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REVISITING THE LONG-RUN RELATIONSHIPS BETWEEN MONEY GROWTH, INFLATION AND OUTPUT GROWTH IN IRAN: BOUNDS TEST APPROACH

This paper investigates the long-run relationship between money growth, inflation, and output growth for the period of 1988-2007 by using quarterly data of the Iranian economy. We use Perron (1990), and Lee and Strazicich (2003) tests to address this issue and test the null of unit roots. The results show that the variables under consideration are not in the same order of integration. Therefore, to investigate the long-run relationship between the variables, this paper applies the bounds test approach to level relationship. This method can be applied irrespective of order of integration of variables. The results reveal that there is a long-run relation between these variables. Moreover, we find that inflation is largely a monetary phenomenon, supporting the quantity theory of money. Our results also show that output in the long run has more affect on money demand.

Keywords: *money demand; bounds test; inflation; growth; Iran.*

JEL classification: C32; C41; C52.

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ПЕРЕГЛЯД ДОВГОТРИВАЛОГО ЗВ'ЯЗКУ МІЖ ЗРОСТАННЯМ ГРОШОВОЇ МАСИ, ІНФЛЯЦІЄЮ ТА РОСТОМ ВИРОБНИЦТВА В ІРАНІ: МЕТОД ГРАНИЧНИХ ЗНАЧЕНЬ

У статті досліджено довготривалий зв'язок між зростанням грошової маси, інфляцією та ростом виробництва для періоду 1988-2007 рр. за квартальними даними економіки Ірану. Для аналізу даних використано тести Перрона (1990) та Лі та Стразісіча (2003). За результатами тестування, досліджені змінні інтегруються не в тому порядку. Тому для дослідження довготривалого зв'язку між цими змінними використано метод граничних значень. Результати його застосування підтверджують існування довготривалого зв'язку між змінними, що досліджуються. Результати також підтримують кількісну теорію грошей та представлення інфляції як в першу чергу монетарного явища. Результати також вказують, що у довготривалій перспективі виробництво суттєво впливає на грошовий попит.

Ключові слова: *грошовий попит; метод граничних значень, інфляція; рост; Іран.*

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ПЕРЕСМОТР ДОЛГОСРОЧНОЙ СВЯЗИ МЕЖДУ РОСТОМ ДЕНЕЖНОЙ МАССЫ, ИНФЛЯЦИЕЙ И РОСТОМ ПРОИЗВОДСТВА В ИРАНЕ: МЕТОД ГРАНИЧНЫХ ЗНАЧЕНИЙ

В статье исследована долговременная связь между ростом денежной массы, инфляцией и ростом производства для периода 1988-2007 гг. по квартальным данным экономики Ирана. Для анализа данных использованы тесты Перрона (1990) и Ли и Стразисича (2003). По результатам тестирования, рассматриваемые переменные

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интегрируются не в том порядке. Поэтому для исследования долгосрочной связи между данными переменными применен метод граничных значений. Результаты его применения подтверждают существование долгосрочной связи между исследуемыми переменными. Результаты также поддерживают количественную теорию денег и представление инфляции как преимущественно монетарного явления. Результаты также указывают, что в долговременной перспективе производство существенно влияет на денежный спрос.

Ключевые слова: *денежный спрос; метод граничных значений; инфляция; рост; Иран.*

I. Introduction. Iranian economy has experienced many booms and recessions, inflations, stagflations, and different periods of high and low economic growth since 1970. We have been experiencing the double-digit inflation rates 4 more than four decades. In fact, after a decade of very low inflation rate in the 1960s, inflation rate began to increase in the 1970s. It increased from nearly zero in 1970 to about 26% in 1978. In 1979-80 inflation increased significantly following the 1979 Islamic revolution, but the acceleration in money growth was almost negligible (from 19.54% to 22.48%). After a short period of low inflation rates at the beginning of 1990s, inflation rate went out of control in 1994-1995 (it increased from 9% in 1990 to 50% in 1995). Although the Iranian government officially estimated for consumer price inflation to be 11.7% in 2006, the International Monetary Fund estimated that inflation reached 17.2% in 2007 and 20% in 2008. Following the sharp increase in Iranian oil incomes, the government began ambitious development programs by injecting oil incomes into the economy. At the same time, with the growth in the monetary base, banks loans increased at very high rates.

