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A vector error correction and nonnested modeling of money demand function in Nigeria

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Abstract

This paper examines the stability of the demand for money in Nigeria. With relatively simple model specifying a vector valued autoregressive process(VAR),the money demand function was found to be stable and evidence gathered from the non−nested tests suggest that income is the more appropriate scale variable in the estimation of money demand function in Nigeria.

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1.0 INTRODUCTION

In most macroeconomic theories, the relation between demand for money balances and its determinants is a fundamental building block. And yet most macroeconomic models, whether theoretical or econometric, generally ignore the rich institutional detail of the financial sector and attempt to capture financial factors via the demand and supply of money. Furthermore, the demand for money is a critical component in the formulation of monetary policy and a stable function for money has long been perceived as a prerequisite for the use of monetary aggregates in the conduct of policy. This has therefore led to the extensive empirical scrutiny of demand for money function in many countries.

The appropriate specification of the relationship between the long run theory and the short-run dynamics has dominated much of the time series economic research in the 1980s and represents the principal response to the collapse of many of the aggregate macro-economic relationships in the 1970s (Davidson et al, 1978). Thus, the econometrics of dynamic specification have led to important revisions to the modelling of macro-economic relationships in recent years, including money demand functions (Engle and Granger, 1987; Johansen and Juselius, 1990). In line with this development, most of the recent applications for the Nigerian economy include studies by Nwaobi (1993) and Nwaobi (1999). And yet a more recent development is concerned with the appropriate scale variable to be utilized in the demand for money relationship. Most theoretical considerations suggest as a more appropriate scale variable in the demand for money, consumer expenditure rather than the traditional income variable (see Mankin and Summers, 1986; Arestis and Demetriades, 1991; and Elyasiani and Zadeh, 1995). This paper therefore sets out to examine the stability of the demand for money in Nigeria by concentrating on these developments.

In seeking to construct an improved model, we formulate an equation that integrates long-run properties with short-run dynamics, based on the recent merging of the theories of error correction and cointegration. The resulting model is critically evaluated. The sequence involves a natural progression from model discovery to model evaluation through replication and testing, and then via new conjectures back to discovery, seeking models that account for previous findings and explain additional phenomena. It is thus the objective of this paper to achieve this last goal for Nigeria's money demand models over the period 1960-1995. An additional objective is to exposit an econometric framework that makes precise the notion of an improved model, explains the construct of accounting for previous findings (denoted encompassing), and delineates the criteria for model evaluation. This will then enable us to clarify the concepts of encompassing and cointegration in the context of current important economics debate. Section two looks at the theoretical and data considerations. Section three analyses the cointegrating and dynamic relationships. The performance of the two estimated dynamic demand for money function is compared through non-nested procedures in section four. Section five summarizes the argument and concludes the paper.

2.0 THEORETICAL AND DATA CONSIDERATIONS

We define vector of variables of interest in determining the demand for money in Nigeria, X as

X	=	[LM1, RLSC, LINT, LP]
	=	[LM1, RLGDP, LP, LINT]
	=	[LM1, RLC, LINT, LP]

where LM1 is Natural Logarithm of nominal money balances; RLSC is the natural logarithm of real scale variable; LINT is the natural logarithm of interest rate; LP is the natural logarithm of prices; RLGDP is the natural logarithm of income variable; and RLC is the natural logarithm of real consumption variable. A number of important issues arise when considering the appropriate data to be used as proxies for the variables of the model. Here, we adopt the money aggregate report by the international momentary fund financial statistics yearbook, namely, MI (defined as notes and coins in circulation outside the banking system plus demand deposits with commercial banks). As concerning the choice f appropriate scale variables, we choose gross domestic product for income scale while choosing total consumer expenditure as consumption scale.

