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Re-investigation of the long run relationship between money growth and inflation in Iran: An application of Bounds test approach to cointegration

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Abstract-**This paper re-investigates the long-run relationship between money growth and inflation, for the period of 1989-2007 by using quarterly data of the Iranian economy. As standard unit root tests, such as Augmented Dickey Fuller (ADF) and Philips and Perron (PP) tests, are biased towards the null of a unit root in presence of structural breaks, we use Lee and Strazicich (2003) test to address this issue and test the null of unit roots. The result reveals that the variables under consideration are not in the same order of integration. Therefore to investigate the long-run relationship between variables under consideration, this paper applies the bounds test approach to cointegration. This method was developed by Pesaran et al. (2001) and can be applied irrespective of the order of integration of the variables. The results reveal that there is a long run relation among these variables and in the long run 1 percent increase in money growth cause to increase 72 percent in inflation rate, which means money is the most important variable that effect inflation in long run. Moreover we find that inflation was largely a monetary phenomenon, supporting quantity theory of money.**

Keywords-component: Money, Inflation, Bounds test, Iran

JEL classification: E3; E4; E5

I. INTRODUCTION

Iranian Central Banks̉ governor announced that the annual inflation rate has dropped below ten percent on June 2010. In fact, the sharp decline in the oil price and rising inflation led the authorities to tighten fiscal and monetary policies in the second half of 2008/09 to this important achievement. Over the last 3 decades, however, the Iranian economy has experienced relatively high inflation with average 19.12 percent which has been generally associated with rapid persistent money growth (22.71 and 24.88 percent for $M1$ and $M2$, respectively). In 1979-80, inflation increased significantly following the 1979 Islamic revolution

But the acceleration in money growth was almost negligible (from 19.54 percent to 22.48 percent). As Bonato (2007) explains, after the relatively sharp increase in the mid 1990s, inflation declined up until the first quarter of 2006-2007, and then increased till 2008.

This decline, however, did not reflect an improvement in monetary control, as both $M1$ and $M2$ continued to grow rapidly. This a vacuum of study and raising questions about the relationship between money growth and inflation in Iran. The relationship between money and inflation in Iran has been investigated by a number of researchers. While, Dadkhah, 1985; Kazeroni and Asghari, 2002; Parsa, 2006; Komeijani, 2006 Bonato, 2007; Hosseini, 2008 and Safaee, et.al, 2009; show that monetary factors play dominant role in the long run inflation and Bahmani Osskoee, 1995; Nasr Esfahani and Yavari, 2003; Tagavi and Nakhjavani, 2003 and Darrat, 1987 show that other factor such as imports, government expenditure and etc. also effect inflation.

This paper re-investigate the relationship between money growth and inflation in the Quantity theory of money (QTM here after) framework. By investigating the linkage between money growth and inflation in Iran, we are going to test the validity of monetarist’s stance that inflation is a monetary phenomenon.

The paper differs from others in the following ways: 1) As standard unit root tests, such as Augmented Dickey Fuller (ADF) and Philips and Perron (PP) tests are biased towards the null of a unit root in the presence of structural breaks, we use Perron (1990) and Lee and Strazicich (2003) tests to address this issue and test the null of unit root in the series. 2) Since existence of structural breaks may cause the series to be integration of different orders, so to investigate a long-run relation between variables under consideration, this paper applies the bounds test for cointegration within the Autoregressive Distributed Lag (ARDL) modeling approach. This method was developed by Pesaran et al. (2001) and can be applied irrespective of whether the underlying regressors are I(1) or I(0) or fractionally integrated.

The paper proceeds as follows: Section II Provides a theoretical background for the intertemporal approach to the long run relationship between money and inflation determination. In section III the data are investigated. Section IV presents the econometric methodology of the study. Section V contains the results and discussions and finally, section VI concludes that paper.

II. THEORETICAL BACKGROUND

A cording to Quantity theory of money, inflation is always and everywhere a monetary phenomenon, produced in the first instance by an unduly rapid growth in the quantity of money "(Milton Friedman 1968, p.18). Friedman's assertion is not that an increased money growth rate is the sole cause of inflation in the long run, just the most important cause "(Friedman 1980). The QTM assumes that the changes in income arise due to the changes in prices and output is always at its permanent level. Therefore, the price level is determined by the money supply via the operation of real balance effect .The simplest form of the QTM, which also known as the Cambridge equation is as follows:

$$MV = PY \tag{1}$$

This equation states that there is a relationship between money supply (M), velocity of money (V), prices (P) and real income (Y) .
The equation (1) can be written into price equation as follows:

$$P = \frac{MV}{Y} \tag{2}$$

By taking log from both side of this equation, we can get

$$Log\,P = log\,M + log\,V - log\,Y \tag{3}$$

By differentiation of equation (3) we can get the equation for inflation such as

$$\frac{1}{p}.\frac{dp}{dt} = \frac{1}{m}.\frac{dm}{dt} + \frac{1}{v}.\frac{dv}{dt} - \frac{1}{y}\frac{dy}{dt} \tag{4}$$

