Inflation in the Islamic Republic of Iran: Apply Univariate and Multivariate Cointegration Analyses

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ABSTRACT

This paper examines the factors that explain and help forecast inflation in Iran. A simple inflation model is specified that includes liquidity (M2), real GDP and import prices, as well as the wheat support price as a monetarist approach. We have used multivariate and univariate cointegration analyses and error correction model (ECM) to determine the effect of liquidity (M2) and other variables on inflation in long run and short run. Quantitative estimates based on the time series annual data from 1961 to 2007, indicate that liquidity (M2) as well as real GDP and import prices have a significant effect on inflation in long run. It is also important that the long run estimated coefficients in ARDL approach the point of view of size element with the Johansen and Juselius (1990) maximum likelihood cointegration approach is symmetrical. The results of ECM show that estimated coefficients of model in short run are less than estimated coefficients in long run. The coefficient of the error correction term (ECT) is equal to -0.31. According to this estimation, speed of adjustment is slow. In addition, the ECM only can explain 85 per cent of fluctuation of prices.

JEL Classifications: E31; C22; C32

Keywords: Inflation; Cointegration; Error Correction Model (ECM); Iran

1. INTRODUCTION

Inflation in an open economy can be influenced by both internal and external factors. Internal factors include, among others, the government budget deficit, monetary policy and structural regime changes (revolution, political regime changes, etc.). External factors include terms of trade and foreign interest rate, as well as, the attitude of the rest of the world (sanctions, risk generating activities, wars, etc.) toward the country. The Iranian economy has suffered from high inflation since the advent of the revolution in 1979. Inflation in Iran has historically been moderately high, and the main source of inflation in the long run has been the financing of large government deficit by monetary expansion (Komijani, 2006). Central bank of Iran has not chosen freely instruments for monetary policy. Iran has experienced the financing of government budget deficit through central bank between 1980 and 2002. Thus, we have observed huge government budget deficit, high growth of liquidity and double-digit inflation rates in the last three decades. Over the period 1989-2002, net debt to government and the total private sector liquidity (namely the M_2 measure of money supply) grew by average annual rates of 22.1 and 26.6 per cent, respectively. On the other hand, the average annual growth of GDP during this period was 4.9 per cent, which was lower than average annual rates of M_2. So, high growth of liquidity can explain some part of inflationary process in Iran. The purpose of this paper is twofold. First, it employs the monetarist model of inflation, augmented with the Import prices to identify the determinant of inflation in Iran using the data over the period 1961 2007 in long run and short run. Second, it compares results of multivariate and univariate cointegration tests on selected model of inflation in Iran.

There are a number of studies concerning the analysis of inflation in Iran[1]. Some recent studies such as Bonato (2007) investigate the determinants of inflation in Iran using multivariate cointegration techniques. But, there is little attention to compare multivariate and univariate cointegration techniques on models of inflation in Iran. This paper attempts to focus on it. The remainder of the paper is organized as follows. Section 2 reviews trend of inflation in Iran pre and post-revolution period. Section 3 presents an econometric model to estimate the relationship among price level, liquidity (M_2) and other variables. Section 4 provides time series analysis and model estimation and final section offers a summary and the conclusion.

2. THE STYLIZED FACTS

Over the period of 1961-1972, the inflation rates were single figures in Iran. Thus, this period was relatively low and stable inflation. The average annual rate of *CPI* inflation was 2.6 per cent. After 1972, with the oil price and quantity of oil exports increasing, the rates of inflation rose sharply and exhibited large fluctuations. The average annual rate of the *CPI* inflation was 15.6 per cent during the period 1973-1977. A spike for the *CPI* inflation appeared in 1977 with a rate of 24.7 per cent. Over the period 1978-1988, the Iranian economy has experienced several events of critical importance, including the 1979 revolution, and the 1980-1988 war with Iraq. The average annual rate of the *CPI* inflation was 18.1 per cent during the period 1978-1988. The ending of the Iran-Iraq war in August 1988 signaled the beginning of a new phase in the development of the Iranian economy. Generally, Iranian economy has experienced three Five-Year Development Plans (FYDPs) during the period 1989-2006. One of the primary aims of these plans was to control inflation rate in Iranian economy. But, it was not successful because when we consider the average annual inflation rate during this period, we see that the average annual inflation rate was 21.2 per cent. In addition, Iran has experienced highest inflation rate (49.4 per cent) in 1995. Figure 1 shows trend of inflation in Iran during the period 1961-2007.

