Another look at the transactions demand for money in Nigeria

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Ayodele Olalekan TERIBA

Being a thesis submitted in partial fulfillment of the requirements for the award of the

Doctor of Philosophy (Ph.D.) Degree in Economics

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ABSTRACT

This study sets out to model non-bank public's desired holdings of five different measures of money in the Nigerian economy. These are currency outside banks (COB), demand deposits (DD), narrow money (M1), quasi money (QM), and broad money (M2).

The study addresses many of the pitfalls inv

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DECLARATION

No part of the materials included in this thesis has previously been submitted for a degree in this or any other University**.

** I am grateful to members of thematic-group on 'Domestic Financial Mobilization' (Group C) in seven biennial AERC workshops held in mostly Nairobi, but also in Harare and Johannesburg, participants at the Oxford CSAE workshop on money demand, CEAR Seminar, and IMF Research Seminar, for the numerous useful comments I received in the course of preparing earlier drafts of the chapters of this thesis. Specifically, I wish to thank Christopher Adam, Ulrich Camen, Paul Collier, Angus Deaton, Laurence Harris, Mark Henstridge, Akin Iwayemi, Moshin Khan, Machiko Nissanke, Sam Olofin, Catherine Pattillo, Klaus Schmidt-Hebbel, Lemma Senbet, Luis Serven and Adedoyin Soyibo for very helpful comments and suggestions. Kehinde Ogunjobi (now late) helped to compile the initial data on money demand, Funke Alaba helped compile the data for interest rates spread, while Yinka Lawanson and Hajara Atta helped with estimation and compilation of the results. Yinka Lawanson also helped revise earlier drafts. The usual disclaimer applies.

For kind guidance into research on monetary economics, I must mention my enduring gratitude to Professor S. Ibi Ajayi, who taught me the final year undergraduate course in *Monetary Theory and Policy*, and also supervised my M. Sc. Dissertation on 'Money and Inflation in Nigeria' at the University of Ibadan. For insights on application of new ideas in econometrics to monetary theory, I am grateful to William Peterson, who taught me the M. Phil. course, 'Topics in Applied Econometrics' and supervised my 8,000-word essay on 'Modeling the Demand for Money in Nigeria', for that course at the University of Cambridge. For patient guidance on how to translate complex and rather vague research ideas into lucid written form, I am grateful to Lynne Evans and John Ashworth, my thesis supervisors at the University of Durham.

I very gratefully acknowledge the funding provided by the Lagos Business School (LBS) for my Ph.D. studies at Durham University. Similarly, for funding provided for the 'writing-up' and 'revision' phases of the thesis, I am grateful to THISDAY Newspaper, especially Mr. Nduka Obaigbena, the publisher and Editor-in-Chief. I also gratefully acknowledge the two separate research grants from the African Economic Research Consortium (AERC) for my works on 'Demand for Money in Nigeria' (May 1995-May 1996) and 'Information Content of Interest Rates Spread in Nigeria' (May 1997-December 1999). For his very kind encouragement on the thesis work and honest guidance on my professional development in general, I want to single out and specially thank Dr. John Elegido, Deputy Director-General of the Lagos Business School. For the strong support throughout the six and a half years I spent at the LBS I will like to thank the Director-General, Professor Albert Alos, and our other colleagues, especially Dr. Doyin Salami, with whom I had the benefit of numerous discussions on the themes pursued in this thesis. I am grateful to the many members of the Lagos Business School Alumni Association who showed keen interest in the progress of this research.

On the social front in England, I am grateful to Paul and Mary Kattuman who happened to be there to offer the much needed guidance for settling down when I arrived Cambridge, and then again, when I arrived Durham; to the Akinolas, whose home in Oxford was my second abode; to my cousins who lent strong moral support, Korede and Titi, Deola, Biola, Dewale, Biodun, Yinka and Tokunbo; to my friends who shared the day-to-day emotional burden of writing the thesis, Al-Habib Onifade, Muyiwa Fagbola, Tope Agboola, Adelowo Oyelade, Lola Ajayi-Obe and Wagner Dada; and to Linda Barclay and Keith her husband, for the numerous German Shepherd Dog shows we attended together. Back home, I am grateful to my dad (who passed on while I was correcting this thesis, may his gentle and cheerful soul rest in perfect peace) and mum, my sister, Funmilayo, and her husband, my brothers, Kayode, Dapo, and their wives, as well as Dayo, for their unwavering moral support over all the years. I am grateful to 'Yinka my wife and our sons, Toluwani, Ifeoluwa, Anuoluwa, and Opeoluwa for sacrificing a lot, showing understanding, and the strong support and encouragement I needed at home to maintain the right frame of mind for this research.

Above all, I give thanks to the Kind and Most Merciful God Almighty for the enabling grace and divine providence to see the conclusion of my thesis work.

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I. PUZZLES ABOUT MONEY DEMAND IN NIGERIA

1.1 INTRODUCTION

Economists and policy makers have long been interested in empirical models of the demand for money in Nigeria. From Tomori (1972) to Moser (1997), there has been a steady output of empirical studies on the demand for different monetary aggregates in Nigeria[1]. This study identifies a set of puzzles in that literature and seeks to address them. The set of questions addressed in extant studies has centered on such classic themes as the nature and importance of scale and opportunity cost effects. Which are the relevant opportunity costs of money holding in Nigeria, and how large is the elasticity of money demand with respect to them? What is the size of the income elasticity of money demand in Nigeria? What is the nature of the short-run re-adjustment of the demand for money following a shock? What is length of the adjustment lag? These concerns have been pursued within the framework of transactions' demand for money, for narrow and broad money alike, as well as for each of their sub-components. At least five of the contributions assessed the responses of different aggregates to the same set of explanatory variables.

The other set of important questions that have not been explicitly addressed in the literature on money demand in Nigeria center on the fit between background information on the Nigerian economy and the theory that we wish to test. Some of these relate to the basic issues of which monetary aggregates should be modelled in the transaction's framework and which ones should not. If differences exist among the different aggregates, how fundamental are such differences? Could we, on intuitive grounds, reasonably expect the transactions' demand framework to be applicable to all available monetary aggregates in Nigeria?

[1] See Chapter three for a review.

Another neglected issue relates to the choice of scale variable. What measure of transactions should we use, output or expenditure? The issues surrounding the choice of deflator and their implications for the resulting empirical models are also largely neglected. Which deflator is the most relevant, given the proliferation of scale variables for each of which there is a deflator, and, what difference does the choice of deflator make? Answers to both sets of questions should make up the stylized facts about the transactions' demand for money in Nigeria today. The main objective of this study is to firmly establish those stylized facts.

1. 2 PLAN OF THE STUDY

The remainder of this Chapter identifies the key puzzles that linger on demand for money in Nigeria and lists the questions that must be answered to resolve the puzzles. Chapter two provides a discussion of the conceptual and econometric frameworks for money-demand Modelling. Chapter three summarizes the key approaches and findings of previous studies and confronts them with the facts of the Nigerian economy. In this process, we identify some old questions that require new answers, and also identify a set of new questions. Chapters four to eight, attempt to generate the answers. Chapter four examines the information content of interest rates in Nigeria. This done, we commence the money demand modelling with M1 in Chapter five, and thereafter check how much the empirical findings for M1 carry through to its sub-components in chapters six and seven. Chapter seven also examines how much we can broaden the focus beyond M1 and its components. Chapter eight compares the qualitative and quantitative attributes of the money demand models recovered. The answers from chapters four to eight are pulled together in the concluding Chapter, Chapter nine, as *stylized facts* on the demand for money in Nigeria.

1.3 THE PUZZLES

1. *Monetary aggregates modelled.* The tendency in extant studies has been to treat outside money, inside money and quasi money and sums of them as if they can be modelled within the framework of the transactions' money demand function[2]. It is in Chapter seven that we examine the appropriateness or otherwise of *applying the transactions demand framework across all the aggregates* available for Nigeria[3]. Since our objective is to model transactions' demand for money in Nigeria, aggregates that are more appropriately modelled within rival conceptual approaches[4] will merely be identified. We will leave the detailed modelling of such to future studies and concentrate on the singular task of generating stylized facts on transactions' demand for money in Nigeria. This involves clearing the haze surrounding puzzles 2 to 5 as below.

2. *Measurement of transactions.* All the previous studies have also *limited their measure of transactions* to output. We strongly question the appropriateness of this. We show in Chapter three that while economic transactions could sometimes coincide with the level of output, both have often diverged rather widely in the Nigerian case in the face of trade and payments shocks that made total domestic-expenditure significantly different from total output. We suggest that the trade-induced divergence between output and expenditure should inform the selection of the appropriate proxy for the scale variable out of the two. The issue of what should be the most appropriate proxy for the transaction variable in the money demand model in Nigeria is addressed as follows in chapters five to eight:

   i.How has the evolution of different proxies compared with the evolution of the monetary aggregates of interest over time?

[2] See Chapter three.
[3] Chapter seven presents the list.
[4] These are discussed in Chapter seven.

ii. Which of the proxies have the hypothesized empirical relationship with money?

3. *Choice of the deflator.* With only a couple of exceptions, previous studies *used the consumer price index (CPI) as the deflator, regardless of the measure of output employed.* We question the appropriateness of this treatment, and explore the possibility of matching the deflator with the measure of scale variable used. The main issues addressed are:

   i. Is it not more appropriate to match the deflator to the chosen scale variable?

   ii. What are the likely effects of sticking to CPI when consumption expenditure is not the scale variable used, as in most extant studies?

4. *Opportunity costs.* Which are the Appropriate Opportunity Cost Variables? Previous studies on Nigeria have adopted a variety of approaches. The alternatives or combinations proposed have included:

   i. Domestic interest rates and/or domestic inflation rate
   ii. Foreign interest rates and/or foreign interest rate differential
   iii. Exchange rate and/or exchange rate depreciation

5. *Information content of interest rates.* Most of the contributions from the 1980s express strong skepticism about the relevance of interest rates in money demand in Nigeria. Chapter four examines the information content of interest rates in detail.

1. 4. SPECIFIC RESEARCH QUESTIONS

The questions to be addressed in the empirical modelling can be summed up thus:

i. *For which of the six monetary aggregates* in Nigeria can the assumed long run equilibrium relationship between the variables in the transaction demand framework be shown to exist?

ii. Are domestic interest rates informative in Nigeria?

iii. If the assumed equilibrium relationships did in fact exist in Nigeria, among which alternative measures of the variables do they exist, given the proliferation of proxies for *transactions*, the *price level*, and *opportunity cost variables*?

iv. What are the signs, magnitudes and other characteristics of the long run responses of money demand to its determinants? What is the structure of the dynamic adjustment and how fast is the speed with which the relationships converge back to equilibrium following a shock? What are the implications of the findings for monetary policy?

v. Finally, in what directions would further research be useful?

II. ANALYTICAL FRAMEWORK

2.1 Conceptual Approach

The basic feature of money that is of interest in money demand modelling is that it serves as a *medium of exchange*. Currency outside banks (COB) and demand deposits (DD) are the two most common forms of exchange media in most developing economies. The sum of the two defines the *narrow money* (M1) in the Nigerian economy[5]. The need for money holding stems from non-synchronization of income and expenditure flows, income being received in less frequent intervals than expenditure is made. Money holders have a choice of keeping all their wealth in near-monetary or non-monetary assets that earn higher returns than monetary assets. The transaction costs involved in moving wealth out of the other assets into money whenever expenditure is required have to be weighed against the interest income or capital gains to be earned from near-monetary or non-monetary assets held. Hence, rational economic agents have to determine their optimal money holding. By the foregoing, two sets of variables enter the money holders' decision framework. The first relates to the expected volume of transactions. The second relates to the cost of money holding.

Level of transactions: The higher the level of transactions to be undertaken, the larger will be the size of cash holding, all things being equal. Thus, the aggregate money holding is expected to be an increasing function of the level of total transactions in the economy. This said, it is useful to note that there are three possible degrees of responsiveness in money holding as transaction rises. The presence of scale effects might mean that an increase in transactions induces a less than proportionate increase in money holding.

[5] We commence the money demand modelling with M1 in Chapter five, and thereafter check how much the empirical findings for M1 carry through to its sub-components in chapters six and seven. Chapter seven also examines how much we can broaden the focus beyond M1 and its components. Chapter eight compares the qualitative and quantitative attributes of the transactions' models recovered.

This is more often observed in advanced economies with mature financial systems and sophisticated technologies for economizing on cash required per unit of transaction, through the use of credit cards for example. Absence of such scale effects means that increases in transactions will induce an equi-proportionate increase in money holding. Finally, a more than proportionate increase in money holding in response to a rise in transactions can be also observed. It means that money is a 'luxury good' such that more of it is held as income increases and more transactions have to be carried out. This could be observed in less developed economies at the initial phases of monetization. To take the Nigerian example, Nigeria's economy was largely agrarian and predominantly rural prior to independence in 1960. With independence came the growth of bureaucracy and urbanization, both of which had the consequence of attracting a growing fraction of the population from subsistence farming into paid employment in the civil service and growing urban centers throughout the 1960s. Monetization and the banking habit grew in tandem with these developments. The sharp rise in oil prices from 1973 to 1979, the 'oil boom', accelerated these processes. It is not unlikely therefore that there could have been a more than proportionate increase in money holding in response to the growth in transactions over that period[6]. The post 1980 period could well be characterized by proportionate responses of money to increases in transactions. Absence of consumer credit, especially credit cards, even at the turn of the 21st century means that no significant scale effects are likely to be observed in Nigeria.

[6] Some credence is lent to this explanation by the fact that the Nigerian currency was changed twice over the sample period. First in 1973 when the Naira replaced the Nigerian pound, and also in 1984 when the Naira notes were redesigned and exchanged with old ones to check suspected cases of counterfeiting. Some rural dwellers had lost their fortunes in 1973 because they did not change the old currency notes they buried in their farms for safekeeping into new notes before the old notes seized to be legal tenders. It was a rude awakening for rural dwellers that subsequently started keeping their cash in the banks. As a result, there were no significant rural casualties in 1984.

Cost of money holding: The opportunity cost of money is the interest income and capital gains forgone by holding money rather than other assets. Thus, aggregate money holding would be a decreasing function of the returns on near-monetary and non-monetary assets. Near money assets include less-liquid bank deposits such as savings and time deposits, while non-monetary assets include stocks, bonds, and all physical assets. Money is only one of the alternative forms of holding wealth. Each of the various alternatives yields a mix of income (such as interest income or capital gains), service flows (such as access to liquidity and the facilitation of transactions in the case of money as opposed to the stronger store of wealth attribute of near- and non-monetary assets). Treated as one of the various assets in economic agents' portfolio, the demand for money function can also be depicted as a portfolio optimization problem, where individuals choose the composition of their portfolio to maximize returns on them.

2.2 Motivation for Money Demand Modelling

For almost three decades now, there has been a steady stream of empirical studies on the demand for money in Nigeria: from Tomori (1972) to Moser (1997)[7]. This suggests that the subject is one of the least obscure in the economics of the country. There is however no clear consensus in extant literature on the nature and how to capture the different shocks in money demand in Nigeria[8]. This justifies the current effort: there is a need to attempt *a more conclusive characterization of the nature* and *relative importance* of the relevant shocks in money demand models for Nigeria. Knowledge of the nature, sources, and characteristics of such shifts will help to ensure that supply side interventions by the Central Bank of Nigeria stabilizes rather than destabilize the economy. Herein lies the primary motivation for the empirical modelling of money demand.

[7] See Chapter three.
[8] As should be obvious from Chapter three.

The two important shocks to private sector's demand for money that are of interest to economists are *spending-shocks* and *portfolio-shocks*. Policy options of the government are largely determined by the relative importance of each of these two shocks in private money-holders' portfolio. The central bank needs a knowledge of the relative roles of these shocks in the public's money demand function to ensure that the exercise of its own influence on money supply does not conflict with shifts in money demand induced by these two known sources of shocks.

Spending shocks: Our understanding of spending shocks in Nigeria is complicated by wide swings in the country's terms of trade and net capital inflows which has led to wide divergence between alternative proxies for spending (production, income, or expenditure) over a significant part of the sample period. These would have reduced the reliability of some potential proxies for aggregate spending in the Nigerian economy, raising the need to explicitly address the choice of the most appropriate proxy for the scale variable to be used in money demand models for Nigeria. Unless this is done, our characterization of real spending shocks would most probably be wrong, and the resulting money demand model will be spurious and therefore misleading for policy purposes. Thus, some care must be exercised in capturing the impact of external trade and payments on total domestic transactions in Nigeria before addressing the issue of the impact of changes in total domestic transactions or spending on demand for money by residents.

Portfolio shocks. The task of characterizing portfolio shocks to the demand for money in Nigeria is even more complex. The portfolio of the private sector is made up of both foreign and domestic assets. This opens up two broad sets of issues. One is the relative contribution of domestic and foreign opportunity cost variables to the shifts in the money demand function. The other is the problem of delineating the impact of financial innovation (either endogenous portfolio adjustments or exogenous changes in transaction technology, or both) on the private sector's money holding behavior.

2.3 Theoretical Specification

A broad framework for modelling money demand is:

$$\left(\frac{m}{p}\right)^d = f(y, p, r^{qm}, r, r_f) \qquad \text{... (2.1)}^9$$

m^d is the desired money stock; y is the level of total real economic transactions, measured as real domestic absorption; p is the general price level, measured as the domestic absorption deflator; r^{qm} is the own rate of interest bearing components of money (quasi-money); r is a vector of interest rates on domestic near-money assets (government securities); r_f is a vector of interest rates on foreign deposits and foreign near-money assets (government securities). Vector r is made up of three elements{r = (r^s, r^{qm}, and r^l)} and vector r_f is made up of four elements {(r_f = r_f^s, r_f^m, and r_f^l, as well as r_f^{qm})}. The superscripts, *s*, *m*, and *l* denote short-, medium-, and long-term interest rates on treasury securities, and any one of the three is allowed to enter the different cointegrating vectors. In no case were interest rates of two different maturities entered together in any model, given the well-known possibility of cointegration among interest rates of different maturities[10].

The two sets of foreign interest rates considered are those for the US and the UK. Again, only one or the other is used to examine which one of the two countries had a closer financial link with money market in Nigeria with respect to the specific aggregate under investigation over the sample period.

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[9] This framework derives from an asset market specification of money demand by domestic agents in an open-economy portfolio-balance framework (Branson and Henderson (1985), Kamas (1986), or Leventakis and Brissimis (1991)).

[10] The idea is to allow for the possibility of the different aggregates responding to interest rates of different maturities, such that short term rate may be more relevant to the decision to hold narrow money aggregates while medium or long term rates may be more relevant to broader aggregates.

In double logarithmic form, equation (2.1) yields,

$$\text{Log}\left(\frac{m^d}{P}\right) = \alpha_0 + \alpha_1\text{logy} + \alpha_2\text{logP} + \alpha_3\log r_{qm}^{nig} + \alpha_4\log r_{tbr}^{nig} + \alpha_5 \log r^f + \mu \qquad \ldots (2.2)$$

2.4 Testable Hypotheses

Stability of long-run relations: Equation (2.2) expresses a relationship between the unobservable *desired* stock of real-balances, determined by the right-hand-side variables, and the *actual* stock, the left-hand-side variable. As such, the residuals from estimation of 2.2 will capture deviations of desired money stock from the actual. Both are equal only in equilibrium. Equation 2.2 is assumed to express such a stable long-run equilibrium relationship.

White noise μ: μ is a white noise residual term and as such estimates of it ($\hat{\mu}$) must have zero mean, constant variance, and be normally distributed. The main testable proposition in money demand modelling is thus the hypothesis that equation (2.2) should define a co-integrating relationship such that the residuals from estimating it should be stationary, even if the individual variables are non-stationary.

Error-correction representation: If the above is the case, the inclusion of the lagged residuals from that cointegrating relation in the short-run (dynamic) model for real-money should enable us to measure two things. One is the sign and statistical significance of the coefficient of the equilibrium correction term - a negative and statistically significant coefficient signifies that equilibrium correction does take place. The other is the size of that equilibrium correction coefficient - this will give a clue to the speed with which desired real-balances re-adjust to equilibrium, following shocks that pushes it out of equilibrium. For stable equilibrium readjustment, the expected size is between zero and minus one. The closer to zero, the slower will be the equilibrium adjustment; and, the closer to minus one, the faster the equilibrium adjustment. Values in the neighborhood of –1 suggests that nearly all the errors in the preceding period are corrected in the present period. Values less than minus one, such as −1.1, will signify unstable equilibrium or error over-correction, like the cobweb model in which equilibrium is never regained once lost.

Parameter constancy: All αs (α_i: i=0 ... 5) are assumed to be constant over the sample period in both the long-run equilibrium and the short-run error correction relations.

