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ON THE STABILITY OF DEMAND FOR MONEY IN A DEVELOPING ECONOMY
Some Empirical Issues

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Abstract

The successes of anti-inflationary stabilization policy depends on the stable demand for money function. Recent developments in econometrics emphasize the need to verify the time series properties of the variables in the demand for money function. In studies with conventional approaches to the estimation of demand for money, this was taken for granted. In this paper, we test for the stability of the demand for money in India. Using Cointegration and the corresponding Error-Correction approach we test for the long and short-run relationships, respectively. This paper concludes that both narrow and broad measures of money exhibit long-run stable relationship with real income and rate of interest. The results presented here have implications for the design of macroeconomic stabilization policy in India.

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by

Basanta K. Pradhan and A. Subramanian

1. Introduction

The stability of the demand for money is one of the most important issues in macroeconomic policy analysis. The success of stabilization programs crucially depends on the predictability of the demand for money so that the central bank's control of the money supply can be a useful instrument of economic policy. A monetary policy that seeks to limit the supply of money to its demand facilitates the tasks of demand management and contributes to the achievement of price stability. The rate of growth in money supply should be in conformity with the desired rate of growth in output and thus constrain the price increase to an acceptable level. A stable demand for money implies a stable money multiplier and, therefore, stability makes it easier to predict the effect of a given money supply on the aggregate money income.

There exists large number of studies in this area for the less developed countries.[1] Some interesting studies are Cardoso (1983), Darrant (1985), Gerlach and Nadal De Simone (1985) and Rossi (1989). These studies have highlighted some key issues for the underdeveloped monetary system. This include: which is the proper scale variable? Should the estimated equation include rate of interest or rate of inflation as opportunity cost variable for money demand? And, how does one properly specify the dynamic adjustment of actual money balance to the desired?

Cardoso use one period lagged values of the dependent variable (Koyck-lag adjustment) to estimate the demand for money function for Brazil. Alternatively, Darrant (1985) with lag variables of its current and past values (almon-lag adjustment) in the demand for money specification show that money demand relationship is well fitting and structurally stable over time. Most studies, in general, estimate the conventional demand for money function which incorporates a partial adjustment mechanism to test for the structural stability of these functions. Studies on the Indian economy also incorporate these partial adjustment mechanisms.[2]

The application of these techniques to the estimation of demand for money function may produce faulty results and misleading conclusions because the variables in these models are likely to exhibit systematic tendencies to change over time where as these models presupposes the variables to be stationary[3]. The recent developments in econometrics of cointegration places great emphasis on the time series properties of the variables involved in the econometric models. Hence, variables need to be appropriately transformed to make them stationary. To explore these questions, we employ the Engle and Granger (1987) two step procedure to the Indian data.

First, from the policy standpoint, it is important to identify the correct measure of money as a better guide to monetary policy for the purpose of price stability or having a more reliable long-run relationship with the price level. The data set used are more recent and cover a wider span of time from 1960-61 to 1993-94, a sample period that includes stock market collapse and reforms in the financial sector. The empirical analysis is undertaken with annual data from the various issues of Currency and Finance, Reserve Bank of India (RBI). Here, the time series properties of the variables considered in the specification are explicitly examined for drifts over time. This, in a way, is the characteristics of the dynamic error correction approach to model the underlying equilibrium relationship between real money balance and a set of variables that explain it.

Section 2 briefly discusses how a distributed lag model can be transformed to a general error-correction model. We then describe an error-correction model for the demand for money using specification with just one exogenous variable in section 3. In section 4, the estimates are provided for money demand function with the classical approach to show that estimates from such an approach gives spurious results. We first test for the stability as well as the existence of long run relationship in the demand for money function. And then a complete error-correction model is specified and estimated which is the short-run demand for money. Section 5 provides the concluding remarks.

2. Alternate Models: Some Theoretical Issues

The distributed lag models (both Koyck and Almon approach) ignores the time series properties of the variables in an econometric model. These variables exhibit systematic tendencies to change over time. These systematic changes in mean, variance or autocovariance over time represents the non-stationary behaviour. Most time series variables in macro economics show such a behaviour (Rao, 1994). Therefore, the distributed lag models has to be adopted for more severe constrains with forward looking behaviour. However, such models with forward looking behaviour for demand for money do not support the use of conventional partial adjustment models (Domowitz and Hakkio 1990). Hence, issues on demand for money can be addressed from a more general dynamic structure of which error-correction forms are most widely adopted.

