AN APPLICATION OF COINTEGRATION AND ERROR CORRECTION MODELLING: TOWARDS DEMAND FOR MONEY IN NEPAL

*Ravindra P. Pandey**

Abstract

This paper makes use of co-integration analysis and error-correction modelling techniques to examine the money demand function in Nepal. In addition to using the recently developed time series techniques, the rate of variables such as agricultural GDP, non-agricultural GDP, rate of return on savings deposits etc. are examined vividly. The co-integration test suggests that the demands for narrow money (m_1) is co-integrated with agricultural as well as non-agricultural income and also with the interest rate on savings deposit. On the whole the study confirms the belief that a statistically robust demand for m1 can be estimated for Nepal using an error-correction dynamic specification as well as the variables under consideration.The empirical analysis of money demand function thus exhibits that demand for real money balance in Nepal is a stable and predictable function of a few variables.

Introduction

The relationship between the demand for money balances and its determinants is a fundamental building block in most theories of macroeconomics and is a critical component in the formulation of monetary policy. Unlike other assets, money has the unique characteristics of being universally accepted as a medium of exchange. Because conversion of other assets into money often entails some costs and trouble, and because money yields

* Research Officer, Research Department, Nepal Rastra Bank.

the convenience of holding means of payment, it comes to be demanded. Several alternative theories have been postulated to provide an explanation to the demand for money. However surveys of theories of the demand for money conventionally start with the Quantity theory of Money and then move more or less historically through to *Milton Friedman's* restatement of the Quantity theory *(Friedman 1959).*

Virtually all of the empirical studies reveal that the central problem at issue is the specification of money demand relationship in a form which best represents the reality and is suitable for statistical fitting. This is because there has been a number of differences among the principal theories of the demand for money. Crucial amongst these have been (i) the extent to which the demand for money is sensitive to changes in the rate of interest and (ii) differing views regarding the stability of the relationship between the stock of money and real income. Some of the problems encountered in employing econometric techniques to test the true nature of the demand for money can be summarised in the following manner.

Firstly there is no agreed definition of money. Monetarists are likely to define money in the way that yields the most accurate prediction whereas *Keynesians* stress the difficulty of distinguishing money from `near-money' and thus of formulating a testable demand for money function. A second problem arises because the demand for money is not directly observable. Thirdly, if a demand for money function appears to be unstable, it may be argued that the problem lies within the specification of the equation, rather than saying anything very much about any of the demand for money theories. Fourthly, even if we agree on the arguments of a money demand function, it is difficult to find the correct form of each variable.

Choice of Scale Variable

Early work on the scale variable in the demand for money functions was dominated by the controversy on measured income and wealth, with wealth generally appearing to perform better (*Meltzer*, 1963; *Brunner* and *Meltzer*, 1963; *Chow*, 1966; *Laidler*, 1971, etc.). Because of the absence of statistics regarding wealth, it was represented in these studies by data on permanent income. This raised the possibility that wealth was the appropriate constraint on money holding and therefore the demand for money was best thought of as an asset demand rather than a transaction demand. This view has gained further support from other studies which have used consumption as the scale variable since consumption moves more closely with permanent than with measured income (*Mankiw* and *Summers*, 1986; and *Summers*, 1990). On the other hand, the study by *Goldfeld* (1973) shows that income performs better than wealth. He, however adds that short run changes in wealth, also help to explain the data. These tend to suggest that income and wealth are both important in determining the demand for money, but it is difficult to separate their relative influence. While the study by *Laidler* and *Parkin* (1970) shows that income has a significant influence on money demand, *Laidler's* 1971 study, reveals that the use of permanent income leads to better results. The apparently superior performance of permanent income arose because it captured important adjustment lags in a function where measured income was the scale variable. In addition, *Laidler* (1993) points out that consumption moves very closely with transactions and would therefore be the appropriate scale variable in a transactions approach like the **shopping time model**. In spite of the differences, however, there seems to be a general consensus that either income or wealth must be involved in the explanation of demand for money. In most conditions where time series on wealth are not available, income may be considered as the most relevant scale variable. The appropriate concept of income would, however, be the permanent income; as such, it is not directly observable, it is derived as a weighted average of past incomes. But computation requires sufficiently long series of national income and where this is not available, as in our case, we are forced to be content with the use of measured income in the empirical studies. This would however raise the tricky issue of the relevant expectation hypothesis (*Laidler* 1993). Fortunately, however, the co-integration approach relieves us of the need to make a choice. In the long-run steady state of a co-integrating relationship between current income and money holdings, the distinction does not make sense (*Laidler* 1993). As such for the purpose of this study GDP is used as the scale variable. Corresponding to real money stocks on the left-hand side, real income i.e. GDP from agricultural and non-agricultural sectors (real YAG, YNAG) has to be kept on the right-hand side. In both cases, we use the GDP price deflator[1] . It must be noted that the coefficient on real GDP should be expected to be positive and significant.