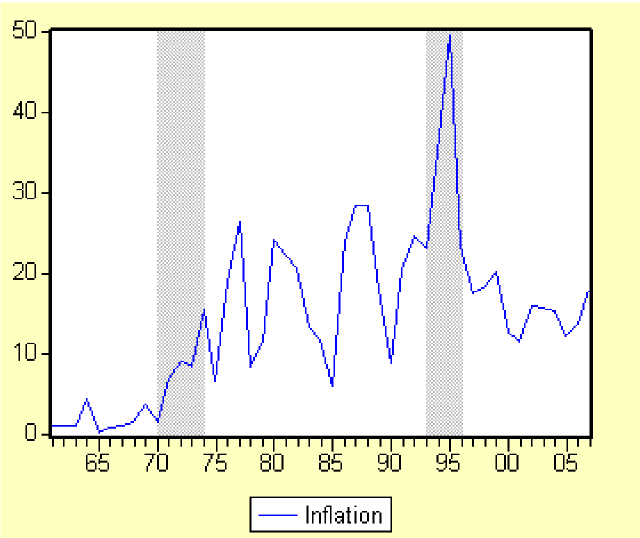

Figure 1: Trend of Inflation in Iran, 1961-2007

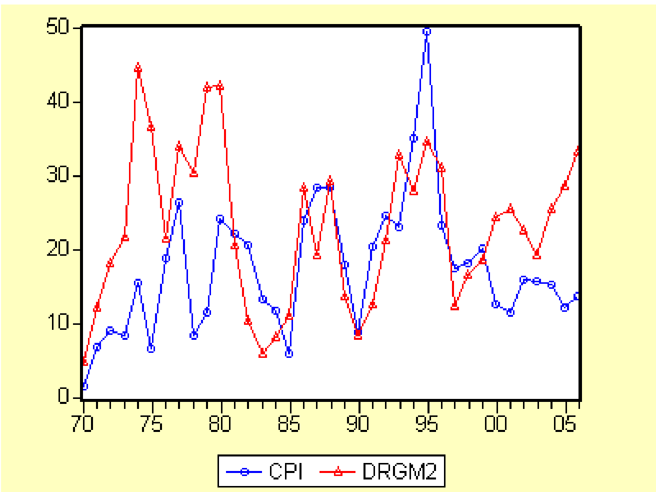

Figure 2: Inflation and Difference between M_2 and GDP Growth, 1970-2006

1 Studies such as Nili (1985), Makkian (1990), Tabatabai-Yazdi (1991), and Taiebian (1995) examined the determinants of inflation without considering the integration properties of the relevant variables. Threfore, these studies are inappropriate.

Iran's economy is dominated by oil exports. Since the early 1960s, and particularly since the first oil shock of 1973–1974, oil has also played an important role in the government budget and economic growth. So, the performance of FYDPs after war shows that real GDP growth is instability in Iran, mainly because high dependency economy on oil revenue. The average annual growth of real GDP during the FYDPs after war was 5.5 per cent, which was lower than the liquidity growth rate of 30 per cent. Figure 2, shows trend of inflation and difference between liquidity (M2) and real GDP growth in Iran during the period 1970-2006.

