THE DEMAND FOR MONEY IN PAKISTAN: AN APPLICATION OF COINTEGRATION AND ERROR-CORRECTION MODELING

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1. Introduction

A stable money demand function is essential for the conduct of efficient and effective monetary policy because it helps policy-makers in ascertaining the liquidity needs of the economy. It is, therefore, important to have a firm knowledge of the factors that affect the demand for money and that there exist a stable and predictable long-run relationship between these factors and money stock. Keeping in view its importance, considerable effort has been made in estimating money demand functions in the literature.[1] This has been an intensive area of research in Pakistan as well.[2] The empirical research on the demand for money in Pakistan focussed mainly on the identification of key economic variables that determine such demand. Less attention has however, been devoted in testing the stability of the money demand function.

Only Khan (1980,1982a) and Ahmed and Khan (1990) have examined the stability of the function using the Chow test and varying parameter technique respectively. Khan (1980, 1982s) using the Chow test and covering a time period from 1959-60 to 1977-78 found the money demand function to be stable. On the other hand, Ahmed and Khan (1990) employing the varying parameter technique and covering a time period from 1959-60 to 1986-87 found the money demand function to be stable till 1980-81, but became unstable thereafter. This instability might have been caused by institutional changes in the banking sector, such as the introduction of partial interest free banking and the change in the exchange rate regime from fixed to managed floating during the early 1980s.

All these studies suffer from one major weaknees that is, they all have ignored the stationary properties of the time-series data and as such their findings may be treated with caution. It has been widely or rather universally accepted that most time-series data used in economic analysis are non-stationary in nature. A regression of one non-stationary series on another can give rise to the so-called spurious regression problem and lead to incorrect statistical inferences.[3]

The non-stationary problem can be resolved by first differencing the data, but in so doing, one may lose potentially interesting information about the long-run equilibrium relationship between economic variables.[4] However, recent advances in the area of time-series analysis have developed a new dynamic modeling approach, which is encapsu-

1. A detailed survey of the studies on money demand is well documented in Laidler (1993).
2. See Ahmad and Khan (1990) for an extensive bibliography.
3. Spurious regression is particularly likely when the adjusted R^2 exceeds the Durbin-Watson (DW) statistics. See Plosser and Schwert (1978) and Granger and Newbold (1974) for further details.
4. Non-stationarity poses problems when one attempts to estimate a functional relationship using conventional econometric techniques. Neither the mean nor the variance is a meaningful concept for non-stationary variables. In particular, the conventional t and F tests are inappropriate because, as shown by Fuller (1985) the limiting distribution of the asymptotic variance of the parameter estimates is not finitely defined.

lated in the cointegration and error correction models. The basic idea of cointegration is that if two or more variables are cointegrated then it confirms the existence of a long-run relationship between these variables and that it can be legitimately used in an error correction model.[5]

The purpose of this paper is to estimate the money demand function for Pakistan by employing cointegration and error correction models. It is argued that the changes in the financial environment alters the relationship between money, income, interest rate and prices and may create instability in the money demand function.[6] The beginning of the 1980s has witnessed many institutional changes in the financial structure in Pakistan. For example, a partial interest free banking system was introduced in 1981 and with effect from July 1, 1985 the system of interest bearing deposits of banks was fully replaced by a system based on Profit and Loss Sharing (PLS). In January 1982, Pakistan shifted from a fixed to managed floating exchange rate system and at the end of 1989 financial sector reforms were introduced that included the removal of credit ceilings, liberalization of interest rates, strengthening of prudential regulations, and development of and development of financial and securities markets. These reforms are likely to affect the determinants of money demand — income, interest rates, prices — and may lead to significant changes, and possibly instability, in the money demand function. Such changes in the demand for money, particularly if they become upredictable in nature, would create problems in ascertaining the liquidity needs of the economy.[7] These developments provide enough motivation for an additional study on money demand in Pakistan with a focus on testing the stability of the function by employing the cointegration technique.

The rest of the paper is organized as follows: section II discusses the methodology and data while results are reported and discussed in section III. The policy implications that stem out from the anlysis as well the concluding remarks are presented in the final section.