Regarding the price series, the ideal prices deflator would be an expenditure deflator in which the weights reflected the components of expenditure for which money is used. This deflator is however not available in Nigeria. Whereas most models of the demand for money in developed economies use the GDP or GNP deflator, we choose to use the consumer price index. In an open economy such as Nigeria, GDP deflator is not appropriate since it is constructed as a value-added deflator, which includes but excludes imports. The CPI deflator avoids this problem since it includes imports and excludes exports. And since the majority of total expenditure is on consumption, the CPI provides a reasonable first-order approximation to the true price deflator. Concerning interest rate, we note that there is only a small number of interest bearing assets held by the private sector. Throughout most of the period under examination, the authorities have controlled domestic interest rates. However, all interest rates have generally been adjusted in a consistent manner over the period such that despite the absence of an active market mechanism through which interest rate changes are transmitted, all the main rates of interest have tended to move together. Consequently, using discount rate (which refers to the rate at which the monetary authorities lend or discount eligible paper for depot money banks) is a reasonable approximation to the true interest rate. More, the choice of discount rate is only determined by the fact that it is the only consisted annual interest rate series.

Next, we investigate the time series characteristics of our data so as to ensure consistency in subsequent econometric modeling. Our results showed that the ADF unit-root test does not reject the null for the model variables but rejects the null for their differences.

3.0 COINTEGRATION AND DYNAMIC ANALYSIS

In order to impose the cointegrating vectors on the error correction model, we regress

$$A(L)\,\Delta\, LM1_t = \delta o + \Delta RLGDP_t + C(L)\Delta LP_t + D(L)\Delta LINT_t + E(L)ECM1_{t-1} + F(L)ECM_{t-1} + \sum \alpha_i D_i + \in_t \qquad (3.1).$$

Where A(L) … F(L) are polynomials of the form $A(L) = \sum\phi_i L^i$ in which L is the lag operator such that $L^r X_t = X_{t-r}$ and D_i are dummy variables. ECM is the Error Correction Vector. Equation (3.1) can be written in a more general form as

$$\Delta LM1_t = \delta o + \phi_1\Delta LM1_{t-1} + \phi_2\Delta LM1_{t-2} + \beta_1\Delta RLGDP_t + \beta_2\Delta RLGDP_{t-1} + \beta_3\Delta RLGDP_{t-2} + \lambda_1\Delta LP_t + \lambda_2\Delta LP_{t-1} + \lambda_3\Delta LP_{t-2} + \theta_1 LINT_t + \theta_2\Delta LINT_{t-1} + \theta_3\Delta LINT_{t-2} + \prod_1 ECM1_{t-1} + \prod_2 ECM2_{t-1} + \alpha_1 SAD + \alpha_2 WAD + e_t \qquad (3.2)$$

The variables of the model are as defined above except for SAD that represents structural adjustment dummy while WAD represents war dummy. The results of the regression equation (3.2) are presented as equation (3.3).

Given the over-parameterization of equation (3.2), a sequential simplification search (similar to general to specific approach) was undertaken to reach a more parsimonious model. The representation was therefore simplified to the error-correction model by transforming the model to an interpretable and near orthogonal specification and eliminating negligible and insignificant effects:

$$\Delta LMI_t = -2.1343 + 0.63910\Delta RLGDP_t + 0.41295\Delta LP_t - 0.097526\Delta LINT_t - 0.36165ECM2_{t-1}$$
$$(-3.6816) \quad (4.3309) \quad (2.2824) \quad (0.88935) \quad (-3.7740) \qquad (3.3)$$

^

Equation (3.3) is similar in form and in numerical parameter values to several successful money demand models for the developing countries (see Arestis and Demetriades, 1991; Adams, 1991; Nwaobi, 1993; and Choudhry, 1995). Its coefficients satisfy the sign restrictions on the equation to be interpretable as a money-demand function. The coefficients sizes imply large immediate responses to changes in income and prices but slow adjustment subsequently to interest rates and remaining disequilibria, via the error correction term. Concerning the statistical attributes of our model, various diagnostic checks are insignificant (if regards as test statistics) and indicate design of a model congruent with the information available. From the reported diagnostic tests, the residuals are white noise. There is no ARCH, RESET, or heteroscedastic evidence of misspecification; the residuals are approximately normally distributed.