The Interest Rate Term

The theoretical logic as well as the empirical studies ask that the demand for money function should contain some interest rate so as to represent the opportunity cost variable. To the extent we view the demand for money in the frame work of broader portfolio selection, yields on equities as well as on bonds would be the more relevant measures of opportunity cost. The *Keynesian* theory also provides support to the long run interest rate because it is better linked with investment and income. On the other hand, if we consider short term assets as the closest substitutes of money, short-term interest rate would be more relevant argument. Since theory does not provide any clear-cut guidance on

1 The base year 1974 (=100). Thus nominal money stocks have been deflated to real money stocks by GDP deflator.

the choice of interest rate, empirical studies have tried different rates depending upon the availability of suitable data.

Empirical finding of the most appropriate interest rate variable is bedeviled by multicollinearity problems since most interest rates tend to move together over time. For example, *Laidler* (1981) experimented with alternative interest rates using narrow money for US quarterly data, 1953-78 and found that either short-term rate or long-term rate plus a dividend/price ratio variable, first used by *Hamburger* (1977) as a measure of the real rate on all equities including durable goods could be used. Investigators using interest rates as opportunity cost variables have usually proceeded as if expected capital gains on non-monetary assets were zero. However *Grice* and *Bennett* (1984) include estimates of expected gains in their opportunity cost measures. Their augmented variables prove significant in their demand for money equations.

In recent years, attention has been paid to the own rate of return on money as a variable in the demand function in addition to opportunity cost variables. In the UK, *Hacche* (1974) used such a measure based on the three-month certificate of deposit rate. *Artis* and *Lewis* (1976) and Grice and *Bennett* (`1984) form measures constructed as weighted averages of the rates of return on various components of the broad money stock. Also *Taylor* (1987) in a broad money equation includes an own-rate variable constructed from the rate on interest bearing cheque accounts and the seven-day deposit rate. Own-rate variables have, of course, a positive relationship with money demand, in contrast to rates reflecting opportunity cost which appear with a negative sign. The successful inclusion of own-rate measures suggests that broad money at least should not be treated as an asset bearing a zero return.

The empirical evidence presented above by no means settle whether the interest rate that is relevant for the demand for money is a short rate or a long rate. It is only by trying out various interest rates, that we may be able to state confidently which interest rate yields the most stable money demand relationship in a particular economic environment. It is, however, to be noticed that the coefficients on the opportunity cost variable is expected to have a negative sign.

Effects of Inflation

Inflation is "a process of continuously rising prices or equivalently of a continuously falling value of money" (*Laidler* and *Parkin*, 1975). The definition implies that a rise in the price of individual commodities is not inflationary if offset by falls in other prices. A sustained rise in the general price level means that a given sum of money will buy a smaller quantity of goods: hence the alternative characterization of inflation as a continuous decline in the purchasing power of money. An increase in the expected rate of inflation would cause a shift out of money and bonds into consumer durable.

Many economists would regard the expected rate of inflation as an important determinant of the opportunity cost of holding money. While theoretically one might expect its influence to be reflected in the nominal rates of interests usually included in demand for money functions, the evidence does suggest that expected inflation rates affect the demand for money directly in a manner over and above their indirect influence via nominal interest rates. That this is so during periods of rapid inflation has been established reasonably clearly in a series of studies dating back to Cagan's (1956) work on European hyper-inflation and *Vogel's* (1974) study of sixteen Latin American republics. Since the studies on US data by *Shapiro* (1973) and *Goldfeld* (1973) it has also been accepted that even more moderate inflation rates can have an effect on money demand in that economy. Investigators such as *Hendry* (1985) and *Taylor* (1987) using general to specific error correction approach also detect long-run inflation effects on the UK demand for money.

In fact the opportunity cost of holding money instead of real assets is usually proxied by some measure of the expected rate of inflation. Although there exists a strong debate about the appropriate model of expectation formation and adjustment mechanism; compared to other concepts, the use of the actual inflation rate as a sort of rational expectation approximation has not fared too badly[2].

Hence this simplification being handy, the *actual inflation rate* has been included in the general specification of the demand for M_1 and is defined as :

$$\Delta CP_t^e = \Delta P_t = \frac{CPI_t - CPL_{t-1}}{CPI_{t-1}}$$

where CPI denotes consumer price index and $\Delta CPI_t^e \approx \Delta p_t$ denotes the expected inflation rate.

2 Foe detail discussion refer to Biefang, Trautwein, Howells, Arestis, Hagemann (1995), "Financial Innovation and the long-run Demand for Money in the UK and West Germany", Weltwirtschaftshiches, Archiv, July, 1995.

Data Constraints

Econometric research work in our country is seriously inhibited by a wide range of data shortcomings. As there are no quarterly time series on GDP annual data have been used, although it does not come too handy in analyzing the seasonal variations in the demand for money. There is a complete absence of any information on certain key variables like wealth, capital stock and monetized income.