2. Methodology and Data

Following the standard practice, the money demand function is specified to depend on a scale variable (income or wealth), the opportunity cost of holding money (interest rate), and expected rate of inflation.

5. For a detailed survey on cointegration and error correction model see Hall and Henry (1988), Perman (1991), Cuthbertson et. al (1992) and Muscatelli and Hurn (1992).

6. See Tseng and Corker (1991).

7. See Khan and Sundararajan (1991).

$$m_t = f\,[y_t, R_t, P^e_t] \qquad (1)$$

using the logarithmic form, equation (1) is written as

$$\ln m_t = \alpha_0 + \alpha_1 \ln y_t + \alpha_2 \ln R_t + \alpha_3 \ln P^e_t + U_t \qquad (2)$$

where m_t is the real money balance (M_1 and M_2 definition), y_t is the real income,[8] R_t is the nominal interest rate (short or medium term time deposit rate);[9] and P^e_t is the expected rate of inflation (actual inflation is used as a proxy for expected inflation).

Equation (2) represents a long-run equilibrium relation and it is implicitly asumed that adjustment between the actual and desired money balances is achieved instantaneously. In practice, this would not be the case because of the sluggish adjustments by money holders to fluctuations in the determinants of money demand. The most popular way of dealing with such a problem has been to assume that agents behave as posited by the "partial adjustment" scheme.

Recently, this approach has been criticized on the ground that it assumes that adjustment costs and expectations can be captured in a very specific and simple fashion.[10] The cointegration and error correction dynamic modelling help us to resolve this problem. This tehnique can be thought of as a more general, intertemporal version of "partial adjustment"in which expectations are based on available information.[11] Since, this paper uses cointegration and error correction models a few words regarding these are in order.

As described by Granger (1986) and Engle and Granger (1987), a non-stationary time series X_t is said to be integrated of order d if it achieves stationarity after being differenced d times. This is usually denoted by $X_t \sim I(d)$. Furthermore, two I(d) variables are said to be cointegrated if a linear combination of them is integrated of any order less than d. Thus, to test for cointegration between two variables X_t and Y_t (both integrated of the same order),

8. We do not use the permanent income because earlier studies by Khan [(1980), 1982c] found no significant difference between the estimated coefficients of permanent and measured income. Furthermore, Laidler (1993) has pointed out that in the long-run equilibium situation which cointegration method permits us to investigate, measured and permanent income are indistinguishable.

9. Short term rate of interest is the return on time deposits of maturity period more than one year but less than two years, whereas the medium term rate of interest is the return on time deposits of more than two years but less than three years maturity period.

10. See Leidler (1993) for details.

11. See Nickel (1985).

we need to obtain an estimate of a linear combination between X_t and Y_t say $Z_t = X_t - \beta Y_t$ where Z_t may be interpreted as a disequilibrium error or short-run deviations from the long-run equilibrium relationship and β is the cointegration vector. If $X_t \sim I(1)$ and $Y_t \sim I(1)$, in order for X_t and Y_t to be cointegrated, the residuals or disequilibrium error term $(X_t - \beta Y_t) \sim I(0)$. An important correspondence exists between cointegration and error correction mechanism: for any set of cointegrated variables there exists a valid error correction representation of the data.[12] The error correction mechanism represents a systematic disequilibrium adjustment process through which X_t and Y_t are pevented from "drifting too far apart".[13]

For the purpose at hand, i.e., to examine the existence of a long-run equilibrium relationship between money, income, price and the interest rate, we employ cointegration and error-correction models as suggested by Engle and Granger (1987). The application of the above technique involves four steps.[14] In step I, we determine the order of integration for each variable under consideration, i.e., differencing each series successively until stationarity is achieved. In step II, we estimate cointegration regressions with the Ordinary Least Squares (OLS) method using variables of the same order of integration. Test for stationary residuals of the cointegration regression is performed in step III. Finally, we estimate the error-correction model.

