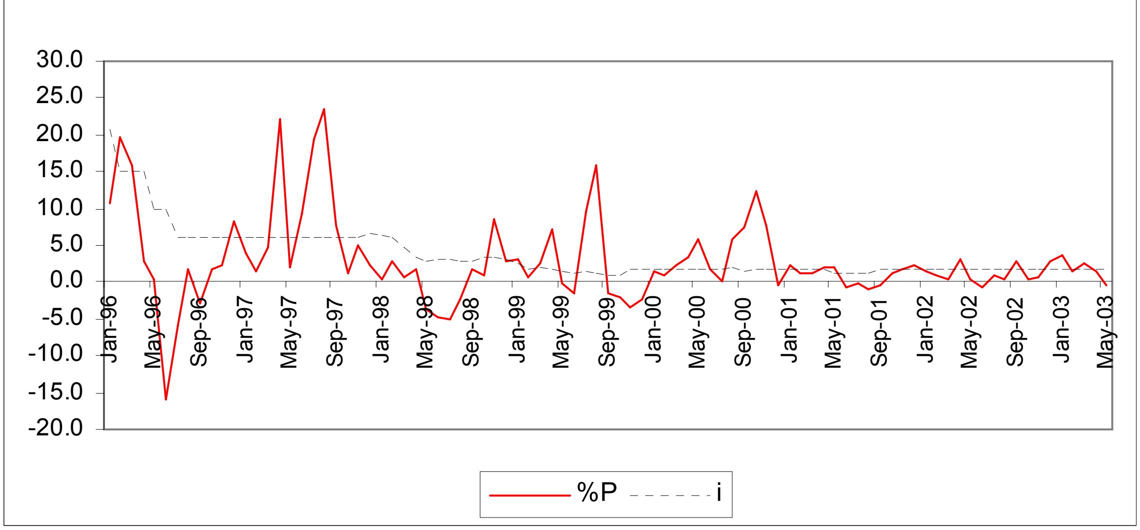


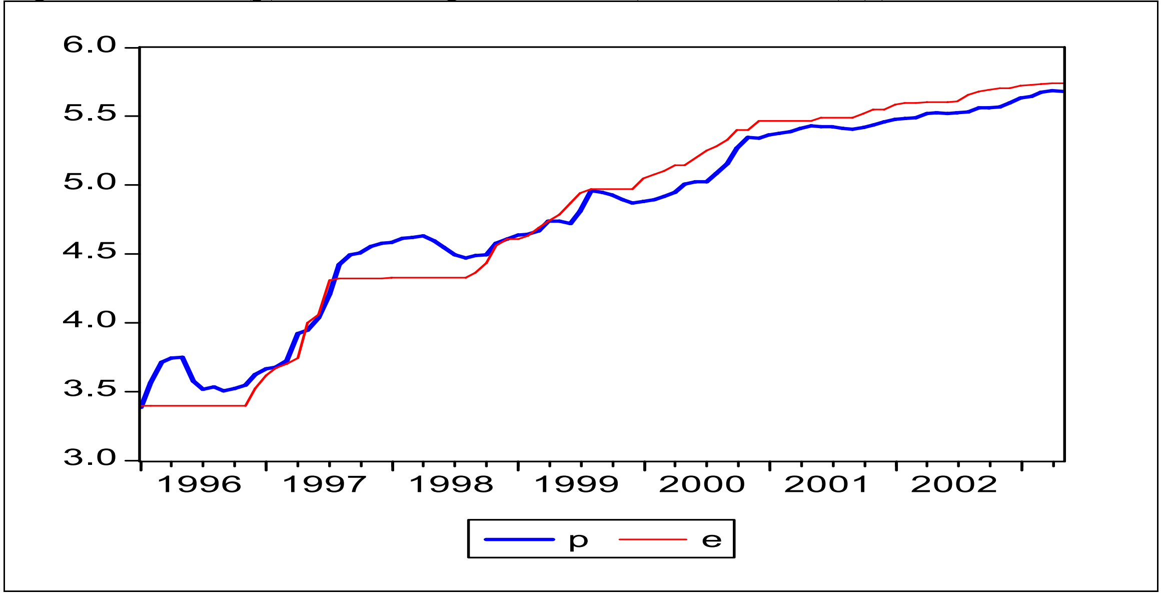
Figure 10. CPI inflation (%P) and interest rates (i)

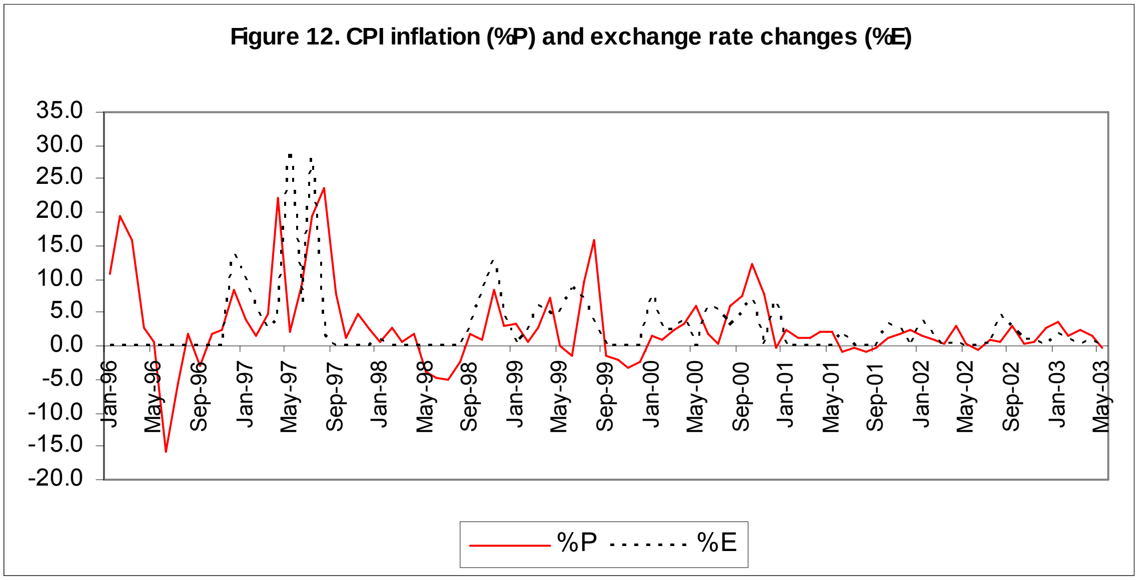


Nominal exchange rate

Data on the nominal exchange rate have been obtained from the NBT on request. Nominal exchange rate is defined as Somoni per US dollar and hence, an increase means a depreciation of Somoni. The exchange rate series has been transformed into the exchange rate index with a base period of December 1998. The exchange rate policy in Tajikistan is managed flexible. Data on exchange rate are official exchange rate. The official exchange rate over the sample was determined every Thursday based on the average weighted exchange rates of banks announced by the NBT on the same day and remained in effect until the following Thursday. A visual analysis of Figures 11 and 12 supports the idea of a strong positive link between prices and nominal exchange rates in Tajikistan.

