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DISAGGREGATED APPROACH FOR MODELLING DEMAND FOR MONEY IN PAKISTAN

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The objective of the paper is to estimate a separate demand function for component of M2 in Pakistan, by using co-integration and error-correction techniques, based on the annual data set for the period of 1971-72 to 1998-99. Results show that currency in circulation and demand deposits are inelastic to interest rates and exchange rates, but highly elastic to income. On the contrary, quasi money is elastic to interest rates and exchange rates and inelastic to income changes.

I. Introduction

A number of attempts have been made to estimate money demand functions in Pakistan since the early 1970s. However, few studies have addressed the issue in a disaggregated manner (i.e., estimating separate functions for currency in circulation, demand deposits, and quasi money). A disaggregated approach in estimating demand for money may be more useful due to a number of reasons. For example, Pakistan's monetary aggregate, M2, is a bunch of interest-bearing and non-interest bearing components and thus respond differently to changes in domestic/foreign interest rates, movements in exchange rate and/or changes in domestic prices. Similarly, the impact of a change in income may not necessarily be the same on different components of board money. Thus a model for overall money demand may not be useful in understanding the behaviour of economic agents in response to various monetary policy instruments.

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The objective of this paper is to model the demand for money by using a disaggregated approach. The paper has made use of the co-integration and error-correction techniques to estimate the money demand function.[1] Efforts have been made to estimate both long-run equilibrium and short-run dynamic relationships between monetary and other macro-economic variables, however, the main emphasis remains on the long-run aspect. The paper has been arranged as follows: Section II gives the methodology, Section III discusses the results, and Section IV evaluates the models in terms of stability and forecast abilities. The last section concludes the paper.

II. Methodology

The first step is to test each series for stationarity and its order of integration. For this purpose the Augmented Dickey-Fuller test has been used. If a series is stationary at level form, it is called integrated of order zero and is represented by I(0). A non-stationary series can be made stationary by differencing. If it becomes stationary by differencing d times, it will be called integrated of order d i.e., I(d). The results (see Appendix-I) show that all the variables except inflation are non-stationary at their level form but become stationary by differencing once i.e., they are I(1). The series of inflation is stationary at level form and thus it is I(0).

The second step is to estimate the long run relationships between monetary and other variables by using the concept of co-integration. Two series, having the same order of integration are said to be co-integrated if their linear combination is stationary (at order of integration less than the original series).[2] Engle and Granger (1987) have suggested a test for the existence of co-integration between the two variables. The test involves the application of an appropriate stationarity test on the residuals of the regression of those variables. If the residuals are stationary at level form then the series are co-integrated. In that case the results of regression are meaningful and all the tests i.e., t-statistic, F-statistic, etc., are applicable. A number of regression equations for each monetary variable (i.e., currency in circulation, demand deposit, quasi money and M2) were estimated with different combinations of regressors. Selection among different combinations for an appropriate co-integration equation was made on the basis of the following criteria:

[1] The two step approach was first adopted by Engle and Granger, (1987). More recent Vector Auto Regression (VAR) techniques popularized by Johansen (1995) were also applied to ensure that there would be no loss of information by estimating a single-equation money demand function as the exercise indicated a unique co-integration equation.

[2] However, more than two series having different order of integration may also be co-integrated. For example x and y are I(2) and z is I(1). If the linear combination 'w' of x and y is I(1) and linear combination of 'w' and 'z' is I(0) then the three series x, y, and z may be termed as co-integrated.

a) The estimated parameters are statistically significant with appropriate signs.
b) The residuals of the co-integration equations are stationary.
c) The equations are better in terms of R^2 and CRDW (Co-integration Regression Durbin Watson) test.

On the basis of the aforesaid criteria the following equations have emerged as the best ones.

$$C_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 R_t + \alpha_3 X_t + uc_t$$

$$D_t = \beta_0 + \beta_1 Y_t + \beta_2 R_t + \beta_3 X_t + ud_t$$

$$Q_t = \gamma_0 + \gamma_1 Y_t + \gamma_2 RR_t + \gamma_3 X_t + uq_t$$

$$M_t = \theta_0 + \theta_1 Y_t + \theta_2 I_t + um_t$$

where

C_t = currency in circulation,
D_t = demand deposits,
Q_t = quasi money (time deposits plus foreign currency deposits),
M_t = broad money (M2),
Y_t = real GDP at market prices,
R_t = weighted average interest rate (nominal) on time deposits,
RR_t = weighted average interest rate (real) on time deposits,
X_t = nominal exchange rate,
I_t = inflation (on the basis of GDP (mp) deflator),
uj_t = residuals of respective equation,
All variables are in log forms except I_t and RR_t.