3. A MODEL OF INFLATION IN IRAN

The literature on inflation in Iran is relatively extensive. Part of the literature focuses on conventional money demand functions. In fact, among several alternative hypotheses, the monetary explanation, with its emphasis on the role of money supply growth, has perhaps most of the attention in Iran. Celasun and Goswami (2002) estimated a function on quarterly data over the period 1990:Q2-2002:Q1, where inflation and depreciation of the parallel market exchange rate proxy the opportunity costs of holding money. After identifying a long run equilibrium condition in the money market, they found a strong impact of money and the exchange rate in the short run inflation equation. Bonato (2007) identified a long run relationship between the price level and money, its rate of return, real output, and the exchange rate in Iran. Using new national accounts series released by the Central Bank of Iran, a parsimonious error correction model (ECM) is estimated for the period 1988:Q4-2006:Q1. He concluded money has a prominent role in determining the equilibrium price level. Moreover, money growth drives inflation even in the short run, with lags of up to four quarters.

On the other hand, there are a number of studies concerning the inflation with different approaches. Looney (1985) studied the inflationary process in pre-revolutionary Iran. He estimated a structural model to explain the relationship between inflation and structural variables in Iran and showed that the structural variables play a major role in inflation in Iran. Ikani (1987) used Harbereger model to examine the impact of money variable and structural variables on inflation rates in Iran by using the Ordinary Least Squares (OLS) method for the period 1959 to 1977. He found that money variable, as well as, the structural variables, have significant impacts on inflation. Becker (1999) used a common trend model to study the behavior of prices, the exchange rate, and real output over a sample of annual data for the period 1959/1960 to 1996/1997. Monetary shocks are found to have permanent effects on the price level and the exchange rate. The selection of variables for our baseline model is based on the following consideration. First, to measure the price inflation, the consumer price index (CPI) is included in the baseline model. Second, we include the real GDP and liquidity (M_2) in the price equation following Quantity Theory of Money. Third, we also include the price of imported goods in model following Chaudhary and Ahmad (1995). The price of imported goods used to detect the effect of this variable on inflation. Hence, price equation may the form:

$$CPI_t = F\left[M2, GDP, IPI\right]_t$$

Where *CPI* is the consumer price index; M_2 is the volume of liquidity, *GDP* is the real gross domestic product; and *IPI* is import price index. We have used log-linear equation as follows:

$$\ln CPI_t = \alpha_0 + \alpha_1 \ln M2_t + \alpha_2 lnGDP_t + \alpha_3 \ln IPI_t + U_t$$

The estimation methods draw on the recent developments in cointegration analysis and the Error Correction Model (ECM) that have been used to explore several economic phenomena. In this paper, from Autoregressive Distributed Lag (ARDL) is used as basic method and also Johansen and Juselius (1990) maximum likelihood cointegration test is used as elementary method for the study of results sensitivity with regard to multivariate and univariate cointegration techniques.

4. MODEL ESTIMATION AND INTERPERATION

4.1. Time Series Analysis

We used annual data in analyses. Its information is according to the time series and duration of this study was in 1961-2007.

Table 1: Results of Unit Root Test

Series	Order	ADF[1]	PP[2]
LnCPI	Level	-3.02	-3.10
	1st difference	-3.35	-3.46
LnM_2	Level	-2.67	-1.92
	1st difference	-3.46	-3.35
LnGDP	Level	-1.56	-2.04
	1st difference	-3.12	-3.88
LnIPI	Level	-1.44	-1.56
	1st difference	-4.54	-3.82

1 Augmented Dickey-Fuller unit root test, denotes significance at 5%

2 Phillips-Perron unit root test, denotes significance at 5%

The main source that is used for the data related to model variables is the Central Bank of Iran (CBI). In general, data on time series are monitored carefully and thoroughly by the best institution. Thus, access to these data is not problematic, which makes the analysis easier and, at the same time, more reliable. The first step of the time series analysis was to investigate the properties of the series individually. We checked for the order of integration of these series. The results of the unit root tests are presented in Table 1.

With respect to the Table 1 the null hypothesis of unit root is not rejected neither by Augmented Dickey-Fuller (1979) nor by the Phillips and Perron (1988) test and so are the series non-stationary in the level. We conducted the same test on the first difference of these series and found them stationary.

4.2. Maximum Likelihood Estimation

Once all the series are non-stationary in the level, one can estimate an econometric model only if they are cointegrated. The cointegration test presented with restricted intercepts and no trends in the VAR. The selection of lag to VAR model is very important step. The order of VAR is one (Table 2). The lag order of the VAR model is selected based on Schwarz Bayesian Criterion (SBC).