The interest rate variable also poses some problems. In the case of narrow money M_1, it would have been preferable to use the treasury bill rates, as treasury bills are a highly liquid asset, and clearly an alternative to money. However, in *Nepal,* the treasury bills have not yet become a truly market oriented instrument as the ownership of treasury bills by individuals is negligible. As such, the rate of interest on savings deposit has been chosen as the yield on competing assets for M_1. The rate of inflation is represented by the changes in consumer price index.

The statistical estimates of the parameters of the functions are based upon the time series data for the period 1964/65 to 1995/96. Period coverage beyond 1964/65 could not be extended because GDP figures are not available for the period prior to 1965. Data on agricultural GDP (YAG), non-agricultural GDP (YNAG) and GDP deflator were extracted from the Economic Survey, *His Majesty's Government of Nepal,* while those on nominal stock of narrow money (M_1), rate of interest on savings deposit (R_{sd}), and Consumer Price Index (CPI) were extracted from the Quarterly Economic Bulletin, *Nepal Rastra Bank.*

Definition of the Variables

The variables used in the study are defined as follows:

YAG = GDP originating in agriculture at 1974/75 price, Rs. in million

YNAG = GDP originating in non- agriculture at 1974/75 price, Rs. in million

M_1 = currency + demand deposits at 1974/75 price, Rs. in million

R_{sd} = rate of interest on saving deposit

Δp = rate of inflation

CPI = Consumer Price Index

Econometric Issues

Research studies regarding money-demand relationships in most developing economies have generally used a log linear *Goldfeld* (1973) type model. Such model relates real money balances to a scale measure such as real income and the returns on one or more assets to represent the opportunity cost of holding money (*Wong*, 1977; *Aghevli et al*, 1979; *Khan*, 1982a, 1982b; and *Ahmad* and *Khan*, 1990). These studies also include a lagged dependent variable term to approximate the short-run, dynamic influences. Study done by *Hendry* and *Mizon* (1978) indicates that the use of lagged dependent variable to approximate short-run adjustment is highly restrictive because it requires that the lag pattern be identical for each regressor. The study of *Lieberman* (1980) suggests that the correlation between the errors and the lagged dependent variable even when adjusted for serial correlation, may result in biased parameter estimates. The bias problem is particularly seen when the equation does not embody any short-run dynamics, as in Khan (1982b) and *Ahmad* and *Khan* (1990). For more on this see *Patterson*, (1987).

Most of the elasticity estimates from the studies mentioned above are generally based on annual data and small sample sizes. For example, *Wong* (1977) uses fifteen observations; *Khan* (1982a) uses twenty-one observations; and *Ahmad* and *Khan* (1990) uses twenty-eight observations. The use of small sample size in these studies decreases the power of statistical tests and in turn, reduces the confidence one can place in the empirical results. Some of the previous studies of small developing economies do not extensively examine the validity of their econometric model, *Khan* (1980, 1982a) includes lagged dependent variable as a regressor and reports the *Durbin-Watson* statistics and does not mention at all the *Durbin-h-statistics*, which however would yield better views. Work by *Granger* and *Newbold* (1974) has shown that the levels of many economic variables are non stationary and, thus, subject to the `spurious regression phenomenon'. Moreover, *Phillips* (1986) has shown that the use of a log-level model generates spurious inferences, because the usual t and F test statistics do not have even the limiting distributions. These specification issues raise questions about the observed instability in the *Goldfeld* (1973) type models. *Ahmad* and *Khan* (1990) found parameter instability in *Pakistan's* money-demand functions.

Econometric Specification

The present study makes use of co-integration analysis and error-correction modelling techniques to estimate money demand function for *Nepal*. The error correction mechanism has received little attention in the money demand literature of developing economies. A few studies (*Domowitz* and *Elbadawi*, 1987 and *Arestis* and *Demetriades*, 1991) have tested the performance of the error correction model (ECM) using annual data and a small sample size. In particular, the econometric methodology used in this study are the recent developments in co-integration and error correction (*Banerjee et al*, 1993; *Inder*, 1993). These developments suggest that in finite samples the Unrestricted Error Correction Model(UECM) estimator has better overall statistical properties than either the two-step *Engle* and *Granger* (1987) estimator or the modified estimator of *Phillips* and *Hansen* (1990). The bias in the *Engle-Granger* estimator of the long-run relationship could be significant because of the small size of sample (30 annual observations) used in the study (*Banerjee et al* 1986). Moreover the power of UECM based co-integration test is substantially higher than that of the *Engle-Granger* test in small samples (*Kremers, Ericsson* and *Dolado*, 1992). An additional problem of the *Engle-Granger* techniques is that the distribution of the first-stage estimate is non-standard even asymptotically (*Park* and *Phillips*, 1988) thus t-statistics will not be valid even in large samples. On the other hand, although the fully modified OLS estimation of *Phillips* and *Hansen* (1990) which is obtained by making semi-parametric corrections to the OLS estimator has a normal asymptotic distribution, it suffers from poor finite sample properties (*Inder*, 1993). Hence the *Banerjee et al* (1986) approach which allows for estimating long-run parameters in an unrestricted ECM specification incorporating all the dynamics is adopted here in the study. The co-integration test in this approach is the t-statistic on the ECM term. Under the null hypothesis of non co-integration this statistics has a non-standard distribution but critical values, obtained by *Monte Carlo* methods are provided by *Banerjee et al* (1993). The general-to-specific approach is followed here. This approach helps in arriving at parsimonious specifications for both the processes. Once a robust parsimonious specification for money demand is obtained, the test for the significance of the parameters and its probable interpretation can be made.