Figure 11. Prices (p) and exchange rate index (Dec. 1998=100) (e)

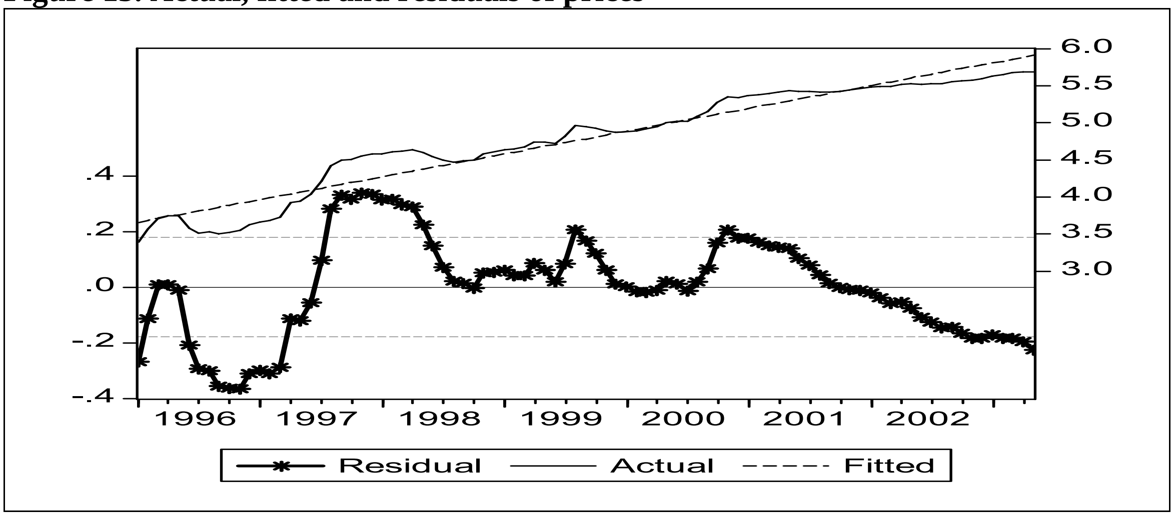




5. Identifying trends, a cointegrating vector and exogenity of variables

Before running the unit root and cointegration test it is worthwhile to stress that while the quality of the data may impact on the tests they are still worth doing. Time series may have time trend or stochastic trend or a mixture of the two (see Hamilton 1994:435). To identify trend characteristics of, say, prices, actual value, time trend (fitted), and residuals have been plotted against time in Figure 13. A solid line on the top fluctuates around a time trend line (a straight dashed line) with small variances. This suggests prices may have a deterministic time trend. For this to be true it is necessary to check whether residuals (difference between actual and fitted values) are stationary. Residuals (a line labeled with star signs in the bottom of the figure) do not look like a stationary process. A thorough analysis of the residual's graph makes it clear residuals have a unit root. This conclusion was confirmed by using the Augmented Dickey Fuller (ADF) test for residuals. Thus, the prices have both time trend and stochastic trend.

Figure 13. Actual, fitted and residuals of prices



Another key characteristic of time series processes is that they vary across time and thereby their mean and variances are not constant over time (Enders 1995:212, Kennedy 2003:319), i.e. in most cases time series are not stationary in levels. In conducting a unit root test for all variables both a visual analysis and the ADF test have been used. A visual analysis represents plotting each variable against time and analyzing its patterns by looking at graphs. For example, as was found in Figure 13, prices have a unit root and the ADF test confirmed it (Table 2).

As can be seen from Table 2 all variables are non-stationary in levels and stationary at first differences. It is important to note that interest rates are usually an integrated order of zero, I(0), but in this case they are an integrated order of one, I(1). This is not always observed in empirical studies. However, during the period 1996-2003, the economy of Tajikistan initially witnessed very high interest rates followed by a gradual reduction. This produced a falling trend over time. Such a trend in the data could be the reason why interest rates in Tajikistan were integrated of order one, I(1).

Table 2. Unit root tests

Variable	Number of lags	Levels		First Differences		Con-clusion
		ADF test statistics	ADF critical values at 5%	ADF test statistics	ADF critical values at 5%	
p_t	4	-2.13	-3.46	-5.80	-3.46	I(1)
y_t	4	-0.16	-2.89	-6.25	-2.89	I(1)
m_t	4	-2.95	-3.46	-9.20	-3.46	I(1)
i_t	4	-2.49	-2.89	-6.01	-2.89	I(1)
e_t	4	-1.70	-3.46	-4.20	-3.46	I(1)
ε_t	0	-4.57	-4.42			I(0)

Decision rule is to reject null hypothesis of unit root if ADF test statistic<ADF critical value.

Next the cointegration relationship between dependent and independent variables needs to be identified. A cointegration relationship exists when there is a linear combination between a dependent and its determinants (Kennedy 2003:327). In the inflation model this implies such a relationship exists if the following holds:

$$\underbrace{p_t}_{I(1)} - \underbrace{\gamma_0 - \gamma_1 m_t - \gamma_2 y_t - \gamma_3 i_t - \gamma_4 e_t}_{I(1)} = \underbrace{\varepsilon_t}_{I(0)} \tag{6}$$

From this identity it is clear the condition for the existence of cointegration is that all variables should be integrated order of one, that is I(1) and the disturbance terms should be integrated of order zero, that is I(0). For the inflation model, the variables are I(1), that is they are non-stationary at levels, but stationary after first differencing. The disturbance terms are I(0), that is they are stationary in levels (Table 2). Hence, according to the Engle-Granger approach, a cointegration relationship for the model exists. However, in the case of more than two variables, say 5 in this case, there may exist $4\,(=5-1)$ cointegrating vectors in a model. In such a case the Johansen (1988, 1991) maximum likelihood procedure can easily deal with identifying the number of cointegrating vectors. The Johansen procedure was used to identify the cointegration relationship between variables of the model. Using notations consistent with the Johansen procedure, the p dimensional vector autoregression (VAR) considered is

$$z_t = A_1 z_{t-1} + \cdots + A_p z_{t-p} + Bx_t + \eta_t \tag{7}$$

where $z_t = (p_t, m_t, y_t, i_t, e_t)'$ is a vector of 5×1 dimension, A_i is matrices of coefficients with 5×5 dimension, x_t is a 5×1 vector of deterministic variables such as constant and time trend, B is matrices of coefficients with 5×5 dimension and η_t is a 5×1 vector of Gaussian random variables that are identically and independently distributed with zero mean and variance matrix.

The above VAR can be transformed into a vector error correction model (VECM) using differencing approach, which is

$$\Delta z_t = \prod z_{t-1} + \Gamma_1 \Delta z_{t-1} \cdots + \Gamma_{p-1}\Delta z_{t-p+1} + Bx_t + \eta_t \tag{8}$$

where $\prod = \sum_{i=1}^{p} A_i - \mathrm{I}$, $\Gamma_i = -\sum_{j=i+1}^{p} A_j$ and I is a 5×5 identity matrix.

The matrix of interest is the coefficient matrix $\prod$. Johansen (1988, 1991) shows that if the coefficient matrix $\prod$ has reduced rank, $r \prec 5$ in this case, then there exist $5\times r$ matrices α and β such that $\prod = \alpha\beta'$ and $\beta' z_t$ is I(0). Here α is the matrix of adjustment coefficients and β is the cointegrating vector and r is a number of cointegrating vector.

Initially the VAR with four lags, a constant and linear deterministic trend has been estimated. Time trend (t) was included for capturing the trend characteristics that emerged from earlier discussion of the data. Then the number of lags have been dropped using Schwartz criteria (See Boswijk and Doornik 2003 and de Brouwer and Erricson 1998). As a result, the reduced form of VAR with two lags has been obtained. The Johansen cointegration test results are presented in Table 3. The trace eigenvalue and maximum eigenvalue statistics strongly reject the null hypothesis of no cointegration and accept the null hypothesis of at least one cointegration relationship. The trace eigenvalue statistic rejects the null hypothesis of one cointegrating rank at 5 percent critical value, but accepts it at 1 percent critical value. The maximum eigenvalue statistic accepts the null hypothesis of one cointegrating rank at 5 percent critical value. Hence, it can be concluded that the variables have one cointegrating vector. The estimated cointegration vector that also represents the long run relationship of price model is presented in equation (9). All coefficients in the cointegrating vector have expected signs.

$$\hat{p} = \hat{\gamma}_0 + 0.15m - 0.05y + 0.09i + 0.96e - 0.003t \tag{9}$$

Table 2 also reports the adjustment coefficients matrix. As one cointegrating vector has been identified, accordingly the first vector of coefficients matrix that relates to the identified cointegrating vector is the focus of the study. This vector of adjustment coefficients is the first column of the adjustment coefficients matrix shown in Table 3. In terms of the VECM discussed earlier, this can be written as follows.