2.5 Empirical Specification

It has been demonstrated that the deceptively simple hypothesis that demand for money is stable requires a proliferation of auxiliary hypotheses (Cross (1982)). Hendry (1995) succinctly encapsulated the same point as follows: 'A range of issues must be resolved to translate an embryonic theoretical model ... into a useful relationship between observables.'[11] Cross (1982) depicted the target hypothesis of stability of equation (2.1) as H_0, and listed ten possible groups of auxiliary hypotheses:

H_1	hypothesis used to define relevant set of explanatory variables, $M^D = M^D(...)$;
H_2	the functional form $M^D = ...$;
$H_3, H_4, ..., H_Z$	auxiliary hypothesis from the rest of economic theory;
$O_1, O_2, ..., O_M$	hypothesis on measurement of variables involved in theory;
$T_1, T_2, ..., T_M$	hypothesis on the appropriate time lag structures of the H_2 relationship;
$I_1, I_2, ..., I_N$	hypothesis sufficient for the identification of H_2 from the observations;
$C_1, C_2, ..., C_P$	hypothesis underlying the ceteris paribus clause;
$E_1, E_2, ..., E_Q$	hypothesis regarding the generation of the error terms in H_2;
S	statistical inference rule adopted;
D	boundary conditions for delineating empirical observations commensurate with the H_0

It may be noted in this vein that H_1, H_3, H_4, ..., H_Z, and D relate to *economic theory*, while H_2 $T_1, T_2, ..., T_M$, $T_1, T_2, ..., T_M$, $I_1, I_2, ..., I_N$, $C_1, C_2, ..., C_P$, $E_1, E_2, ..., E_Q$, and S

[11] Hendry (1995) Chapter 16 page 581.

relate to the *practical application of econometric analysis* to that theory. O_1, O_2, ..., O_M, hypothesis regarding the *measurement of the variables* involved in the theory, is of necessity the bridge between the two. Cuthbertson (1997) rightly observed that, 'recent studies of the demand for money are essentially '1950s theory and 1990s econometrics' (p. 1197), as empirical studies simply apply new econometric techniques to extant theoretical models. In extending the research to the African setting which differs in several important regards from the OECD settings in which the theoretical models have been extensively tested, a third component needs to be added to the '1950s theory' and '1990s econometrics'. According to Smith (1994), 'this step requires theorists' models to reflect a close understanding of the circumstances that produced the observations' (p 129). In the words of Stanley (1998, p.192, and 198),

> 'Empirical testing requires that the background knowledge be relatively hard ... background knowledge must be at least as well known as the hypothesis under test if our efforts are to be rewarded. ... One might regard econometric results as the hammer, the requisite background knowledge as the anvil, and the theory under test as the nut that we wish to crack'[12].

Chapter three will therefore devote a fair amount of space to extract background information on the Nigeria macro-financial system that will permit a meaningful test of the target hypothesis. The theory is 'the nut', econometric methods represent 'the hammer', and the *recovery of meaningful models in the Nigerian context* is the 'anvil'. Since both the nut and the hammer are relatively well defined in the literature, some extra care is taken to establish the anvil, by giving detailed treatment to the auxiliary hypotheses O_1, O_2, ..., O_M to gain a close understanding of the circumstances that produced the observations. These relate to appropriate measures of the money stock, the purchasing power of money, the opportunity cost, and the transactions' variables in the Nigerian context (Cross (1982)).

[12] Stanley (1998) attributes this metaphor to Lakatos [1970, 186].

These are addressed in Chapter three, in the hope that the background knowledge on Nigeria becomes at least as well known as the hypothesis under test, so that our empirical modelling efforts can be rewarded with congruent and interpretable representations of the data.

2.6 Hypothesis Testing

Since long run stability is statistically testable as the presence or absence of cointegration among the variables in equation (4.2). Cointegration tests equip us with the tool for a meaningful specification search. They also provide us with a reliable basis for discriminating among the competing hypotheses about the expected values of the α_s.

The first step in the empirical modelling of demand for money thus involves testing for the presence of cointegration. The Engle-Granger single-equation static OLS tests (EG) provide a useful starting point (Engle and Granger (1987) in detecting possible cointegrating vectors. In testing for the presence of cointegration, Johansen's maximum likelihood (JML) systems estimator is usefully applied to complement the OLS method. In empirical applications with finite samples, EG is known to have a tendency to accept the null of non-cointegration rather too often, even in cases where cointegration is probably present. In contrast, the JML approach tends to reject the null of non-cointegration rather too often, raising a genuine possibility of 'spurious cointegration' within the JML framework (Gonzalo and Lee (1998)). Podivinsky (1998) in a recent simulation comparison of the powers of Johansen's tests (using size-corrected critical values) and EG tests found that the two tests often have comparable power in detecting a cointegrating vector. And that generally, JML test 'is about as powerful as' the EG test. On the contrary, Gonzalo and Lee (1998) also investigated the robustness of the EG-OLS and the JML and found that the EG test is more robust in detecting the presence of valid cointegrating relations. Both Podivinsky (1998) and Gonzalo and Lee (1998) however recommended the use of both EG and JML tests in empirical applications since we learn from using both tests. It is already well known that in other dimensions the Johansen procedure is superior to the EG method. JML allows one to explore the properties of the cointegrating vectors in a greater detail than could be done with the OLS. Additional possibilities within JML modelling include, tests for the presence of multiple cointegrating vectors, the exact number of such vectors, tests for weak-exogeneity of the regressand and the regressors, and determination of the variables on which each of the cointegrating vectors will be normalized based on revealed exogeneity relationships.

2.7 Model Estimation

Long-run elasticities. Assuming that the existence of a valid cointegrating relationship has been established, *The second step* in empirical modelling is to estimate long run point-elasticities of the money demand models. Again, static OLS estimates of the coefficients of the long-run model will only provide a starting point. The presence of an 'omitted dynamics bias' or 'OLS bias' in finite samples makes this estimator inefficient (Barnerjee et al (1986) and Stock (1987)). For estimating long-run responses in single-equation relationships, there is no reason to expect JML systems estimator to offer any particular advantage. The auto-regressive distributed lag class of single-equation estimators yield more efficient estimates of the long-run elasticities than the static-OLS approach of E-G Wickens and Breusch (1988) provides very detailed exposition of this point in relation to the estimation of long-run elasticities[13]. Bewly and Orden (1994) showed that the ARDL estimator provides more reliable esimates of long run coefficients in single equation relationships than the JML.

Wickens and Bruesch demonstated that the 'Engle and Granger's co-integrating regression is identical to estimating the long-run multipliers from a model misspecified through the omission of short-run dynamics' (Wickens and Breusch (1988), p. 203). The finite sample

[13] Hendry et al (1984), Banerjee et al (1993), and Hendry (1995) provides very detailed discussion of the superiority of the ARDL model in the context of short-run dynamic modelling.

biases of long run estimates will be reduced by not omitting the short run dynamics, as in the ARDL specification. Wickens and Breusch argued that in empirical applications where interest centres on the long run, the one-step ARDL estimator yields better results and is more convenient than the Engle-Granger OLS technique (see also, Wickens (1993)). We thus rely primarily on the Wickens-Breusch ARDL estimator to obtain estimates of the long-run elasticities of the money demand models. These will be compared with estimates obtained from EG-OLS and JML approaches.

Short run elasticities: *The third step* is to estimate the elasticities of the short-run money demand models. The single-equation error-correction models (SEECM) conditioned on lagged residuals from EG regressions (EG-ECM) are widely used in empirical studies concerned with the estimation of the coefficients of dynamic (short-run) models.

Diagnostic tests: *The fourth step* is to ascertain the congruency of EG-ECM using conventional diagnostic tests. Gerrard and Godfrey (1998) cautioned that the finite sample significance levels of diagnostic tests could be sensitive to the method used to estimate the long run coefficients that yield the error correction term in the ECM. They showed that diagnostic tests on Engle-Granger ECM would be unreliable in finite samples.

Gerrard and Godfrey (1998) recommended the estimation of long run coefficients from auto-regressive distributed lag models as proposed by Wickens and Breusch (1988) for use in ECMs. They demonstrated that this approach leads to more reliable misspecification tests for an assumed ECM than the Engle–Granger procedure. They therefore suggested a modelling strategy that involves:

- ◊ Estimating the full ARDL model, that satisfies congruency requirements on the basis of standard diagnostic checks, by OLS to derive estimates of long-run parameters as a first step;
- ◊ Using the estimated long run coefficients to form 'Wickens–Breusch ECM' (WB-ECM), as

they referred to the ECM associated with the ARDL model[14], the application of the usual battery of diagnostic checks to the WB-ECM is the second step.

The misspecification tests on the WB-ECM provide the evidence with which to judge the data consistency of the initial ARDL model itself. The procedure is necessary to ensure the data congruency of the WB-ECM and the associated ARDL model.

The original point of Wickens and Breusch was that the second step of the Engle-Granger procedure is unnecessary if the purpose is to estimate long-run responses. Gerrard and Godfrey showed that the ECM may be neccesary for the purpose of computing the diagnostic statistics needed to evaluate the estimated long run responses, even in cases where the ECM is of no interest in itself. In the empirical modelling of demand for money, however, the ECM is as interesting as the long run relations are. The main point of Gerrard and Godfrey (1998) therefore was that, ' ... the ARDL approach provides not only better estimators of long-run coefficients but also more reliable diagnostic procedures for the derived ECM', (pp. 235). This study will therefore rely on the Wickens-Breusch ARDL estimator for both the long run multipliers and for the ECM models.

2.8 Model Selection Criteria

The fact that conventional t-tests in classical hypothesis testing procedures do not always have good finite sample properties has necessitated widespread use of model selection criteria *to supplement* virtually all hypothesis testing and estimation routines[15]. Model selection criteria are now used *in conjunction with* the classical procedures for the determination of lag lengths, trends/integration order required for unit roots testing in both auto-regressive (AR) and vector auto-regressive (VAR) settings. Model based information criteria are also used for guiding decisions in both residuals-based cointegrated tests and Langrange ratio (LR) based test for

[14] Gerrard and Godfrey (1998), page 234.
[15] See Mills (1998), for example, for a detailed discussion.

cointegrating rank. Information criteria are also used in the ARDL-ECM general-to-specific (GTS) approach in selecting initial congruent generalized unrestricted models (GUM) as well as in checking the validity of reduction/marginalization as modelling progresses towards the final parsimonious form. The most widely used information criteria are Theil's $\overline{R}^2$ criterion, Akaike information criterion (AIC), Schwarz Bayesian criterion (SBC), and Hannan–Quinn criterion (HQC)[16]. A brief discussion of these now follows. In general, Let $\lambda_n(\tilde{\theta})$ be the maximized value of the log-likelihood function of an econometric model, where $\tilde{\theta}$ is the maximized likelihood (ML) estimator of $\tilde{\theta}$, based on a sample of size *n*.

*Akaike information criterion (AIC):* Akaike information criterion (AIC) is defined as; $AIC_\lambda = \lambda_n(\tilde{\theta})$ -p, Where, p ≡ Dimension (θ) ≡ The number of freely estimated parameters. In the case of a single-equation regression model, the AIC_λ can equivalently be written as: $AIC_\sigma = \log\ (\tilde{\sigma}^2) + \frac{2p}{n}$ Where $\tilde{\sigma}^2$ is the ML estimator of the variance of regression disturbances, u_t, given by $\tilde{\sigma}^2 = e'e/n$ in the case of linear regression models. The two versions of AIC yield identical results. When using AIC_λ, the model with the highest value is chosen. But when using AIC_σ, the model with the lowest value is chosen. However, in the case of regression models estimated over the same sample period, the same preference ordering across models will result for both AIC_λ and AIC_σ .

*Schwarz Bayesian criterion (SBC):* Schwarz Bayesian criterion (SBC) is defined by

[16] See Akaike (1973, 1974), Hannan and Quinn (1979), Schwarz (1978), and Theil (1971).

$SBC_\lambda = \lambda_n(\tilde{\theta}) - \frac{1}{2} p \log n$. In application of SBC across models, the model with the highest SBC value is chosen. The alternative version based on the estimated standard error, $\tilde{\sigma}$, is used for regression models: $SBC_\sigma = \log(\tilde{\sigma}^2) + \left(\frac{\log n}{n}\right)p$. In which case, a model with the lowest SBC_σ value is chosen.

Hannan-Quinn criterion (HQC): Hannan-Quinn criterion (HQC) is defined by:

$HQC_\lambda = \lambda_n(\tilde{\theta}) - (\log\log n)p$, or in the case of regression models:

$$HQC_\sigma = \log\tilde{\sigma} + \left(\frac{2\log\log n}{n}\right)p$$

Reliability of the different choice criteria: These criteria select the models primarily on the basis of 'statistical fit' or the maximized value of the log likelihood function. Thereafter each adopts varying degrees of tradeoff between 'fit' and 'parsimony' by using different penalty functions to reflect the different numbers of unknown parameters estimated in the different models. In general, for models involving eight or more freely estimated parameters, the $\bar{R}^2$ criterion and AIC will select the least parsimonious model while the SBC will select the most parsimonious model. The HQC will often lie somewhere between these extremes[17]. Assuming that the 'true' model does in fact belong to the set of models over which one is searching, the SBC and HQC will lead to the correct model choice for large enough samples and under certain regularity conditions (i. e., they can be shown to be consistent[18]). This not true of AIC or $\bar{R}^2$ criterion.

It is important to note that since one is rarely sure that the 'true' model is among one of the models under consideration in most empirical applications, the SBC or HQC is not necessarily preferred to either AIC or $\bar{R}^2$ criterion. The assumption that the model suggested by

[17] See Pesaran and Pesaran (1997).

[18] Lutkepohl (1991) provides a discussion of the consistency property of the model selection criteria.

each criterion is not misspecified must in this case be tested against the sample data: whether diagnostic statistics associated with the specific model selected on the basis of each criterion satisfy congruency requirements or not.

Table 2.1: General robustness properties in specific applications

Empirical application	**Preferred**
i. ADF tests	SBC[19]
ii. Order Selection in Unrestricted VAR	
➢ Small Dimensional VAR	AIC[20]
➢ Large Dimensional VAR	AIC[21]
iii. JML LR Test of the Rank of the CVs	
➢ Small Dimensional VAR	SBC[22]
➢ Large Dimensional VAR	HQC[23]
iv. Generalized Unrestricted Model (*GUM*)	AIC
v. Validity of Model Reduction	SBC

Table 2.1 provides a summary of the specific criterion that has been found better suited to particular applications in recent literature. SBC has been indicated as the most reliable information criteria for use in choosing the optimal lags for ADF tests, while AIC is more reliable in determining the lags for unrestricted VAR, in both small and large dimensional settings. SBC is more reliable in selecting the rank of a small dimensional cointegrating VAR, while the HQC is better in large dimensional settings. In selecting an over-parameterized Generalized Unrestricted Model (GUM), AIC is shown in Chapter five to be more likely to select a congruent model, while the SBC in general takes over in validating sequential steps in model reduction.

[19] See Hall (1994); Agiakloglou and Newbold (1996).
[20] See Ozcicek and McMillin (1999).
[21] See Gonzalo and Pitarakis (1999a).
[22] See Reimers (1992); Cheung and Lai (1993); Haug (1996).
[23] See Gonzalo and Pitarakis (1999b).

2.9 Economic Interpretation/Insights into Economic Behaviour

If long run equilibrium holds, the estimated coefficients and the residuals are well behaved, the interpretable economic information from 2.2 include:

◊ *Transactions elasticity*

A common concern is whether the elasticity of real money demand with regard to the level of economic transactions is unity ($\eta_y = 1$), or not ($\eta_y \neq 1$). In the later case, it becomes interesting to verify the presence or absence of economies of scale in real money holding ($\eta_y \leq 1$)[24]; or, see if real money is a luxury good ($\eta_y > 1$). Thus, *a priori* we expect that $0.5 \leq \alpha_1 \geq 1$ in the long run.

◊ *Price elasticity*

In the absence of money illusion, which means that people behave differently when the same objective situation is represented in nominal terms rather than in real terms, the price elasticity of money demand is expected to be zero for real balances ($\alpha_2 = \eta_p = 0$) and unity for nominal money balances ($\alpha_2 = \eta_p = 1$). Since equation (2.2) is a model of real balances, α_2 is only included to allow a data based test of the presence or absence of money illusion: α_2 will therefore not be reported in cases where it is found to be zero.

◊ *Interest elasticity*

The coefficient of the interest rate on time deposits, α_3, could either be positive or negative across the different measures of money modelled depending on whether quasi-money complements or substitutes the particular aggregate being modelled in money holders' portfolios. For quasi-money itself, this will be the own rate. Coefficients of opportunity costs of money,

[24] Baumol-Tobin inventory theoretic framework posits an income elasticity of half. Friedman's portfolio-theoretic framework posits an income elasticity of unity.

treasury bills at home, α_4, and time deposits and/or treasury bills abroad, α_5, are expected to be negative. In this regard, an alternative specification is:

$$\left(\frac{m}{p}\right)^d = f(y, p, r^{qm}, r, \frac{r}{r_f}) \qquad \text{... (2.1')}$$

Where, $\frac{r}{r_f}$ = the differential between any interest rate in Nigeria and the corresponding interest rate abroad. In double logarithmic form, (4.1') also yields:

$$\text{Log}\left(\frac{m}{p}\right)^d = \alpha_0 + \alpha_1 \log y + \alpha_2 \log p + \alpha_3 \log r_m + \alpha_4 \log r + \alpha'_5 \log (\frac{r}{r_f}) + \mu \text{ ...(2.2')}$$

The only difference between the first specification (equations 2.1 and 2.2) and the second specification (equations 2.1' and 2.2') is that the differential between the relevant interest rate in Nigeria and the corresponding foreign interest rate used in place of the foreign interest rate. This imposes an equality restriction on the coefficients on the interest rates on domestic and foreign assets, thus treating the domestic and foreign assets as perfect substitutes in money-holders' portfolios. Whether this restriction applies to some assets in Nigeria or not is treated as a testable issue in the modelling exercise. Whenever the restricted model dominates the unrestricted one in explanatory power, estimates of equation 2.2' are reported rather than those of equation 2.2.

Either α_3 or α_4 (coefficients of domestic interest rates) will be zero if there are no significant cross-price effects in one of the two directions (complementary or substitution effect) in the long run relation. Both will be zero if interest rate controls succeeded in purging domestic interest rates of useful information to money-holders. Also, α_5 for the foreign opportunity cost variables, will only be non-zero if weak or indirect currency substitution holds, and zero otherwise. If capturing the foreign interest rate effect with a differential, r/r_f results in a better model than including r_f, then α'_5, is reported rather than α_5. This would imply perfect substitutability between local and foreign assets, in the sense that their elasticities are better constrained to be equal. Again, it is expected that $\alpha'_5 \leq 0$. Also, α_5 for the foreign opportunity cost variables will only be non-zero if weak or indirect currency substitution holds, and zero otherwise.

2.10 Econometric validity of empirical models of money demand[25]

i. Additive stability

Additive Stability has to do with the degree of uncertainty about the scope for monetary policy offered by money demand equation. It requires that the standard error of regression should play a negligible role in the explanation of money demand. The additive stability of a money demand equation can be measured by the size of the standard error of the regression equation. The smaller the SER, or conversely, the higher adj. R^2 for the equilibrium relation among non-stationary series, the more additively stable is the equation under consideration. Money demand shifts are more predictable and active monetary policy becomes feasible, as the level of uncertainty about the shift in money demand is minimal.

ii. Multiplicative stability

Multiplicative stability refers to the uncertainty surrounding the effects of policy actions. This can be measured by the size of the standard errors of the individual coefficients in the money demand equation. The smaller the standard errors of the coefficients, the lower would be the additive uncertainty about the impact of policy interventions, and therefore, the larger the scope for active monetary policy, and vice versa. For the purposes of monetary policy, it is the size of the standard errors of coefficients of the long run equation that are more relevant. The practical usefulness of this notion of stability is that it provides clues on the relative degrees of uncertainty surrounding the impacts of spending and portfolio shocks in money demand. It also indicates the level of uncertainty surrounding the use of interest rates to control money demand.

[25] This section draws on the very useful discussion of the different notions of stability in Clausen (1998).

iii. Dynamic stability

Dynamic stability deals with uncertainty about the length and variability of the dynamic adjustment in the money demand equation. It is concerned with the reliability of the average adjustment lag. The length of the mean adjustment lag is measured by the coefficient on the error correction term in the short run equation. To minimize uncertainty, the mean adjustment lag must be accompanied with relatively small standard error and remain stable over time. When these conditions are met, the mean adjustment lag provides a reasonable idea of the *impact-lag* associated with monetary policy actions.

iv. Structural stability

Structural stability has to do with uncertainty about the underlying parameters of the money demand equation. This has implications for the precision with which the coefficients and lags in money demand can be estimated. For reliable estimates, all the underlying parameters must behave predictably over time in the face of changes in the values of the explanatory variables. The parameters must be invariant even to regime shifts/structural changes in individual explanatory variables. It also requires that underlying parameters must be predictable in the face of policy interventions. Structural stability is measurable with the Chow and/or CUSUM tests of the structural stability of all parameters in both the long run and short run models. A first impression can also be gained by recursive estimates, although this is not a formal test. Structural invariance is minimum requirement for the policy usefulness of money demand equations.

