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RELATIONSHIP AMONG MONEY, INTEREST RATE, PRICES AND OUTPUT
Evidence from Pakistan

TAHIR MEHMOOD and MOHAMMAD FAROOQ ARBY*

Abstract. This paper estimates long-run and short-run relationships among key macroeconomic variables *viz.*, money, interest rate, output and prices in Pakistan. For this purpose Johansen and Juselius (1990) test of cointegration, and error correction models have been used. The test shows that there exists one cointegrating vector among the four variables. On the basis of error correction models, we found a unidirectional causality running from money to output. Money and prices have been found independent in the short run which may be a typical case with a developing country like Pakistan. The results also show a unidirectional causality from money to interest rate and no causality between output and interest rate. We construe from these findings that money supply is an appropriate intermediate target (with output growth being final target), not interest rate.

1. INTRODUCTION

This paper aims to estimate long-run and short-run relationships among key macroeconomic variables *viz.*, money, interest rate, output and prices in Pakistan. There has been a long debate on these relationships revolving mostly around Keynesian and Monetarists views on the role of money and behaviour of prices. The fantasy of ideas attracted a number of economists to examine the relationship empirically. Different authors came up with different results depending on the data and methodology they used. One of the pioneers in empirical testing of money output nexus, Sims (1972)

*The authors are Lecturer in Economics at Government College, Nankana Sahib, Punjab, Pakistan (E-mail: tahirmns@yahoo.com) and Officer at State Bank of Pakistan, Karachi, Pakistan (E-mail: farooq.arby@sbp.org.pk). Presently they are students of Ph.D. at Pakistan Institute of Development Economics (PIDE), Islamabad (Pakistan).

concluded on the basis of US post war data that money caused output. Brillembourg and Khan (1979) also found that money caused nominal income and prices in US Feige and Pearce (1974), on the other hand, argued for the post war period that prices are, to a great degree, independent of variations in monetary aggregates.[1] Lee and Li (1983) applied Granger causality test on Singapore data and found that money and income caused each other and money also caused prices without feedback. A similar result is obtained by Ibrahim (1998) for Malaysia. In case of India, Rangarajan and Arif (1990) found that changes in real output do not and inflation does response to money supply. Dutta and Gangadhar (2000) concluded that structural factors, in addition to monetary factors, play an important role in generating and sustaining the process of inflation and fluctuations in economic activity in India. In case of Pakistan also, a number of studies investigated the relationship, like Jones and Khilji (1988), Khan and Siddiqui (1990), Abbas (1991), Husain and Mahmood (1998), Husain and Abbas (2000), etc.[2] The present study is different to other studies on Pakistan in two respects: first we have used Johansen cointegration test which is superior to residual based tests of cointegration, and second we have included interest rate also in the set of macroeconomic variables in an expectation of its active role after financial liberalization. Theoretically there are two types of relationships between the four variables: (*i*) quantity theory of money according to which nominal money balances are proportional to nominal income, and (*ii*) money demand function, wherein real money balances (nominal money deflated by prices) is a function of income and interest rate. Thus in a study of macroeconomic relationships, it makes sense to include interest rate as a key variable, particularly when official control over it has been removed. Further, the use of VAR based cointegration test helps us by-passing the issue of exogeneity in estimating the equations between macroeconomic variables. The paper is organized as follows: the next section gives methodology, section III presents results and the last section concludes the paper.

II. METHODOLOGY

For testing the existence of long-run relationship we have used Johansen and Juselius (1990) test of cointegration, and for examining short-run causality

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[1] As quoted by Brillembourg and Khan (1979).

[2] See Table 2 for a review chart.

and dynamics error correction models have been used. The cointegration test requires that the series should have the same order of integration. The order of integration of a series is the number of differencing required for making a series stationary. We used Augmented Dickey Fuller (1979) test of unit root for determining the order of integration.[3] We have applied the following ADF test on the level form of each series:[4]

$$\Delta z_t = \alpha + \delta z_{t-1} + \pi \Delta z_{t-1} + \varepsilon_t \qquad (1)$$

z_t is any one of the money supply (m), prices (p), Interest rate (r), and output (y). Initially we started the test without using the lag dependent in (1) and applied Langrange Multiplier test on the residual for existence of serial correlation. The inclusion of first lag of the dependent variable removed serial correlation in the residual in case of test on level form. When the test was applied on first differences there was no need of augmenting it with any lag dependent. The null hypothesis of the test is:

H_0: $\delta = 0$ (if true, it implies z_t has one unit root)

τ statistic is used for testing significance of the null by comparing it with McKinnon (1991) values at 5% critical level.