$$\Pi z_{t-1} = \alpha\beta' z_{t-1} = \begin{bmatrix} \alpha_{11} \\ \alpha_{21} \\ \alpha_{31} \\ \alpha_{41} \\ \alpha_{51} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14} & \beta_{15} \end{bmatrix} \begin{bmatrix} p_{t-1} \\ m_{t-1} \\ y_{t-1} \\ i_{t-1} \\ e_{t-1} \end{bmatrix}$$

$$= \begin{bmatrix} -0.012 \\ -0.012 \\ 0.005 \\ 0.396 \\ -0.005 \end{bmatrix} \begin{bmatrix} 1.00 & -0.15 & 0.05 & -0.09 & -0.96 \end{bmatrix} \begin{bmatrix} p_{t-1} \\ m_{t-1} \\ y_{t-1} \\ i_{t-1} \\ e_{t-1} \end{bmatrix} \tag{10}$$

Table 3. A cointegration analysis of prices for Tajikistan

Unrestricted Cointegration Rank (r) Test /1

Null hypothesis	Eigenvalue	Trace statistic	5 percent critical value	1 percent critical value
r = 0 **	0.540	132.0	87.3	96.6
r ≤ 1 *	0.271	65.2	63.0	70.1
r ≤ 2	0.228	38.0	42.4	48.5
r ≤ 3	0.122	15.7	25.3	30.5
r ≤ 4	0.051	4.5	12.3	16.3
Null hypothesis	**Eigenvalue**	**Max. Eigen statistic**	**5 percent critical value**	**1 percent critical value**
r = 0 **	0.540	66.9	37.5	42.4
r ≤ 1	0.271	27.2	31.5	36.7
r ≤ 2	0.228	22.2	25.5	30.3
r ≤ 3	0.122	11.2	19.0	23.7
r ≤ 4	0.051	4.5	12.3	16.3

Normalized eigenvectors (beta prime)

p	m	y	i	e	t
1	-0.154	0.054	-0.086	-0.967	0.003
-1.532	1	-0.410	-0.044	0.691	-0.019
-6.808	5.644	1	0.223	5.999	-0.179
12.577	13.689	-7.913	1	-0.320	-0.585
-0.719	-0.439	-0.021	0.017	1	0.007

Standardized adjustment coefficients (alpha)

p	-0.012	0.009	-0.012	-0.002	-0.002
m	-0.012	0.009	0.018	-0.012	-0.010
y	0.005	0.104	0.090	0.085	0.008
i	0.396	0.116	-0.090	-0.044	-0.023
e	-0.005	0.009	0.005	-0.008	0.005

Weak exogeneity test statistics /2

	p	m	y	i	e
$X^2(1)$	7.10*	2.16	0.01	1.19	1.26
P value	[0.00]	[0.14]	[0.91]	[0.27]	[0.26]

*(**) denotes rejection of the hypothesis at the 5%(1%) level

/1 The VAR was estimated for the period 1996:04-2003:05 with 2 lags, an intercept, and linear trend. Trace eigenvalue and maximum eigenvalue statistics are used to test number of cointegration rank, r. The rejection of null hypothesis of r = 0 is evidence in favor of at least one cointegrating vector and so forth.

/2 The test for weak exogeneity run under assumption of r = 1. The failure to reject the null hypothesis is evidence of weak exogeneity of variable of interest.

Each coefficient in the coefficients adjustment matrix measures the speed of adjustment of a particular variable to the equilibrium in cointegration relation. For example, the first coefficient in the matrix (-0.012) represents the speed at which prices adjust to their long run equilibria.

A weak exogeneity test for all variables has been conducted to make sure all right hand side variables are exogenous and prices are endogenous. This helps to estimate a single equation model of inflation. The weak exogeneity test is an asymptotically distributed $\chi^2(1)$ test under the null hypothesis of the existence of weak exogeneity (see Engle, Hendry and Richard 1983, Johansen 1992, Erricson, Hendry and Mizon 1998 and Chen and Chiying 2004). The results of the weak exogeneity test are presented in Table 3. As one cointegration relationship has been identified, the test has accordingly been conducted under the assumption of one cointegrating rank. The weak exogeneity test for each variable is conducted by imposing linear restriction on the corresponding row of the coefficients adjustment matrix. The results of the weak exogeneity test reported in Table 3 show that money (m), real GDP (y), interest rate (i) and exchange rate (e) are weakly exogenous, and prices (p) are endogenous.

6. The structure of a short run and long run model of inflation

6.1 The short run model

The existence of one cointegration relationship and weak exogeneity of exogenous variables implies a single equation error correction model (ECM) can be used to determine the short run dynamics and long run relationship of prices. The speed of adjustments of prices to their long run equilibria can also be found. The full derivation of ECM is given in Appendix 2. The general form of ECM for the model is as follows:

$$\Delta p_t = \gamma_0 + \gamma_1 m_{t-1} + \gamma_2 y_{t-1} + \gamma_3 i_{t-1} + \gamma_4 e_{t-1} + \gamma_5 (t-1) - \lambda p_{t-1} + \sum_{i=1}^{11} \gamma_{i+5} S_i +$$

$$+ \delta D + \gamma_1 \Delta m_t + \gamma_2 \Delta y_t + \gamma_3 \Delta i_t + \gamma_4 \Delta e_t + \sum_{i=1}^{5} \alpha_i \Delta p_{t-i} + \sum_{i=1}^{5} \varphi_i \Delta m_{t-i} +$$

$$+ \sum_{i=1}^{5} \phi_i \Delta y_{t-i} + \sum_{i=1}^{5} \omega_i \Delta i_{t-i} + \sum_{i=1}^{5} \kappa_i \Delta e_{t-i} + u_t \qquad (11)$$

Seasonal dummies (S_i) and policy change dummy (D) were included in equation (11) for capturing the seasonality patterns that emerged from the earlier discussion of data and policy change. The subscript i in seasonal dummies S_i represents number of months, taking values of 1 up to 11. For example, S_1 stands for January, S_2 for February of a year and so forth. A policy change dummy (D) represents the introduction of a new currency-the Somoni in October 2000, taking the value of one in October 2000 and zero otherwise. In equation (11) all variables with sign of first differences of delta (Δ) including seasonal dummies are stationary and the linear combination of all variables in levels with first lag values are equal to first lag of disturbance terms (ε_{t-1}) in equation (5), which are also stationary (Table 1). This enables the model to be estimated by OLS (Wooldridge 2000:592).

6.2 The long run model

It is important to point out that in the short run all first differenced variables in equation (11) are nonzero, but in the long run once a price level reaches its equilibrium, all first differenced variables may become zero. This is consistent with the theory that in the steady state all variables grow at a constant rate and therefore, all first differenced variables can take zero values. Hence, from the ECM the long run relationships can be derived by setting all first differenced variables in equation (11) equal to zero and applying the steady state condition (for example, a condition of $p_{t-1} = p_t$, $m_{t-1} = m_t$) for all variables. Dummy variables can also be set to zero. This leads to equation (12).

$$p_t = \mu_0 + \mu_1 m_t + \mu_2 y_t + \mu_3 i_t + \mu_4 e_t + \mu_5 t + \varepsilon_t \,, \tag{12}$$

where $\mu_0 = \frac{\gamma_0}{\lambda}, \mu_1 = \frac{\gamma_1}{\lambda}, \mu_2 = \frac{\gamma_2}{\lambda}, \mu_3 = \frac{\gamma_3}{\lambda}, \mu_4 = \frac{\gamma_4}{\lambda}, \mu_5 = \frac{\gamma_5}{\lambda}$

Equation (12) is the long run model for inflation (see Appendix 2 for more derivation) as presented in equation (5).

7. Estimation of model

7.1 The short run model

Using E-Views 4.0 computer software the ECM in equation (11) was estimated by OLS. The parsimonious form of the model was determined by the "general to specific" method (Hendry 1995). That is the model was estimated with 5 lags and then joint Wald tests were used to drop insignificant lags[9]. Each time after dropping insignificant coefficients diagnostic tests has been conducted and, as a result, the parsimonious form of ECM has been achieved (equation 13).