Error-correction terms were first used by Sargan (1964) and later popularised as error-correction modelling as a way of capturing adjustment in a dependant variable which depends not on the levels of some explanatory variable, but on the extent to which an explanatory variable deviated from an equilibrium relationship with the dependent variable. Error-correction model is a linear transformation of the autoregressive distributed lag model with a distinguishing feature that the extent of short-run adjustment to disequilibrium are immediately provided by the regression. [4]

Consider an first order linear autoregressive distributed lag model as given in the following equation:

$$\mathbf{Y_t = \delta_0 + \delta_1 Y_{t-1} + \rho_0 X_t + \rho_1 X_{t-1} + \varepsilon_t} \qquad \textbf{(1)}$$

where ε_t is independently and identically distributed with zero mean and constant variance.

Now consider the following linear transformation which preserves the error process. Subtract Y_{t-1} from both sides of (1) and then add and subtract $\rho_0 X_{t-1}$ on the right hand side we get the following representation:

$$\mathbf{\Delta Y_t = \delta_0 + (\delta_1 -1) Y_{t-1} + \rho_0 \Delta X_t + (\rho_0 + \rho_1) X_{t-1} + \varepsilon_t} \qquad \textbf{(2)}$$

and finally add and subtract $(\delta_1 -1) X_{t-1}$ on the right side, then equation (2) becomes

$$\mathbf{\Delta Y_t = \delta_0 + (\delta_1 -1) (Y_{t-1} - X_{t-1}) + \rho_0 \Delta X_t + (\rho_0 + \rho_1 + \delta_1 -1) X_{t-1} + \varepsilon_t} \qquad \textbf{(3)}$$

All the equations can be derived from one another without violating the equality. In equation (3), the error correction is represented in the discrepancy between Y_{t-1} and X_{t-1}. The coefficient in these terms represent the speed of adjustment of Y to discrepancy between Y and X in the previous periods. Therefore, an error-correction model is simply a linear transformation of a autoregressive distributed lag model.

Error-correction models achieve its importance if the variables are integrated of the same order or that the individual series should atleast have constant conditional mean and variance over time. Some variables need to be differenced to achieve stationarity, while some are stationary at levels. These variables becomes integrated of that order, depending on the number of times the series are differenced to make them stationary. If two variables are integrated of the same order and the linear combination of these variables are stationary then we have a cointegrating relationship or a long run relationship. The concept of error-correction, represents the existence of a long-run equilibrium relationship with short-run adjustments over time. It implies that if a set of variables are cointegrated then there always exists an error-correction formulation of the dynamic model and vice versa. Therefore, a formulation of this type provided in equation 4 necessarily requires a long-run relationship between Y and X with short run dynamics such as the discrepancy between Y_{t-1} and X_{t-1} incorporated in the model.

3. Specification: An error-correction model for money demand

Consider the following simple specification with M_t, the measure of money and Y_t, the real income and U_t, the error term.

$$\Delta M_t = \beta \Delta Y_t + U_t \qquad (4)$$

The change represented by Δ in the demand for money from one period to the next is explained by the change in income over the same time interval. In order to understand the dynamics of adjustment in equation 4 with an error-correction representation, consider the following transformation.

Assume the equilibrium value of $M_t = f(Y_t)$

and at equilibrum

$$\mathbf{M}_{t-1} = \mathbf{f}(\mathbf{Y}_{t-1}) = \Gamma \mathbf{Y}_{t-1} \quad (5)$$

Let Ω be defined as a negative parameter which denotes the degree of adjustment, then represent a relationship such as

$$\Omega\ (\mathbf{M}_{t-1} - \Gamma\ \mathbf{Y}_{t-1}) \quad (6)$$

This takes into account the level of M in period (t-1) relative to the equilibrium value of M for the same period, $\Gamma\ \mathbf{Y}_{t-1}$. Introducing this expression in equation (4) we obtain

$$\Delta\mathbf{M}_t = \beta\Delta\mathbf{Y}_t + \Omega(\mathbf{M}_{t-1} - \Gamma\mathbf{Y}_{t-1}) + \mathbf{U}_t \quad (7)$$