After Islamic revolution, almost all large scale businesses and industries were nationalized and became public (or quasi-public). The imposed war began in 1980. In this period, oil incomes decreased and government budget deficit increased rapidly. Although the banking system loans to private sector were reduced substantially, the growth rate of liquidity increased as the result of budget deficit. The combined effect of large budget deficits and the increased government intervention into the economy with damaging effects on efficiency was high rates of inflation and low rates of economic growth and even negative economic growth.

The relationship between money and inflation in Iran has been investigated by a number of researchers. Dadkhah (1985), Kazeroni and Asghari (2002), Parsa (2006), Bonato (2007), and Safaee et. al., (2009) show that monetary factors play dominant role in the long-run inflation; Darrat (1987), Bahmani Oskoee (1995), Nasr Esfahani and Yavari (2003), Tagavi and Nakhjavani (2003) show that other factors such as import, government expenditure etc. also affect inflation.

Theoretical studies results show that we cannot come to a single conclusion on the relation between inflation and economic growth. For example, Campos (1961), Bhagwati (1978), and Golizade (2007) state there is a negative relation between inflation and economic growth, while other theoretical studies show a positive relation between them (Felix, 1961; Bear, 1967 among others).

Within the relation between money and economic growth, money causes the economic sectors' mobility and leads to economic growth. Some studies (Hafer and Kutan, 1997; Kharti-Chhetri et al., 1990; Komyjani, 2006; and Heidari and Johari Salmasi, 2010) show the long-run relationship between money and economic growth.

In other words, these studies reject the rational expectation hypothesis, based on neutrality of monetary policy, while other studies such as Cooly and Hansen (1997) and Khachaturian (1999) accept the rational expectation hypothesis.

To the best of our knowledge, there isn't any empirical study on assessing the relationship between inflation, economic growth and their respective uncertainties in the case of Iran. However, this relationship in other countries' data has mixed nature; there isn't any empirical study assessing the relationship between money growth, inflation and economic growth on the Iranian data. However, this relationship with other countries' data has been mixed (see, e.g., Ramachandran, 2004; and Budina, 2006; among others). With regards to ambiguity in the results, we perform an empirical investigation of the long-run relationship between money growth, inflation and output growth in Iran applying a bounds test approach to level relationship in the Cagan (1956) money demand model. This method was developed by Pesaran et al. (2001) and can be applied irrespective of whether the underlying repressors are I(1) or I(0) or fractionally integrated. The paper uses the quarterly data (1988q1-2007q4) to conduct an indepth analysis of the lagged effects for the variables under consideration.

The paper proceeds as follows: Section II provides a theoretical background. In Section III the data is investigated, and in section IV the empirical results are presented. Finally, section V concludes the paper.

II. Theoretical background. This paper utilizes a modified version of Cagan's (1956) model. Cagan assumes that during the periods of hyperinflation, the demand for money is almost wholly explained by the expected rate of change in prices and that change in expected inflation have the same effect on real balances without attention to initial money balances. Cagan's model is on the initial work in the practical empirical analysis of hyperinflations, and in fact is the extension of Friedman's (1956) function. Cagan's money demand function can be represented as follows:

$$\log\left(\frac{m_t}{p_t}\right) = \alpha_0 + \alpha_1 \log y_t + \alpha_2 R_t + u_t \qquad (1)$$

where $m_t = logM_t$ is the money stock, $p_t = logP_t$ is the price level, y_t is real income, $R_t = r_t + \pi^e_t$ is the nominal interest rate, π^e_t is the expected inflation rate, and u_t is white noise money demand innovation term (see Serletis, 2007).