Step I: In order to determine the stationarity of each series, we use the Augmented Dickey-Fuller (ADF) class of unit root tests with and without a time trend.[15] The ADF test is usually formulated by the following equation

$$(1-L)X_t = \lambda_0 + \lambda_1 X_{t-1} + \sum_{i=1}^{n} \Psi_i (1-L) X_{t-i} + U_t \quad (3)$$

where L is the lag operator and U_t is an error term. These tests determine whether the estimate of $\lambda_1 = 0$. It is important to note that although these statistics are calculated as t-

12. See Engle and Granger (1987).
13. See Perman (1991).
14. These steps are mentioned in Miller (1991). For the sake of expositional clarity we also follow these steps.
15. The Dickey-Fuller (DF) method is a test on the size of the co-efficient l_1 in the following equation.

$$(1-L)X_t = \lambda_0 + \lambda_1 X_{t-1} + U_t$$

The null hypothesis is that X_t is a non-stationary series. One of the drawbacks of the DF test is that it necessarily assumes that the structure of the long-run relationship is first-order auto-regressive. If it is not, then auto-correlation in the error term will bias the test. In order to overcome this problem, the ADF test is used.

ratios they do not have the standard t-distribution because under the null hypothesis of non-stationarity, the variance is unlimited. The cumulative distribution of the ADF test statistics is, however, provided by Fuller (1976). If the calculated t-ratio of coeffcient λ_1 with negative sign is less than its critical value from Fuller's table, then X_t is said to be stationary or integrated of order one i.e., $X_t \sim I(1)$.

Step II: In the second step, we use variables of the same order of integration to estimate long-run money demand function (cointegration regressions) with the help of the OLS method. The cointegration regression to be estimated is given in equation (2).

Step III: In the third step, residuals of the cointegration regressions are tested for stationarity. The ADF test is used again, but applied to the residuals of the cointegration regression instead of on the levels or difference of the series themselves. The ADF test is given as

$$(1-L)e_t - \beta_0 + \beta_1 e_{(t-1)} + \sum_{i=1}^{K} \Phi_j (1-L) e_{t-i} + V_t \tag{4}$$

where e_t is the residual from the cointegration regression, L is the lag operator and V_t is the error term.

The critical values of the tests differ according to the number of variables in the cointegrating regression. Like testing for stationarity in Step I, we also compare t-statistics of β_1 with negative sign with the critical values given in Engle and Granger (1987), Table II. If the T-statistic of β_1 is less than the critical value then we reject the null hypothesis of non-cointegration or the non-stationarity of the error term. This suggests the existence of a long-run stable equilibrium relationship between the variables included in the cointegration regressions. If errors are found to be non-stationary, it implies non-cointegration of variables which would, for exmple, indicate that money, income, prices, and interest rates are not related in a particularly stable, predictable fashion over the course of the data sample, perhaps because of significant changes in the institutional environment.

There is yet another quick way to test the stationarity of the residuals. The Durbin-Watson statistics from the cointegrating regression (CRDW) may be used to determine whether two or more variables are cointegrated. If the CRDW approaches zero then two or more variables are not cointegrated. Under the null hypothesis of non-cointegration CRDW should be close to zero, so we seek a value of the CRDW which is high enough to reject the null hypothesis.

Step IV: Although, the existence of a long-run relationship is useful from the point of view of monetary policy short-run behaviour is not without significance either, since the usefulness of the long-run relationship will not be as great if short-run movements in the aggregate have weak correlation with policy controlled variables. In the final stage, therefore, the error correction model is estimated for those monetary aggregates for which cointegrating relationships have been found.