This gives an error-correction representation of demand for money with Ω as the error-correction coefficient (or adjustment parameter), while Γ is the long run multiplier and β, the impact multiplier. Further, U_t is white noise error term, i.e., a mean-zero uncorrelated process. If $-2 < \Omega < 0$, then the characteristics equation of (4) implies a stable long-run relationship $M=\Gamma Y$. Assume that the explanatory variable is integrated of order 1[I (1)]. If the model is stable, then the linear combination $M_t - \Gamma Y_t$ is stationary, although M_t (and Y_t if $\Gamma \neq 0$) are integrated of order 1; i.e., M_t and Y_t are cointegrated of order (1,1) with cointegrating vector $(1,-\Gamma)$. On the other hand, if $\Omega = 0$, then there is no adjustment towards equilibrium and hence no cointegration.[5]

4. The Demand for Money: Some estimates

The issues on demand for money in the literature can be summarised as follows: The first issue is about the choice of variable for the opportunity cost of holding money - interest rate or rate of inflation. High inflation uncertainty would make money a risky asset, leading to a reduction of both long and short term demand for money.

Cardoso (1983) questioned the emphasis placed on the role of expected inflation in demand for money function in Brazil. The emphasis was on interest rate rather than expected inflation while Darrant questioned this proposition with a superior specification for money demand[6]. Darrant found both interest rate and inflation rate to be significant and the demand for money function based on this specification showed stability over time. Kamath (1984) favors expected inflation as an opportunity cost of money balance for India. However, there are diverse views on the appropriate opportunity cost variable. Considering these diverse views, we introduce in our specification both the rates of interest and inflation.

The second issue is about the appropriate scale variable to be used in the demand for money function. Large number of specifications exist in the literature on this issue. Some use consumer expenditure as more appropriate scale variable while others emphasis on per capita income or Gross Domestic Product (GDP). Since GDP is widely adopted, we estimate the demand for money function with GDP at 1980-81 prices as the scale variable.

The third issue is about the structural stability aspects of the estimated demand for money function or the choice of proper functional form which exhibit structural stability. This issue is addressed in this paper with a dynamic specification such as the error correction modelling, discussed in the previous section. We begin the empirical exercise with the estimation of demand for money function with the classical approach to show that estimates from such an approach gives spurious results.

The demand function for money is specified as

$$\ln M_t = b_0 + b_1 \ln I_t + b_2 \ln R_t + b_3 \ln Y_t + e_t \quad (8)$$

where $b_1 < 0;\ b_2 < 0; b_3 > 0$

The M_t is the stock of real money balance defined both in the narrow measure of money (M1) and broad measure of money (M3). The M1 is defined as currency and demand deposit while M3 is defined as M1 plus time deposits with the banks. The I_t is defined as **(1+i)/(1+R)**, where i and R are short term commercial bank deposit rate and inflation rate, respectively. The Y_t is the real GDP and e_t, the disturbance term assumed to have zero expectation. Both M_t and Y_t are in logarithmic form as they give better results than the simple linear form, while rate of interest enters in the original form where log (M/P) is the dependent variable. The P indicates wholesale price index.

The results of the estimates are reported in Table 1. The negative signs for rate of interest and inflation are as expected. This is also true for Y with a positive sign. For alternate models of money defined narrowly, Y is significant in all the cases while one year lagged values of inflation rate is significant.

Table 1: Results of the OLS Estimates

Independent Variable(s)	Dependent Variable							
	LM_1	LM_1	LM_1	LM_1	LM_3	LM_3	LM_3	LM_3
Constant	-7.347	-6.650	-7.838	-5.655	-16.780	-17.041	-16.334	-17.729
	(7.04)	6.05)	(7.26)	(5.19)	(16.57)	(17.41)	(17.49)	(19.04)
I		-0.004		0.020	-0.059			-0.068
		(0.21)		(0.91)	(3.01)			(3.75)
I(-1)	-0.016		-0.028			-0.061	-0.045	
	(0.81)		(1.35)			(3.25)	(2.47)	
R		-0.000	-0.001		0.000	-0.002		-0.001
		(0.10)	(0.39)		(0.31)	(1.19)		(0.63)
R(-1)	-0.004			-0.006			-0.005	
	(1.72)			(2.23)			(2.29)	
Y	1.222	1.052	1.168	0.955	2.012	2.037	1.969	
	(11.18)	(9.94)	(11.19)	(9.09)	(20.62)	(21.53)	(21.92)	
Y(-1)							2.108	
						(23.38)		
R^2	0.96	0.96	0.96	0.96	0.98	0.98	0.98	0.99
DW	0.91	0.97	0.94	0.91	1.51	1.42	1.35	1.47

Note: (a) inc refers to variable included in the estimation.
(b) Figures in the parenthesis are t-values.