Kivilcim and Ilker (1999) and Christev (2005) use an augmented Cagan's model and estimate the Cagan's model with the additional assumption of rational expectations:

$$(m-p)_t = -\alpha \Delta p^e_{t+1} + \psi_t \qquad (2)$$

where Δ, Δp^e_t+1 and ψ are the difference operator, the subjective anticipation formed in period t of the period $t+l$ rate of inflation, and the stochastic disturbance term, respectively.

Aarle and Budina (1996) show that the standard way to allow for the influence of currency substitution on money demand is to add depreciation expectations to real money demand. They use the expected rate of exchange rate depreciation to measure the effect of currency substitution on money demand:

$$\frac{m_t}{p_t} = ce^{-(\beta\pi^e + \gamma e^e)} \qquad (3)$$

where π^e is the expected rate of inflation and e^e is the expected rate of depreciation. In this paper, however, we follow Aarle and Budina (1996), Choudhry (1998), Budina et al., (2006) among others in basing our analysis of money demand in a simple form. In fact the model we use is an extended Cagan's model:

$$m\text{-}p = \beta_0 + \beta_1(p^e - p_{-1}) + \beta_2 y \quad (4)$$

where p^e is the expected inflation rate. As exchange rate was controlled by the Iranian government before 1993, and it is managing float after 1994, exchange rate does not have sufficiently independent variation to be an additional determinant of the long-run real demand for money (see, e.g., Budina et al., 2006).

III. Data and its property

A. Data: This paper uses quarterly data of the Iranian economy covering the period of 1988: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:

$$\text{inflation} = \left(\frac{cpi - cpi(-4)}{cpi(-4)} \right) \times 100$$

Real output growth (hereafter growth) is measured by the difference in the log of the real GDP. We have used the same approach to calculate money growth from money. Summary statistics for the series are given in Table 1.

Table 1. **Summary statistic for variables, 1988q1 – 2007q4**

series	inflation	money	growth
Mean	19.98260	7.037416	5.62
Maximum	55.47445	8.202664	22.43817
Minimum	2.505695	6.896168	-7.814674
Std.deviation	9.609431	0.380159	5.243863
Skewness	1.758927	1.064234	0.345901
Kurtosis	6.556450	2.865872	4.196139
Jarque-Bera stat.	79.241148	15.16123	0.046233
probability	0.0000	0.00051	0.048649

B. Standard Unit root tests: In order to determine stationarity properties of the series, we apply 4 different methods in the first step: Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), Kwiatkowski et.al (KPSS), and Ng-Perron (NP) tests. These tests with null hypothesis of unit root reveal that inflation, money and growth are non-stationary at their levels, but stationary at their first differences. However, with KPSS test[4], we cannot reject the null hypothesis of I(0) at 5% level of significance for inflation and growth.

C. Structural break tests for the data: As Iranian economy has been subject to numerous shocks and regime shifts, ignoring the effects of any possible structural breaks can lead us to spurious unit root test results (see, e.g., Perron, 1990). To investigate and determine any possible breaks in our data, we apply the endogenously

[4] It is important to note that the KPSS test statistic is robust to general specification of the error process.

determined multiple break test developed and applied by Bai and Perron (1998 and 2003). By considering maximum 5 possible endogenous break points, Bai and Perron's D_{max} and $supF_T(l+1/l)$ tests as well as Andrews (1993) $SupF_T(m)$ test[5] reveal that there is at least one break in all the series, though some tests show more than one break. These results are strongly supported by CUSUM, and Chow break point tests.