At this juncture, and inline with the objectives of the study, we re-estimated our dynamic money demand equation using consumption, as the appropriate scale variable. Indeed, we adopted the same procedure as that used in estimating the final error correction model (vector) of the income-scaled money demand function. And for space limitation, we report only the estimated final equation as shown below:

$$\Delta LM1t = -1.6772 + 0.79790\Delta RLC + 0.96882\Delta LP - 0.10383\Delta LINT - 0.29282ECM11_{t-1}$$
$$(-2.2912) \quad (4.2444) \quad (5.3710) \quad (-0.58900) \quad (-2.3780) \qquad (3.4)$$

Again, the reported diagnostic tests supports a sensible consumption scale-money demand function of the Nigerian Economy. But comparing it to income scale-money demand function will result in the selection of the income as the more appropriate scale for the Nigerian case.

4.0 NONNESTED MODELLING (ENCOMPASSING)

The theory of encompassing offers an improved empirical research strategy, specifically developed to augment the tradition of empirically testing with the further requirement that a model should be able to explain or account for the results obtained by rival models. Consider the following two linear regression models:

$$M_1 : y = X\beta_1 + u_1, \qquad u_1 \sim \quad N(0, \sigma^2 I_n) \qquad (4.1)$$

$$M_2 : y = Z\beta_2 + u_2, \qquad u_2 \sim \quad N(0, w^2 In) \qquad (4.2)$$

Where y is the n x 1 vector of observations on the dependent variable; X and Z are n x k_1 and n x k_2 observation matrices for the repressors of models M_1 and M_2; β_1 and β_2 are the k_1 x 1 and k_2 x 1 unknown regression coefficient vectors; and u_1 and u_2 are the n x 1 disturbance vectors. Models M_1 and M_2 are said to be non-nested if the regressors of M_1 (respectively M_2) cannot be expressed as an exact linear combinations of the regressors of M_2 (respectively M_1). For the purpose of our paper therefore, the consumption scale money demand model is labeled model 1 while the income scale-money demand model is labeled model 2.

The various kinds of non-nested tests, information and likelihood criterion are portrayed in tables 4.1 and 4.2. The N-test is attributed to Cox (1961, 1962) as modified by Persaran (1974). The NT-test is the adjusted Cox-test derived in Godfrey and Pesaran (1983). The W-test is the Wald-type test of M_1 against M_2 proposed in Godfrey and Pesaran (1983) The J-test is due to Davidson and Mackinnon (1981). This test is valid asymptotically, but in small samples the NT-test, and W-test are preferable to it. The JA-test is due to Fisher and Mcaleer (1981). The Encompassing test was proposed by Deaton (1982), Dastoor (1983), and Mozon and Richard (1986). In the case of testing M_1 against M_2, the encompassing test is the same as the classical F-test and is computed as the F-statistic for testing $\delta = 0$ in the combined OLS regression.

$$y = X_{ao} + Z^*\delta + u \qquad (4.3)$$

where Z* denotes the variables in M_2 that cannot be expressed as exact linear combinations of the regressors of M_1. This is encompassing test is asymptotically equivalent to the above non-nested tests under the null hypothesis, but in general it is less powerful than these for a large class of alternative non-nested models. The choice criteria or model selection criteria are Akaika Information Criterion (Akaike, 1973) and Schwartz Bayesian Information 'Criterion (Schwartz, 1978). Both use statistics, which incorporate measures of the precision and parsimony in parameterization of models.