Or

$$gp = gm + gv - gy \tag{5}$$

In the equation (5) gp is inflation, gm indicates money growth, gv and gy indicate growth in the income velocity of money and output growth respectively, Laidler (1997) in a simple version of QTM, assumes that the real income growth at the long-run rate and the velocity of money remains constant. Therefore the velocity and income grow slowly and this behaviour is independent of the behaviour of money supply or prices .Regardless, the empirical evidence from Iran shows that the income velocity of money is not constant and the real income growth deviates from potential level of real income growth. (Shakeri, 2000)

III. DATA

This paper uses quarterly data of the Iranian economy covering the period of 1989:q1-2007:q4. All data are obtained from Central Bank of Iran. We use consumer price index (CPI), Gross Domestic Product (GDP) and money stock (money plus quasi money) for the Iranian economy as proxies for the price level, output, and money, respectively. All data are seasonally adjusted except for money. Inflation is measured by the following equation:
$\text{inflation} = ((\text{cpi} - \text{cpi}(-4))/\text{cpi}(-4)) * 100).$

We have used the same approach to calculate money growth from money, growth of the income velocity of money (v) and output growth from GDP. Result shows the ADF, PP and NP tests with null hypothesis of unit root, reveal that inflation, and money growth are non-stationary at their levels, but stationary at their first differences. However, output growth and growth in the income velocity of money are stationary at their levels. As Iranian economy has been subject to numerous shocks and regime shifts, ignoring the effects of any possible structural break can lead us to spurious unit root test results. To determine possible breaks in the data, we apply the endogenously determined multiple break test developed by Bai and Perron (1998, 2003). The result of Bai and Perron's $Dmax$ and $\text{supF}_\text{T}(\ell + 1|\ell)$ tests as well as Andrews (1993) $\text{SupF}_\text{T}(\text{m})$ test, reveal that there is at least one break in the variables under consideration. This result is strongly supported by CUSUM, CUSUM of Square and Chow tests. To carry out unit root test with presence of any structural break, we use Perron (1990), Lee and Strazicich (2003) tests. Perron (1990) suggests a modified DF unit root test that includes dummy variable to account for one known break. Lee and Strazicich(2003) extended Lumsdaine and Papell(1997) endogenous two break unit root test, and introduced a new procedure to capture two unknown structural breaks. The results of perron (1990) test indicates that in the presence of structural break, money, output growth and growth in the income velocity of money has unit root and there are integrated of order one I(1), but inflation is stationary. The result of Lee and Strazicich (2003) test, however reveals that, we can't reject the null hypothesis of unit root for inflation, output growth, while we reject the null hypothesis for money growth and growth in the income velocity of money.

IV. ECONOMETRIC METHODOLOGY

To investigate a long run relationship between inflation and money growth, the bounds test for cointegration within ARDL (the autoregressive distributed lag) modeling approach was mainly adopted in this study. This method has definite advantages in comparison to other cointegration procedures. First, all other techniques require that the variables in the model are integrated of the same order, whereas the approach developed by Pesaran et al.(2001) could be employed regardless of whether the underlying variables are I(0), I(1) or fractionally integrated. Secondly, it can be used in small sample sizes, whereas the Engle–Granger and the Johansen procedures are not reliable for relatively small samples. The ARDL modeling approach involves estimating the following error correction models:

$$\Delta \ln Y_t = a_{0y} + \sum_{i=1}^{n} b_{iy}\,\Delta \ln Y_{t-i} + \sum_{i=1}^{n} c_{iy}\,\Delta \ln X_{t-i} + \sum_{i=1}^{n} d_{iy}\,\Delta \ln Z_{t-i} + \sigma_{1y}\ln Y_{t-1} + \sigma_{2y}\ln X_{t-1} + \sigma_{3y}\ln Z_{t-1} + \varepsilon_{1t} \tag{6}$$

$$\Delta \ln X_t = a_{0x} + \sum_{i=1}^{n} b_{ix}\, \Delta \ln X_{t-i} + \sum_{i=1}^{n} c_{ix}\, \Delta \ln Y_{t-i} + \sum_{i=1}^{n} d_{ix}\, \Delta \ln Z_{t-i} + \omega_{1x} \ln X_{t-1} + \omega_{2x} \ln Y_{t-1} + \omega_{3x} \ln Z_{t-1} + \varepsilon_{2t} \quad (7)$$

Where Δ is the difference operator, $\ln Y_t$ is the natural log of the dependent variable, $\ln X_t$ and $\ln z_t$ are the natural logs of the independent variables and ε_{1t} and ε_{2t} are serially independent random errors with mean zero and finite covariance matrix.

V. Results and Discussions

Now having the fact that the variables under consideration are not in the same order of integration, a long –run equilibrium relationship will be investigated by using the bounds test for cointegration within ARDL modeling approach.