D. Unit root test with presence of structural breaks. In order to decrease uncertainty of the results reported in Table (2) we continue our investigation by applying some unit root tests with presence of possible structural breaks. Perron (1990), and Perron and Vogelsang (1992) suggest a modified Dickey-Fuller unit root test that includes dummy variables to account for one known break. These kind of structural break tests have experienced two major drawbacks: The break occurs once, and has to be exogenous. Subsequent papers such as Lumsdaine and Papell (1997) modified the test to allow for more than one unknown break point. However, one important problem with this test is that it assumes no breaks under the unit root null, and thus, rejection of the null does not necessarily imply rejection of a unit root, but would imply rejection of a unit root without breaks. Lee and Strazicich (2003) extended Lumsdaine and Papell (1997) endogenous two break unit root test, and introduced a new procedure. They proposed two break minimum Lagrange Multiplier (LM) unit root test in which the alternative hypothesis unambiguously implies trend stationarity (see, e.g., Heidari and Hashemi Pour Valadi, 2011).

Tables 2 and 3 present result of Perron (1990) and Lee and Strazicich (2003) unit root tests, respectively. The results in Table 2 indicate that in the presence of one structural break, money and output are integrated of order one, but inflation is stationary.

Table 2. **Results of Perron's unit root test**

Series	Model	Break point	Dummy variable	Test statistic	Critical value (5%)	Result
Inflation	(1)	1995q4	Du74q4,D(TB)74q4	11.018	-3.72	I(0)
Inflation	(2)	1995q4	Du74q4,DT74q4	11.887	-3.94	I(0)
Money	(1)	1993q2	Du72q2,D(TB)72q2	-2.53	-3.76	I(1)
Money	(2)	1993q2	Du72q2,DT72q2	-2.551	-3.87	I(1)
Growth	(1)	1998q3	Du77q3,D(TB)77q3	-3.083	-3.76	I(1)
Growth	(2)	1998q3	Du77q3,DT77q3	-3.709	-3.96	I(1)

Notes: Models (1) and (2) refer to the models specified in Perron (1990). The dummy variables are specified as follows: D (TB) 74q4,D (TB) 72q2 and D (TB) 77q3 are impulse dummy variables with zeros everywhere except for a one in 1995, 1993 and 1998. DU74q4, DU72q2 and DU77q3 are 1 from 1995, 1993 and 1998 onwards and 0 otherwise. DT74q4, DT72q2 and DT77q3 are 0 before 1995, 1993 and 1998 and t-TB otherwise. Critical values for the levels are provided by Perron (1997). Critical values for the first differences are from MacKinnon (1996). For the first differences only impulse dummy variables were included in the regression. Impulse dummy variables, that is those with no long-run effect, do not affect the distribution of the MacKinnon (1996) test statistics.

Table 3. **Lee and Strazicich two structural breaks unit root test**

Variable	TB1	TB2	K	t-statistic	Result
Output	1992q1	2000q4	0	-7.5084**	I(1)
Inflation	1993q2	1995q4	5	-7.5601**	I(1)
Money	1994q2	2000q4	4	-6.9861**	I(1)

Note: 1) The critical values at 1%, 5%, 10% are 5.823, -5.286and -4.989, respectively (Lee and Strazicich, 2003). 2) ** indicates that the corresponding null is rejected at the 1%, 5% and 10% levels of significance.

[5] A GAUSS code to carry out these tests can be downloaded freely from Perron's homepage at: http://econ.bu.edu/perron.

The results in Table 3 reveal that at the 1% level of significance, we cannot reject the null hypothesis of unit root for inflation, output and money. This test however has a major drawback: it considers only two endogenous structural breaks, while the results of structural breaks, including the number of breaks, are uncertain. In other words, even taking into account the breaks, the results of unit root tests with structural breaks are biased, so we cannot conclude that the series under consideration are in the same order of integration. Since most of cointegration tests such as Engel-Grenger, and Johansen and Joselius (1992) are confident when the series are in the same order of integration, these tests cannot be suitable for our study. Thus we use bounds test approach to level relationship developed by Pesaran et al. (2001), which can be applied irrespective of whether the underlying regressors are I(1) or I(0) or fractionally integrated. Thus, the bounds test approach to level relationship eliminates the uncertainty associated with the order of integration.