III. RESEARCH ON MONEY DEMAND IN NIGERIA

Out task in this Chapter is to specify an empirically testable model of money demand in Nigeria using the ideas laid out in Sections 2.3 to 2.5. In section 3.1, we begin with an overview of the approaches taken in previous studies. We note a series of loopholes in their model specification in section 3.2, before suggesting ways of plugging them in section 3.3. Section 3.4 examines the time series properties of the data.

3.1. *Overview*

The first published empirical money demand study on Nigeria (Tomori, 1972) provoked a lively debate on the relevant issues and methodology for modelling money demand in Nigeria (Tomori (1974), Ajayi (1974), Teriba (1974), Ojo (1974a, b) and Odama, (1974)[26]. The debate addressed a fairly exhaustive set of questions on money demand in Nigeria. The sample period covered, 1958 to 1972, was however rather short, especially since all contributors used annual data. There is a limit to which we could expect robust answers to many of the complex questions from fifteen annual observations. The sample period also covered the pre oil-boom period in which the Nigerian economy and financial system could rightly be described as rudimentary. Numerous other studies have therefore attempted to fill the gaps left by that debate as improved data availability, institutional evolution, and advancement in empirical analysis of monetary data permitted over the past decades. These are summarized in Table 3.1. In the two and a half decades from 1972 to 1997, there have been a total of *two* contributions on demand for currency outside bank, *one each* on demand deposits and quasi-money, *a dozen* on M1, and *eight* on M2. This Chapter attempts to glean what we might learn about transactions' demand for money in Nigeria from the numerous contributions and confront these with the facts of the Nigerian economy.

[26] The debate is usually referred to as the "TATOO Debate", using the first letters of the names of the five economists that contributed to it.

Table 3.1: Empirical Studies on Money Demand in Nigeria[27]

S/n	Authors	Data frequency	Sample period	Model type	Monetary aggregates	Scale variables	Deflator	Domestic opportunity cost variable	Foreign opportunity cost variable
1	Tomori(1972)	Annual	1960-70	Static OLS	M1, M2.	GDP	GDP Deflator	Central Bank's Rediscount Rate	None
2	Teriba (1974)	Annual	1958-72	Static OLS and PA	M1, COB, DD.	GNP	GNP Deflator	Long Term Bond, Treasury Bill, Time Deposit, Savings Deposit Rates	None
3	Ojo (1974)	Annual	1960-70	Static OLS and PA	M1	Unstated[28]	Unstated	Interest Rate, Expected Rate of Inflation	None
4	Ajayi (1974)	Annual	1960-70	Static OLS and PA	M1, M2	GDP	CPI	Treasury Bill Rate	None
5	Iyoha (1976)	Annual	1950-1965	Static OLS and PA	M1	GDP	CPI	UK Bond Rate	None
6	Fakiyesi (1980)	Quarterly	1960I-75IV	Static OLS and PA	M1, M2	GNP	CPI	None	None
7	Darrat (1986)	Quarterly	1963I-79IV	PA	M2	GNP	CPI	Rate of Inflation (CPI-based)	Foreign Interest rate (Average of Short Term Interest Rates in 5 Major OECD economies)
8	Arize, Darrat, and Meyer, (1990)[29]	Annual	1960-87	PA	M1	Non-Agric GDP	CPI	Expected Rate of Inflation (CPI-based)	Foreign Interest rate (Average of Short Term Interest Rates in 5 Leading OECD economies); Expected Exchange Rate with regard to the US dollar
9	Oresotu & Mordi (1992)	Annual	1960-91	PA	M1, QM, and M2	GDP	CPI	Inflation rate (CPI-based); Average of Savings and Time Deposit Rates	Foreign interest rate (Eurodollar rate), Depreciation of the Exchange Rate
10	Fielding (1994)	Quarterly	1976I-89II	E-G	M2	GNP	CPI	Treasury Bill Rate	Depreciation of the Parallel Market (Naira/US$) Exchange Rate
11	Arrau, De Gregorio, Reinhart, and Wickham (1995)	Quarterly	1975I-83IV	Static OLS	M1	Industrial Production	CPI	Rate of Inflation (CPI-based); 'Financial Innovation'	None
12	Hassan, Chouldhurry, and Waheedzzaman (1995)	Quarterly	1976I-88IV	PA	M1, M2	GDP	CPI	Rate of Inflation (CPI-based)	Parallel Market (Naira/US$) Exchange Rate; US Rate of Inflation
13	Moser (1997)	Annual	1970-94	E-G	COB, M1, M2	GDP	CPI	Deposit Rate; Rate of Inflation (CPI-based)	Real Exchange Rate Index

E-G means 'Engle-Granger test', PA means 'partial adjustment', OLS means 'ordinary least squares', ARDL means 'Auto-regressive distributed lag'; ECM means 'error-correction model'. For the monetary aggregates, COB is currency outside banks, DD is demand deposit, and QM is quasi money or the sum of time and savings deposits. M1 is the sum of COB and DD. M2 is the sum of M1 and QM. For scale variables, GDP is gross domestic product; GNP is gross national product. Finally, among the deflators, CPI is the consumer price index.

In this process, we identify some of the old questions to which new answers are needed, and also find a new set of interesting questions. Subsequent chapters attempt to answer both sets. The

[27] Only studies that reported numerical estimates of the money demand function are included. As an example, Odama (1974) contributed to the TATOO debate but presented no numerical estimates. This contribution, although quite important, is not summarized in the Table. The same goes for Tomori (1974).

[28] Ojo's empirical proxies for income, deflator, interest rate and inflation rate were not stated in the paper, which merely referred to 'income', 'interest rate', 'real money balances' and 'inflation'.

[29] Obviously built on two earlier studies: Arize and Lott (1985) and Arize (1987), which are not reviewed here because Arize et al encompasses them.

answers are pulled together in the concluding Chapter as the *stylized facts* on transaction's demand for money in Nigeria.

3.2. Some general observations

Some general observations can be made on the information summarized in Table 3.1. These observations relate to the aggregates modelled, the framework adopted, and the choice of proxies for the explanatory variables by the different contributors.

i. *Monetary aggregates modelled*: Five of the six aggregates available for Nigeria had been modelled. Only base money (MB) has not been modelled[30]. It should be noted that all contributors had modelled each aggregate within the *transactions' demand framework*, the main differences being the choice of empirical proxies for the explanatory variables suggested by the framework.

ii. *Proxy for scale variable*: All contributors had used output as the empirical proxy for transactions or the scale variable. Indeed, GDP or GNP was used in all cases, with only two exceptions, Arize et al (1990) who used non-agricultural GDP; and, Arrau et al (1995) who used index of industrial production.

iii. *Proxy for deflator*: Also with only two exceptions, all previous contributors used the consumer price index (CPI) as the proxy for the price level, regardless of the proxy they had selected for the scale variable. They also used the consumer price index to deflate the monetary aggregates and define the rate of inflation whenever the need arose. The two exceptions were Tomori (1972), used the GDP deflator along with GDP as scale variable, and Teriba (1974) used the GNP deflator along with GNP as a scale variable. They were thus also the only two contributors who matched the deflator with scale variable employed.

iv. *Proxies for domestic opportunity costs:* Proxies selected for domestic opportunity costs by contributors varied more widely. Three broad candidates were: domestic inflation rate only; domestic interest rates only; and, both domestic inflation and interest rates.

- *Domestic inflation rate only:* Darrat (1986), Arize et al (1990), Arrau et al (1995), and Hassan and Waheedzzaman (1995), Ojo (1974a) belong to the group that entertained only the rate of inflation as the 'relevant' domestic opportunity cost variable. This group of authors usually excluded interest rates from consideration *a priori*, i.e., with a mere wave of hand. None of them tested for the relevance of interest rates. Rather, they would typically advance one or two reasons why interest rates should not be considered. Arrau et al (1995) argued that since, 'rates were regulated and virtually constant over the sample period ... inflation was used as a more relevant opportunity cost measure' (p. 323). Hassan and Waheedzzaman (1995) put it more strongly that, '... the expected rate of inflation has been accepted as the true opportunity cost of holding money for developing countries. ... because money markets are relatively thin and controlled in developing countries, the interest rate does not represent the true opportunity cost of holding money' (p. 35).
- *Domestic interest rates only:* Ajayi (1974), Fielding (1994), Iyoha (1976), Moser (1997), Teriba (1974), and Tomori (1972) belong to the group that found domestic interest rates only to be the relevant opportunity costs in money demand function in Nigeria. Among them, only Teriba (1974) allowed for the possibility of more than one rate entering the money demand function at the same time, and found this to be data-admissible. Iyoha (1976) used the UK bond rate as the proxy for 'domestic interest rate' over the 1950-1965 sample-period he modelled[31].
- *Both domestic interest rate and inflation:* Only Oresotu and Mordi (1992) sought roles for both inflation and domestic interest rates as opportunity cost variables in Nigeria.

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[30] Chapter four provides more details on base money in Nigeria.

[31] Nigeria was a British colony until October 1960, and gained republican status only in October 1963, about two years to the end of Iyoha's 15-year sample. It was thus in order for Iyoha to use the UK bond rate as the domestic interest rate over that sample period.

v. *Proxies for foreign opportunity costs:* Contributors before 1981, Tomori (1972), Teriba (1974), Ojo (1974), Ajayi (1974), Iyoha (1976), and Fakiyesi (1980), typically excluded foreign opportunity cost variable from consideration by making no mention of it. Arrau et al (1995) is the only post-1980 study that shares this attribute of the pre-1981 studies. Post oil boom contributors typically considered one foreign opportunity cost variable or more. Again, the proxies selected for foreign opportunity costs by the different contributors varied widely. The following broad groups can be identified: foreign interest rates only Darrat (1986); exchange rate or its depreciation only (Fielding (1994), Hassan et al (1995), and Moser (1997); both foreign interest rates and depreciation (Arize et al (1990), Oresotu and Mordi (1992).

3.3 Moving forward

Previous contributions are thus fraught with widely divergent claims on the empirical representation of money demand in the Nigerian economy. This underscores the point earlier made by Hendry (1995), who said,

> 'Alternative decisions could be made at almost every stage during modelling, so that different scholars could legitimately follow different routes and conclude with disparate models. Most models must be invalid, although each could cover important aspects of the overall picture. Since we are trying to discover an empirical relationship, such proliferation is neither surprising nor worrying: rather, a diverse set of congruent empirical models provides a challenging encompassing exercise.'[32]

At issue here is the validity of the presumptions that could be made by different authors about the correspondence between the underlying theory and the macro-financial setting. This is easily the main source of disparity among the various contributors to the literature. This section therefore devotes some space to a discussion of the relevant features of the Nigerian macro-financial setting.

[32]Hendry (1995) Chapter 16 page 581.

a. *Monetary aggregates to be modelled:* We strongly question the tendency in extant studies to treat all available monetary components and aggregates as if they belong to the transactions' demand framework. We therefore examine the appropriateness of this in Chapter seven.

b. *Proxy for scale variable:* We also question the appropriateness of *limiting the measure of transactions* to output in all of the previous studies. While economic transactions could sometimes coincide with the level of output, both have often diverged rather widely in the Nigerian case in the face of trade and payments shocks that made total domestic-expenditure significantly different from total output.

Figure 3.1a: Logarithms of Real M1 (right scale) and Real Domestic Absorption (left scale)

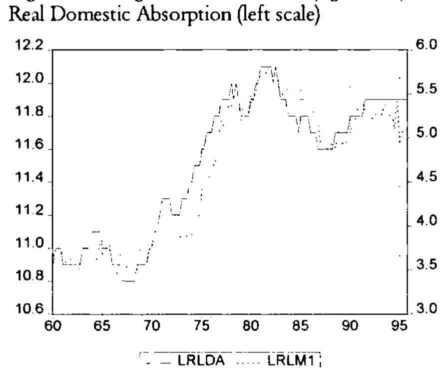


Figure 3.1c Logarithms of Real M1 (right scale) and Real Gross Domestic Product (left scale)

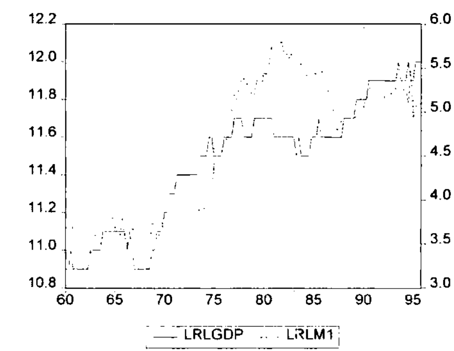


Figure 3.1b: Logarithms of Real M1 (right scale) and Real Private Consumption (left scale)

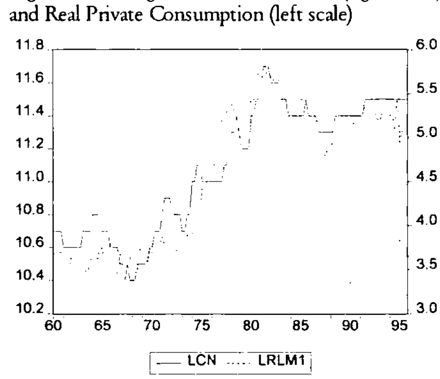
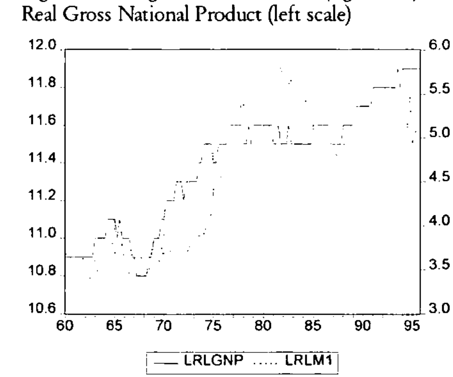


Figure 3.1d: Logarithms of Real M1 (right scale) and Real Gross National Product (left scale)



The trade-induced divergence between output and expenditure should inform the selection of the appropriate proxy for the scale variable out of the two. The issue of what should be the most appropriate proxy for transaction variable in the money demand model in Nigeria could easily be resolved by addressing these two questions:

(i.) How has the evolution of alternative proxies for total transactions compared with the evolution of the monetary aggregates over time?

(ii.) Which of the proxies have the hypothesized long run relationship with the monetary aggregates?

We deal with the first of these two questions here by plotting each of the four proxies available for total transactions with M1 on dual scales. The second question is addressed in Section 5.1. The plots clearly reveal rather weak association between money and measures of output and very close association between money and expenditure[33]. Of the two measures of expenditure, domestic absorption is more closely related to the monetary aggregate.

c. *Proxy for the deflator:* We question the appropriateness of this treatment, and explore the possibility of matching the deflator with the measure of scale variable used. The question that must be addressed on the choice of the deflator for money demand in Nigeria is:

(i.) If a scale variable is judged to be inappropriate for use in money demand modelling, can its deflator still be used in deflating nominal balances without biasing the empirical results?[34] It seems the choice of the deflator should be guided by the same consideration involved in the choice of the scale variable. Some authors use the deflator corresponding to the chosen scale variable (Mankiw and Summers (1986)).

(ii.) Is anything lost by not harmonizing the choice deflator with the scale variable?

A choice has to be made on which deflator to use for deriving real balances from nominal aggregates and also calculating the rate of inflation. It has to be noted that many empirical studies of demand for money in other countries also use the CPI as deflator in conjunction with an output-based proxy for transaction. It is therefore not too clear in the literature if

[33] See Bomberger and Makinen, (1980) and Mankiw and Summers (1986), Arrau and De Gregorio (1991), Sumner (1991), and Elyasiani and Zadeh (1999) for more detailed arguments and some OECD evidence in favour of expenditure based proxy for scale variable in money demand models.

[34] Brajer (1992) and Siklos (1995) both demonstrate the sensitivity of empirical models to the choice of deflators.

this choice should matter in modelling demand for money in general, much less in the Nigerian context. But since we are concerned about discriminating between alternative hypotheses on whether the rate of inflation should be an opportunity cost of holding money or not, clarifying why a particular deflator is chosen rather than the other would seem sensible. Tests of three of the interesting hypotheses in the long run model of money demand crucially depend on the choice of deflator. These are:

i. Zero homogeneity of real balances with regard to the price level ($\alpha_2=0$)[35].

ii. Whether or not the rate of inflation belongs to the long run relationship ($\alpha_3 \leq 0$).

iii. Since the inflation rate has been favoured to replace nominal interest rates in some studies, tests of hypothesis about the empirical relevance of interest rates, $\alpha_4 \neq 0$ (more specifically, $-1 \leq \alpha_4 \leq +1$), and $-1 \leq \alpha_5 \leq 0$ will also depend on the proxy used for inflation.

Thus, it seems in order to find out whether the choice among the various proxies for the price level is important by assessing the impact of the different choices on the different hypotheses about α_2, α_3, α_4, and α_5.

d. *Proxies for domestic opportunity costs:* The following issues must be resolved about the choice of the domestic opportunity costs:

- Does the domestic rate of inflation belong to the long run relation, or not?
- Are domestic interest rates relevant in money demand models for Nigeria, or not?
- Does only one domestic interest rate belong to the model, rather than two?
- Does the rate of inflation belong to model in presence of domestic interest rates, or not?

[35] ($_i$; $i=1 \ldots 5$) defined in equation 2.2 in Chapter two.

We now review the evolution of government regulation in credit and interest rates in Nigeria to see whether the intervention could justify exclusion of interest rates from money demand models.

Government intervention: Table 3.2a provides some history of interventions in the domestic money market, while Table 3.2b provides details of government interventions in the determination of interest rates, both from 1960 to 1997.

Table 3.2a: History of Money Market Interventions in Nigeria

DATES	ACTION
Oct-64	Ceiling on rate of expansion on bank loans and advances was 15% limit.
Nov-66	Removal of credit guidelines and specific selective credit restraints by CBN as the volume and value of money instruments were determined by the financial requirement of the Fed Govt.
Jun-67	Treasury Bill Act of 1962 was amended at the outbreak of civil war to enable government to borrow by means of treasury bills up to 50% of its budgetary requirements.
May-68	Central Bank's rediscount rate was lowered as monetary policies were dictated by financial requirements of government.
Nov.1968	Introduction of treasury certificates (12 to 24 months maturity) due to increasing volume of government short term debts government borrowing capacity is to be enlarged
Dec.1968	Banking Amendment Act was promulgated to equip the CBN with wider powers of monetary control. This was a precautionary measure against strong inflationary pressures at the end of the civil war.
Apr-75	Three new money market instruments were introduced: (a)Certificate of deposit (i. Negotiable CD; maturity between 3 & 36 months; ii. Non-Negotiable CD; interest rate should comply with Central Bank's prescribed range. (b) Bankers Unit Fund (Now Bankers Acceptances); © Eligible development stocks.
Apr-76	CBN re-imposed credit ceilings on bank's aggregate loans and advances to restrain overall level of credit expansion.
1985	Reduction of credit ceiling from 12.5 to 7.0
Aug-87	Credit ceiling of 7.4%.
Aug-88	Credit ceiling reduced to 7%.
Nov-89	Auction based system for issuing treasury bills & certificates was introduced.
1990	CBN reverted to the issuance of non-transferable & non-negotiable stabilization securities to banks with excess liquidity.
Jun-93	OMO was introduced as the final step in the transition to indirect monetary control.
Oct-96	Mandatory sectoral credit allocation was abolished for all banks.
1997	CBN is to disengage from commercial banking business.
	Minimum paid up capital requirement of banks was raised to a uniform level of half a billion Naira owing to the erosion of their capital base by inflation and exchange rate depreciation; high rates of loan failure; and, the distress in the sector

Source: CBN Annual Reports, 1960-1996; Monetary and Credit Policy Guidelines, 1997.

Interest rate caps and floors: Charts 4.4a and 4.4b plots interest rates in monthly frequency from January 1960 to December 1990. Nigeria introduced floors and ceilings for bank deposit and loan rates in 1970, ostensibly to discipline banks after the civil war. It is worthy of note however, that the rates showed virtually no variability between 1964 and that date.