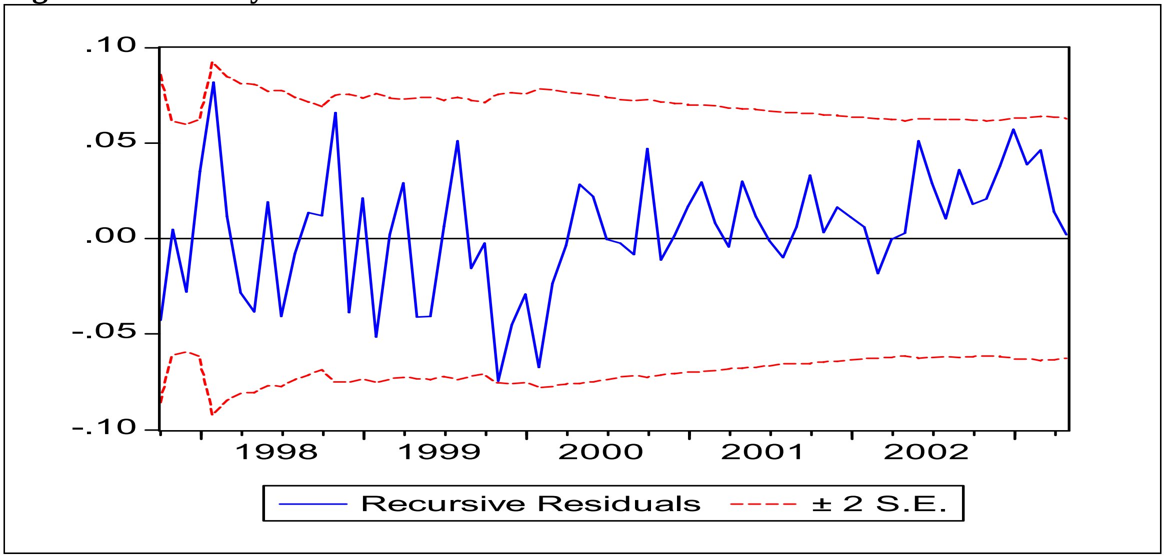
Diagnostic checking for normality (dependant variable/unobservable terms are normally distributed), no serial correlation (the residuals/variables are not correlated with their own lagged values), homoscedasticity (the unobservable terms have constant variances), no omitted variables, correct functional forms and stability of unobservable terms conducted for the general form and the parsimonious form of ECM confirmed that the model passes all these tests (see Wooldridge 2000:320-2, Kennedy 2003:48-56, Seddighi, Lawler and Katos 2000:59-91, Hendry and Erricson 1991). The test statistics for the parsimonious form of ECM listed in equation (13) show that unobservable terms of the inflation model are normally distributed, not serially correlated and homoscedastic. The Ramsey regression specification error test (RESET) statistic confirmed that no variable has been omitted from the model and the model is well specified.

In time series analysis it is important to test for the parameter stability over the period of investigation, i.e., to examine whether the parameters of the model are stable across various sub-samples of data (E-Views 1994-2000:363). The aim is to see whether the underlying regression model has remained unchanged. For this to be true, the parameters of the model must have remained constant (Kennedy 2003:114). Recursive Estimation method was used to test for stability of parameters in the inflation model[10]. In Figure 14 recursive residuals (a solid line) plotted with +/- 2 standard errors (dashed lines).

[9] Introducing at least 8 lags would be better to capture monthly lag effects, but could reduce the sample size and impact on the results, making it difficult to model the long run behaviour of prices. The model was also reduced from 8 lags and the result was identical to the one with 5 lags.
[10] Although the small sample size may impact on the results of the test this is worthdoing.

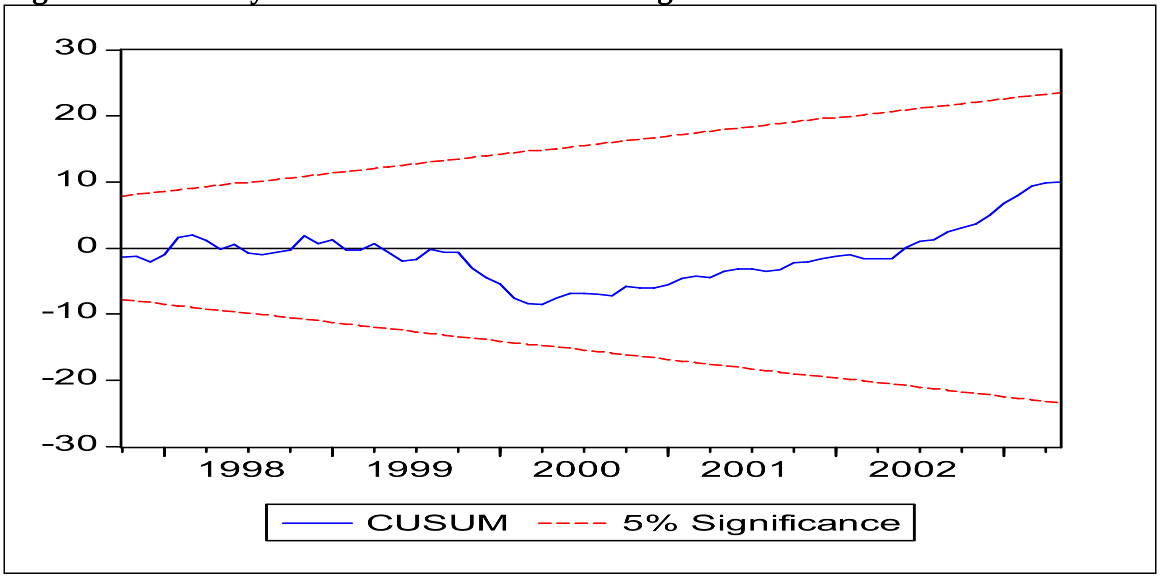
Recursive residuals are inside +/- 2 standard errors (s.e.) lines indicating the stability of the parameters in the inflation model (Equation 13).

Figure 14. Stability test: Recursive residuals with +/- 2 s.e. for the inflation model



CUSUM (cumulative sum of recursive residuals) are also used to test for stability of parameters. In Figure 15, CUSUM (a solid line) is graphed with +/- 5 percent significance level (dashed lines). CUSUM lie inside +/- 5 percent significance bands that indicates parameters stability in the inflation model (equation 13).

Figure 15. Stability test: CUSUM with +/- 5% significance for the inflation model



Recursive coefficient estimates (solid lines) with +/- 2 standard errors (dashed lines) are plotted in Figure 16 in Appendix 3. Since there are 17 coefficients in the inflation model (including constant) there are 17 diagrams each corresponding to one of these coefficients[11]. In all diagrams recursive estimates do not lie outside standard errors bands, indicating stability of coefficients in the estimated inflation model (Equation 13).

The estimated ECM is:

$$\Delta\hat{p}_t = -0.12 + 0.11m_{t-1} - 0.03y_{t-1} + 0.02i_{t-1} + 0.34e_{t-1} - 0.003(t-1) - 0.41p_{t-1} +$$

t-St: (-0.9) (3.0) (-2.3) (2.9) (5.4) (-2.5) (-6.8)

$$+0.10\Delta m_{t-3} - 0.03\Delta y_t - 0.02\Delta y_{t-1} + 0.02\Delta i_t + 0.02\Delta i_{t-1} + 0.01\Delta i_{t-2} +$$

t-St: (2.0) (-2.5) (-1.7) (1.9) (4.1) (2.0)

$$+0.19\Delta p_{t-1} - 0.22\Delta p_{t-2} - 0.05S_2 - 0.03S_5 \qquad (13)$$

t-St: (2.1) (-2.4) (-2.5) (-1.6)

where T=85[1996:05-2003:05], R^2=0.71, **Normality:** $\chi^2(2)$=5.57[0.06], **AR:** F(5,63)=0.27[0.92], DW=1.91, **ARCH:** F(4,60)=0.28[0.88], **RESET:** F(1,67)=2.32[0.15] and p-values are in square brackets.

The speed of adjustment of prices to their long run equilibria is a negative 0.41 and highly significant (equation 13). This is exactly what was expected. A negative sign of the coefficient shows prices converge to their long run equilibria. The convergence occurs at a speed of 41 percent per month. The adjustment coefficient is very close to the minus 0.44 found in Pelipas (2005) for Belarus (Table 4).