After determining the order of integration of all the four series we applied test of cointegration. Cointegration is a statistical property that describes long-run behaviour of economic time series. Formally if A_t and B_t are two integrated processes of the same order d, they are called cointegrated if their linear combination $\varepsilon_t = \alpha A_t + \beta B_t$ is integrated of order d-b, where b is any integer such that $d \geq b \geq 1$. The long-run relationship will be stationary if $\varepsilon_t \sim I(0)$.

There are number of tests available for cointegration. We have used Johansen's test on our series of m, p, r, and y. A brief review of test procedure is given below (adopted from Ericsson, 1992; Johansen, 1992 and Johansen and Juselius, 1990).

Let X_t be a vector such that $X_t' = (y_t\ p_t\ r_t\ m_t)$. We considered the following VAR model:

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[3]The unit root testing is equivalent to testing the order of integration because a series have the same number of unit roots as the number of differencing required to make it stationary.

[4]In the exercise of unit root testing, we also included trend in the equation (1), but it did not make any difference to the implied order of integration.

$$X_t = \pi_1 X_{t-1} + \ldots + \pi_k X_{t-k} + \mu + \Phi D_t + \varepsilon_t \quad (2)$$

where $\varepsilon_t \sim \text{IIN}(0, \Omega_{4\times4})$. $D_t = 1$ for the years 1991-92 onward and 0 otherwise. D_t represents the financial reforms particularly introduction of auctioning of t-bills and allowing private sector to open banks in 1991-92 (see SBP 2002, Annex 2.1 for a matrix of reforms). We determined the appropriate value of k starting with $k = 1$ on the basis of minimum SIC value. With little manipulation of the above model, we get:

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{k} \Gamma_i \Delta X_{t-k} + \mu + \Phi D_t + \varepsilon_t \quad (3)$$

We have to investigate whether the coefficient matrix Π has information about long-run relationship among the four variables. There are three possible cases:

(*i*) Rank (Π) = 4, *i.e.* the matrix has full rank and the four variables are stationary

(*ii*) Rank (Π) = 0, *i.e.* the matrix is the null matrix

(*iii*) Rank (Π) = r and $0 < r < 4$

If the third possibility holds, then according to Granger representation theorem, there are matrices α and β (both having $4 \times r$) such that $\Pi = \alpha\beta' \cdot \beta'$ is a matrix of coefficients of the cointegrating vector and α is matrix of adjustment factors. β' has the property that linear combination $\beta' X_t$ is stationary. Thus the main hypothesis of Johansen's technique is that there are r cointegrating vectors, *i.e.*

$$H_0: \Pi = \alpha\beta'$$

The hypothesis is tested by the two likelihood statistics *viz.*, trace statistic and maximal eigenvalue statistic. The Johansen test proceeds step-by-step. The first hypothesis tested is:[5]

H_0: $r = 0$ against H_1: $r = 1$

If it is rejected then the following hypothesis is tested:

H_0: $r \leq 0$ against H_1: $r = 2$

The test procedure will stop when we fail to reject the null hypothesis.

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[5]The hypotheses are for likelihood ratio test based on eigenvalue statistic. If we use trace statistic then hypotheses are formulated in a slightly different way.

The cointegration test only reveals the existence or absence of any long-run relationship between the variables; it tells nothing about the direction of causality. For causality and dynamics of the relationship among the four variables we estimated the following error correction models:

$$\Delta Z_t = \alpha E_{t-1} + \sum_{k=1}^{i} \Gamma_k \Delta Z_{t-k} + \mu + \Phi D_t + v_t \qquad (4)$$

Z_t is one of the four variables *viz.*, m_t, p_t, y_t, or r_t. E_{t-1} is linear relationship estimated by cointegrating equation; other terms have the same interpretation as before. Causality is determined by applying redundancy test on lags of alternative variables in each of the four error correction models.

For money supply, we have used M2 definition, call money rate is used as a representative interest rate, consumer price index is used for prices, and real GDP at factor cost is taken as a measure of output. Annual data from 1973 to 2003 is taken from various issues of monthly Statistical Bulletin of the State Bank of Pakistan. All variables are used in log form.

III. RESULTS

The results of unit root test show that all the variables are integrated of order one as reported in Table 1.

TABLE 1

Augmented Dickey Fuller Test

	Lags	Coefficients	τ-statistic	McKinnon c.v. (5%)	LM-test (order 3)*	
					F-statistic	Prob
m	1	−0.0082	−1.08	−2.9627	0.48	0.70
Δm	0	−0.7179	−3.98	−2.9665	0.41	0.75
p	1	−0.0070	−0.79	−2.9665	0.13	0.94
Δp	0	−0.3964	−3.86	−2.9665	0.19	0.90
y	0	−0.0142	−2.16	−2.9627	0.09	0.97
Δy	0	−0.8057	−4.36	−2.9665	0.87	0.47
r	1	−0.2773	−1.58	−2.9665	0.63	0.60
Δr	0	−0.8701	−4.55	−2.9665	0.94	0.44

*We have ensured that there is no first to third order serial correlation in errors on the basis of LM test.