Four other non-nested test statistics and two choice criteria are used for pair-wise testing and choice between linear, log-linear and ratio models. The PE-test statistic is proposed by Mackinnon et al. (1983). The BM-test statistic is proposed by Bera and McAleer (1989) and is used for testing linear versus log-linear models. The Double-Length (DL) regression statistics is proposed by Davidson and Mackinnon (1984). The Simulated Cox test statistics, denoted by S-test, is developed by Pesaran and Pesaran (1993) and subsequently applied to tests of linear versus log-linear models, and first-difference versus log-difference stationary models (Pesaran and Pesaran, 1995). Sargan's (1964) likelihood criterion compares the maximized values of the log-likelihood functions under M_1 and M_2, while Vuong's criterion (1989) is motivated in the context of testing the hypothesis that M_1 and M_2 are equivalent, using the Kullback Leibler information criterion as a measure of goodness of fit.

TABLE 4.1 TESTS FOR NON-NESTED REGRESSION MODELS.

	HO: MODEL 1	HO: MODEL 2
	H1: MODEL 2	H1: MODEL 1
N-TEST	-4.7688	-3.2303
NT-TEST	-3.1782	-2.1028
W-TEST	-2.6258	-1.8589
J-TEST	3.3964	2.5626
JA-TEST	1.8419	1.4605
ENCOMPASSING F(3,25)	3.7696	2.2986 F(3,25)

AIC (MODEL 1 VERSUS MODEL 2) = -2.1381 FAVOUR MODEL 2
SBIC (MODEL 1 VERSUS MODEL 2) = -2.1381 FAVOUR MODEL 2

TABLE 4.2 NON-NESTED TESTS BY SIMULATION.

	M1 AGAINST M2	M2 AGAINST M1
S-TEST	-2.4929	-1.5062
PE-TEST	3.3964	2.5626
BM-TEST	1.8419	1.4605
DL-TEST	3.4330	2.7304

SLC (MODEL 1 VERSUS MODEL 2) = -2.1381 FAVOURS M2
VLC (MODEL 1 VERSUS MODEL 2) = -4.4447 FAVOURS M2

AIC = AKAIKE INFORMATION CRITERION
SBIC = SCHWARTZ BAYESIAN INFORMATION CRITERION
SLC = SARGEN'S LIKELIHOOD CRITERION
VLC = VUONG'S LIKELIHOOD CRITERION

Looking at table 4.1 (the non-nested regression models tests), we observe that the evidence adduced therein is overwhelmingly in favour of model 2, in which income is the scale variable. All the six test statistics clearly reject model 1 against the alternative of model 2. at the same time, in no case did the null hypothesis that model 2 is true be rejected model 1. Also, the two information criteria (AIC and SBIC) reported clearly favours model 2. All the four tests in the various replications clearly reject model 1 in favour of model 2. Equally, the two-likelihood criterion (SLC and VLC) reported clearly favours model 2 as the acceptable demand for money function in Nigeria. These evidence provides strong support to the proposition that income is a better scale variable than consumption scale variable in modeling the demand for money function in Nigeria.

5.0 SUMMARY AND CONCLUSIONS

This paper has addressed the estimation and testing problem of long-run relations in economic modeling. With a relatively simple model-specifying vector valued autoregressive process, the hypothesis of the existence of cointegration vectors is formulated. Using Nigerian data, we found that the demand for money (LM1) is cointegrated with real income (RLGDP), interest rate (LINT) and price level (LP). The four variables were found to be integrated of order one. That is, they are I(1). This implied that the levels of these variables are differenced once to achieve stationarity, and applying the Johansen maximum likelihood estimation procedure, we accepted the alternative hypothesis of two cointegrating vectors. Adopting general to specific approach, an over parameterized dynamic money demand function was estimated. Furthermore, evidence gathered from the non-nested tests, suggest that income is the more appropriate scale variable in the estimation of the demand for money in Nigeria. This results sharply contradict most findings based on developed countries studies but the results are in tune with the majority of studies that used income as the appropriate scale variable in demand for money functions estimated through techniques of cointegration and error correction mechanism.

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