Table(1) gives results of the bounds test for cointegration between inflation and money growth for Iran under three different scenarios as suggested by Pesaran et al.(2001:pp.295-96), that are F_{IV} ,F_V and F_{III} Critical values for F and t statistics are presented in Table (2) as taken from Narayan (2005) to be used in this study. Results in Table (1) suggest that the existence of a level relationship (a long-run relationship) between money growth and Inflation. The optimal ARDLs order determined by AIC and SBC criterions. ARDL (4,0,0), model is presented as below :

$$\begin{aligned} \mathrm{Inf} = {} & 1.929539 + 0.770182\,\mathrm{inf}(-1) + 0.132787\,\mathrm{inf}(-2) \\ & + 0.194541\,\mathrm{inf}(-3) - 0.471950\,\mathrm{inf}(-4) \\ & - 0.064501\mathrm{growth} + 0.059516\mathrm{RV} \\ & + 0.271219\,\mathrm{RM} - 3.327946\,\mathrm{Du78q2} \end{aligned}$$

The intercept was found to be insignificant, and it was dropped from the model. Result shows The long-run static solution of the estimated ARDL (4, 0,0) model. In the long run estimates have the expected signs, but output growth and growth in the income velocity of money are insignificant in the 1, 5 and 10 percent levels. The main result of this paper is that, RM (money growth), has a positive and significant effect on inflation in long run in Iran. And money is the most important variable that effect inflation. In long run coefficient of money growth very close to one and because of different is that price controls in market in recent years. In the ECM model, second and third lags of inflation with positive sign are statistically significant. This shows that the previous period growth in inflation brings positive changes in the Inflation rate over the short-run. This implies that Inflation decisions are based on previous behavior. The changes in the RV have positive and significant effect on inflation, over the short-run, as its coefficient is (0.074). The estimated coefficient of changes in the RM is 0.33337 and has a positive and significant effect on inflation rate. The Error Correction term, is statistically significant at the, 5 and 10 per cent level, with theoretically correct signs. The estimated coefficient of $\mathrm{ecm}(-1)$ indicates that 36 percent of the disequilibrium in the inflation is corrected immediately, in the next season. The short-run coefficient of RM is estimated (0.34), less than the long-run coefficient (0.724), therefor long run effected is strong. In the short run dummy variables have negative effect on inflation. The result of Granger Causality test shows that, there is a unilateral relationship between growth with RV and RM with inflation with and without deterministic trend. The sign of the Error Correction term for inflation and money is negative and significant at the 10% and 5% level. There for money Granger causes inflation. The findings of this paper are in accordance with the results of Bonato, 2007; Hosseini, 2008 and Komeijani, 2006. In the end we do diagnostic tests, which includes testing for serial correlation, heteroscedasticity, miss-specification of functional form and normality of the residuals, these tests include Breusch-Godfrey serial correlation test, ARCH heteroskedasticity test and CUSUM and CUSUM of Squares stability tests. These tests indicate that there aren't any serial correlation, heteroskedasticity and structural instability in the residual of the inflation function.

VI. Conclusion

This paper attempts to re-investigate the causal relationship between inflation and money growth for the Iranian economy, by employing, the bounds test approach to cointegration, in the Quantity theory of money. The bounds test results reveal that a long-run cointegration relationship exist between Money growth and inflation. Moreover our results show stability relationship between two variables and in the long run 1 percent increase in money growth cause to increase 72 percent in inflation in Iran, which means money is the most important variable that effect inflation in long run. By review this relationship, we can be attributed apparent dissociation in related to inflation and money in recent years, factors such as decrease in income velocity of money because of decrease in inflation expectations, in the third development plan and improvement in oil prices in world oil markets.

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Figures and Tables

TABLE1. Bounds test for cointegration

Variables	**with deterministic trend**			**ithout deterministic trend**	
Finf(inf|gm,gy ,gv,du78q2)	F_{IV}	F_V	t_V	F_{III}	t_{III}
	9.25021*	11.56228*	-6.740912	11.7893*	-6.806762

Notes:Akaike Information Criterion (AIC) and Schwartz Criteria (SC) were used to select the number of lags required in the cointegration test. F_{IV} represents the F statistic of the model with unrestricted intercept and restricted trend.F_v represents the F statistic of the model with unrestricted intercept and trend,and F_{III} represents the F statistic of the model with unrestricted intercept and no trend .

Note: H_0: No existences long run. * indicates that the statistic falls outside the upper bound at all levels.

TABLE2. F- statistic critical values for Bound test

K=3	**10%**		**5%**		**1%**	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
$\mathbf{F_{IV}}$	3.11	3.90	3.624	4.488	4.808	5.786
$\mathbf{F_V}$	3.618	4.630	4.253	5.333	5.698	6.970
$\mathbf{F_{III}}$	2.838	3.898	3.408	4.55	4.725	6.08

Critical values are from Narayan (2005). Note: k is the number of regressores for dependent variable in ARDL model, FIV, represents the F statistic of the model with unrestricted intercept and restricted trend, FV, represents the F statistic of the model with unrestricted intercept and trend, and FIII, and represents the F statistic of the model with unrestricted intercept and no trend. The lag length (p) for this test is based on Schwarz-Bayessian (SBC) and Akike information criteria (AIC).the best choice of lag order is four