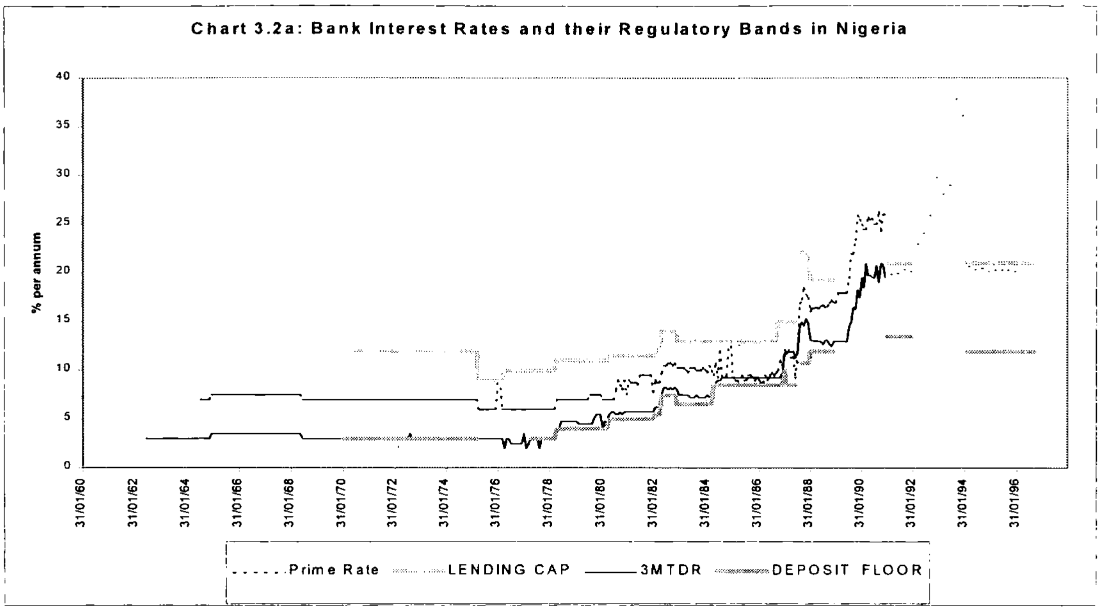
Table 3.2b: History of Interest Rate Control in Nigeria[36]

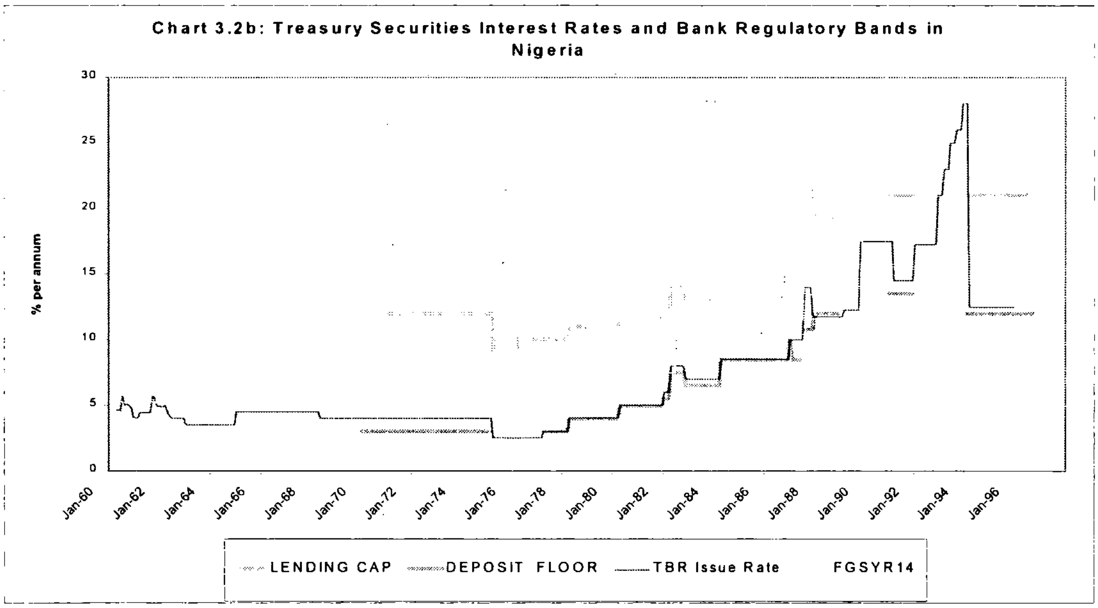
DATE	ACTION
Jun-62	Central Bank began to exert informal influence on banks' by asking them to link their rates to the Central Bank's minimum rediscount rate (MRR).
Mar-70	For the first time, CBN formally linked commercial banks' rates to the MRR and set up a uniform structure of interest rate for all the banks: Deposit rates 3%(Min)-6%(Max); Lending rates 7%(MIN)-12%(MAX). The stated objective was to induce discipline and co-ordination in banks after civil war.
Apr-75	Interest rates structure was altered as follows: Lending rates cap and floor were reduced; 6%-9%; Deposit rates floor was raised; 4%; MRR was reduced to 3.5
Apr-76	Interest rates structure was revised: lending rates, 6%-10%; Deposit rates floor, 4%; rates on large deposits from 20,000 Naira (equivalent to US$30,000 at the time) became negotiable.
Apr-77	Interest rate structure was revised; MRR was increased to 4%; Deposit rates floor was 3%.
Apr-78	Interest rates were revised- MRR: 5%; Deposit rate floor: 5%; Lending rates cap: 11%.
Apr-80	Interest rates structure were revised: MRR: 6%; Lending rates cap: 11.5%; deposit floor: 6%.
Jan-82	Most interest rates were revised upwards by not more than 1percentage point: MRR became 7%; deposit floor was increased to 6.5%;
Apr-82	All interest rates were revised upwards by 2 percentages points: MRR became 9%; deposit rate floor was raised to 8.5%; lending rates; 10.5%-14%.
Nov.-82	Downward review of all rates: MRR became 8%, and savings deposit rate, 7.5%.
Jan-84	Adjustment of rates: MRR: 10%; deposit rate floor: 9.5%; lending rates ceiling: 13%.
Sep-86	Partial deregulation of interest rates was introduced; floor for time deposits was 8.5% but ceiling became negotiable, taking the size and maturity of deposits or loans and the forces of supply and demand for funds into consideration; ceiling on lending rates was raised to 15%
Jan-87	Partial deregulation continued; MRR: 11%; Floor of time deposit was 12%.
Aug-87	***Complete deregulation of interest rates***; All controls on interest rates were removed though MRR continued to indicate the desired direction of interest rates; MRR became 15% (signaling upward revision for other rates)
Dec-87	MRR was reduced by 2.25 percentage points to 12.75%
Jan-89	MRR rose by 0.5 percent to 13.25% this was to be reflected in all other rates.
Nov-89	***Slight Re-regulation***: Margin between prime and highest lending rates should not exceed 4 percentage points; MRR rose to 18.5% *in line with other interest rates* which were quite high.
Jan-90	***Full Deregulation again***: all segments of interest rate structure were to be market determined.
Jan-91	***Back to regulation***; Lending rate ceiling: 21.0%. Deposit rate floor: 13.5%.
Jan-92	***Deregulation again*** with the removal of interest rate cap and floor. However, a maximum spread of 5% between prime & maximum lending rates was to be observed. Interest rates were to move in line with the inter-bank rate to ensure a more active market and provide the institutional base for OMO.
Jun-93	OMO was introduced as the final step in the transition to indirect monetary policy.
Feb-94	**Regulation once more** as interest rates were capped and floored: deposit rate: 12%-15%; lending rate: 21% max.
Feb-95	Further regulation as banks were to maintain a maximum spread of 7.5 percentage points between deposit and lending rates subject to maximum lending rate of 21%.
Oct-96	**Interest rates were fully deregulated.** MRR was to reflect market conditions; other rates were to follow. MRR was maintained at 13.5%; deposit rates ranged between 10.3% & 13.3.
Jan-97	Interest rates stayed deregulated but CBN would intervene if necessary; MRR: 13.5%.

Since the 1960s saw a period of steady real economic growth with low inflation, absence of variation in interest rates is more suggestive of macroeconomic and financial

[36] Source: CBN Annual Reports, 1960-1996; Monetary and Credit Policy Guidelines, 1997.

tranquility[37]. The regulatory floor also appeared to have been fixed at the rate that had prevailed for the half decade preceding the prescription.





Also, the regulatory band prescribed in 1970 remained unchanged until 1975. The prescribed ceilings were far above the lending rates until the mid-eighties (except for a month in 1976), suggesting that the ceilings were redundant for most of that period.

[37] Some authors interpreted this as evidence of a rudimentary financial system.

Similarly, the deposit floors either coincided with or fell below bank deposit rates while they lasted. Deposit rates became more volatile from 1976, and lending rates followed suit from 1980, suggesting a rise in the turbulence in the macro-economy from the time of the oil boom. Modifications of the interest rate bands therefore became more or less an annual ritual from 1976, but these always appeared to follow, rather than restrict or violate, market realities.

Loan and deposit rates were deregulated in 1987. As is common knowledge these were reversed in 1991 and 1994-1996. Market rates therefore prevailed from August 1987 to December 1990, and January 1992 to December 1993. By and large, combining information in Tables 3.2a and 3.2b with that in Charts 3.2a and 3.2b the main motivation for the liquidity and interest rate control measures imposed from 1960 to the mid-1990s tended to be government's financing needs. As such they moved largely in line with the dictates of economic fundamentals (what rates would make the public buy government securities), rather than contrary to fundamentals.

Relevance of interest rates: Note that the deposit rate tended to stay at the same point for many years in the 1960s (Chart 3.2a). This largely reflected the macroeconomic tranquility of that period. Thus in the seven years before the introduction of deposit rate floors in Nigeria, deposit rates had changed only twice, by half a percentage point on each occasion. Also note that the prescribed floor coincided with the rate that has prevailed for more than one and a half years before the 'regulation'. Suggesting that the government merely told the banks to do what they had already been doing for years, making the floor redundant at that time, as in much of the period of deposit rate regulation. Notice also that both the floor and the deposit rate remained at the same number for the first six years of the 1970s (the deposit rate moved up and back only once in that period). There were only a couple of instances when the rates charged by banks violated the floor. At most other times, the deposit rate was actually higher than the floor, suggesting that banks willingly offered deposit rates that were higher than the floors to attract deposits, rendering the prescribed floors redundant. The deposit-rate also showed high variability from quarter to quarter from the mid-1979s onwards, while the floor remained the same for long periods, or was not stipulated at all for some periods. Thus, the existence of deposit rate floors should not necessarily reduce the relevance of interest rates in money demand models. The floors were not binding. The balance of the evidence suggests that government followed the market tendencies in prescribing the floors. Even if the floors had been binding, it might make more sense to expect that the significance of interest rates in money demand models would increase as government would have forced banks to pay depositors more, and that should increase the volume of deposits made. Interest rates would therefore still expected to be strong candidates for the money demand function whether the floors were binding or redundant. Since the floors were redundant, we suggest that interest rates should be candidates in the money demand models for Nigeria in line with standard theory. Again, the claims that regulations made interest rates irrelevant in money demand models are not supported by the facts, but we will still leave the final resolution of the claims to empirical tests presented in Chapters 5.1. We treat issues about the relevance of interest and/or inflation rates and the impact of regulation on the relevance of interest rates as testable empirical propositions. We present detailed tests of the alternative propositions in Section 5.1.

Relevance of interest rate spreads: Assertions about the superiority of interest rate spreads over the level of any individual interest-rate in the money demand function is not new in the literature: theoretical adumbration of the role of spreads in money demand dates back to

Samuelson (1947), Tobin (1958) and Friedman (1977). Tobin (1958) argued strongly for the inclusion of both the own rate of return of money and the opportunity cost of money (that is, the spread between the two) rather than the level of any single rate of interest. His words:

> "Why should anyone hold the non-interest bearing obligations of the government instead of its interest bearing obligations? The apparent irrationality of holding cash is the same, moreover, whether the interest rate is 6%, 3% or 1/2 of 1%. What needs to be explained is not only the existence of a demand for cash when its yield is less than the yield on alternative assets but an inverse relationship between the aggregate demand for cash and the size of this differential in yields. ... Liquidity preference must be regarded as an explanation of the existence and level, not of the interest rate but, of the differential between the yield on money and the yields on other assets".

Tobin thus gave a clearer expression to a point earlier adumbrated by Samuelson (1947):

> "'... in a world involving no transaction friction and no uncertainty, there would be no reason for a spread between the yield on any two assets, and hence there would be no difference in the yield on money and on securities ... in such a world, securities themselves would circulate as money and be acceptable in transactions; demand bank deposits would bear interest, just as they often did in this country in the period of the twenties' (Samuelson (1947), p. 123)".

Note that Tobin and Samuelson implied a role for the spreads among yields on money and non-money assets in demand for money functions. This has to do with the risk structure of interest or what is commonly referred to as the yield spread (as in Dialynas and Edington (1992)). On the contrary, Friedman (1977) suggested a role for the information in the entire term structure of interest rates, i.e. the yield curve or term structure spreads, in the demand for money function. On the empirical side, Klein (1974) and Heller and Khan (1979), and Friedman and Schwartz (1982) were early attempts to specify and estimate the role of interest rate spreads within the money demand function. More recent attempts to account for the empirical roles of the risk and/or term structure of interest rates in the money demand framework include Koenig (1996), Sumner (1996), and Mehra (1997).

Klein (1974) suggested the inclusion of *both* long and short run interest rates. Demand deposits did not explicitly earn a competitive interest rate in the sample period covered by Klein's study. However, the services enjoyed by account holders could be regarded as implicit returns, such that the actual return on checkable deposits is not zero. He used the three months deposit rate as the *proxy* for the own-rate of return on these and a longer maturity deposit rate to represent the return on money substitutes. The own rate will have a positive influence while the opportunity cost will exert a negative impact on money holding. Klein maintained however that the "net interest effect" would remain negative (as the own rate on money *will not* be dominant). The strong point of Klein's study was that if the two rates are not included together, the estimated own and/or the cross price effects of changes in interest rate on money demand will be biased because of the omitted interest rate.

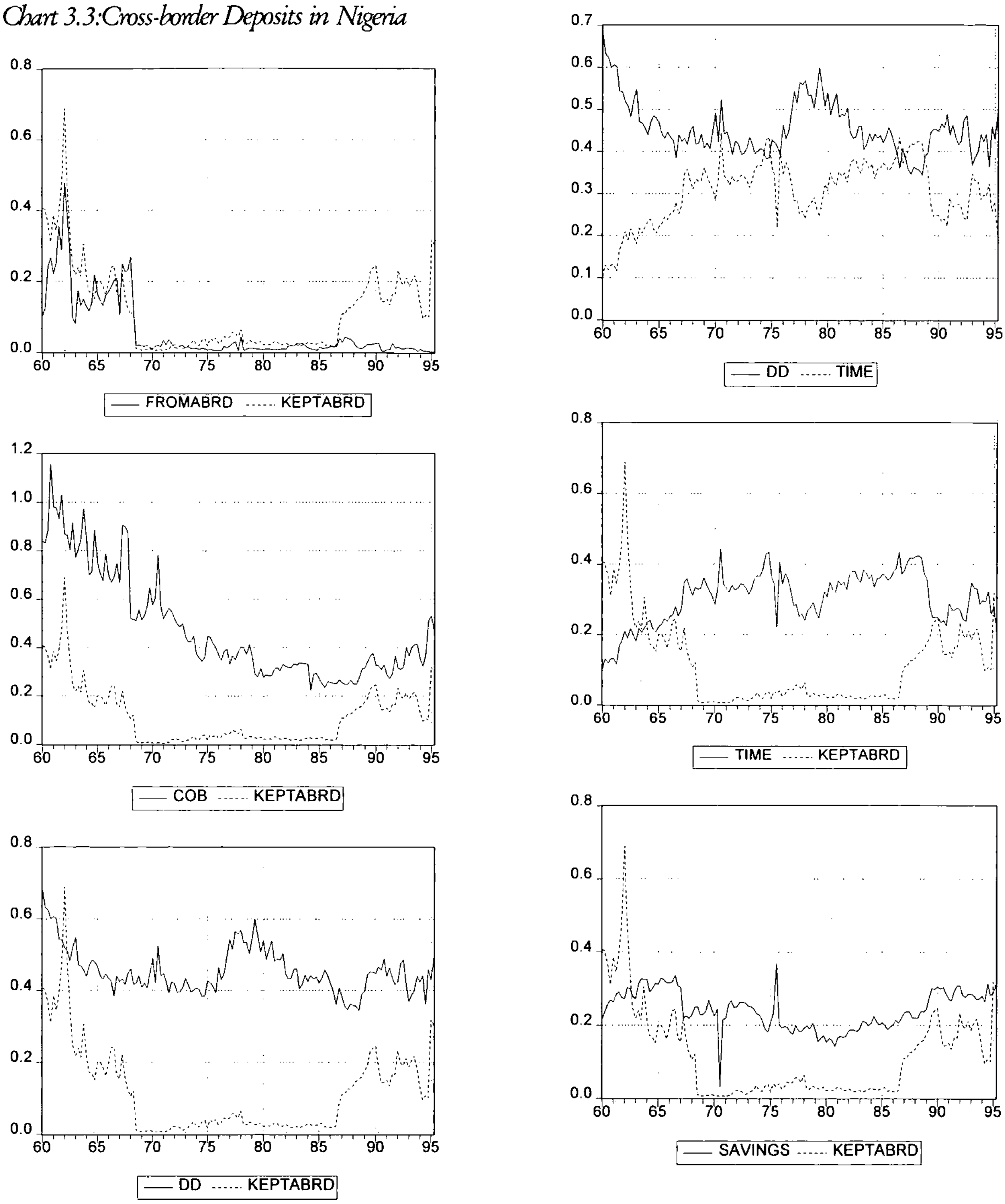
Dialynas and Edington (1992) established the equivalence of yield spreads and term spreads in such a way that risk spreads can also be viewed from a yield curve or term structure perspective. The reasoning is that periods of high liquidity risk/default risk will be characterized by an inverted yield curve as short-rates rise higher than long-rates resulting in a wider spread between risky private securities and risk-free government securities (the commercial paper-treasury bill spread is an example). Taken separately, each of the two mechanisms has a tendency to predict an impending decline in real economic activity- an indication of increased friction in the economy. The fact that the two often occur together implies that in practice, it will be difficult to separate the two effects within a money demand framework. Each of the two picks up essentially the same information about the economy. In general, it should not matter much for the purpose of money demand modelling whether a risk spread or a term spread is used. The key issue is that more than one interest rate should be included in the model. The fact that term structure spreads are known to define cointegrating relations on their own must tilt the balance in favour of risk-spreads in empirical applications that rely on single-equation models of money demand.

e. *Proxies for foreign opportunity costs:*

Foreign interest rates: It is instructive that Iyoha (1976) used the bond rate in the UK as the interest-rate for Nigeria. The study covered the period, 1950-1965. An economist at the Central Bank of Nigeria, Oke (1992) also noted that, "at the inception of treasury bills in 1960, there was free movement of capital between Nigeria and the sterling area". Adding that, "In fixing rates on treasury securities, therefore, account had to be taken of yields on the London Market" by the Central Bank of Nigeria. This revealed that the setting of local rates, by the CBN, was indeed influenced by prevailing foreign rates, at least for some time after independence.

Cross-border inter-bank deposits: Influence of the foreign interest rates on the price setting behavior of the CBN apart, the key issue here is also whether private holders of financial assets are influenced by foreign interest rates in deciding to hold local monetary assets or not. The history of frequent capital movements out of Nigeria by the private sector might suggest that the levels of foreign interest rates relative to local ones influence domestic cash holding. Multinational companies in Nigeria must be aware of the evolution of interest rates in both host and home countries. It is unlikely that they will ignore international interest rate differentials in deciding whether to hold their assets in domestic money and bonds or in foreign bonds. The problem here is the lack of data on the disaggregated monetary liabilities of Nigerian banks by holders (business or private sector). Hence it remains difficult to confirm if and to what extent Nigerian businesses and individuals have been influenced by foreign interest rates, beyond any evidence that may be gleaned from the role of these rates in empirical money demand functions. An indirect clue on the asset holding behavior of the Nigerian private sector can be obtained from the available data on pattern of deposit placement by Nigerian banks over time. We provide some information on the market for inter-bank deposits in Nigeria from 1960 to 1995.

Chart 3.3:Cross-border Deposits in Nigeria



We express deposits placed by Nigerian banks with other banks abroad (KEPTABRD) and deposits placed with Nigerian banks by other banks abroad (FROMABRD) as decimal fractions of the total deposit liabilities of the Nigerian banks. Total deposit liabilities are the sum of demand deposits (DD), time deposits (TIME) and savings deposits (SAVINGS). Currency outside banks (COB), DD, TIME, and SAVINGS are also expressed as decimal fractions of total deposits and plotted alongside the cross-border inter-bank placements to give an idea of the size of these placements vis-à-vis COB, DD, and the two components of QM (TIME AND SAVINGS). A striking feature of the Nigerian inter-bank market is its integration with the international financial system prior to 1970. Funds moved in and out of the inter-bank market on a month-by-month basis[38] and domestic and foreign banks were equally active in making it happen then. After 1970, the size of these flows declined markedly until the mid-80s when outflows picked up again but inflows remained small.