The Error Correction Model to be estimated in the final stage is given as

$$\Delta m_t = \alpha_0 + \alpha_1 \Delta m_{t-i} + \alpha_2 \Delta y_{t-i} + \alpha_3 \Delta R_{t-i} \quad (5)$$
$$\alpha_4 \Delta P_{t-i} + \alpha_5 (m - \hat{m})_{t-1} + \varepsilon$$

where the symbol Δ represents a first difference of a variable and *m* stands for fitted values from equation (2). The money demand function specified in first difference in equation (5) along with contemporaneous and lagged first difference terms represent the short-run dynamics - a procedure that eliminate long-run movements. The term representing deviation from the long-run equilibrium gives the equation its error correcting properties. The statistical significance of the error correction term suggests tjat market forces are in operation to restore long-run equilibrium following a short-run disturbance. While a cointegration test identifies the existence of a stable long-run equilibrium relationship between the variables, an error correction representation of the demand for money function allows for adjustment towards long-run equilibrium as a result of a short-run disturbance.

Conventional statistical tests such as CUSUM and CUSUMSQ are also carried out to guage whether the coeffecients of the full error correction model are stable across differet sub-periods of the data sample. It may be the case, for example, that financial liberalization has not affected the long-run relationship between money, income, interest rate and price level but has rendered somewhat the unpredictable short-run deviations from the long-run equilibrium.

Before we close this section a few words regarding data and their sources are in order. The present study covers a time period from 1972-73 to 1991-92. Data pertaining to two definitions of money (M_1 consisting of currency in circulation and demand deposits and M_2 consisting of M_1 plus time and saving deposits), interest rates, and prices (GDP deflator) are taken from the various issues of *Monthly Bulletin* fo the State Bank of Pakistan. However, real income, represented by the GDP at constant factor cost of 1980-81 was taken from Kemal and Ahmed (1992).

3. Results

From the procedure outlined in the preceding section the results are presented in the same order.

3.1 Test for the Order of Integration

In the first step the order of integration for each variable used in the estimation process is tested with the help of DF class of unit root tests. These tests are applied to the first difference of the natural logarithm of each variable over the period 1972-92[16] with and without a time trend. As shown in Table 1, both the DF and ADF tests reject the null hypothesis of non-stationarity for all the variables used in the money demand function at the 5 percent level. The calculated values for both the DF and the ADF tests are found to be less than the critical values at the 5 percent level which suggest that the order of integration for all variables is unity i.e., all series are stationary in first difference.

Table 1: Tests for the Order of Integration

Variables	Dickey-Fuller (DF)		Augmented Dickey-Fuller (ADF)	
	Without Trends	With Trend	Without Trend	With Trend
ΔlnM_1	-3.73	-3.61	-4.88	-4.53
ΔlnM_2	-3.39	-3.27	-4.49	-4.47
Δlny	-3.96	-4.01	-3.43	-2.95
ΔlnR_1	-2.56	-2.40	-3.09	-2.64
ΔlnR_2	-3.62	-3.61	-3.60	-3.29
ΔRR_1	-5.18	-5.69	-3.19	-3.99
ΔRR_2	-5.23	-5.81	-3.15	-4.04
ΔP	-5.69	-5.96	-3.48	-4.09

Note: The critical value of the DF and the ADF statistics are -3.05 and -3.05 for 18 and 17 degrees of freedom respectively at the 5% level of significance.

3.2 Cointegration Regressions

The variables which are found to have the same order of integration are used to estimate cointegration regressions with the OLS. Various specifications for the long run money demand function pertaining to m_2 definition of money are estimated and results are

16 DF and ADF tests applied at level form do not reject the null hypothesis of non-stationarity for all variables. These results are, however, not shown here.

reported in Tables 2.[17] A cursory look at Table 2 is sufficient to see that the ADF and CRDW statistics reject the null hypothesis of no cointegration between money (m_2 definition), real income, real interest rates, nominal interest rates and prices. In other words, these variables are cointegrated, that is, there exist a stable long-run equilibrium relationship between these variables. The income elasticity of money demand is found to be in the neighbourhood of 1.1 which suggests that the demand for money has been rising at a rate which is more or less proportional to income growth. It is interesting to note that the income elasticity of money demand is declining with the passage of time. Khan and Raza (1989) reported income elasticity as 1.3 corresponding to m_2 definition of money for the period 1972-87.