Once the long-run equilibrium has been established, the next step is to estimate short-run relationships between the variables. For this purpose all the variables (both regressands and regressors) are taken in their stationary forms that are usually their first differences. However by taking first differences long-run information about the data generating process is lost. The technique of error-correction is used to restore this information whereby the lag residuals of the co-integrating equations are introduced as regressor in the first difference equations. The co-efficient of the residual series shows the speed of adjustment towards long-run equilibrium. Following this technique, the error-correction equations specified in the present case are given below.

$$\Delta C_t = \mu_0 + \mu_1 \Delta Y_t + \mu_2 \Delta R_t + \mu_3 \Delta X_t + \mu_4 uc_{t-1} + \varepsilon c_t$$

$$\Delta D_t = \eta_0 + \eta_1 \Delta Y_t + \eta_2 I_t + \eta_3 \Delta X_t + \eta_4 ud_{t-1} + \varepsilon d_t$$

$$\Delta Q_t = \omega_0 + \omega_1 \Delta Y_t + \omega_2 \Delta RR_t + \omega_3 \Delta X_t + \omega_4 \Delta T_{t-1} + \omega_5 DUM + \omega_6 uq_{t-1} + \varepsilon q_t$$

$$\Delta M_t = \phi_0 + \phi_1 \Delta Y_t + \phi_2 \Delta RR_t + \phi_3 \Delta M_{t-1} + \phi_4 \Delta um_{t-1} + \varepsilon m_t$$

In the quasi money equation DUM is a dummy variable with 1 for the period 1992-98 and 0 otherwise.[3] Data for each series is culled from various issues of State Bank of Pakistan's Annual Reports, Pakistan Economic Survey and 50 Years of Pakistan in Statistics for sample period of 1971-72 to 1998-99. Nominal variables have been made real by using the GDP deflator. Eviews 3.1 is used for all estimations and tests.

III. Results

a) Co-Integration Equations

Results of the co-integrating equations are given in Appendix-II. Both the ADF test[4] on residuals and CRDW test[5] confirm the existence of co-integration between the variables in all the specified equations. The parameters of these equations show long-run elasticities of monetary variables with respect to scale and opportunity cost variables. The signs of all parameters are as expected, revealed in the table given below:

Long-Run Elasticities

Monetary variables	Income Elasticity	Interest rate Elasticity	Exchange rate Elasticity
Currency in circulation	1.969	-0.341	-0.752
Demand Deposit	2.112	-0.792	-1.149
Quasi money (Time plus FC Deposit)	0.486	1.091*	0.923
M2	1.155	-0.615**	–

* Parameter with real interest rate showing percent change in quasi money due to one percentage point change in real interest rate.

** Parameter with inflation as opportunity cost variable.

[3] Dummy variable is used to normalize the effect of Resident Foreign Currency Deposits (RFCDs) allowed in 1991-92.

[4] In addition to MacKinnon Critical Values, calculated ADF values are also checked against t-statistics proposed by Engle and Yoo. It is observed that residual of C_t and M_t are stationary on its level form at one per cent level of significance, D_t at 10 per cent, while residual of Q_t is not stationary at 10 per cent level of significance.

[5] Null Hypothesis in CRDW test is d=0. Critical values for this test at 1 per cent, 5 per cent, and 10 per cent level are 0.511, 0.386, and 0.322 respectively, [Sargen and Bhargava, (1983)].

Currency in circulation and demand deposits have high income elasticities of 2 which shows that a one per cent increase in GDP leads to 2 per cent increase in the demand for both currency in circulation and demand deposits. On the other hand quasi money is inelastic to GDP changes (with elasticity parameter of only 0.486). Comparatively low elasticity of quasi money shows that role of money as a store of value is not comprehended much in Pakistan. Instead the dominant role of money is the medium of exchange. As income rises, people demand monetary balances primarily for transaction purposes, that is a typical characteristic of a consumers' society like ours. The income elasticity of broad money demand is near unity (1.155) that is close to estimates of earlier studies.

As for the opportunity cost, we have used different variables for different equations. For currency in circulation and demand deposits, the nominal interest rate (on time deposits) and exchange rate are the appropriate opportunity cost variables. Responsiveness of currency in circulation to nominal interest rate is –0.341 and that to exchange rate is –0.752. This means that the cost of rupee holdings resulting from one per cent devaluation is higher than that from one per cent increase in the interest rate. A similar trend is witnessed in demand deposits with price elasticities of –0.792 and –1.149 with respect to the exchange rate and interest rate, respectively. Quasi money, on the other hand, has about a unit elasticity with respect to the exchange rate and also has a unit interest rate parameter. It may be noted that signs of these parameters are positive because for quasi money interest rate and exchange are not prices, rather they are returns on it. Interest rate is return on time deposits and exchange rate is return on foreign currency deposits. The interest rate parameter shows that one percentage point increase in the real interest rate increases quasi money by about one per cent.