IV. Empirical results. In order to avoid uncertainty about the results of unit root tests, the bounds test approach to level relationship is applied to test for the existence of a long-run relationship between money, inflation and output. Table 5 presents the results of the bounds test under 3 different scenarios as suggested by Pesaran et al. (2001), which are with restricted deterministic trend (FIV), with unrestricted deterministic trend (FV), and without deterministic trend (FIII). Intercept in these scenarios are all unrestricted. Critical values for F-statistics are taken from Narayan (2005) and presented in Table 4. The lag length (for this test is based on Schwarz Bayessian Criterion (SBC) and Akaike Information Criterion (AIC). The best choice of lag length is 4.

Table 4. **F-statistic critical values for ARDL modeling approach:**

K=2	10%		5%		1%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F_{III}	3.26	4.247	3.940	5.043	5.407	6.783
F_{IV}	2.713	3.453	3.235	4.053	4.358	5.393
F_{V}	4.307	5.223	5.067	6.103	6.730	8.053

Note: Critical values are from Narayan (2005) 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 represents the F statistic of the model with unrestricted intercept and no trend.

As it can be seen from Table 5, the F-statistic values are higher than the upper bound at all levels with deterministic trend. It means that the null hypothesis of no long-run relationship among money, inflation and output can be rejected.

Table 5. **Bounds test for level relationship**

without deterministic trend		with deterministic trend			Variables
T_{III}	F_{III}	T_{V}	F_{V}	F_{IV}	F_{lmreal} (lmreal/inf, lgdp, du74q4, du77q3)
-1.932837	13.79532*	-2.726274	12.28946*	12.81400*	

Note: AIC and SBC are used to select the number of lags required in the cointegration test. FIV represents the F-statistics of the model with unrestricted intercept and restricted trend. FV Represents the F-statistics of the model with unrestricted intercept and trend, and FIII represents the F statistics of the model with unrestricted intercept and no trend. H0: No existences long run. * indicates that the statistic falls outside the upper bound at all levels.

Moreover, the estimation results of ARDL (4, 0, 0) model in Table 6 show that all of the coefficients are significant and have the expected signs. In the long run 1% increase in inflation causes 3% unit decrease in money demand. Also 1% increase in output makes 68% increase in money demand. In the long run dummy variables have negative effect on money demand. We may claim that output and inflation have significant effects on money demand in the long run, and output is the most important variable that affects money demand growth.

Table 6. **Estimation results of ARDL (4, 0, 0) model**

Variables	Coefficients	Standard Errors	T-Ratio	(Prob)
Inflation	-0.038447	0.012805	-3.0025	(0.004)
Output	0 .67427	0.022726	29.6690	(0.000)
T	0.031471	0.0061795	5.0928	(0.000)
DU74Q4	-0.65339	0.12887	-5.0703	(0.000)
DU77Q3	-0.36057	0.13678	-2.6361	(0.011)

The results of the short-run dynamic coefficient associated with the long run relationships obtained from ECM are given in Table 7.

Table 7. **ECM specification results for the ARDL (4, 0, 0):**

Prob.	t-Statistic	Std. error	Coefficient	Variable
0.0000	-6.009157	0.092948	-0.558538	Δmoney(-1)
0.0009	-3.474766	0.103221	-0.358667	Δmoney(-2)
0.0000	-6.323521	0.089484	-0.565854	Δmoney(-3)
0.0000	-7.330420	0.000909	-0.006663	Δinflation
0.005	2.8911	0.030920	0.089392	Δoutput
0.0138	-2.529013	0.032007	-0.080947	ΔDU74Q4
0.0395	-2.101053	0.028796	-0.060501	ΔDU77Q3
0.000	4.2808	0.9747E-3	0.0041723	ΔT
0.010	-2.6643	0.049759	-0.13258	ECMT(-1)