The test of Johansen's cointegration shows that the four variables are cointegrated and there is one cointegrating relationship among them. Table 2 shows the test results.

TABLE 2

Johansen's Cointegration Test

Eigenvalue	Likelihood Ratio	Critical Values		Hypothesized No. of Cointegrating Equations
		5%	1%	
0.7127	55.12	47.21	54.46	None
0.4523	20.19	29.68	35.65	At most 1
0.1060	3.34	15.41	20.04	At most 2
0.0071	0.20	3.76	6.65	At most 3

Note: 2 lags were used in VAR, at which Schwarz info criterion had minimum value (−12.1).

It is clear that the hypothesis of no cointegrating equation is rejected at 1% critical value. Since the hypothesis of at most one cointegrating equation is accepted, so there are no more than one cointegrating equations in the system. The test is undertaken in Eviews 3.1 which also reports un-normalized and normalized cointegrating coefficients. The cointegrating equation is normalized for y_t as below just to get some meanings from the coefficients.[5]

$$y_t = \underset{}{5.36} + \underset{(5.2)}{1.15}\, m_t + \underset{(0.6)}{0.05}\, r_t - \underset{(3.4)}{1.38}\, p_t + \varepsilon_t \qquad (5)$$

Although the equation cannot be interpreted as cause and effect sense, we can say that 1% growth in money supply is associated with a 1.15% growth in real GDP in the long-run. If we are willing to accept these parameters as elasticities, then the result shows that output is elastic to money supply or conversely money demand is less than unitary elastic to output (with elasticity equal to 0.88, *i.e.* inverse of 1.15). Similarly 1% inflation is association with 1.38% decline in real GDP, and in terms of elasticity output is highly responsive to inflation in the long-run. Since the

[5]In parentheses are t-statistics.

parameter of interest rate (r_t) is insignificant, it implies there is no long-run relationship between interest rate and real GDP.

In order to get causal relationship we estimated error correction models (ECM). The results of causality on the basis of ECM are given below.

TABLE 3

Causality among Macroeconomic Variables (ECM Based)

Hypothesis (H_0)	F-statistics	Probability
OUTPUT does not cause MONEY	0.34	0.72
MONEY does not cause OUTPUT	3.38	0.06
OUTPUT does not cause PRICES	0.23	0.80
PRICES does not cause OUTPUT	6.68	0.01
OUTPUT does not cause INTEREST RATE	0.86	0.44
INTEREST RATE does not cause OUTPUT	0.41	0.67
MONEY does not cause PRICES	0.33	0.72
PRICES does not cause MONEY	0.62	0.55
MONEY does not cause INTEREST RATE	2.04	0.16
INTEREST RATE does not cause MONEY	0.96	0.40
PRICES does not cause INTEREST RATE	1.78	0.20
INTEREST RATE does not cause PRICES	0.40	0.68

Note: All the variables are in first difference form thus representing growth rates.

With respect to money and output nexus, the results show that there is unidirectional causality from money growth to output growth. On the other hand, monetary expansion and inflation are independent to each other. Thus, although money plays a monetarist role in affecting output, it does not lead inflation; this may be a typical case of a developing country. GDP is affected also by inflation. If 80% confidence level is considered then the results show that money growth and inflation also cause interest rate to change. While expansion in money supply may affect interest rate, changes in interest rate do not affect money supply. No causality is found between GDP growth and changes in interest rate. Thus, the results suggest that appropriate intermediate target of money policy is money supply, not interest rate. Further output growth can be increased by increasing money supply without any adverse effect on inflation.

Our results do not support those obtained by previous studies. For a comparison of results on causality see Table 4. We are contented with our results, as these are in accordance to our understanding of Pakistan's economy. For example, in a developing country like Pakistan it is less likely that growth in monetary assets follows output growth; instead monetary