The key point to note about the nature of the inter-bank market in Nigeria is that it does link the domestic financial system with the international financial markets, in spite of the exchange control laws in existence between 1962 and 1995. For this reason, one might expect foreign interest rate to play a role in the demand for money in Nigeria. The plots also give some hint about which of the domestic components of money were substitutes for these offshore placements. COB and SAVINGS appeared largely independent of the placements while TIME showed a clear tendency to decline (increase) when the funds placed above increase (decrease)[39]. DD was largely independent of these placements until about 1986 when it also started to move in the opposite direction to these placements. The stronger substitution relationships are between DD and QM on the domestic front, and QM and KEPTABRD on the foreign front.

[38] Only quarter-end figures are plotted here.

[39] Note the fact that the two components of quasi-money, savings and time deposits clearly evolved differently over the 1960-95 period. We shall return to this point in Chapter eight.

The upshot of all these for money demand modelling is that the interest rates on time deposits in both Nigeria and abroad should be included in the models for DD and QM. The same initial model is however fitted for the different measures to treat the issue of which variable is relevant as an empirical matter.

Asset vs. currency substitution: To capture the influence of foreign economic conditions on the demand for money in Nigeria, portfolio theory, suggests two possible channels: capital mobility; and currency substitutability (see Thomas (1985), Kamas (1986), and Giovannini and Turtelboom (1993)). Specifically, there are two possibilities:

(a). Inclusion of a representative foreign interest rate in addition to the domestic interest rate will capture the influence of capital mobility or substitutability between local money and foreign near-monetary assets (bonds) on the money holders' portfolio;

(b). Inclusion of a measure of the expected depreciation of the exchange rate would capture the influence of the substitutability between domestic and foreign money.

Both possibilities are explored in the modelling exercises reported in Chapter five.

Exchange rate depreciation: The return on foreign assets will be influenced by the exchange rate. Appreciation of the domestic currency relative to foreign currencies leads to a decline in the return on foreign assets to domestic holders. Depreciation will do the opposite. Hence an attempt should be made to capture the influence of exchange rate movements on the return on foreign assets. The external value of the Nigerian currency has been closely related to the value of the US dollar since 1972. Indeed, since the introduction of the auction based foreign exchange market in 1986, the value of the Naira is only determined with reference to the US Dollar. Prevailing exchange rates between the US Dollar and all other major currencies are then used to calculate the cross rates between the Naira and such other currencies. This implies that the Naira\US$ exchange rate is the appropriate one to use for empirical analysis.

3.4. Time Series Properties of the Variables

The *six nominal monetary aggregates* available for Nigeria are plotted in Chart 3.4 (in logarithms). These are currency outside bank (COB), monetary base (BM), demand deposits (DD), narrow money (M1), quasi money (QM), and broad money (M2).

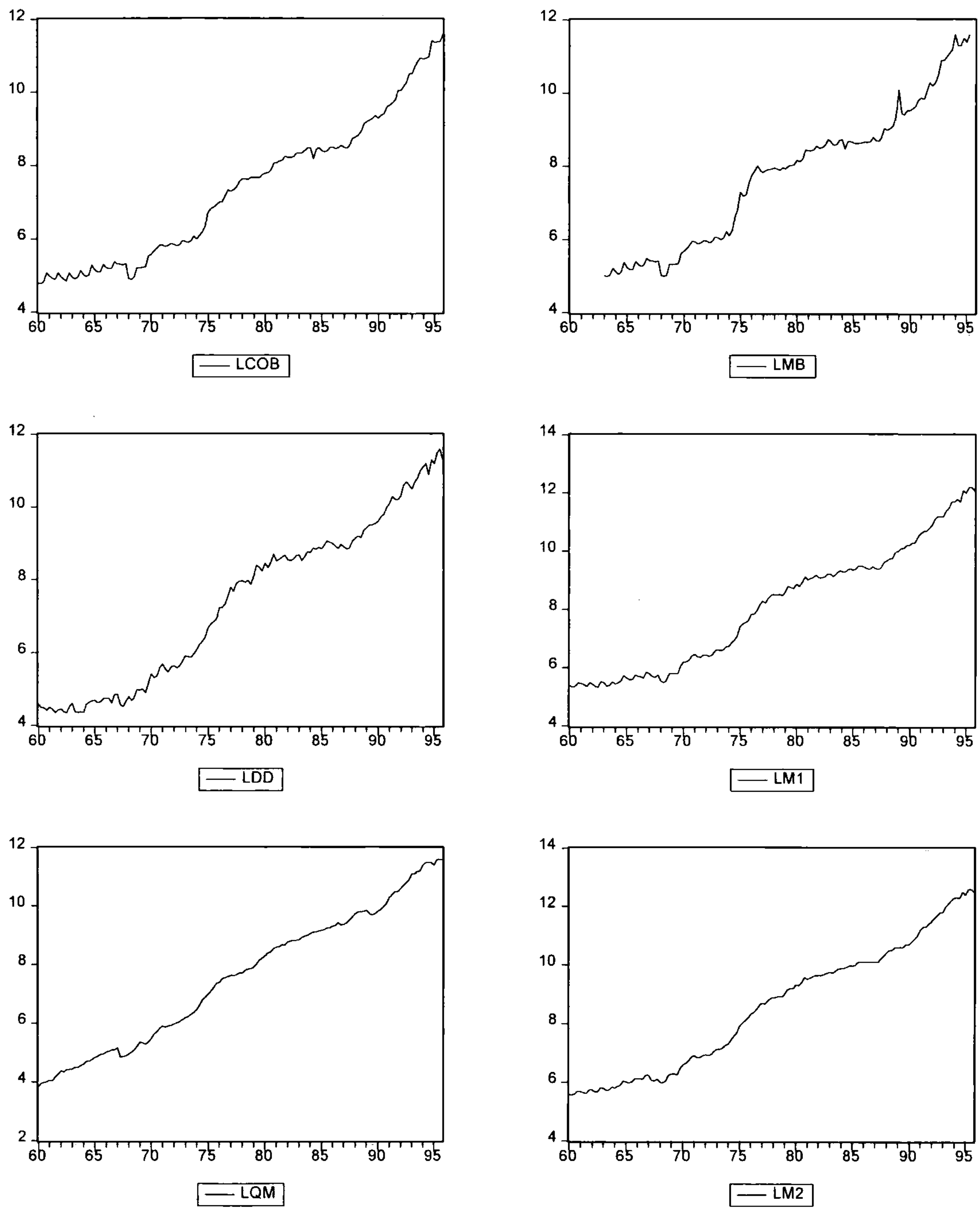


Chart 3.4: Nominal Monetary Aggregates

Table 3.4: Nominal monetary aggregates

VARIABLE	ADF (LOGX) 95% CRIT VAL: -2.88 FOR t=0 -3.44 FOR t≠0	ADF (ΔLOGX) 95% CRIT VAL: -2.88 FOR t=0 -3.44 FOR t≠0	ZIVOT-ANDREWS TEST 95% CRIT VAL= -5.08
LCOB	-2.1388 (4, t)	-3.7961(3,0)**	-1.8051
LMB	-2.1765(0,t)	-12.4507 (0,0)**	-3.1093
LDD	-2.6069(0,t)	-10.7718 (1,0)**	-2.4110
LQM	0.5265(0,0)	-10.5233 (0,t)**	-1.3839
LM1	-2.5492(4,t)	-3.8690 (3,t)**	-2.4282
LM2	-2.2226(0,t)	-3.7382 (3,0)**	-1.6673

The first number in the parenthesis indicates the number of lags used in the reported ADF statistic. The second number is zero if the relevant series does not have a significant trend component, and t otherwise. "**" indicates significance at the 5% level.

They appear to be non-stationary series. It is however hard to differentiate between difference-stationary (DS) and trend stationary (TS) processes by visual inspection. To ascertain whether the series are trend or difference stationary, Table 3.3 reports Dickey-Fuller tests on each of them. The Table also reports Zivot-Andrews tests for the presence of structural breaks of unknown dates in each of the series (Zivot and Andrews (1992)). All but quasi money have statistically significant trend components in the levels ADF regressions. But none is trend stationary, as all the ADF statistics are higher than the 95% critical values. The ADF tests on their first differences reveal that they are all first difference stationary. Only nominal M1 and quasi-money still exhibit significant trend components after first differencing, although they are also stationary. The Zivot-Andrews tests did not reveal any significant structural break in any of the nominal monetary aggregates.

Chart 3.5 presents the *four scale variables* available for Nigeria: two measures of real output and, two measures of real expenditure. Gross domestic product (RLGDP) and gross national product (RLGNP) are plotted on row 1, while domestic absorption (RLDA) and consumption spending (RLCN) are plotted on the second row. Table 3.4 reports Dickey-Fuller and Zivot-Andrews tests on the scale variables.

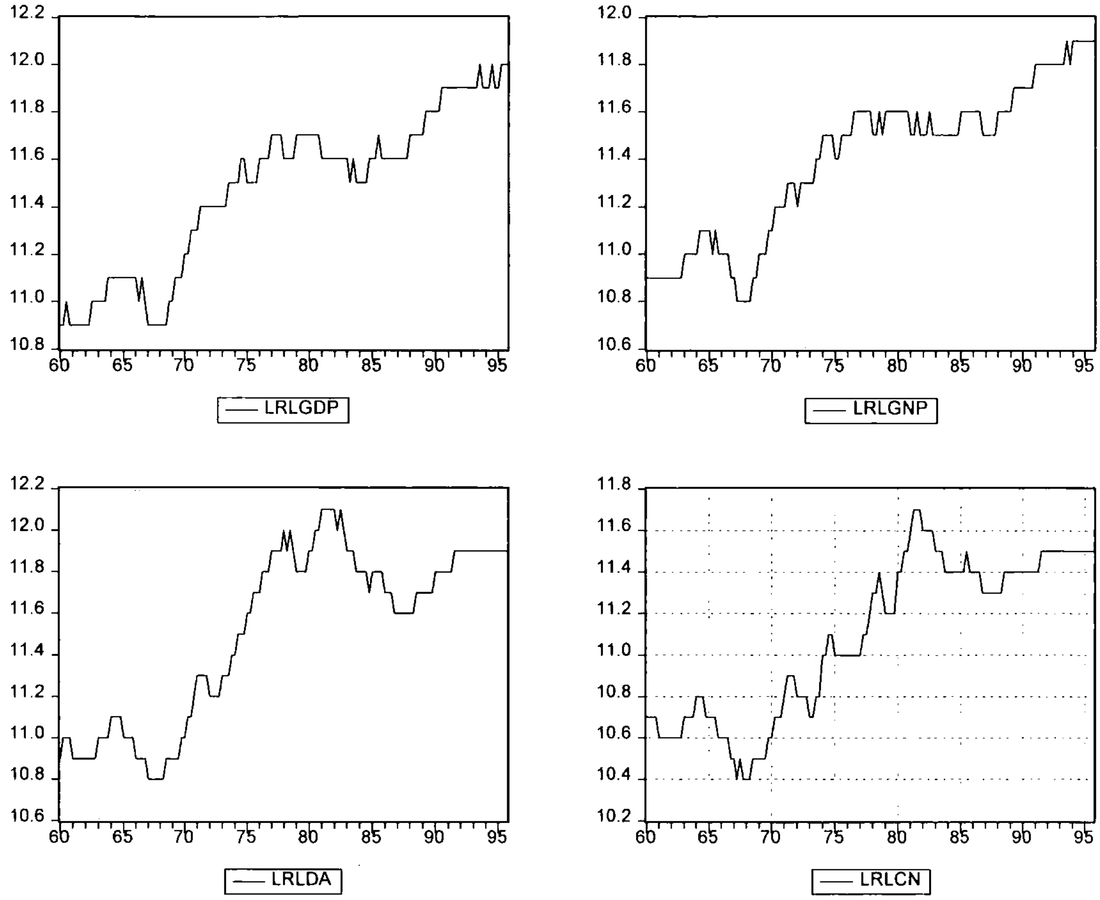


Chart 3.5: Real Output and Real Expenditure

None exhibits a statistically significant trend component in levels or first differences. Again, they are all first difference stationary without any significant structural break over the sample period.

Table 3.4: Scale variables

VARIABLE	ADF (LOGX) CRIT VAL: -2.88 FOR t=0 -3.44 FOR t≠0	ADF (ΔLOGX) CRIT VAL: -2.88 FOR t=0 -3.44 FOR t≠0	ZIVOT-ANDREWS TEST 95% CRIT VAL= -5.08
LRLGDP	-0.93065(1,0)	-14.4945(0,0)**	-3.1184
LRLGNP	-0.78657(1,0)	-15.47(0,0)**	-3.0036
LRLDA	-1.2210(0,0)	-5.0091(2,0)**	-1.7066
LCN	-1.0217(0,0)	-6.8487(1,0)**	-1.8878

The first number in the parenthesis indicates the number of lags used in the reported ADF statistic. The second number is zero if the relevant series does not have a significant trend component, and t otherwise. '**' indicates significance at the 5% level.

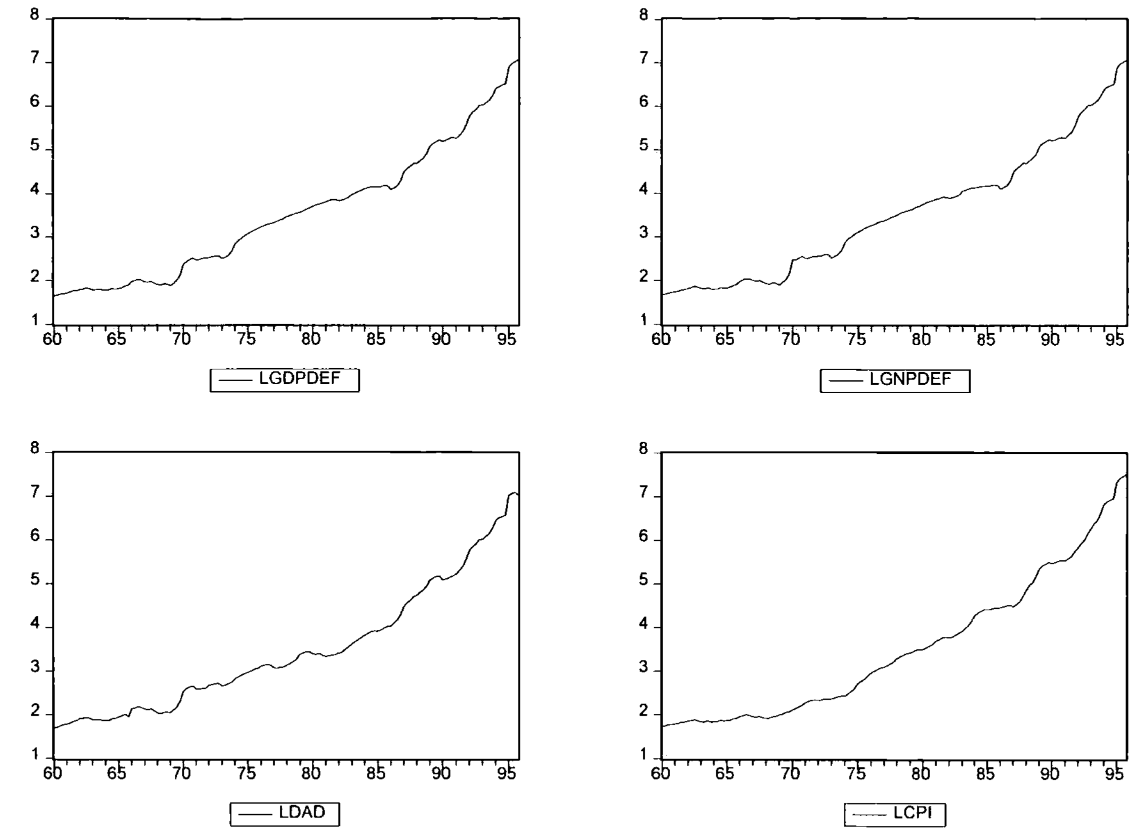


Chart 3.6: Deflators

Table 3.5: Deflators

VARIABLE	ADF (LOGX) CRIT VAL: -2.88 FOR t=0 -3.44 FOR t≠0	ADF (ΔLOGX) CRIT VAL: -2.88 FOR t=0 -3.44 FOR t≠0	ZIVOT-ANDREWS TEST
LGDPDEF	-0.29606(1,t)	-8.2217 (0, t)**	0.79314
LGNPDEF	2.6766 (1,0)	-8.5474 (0. t)**	0.63423
LDAD	2.9351 (1,0)	-8.9388 (0, t)**	0.82020
LCPI	4.2773 (1,0)	-8.2337 (0, t)**	1.5368

The first number in the parenthesis indicates the number of lags used in the reported ADF statistic. The second number is zero if the relevant series does not have a significant trend component, and t otherwise. '**' indicates significance at the 5% level.

Chart 3.6 presents the *four deflators* corresponding to the scale variables in Chart 3.5. The stationarity and structural break tests for the deflators in Table 3.5 shows that only the GDP deflator exhibits a statistically significant trend component in level. All four deflators are non-stationary in levels, requiring first differencing to induce stationarity. All four have statistically significant trend components in first differences. The four deflators are first difference stationary, without any evidence of structural break over the sample period.

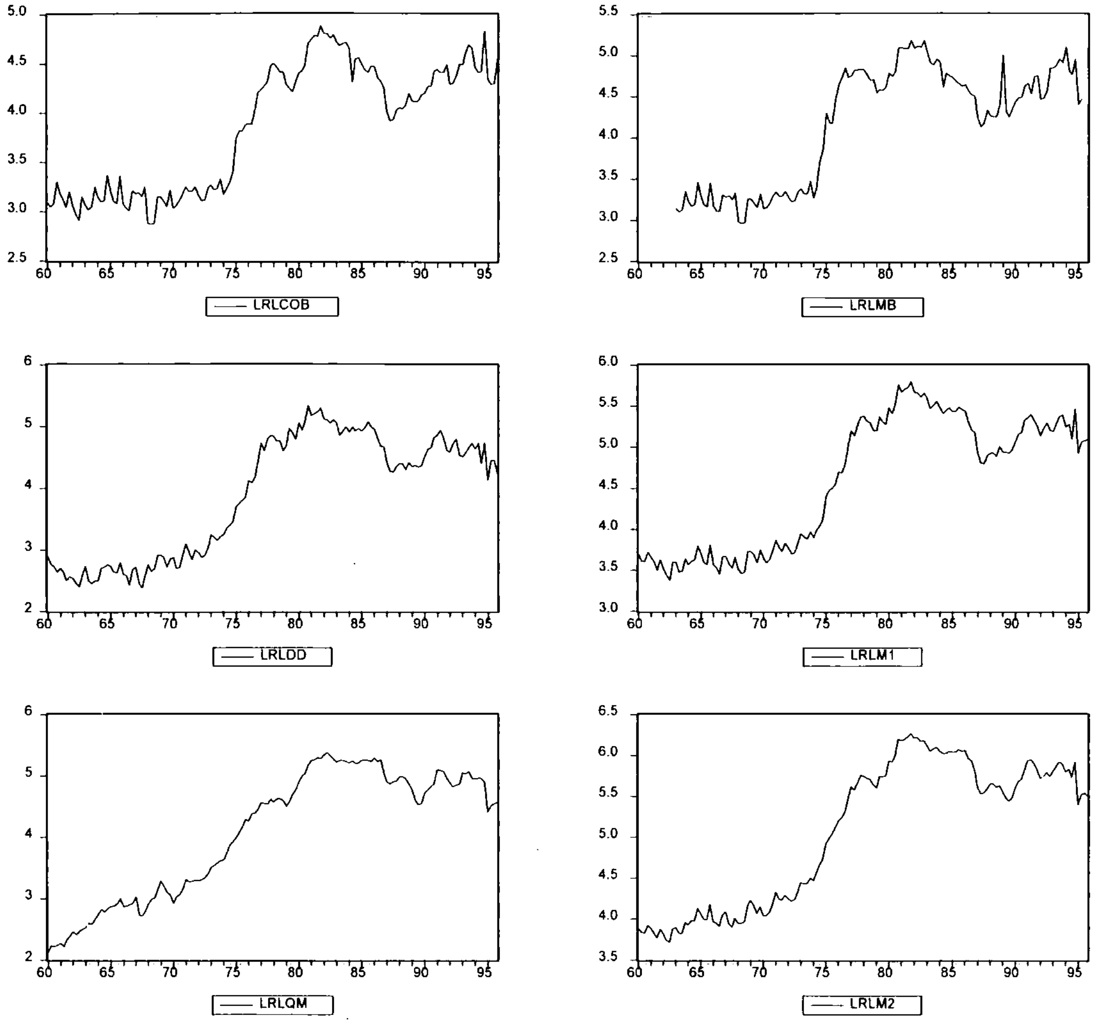


Chart 3.7: Real Monetary Aggregates

Chart 3.7 presents the *six real monetary aggregates*, now deflated with the domestic absorption deflator[40]. Table 3.6 presents the Stationarity and structural stability tests. It is noteworthy that none of the real aggregates has any significant trend component that the nominal aggregates had exhibited in levels, and which M1 and QM had exhibited in first differences. All the real aggregates are non-stationary in levels, but stationary after first differencing.