Rate of interest with and without lags show significant results with respect to M3. One year lag for inflation rate and real income also show significant results for M3.

The measure of goodness of fit, R^2 is close to one; the perfect fit, while DW statistics for all the equations are in the inconclusive range and too low. Low DW statistics is an indication that the variables in a regression models are non-stationary (Phillips, 1986). Hence, the application of Ordinary Least Square in the estimation of demand for money function of the above form could lead to produce faulty results. Thus, this problem demands a different approach to modelling of demand for money which tests individual variables for the existence of unit roots and the necessary transformation of the variables which exhibits non-stationarity in the data. One such modelling approach described previously in section-3 is the error-correction approach which requires the variables to be integrated of the same order.

Test of Integration

To test for stationarity of the individual variables, we examine all the variables for the existence of unit roots. We also test for the stationarity of the linear combination of different variables (test of cointegration). All the variables tested for unit roots are in log form except the rate of inflation.

Before testing for cointegration, the order of integration of the individual time-series must be established. The tests used to investigate the existence of unit roots in the variables are based on the Dickey- Fuller (DF) and Augmented Dickey-Fuller (ADF) test. The regressions for DF and ADF tests are presented below - equation 9 and equation 10 representing DF test and ADF test, respectively.

$$\Delta \ln Z_t = \alpha_t + \beta_1 \ln Z_{t-1} + \beta_2 T + e_t \quad (9)$$

$$\Delta \ln Z_t = \alpha_t + \beta_1 \ln Z_{t-1} + \beta_2 T + \sum_{f=1}^{n} \beta_f \Delta \ln Z_{t-f} + e_t \quad (10)$$

where Z_{t-1} is the one year lag of the relevant time series, Δ is the first difference and e_t is the residual, and T is a linear deterministic time trend. The null hypothesis that Z_t is a stationary series is rejected when the coefficient of Z_{t-1} is not significantly negative.

Table 2 given below presents the results of the test of Dickey-Fuller (1979) and Augmented Dickey-Fuller test for Narrow measure of money (M1), broad measure of money (M3), real interest rate (I), and Gross Domestic Product (Y).

In all the cases the null hypothesis of non-stationarity is accepted except the rate of inflation which is significant at 1% level. Therefore, rate of inflation is stationary at levels.

Table 2. Results based on Unit Root Test

Variables	DF	ADF
Lm1	- 1.51	-0.83
Lm3	- 2.61	-2.57
R	- 4.16 *	-4.61
LI	- 3.46	-1.28
LY	- 1.88	-1.47

Mackinon critical values - 5% level is -3.55
and at 1% level is -4.27. * significant at 5% level.

Proceeding further, we make use of the unit root test to find out if the series becomes stationary after differencing once[7]. If the series becomes stationary after differencing once then the original series is Integrated of order one.

Table 3. Results based on Unit Root Test after differencing

Variables	DF test	ADF test
Lm1	- 7.67	-6.05
Lm3	- 5.64	-4.49
LI	- 5.62	-5.38
LY	- 6.68	-5.40

All the variables are significant at 1% level

The t values in the table exceeds the Mackinnon critical value at 1% level of significance (-3.657). Therefore, first-differenced series do not exhibit unit roots. In other words the series are stationary in differences which can be represented as I(0) and the original series as I (1).