The short run elasticity of prices with respect to the third lag of money supply is 0.10, has the expected sign and is significant. A one percentage increase in money supply three months earlier causes current prices to rise by 0.10 percent. This means monetary policy with consideration of money supply change can affect prices with three months lags.

[11] Coefficients are numbered in order according to their appearance in equation (13).

The short run elasticity of prices with respect to the current and first lag of real GDP are negative 0.03 and negative 0.02, respectively, have expected signs and are both significant. The first means a one percentage increase in real GDP causes prices to fall by 0.03 percent. The second implies that if the previous period's real GDP goes up by one percent the current period's prices go down by 0.02 percent. The diminishing size of the coefficients also captures the output inertia so that as the number of lags increases the effect of real output on prices diminishes.

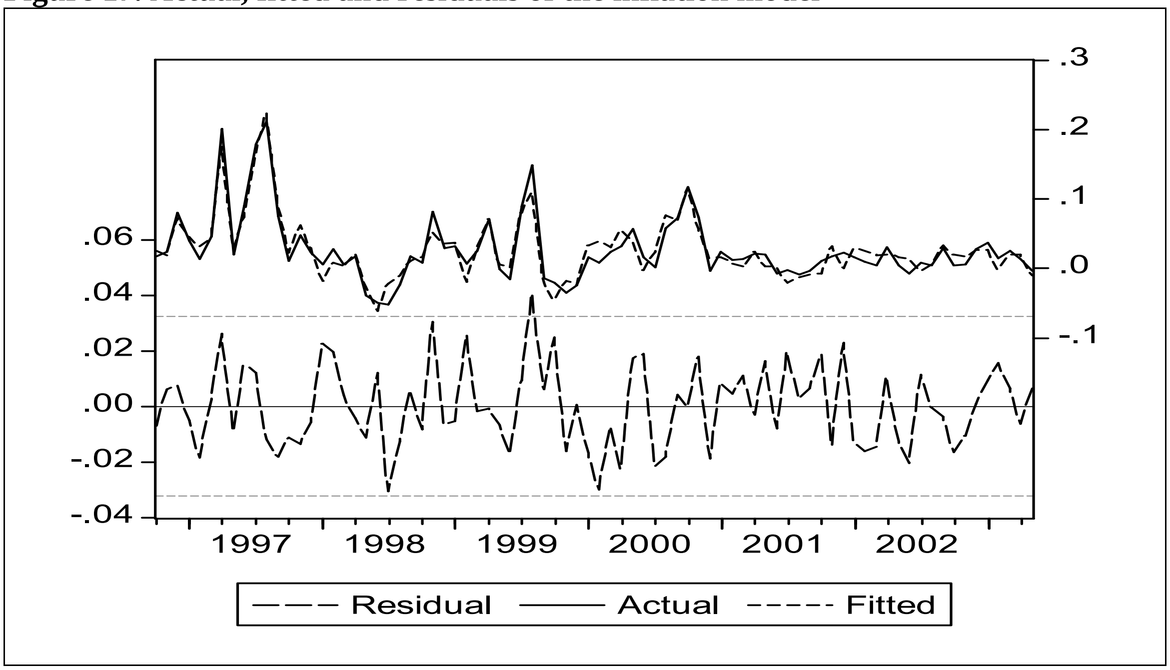
The short run interest rates semi elasticity of prices is 0.02, is significant and has the expected sign based on the Fisher effect, which says that if current interest rates increase by one percentage point current prices will rise by 2.0 percent. The short run semi elasticity of prices with respect to the first and second lags of interest rates are 0.02 and 0.01, respectively, and both are very significant with expected positive signs. This also indicates the presence of the interest rates inertia implying the diminishing effects of interest rates on prices over time.

The short run elasticity of prices with respect to its first lag is 0.19. This is also significant and has the expected sign. This says if the previous period's prices go up by one percent the current period's prices will rise by 0.19 percent. This is evidence of inflationary persistence due to the effects of backward looking inflationary expectations on the inflationary process. One example of such backward looking inflationary expectations is wage indexation. Although the short run elasticity of prices with respect to its second lag is significant it does not have the expected sign. When an attempt was made to drop this out, the model failed to pass on all diagnostic tests and therefore it was recovered back and included in the model.

The coefficient of seasonal dummies for February and May are minus 0.05 and 0.03, respectively and significant. The first coefficient was expected to be positive, but not negative because prices increase in February as explained earlier. The second coefficient has the expected sign. This suggests 3.0 percent of the prices fall occurs because of seasonality. In other words, as explained earlier prices fall when there is a seasonal production boost in May.

In Figure 17 actual, fitted and residuals of the inflation model are shown. As it can be monitored, fitted (a dashed line on the top) mimic actual (a solid line on the top) values with a little variation. Fitted values move almost to the same direction as actual values. This indicates the estimated model of inflation (equation 13) is well fitted.

Figure 17. Actual, fitted and residuals of the inflation model



7.2. The long run model

The long run model of prices was estimated by applying the methodology described in equations (11) and (12) to the estimated model of inflation in equation (13). The result is presented in equation (14) is equivalent to the long run cointegrating relationship estimated in equation (9). The majority of the coefficients in equation (14) are similar or closer to the coefficients in equation (9).

$$\widehat{p}_t = -0.32 + 0.28m_t - 0.08y_t + 0.06i_t + 0.92e_t - 0.007t \quad (14)$$

t-St: (-0.9) (2.8) (-2.1) (3.8) (11.9) (-2.4)

The long run money supply elasticity of prices is a positive 0.28, has the expected sign and is very significant. This implies that if money supply increases by one percent prices in the long run rise by 0.28 percent. As can be seen from equation (14) the price elasticity of money is the second highest among all explanatory variables in the model. Thus, money supply takes second place in predicting prices in Tajikistan. This is consistent with empirical results obtained for other transition countries. For example, the money supply elasticity of prices was 0.26 in Coorey, Macegni and Offerdal (1997) for 21 transition countries, 0.25 in Malizewski (2003) for Georgia, 0.28 in Ohnsorge and Oomes (2003) for Russia, and 0.20 in Lissolovik (2003) for Ukraine (Table 4). The figure was a slightly higher 0.41 in Kim and Pirttila (2004) for Russia and 0.43 in Inoue (2005) for 20 transition countries (Table 4). Table 4 reveals that on average the long run money supply elasticity of prices is lower in transition countries than in developing countries. This possibly explains the lower level of development of financial institutions in transition countries compared with developing countries.

The long run real GDP elasticity of prices is minus 0.08. It also has the expected sign, and is significant. This means that if real GDP increases by one percent prices in the long run fall by 0.08 percent. The majority of empirical studies found similar results in the sense that real GDP negatively affects prices (Table 4). The size of the coefficient varies across different countries due to different measures of real output and different methodologies used in these studies.

The long run interest rates semi elasticity of prices is 0.06, has the expected sign and is highly significant. That is a one percentage point increase in interest rates leads to a 6.0 percentage price rise. The result is consistent with the results found for other transition countries. For example, the interest rate semi elasticity of prices was 0.08 for Belarus in the estimation of Pelipas (2005) and 0.01 for Russia in the estimation of Ohnsorge and Oomes (2003) (Table 4). The relatively low interest rate semi elasticity of prices indicates money markets are under developed in Tajikistan and the effects of the interest rate channel on the economy relatively weak.