[40] Justification for this choice of deflator is presented in Chapter five, section 5.1.

There is no evidence of structural break in any of the real monetary aggregates.

Table 3.6: Real monetary aggregates

VARIABLE	ADF (LOGX) CRIT VAL: -2.88 FOR t=0 -3.44 FOR t≠0	ADF (ΔLOGX) CRIT VAL: -2.88 FOR t=0 -3.44 FOR t≠0	ZIVOT-ANDREWS TEST 95% CRIT VAL= -5.08
LRLCOB	-1.2157 (4, 0)	-4.7286 (5, 0)**	-2.4835
LRLMB	-1.5995 (0, 0)	-13.1003(0, 0)**	-2.2558
LRLDD	-1.2740 (0, 0)	-13.9347(0, 0)**	-1.7213
LRLQM	-2.1239 (0, 0)	-9.9484(0, 0)**	-1.6887
LRLM1	-1.3057(4, 0)	-4.1330(3, 0)**	-2.4384
LRLM2	-1.3261(0, 0)	-12.2092(0, 0)**	-2.0694

The first number in the parenthesis indicates the number of lags used in the reported ADF statistic. The second number is zero if the relevant series does not have a significant trend component, and t otherwise. '**' indicates significance at the 5% level.

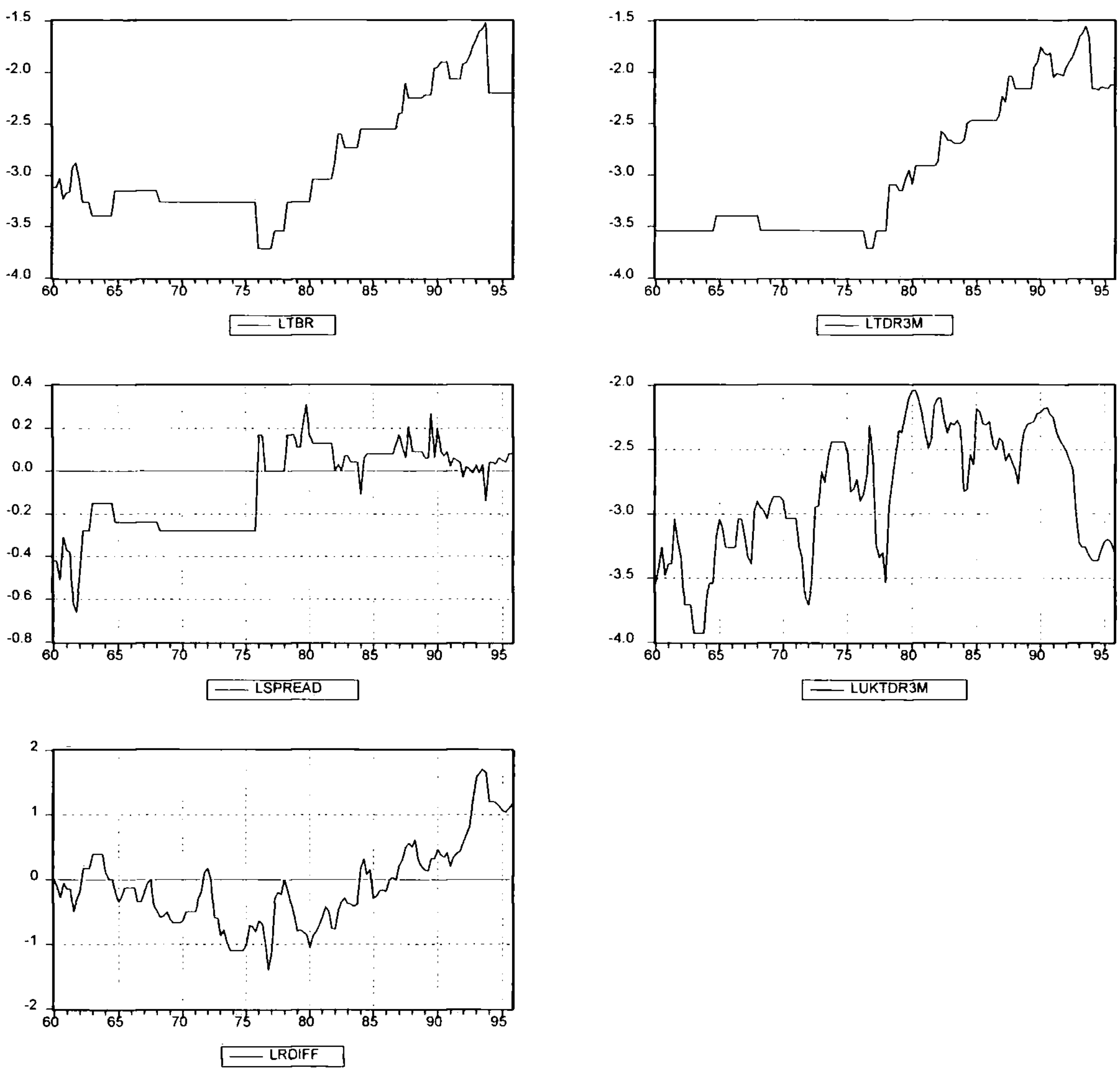


Chart 3.8: Interest Rates and Spreads

Finally, Chart 3.8 presents three interest rates and two spreads defined from them. The domestic treasury bills (TBR) and time deposit rates (TDR3M) and the UK time deposit rate (UKTDR3M). All three rates are for 3-month maturity.

The two spreads are the difference between the domestic time deposit and treasury bills rates (SPREAD) and the difference between the domestic and UK time-deposit rates (RDIFF). The three interest rates and the Nigeria-UK time deposit differential are not trended, either in level or first difference, and they are first difference stationary.

Table 3.7: Interest rates and spreads

VARIABLE	ADF (LOGX) CRIT VAL: -2.88 FOR t=0 -3.44 FOR t≠0	ADF (ΔLOGX) CRIT VAL: -2.88 FOR t=0 -3.44 FOR t≠0	ZIVOT-ANDREWS TEST 95% CRIT VAL= -5.08
LTBR	-0.84699(0,0)	-11.4952 (0,0)**	-3.0100
LTDR3M	-0.55702(0,0)	-11.4349 (0,0)**	-2.6349
LSPREAD	-3.7771 (0,t)	-	-8.0337** (1976Q1)
LUKTDR3M	-2.5661(1,0)	-9.8076 (0,0)**	-3.0434
LRDIFF	-1.6568 (1,0)	-9.4002 (0,0)**	-3.1878

The first number in the parenthesis indicates the number of lags used in the reported ADF statistic. The second number is zero if the relevant series does not have a significant trend component, and t otherwise. '**' indicates significance at the 5% level.

The spread between the domestic rates, SPREAD, however appears to be a trend stationary variable. Zivot-Andrews test however picks up a significant structural break in SPREAD, around 1976Q1. This fact is rather glaring from a visual inspection of the SPREAD in Chart 3.8. The main clue from the Chart is that a *regime switch* occurred in the interest rates between the two sample periods: LTBR was higher than LTDR3M until 1976, and LSPREAD was negative for most of the early sample. It was zero for about three years in the late 1970s, and, with the exception of about seven quarters, it turned significantly and persistently positive for the whole of the late sample. No other interest rate exhibits structural break.

IV. INFORMATION CONTENT OF INTEREST RATES SPREAD IN NIGERIA

It must be clear from previous research on Nigeria reviewed in Chapter three that not much is known about the information content of interest rates in Nigeria. A few authors have either opined that individual interest rates are uninformative in that setting. Some suggested that, even if the individual rates are informative, no information can be obtained from the spread between them. Consequently, there is a wide scope for fruitful research on establishing the information content of interest rates in Nigeria. The empirical role of interest rates in empirical models of money demand in Nigeria will be investigated in chapters five and six. Since the research interest on the information content of interest rates is much broader than those narrowly focused on the role of interest rates in money demand, it is interesting to explore the extent to which interest rates are informative about other aspects of the Nigerian economy, given the high level of skepticism in extant literature.

4.1. Information content of interest rates

The notion that the slope of the nominal yield curve is a leading indicator of real economic activity has long been believed and used informally by financial journalists[41]. It is a matter of considerable interest to academics, policy-makers and business people alike to know if the yield curve can predict future variations in real economic activity. In the course of the 1990s, numerous empirical studies have provided formal evidence that gives compelling empirical support for that notion in the OECD settings. The long list includes Bonser-Neal and Morley (1997), Caporale (1994), Dotsey (1998), Dueker (1997), Estrella and Hardouvelis (1991), Haubrich and Dombrosky, (1996); Hu (1993), Kozicki (1997), Moersch (1996), Peel and Taylor (1998), and Plosser and Rouwenhurst (1994). This high volume of literature on the subject has

[41] See Clark (1996).

covered theoretical, methodological, and empirical as well as policy issues with quite convincing results. However, they have been confined to OECD economies.

This Chapter seeks to extend our knowledge on this subject by focusing on the predictive content of the yield curve for real-economic activity in the Nigerian economy, where financial markets are not as mature as in the OECD economies. If some of the established results from the broader markets hold in Nigeria, the significance of the earlier findings is boosted, as they would have been shown to be robust to variations in the levels of maturity of national financial systems. On the other hand, if some of the evidence from the major markets do not show up in the Nigerian context, we are presented with another opportunity to fill a gap in knowledge by explaining how this can be accounted for by the particularities of the Nigerian financial system.

Nigerian economic reform history has been dominated by frequent reversals of many policy measures, before sufficient time for assessing benefits from them had been allowed to elapse. Large amounts of useful information about future economic activity could have been concealed in the term spreads but since the relationships between the spread and the economy have yet to be studied, such information have remained unknown, and therefore, unused. With the government acting on the basis of little or no information on the links between policy instruments and ultimate objectives, policy responses have often been arbitrary. Sometimes, Government has even introduced measures that could obscure some of the information contained in interest rates spreads. Re-imposition of ceilings on interest rates between February 1994 and September 1996 is a good example. If the informational role of the spread is established, government might benefit more from responding to the information rather than suppressing it by imposing ceilings as in the past.

4.2. YIELD CURVE AND REAL ACTIVITY

It is a matter of considerable interest to academics, policy-makers and business people alike to know if the yield curve can predict future variations in real economic activity in the Nigerian setting. On the part of academics and policy-makers, there is a need for a careful identification of the leading indicators of short-to-medium-term real-growth prospects of the economy. Nigerian economic reform history has been dominated by frequent reversals of many policy measures before sufficient time for assessing benefits from them had been allowed to elapse. Large amounts of useful information about future economic activity could have been concealed in the term spreads, but since the relationships between the spread and the economy have yet to be studied, such information have remained unknown, and unused. With the government acting on the basis of little or no information on the links between policy instruments and ultimate objectives, policy responses have often been arbitrary.

Sometimes, Government has also introduced measures that could obscure some of the information contained in interest rates spreads. Re-imposition of ceilings on interest rates between February 1994 and September 1996 is a good example. If the informational role of the spread is established, government might benefit more from responding to the information rather than suppressing it by imposing ceilings as in the past.

Information contained in the yield curve is usually summarized with the expectations' hypothesis (EH) according to which the long-term nominal interest rate equals the weighted average of expected short-term nominal interest rates over the time to maturity plus a risk premium that depends on the time to maturity. By splitting the nominal rates into expected inflation and real interest rates, the yield curve can be used to predict the rate of inflation. Similarly, by relying on the correlation between real interest rate and real economic growth over the business cycle, the yield curve can be used to predict future economic growth. Therefore two of the testable implications of the maintained hypothesis, EH, are that:

(i) The slope of the yield curve should contain information about future changes in the level of inflation; and that,

(ii) The slope of the yield curve should predict future changes in the level of real economic activity.

Mishkin (1990) advanced a simple statistical framework for a qualitative testing of the implication of the EH for future change in the level of inflation. Estrella and Hardouvelis (1991) adapted the statistical framework of Mishkin (1990) to test the implication of the EH for real activity. Like the Mishkin (1990) results for inflation and the yield curve, the Estrella and Hardouvelis (1991) results for yield curve and real activity turned out to be seminal. Both articles provided simple but powerful direct statistical evidence for notions that have been long held by financial economic theorists and financial market pundits and practitioners, but for which there had hitherto been no concrete direct empirical support[42]. Following the seminal work of Estrella and Hardouvelis (1991), many other studies have provided further evidence in support of the fact that the yield curve predicts future growth in real economic activity in the US and almost all OECD economies. Bonser-Neal and Morley (1997), Caporale (1994), Dotsey (1998), Dueker (1997), Estrella, Rodrigues, and Schich (2000), Hamilton and Kim (2000), Haubrich and Dombrosky, (1996); Hu (1993), Kozicki (1997), Moersch (1996), Peel and Taylor (1998), and Plosser and Rouwenhurst (1994) are just a few of the many examples.

A positive spread between long-term and short-term interest rates is associated with an increase in real economic activity, while a negative spread is associated with a decline in real activity.

[42] Mishkin (1990) provided a simple test of one implication of what had long been known as the 'Fisher effect' (Fisher (1930)). Estrella and Hardouvelis (1990) provided a simple test of what had earlier been mentioned in Kessel (1965) as an empirical regularity.

In addition, the larger the yield-spread, the higher would be the growth in the level of future activity. Two explanations have been offered for the empirical link between the yield curve and real activity. The first is that the slope of the yield curve may reflect the stance of monetary policy. Following this reasoning, a monetary tightening will raise short tem-rates, but not all the increases in short-term rates as a result of monetary tightening will be transmitted to long rates, thereby narrowing or even inverting the spread between the two. The increase in the short-term rate will reduce spending in interest rate sensitive sectors of the economy, causing the economy to slow down in the future. Consequently, either a narrowing or an inversion of the spread will be associated with slower economic growth in the future. The second explanation is that the spread reflects market expectations about future economic growth. By this reasoning, an increase in expected future real income implies an increase in profitable investment opportunities today. Increased demand for long-term borrowing, to take up the investment opportunities, raises long-term yield relative to short-term rates, thus steepening the yield curve. As long as these expectations for higher economic growth are at least partially realized, a steepening of the yield curve will be associated with a future increase in real economic activity.

Available empirical evidence has lent support to both explanations as both the yield spread and proxies for current monetary policy stance often retain significant predictive ability in the presence of the other in the same forecasting equations.

4.3 THE FORECASTING MODEL

The dependent variable is the annualized cumulative percentage change in economic activity.

$$\Delta y_{t,\,t+k} = (400/k)[\log(y_{t+k}/y_t)] \qquad (1)$$

where,

k = forecasting horizons in quarters;

y_{t+k} = level of economic activity in quarter t+k;

$\Delta y_{t,t+k}$ = percentage change from current quarter to future quarter t+k.

The slope of the nominal yield curve is defined as the spread between the 14-year Federal Government Development Stock rate and the Treasury bill rate.

$$s_t = r_t^L - r_t^S \qquad (2)$$

The basic regression equations are of the following general form:

$$\Delta y_{t,t+k} = \alpha_0 + \alpha_1 s_t + \varepsilon_t \qquad (3)$$

where, *equations (1) and (2) above define $\Delta y_{t,t+k}$ and s_t.* ε_t is the forecast error. The sampling period is quarterly, but forecasting horizon varies from one to 20 quarters ahead. When the sampling period is quarterly, regressions with annual growth rates will have a data-overlapping problem that generates a moving average error of order k-1, where k is the forecasting horizon. The moving average error does not affect the consistency of the OLS regression estimates but does affect the consistency of the OLS standard errors. For correct inferences on the statistical significance of the regression estimates, the OLS standard errors have to be adjusted. Asymptotically valid standard errors are derived with the Newey and West (1987) adjustment.

4.4. SPECIFIC RESEARCH ISSUES

Firstly, we address the primary empirical issue of whether the term-structure spread predicts the future course of real economic activity in Nigeria, or not. To do this we present evidence on the in-sample and out-of-sample predictive ability of the spread over horizons of one quarter to twenty quarters.

Secondly, we investigate whether the spread contains any extra information about future growth in real-activity over and above the one summarized in the level of short-term rate, which often reflects the current stance of monetary policy, or information already available to policy makers. We thus compare the relative predictive power of the spread in the absence and presence of the short-term rate with in-sample and out-of-sample tests. The spread is potentially useful for policy management, perhaps as an information variable or a leading indicator of economic condition, if it has any extra information for the future course of economic activity over and above the one reflected in the short rate, otherwise, it is redundant.

Thirdly, if the spread has any predictive power for future growth of real-activity, it is of interest to pinpoint the precise mechanism by which the spreads are linked to future activity: we need to isolate the transmission mechanism. Like Peel and Taylor (1998), we therefore also try to explore the possible sources of the predictive power of the spread for future changes in real activity by examining its relative predictive power for the supply-side and the demand-side of the economy. Given two alternative routes of doing this, we chose to apply the tests directly to separate measures of aggregate output (supply-side) and expenditure (demand-side) and key sub-components of each (an extension of the approach adopted in Estrella and Hardouvelis (1991)). The alternative route of decomposing the GDP growth into demand (transitory) and supply (permanent) components taken by Peel and Taylor (1998) is controversial. Robertson and Wickens (1997) argued that the two components are unlikely to be demand and supply shocks as they could be better described as nominal (transitory) and real (permanent) shocks respectively.

4.5 EXTENDING THE RESEARCH TO NIGERIA

In the effort to extend this fruitful and growing research on the information content of interest rate spreads to Nigeria, we now turn to the various issues involved in translating largely OECD-based research to the Nigerian setting. Unlike what is usually assumed about the typical African country, the Nigerian economy is characterized by the coexistence of relatively large markets for short-, medium and long-term non-money financial instruments with the banking system since independence in 1960. Chart 4.1 shows that outstanding treasury securities at the secondary money market alone often exceeded the value of broad money (M2) in the economy. Yet while there has been a proliferation of money demand studies, not much attention has been given to the credit markets. There is also a sizeable market for private short-term debt instruments. The three private instruments traded are certificates of deposit, commercial papers and bankers' acceptances. Finally, a significant volume of medium and long-term instruments are traded in the capital market. These include Federal Government's development stocks and corporate debenture stocks.

Table 4.1: Selected Macroeconomic Indicators

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998
Growth									
Real GDP (Annual % Change)	8	5	3	2.7	1	2.2	3.4	3.2	2.4
Inflation									
Consumer Prices (Annual % Change)	7	13	45	57.2	57	72.8	29.3	8.5	10.0
Commercial Banks Interest Rates									
Commercial Bank Time Deposit Rate[43]	19.8	15.2	20.8	26.3	13.4	13.6	12.3	9.4	10.4
Commercial Banks' Prime Lending Rate		20.2	29.8	36.1	20.2	20.2	19.1	18.4	18.3
Commercial Banks' Maximum Lending Rate		21	31.2	39.1	21	20.8	20.8	20.9	21.8
Merchant Bank Interest Rates									
Merchant Bank Time Deposit Rate	21.9	18.2	38.8	37.7	13.8	14.3	13.4	11.3	15.4
Merchant Banks' Prime Lending Rate		20.9	44.4	59.1	20.6	20.7	20.10	19.3	22.2
Merchant Banks' Maximum Lending Rate		21	48	61.5	21	20.8	20.7	20.9	24.9
Interest Rates on Government Securities									
3 Months Treasury Bill Rate	17.5	14.5	21	28	12.5	12.5	12	12.0	13.0
14-Year Federal Government Stock Rate	20.4	17.9	20.1	29.2	15.8	15.8	15.8	15.8	15.8
Government Bond Term Spread									
Spread (rl-rs)	2.9	3.4	-0.9	1.2	3.3	3.3	3.8	3.8	2.8

Source: Central Bank of Nigeria, *Annual Reports and Statement of Accounts, 1994-1998.*

Thus, a wide range of interest rates (corresponding to these assets) is available for the Nigerian economy (Table 4.1). However, not much is known about the predictive content of the term structure for economic activity in Nigeria. Consequently, there is a wide scope for fruitful research on the information content of interest rate spreads in Nigeria.

Academic interest in the information content of interest rate is now much wider than those justified primarily by interest in the empirical relationships between prices in the credit market and real economic activity[44]. This aspect of the research however provides a convenient entry

[43]Commercial and Merchant Bank rates are weighted averages of three months interest rates per annum reported by the Central Bank of Nigeria.

[44] Information can be extracted for future interest rates, future inflation and exchange rate depreciation as well.

point. The limitations imposed by the typical quality of African financial data[45], also restricts the extent to which one can branch out of the narrow question of the links between spreads and real activity.

❑ *Money and Credit Markets in Nigeria*

This section seeks to address in a greater detail the issue of the extent to which Nigeria is materially different from or similar to the OECD economies from which the research on interest rate spreads originated. The specific issues to be addressed include: the depth of securities markets in Nigeria which has implications for the extent to which observed interest rates can be regarded as the results of active trading.