Table 2: Test for Selecting the Order of the VAR Model

Order	LL	AIC	SBC	LR test	Adjusted LR test
4	305.5	237.5	177.6	……….	………
3	294.7	242.5	196.9	CHSQ(16) = 21.52[.159]	13.0175[.671]
2	278.5	242.7	210.8	CHSQ(32) = 53.91[.009]	32.5996[.437]
1	253.8	233.8	216.2	CHSQ(48) = 103.21[.000]	62.4102[.079]
0	-65.8	-69.8	-73.3	CHSQ(64) = 742.62[.000]	449.0288[.000]

AIC=Akaike Information Criterion
SBC=Schwarz Bayesian Criterion

Table 3 shows the cointegration test based on Johansen and Juselius (1990) approach. The results indicate that the hypotheses that there are only two cointegration vector among the series can not be rejected neither by the Lambda Max nor by the trace statistics and so the series are cointegrated.

Table 3: Cointegration Test

Null Hypothesis	r = 0	r = 1	r = 2	r = 3
λ_{max}	141.93	41.80	8.35	4.18
Critical value 95%	28.27	22.04	15.87	9.16
Null Hypothesis	r = 0	$r \leq 1$	$r \leq 2$	$r \leq 3$
λ_{trace}	196.28	54.34	12.53	4.18
Critical value 95%	53.48	34.87	20.18	9.16

When we considered the two individual cointegration vectors, we saw that in the first cointegration vector coefficient of LnGDP enters with an incorrect sign, since an increase in real GDP tend to increase in consumer price index (CPI). However, in the second cointegration vector, estimated coefficients have correct signs and are statistically significant. Second estimated cointegrated vector in Johansen estimation is shown in Table 4.

Table 4: Estimated Cointegrated Vector in Johansen Estimation

	LnCPI	LnM_2	LnGDP	LnIPI	Intercept
Vector	-1.00	0.53	-0.74	0.45	5.57
t-statistics	-	12.53	-7.54	13.67	1.54

In this vector the positive coefficient of log M_2 indicates that an increase in liquidity is inflationary. The negative but large coefficient of log *GDP* indicates that an increase in real domestic production should reduce the price level. Finally, the positive coefficient of log *IPI* indicates that an increase in the price of imported goods is inflationary. While the coefficients of all the regressors have expected signs and are statistically significant in Johansen and Juselius (1990) procedure, but there are some limitations that can affect the validity of the estimation results. First, with an annual data comprising 46 observations, the Johansen tests can be subject to size and power bias. The importance of applying a correction factor for the Johansen procedure in small samples is now well known. The correction factor is necessary to reduce the excessive tendency of the tests to falsely reject the null hypothesis of no cointegration often associated with data of relatively short span. A number of papers including Reimers (1992) and Cheung and Lai (1993) have documented the importance of this correction factor for the small sample. Cheung and Lai (1993) had provided the correction factor of Johansen likelihood ratio test while Reinsel and Ahn (1992) suggested an adjustment to the estimated maximum eigenvalue and trace statistics.

So, the small number of observations affects the validity of the estimation results. Second, the cointegration test based on Johansen and Juselius (1990) approach showed that there are two cointegration vectors among the series, but we selected second cointegrated vector to confirm our theoretical model. It can be concluded from the above discussion that we can use other procedures such as Autoregressive Distributed Lag (ARDL) modeling for univariate cointegration test. It seems that this procedure is appropriate method to estimate the model. Like the Johansen and Juselius (1990) procedure, the ARDL method estimates the long run effects jointly with the short run effects. Pesaran and Shin (1995) showed that ARDL modeling for univariate cointegration test for small sample will be the most appropriate. On the other hand, ARDL method allows for a mix of $I(0)$ and $I(1)$ variables in the same cointegration equation. Finally, ARDL method is appropriate to account the effects of shocks in the model. Thus, in this paper, from Autoregressive Distributed Lag (ARDL) procedure is used as basic method.