TABLE 4

Comparison of Results of Different Studies on Pakistan

Study	Sample and Data	Methodology	Results	Remarks
Mehmood and Arby (2004) *(this study)*	1973-2003 (A)	Johansen/ECM	M → Y P → Y M → R	
Husain and Kalhe (2000)	1949-99 (A)	Residual based/ Granger/ECM	Y → M M ↔ P	• Ignored separation of Bangladesh • Took nominal GNP and prices together in trivariate case
Husain and Mehmood (1998)	1981:7 – 1998:6 (M)	Residual based/ ECM	M → P	• Ignored reforms of 1990s • Ignored seasonality in data
Bayers (1993)	1961-86 (A)	Residual based/ Granger/ECM	M → P[a] M-/-Y Y-/-P	Ignored separation of Bangladesh
Abbas (1991)	1960-88 (A)	Granger causality	M ↔ Y	Ignored separation of Bangladesh
Khan and Siddiqui (1990)	1972:1 – 1981:4 (Q)	Sim's test for causality	Y → M M ↔ P[b]	• Sims method applied without considering seasonality in data • Time span could be extended in a study of 1990
Jones and Khilji (1988)	1973-85 (M)	Granger causality	M -/- P[c]	

→ = unidirectional causality
↔ = bi-directional causality
-/- = no causality

[a]In his ECM model, M does not appear in the equation of P, implying P is not caused by M.

[b]For M1 it is M → P.

[c]M → WPI, not CPI.

assets (as a proxy of financial development) lead growth in output.[7] Similarly on the relationship of money and prices we conjecture that in a developing country monetary expansion may not necessarily lead to inflation. Since a developing economy has unemployed resources and there exists a scope for output growth the increase in money supply would likely be transmitted into real sector of the economy instead of prices. On Pakistan, the first study on the subject was undertaken by Jones and Khilji (1988) who found the similar results as ours. However, the later studies came up with different results which themselves are contradictory. Some brief remarks on those studies are given in the last column of Table 4 that may shed some light on their contradictory results.

In order to see the dynamics of the relationship between the macroeconomic variables, we are reporting those coefficients of the error correction models that are significantly different from zero (t-statistics are thus not reported).

$$\Delta Y_t = 0.053 + 0.307\ \Delta P_{t-1} - 0.348\ \Delta P_{t-2} + 0.143\ \Delta M_{t-1} - 0.023\ D_t \quad (R^2 = 0.71)$$

$$\begin{aligned} \Delta P_t &= 0.018 - 0.268\ E_{t-1} + 0.464\ \Delta P_{t-1} && (R^2 = 0.71) \\ \Delta M_t &= 0.050 + 0.708\ E_{t-1} + 0.657\ \Delta M_{t-1} && (R^2 = 0.50) \\ \Delta R_t &= -0.732 - 0.555\ \Delta R_{t-2} && (R^2 = 0.44) \end{aligned} \qquad (6)$$

The following dynamics can be noted from the above mentioned equations:

1. 1% inflation in first year increases output growth by 0.31% in the second year but reduces it by 0.35% in the third year.
2. If money supply grows by 1% in a year, the GDP will grow by 0.15% in the next year.
3. The reforms of 1990s and onward have depressed GDP growth by 0.02 percent per year (as reflected by the coefficient of the dummy variables D_t).
4. Output and interest rate do not bear any adjustment mechanism to long-run equilibrium (insignificant coefficient of cointegrating

[7] Indeed this argument leads us to the debate on finance-growth nexus. We would not involve in this debate except that majority of studies on this subject support finance as a leader (see Levine, 2003, for a survey).

vector). Money supply also does not converge to equilibrium path if a shock occurs. It is inflation which has converging adjustment mechanism that in fact derives the system to equilibrium path in case of shocks.

5. Inflation follows a first order autoregressive process. 1% inflation in one year further increases prices by 0.5% in the next year.

6. Change in money supply also follows as autoregressive process.

The crux of the results is that nominal variables of money, prices and nominal interest rate follow an autoregressive process within this structure of the model,[8] while the real variable is affected by them.

IV. CONCLUSION

In this paper we have examined the long-run and short-run relationships among four key macroeconomic variables *viz.*, money, output, prices and interest rate. Using Johansen cointegration test, we found that there exists one cointegrating equation in the set of variables. We tested the existence and direction of causality on the basis of error correction models. The results show that growth in money causes output growth, and does not cause inflation. Interest rate is independent of the money, prices and even output. Further, financial liberalization of 1990s has caused no shift in the functions of key macroeconomic variables except a reduction in GDP growth by 0.02 percent per year. However, more advanced techniques are needed to investigate the impact of financial reforms on macroeconomic relationships, like testing of co-breaking.[9] A clear policy implication is that expansion in money supply helps real GDP growth without any adverse impact on inflation, or equivalently an attempt to control inflation through monetary contraction may lead to contraction in real economic activity instead of inflation.

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[8]Further investigation into the processes of money and inflation may reveal their other determinants, but this is outside the scope of this study.

[9]See for example Johansen *et al.* (2000), Hendry and Mizon (1998) and Massmann (2003) on techniques of test of co-breaking.

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