Table 4. Long run estimates of prices model across different studies and countries

Empirical Studies	Country	m	y	i	e	t	λ^*
This paper	Tajikistan	**0.28**	**-0.08**	**0.06**	**0.92**	**-0.007**	**-0.41**
Transition countries (TC)		**0.38**	**0.08**	**0.08**	**0.41**	**-0.06**	**-0.13**
Maliszewski (2003) /1	Georgia	0.25	-0.44		0.52		-0.06
Lissolovik (2003) /2	Ukraine	0.20	1.50		0.22		-0.03
Kim and Pirttila (2004) /3	Russia	0.41	-0.45		0.74		-0.04
Ohnsorge and Oomes (2003) /4	Russia	0.28		0.01	0.48		-0.12
Pelipas (2005) /5	Belarus	1.21	-0.70	0.08	0.09	-0.06	-0.44
Ahlgren, Juselius and	Estonia	0.40	0.51				-0.06
Siliverstovs (2004) /1	Latvia	-0.05					-0.19
Inoue (2005)	20 TC	0.43					
Coorey, Macegni & Offerdal (1997)	21 TC	0.26					
Developing Countries		**0.63**	**-1.48**	**-0.03**	**1.27**		**-0.51**
Callen and Chang (1999) /1	India	0.68	-0.42	-0.03			-0.08
Hasan (1999) /1	China	0.36	-0.34				-1.19
Price and Nasim (1999) /1	Pakistan	1.00	-5.12		2.38		-0.71
Ubide (1997) /6	Mozambique	0.46	-0.02		0.16		-0.06

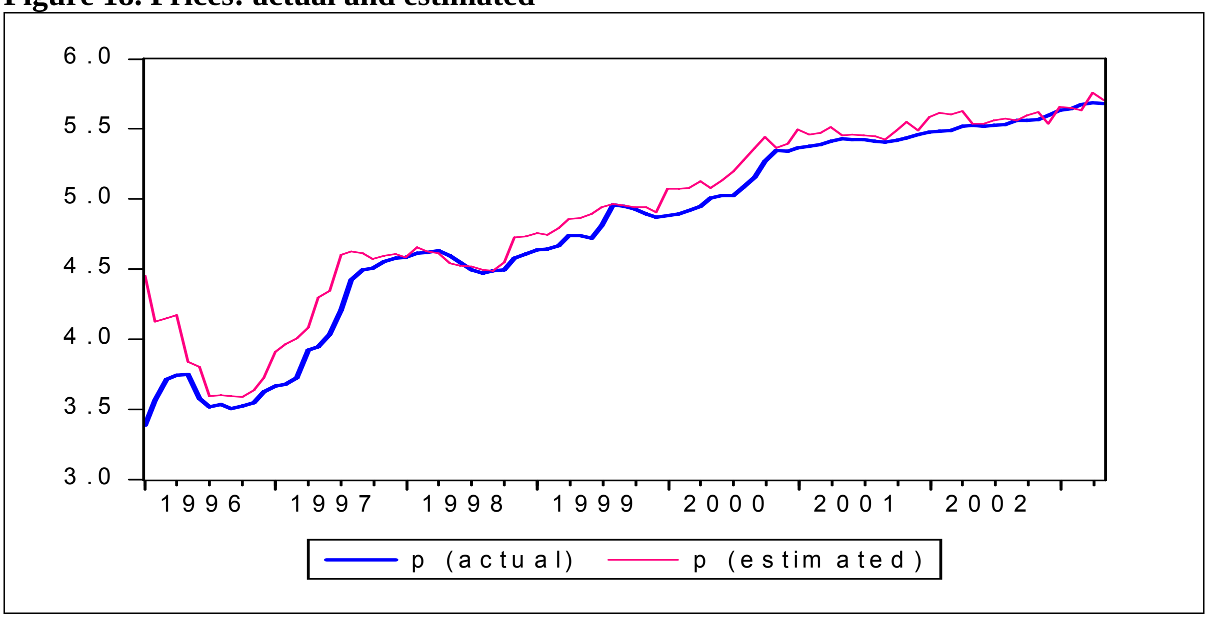
*Values of lambda were taken from corresponding ECMs
/1 Numbers were taken from a cointegrating vector (CV)
/2 Values of “m” and “y” were taken from eq.(9), and “e” from eq.(10)
/3 Values of “m” were taken from CV3 in Table 7, “y” and “e” from CV3 in Table 5
/4 Values of “i” were taken from CV in Table 3, “e” from CV in Table 2 and others from ECM
/5 Numbers were derived from the cointegrating vector of nominal money balances
/6 Numbers were taken from ECM and hence are short run coefficients

The long run exchange rate elasticity of prices is 0.92. It is highly significant and has the expected sign. This indicates a 0.92 percent rise in prices comes from depreciation of the nominal exchange rate by one percent, holding everything else constant. The high elasticity shows the nominal exchange rate has the highest predicting power for inflation in Tajikistan. Such a high exchange rate elasticity of prices is consistent with the theory of a small open economy and the theory of dollarization discussed in the next section. This is also consistent with other empirical works applied to other transition countries. For example, in Kim and Pirttila (2004) for Russia the figure was 0.74 and a dominant factor, in Maliszewski (2003) for Georgia it was 0.52 and a dominant factor (Table 4). In Lissolovik (2003) it was 0.22, not dominant, but very close to the dominant wage factor of 0.25.

The time trend coefficient is minus 0.007 and highly significant. The interpretation of this is that a 0.7 percent of the decline in prices occurs over time. This could be capturing the impact of productivity growth, ongoing reforms and price adjustments during the transition period, and efficiency of the financial sector. This is consistent with the behaviour of prices over the sample. But the results are sample specific and too much extrapolation cannot be done from it. Pelipas (2005) found similar result for Belarus with the coefficient of minus 0.06 (Table 4).

Figure 18 illustrates the actual (a thick line) and estimated (a thin line) price levels. The latter is the long run solution of the estimated price model. Assuming change variables grow at zero rates implies this is both a static and dynamic solution to the long run model of prices in Tajikistan[12]. The graph of the estimated price levels has been constructed using observable values of variables in the estimated model in equation (14)[13]. This indicates the estimated long run equilibrium of prices in equation (14) closely follows the actual long run equilibrium of prices.

Figure 18. Prices: actual and estimated



[12] By definition all change variables are constant in a static state equilibrium whereas in a steady state or dynamic equilibrium they grow at a constant rate. In future work this assumption will be relaxed and static and dynamic solutions separately presented.
[13] de Brouwer and Erricson (1995) applied this approach.

7. Policy implications

The results of the estimated model of inflation provide a number of useful policy implications for the Tajikistan's monetary authorities. The short run dynamic path of inflationary process in Tajikistan is determined by money growth, past inflation, real output growth and interest rates changes. The money growth enters the dynamic path of inflation with three months lags. The NBT needs to consider this when it wants to change money supply in order to affect prices.

The second important policy implication provided by the model is persistent inflation. The impact of the inflationary persistence on inflation is about 0.2 percent. The inflationary persistence caused by backward looking inflationary expectations needs to be reduced through gaining more credibility in the future. This is a long term rather than a short term task for the NBT as the credibility of monetary policy cannot be achieved overnight.

The results also show real output growth inertia and interest rates changes inertia. Both real output growth and interest rates changes are important short run determinants of inflation through the real money demand with contemporaneous and lagged effects. When real output grows and interest rates fall this leads to a rise in real money holdings, contributing to lower inflation or disinflation. While real output expansion is not a direct objective of monetary policy, the development of money markets in the country is one of the tasks of the NBT. The NBT should take necessary measures in developing financial markets and thereby improve the transmission channel of interest rates.

The speed at which prices converge to their long run equilibria is 41 percent a month. This is also important for policy implications. The figure could guide the monetary authorities that it would take 2.4 months for any policy shock (i.e. money shock or exchange rate shock) on prices to entirely disappear.

The estimated results also supply crucial long run policy implications. In the long run, exchange rate, money, real output and interest rates provide good predicting power in determining prices. The model indicates a very high long run exchange rate elasticity of prices that is consistent with the theory of a small open economy and the theory of dollarization. Tajikistan has a very small open economy. For example, the ratio of imports to GDP in 2000 was 101.5 percent (Source: the author's calculation using SSCT 2003). With such a high imports to GDP ratio the exchange rate depreciation raises the prices of imported goods in domestic currency contributing to a higher overall price rise.

With regard to the existence of high dollarization, the country has a very high dollarization ratio. In 2001, the dollarization ratio defined as the ratio of foreign currency deposits to broad money (M2) was 43.0 percent (Source: the author's calculation using data obtained from the NBT). In the absence of developed domestic financial institutions and access to world financial institutions people in Tajikistan usually do not have much investment choice. Thus the fear of high inflation means people will tend to invest (or save) in US dollars. This will have two effects on prices. One is a direct effect through rises in the prices of traded goods due to exchange rate depreciation. The second is an indirect effect through reduction of money demand, which in turn leads to excess money supply resulting in higher prices. This suggests the NBT should take some measures in reducing the dollarization ratio over the long term. This would help to control both the direct and indirect effects of dollarization on prices, resulting in disinflation.