The real deposit rates for different maturity periods are statistically significant with positive signs but the coefficients are very small, i.e., around 0.007. The positive sign of the real interest rate suggests that there has been financial repression in the economy during the sample period.[18] The rate of inflation as an opportunity cost variable is also found statistically significant with the expected negative sign. The coefficients are fairly robust as they remained constant at 0.1 whether rate of inflation is used separately or with other nominal interest rates.

17. Monetary aggregate corresponding to m_1 definition did not show cointegrating relationship with income, interest rate and rate of inflation. In other words, they failed to pass the ADF test. This finding suggests that there exist no long-run stable equilibrium relationship between money stock with m^1 definition and real income, nominal and real interest rates, and rate of inflation. These results are not reported here but can be supplied on request.

18. This finding is consistent with Khan (1993).

Table 2: Cointegration Regressions For Log m_2

Constant	Log y	$R_1 - P$	$R_2 - P$	Log R_1	Log R_2	P	R^2	CRDW	DF	ADF	CHI-SQ	F-Value
a. -6.46 (-8.78)	1.08 (18.40)	0.007 (2.28)					0.97	0.96	-3.65	-5.43[1]	3.59	3.50
b. -6.38 (-8.64)	1.07 (18.18)		0.008 (2.39)				0.97	0.96	-3.66	-5.46[1]	3.48	3.37
c. -6.11 (-7.99)	1.08 (19.32)			-0.09 (-0.87)		-0.10 (-2.70)	0.97	1.07	-3.19	-4.66[1]	2.61	2.25
d. -6.16 (-8.06)	1.09 (18.83)				-0.09 (-0.70)	-0.11 (-2.63)	0.97	1.10	-3.32	-4.87[1]	2.34	1.99
e. -6.26 (-8.48)	1.08 (19.48)					-0.10	0.97	1.06 (-2.58)	-3.64	-5.36[1]	2.16	1.93

Note: Figures in parentheses are t-statistics
Numbers in square bracket are Lag Length.
*means significant at the 5 percent level
For critical values of DF and ADF unit root tests see Pesaran and Pesaran (1991)
Critical values at 95% for the two version of Godfrey's test of residual serial correlation are:
- LM - Version: CHI-SQ(1)=5.0229
- F - Version: F(1,16) = 4.4900
F(1,15) = 4.5400

3.3 Error Correction Model

In the final stage, the error correction model is estimated for those monetary aggregates for which a cointegrating relationship has been found. This stage involves regressing the first difference of each monetary aggregate in the cointegration regression into the first difference of all variables plus the lagged value of the dependent variable and the lagged value of the error correcting term i.e. the error term from the cointegration regression. Table 3 documents the results of the error correction model for m_2 definition.

The presence of significant coefficient of error correction term indicates a strong feedback effect of deviation of money demand from its long-run growth path. The interpretation of error-correction coefficient is as follows:take for example, the error correction equation for m_2 on real income and real rate of interest, a coefficient of 0.786 means that about 79 percent of the discrepancy between actual and equilibrium value of the money demand is corrected each period. This implies that the market forces are in operation to restore long-run equilibrium following a short-run disturbance.

Table 3: Error - Correction Equations for Δ Log m_2

Constant	$(\Delta \log m_2)_{-1}$	Δ Log Y	$\Delta(R_1 - P)$	$\Delta(R_2 - P)$	$\Delta \log R_1$	$\Delta \log R_2$	$\Delta \log P$	ECM_{t-1}	R^2	DW
-0.084 (-2.274)**	0.552 (3.131)*	1.833 (2.679)**	0.009 (2.433)**					-0.786 (-3.718)*	0.78	1.91
-0.084 (-2.316)**	0.527 (3.195)*	1.857 (2.773)**		0.009 (2.602)**				-0.811 (-3.978)*	0.78	1.91
-0.082 (-1.734)**	0.589 (3.513)*	1.843 (2.199)**			-0.016 (-0.140)		-0.104 (-3.899)*	-0.848 (-4.071)*	0.72	1.69
-0.81 (-1.768)**	0.557 (3.515)*	1.864 (2.261)**				0.042 (-0.434)	-0.098 (-3.724)*	0.869 (-4.148)*	0.73	1.72
-0.080 (-1.950)***	0.513 (3.698)*	1.860 (2.500)**					-0.087 (-3.588)*	-0.902 (-4.818)*	0.78	1.80