Co-integration: Engle-Granger test

The possibility of a cointegrated relationship between variables integrated of the same order can be examined by estimating a cointegrating regression with these variables. As indicated earlier, a cointegrating regression attempts to fit a long-run relationship among variables which are theoretically correlated and whose time series has the same order of integration.

$$\ln M_t = a_0 + \ln I_t + U_t \quad (11)$$

$$\ln M_t = a_0 + \ln Y_t + U_t \quad (12)$$

$$\ln M_t = a_0 + \ln I_t + \ln Y_t + U_t \quad (13)$$

$$\Delta U_t = \delta U_{t-1} + \sum_{s=1}^{n} \beta_s \Delta U_{t-s} + e_t \quad (14)$$

Where U_t is tested for stationarity using Engle-Grange (EG) test. Based on equation 14, we report the results in Table 4 with DF test, and ADF test statistics; for correcting the autocorrelation in error terms.

Table 4: Results based on test for stationarity

Variables	co-efficient	R^2	Test of cointegration DF	ADF
	Narrow measure of money (1M1)			
lnI	1.21	0.76	-2.19*	-2.54*
lnY	1.02	0.96	-3.09**	-2.19*
lnI & lnY	-0.16 1.14	0.96	-3.46**	-2.32*
	Broad measure of money (1M3)			
lnI	2.03	0.76	-2.35*	-2.72**
lnY	1.73	0.98	-3.27**	-3.00**
lnI & lnY	-0.40 2.00	0.98	-4.61**	-3.65**

* Significant at 1% level - ADF(-2.63)
** Significant at 5% level - ADF(-1.95)

The first combination M1 and Y in log form shows that the linear combination of M1 and Y are stationary at 5% level of significance. This is also true for M3 and I. The linear combination of Y and I for both the measures of money show results which are significant. The levels of significance are provided below the tables. Therefore, both M1 and M3 are cointegrated with real income and rate of interest.

Estimation: The error-correction approach

The estimated equations 15 and 16 for demand for money differed from equation 6 in section-3 in the sense that the new specification includes an opportunity cost variable. Thus, the following specifications were estimated for the demand for money subject to the test of stationarity to determine the order of integration of the individual variables. The results from these tests are reported at a later stage in this paper.[8]

$$\Delta \ln M1_t = \alpha_t + \sum_{i=1}^{n_1} \beta_{1i} \Delta \ln Y_{t-i} + \sum_{i=1}^{n_2} \beta_{2i} \Delta \ln I_{t-i} + \delta_1 e_{t-1} + z_t \qquad (15)$$

and

$$\Delta \ln M3_t = \alpha_t + \sum_{i=1}^{n_1} \beta_{1i} \Delta \ln Y_{t-i} + \sum_{i=1}^{n_2} \beta_{2i} \Delta \ln I_{t-i} + \delta_1 e_{t-1} + z_t \qquad (16)$$

where e_{t-1} is the one year lag residual of the cointegration regression while z_t is the disturbance term. The coefficient of the error correction term (δ_1) in this specification measures the speed of adjustment back to the cointegrating relationship which is comparable to Ω in equation 6. The estimates based on these equations are presented in Table 5.

Table 5 reports the best empirical results after experimenting with a large number of alternative specifications. The results are consistent with the theory of a*priory expectations*.

Table 5. Results based on the Error Correction Model

ECM for M1 & M3	Coefficient estimates	t-values	R^2, DW respectively
Equation 1 (log $M1_t$)	a_0 = 0.025	1.24	
	Y_{t-3} = 0.418	1.09	0.38
	I_{t-1} = -0.119	-0.96	1.78
	e_{t-1} = -0.580	-3.44	
Equation 2 (log $M1_t$)	a_0 = 0.013	0.72	
	Y_{t-3} = 0.714	1.97	0.51
	I_{t-2} = -0.014	-0.12	1.66
	R_{t-2} = -0.713	-2.74	
	e_{t-1} = -0.491	-3.16	
Equation 3 (log $M3_t$)	a_0 = -0.388	-1.30	
	Y_{t-1} = 0.040	1.56	0.42
	I_t = -0.307	3.29	2.14
	e_{t-1} = -0.471	-3.51	
Equation 4 (log $M3_t$)	a_0 = 0.051	2.74	
	Y_t = 0.588	1.63	0.47
	I_t = -0.256	-2.37	2.09
	R_{t-1} = -0.266	-1.22	
	e_{t-1} = -0.514	-3.48	
Equation 5 (log $M3_t$)	a_0 = -0.513	-1.59	
	Y_{t-2} = 0.051	1.83	0.45
	I_t = -0.336	-3.44	2.13
	M_{t-1} = -0.045	-0.31	
	e_{t-1} = -0.482	-3.51	