Dynamic Modelling

If an endogenous variable y_t is expressed as a function only of the value of a set of exogenous variables x_t at the same point in time, the effect of x_t on y_t is immediate and complete; however, if a lag distribution applies to every variable in the model, the long-term effect must be derived as a function of all the lag distributions.

Moreover, there are other types of information that can be revealed by a dynamic equation; any of a number of equivalent forms will provide the same information about, say, short-run and long-run adjustment, but different forms of the equation will reveal different types of information conveniently. Hence an econometric model should represent both the short-run adjustment process and the long-run steady state. Since the observed data may not have been produced through an equilibrium process, the dynamics of the relationships will become relevant. Dynamic models account for any time lags in the response of endogenous variables. The econometric model adopted here is the general to specific (GS) methodology from the outset, starting with a general short-run model and testing down to a suitably parsimonious final model. Both long and short-run elasticities are estimated together in this approach. However, because the co-integration analysis suggests that a long-run relationship exists (see below), we can be hopeful that it will be possible to express the short-run relationship in Error Correction Model (ECM) form.

Co-integration

The practice of exploiting information contained in the current deviation from an equilibrium relationship, in explaining the path of a variable, has benefited from the concept of co-integration by Granger (1981) and *Engle* and *Granger* (1987). A series that is tending to grow over time can not be stationary (although it may possibly be stationary around some deterministic trend), but the changes in that series might be stationary. In the long run, two or more series can move closely together and the difference between them can be constant even when the series themselves are trended. It is observed that most economic variables are non-stationary and they follow a random walk (*Granger*, 1986). A non-stationary series within the framework of ordinary least square (OLS) estimation violates its basic assumption and as such one can not get the best unbiased linear estimates (BLUE). However, even if there exists a spurious correlation between non stationary variables, the basic statistical test may still be significant, but it still violates the BLUE property (*Granger* and *Newbold*, 1974). There are no limiting distribution for t-ratios for regressions between I (1) variables i.e. many economic time series become stationary after first differencing, (or at least their logarithms do), and are therefore said to be integrated of order one [I (1)], R^2 has a non-degenerate limiting distribution and the *Durbin-Watson* statistics tends to converge towards zero. The above discussion gives us the essence that any ECM must be formulated in such a way that both the long and short run components are of the same order of integration.

To establish the existence or non-existence of an equilibrium relationship between two economic time series x and y, we must first test whether x and y are integrated to the same order. This can be done by using the Augmented *Dickey Fuller* test for stationarity. If they both are co-integrated of order one, then the test for co-integration can be completed.

The *Johansen* maximum likelihood procedure (*Johansen*, 1988) offers a solution to some of the major problems of the two step OLS estimation procedure suggested by *Engle* and *Granger* (1987). Although the later procedure has many advantages, it is not free from drawbacks either. However, since the power of the ECM based co-integration test is higher than that of *Engle-Granger* test in small samples (*Kremers, Ericsson* and *Dolado* 1992), in this study we make use of the t-ratio on coefficient of β_{1i} to test for co-integration. We also make use of the residual based approach to reconfirm the test for co-integration.

Error Correction Models

In economics controlled experiments are not as vivid as in econometrics. Variables are stochastic and much of the data consist of non-stationary time series and as such we can't rely on the standard regression procedure. As the variables are non-stationary, the OLS estimators have sampling distribution with properties very different from what we know so far. A major advantage of error-correction model is that they result in equation with first differenced and hence stationary dependent variable but avoid the problem of losing long run information on data:

$$\Delta y_t = \beta_o + \beta_1 \Delta x_t - (1 - \alpha) [y_{t-1} - x_{t-1}] + u_t \quad \text{............... (i)}$$

The error correction model of the above type links both long and short run components. If y and x are in logarithms, the model describes a growth rate of the form

$$\Delta y_t = \beta_1 \Delta x_t \quad \text{.. (ii)}$$

The underlying long run relationship can be described as :

$$y' = \text{constant} + x' \quad \text{.. (iii)}$$

where $u_t = 0$, $x_{t-1} = x'$, and $y_{t-1} = y'$ are constant and $\Delta y_t = \Delta x_t = 0$ in the long run steady state equilibrium.

Equation (i) can hence be written as :

$$\Delta y_t = \beta_0 + \beta_1 \Delta xt - (1 - \alpha) [y_{t-1} - y'_{t-1}] + u_t \quad \text{......................... (iv)}$$

If actual y_{t-1} is greater than its long run equilibrium value y'_{t-1}, then Δy_t can be expected to fall and if $y'_{t-1} > y_{t-1}$ then Δy_t can be expected to rise. The growth in y_t depends on the growth of xt. We notice that the error correction term $(y_{t-1} - x_{t-1})$ is the logarithm of the y-x ratio lagged once. If this is related to growth in real money, then one may interpret it as changes in money holdings in the future occurs when the y-x ratio deviates from its long run value as economic agents attempt to move nearer to their long-run desired position.