The estimated results contribute to a current debate on whether the NBT should let the market freely determine the exchange rate. The NBT's participation share in the foreign exchange market has been above 70 percent on average over the period 1996-2003. From the results of the model, the exchange rate appears to be a dominant factor of price changes in the long run. Such a high exchange rate responsiveness to prices suggests the NBT should be cautious about reducing intervention in the foreign exchange market.

The results add to another debate on whether money or interest rates should be used as an instrument of monetary policy. The results in this paper show money is still preferable over interest rates as a policy instrument. Money is the second dominant determinant of prices in the long run whereas interest rates are the last one. In this case, interest rates have a relatively smaller impact on prices, since the interest rates semi elasticity of prices is very low. The relatively low interest rates semi elasticity of prices indicates money markets are under developed in Tajikistan. This is consistent with the economic development of less advanced transition countries with an under-developed financial sector. Hence, in transmitting the effects of monetary policy onto the economy, the domestic credit channel may dominate the interest rates channel. However, this does not imply that interest rates should be ignored. As pointed out earlier, development of the financial sector is important for enhancing and consideration of the interest rates channel in the future.

In short, the estimated inflation model of Tajikistan is a combination of money market equilibriums that determines the price of non-traded goods and foreign exchange market equilibrium, which determines the price of traded goods. The results of the model suggest controlling excessive money growth and stabilizing excessive exchange rate fluctuations should be the key ingredients of monetary policy in controlling inflation of the country.

9. Conclusion

This paper estimates a model of inflation in Tajikistan. The estimated model is data coherent, has sensible economic and statistical properties and its coefficients are stable over the sample. The long run and short run relationships of inflation with its determinants have been determined. In the long run, exchange rate, money, real output and interest rates provide good predicting power in determining prices. In the short run, inflation is determined by past values of money growth and inflation, and current and past values of real output growth and interest rate changes. The coefficient of adjustment of prices level to its long-run equilibrium has been found to be high. The adjustment process occurs at a speed of 41 percent per month.

It was found that the long run exchange rate elasticity of prices is 0.92 and highly significant. This shows the nominal exchange rate is the dominant factor in predicting inflation in Tajikistan. This is also consistent with empirical work that has been applied to other transition countries discussed in the paper. The high exchange rate elasticity of prices is not surprising given that the country has a very open and highly dollarized economy.

The second dominant long run factor determining inflation in Tajikistan is money supply. The money supply elasticity of prices is 0.28. This is also highly significant and consistent with the money market approach that has been applied to modeling inflation in this paper. Disequilibria in money markets that were created mainly by excess money supply over real money demand always led to higher prices. McLeod (2002) found similar results for Indonesia. The empirical studies on modeling inflation in transition countries discussed in the paper support this result.

The long run real GDP elasticity of prices is minus 0.08. It also has the expected sign and is significant. This means if real GDP increases by one percent prices in the long run will fall by 0.08 percent. The majority of empirical studies found similar results in the sense that real GDP negatively affects prices (Table 4). The size of the coefficient varies across different countries due to different measures of real output and the different methodologies used in these studies. The achieved favourable result for the real GDP elasticity of prices also shows the created monthly real GDP series fit the model better. The methodology used to create monthly real GDP series is specific to this paper and was not found in other related studies. Thus, this methodology can be used to create monthly real GDP series for other transition countries facing similar data limitations problems.

The long-run interest rates semi elasticity of prices is 0.06 and is also highly significant. As mentioned earlier, this is also consistent with the economic development of less advanced transition countries with an under-developed financial sector. In this case, interest rates have relatively smaller impact on prices, since the interest rates semi elasticity of prices is relatively low.

Time trend coefficient is minus 0.007 and highly significant, confirming that a 0.70 percent decline in prices over time is possibly due to the impact of productivity growth, ongoing reforms and price adjustments during the transition period, and efficiency of the financial sector. This is consistent with the behaviour of prices over the sample.

Further research is needed to estimate alternative models of inflation for Tajikistan such as an output gap approach and a mark-up approach that would be better for comparison purposes.

Appendix 1

Table 1. The created monthly real GDP series, mln Somoni (in log, y-unadjusted, ya-adjusted)

Obs.	y	ya	Obs.	y	ya
1996:01	3.925926	4.273170	2000:04	3.828641	4.481258
1996:02	3.850148	4.175507	2000:05	4.428433	4.441445
1996:03	3.918005	4.279015	2000:06	4.794964	4.496083
1996:04	3.703768	4.266808	2000:07	4.737075	4.554712
1996:05	4.332048	4.298108	2000:08	4.637637	4.530509
1996:06	4.489759	4.274807	2000:09	4.854371	4.467861
1996:07	4.414010	4.318182	2000:10	4.664382	4.366037
1996:08	4.329417	4.268420	2000:11	4.681205	4.519208
1996:09	4.755313	4.304752	2000:12	5.203457	4.641953
1996:10	5.021905	4.670375	2001:01	4.074142	4.519889
1996:11	4.469350	4.256440	2001:02	4.014580	4.537287
1996:12	4.567468	4.247106	2001:03	4.182050	4.583510
1997:01	3.964615	4.329313	2001:04	3.914021	4.544054
1997:02	3.903991	4.356738	2001:05	4.517431	4.610344
1997:03	3.966511	4.314240	2001:06	4.936630	4.599273
1997:04	3.763523	4.363252	2001:07	4.774913	4.599086
1997:05	4.390739	4.393498	2001:08	4.819475	4.631263
1997:06	4.546481	4.265125	2001:09	5.028475	4.656314
1997:07	4.356709	4.323862	2001:10	4.686750	4.403271
1997:08	4.322807	4.212962	2001:11	4.734443	4.580426
1997:09	4.740575	4.346825	2001:12	5.295313	4.668629
1997:10	4.979489	4.572715	2002:01	4.144721	4.682008
1997:11	4.516339	4.321214	2002:02	4.100989	4.642765
1997:12	4.627910	4.270240	2002:03	4.289089	4.655394
1998:01	3.972177	4.386258	2002:04	3.951244	4.656006
1998:02	3.918005	4.379945	2002:05	4.621044	4.645259
1998:03	3.983413	4.358400	2002:06	5.003275	4.676395
1998:04	3.775057	4.377800	2002:07	4.940928	4.731820
1998:05	4.377014	4.355476	2002:08	4.797442	4.637799
1998:06	4.630838	4.376664	2002:09	5.146913	4.709803
1998:07	4.447346	4.338484	2002:10	4.857484	4.653906
1998:08	4.527209	4.373582	2002:11	4.691348	4.532124
1998:09	4.803201	4.437494	2002:12	5.412092	4.785392
1998:10	4.846547	4.499363	2003:01	4.252772	4.733064
1998:11	4.762174	4.503372	2003:02	4.220977	4.782520
1998:12	4.654912	4.320467	2003:03	4.404277	4.758790
1999:01	3.974058	4.375505	2003:04	3.981549	4.727355
1999:02	3.960813	4.447830	2003:05	4.723842	4.781416
1999:03	4.010963	4.375308			
1999:04	3.772761	4.388754			
1999:05	4.377014	4.357951			
1999:06	4.683981	4.432038			
1999:07	4.455509	4.357034			
1999:08	4.617099	4.469682			
1999:09	4.695925	4.338871			
1999:10	4.734443	4.387682			
1999:11	4.844974	4.645404			
1999:12	4.945207	4.471792			
2000:01	3.987130	4.393708			
2000:02	3.977811	4.369347			
2000:03	4.089332	4.461809			

Appendix 2

Derivation of an ECM of inflation

$$p_t = \gamma_0 + \gamma_1 m_t + \gamma_2 y_t + \gamma_3 i_t + \gamma_4 e_t + \gamma_5 t + \varepsilon_t \text{ ....} \underline{\textit{Original regression}}$$