Equation 2: $M1_t$
LM test-$X^2(1)=0.87$; $X^2(2)=1.08$; $X^2(3)=0.64$; $X^2(4)=0.54$; $X^2(5)=0.45$
ARCH test-$X^2(1)=1.32$; $X^2(2)=1.05$; $X^2(3)=0.98$; $X^2(4)=0.63$; $X^2(5)=0.58$

Equation 3: $M3_t$
LM test-$X^2(1)=1.02$; $X^2(2)=0.99$; $X^2(3)=1.02$; $X^2(4)=0.85$; $X^2(5)=0.58$
ARCH test-$X^2(1)=1.12$; $X^2(2)=1.02$; $X^2(3)=0.95$; $X^2(4)=1.01$; $X^2(5)=0.95$

In all the equations, the error-correction terms are negative and significant. The scale and the opportunity cost variables are of expected signs in all the equations with negative signs for rate of interest and positive signs for real income. In the first equation, all the variables are insignificant but with expected signs. In equation 2 (see table 5), the rate of inflation is introduced exogenously to observe the impact of this variable on the demand for money. Though, this variable is not included in the cointegration regression because it is integrated of a different order, as mentioned previously. The inclusion of this variable improves the specification with real income showing significant results. The impact of both real income and rate of inflation are equally higher than the rate of interest which has an insignificant influence. Thus, both real income and the expected rate of inflation are significant variables in explaining real money demand in India.

Equations 3, 4 and 5 in table 5 provide the results for M3. The rate of interest, as seen from equation 3, is the major determinant of money while real income is not. The rate of inflation and one year lagged value of money are introduced in equation 4 and 5 to register their impact on M3. Equation 4 shows that the rate of inflation has an insignificant influence on demand for money. One year lagged value of money also showed insignificant influence on money demand. Under both the specifications, interest rate remained the major determinant of the demand for M3.

A number of diagnostic tests were performed for both narrow (equation 2) and broad (equation 3) measures of money. The results of these test are presented in Table 5. In order to check for serial correlation and heteroscedasticity, Lagrange Multiplier (LM) and Autoregressive Conditional Heteroscedasticity (ARCH) tests, respectively were performed upto order 5. Some common tests for parameter stability such as Cumulative Sum of the recursive residuals (CUSUM) and the Cumulative Sum of recursive residual Squares (CUSUMSQ) were performed. These tests showed no evidence of serial correlation, heteroscedasticity or parameter instability. Therefore, the estimated equations are stable over time.

Before concluding this paper, it is important to test whether the variables in the long-run relationship are cointegrated. The initial conditions for the variables to have cointegrating relationship is for the variables to be stationary and integrated of the same order. The remainder of this section is devoted to test for the order of integration of the individual variables and the existence of long run relationship in the demand for money function.

5. Some Concluding Remarks

This paper set out to estimate the demand for money function with money defined narrowly (M1) as well as broadly (M3), for the Indian economy. In the light of some serious statistical problems in the empirical application of distributed lag models, we estimate the demand for money function with an cointegration analysis and dynamic error-correction modelling. The cointegration analysis showed that both the definitions of money showed long-run relationship with real income and rate of interest.

The error-correction models showed that interest rate is insignificant in a specification for money defined narrowly. Both real income and rate of inflation are significant when real income and rate of interest are introduced together in the demand for money function. The M3 showed significant results with only rate of interest.

Notes

1.A summary of the studies on developed countries are given in Laidler (1993).

2.For a review of the studies on the Indian economy see Kamath (1984).

3.A stationary series refers to a series exhibiting constant mean, variance and autocovarience over time.

4.See Banerjee, Dolado, Galbraith and Hendry (1993) for several other transformations.

5.For a more explicit exposition see Holden and Perman (1994).

6.Almon method used by Darrant (1985) has a distinct advantage over the Koyck method (used by Cardoso (1983)) as the latter has some serious estimation problems that results from the presence of the stochastic explanatory variable and its likely correlation with the disturbance term.

7.Differencing the logarithmic series.

8.Rate of Inflation is not specified in the model because this variable is integrated of a different order; I(0), while other variables are I(1).

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