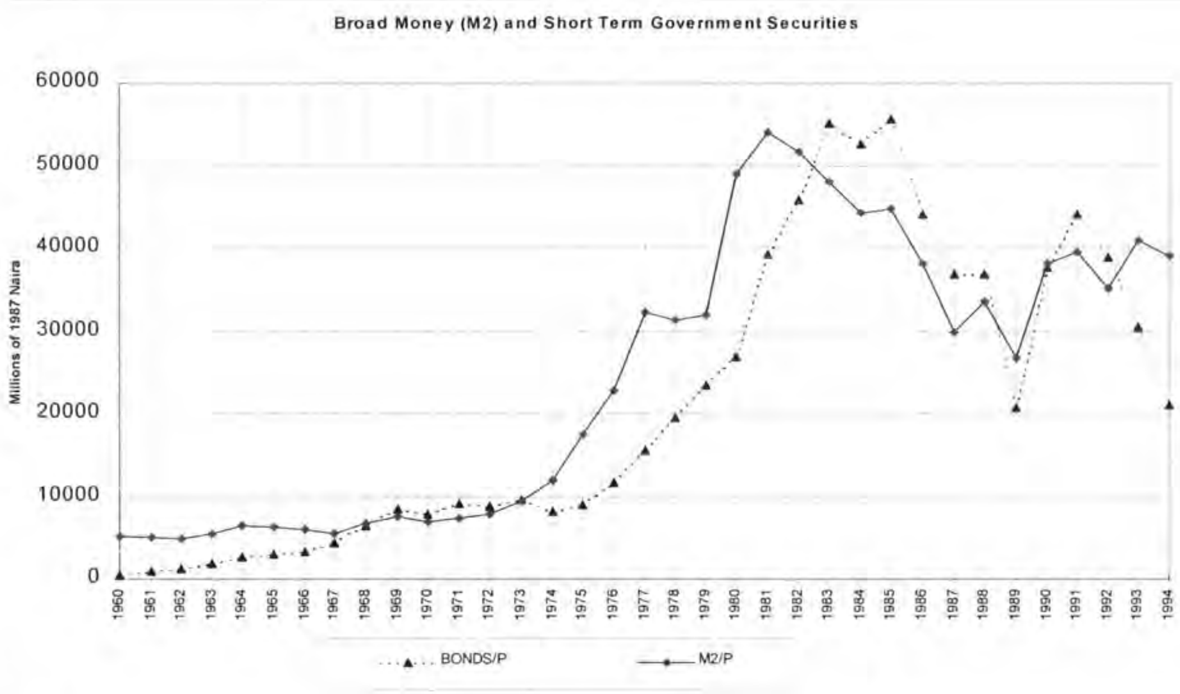


Chart 4.1

Trading in Government securities has swung at various times between 90-day Treasury bills and the 1-2 years Treasury Certificates (Chart 4.2,). Trading in eligible development stocks

[45] Rates are only available for a limited number of maturities, little or no forward contracts, etc.

(development stock that will mature within the next four years) has remained very small relative to the other two instruments.

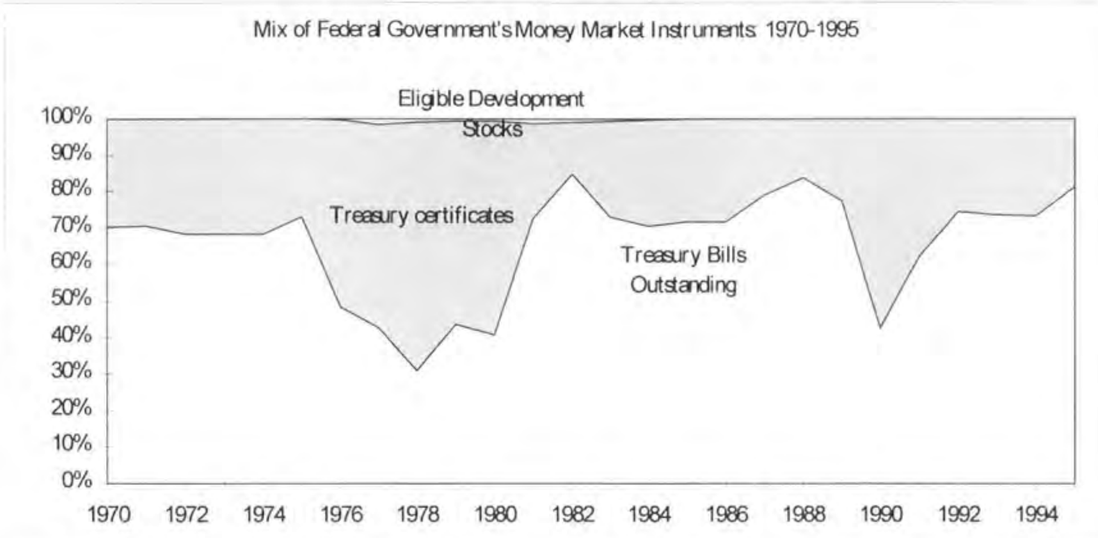


Chart 4.2

More details on the evolution of private securities on the Nigerian secondary money market are provided in Chart 4.3.

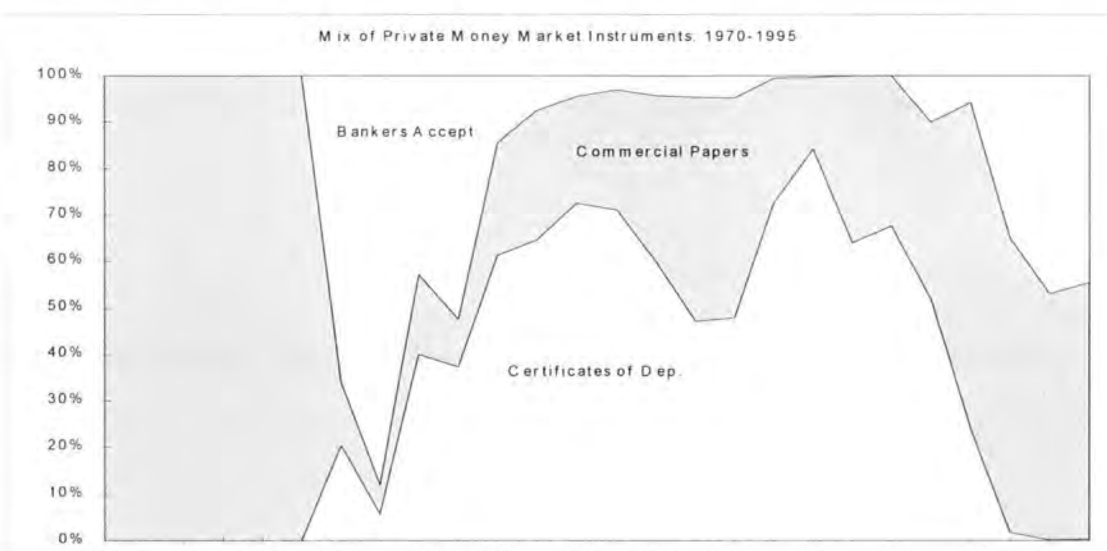


Chart 4.3

While relatively much smaller than government securities in size, the evolution of the private-securities in Nigeria clearly suggests an active market in which each of the three private instruments had dominated trading at different period, following the introduction of Certificates of Deposit and BAs in the mid-1970s.

Commercial Papers were the only private instrument until the other two were introduced. CDs rose to dominance within five years of its introduction accounting for between 40 and 80 per cent of total private securities between 1980 and 1990. It has steadily become unpopular since 1991, however, presumably because the re-regulation of interest rates of 1991 and 1994-96 did not treat interest payable on large denomination CDs as 'negotiable' as was the practice from 1975 to 1990.

Consequently, CDs actually dropped to the neighborhood of zero since 1994. With the demise of CDs, CPs started getting back into their pre-1975 prominence. The market for BAs has also grown rapidly since 1990, after inactivity in the 1987-90 period.

4.6 EMPIRICAL EVIDENCE

❒ Preliminary Statistics

Table 4.2: Summary Statistics for Long rate, Short rate and Spread: 1987q1-1995q4

SERIES	MEAN	STANDARD DEVIATION	AUTOCORRELATION COEFFECIENTS				
			ρ_1	ρ_2	ρ_3	ρ_4	ρ_{12}
3-month TBR	15.26	4.51	0.75	0.54	0.35	0.16	0.03
14 year FGSR	16.71	4.08	0.75	0.49	0.27	0.09	0.06
Spread	1.45	0.95	0.42	0.02	0.11	0.28	-0.24

From Table 4.2, it can be observed that in the Nigerian economy the sample mean of the long rate (16.71) is higher than that of the short rate (15.26), the difference is identical to the sample mean of the yield spread, which is 1.45. This conforms to the basic feature of the yield curve, that it will normally have an upward slope. Also we observe that the standard deviation of the short rate is higher than that of the long rate implying that the short rate is more volatile than the long rate: not all the volatility in the short rate is transmitted to long rates. The level of the short-term rate is often believed to reflect the stance of monetary policy while the long-term rate is often believed to be outside the direct influence of policy makers and therefore reflects underlying real economic conditions.

Finally, we note the fact that the standard deviation of the spread is more than twice the difference between the standard deviations of the long and short rates.

The preliminary statistical information we have just reviewed can be linked with the research issues defined earlier in the following ways:

(i) Does the extra variation in the spread translate to any extra information on the future course of real economic activity than can be recovered from the short-end of the term-structure?

(ii) If it contains such information, over what horizons does it do so?

(iii) To which aspects of real economic activity is extra variation in the spread more closely linked? Or, through which channel is the bond market linked to the real economy, the demand side, or the supply side (transmission mechanism)?

Table 4.3: Summary Statistics for Selected Macroeconomic Variables: 1987I-1995IV

SERIES[46]	MEAN	STANDARD DEVIATION	AUTOCORRELATION COEFFECIENT				
			ρ_1	ρ_2	ρ_3	ρ_4	ρ_{12}
GDP	1.94	1.36	0.95	0.86	0.76	0.66	-.07
IND	1.08	3.26	0.66	0.53	0.50	0.31	0.00
MFG	0.23	5.89	0.53	0.30	0.19	0.01	0.00
RLDA	1.76	1.54	0.93	0.86	0.75	0.66	-0.05
INV	1.76	6.82	0.93	0.81	0.66	0.50	
CN	1.35	1.49	0.81	0.48	0.09	-0.28	0.17

Table 4.3 presents the corresponding summary statistics for measures of real activity. Observe that standard deviations of gross capital formation, industrial and manufacturing production are

[46] The statistics reported are for the four-quarter cumulative growth rates for each variable.

the highest. These are much more volatile than all the other measures of economic activity, although close to the volatility of the levels of interest rates. The volatility of the GDP, RLDA, and consumption are much lower, and closer to the volatility of the spread. This might suggest that the spread would be more informative about growth in future aggregate output, aggregate spending and consumption, while the short rate (policy stance) might be informative about industrial and manufacturing production and Gross Capital Formation.

❒ In-Sample Results

Tables 4.4 to 4.10 present predictions of future cumulative changes in real activity with

(a) the term-structure spread; and,

(b) a combination of the term-structure spread and the short-term rate.

The sample period is 1987Q1 through 1995Q4.

The model estimated for (a) is:

Cumulative Change ($\Delta y_{t,\ t+k}$)=(400/k)[log (y_{t+k}/y_t)]= $\Delta y_{t,t+k} = \alpha_0 + \alpha_1 s_t + \varepsilon_t$

Δy_{t+k} is the change in real activity from quarter t to t + k, k is the forecasting horizon. Spread (s_t) is the difference between the 9-14 year Federal Government development stock rate and the 3-month Treasury bill rate (short-rate, r_t).

The model estimated for (b) is:

Cumulative Change ($\Delta y_{t,\ t+k}$) = (400/k)[log (y_{t+k} / y_t)]= $\Delta y_{t,t+k} = \beta_0 + \beta_1 s_t + \beta_2 r_t + \upsilon_t$

Spread (s_t) is the difference between the 9-14 year Federal Government development stock rate and the 3-month Treasury bill. For simplicity, we use only two interest rates to construct the slope of the yield curve, the 14-year government bond rate R^L, and the 3-month Treasury Bill rate R^S. Both R^L and R^S are annualized bond equivalent yields. A richer array of interest rate maturities would provide finer information on the predictive accuracy of the term structure, but our purpose here is to find simple qualitative evidence on the predictive ability of the slope of the yield curve, and these two rates suffice. Our measure of the slope of the yield curve is the difference between the two rates.

Recent analyses of the number of factors in the term structure of interest rates revealed three factors, namely the level of short rate, slope of the long rate relative to short rate, and curvature of the yield curve. In our analysis, we only use the level of short rates, and the slope between long rate (R^L) and short rate (R^S). We do not use the curvature of the yield curve, which captures information of the volatility of interest rates across maturities. Thus, while data on additional maturities would give us more spreads, previous empirical research has shown that additional information from that exercise is negligible[47]. Consequently, there is also no need to match the horizon over which the slope is calculated with the horizon over which real activity is being predicted, as would have been necessary if the curvature of the yield curve was as informative as the slope in predicting real activity. These considerations make it possible to apply the simple definition of the slope proposed above to the Nigerian data, where more detailed information on the different maturities of interest rates would be hard to come by.

The number of observations declines progressively from 36 by k (k = 1 ... 20) over the forecast horizons. The coefficient of determination adjusted for degrees of freedom, $\overline{R}^2$, provides an indication of the explanatory power of the spread for each measure of real activity. The estimated coefficients for the spread (α_1 from equation 3 and β_1 from equation 4) measure how much real activity will change following a one-percentage point change in the spread. A positive α_1 or β_1 would imply a positive relationship between current term-structure spread and future economic growth. That is, the steeper the term-structure spread, the stronger real growth will be

[47] For example, Hamilton and Kim (2000) found that 'while volatility displays important correlations with both the term structure of interest rates and GDP, it does not appear to account for the yield spread's usefulness for predicting GDP growth'.

in the future. Estimates of α_1 or β_1, $\hat{\alpha}_1$ or $\hat{\beta}_1$, themselves indicate the economic significance of the yield curve as a predictor of future real economic activity. Figures in parentheses denote Newey and West (1987) corrected t-ratios, which take the moving average created by the overlapping of forecasting horizon as well as conditional heteroscedasticity into account. These indicate the statistical significance of the corrected t-ratios. One (two) asterisk(s) denotes the corresponding t-ratios indicate that the reported $\hat{\alpha}_1$ or $\hat{\beta}_1$ is significantly different from zero at the five (ten) percent level. Specifically, $\hat{\alpha}_1$ or $\hat{\beta}_1$ measures the change in real activity for a given one percentage point change in the spread.

Table 4.4a: **PREDICTING** GDP **GROWTH WITH** SPREAD

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\alpha}_0$	Spread $\hat{\alpha}_1$	$\overline{R}^2$	SEE
1987Q1-1995Q3	1	35	0.80** (1.79)	0.74* (4.98)	0.04	2.63
1987Q1-1995Q2	2	34	1.02* (3.14)	0.65* (3.81)	0.11	1.60
1987Q1-1995Q1	3	33	1.42* (4.37)	0.36** (1.85)	0.02	1.53
1987Q1-1994Q4	4	32	1.21* (3.51)	0.53* (3.56)	0.12	1.27
1987Q1-1994Q3	5	31	1.09* (3.18)	0.60* (4.38)	0.15	1.28
1987Q1-1994Q2	6	30	1.11* (3.36)	0.59* (4.26)	0.18	1.21
1987Q1-1994Q1	7	29	1.25* (3.78)	0.48* (3.19)	0.11	1.23
1987Q1-1993Q4	8	28	1.18* (3.66)	0.53* (3.76)	0.16	1.14
1987Q1-1992Q4	12	24	1.37* (3.47)	0.36* (2.91)	0.06	1.09
1987Q1-1991Q4	16	20	3.27* (2.30)	-0.81 (-1.22)	0.02	0.92
1987Q1-1990Q4	20	16	2.58* (2.41)	-0.42 (-0.84)	-0.03	0.69

Table 4.4b: **PREDICTING** GDP **GROWTH WITH** COMBINED MODEL

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\beta}_0$	Spread $\hat{\beta}_1$	SHORT RATE $\hat{\beta}_2$	$\overline{R}^2$	SEE
1987Q1-1995Q3	1	35	3.20 (1.28)	0.42 (0.90)	--0.13 (-1.00)	0.05	2.62
1987Q1-1995Q2	2	34	4.06* (3.30)	0.25 (1.07)	-0.16* (-2.51)	0.23	1.49
1987Q1-1995Q1	3	33	4.83* (4:44)	-0.09 (-0.36)	-0.18* (-3.33)	0.21	1.38
1987Q1-1994Q4	4	32	4.77* (7.76)	0.07 (0.54)	-0.18* (-3.78)	0.41	1.04
1987Q1-1994Q3	5	31	4.56* (6.40)	0.16 (1.09)	-0.18* (-4.98)	0.42	1.06
1987Q1-1994Q2	6	30	4.72* (8.32)	0.14 (1.00)	-0.19* (-6.43)	0.51	0.94
1987Q1-1994Q1	7	29	4.84* (8.29)	0.03 (0.22)	-0.19* (-5.86)	0.46	0.96
1987Q1-1993Q4	8	28	4.76* (9.99)	0.09 (0.79)	-0.19* (-6.87)	0.56	0.83
1987Q1-1992Q4	12	24	6.79* (9.61)	-0.16 (-1.16)	-0.32* (-7.73)	0.59	0.72
1987Q1-1991Q4	16	20	6.11* (7.08)	-0.25 (-0.55)	-0.28* (-10.45)	0.53	0.64
1987Q1-1990Q4	20	16	4.66* (10.68)	-0.06 (-0.24)	-0.20* (-9.51)	0.60	0.43

For example, the information provided in Table 4.4a shows that a one-percentage-point increase in the term-structure spread today is associated with the following: an annualized 0.74 percentage point increase in real GDP growth in the next quarter; an annualized 0.53 percentage point increase in growth in the next year; an annualized 0.53 percentage point increase in growth in the next two years; and, an annualized 0.36 percentage point increase in growth in the next three years. Hence, all other things equal, if real GDP growth in Nigeria was 2 percent, an increase in the term-structure spread by one percentage point would imply an increase in real GDP growth to 2.74 percent (2+0.74x1) over the next quarter. An increase to 2.53 percent (2+0.53x1) over the next one year, to 2.53 percent (2+0.53x1) on average over the next two years, and 2.36 percent (2+0.36x1) on average over the next three years. SEE is the regression standard error. From tables 4.4a and 4.4b we observe that the spread contains information of the future growth of real output in the Nigerian economy but such information is not independent of what is recoverable from the stance of monetary policy as reflected in the short rate. This interpretation derives from the fact that the spread is statistically significant in predicting the future course of real output from one quarter to 12 quarters ahead in the spread alone regressions but is not significant at all in the regressions that included the short rate. In that equation, the short-rate exhibits strong negative predictive power from the second to twentieth quarter ahead.

Table 4.5a: **PREDICTING** DOMESTIC ABSORPTION GROWTH WITH **SPREAD**

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\alpha}_0$	Spread $\hat{\alpha}_1$	$\overline{R}^2$	SEE
$1987Q_1$-$1995Q_3$	1	35	0.2 (0.5)	0.9(5.0)*	0.06	3.0
$1987Q_1$-$1995Q_2$	2	34	0.5 (1.6)**	0.8(4.4)*	0.15	1.7
$1987Q_1$-$1995Q_1$	3	33	0.97(3.2)*	0.5 (2.4)*	0.05	1.7
$1987Q_1$-$1994Q_4$	4	32	0.77 (2.36)*	0.71 (3.97)*	0.19	1.4
$1987Q_1$-$1994Q_3$	5	31	0.66 (2.0)*	0.78 (4.49)*	0.23	1.4
$1987Q_1$-$1994Q_2$	6	30	0.7 (2.17)*	0.77 (4.19)*	0.24	1.3
$1987Q_1$-$1994Q_1$	7	29	0.87 (2.5)*	0.64 (3.2)*	0.17	1.4
$1987Q_1$-$1993Q_4$	8	28	0.8 (2.4)*	0.67 (3.8)*	0.21	1.3
$1987Q_1$-$1992Q_4$	12	24	1.1 (2.5)*	0.45 (3.1)*	0.08	1.3
$1987Q_1$-$1991Q_4$	16	20	3.3 (2.03)*	-0.9 (-1.1)	0.01	1
$1987Q_1$-$1990Q_4$	20	16	2.6 (2.2)*	-0.45 (-0.8)	-0.03	0.7

From Tables 4.5a and 4.5b we observe that the spread contains information of the future growth of real expenditures in the Nigerian economy and some of that information is independent of what is recoverable from the stance of monetary policy as reflected in the short rate.