The General Specification of the Model

In recent years, the technique of co-integration has been applied to the estimation of demand for money equations. This technique has been used by *Hall, Henary* and *Wilcox* (1989) to judge whether given set of explanatory variables are sufficient to model various UK monetary aggregates. Similarly *Biefang, Trautwein, Howells, Arestis* and *Hagemann* (1995) have made use of this technique to compare the long-run demand for broad money in the UK and West Germany. If the set of variables under consideration do not co-integrate then there is little point in trying to estimate dynamic short-run error correction models since these will be subject to spurious correlation problems.

The general to specific (GS) methodology is adopted from the outset, starting with a general short-run model and testing down to a suitably parsimonious final model. Both the long and short-run elasticities are estimated in this approach. Hence the general formulation of the process for the demand for money is as follows:

$$\Delta m_t = \alpha_o + \sum_{i=0}^{n-1}\alpha_{1i}\,\Delta m_{t-1} + \sum_{i=0}^{n-1}\alpha_{2i}\,\Delta yag_{t-i} + \sum_{i=0}^{n-1}\alpha_{3i}\,\Delta ynag_{t-i}$$

$$+ \sum_{i=0}^{n-1}\alpha_{4i}\,\Delta r_{sd\ t-1} + \sum_{i=0}^{n-1}\alpha_{5i}\,\Delta\Delta P_{t-i} + \sum\beta_{1i}\,m_{t-i} + \sum_{i=1}^{n-1}\beta_{2i}\,yag_{t-i}$$

$$+ \sum_{i=1}^{n-1}\beta_{3i}\,ynag_{t-1} + \sum_{i=1}^{n-1}\beta_{4i}\,r_{sd\ t-i} + \sum_{I=1}^{n-1}\beta_{5i}\,\Delta p_{t-1} + \delta_t + \varepsilon_t \text{..................} \quad (v)$$

where t is the time trend and $\alpha_{1i}, \alpha_{2i}, \alpha_{3i}, \alpha_{2i}, \alpha_{3i} > 0$, $\alpha_{4i}, \alpha_{5i}, \beta_{4i}, \beta_{5i} < 0$.

It is to be noted that the level terms which enter into the ECM process are trended variables. Hence a time trend is included in the equation which is equivalent to detrending these variables individually (see *Stock* and *Watson*, 1989 and *Friedman* and *Kuttner*,1993).

Unit Root Test

Although most economic variables are non-stationary, an identification of cointegrating combinations of variables allow valuable information concerning the long-run behaviour between such non-stationary variables to be embedded in stationary econometric models, through an error-correction term.

The following table gives the results of the unit root-tests. The test suggests that the logarithms of narrow money (m_1), agricultural GDP (yag), non-agricultural GDP (ynag) are integrated of order one. There is, however, a little room to shed doubt on the order of integration of logarithms of the rate of return on savings deposit (r_{sd}). The DF test without trend indicates that the series is stationary while DF test with trend, and both the ADF tests with and without trend accept the null hypothesis of non-stationarity. Since the first difference of r_{sd} i.e (r_{sd} is I (0), we conclude that rsd is an I (1) variable.

Table

Test of the Order of Integration, 1865–1995

Variable	DF (trend)	ADF	ADF (trend)	I
cpi	–1.8934	1.6010	–3.0472	
$\Delta cpi = (\Delta p)$	-5.1178	-4.4613	-5.3403	0
$\Delta\Delta p$	-5.1852	-4.3685	-5.5712	
m_1	-3.2074	0.024782	-2.9186	1
Δm_1	-6.0858	-5.8478	-5.8965	
y	-1.8962	1.7792	-2.0619	1
Δy	-7.7769	-4.4573	-5.2244	
yag	-2.4557	0.021687	-2.3121	1
Δyag	-6.6672	-4.7726	-4.7298	
ynag	-3.4991	-0.0029263	-.1246	1
$\Delta yang$	-6.2689	-5.3884	-5.4126	
R_{sd}	-1.9076	-1.6693	-1.0562	1
ΔR_{sd}	-6.3083	-4.2102	-4.6210	
r_{sd}	-3.2167	-1.7547	-0.89098	1
Δr_{sd}	-7.6709	-4.4485	-4.9576	

As most of the series are trended, a trend is included in the tests. DF (trend) denotes the *Dickey-Fuller* test including a trend. ADF denotes the *Augmented Dickey-Fuller* test without trend, whereas ADF (trend) includes a trend. ADF is based on the following regression :

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \Sigma\alpha_{1+i} \Delta y_{t-i} + \varepsilon t$$

where Δ is the first difference operator, e is the random error and since the sample size is small, the lag length is restricted to two periods only. The null hypothesis in all the three tests is that y_t is a non-stationary series; it is rejected when α_t is significantly negative. The critical values for DF (trend), ADF and ADF (trend) are 3.45, 2.88, 3.45 respectively. *I* denotes the probable order of integration.