All variables are I(1) and u_t are I(0). Thus, the cointegration relationship can be written as:

$$p_t = \gamma_0 + \gamma_1 m_t + \gamma_2 y_t + \gamma_3 i_t + \gamma_4 e_t + \gamma_5 t + \alpha_0 p_{t-1} + \sum_{i=1}^{11} \gamma_{i+5} S_i + \delta D + \sum_{i=1}^{5} \alpha_i \Delta p_{t-i} +$$
$$+ \sum_{i=1}^{5} \varphi_i \Delta m_{t-i} + \sum_{i=1}^{5} \phi_i \Delta y_{t-i} + \sum_{i=1}^{5} \omega_i \Delta i_{t-i} + \sum_{i=1}^{5} \kappa_i \Delta e_{t-i} + u_t$$

In this equation $p_t, m_t, y_t, i_t, e_t, p_t, t$ are nonstationary. Hence they need to be converted to stationarity. It can be done by simple arithmetic manipulation. Subtract p_{t-1} from both sides, subtract and add $\gamma_1 m_{t-1}, \gamma_2 y_{t-1}, \gamma_3 i_{t-1}, \gamma_4 e_{t-1}$ and $\gamma_5 (t-1)$ from and to the equation imply the following:

$$\Delta p_t = \gamma_0 + \gamma_1 m_{t-1} + \gamma_2 y_{t-1} + \gamma_3 i_{t-1} + \gamma_4 e_{t-1} + \gamma_5 (t-1) - \lambda p_{t-1} + \sum_{i=1}^{11} \gamma_{i+5} S_i + \delta D +$$
$$+ \gamma_1 \Delta m_t + \gamma_2 \Delta y_t + \gamma_3 \Delta i_t + \gamma_4 \Delta e_t + \sum_{i=1}^{5} \alpha_i \Delta p_{t-i} + \sum_{i=1}^{5} \varphi_i \Delta m_{t-i} +$$
$$+ \sum_{i=1}^{5} \phi_i \Delta y_{t-i} + \sum_{i=1}^{5} \omega_i \Delta i_{t-i} + \sum_{i=1}^{5} \kappa_i \Delta e_{t-i} + u_t \text{ ....} \underline{\textit{ECM}}$$

where $\lambda = (1 - \alpha_0)$ is a speed of adjustment.

Now, in the ECM all variables with delta (Δ) are stationary, linear combination of all variables with subscripts of $t-1$ is equal to ε_{t-1}, which is stationary. Therefore, the ECM can be estimated by OLS.

Derivation of a long run model of prices

Steady state condition implies that all variables with Δ in the ECM above are equal to zero and hence, the ECM becomes

$$\gamma_0 + \gamma_1 m_{t-1} + \gamma_2 y_{t-1} + \gamma_3 i_{t-1} + \gamma_4 e_{t-1} + \gamma_5 (t-1) - \lambda p_{t-1} + u_t = 0$$

$$\lambda p_{t-1} = \gamma_0 + \gamma_1 m_{t-1} + \gamma_2 y_{t-1} + \gamma_3 i_{t-1} + \gamma_4 e_{t-1} + \gamma_5 (t-1) + u_t$$

In the steady state $p_{t-1} = p_t$, $m_{t-1} = m_t$, $y_{t-1} = y_t$, $i_{t-1} = i_t$, $e_{t-1} = e_t$ *and* $(t-1) = t$ and thus,

$$\lambda p_t = \gamma_0 + \gamma_1 m_t + \gamma_2 y_t + \gamma_3 i_t + \gamma_4 e_t + \gamma_5 t + u_t$$

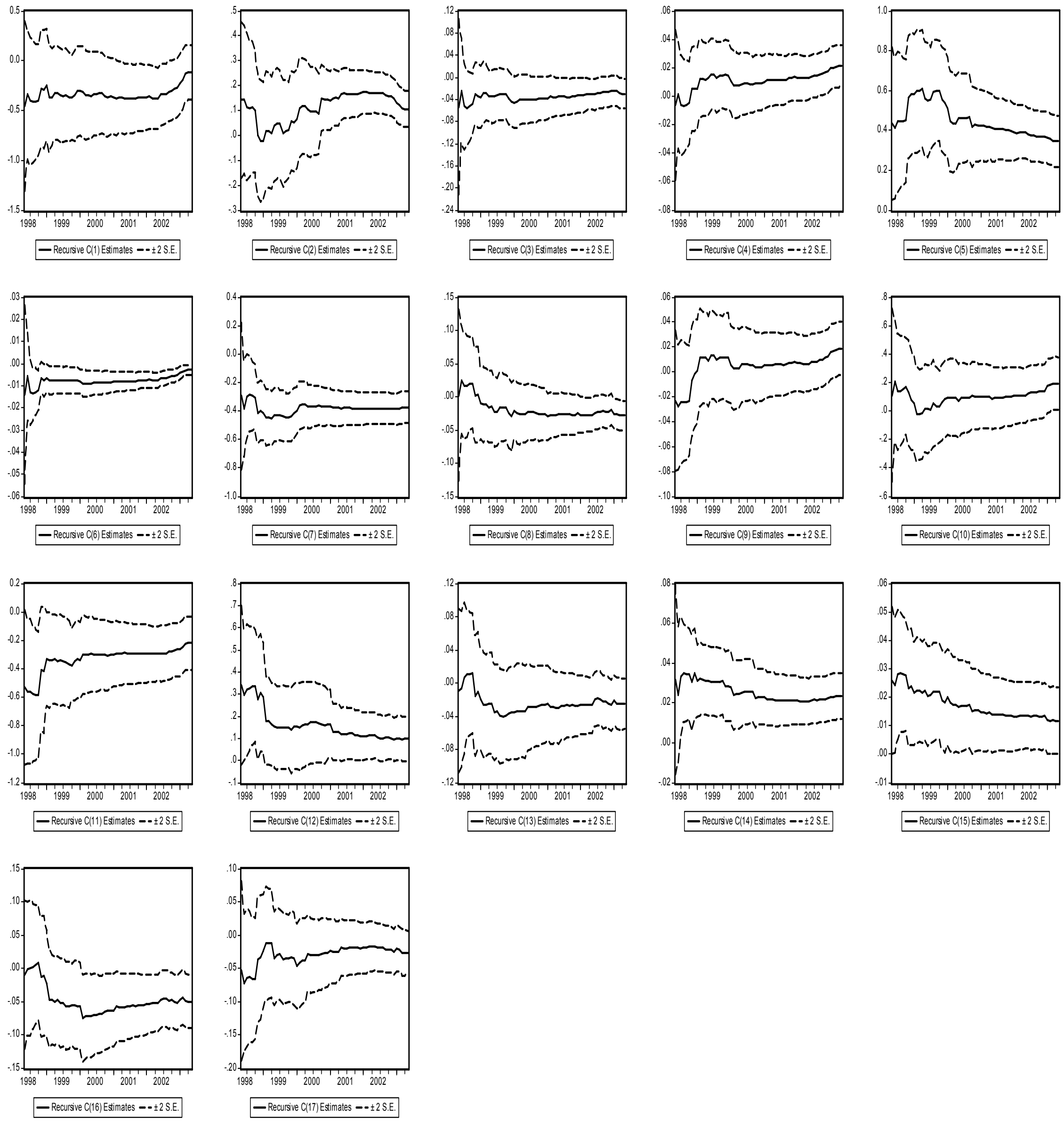
Rearranging terms gives the following:

$p_t = \mu_0 + \mu_1 m_t + \mu_2 y_t + \mu_3 i_t + \mu_4 e_t + \mu_5 t + \varepsilon_t$ ……………….…..*Long-run relationship*

where $\mu_0 = \dfrac{\gamma_0}{\lambda}, \mu_1 = \dfrac{\gamma_1}{\lambda}, \mu_2 = \dfrac{\gamma_2}{\lambda}, \mu_3 = \dfrac{\gamma_3}{\lambda}, \mu_4 = \dfrac{\gamma_4}{\lambda}, \mu_5 = \dfrac{\gamma_5}{\lambda}$

Appendix 3

Figure 16. Stability test: Recursive coefficient estimates for the inflation model



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