*Significant at 1% level.
**Significant at 5% level
***Significant at 10% level

The above analysis confirms the existence of a stable money demand function pertaining to m_2 definition. It may, however, be the case that the changes in the financial environment have not affected the long-run relationship between broad money demand and its determinants but might have rendered somewhat unpredictable short-run deviations from long-run equilibrium. In order to check whether the coefficients of the full error correction model are stable over the sample period we carried out Cumulative Sum (CUSUM) and CUSUM of squares (CUSUMSQ) tests of structural stability proposed by Brown et al. [1975]. These tests employ a graphical technique which shows the plot of CUSUM statistic, CUSUMSQ statistic and also a pair of straight lines drawn at 5% level of significance. If either of the lines is crossed, the null hypothesis that the regression coefficient is stable, must be rejected at the 5% level of significance. The CUSUM test is particularly useful for detecting systematic changes in the regression coefficients and the CUSUMSQ test is useful in situations where the departures from the constancy of the regression coefficient is haphazard and sudden. As shown in Figures 1-4, these two tests do not detect any unpredictable short-run deviations from long-run equilibrium for the sample period 1972-92 corresponding to broad money.

4. Concluding Remarks

A stable money demand function is essential for the conduct of effective monetary policy. Since the beginning of the 1980s many institutional changes in the areas of banking practices and change in the exchange-rate regime have taken place in Pakistan. In recent years the government has undertaken financial sector reforms that include a shift from direct to indirect monetary control and interest rate liberalization. These changes may have caused instability in the money demand function in Pakistan and as such formed the subject-matter of this study.

This paper estimated a money demand function by employing cointegration and error correction models for the period 1972-92. We began by testing the stationarity of two monetary aggregates (m_1 and m_2 definitions of money), real income, real and nominal interest rates and inflation rates using the DF and the ADF tests. These tests showed that all variables are integrated of order 1. Having established the order of integration we proceeded to test for cointegration using the Engle-Granger approach. The results showed that the changes in the financial sector have rendered the narrow monetary aggregate unstable and unpredictable in the long run. On the other hand, the broad monetary aggregate has exhibited stable long-run relationship with real income, real interest rate and inflation. Also, we do not find any short-run deviations from the long-run path for the m_2 definition of money during 1972-92. The structural changes in the financial sector after 1989, especially interest rate liberalization did not affect the stability of the broad monetary aggregate, perhaps because the move from one financial regime to another was more cautious and gradual. These findings, therefore, suggest that the m_1 monetary aggregate may not be used for policy purposes,rather we concentrate on the use of broad money as the targeted monetary aggregate. Furthermore, the process of financial liberalization which started at the end of 1989 should, continue at a moderate pace. Haste should be avoided in the implementation of financial reforms as this may render the money demand function unstable.

The present study also finds the income elasticity of broad money demand in the neighborhood of 1.1 which suggests that the demand for money has been rising at a rate more or less proportional to the changes in income growth. As regards the interest rate, the coefficient of the real interest rate is found to be very low but significant. The positive sign of the real interest rate indicates that the economy has experienced financial repression during the sample period. The rate of inflation as an oppourtunity cost variable is also found statistically significant with the expected negative sign.

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Abstract

Pakistan's financial sector has witnessed many changes since the beginning of the 1980s which include a shift from an interest bearing deposits of bank to a system based on profit and loss sharing (PLS), shift from a fixed to managed floating exchange rate system and at the end of 1989 financial sector reforms were introduced. These changes are likely to affect the determinants of money demand and my cause instability in the money demand function. The instability in the money demand function will create problems in ascertaining the liquidity needs of the economy. This paper, using cointegration and error-correction modeling, estimate the money demand function for Pakistan and found that the above mentioned changes in financial sector did not affect the stability of the broad monetary aggregate but rendered the narrow monetary aggregate unstable and unpredictable.