In case of broad money (M2), inflation is used as the opportunity cost variable because the impacts of interest rate and exchange rate are found to be insignificant as expected *a priori*. Both the interest rate and exchange rate have positive impacts on quasi money and negative on currency in circulation and demand deposits. As a result the conflicting impacts of both these variables on components offset each other for M2. The results show that real money demand has less than unit elasticity (–0.615) with respect to price changes. Some of the other studies on demand for money in Pakistan also came out with similar results, like Khan (1980): –0.59; Saqib and Ahmed (1986): –0.25; Khan and Bilquees (1989): –0.50, etc.

b) Error-Correction Mechanism

Results of error-correction equations are given in Appendix-III. Almost all variables in these equations are in growth terms. Thus the parameters of independent variables show the partial impact of their growth rates on those of monetary variables. However, the co-efficient of lag residuals of co-integrating equations show the speed of adjustment in case of deviations of monetary variables from their long-run equilibrium path. The results show that the currency in circulation adjusts quickly toward its equilibrium as compared to other components of money demand. The speed of adjustment of quasi money is the lowest, while that of broad money (M2) is a moderate one.

IV. Stability and Forecast Ability

Stability and forecast ability of the estimated parameters, both in co-integration and error-correction equations, have been checked by using the following Chow forecast test:

$$F = \frac{\sum_{1}^{T} \varepsilon_t^2 - \sum_{1}^{T_1} \bar{\varepsilon}_t^2}{\sum_{1}^{T_1} \bar{\varepsilon}_t^2} * \frac{T-k}{T_1}$$

where $\sum_{1}^{T} \varepsilon_t^2$ is the sum of squared residuals of the original models; $\sum_{1}^{T_1} \bar{\varepsilon}_t^2$ is the sum of squared residuals of the re-estimated models with a truncated sample size; T are the total number of observations in the original models; T_1 are the observations in reduced sample (1971-72 to 1994-95) ; and 'k' are the number of parameters estimated. F-statistic has an exact finite sample F-distribution given the errors are independent, and identically, normally distributed. The Null hypothesis of the test is that the model is not unstable. The results of the test are given below showing that all the models (co-integration as well as error-correction) are stable.

Results of Chow Forecast Test

Equation of:	F-statistic	Probability
	Co-integration Equation	
C_t	0.238	0.87
D_t	1.100	0.37
Q_t	0.453	0.72
M_t	0.069	0.98
	Error-Correction Equations	
ΔC_t	0.461	0.71
ΔD_t	1.483	0.25
ΔQ_t	0.480	0.75
ΔM_t	0.393	0.76

To further evaluate the performance of each model in terms of forecast, the above models were re-estimated with a truncated sample size by dropping the last 3 observations. The last 3 observations were then projected on the basis of a re-estimated model and the projections were evaluated by using the following statistics;

1. Root Mean Squared Error (RMSE).
2. Mean Absolute Error (MAE).
3. Mean Absolute Percentage Error (MAPE).
4. Theil Inequality Co-efficient.

The lower these statistics are, the better would be the model. The results are given below which reveal that forecast performance of co-integration equations are better compared to the error-correction models.

Forecast Evaluation

Equation of:	RMSE	MAE	MAPE	Theil I.C.
		Co-integration Equation		
C_t	0.050	0.045	0.401	0.002
D_t	0.170	0.166	1.532	0.008
Q_t	0.142	0.140	1.171	0.006
M_t	0.022	0.022	0.172	0.001
		Error-Correction Equations		
ΔC_t	0.054	0.046	106.20	0.798
ΔD_t	0.053	0.041	79.45	0.222
ΔQ_t	0.107	0.091	94.79	0.398
ΔM_t	0.017	0.013	93.12	0.184

V. Conclusion

The main objective of the paper is to model demand for money by using a disaggregated approach. For this purpose, Co-integration and Error-correction techniques were used. The results show that currency in circulation and demand deposits are inelastic to opportunity cost variables, i.e., interest rate on time deposits and the exchange rate, while highly elastic to income as expected for a consumers' society with a large informal sector as in Pakistan. Quasi money, on the other hand, is elastic to the interest rate and exchange rate changes and inelastic to income changes. It increases by one per cent with a one-percentage point increase in real interest rate or with one per cent devaluation in the exchange rate. Income elasticity of broad money is near unity. It is found that interest rate and exchange rate changes have a neutral impact on the demand for broad money due to their offsetting impacts on its components. The models developed for M2 and its components can safely be used for projecting demand for money in Pakistan, as all the estimated relationships are stable.