4.3. Autoregressive Distributed lag Estimates

We propose an Autoregressive Distributed Lag (ARDL) modeling for univariate cointegration test, where the *CPI* is considered to be the dependent variable and the best lag distribution of the independent variables, liquidity (M_2), real *GDP* and the price of imported goods, was modeled. The ARDL model was estimated from a recursive search of the optimal number of lags through the Schwarz Bayesian Criterion (SBC) and from the diagnostic statistics. Given the few observations available for estimation we set the maximum lag order of the various variables in the model equal to two. Table 5 presents the Autoregressive Distributed Lag estimates. In fact, this is the first stage of an Autoregressive Distributed Lag (ARDL) modeling for univariate cointegration test. The results of a few diagnostic tests in Table 5 indicate that there is no error autocorrelation and conditional heteroskedasticity, and that the errors are normally distributed. This evidence indicates that the relationship between variables is verified.

Table 5: Autoregressive Distributed Lag Estimates
ARDL (1, 0, 0, 1) selected based on Schwarz Bayesian Criterion
Dependent variable is LnCPI

Regressors	Coefficient	Standard Error	T-Ratio [Prob]
LnCPI(-1)	0.68321	0.060538	11.2856[.000]
LnM2	0.13337	0.024029	5.5505[.274]
LnGDP	-0.15419	0.044727	-3.4475[.001]
LnIPI	0.41998	0.053925	7.7883[.000]
LnIPI(-1)	-0.24291	0.070639	-3.4388[.001]
Intercept	1.1009	0.40733	2.7028[.000]
R-Squared	0.99975	R-Bar-Squared	0.99972
S.E. of Regression	0.035138	F-stat. F(5,39)	31067.9[.000]
Mean of Dependent Variable	2.4201	S.D. of Dependent Variable	2.0881
Residual Sum of Squares	0.048153	Equation log-likelihood	90.0483
Akaike Info. Criterion	84.0483	Schwarz Bayesian Criterion	78.6283
DW-statistic	1.8394	Durbin's h-statistic	0.58960[.099]

Diagnostic Tests

Test Statistics	LM Version	F Version
A: Serial correlation	CHSQ(1) = 0.26758[.605]	F(1,38) = 0.22731[.636]
B: Functional form	CHSQ(1) = 0.41980[.517]	F(1,38) = 0.35784[.553]
C: Normality	CHSQ(2) = 2.4923[.288]	Not applicable
D: Heteroscedasticity	CHSQ(1) = 0.89005[.345]	F(1,43) = 0.86765[.357]

A: Lagrange multiplier test of residual serial correlation.
B: Ramsey's RESET test using the square of the fitted values.
C: Based on a test of skewness and kurtosis of residuals.
D: Based on the regression of squared residuals on squared fitted values.

The second stage of an Autoregressive Distributed Lag (ARDL) modeling for univariate cointegration test is to estimate the long run coefficients of model. Table 6 presents the solved static long run results of the ARDL model.

Table 6: Estimated long run coefficients the ARDL approach
ARDL (1, 0, 0, 1) selected based on Schwarz Bayesian Criterion
Dependent variable is LnCPI

Regressors	Coefficient	Standard Error	T-Ratio (Prob)
LnM2	0.42101	0.039997	10.5262[.000]
LnGDP	-0.48674	0.10020	-4.8578[.000]
LnIPI	0.55895	0.041629	13.4269[.000]
Intercept	3.4752	1.0166	3.4183[.001]

The estimates show that prices are directly related to liquidity (M_2), real *GDP* and the price of imported goods (*IPI*) and the coefficients of all the regressors have expected signs and are statistically significant. In addition, the long run estimated coefficients in ARDL approach the point of view of size element with the Johansen approach, is symmetrical. The long run coefficients of prices equation in current paper with the multivariate and univariate cointegration tests are presented in Table 7.