Adjusted R^2 = 0.635934, F-statistic = 17.15750 (0.000)

All lagged changes in the money demand coefficients are negative and statistically significant. This shows that the previous period growth in money demand brings negative changes in the money demand growth over the short-run. This implies that money demand decisions are based on previous behavior. The EC term is statistically significant at 5% level of significancy, with theoretically correct signs. The t-statistics of the coefficients of the lagged EC term indicate the significancy of the long-run causal effect, implying that the series are non-explosive and long-run equilibriums are attainable. The estimated coefficient of the EC term (-0.13258) indicates that nearly 13% of disequilibrium of the current seasons shock converges back to the long-run equilibrium within the next season.

The signs of the short-run coefficients are the same as those of the long-run parameters, and are theoretically correct according to Budina et al. (2006); Korap (2008) and Ramachandran (2004). All of the coefficients are statistically significant at 5% level. According to our results, the short-run coefficient of inflation is -0.0066, less than the long-run coefficient (-0.038447), and the short-run coefficient of the output is found to be 0.09, less than its long-run coefficient (0.67427). Therefore, output in the long-run has more effect on money demand, compared with short run.

The existence of the long-run relationship between money demand, inflation and output suggests that there must be Granger causality, at least in one direction. Table 8 presents the results of the short-run and long-run Granger causality within ECM framework.

Table 8. **Results of Granger causality tests**

ECT_{t-1}(t-statistic)	Money	Output	Inflation	y/x
Without Deterministic Trend				
-2.33958 (0.02239)	0.240723 (0.7868)	1.353497 (0.2655)	-	Inflation
0.27907 (0.78108)	0.318285 (0.7285)	-	0.132810 (0.8759)	Output
-3.13177 (0.00260)	-	0.370810 (0.6916)	2.653203 (0.0780)*	Money
With Deterministic Trend				
-2.44596 (0.01716)	0.287788 (0.7509)	1.081936 (0.3450)	-	Inflation
-0.10318 (0.91813)	0.233779 (0.7922)	-	0.141562 (0.8683)	Output
-3.17404 (0.00230)	-	0.565614 (0.5708)	2.679942 (0.0761)	Money

Figures in parenthesis are probability values.

Beginning with the short-run effect, both inflation and output are found to be statistically insignificant at 1, 5 and even 10% levels of significancy, implying that inflation does not have Granger causes output in the short-run. The results of Table 8 also reveal that inflation Granger causes money demand in the short run with and without trend. Turning to the long-run causality result, the coefficient of the lagged EC term is significant at 1% with expected sign. These findings are in line with the results of Budina et al. (2006), Korap (2008) and Ramachandran (2004).

We also did some diagnostic tests, which include tests for serial correlation, heteroscedasticity, miss-specification of functional form and normality of residuals. The results indicate that there are no any serial correlation, heteroskedasticity, miss-specification, and instability in the residual of the money demand function.

V. Conclusions. This paper reinvestigates the relationship between inflation, output growth and money growth for the Iranian economy by employing the bounds test approach to level relationship. As standard unit root tests are biased towards the null of unit root in presence of structural breaks, we use Perron (1990), and Lee and Strazicich (2003) tests to address this issue and test the null of unit roots. The result shows that the variables under consideration are not in the same order of integration. Our estimation results of the bounds test within the ARDL model show there is a long-run relationship between the variables under consideration. Moreover, the results reveal that inflation is largely a monetary phenomenon, supporting the quantity theory of money. Our results also show that output in the long run has more affect on money demand. In addition to the likely asymmetric effect, the fast speed of adjustment to equilibrium following a shock, as estimated by the error correction term, is an indication of quick recovery in money demand. Nearly 13% of disequilibrium of the current seasons shock converges back to the long-run equilibrium within the next season.

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