Co-integration Test

Several tests for co-integration have been proposed in the literature (Engle and *Granger*, 1987; *Engle* and *Yoo*, 1987; *Johansen*, 1988). The importance of allowing for alternative methods of estimating long-run coefficients is stressed by *Arize* and *Shwiff* (1993) and also *Hansen* (1990).

In our general specification of the model equation (v), the test for co-integration is the t-ratio on β_{1i} (*Banerjee et al*, 1993). However in this study, further insights on co-integration is obtained by performing ADF tests on the residuals of the estimated equation. The residuals from the cointegrating regressions were retained and treated as the estimates of the disequilibrium errors; these were then tested for stationarity using ADF tests. That is, an equation of the following type was tested for stationarity:

$$\Delta e_t = \phi^* e_{t-1} + \sum_{I=1}^{p-1} \phi^*_i \Delta e_{t-1} + v_t \quad \text{.. (vi)}$$

If the variables in the cointegrating regression are co-integrated, then the residuals, (e) from it should form a stationary series. We used Δe terms lagged up to four quarters and obtained the following results.

$$\Delta resm_1 = -1.0018\ resm_{1\ t-1} - 0.04724\ \Delta resm_{1\ t-1} + 0.19944\ \Delta resm_{1\ t-2}$$
$$(-2.7980) \qquad (-0.13668) \qquad (0.61131)$$

$$+ 0.50375\ \Delta resm_{1\ t-3} + 0.51535\ (resm_{1\ t-4} \quad \text{...................... (vii)}$$
$$(1.7763) \qquad (2.7970)$$

The ADF statistic is the `t-ratio' on $resm_{1\ t-1}$ and is given in the bracket. Critical values for m = 3 at five per cent level of significance for sample size of 50 is 3.75.

The residual of the equation will be non-stationary under the null hypothesis of non co-integration. The co-integration tests can also be supplemented by an examination of the auto-correlation function of the residual and by the standard test statistics for serial correlation. If the residual is found not to be correlated at all across time, then it will be safe to conclude that there is co-integration between the I (1) variables in the equation. The results of the various tests in fact show no evidence of non co-integrations for the equation (vii). The t-ratio on the ECM term of m_1 specification is significant and the *Dickey-Fuller* statistic rejects the hypothesis of a unit root (see equation vii).

Hence it can be concluded that demand for narrow money (m_1) is co-integrated with agricultural as well as non-agricultural income and the interest rate on savings deposit.

The Empirical Results : Demand for Money in Nepal

Although economic theory is a guide to the basic steady state, long-run specification, it is the data that determines this specification along with the signs, lags and the size of the coefficient in the dynamic specification (*Hendry* and *Ericsson*, 1991). We exclude the inflation rate from the long-run relationship because it is a I (0) variable. Since the sample size is small (only 30 annual observations), the lag length in the general specification is restricted to two periods only.

The general to specific modelling process, adopted in this study (equation v) revealed the following estimates of demand for narrow money m1 in *Nepal*.

$$\Delta m_1 = \underset{(-2.8609)}{-4.2918} + \underset{(2.2266)}{0.5648}\,\Delta yag + \underset{(1.7508)}{0.2509}\,\Delta ynag - \underset{(-1.5122)}{0.1248}\,\Delta r_{sd}$$

$$\underset{(-4.2104)}{-0.62499}m_{1\ t-1} + \underset{(2.1729)}{0.42565}\,yag_{t-1} + \underset{(4.1868)}{0.5749}\,ynag_{t-1} \ .... \ (viii)$$

R^2	= 0.5589	F(6,23)	= 4.8571	RESET	= 3.5646
$\overline{R}^2$	= 0.4438	SE	= 0.0577	Serial Corr.	= 0.38893
RSS	= 0.07669	NORM(2)	= 1.9950		
DW Statistics	= 2.1378	HET	= 1.6029		

Figures in brackets in equation (vii) indicate `t' values. Most of the co-efficient are significant at five per cent level of significance; however, the coefficient on non-agricultural income is significant at ten per cent significance level only. The income elasticity of money with respect to agricultural income is seen to be higher than that with non-agricultural income. However in an agricultural dominated economy like Nepal where agricultural income remains mostly non-monetized, increase in such income in comparison to non-agricultural income simply reflects the fact that there is less demand for money for transaction purposes. Whereas in the non-agricultural sectors, the demand for money for asset purpose is relatively higher. It implies that most of the savings in the agricultural sector is normally held in the form of physical assets in relation to the savings from non-agricultural sectors which is usually held in the form of financial assets.