Table 7: Long run coefficients of prices equation with three approaches

Approaches	LnM2	LnGDP	lnIPI
Johansen	0.53	-0.74	0.45
ARDL	0.42	-0.48	0.55

Now, with the acceptance of long run coefficients of prices equation, we can estimate short run coefficients. Arising from this is the need to develop an error correction model (*ECM*). An error correction model has two important parts. First, estimated short run coefficients and second, error correction term (*ECT*) that provides the feedback or the speed of adjustment whereby short run dynamics converge to the long run equilibrium path in model. Microfit (4.0) provides estimates of the error correction model implied by the selected ARDL model. The results are presented in Table 8.

Table 8: Error correction representation for ARDL model
Dependent variable is ∆LnCPI-Preferred specification

Regressors	Coefficient	Standard Error	T-Ratio [Prob]
∆LnM2	0.13387	0.024029	5.5505[.000]
∆LnGDP	-0.15419	0.044727	-3.4475[.001]
∆LnIPI	0.41998	0.053925	7.7883[.000]
∆ Intercept	1.1009	0.140733	2.7028[.010]
ECT(-1)	-0.31679	0.060538	-5.2329[.000]
R-Squared	0.85128	R-Bar-Squared	0.83221
S.E. of Regression	0.035138	F-stat. F(4, 40)	55.8098[.000]
Mean of Dependent Variable	0.13621	S.D. of Dependent Variable	0.085783
Residual Sum of Squares	0.048153	Equation log-likelihood	90.0483
Akaike Info. Criterion	84.0483	Schwarz Bayesian Criterion	78.6283
DW-statistic	1.8394		

Estimates show that the coefficients of all the regressors have the hypothesized signs and are statistically significant at the 5 % level. The results of error correction model show that the coefficient of M_2 (0.13), *GDP* (-0.15) and *IPI* (0.41) are less than it in long run. The coefficient of the error correction term (*ECT*) is equal to -0.31. According to this estimation, speed of adjustment is slow. In addition, error correction model only can explain 85 percent of fluctuation of prices.

5. CONCLUSION

The purpose of this paper was to determine the factors that explain and help forecast inflation in Iran in long run and short run. In this study, an attempt has been made to estimate the model with the multivariate and univariate cointegration tests.

First, quantitative evidence indicated that import prices, liquidity (M_2) and real *GDP* impact on inflation in Iran during the period under investigation in long run and short run. Our analyses showed that the long run coefficients of model in Johansen and ARDL approaches for cointegration tests are very similar together. The results support other studies in Iran, such as Bahmani-Oskooee (1995) and Tavakkoli and Karimi (1999).

Second, we estimated short-run coefficients and Error Correction Term (*ECT*) that provides the feedback or the speed of adjustment whereby short-run dynamics converge to the long-run equilibrium path in model. The results of this study indicate that liquidity (M_2), *GDP* and the price of imported goods do have significant impact on the prices in short run, but less than in long run and speed of adjustment is slow.

Finally, it is clear that the Iranian economy heavily controls by government. On the other hand, government has most roles in the management of the Iran's macro-economic variables such as volume of liquidity. Our major findings show that to control or decrease the inflation rate in Iran, government needs to control the high growth rate of liquidity. To reduce inflation through monetary policy, at first, it is necessary that government cut size of budget deficit. In addition, the authorities must manage the total private sector liquidity (M_2) to economic growth and reconsideration to converse the oil revenue into domestic currency. Moreover, estimated coefficients of model showed that negative but large coefficient of *GDP* indicates that an increase in real domestic production should reduce the price level. According to the empirical results of this study import price is another determinant of inflation rate in Iran.

It was shown that an increase in import price causes an increase in domestic inflation. Generally, depreciation of exchange rate can effect on the domestic prices in direct and indirect channels. In direct channel, a depreciation of domestic currency causes imported inputs and imports of finished goods become more expensive. Then, production costs rise and leads to a rise in domestic prices. In indirect channel, a depreciation of domestic currency causes demand for exports rises, and then demand for labor will increase. This increase in demand for labor will cause wages to rise, and finally, domestic prices rise. Therefore, since anti-inflationary policy requires an increase in the value of the domestic currency, Central Bank of Iran should manage the exchange rate markets to design an anti-inflationary policy through time.

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