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APPENDIX-I

Results of Augmented Dicky-Fuller Test

Variables	Test on Level		Test on First Difference	
	ADF Test Statisitc	*MacKinnon Critical Values	ADF Test Statisitc	*MacKinnon Critical Values
C	-2.443	-2.975	-4.910	-2.980
D	-0.764	-2.980	-3.427	-2.985
T	-0.825	-2.985	-3.738	-2.985
M	-0.422	-2.985	-4.027	-2.980
Y	-1.535	-2.980	-4.063	-2.980
X	2.467	-2.980	-4.061	-2.980
R**	-2.093	-2.991	-2.372	-2.632
RR	-2.586	-2.980	-5.508	-2.985
I	-2.798	-2.980	-5.823	-2.985

* MacKinnon Critical Values for rejection of hypothesis of a unit root.

** R is stationary at 10 per cent level significance at its first difference.

APPENDIX-II

Co-Integration Equations

Dependent	Constant	Y_t	I_t	R_t	RR_t	X_t	R^2	DW	Residual ADF Test Statisitc	Residual *MacKinnon Critical Values
C_t	-13.252 (-10.88)	1.969 (19.74)		-0.341 (-3.93)		-0.752 (-9.46)	0.99	2.07	-5.43	-1.95
D_t	-14.974 (-6.55)	2.112 (11.20)		-0.792 (-5.02)		-1.149 (-7.35)	0.95	1.44	-3.94	-1.96
T_t	2.055 (0.84)	0.486 (2.09)			1.091 (1.83)	0.923 (4.63)	0.97	0.61	-2.86	-1.96
M_t	-2.852 (-7.36)	1.155 (38.86)	-0.615 (-2.25)				0.99	0.81	-5.64	-2.99

Note: Figures in parantheses are t-statistics.

APPENDIX-III

Error-Correction Equations

De-pen dent	Cons-tant	ΔY_t	ΔR_t	ΔX_t	ΔRR_t	I_t	Lag Depen-dent	RES(-1)	DUM1	R^2	DW	Residual ADF Test Statisitc	Residual *MacKinnon Critical Values
ΔCt	0.003 (0.07)	1.887 (2.97)	-0.528 (-2.87)	-0.623 (-3.17)				-0.995 (-4.15)		0.58	1.87	-0.393	-1.96
ΔDt	0.130 (2.12)	2.090 (2.98)		-0.665 (-3.00)		-0.019 (-5.63)		-0.423 (-2.70)		0.72	1.91	-3.15	-1.96
ΔTt	-0.105 (-1.77)	1.687 (1.78)		0.579 (2.28)	1.316 (3.58)		0.441 (2.81)	-0.372 (-3.19)	0.068 (1.68)	0.69	2.05	-3.01	-1.96
ΔMt	-0.023 (-0.92)	0.792 (1.80)			0.859 (3.39)		0.551 (3.73)	-0.58 (-3.89)		0.75	2.29	-3.43	-1.96

Note: Figures in parantheses are t-statistics.

APPENDIX-IV

Evaluation of Forecast Ability of Co-Integration Equations

	Chow Forecast Test		Out of sample forecast			
Equations	F statistic	Probability	RMSE	MAE	MAPE	Theil I.C.
C_t	0.238	0.87	0.0498	0.0445	0.4008	0.0022
D_t	1.100	0.37	0.1696	0.1663	1.5319	0.0077
T_t	0.220	0.88	0.0595	0.0588	0.7630	0.0039
T_t	0.453	0.72	0.1420	0.1402	1.1714	0.0060
M_t	0.069	0.98	0.0222	0.0216	0.1723	0.0009

Evaluation of Forecast Ability of Error-Correction Equations

	Chow Forecast Test		Out of sample forecast			
Equations	F statistic	Probability	RMSE	MAE	MAPE	Theil I.C.
ΔC_t	0.461	0.71	0.0543	0.0457	106.2813	0.7983
ΔD_t	1.483	0.25	0.0529	0.0410	79.4571	0.2223
ΔT_t	0.062	0.98	0.0156	0.0154	0.2000	0.0010
ΔT_t	0.480	0.75	0.1071	0.0914	94.7946	0.3979
ΔM_t	0.393	0.76	0.0168	0.0126	93.1271	0.1837