The opportunity cost variable although correctly signed seems to be insignificant even at ten per cent level of significance in explaining the observed variations in real m1. However since its `t' ratio at least exceeds one, we retain it in the equation. The interest elasticity of demand for money being insignificant, contradicts the *Keynesian* liquidity preference hypothesis. The poor performance of the interest rate variable would mean that the particular rate chosen is not an appropriate measure of the cost of holding money. We also tried to see, if the weighted average rate or the rate of interest on 12 month deposit would serve as a better measure of the opportunity cost of holding money; both of them did not prove to be fruitful.

In a study on the demand for money in nine industrial countries' *Kaufman* and *Latta* (1966) found that interest elasticity was significant in four countries and insignificant in the remaining five. They then opined that interest rate would serve to be significant only in those countries with well developed money markets. This reasoning in fact seems to hold in *Nepal's* case, also since her money market is still rudimentary.

The coefficient for our dynamic specification confirms the fact that the rate of growth of m1 depends positively and significantly on both the rate of growth on the agricultural and the non-agricultural income. However the positive and significant coefficient in the long run relationship prompts us to opine that money is a luxury good because higher the level of income, the more rapid is the rate of growth. The results show that the long-run effects are being fully felt after just a period of one year. Equation (viii) can be reparameterised in the error- correction form as :

$$\Delta m_{1t} = 0.56484\ \Delta yag_t + 0.25096\ \Delta ynag_t - 0.12484\ \Delta rsd_t$$
$$(2.2266) \qquad (1.7508) \qquad (-1.5122)^{@}$$

$$-0.62499\ [m_{1\ t-1} + 6.8669 - 0.6811\ yag_{t-1} - 0.9199\ ynag_{t-1}] \ldots\ldots\ldots\ (ix)$$
$$(-4.2104)$$

This implies that about 62 per cent of any disequilibrium money balance in any one year is made up within the next year.

The t-ratio on the ECM term is significant even at one per cent level, and the DF statistic rejects the hypothesis of a unit root. The diagnostic statistics do not suggest any mis-specification. The LM test confirms the absence of serial correlation, which is also supported by the *Durbin-Watson* statistic. Hence we can conclude that the demand for narrow money in *Nepal* is co-integrated with the level of real agricultural as well as non-agricultural income, and to some extent with the stock of money balance held previously. The signs of coefficient in the cointegrating vector conform to prior expectations. Demand for nominal money balances exhibit a long-run positive association with agricultural GDP as well as with non-agriculture GDP, but it does not show significant association with the opportunity cost of holding money. Besides co-integration and the absence of serial correlation, the model passes a number of diagnostic and stability tests. In particular no evidence of the presence of heteroscedasticity is found. There is no evidence of non-normality in the residuals. RESET test does not detect any mis-specification in the functional form.

Effects of Inflation

Economic theory suggests that in an inflationary situation people would shift out of money into assets which are not significantly affected by inflation, and spend more on consumer goods. This hedging against inflation should however bring about a reduction in real money balances. The rate at which such balances are reduced depends upon how public expect inflation rate to move in future. It is, however, to be noted that since inflationary expectation is not an observable variable, it has to be created; in our case the expected inflation for the present is assumed to be determined by the behaviour of prices in the immediate past. As specified in the general equation (v), inflation was one of the explanatory variables envisaged for the demand for narrow money in *Nepal*. It was found out that the inflationary expectations approximated thus did not perform well in

@ Significant at ten per cent.

explaining the observed variations in the demand for money. The coefficients were wrongly signed and insignificant, as such they were dropped out from the final specification.

The poor performance of the actual rate of inflation may mean either the expected rate of inflation does not hold any relevance in the *Nepalese* context or the actual rate is not a good proxy for the expected rate of inflation. The latter explanation seems to be sensible in our case, since the rate of change of price in *Nepal* shows instability during the period 1965 to 1996 and under such situations of oscillations, it does not seem convincing to conclude that the rate of inflation has no effect on the demand for real m1. It is worth mentioning that the study done earlier in the *Nepalese* context confirms this fact (see *Poudyal*, 1987 for more discussion).

Stability Tests

The stability of the model and the parameters, is of great concern here, especially because unstable results would invalidate the model and they could also indicate that money demand in *Nepal* does not maintain consistent dynamic relationships with the determinants under consideration[3].

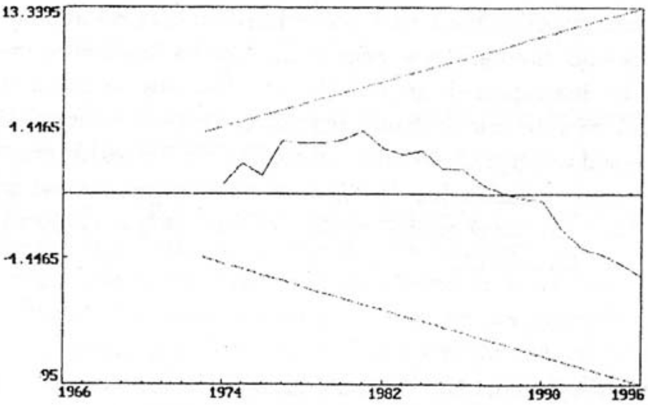
The stability of the parameters was assessed by recursive and rolling estimation of the equation and the results show that none of the estimated parameters cross the five per cent standard error bands, hence no change in the structural parameters is needed and there are no outlier problems.

The equation was also subjected to the CUSUM and CUSUMQ tests, a rigorous test of model stability (*Brown et al*, 1975). It passed both the tests very comfortably thereby confirming that the equation under consideration is correctly specified (Fig 1 and 2). Previous studies done in this area also confirm this fact. *Dr. Y.R. Khatiwada*[4] in his study for the demand for money in Nepal states that the demand for real money balance has been found as a stable function of real income and interest rate for both narrow and broad definitions of money.

3 The RESET test does not indicate any mis-specification in the functional form.

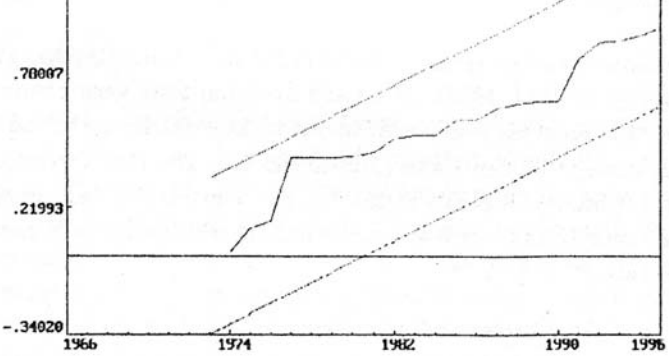
4 For detail discussion see Dr. Y.R. Khatiwada, "Estimating the Demand for Money in Nepal: Some Empirical Issues", Economic Review, 1997, No. 9, Nepal Rastra Bank.

Figure 1
Plot of Cumulative Sum of Rescuresive Residuals



The straight lines represent critical bounds at 5% significance level

Figure 2
Plot of Cumulative Sum of Squares of Rescursive Residuals



The straight lines represent critical bounds at 5% significance level

Conclusions

The purpose of this study has been to investigate empirically the money-demand relationship in *Nepal*. The emphasis has been on using the error-correction dynamic specification. The data set is extended to include those variables which the previous studies of money demand function have found to be relevant. The major finding of this study is that a statistically robust demand for m1 can be estimated for *Nepal* using an error-correction dynamic specification as well as the variables under consideration.

In order to implement monetary policy effectively, it is important to have a stable demand for money and this makes it implicit why one should estimate a money demand function accounting for the variables thought to have an influence on the stability of money demand over the recent past.

The approach followed in this study is believed to rectify the mis-specification error (due to omitted variables) and remove parameter instability. The estimates of the money demand function of *Nepal* brings forward the following concluding remarks:

The demand for narrow money m_1 is highly stable, this has been confirmed by all the statistical tests that were employed.

The agricultural income elasticity of demand for m1 is seen to be higher than that for the non-agricultural income. In an agriculture dominated economy like Nepal where agricultural income remains mostly non-monetized, the share of non-monetized income is expected to be higher because of the existence of subsistence level of farming and also prevalence of barter system in factor payment. In our estimation, the rate of monetization, an important factor affecting the demand for money has not been included while selecting the explanatory variables, as such the co-efficient of agricultural income might have also absorbed the demand for money for monetization of the barter economy resulting in a higher income elasticity. However with the growing ratio of non-agricultural income to total income, demand for money is expected to increase; this has also been found true empirically. (For detail discussion see *Dr. Y.R. Khatiwada*, Economic Review 1997 No. 9, Nepal Rastra Bank).

The study also establishes the fact that the interest rate on non-monetary assets (rates of interest on savings deposits) does not seem to have a significant effect on the demand for m1 balances. In Nepal, savings are mostly held in the form of physical assets, and financial assets consist of a very small chunk in the assets portfolio. Hence in Nepal's case a relatively poor performance of the interest rate on savings deposits suggests that either the money holders are sensitive to the rate of return on alternative assets or the rate of interest on savings deposit is not a good proxy for the opportunity cost of holding money. If we consider the first proposition correct, then the Monetarist's version regarding the opportunity cost variable holds true in our case. The view emphasizes the fact that like in the case for the demand of any other asset, demand for money also depends upon own rate (interest rate) and return on its substitutes (price of physical capital) since these assets serve as the alternatives to the holding of money. The long-run elasticity is substantially larger in case of non-agricultural income whereas it seems to be smaller in the short-run. This suggests that in the long-run the rate of growth of m1 is influenced mostly by non-agricultural income. The positive as well as significant coefficient of income variables appearing in the long-run relationship gives a mild hint that money is still a luxurious item for the Nepalese people. The significant coefficient of the error-correction term establishes the fact that the long-run effects are being felt after a year's period and that about 62 per cent of any disequilibrium money balances in any one year is being made up within the next year. The expected rate of inflation does not seem to have a significant influence on the demand for m1 in Nepal and this is in contradiction with the finding of several studies. This might be either due to that the actual rate of inflation used here is not a good proxy of the expected rate or the expected inflation does not impact upon money demand if it is at a moderate level.

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