Table 4.5b: **PREDICTING** DOMESTIC ABSORPTION **GROWTH WITH** COMBINED MODEL

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\beta}_0$	Spread $\hat{\beta}_1$	SHORT RATE $\hat{\beta}_2$	$\bar{R}^2$	SEE
$1987Q_1$-$1995Q_3$	1	35	2.23 (0.77)	0.67 (1.30)	-0.10 (-0.71)	0.04	3.05
$1987Q_1$-$1995Q_2$	2	34	3.14** (1.84)	0.49 (1.62)	-0.14 (1.56)	0.21	1.73
$1987Q_1$-$1995Q_1$	3	33	4.12* (2.66)	0.11 (0.36)	-0.17* (-2.14)	0.16	1.65
$1987Q_1$-$1994Q_4$	4	32	4.17* (5.01)	0.27 (1.65)	-0.18* (-4.15)	0.39	1.20
$1987Q_1$-$1994Q_3$	5	31	3.92* (4.92)	0.37* (2.13)	-0.17* (-3.98)	0.41	1.21
$1987Q_1$-$1994Q_2$	6	30	4.14* (5.98)	0.34** (1.86)	-0.18* (-4.86)	0.47	1.11
$1987Q_1$-$1994Q_1$	7	29	4.34* (6.18)	0.21 (1.10)	-0.18* (-4.67)	0.40	1.16
$1987Q_1$-$1993Q_4$	8	28	4.34* (7.83)	0.25** (1.79)	-0.18* (-5.73)	0.48	1.05
$1987Q_1$-$1992Q_4$	12	24	6.88* (6.73)	-0.10 (-0.54)	-0.34* (-5.71)	0.51	0.91
$1987Q_1$-$1991Q_4$	16	20	6.52* (6.27)	-0.25 (-0.47)	-0.32* (-10.16)	0.50	0.75
$1987Q_1$-$1990Q_4$	20	16	4.75* (10.52)	-0.06 (-0.24)	-0.21* (-9.69)	0.60	0.46

This interpretation derives from the fact that the spread is statistically significant in predicting the future course of real expenditure from one quarter to 12 quarters ahead in the spread alone regression. The spread is however significant in the regressions that included the short rate only at the 5, 6,and 8, quarters horizon. In that equation, the short-rate exhibits strong negative predictive power from the third to twentieth quarter ahead.

Table 4.6a: **PREDICTING** MANUFACTURING **GROWTH WITH** SPREAD

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\alpha}_0$	Spread $\hat{\alpha}_1$	$\bar{R}^2$	SEE
$1987Q_1$-$1995Q_3$	1	35	1.10 (0.56)	-0.42 (-074)	-0.03	17.31
$1987Q_1$-$1995Q_2$	2	34	-0.06 (-0.49)	0.35 (0.57)	-0.03	11.79
$1987Q_1$-$1995Q_1$	3	33	-2.15* (-2.07)	1.79** (1.71)	-0.2	8.01
$1987Q_1$-$1994Q_4$	4	32	-3.42* (-2.60)	2.61* (2.32)	0.17	5.37
$1987Q_1$-$1994Q_3$	5	31	-2.26* (-2.92)	1.60* (2.34)	0.07	4.84
$1987Q_1$-$1994Q_2$	6	30	-1.43 (-1.42)	1.06* (2.17)	0.01	5.02
$1987Q_1$-$1994Q_1$	7	29	-1.60** (-1.83)	1.21* (2.37)	0.03	4.69
$1987Q_1$-$1993Q_4$	8	28	-2.53* (-3.12)	1.89* (4.21)	0.20	3.73
$1987Q_1$-$1992Q_4$	12	24	1.39 (-1.20)	1.02* (3.35)	0.03	3.66
$1987Q_1$-$1991Q_4$	16	20	2.97 (-0.64)	-1.68 (-0.80)	-0.02	3.00
$1987Q_1$-$1990Q_4$	20	16	2.57 (0.66)	-1.48 (-0.79)	-0.02	2.34

From Table 4.6a we observe that the spread contains information on the future growth of real manufacturing output in the Nigerian economy. It is found to significantly predict real output growth in the manufacturing sector in the three-quarter to twelve-quarter horizon.

Table 4.6b: **PREDICTING** MANUFACTURING **GROWTH WITH** COMBINED MODEL

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\beta}_0$	Spread $\hat{\beta}_1$	SHORT RATE $\hat{\beta}_2$	$\bar{R}^2$	SEE
1987Q_1-1995Q_3	1	35	12.00 (0.99)	-1.88 (-0.90)	-0.57 (-0.85)	-0.04	17.43
1987Q_1-1995Q_2	2	34	9.62** (1.76)	-0.93 (-1.01)	-0.51 (-1.56)	-0.03	11.80
1987Q_1-1995Q_1	3	33	3.27 (0.60)	1.09 (0.93)	-0.28 (-1.00)	0.01	8.06
1987Q_1-1994Q_4	4	32	4.40 (0.96)	1.60 (1.23)	-0.41** (-1.92)	0.22	5.19
1987Q_1-1994Q_3	5	31	8.04* (3.36)	0.28 (0.60)	-0.54* (-4.49)	0.24	4.38
1987Q_1-1994Q_2	6	30	11.53* (3.66)	-0.56 (-1.18)	-0.68* (-4.01)	0.30	4.22
1987Q_1-1994Q_1	7	29	10.21* (4.29)	-0.24 (-0.68)	-0.62* (-4.44)	0.31	3.97
1987Q_1-1993Q_4	8	28	6.46* (3.25)	0.80 (1.67)	-0.47* (-4.07)	0.41	3.20
1987Q_1-1992Q_4	12	24	15.03* (4.81)	-0.54 (-1.06)	-0.98* (-5.18)	0.47	2.72
1987Q_1-1991Q_4	16	20	11.81* (4.11)	0.07 (0.03)	-0.87* (-3.48)	0.64	2.18
1987Q_1-1990Q_4	20	16	9.92* (5.38)	-0.20 (-0.21)	-0.71* (-5.31)	0.66	1.34

The coefficients exceed unity over these horizons, being highest (2.61) in the four-quarter horizon. However, from Table 4.6b, with the introduction of the short rate into the regressions, the spread losses all its information-content for future manufacturing output.

Table 4.7a: **PREDICTING** INDUSTRIAL OUTPUT **GROWTH WITH** SPREAD

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\alpha}_0$	Spread $\hat{\alpha}_1$	$\bar{R}^2$	SEE
1987Q_1-1995Q_3	1	35	0.95 (1.08)	0.32 (0.75)	-0.03	3.31
1987Q_1-1995Q_2	2	34	0.55 (0.57)	0.55** (1.90)	-0.02	2.08
1987Q_1-1995Q_1	3	33	-0.63 (-0.93)	1.30* (3.59)	0.09	1.85
1987Q_1-1994Q_4	4	32	-0.78 (-1.02)	1.33* (2.89)	0.14	1.47
1987Q_1-1994Q_3	5	31	-0.24 (-0.34)	0.86* (2.46)	0.05	1.38
1987Q_1-1994Q_2	6	30	-0.18 (-0.27)	0.81* (2.33)	0.05	1.19
1987Q_1-1994Q_1	7	29	-0.37 (-0.56)	0.98* (3.26)	0.10	1.09
1987Q_1-1993Q_4	8	28	-0.49 (-0.69)	1.08* (3.72)	0.15	0.87
1987Q_1-1992Q_4	12	24	0.17 (0.21)	0.52* (2.30)	0.01	0.43
1987Q_1-1991Q_4	16	20	3.17 (1.05)	-1.33 (-0.97)	-0.01	0.41
1987Q_1-1990Q_4	20	16	2.93 (1.22)	-1.22 (-1.05)	0.01	0.36

Table 4.7b: **PREDICTING** INDUSTRIAL OUTPUT **GROWTH WITH** COMBINED MODEL

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\beta}_0$	Spread $\hat{\beta}_1$	SHORT RATE $\hat{\beta}_2$	$\bar{R}^2$	SEE
1987Q_1-1995Q_3	1	35	6.98 (1.37)	-0.48 (-0.53)	-0.32 (-1.10)	-0.03	7.68
1987Q_1-1995Q_2	2	34	6.60* (2.09)	-0.26 (-0.54)	-0.32** (-1.87)	0.01	4.97
1987Q_1-1995Q_1	3	33	4.69* (1.84)	0.61 (1.42)	-0.28* (-2.17)	0.15	3.48
1987Q_1-1994Q_4	4	32	6.38* (3.61)	0.40 (0.92)	-0.38* (-4.42)	0.33	2.66
1987Q_1-1994Q_3	5	31	8.17* (6.74)	-0.21 (-0.96)	-044* (-7.16)	0.39	2.36
1987Q_1-1994Q_2	6	30	8.37* (5.66)	-0.26 (-1.04)	-0.45* (-5.64)	0.45	2.13
1987Q_1-1994Q_1	7	29	7.68* (5.74)	-0.01 (-0.05)	-0.42* (-5.57)	0.49	1.99
1987Q_1-1993Q_4	8	28	6.64* (5.05)	0.22 (0.65)	-0.37* (-4.97)	0.49	1.91
1987Q_1-1992Q_4	12	24	11.92* (7.84)	-0.59* (-2.18)	-0.70* (-7.62)	0.59	1.50
1987Q_1-1991Q_4	16	20	9.28* (5.50)	-0.12 (-0.12)	-0.60* (-5.27)	0.55	1.30
1987Q_1-1990Q_4	20	16	7.58* (7.73)	-0.41 (-0.82)	-0.45* (-7.97)	0.70	0.79

As obtained for manufacturing sector activities, we observe from Table 4.9a that the spread likewise significantly predict growth of the real industrial output over the two-quarter to twelve-quarter horizon, although the predictive power is substantially weaker. In Table 4.9b, the spread also losses its information-content for future growth in industrial activity once the short rate is included in the model (except in the three-year horizon, where it is negatively signed).

This suggests that the spread does not contain any additional information on the future course of manufacturing or industrial output than could be recovered from the short-term rate, which more often reflects the stance of monetary policy.

Table 4.8a: **PREDICTING** GROSS CAPITAL FORMATION **GROWTH WITH** SPREAD

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\alpha}_0$	Spread $\hat{\alpha}_1$	$\overline{R}^2$	SEE
$1987Q_1$-$1995Q_3$	1	35	-5.07* (-3.48)	4.57* (8.21)	0.31	6.69
$1987Q_1$-$1995Q_2$	2	34	-3.96* (-2.84)	4.01* (6.97)	0.30	6.07
$1987Q_1$-$1995Q_1$	3	33	-2.81** (-1.91)	3.26* (4.66)	0.20	6.26
$1987Q_1$-$1994Q_4$	4	32	-2.98* (-2.09)	3.57* (5.70)	0.28	5.81
$1987Q_1$-$1994Q_3$	5	31	-3.48* (-2.29)	3.86* (6.65)	0.28	5.66
$1987Q_1$-$1994Q_2$	6	30	-2.82 (-1.66)	3.53* (6.23)	0.26	5.54
$1987Q_1$-$1994Q_1$	7	29	-2.33 (-1.38)	3.36* (5.87)	0.25	5.41
$1987Q_1$-$1993Q_4$	8	28	-1.70 (-0.90)	2.99* (5.32)	0.21	5.37
$1987Q_1$-$1992Q_4$	12	24	8.80 (1.20)	-3.28 (-0.85)	-0.01	4.86
$1987Q_1$-$1991Q_4$	16	20	6.89 (1.08)	-2.10 (-0.70)	-0.03	3.63
$1987Q_1$-$1990Q_4$	20	16	12.05* (13.86)	-5.18* (-6.87)	0.44	1.73

Table 4.8b: **PREDICTING** GROSS CAPITAL FORMATION **WITH** COMBINED MODEL

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\beta}_0$	Spread $\hat{\beta}_1$	SHORT RATE $\hat{\beta}_2$	$\overline{R}^2$	SEE
$1987Q_1$-$1995Q_3$	1	35	3.86 (0.71)	3.43* (4.66)	-0.47** (-1.68)	0.34	6.52
$1987Q_1$-$1995Q_2$	2	34	7.69 (1.32)	2.55* (2.65)	-0.61* (-2.08)	0.40	5.62
$1987Q_1$-$1995Q_1$	3	33	9.99 (1.58)	1.68 (1.55)	-0.67* (-2.11)	0.34	5.70
$1987Q_1$-$1994Q_4$	4	32	10.10** (1.81)	1.99* (2.30)	-0.68* (-2.49)	0.44	5.11
$1987Q_1$-$1994Q_3$	5	31	10.80* (2.18)	2.54* (3.87)	-0.80* (-3.12)	0.50	4.72
$1987Q_1$-$1994Q_2$	6	30	11.80* (2.26)	2.28* (3.20)	-0.84* (-2.94)	0.47	4.70
$1987Q_1$-$1994Q_1$	7	29	13.97** (1.97)	1.71 (1.57)	-0.94* (-2.24)	0.43	4.74
$1987Q_1$-$1993Q_4$	8	28	16.97** (1.82)	1.21 (0.91)	-1.12** (-1.92)	0.41	4.64
$1987Q_1$-$1992Q_4$	12	24	21.33* (2.58)	-0.81 (-0.25)	-1.23* (3.79)	0.34	3.92
$1987Q_1$-$1991Q_4$	16	20	18.71* (6.49)	-0.04 (-0.04)	-1.14* (-7.34)	0.72	1.91
$1987Q_1$-$1990Q_4$	20	16	9.84* (3.02)	-8.16* (2.29)	0.61 (0.87)	0.42	1.76

As usual, from Table 4.8a, we observe that the spread contains information on the future growth of real *Gross Capital Formation expenditures* in the Nigerian economy for the first two-year horizons.

In the presence of the short rate in Table 4.8b, the spread still retains significant information about the future growth of real Gross Capital Formation for up to six-quarters ahead. The well known fact of the predominance of bank loans in corporate financing in Nigeria makes it reasonable to expect that short-term interest rate should exert a significant constraint on Gross Capital Formation growth in Nigeria. It is interesting however, to find that the spread has additional explanatory power for future Gross Capital Formation in the presence of short rate.

Table 4.9a: **PREDICTING** PRIVATE CONSUMPTION **GROWTH WITH** SPREAD

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATION	Constant $\hat{\alpha}_0$	Spread $\hat{\alpha}_1$	$\bar{R}^2$	SEE
1987Q1-1995Q3	1	35	0.40 (0.49)	0.58 (1.06)	0.00	3.31
1987Q1-1995Q2	2	34	0.59 (1.05)	0.53 (1.52)	0.03	2.08
1987Q1-1995Q1	3	33	1.02** (1.81)	0.22 (0.73)	-0.02	1.85
1987Q1-1994Q4	4	32	0.85** (1.80)	0.36 (1.54)	0.03	1.47
1987Q1-1994Q3	5	31	0.82* (2.10)	0.37* (2.31)	0.04	1.38
1987Q1-1994Q2	6	30	0.86* (2.81)	0.35* (3.34)	0.05	1.19
1987Q1-1994Q1	7	29	1.00* (3.360	0.23* (2.22)	0.01	1.09
1987Q1-1993Q4	8	28	0.92* (4.03)	0.28* (3.73)	0.07	0.87
1987Q1-1992Q4	12	24	0.90* (5.83)	0.22* 5.58)	0.18	0.43
1987Q1-1991Q4	16	20	2.64* (4.85)	-0.74* (-2.63)	0.21	0.41
1987Q1-1990Q4	20	16	1.99* (6.75)	-0.38* (-2.45)	0.05	0.36

Table 4.9b: **PREDICTING** PRIVATE CONSUMPTION **WITH** COMBINED MODEL

SAMPLE PERIOD	FORECAST HORIZON (QUARTERS)	NUMBER OF OBSERVATIONS	Constant $\hat{\beta}_0$	Spread $\hat{\beta}_1$	SHORT RATE $\hat{\beta}_2$	$\bar{R}^2$	SEE
1987Q1-1995Q3	1	35	1.76 (0.58)	0.40 (0.58)	-0.71 (-0.47)	-0.03	3.35
1987Q1-1995Q2	2	34	1.32 (0.82)	0.43 (1.06)	-0.04 (-0.51)	0.00	2.10
1987Q1-1995Q1	3	33	1.54 (1.15)	0.15 (0.54)	-0.03 (-0.42)	-0.05	1.88
1987Q1-1994Q4	4	32	1.26 (1.28)	0.30 (1.47)	-0.02 (-0.46)	0.00	1.50
1987Q1-1994Q3	5	31	1.02 (1.04)	0.34* (2.06)	-0.01 (-0.23)	0.01	1.41
1987Q1-1994Q2	6	30	1.15 (1.34)	0.31* (2.07)	-0.02 (-0.37)	0.02	1.21
1987Q1-1994Q1	7	29	1.31 (1.64)	0.19 (1.31)	-0.02 (-0.41)	-0.02	1.10
1987Q1-1993Q4	8	28	1.24* (2.03)	0.24* (2.37)	-0.02 (-0.56)	0.04	0.89
1987Q1-1992Q4	12	24	1.94* (3.98)	0.12 (1.58)	-0.06** (-2.01)	0.27	0.40
1987Q1-1991Q4	16	20	3.14* (5.59)	-0.64* (-2.67)	-0.05* (-2.34)	0.24	0.40
1987Q1-1990Q4	20	16	2.27* (4.62)	-0.33 (-1.68)	-0.03 (-1.19)	0.03	0.36

Similarly, tables 4.9a and 4.9b shows that the spread contains significant information about the future growth in real private consumption expenditures. It predicts the future course of real private consumption rather well from five quarters to 12 quarters ahead, but becomes perversely signed at 16 to 20 quarter horizons though still statistically significant (Table 4.9a). From Table 4.9b, in the presence of short rate, the spread retains significant information for the future growth in real private consumption over 5, 6, and 8 quarters horizon. Over these horizons, the short-rate was statistically insignificant. Suggesting there was no additional information from short-rate over and above what is recoverable from the spread on the future course of real consumption spending. Indeed, addition of the short-term rate resulted in a decline of the predictive power of the model for consumption growth. Addition of the short-rate had increased the fit of the model substantially for all other measures of real activity.

Both the irrelevance of short rates for future consumption growth and dominance of the spread in explaining future consumption growth, are interesting for different reasons. The well-known fact that banks in Nigeria tend to extend only an insignificant amount of consumer loans, if any, makes the finding that short-term rate has no meaningful link with future growth in consumption spending quite understandable. The dominance of the spread in explaining future growth in consumption spending is consistent with the postulation of the consumption capital asset pricing model (CCAPM) of close inter-temporal links between the slope of the real yield curve and future real consumption growth. See Estrella, Rodrigues, and Schich (2000) for a recent treatment.

However, the spread provides a stronger prediction o f future Gross Capital Formation growth and even domestic absorption growth than it does for future consumption growth: it is just that the spread has exclusive predictive ability in the case of consumption, only the spread has a predictive content for consumption. The fact that the spread contains information for the future growth in private sector demand in general suggests that CAPM framework explain only a part of the underlying influences in the Nigerian economy[48]. As Estrella and Hardouvelis already suggested for the US context, a broader framework is also needed to explain why the spread predicts gross capital formation and domestic absorption more than it is able to predict

[48] Consistent with the original findings of Estrella and Hardouvelis (1991) that the spread predicted consumer durables and investment better than it was able to predict consumption in the US economy.

consumption spending in the Nigerian context. Contrary to what obtained for the sub-components of real-output, the spread tends to contain information on the future growth in the components of real-expenditure, even in the presence of the short rate.

❒ **Out-of-Sample Results**

While the in-sample forecasts discussed above permit the numeric estimation of impact coefficients ($\hat{\alpha}_1$ or $\hat{\beta}_1$) and predictive power ($\overline{R}^2$), it is out-of-sample forecasting tests that permit a test of the accuracy of the forecasts, measured by mean square absolute error (MSAE) or root mean square error (RMSE). The model with a lower forecast error at each horizon is the better predictor. Results from out-of-sample forecasts in Table 4.10 are summarized as follows:

Total output: Over all the horizons considered, the random walk model does a better job of predicting growth in total output than the spread plus short rate model. *Total expenditure:* Over all the horizons, the random walk model does a better job of predicting growth in total expenditure than spread plus short rate model. *Manufacturing:* Random walk model also fared best at all horizons in forecasting growth in manufacturing output. *Industrial output:* The random walk model provided superior forecasts of industrial output growth at one-year through to four-year horizons. Only at the five-year horizon did the spread plus short rate model provide a superior forecast than the random walk model. *Investment:* The random walk model fared best at all horizons in forecasting growth in investment spending. *Consumption:* The random walk model fared best at four horizons, one-year to three-year, as well as five-year. Spread plus short rate model delivered better forecast performance at the four-year horizon.

Table 4.10: Out-of-Sample Forecasting Performance of the Spread: $1987Q_1$-$1995Q_4$

ACTIVITY	PREDICTORS	ONE YEAR		TWO YEARS		THREE YEARS		FOUR YEARS		FIVE YEARS	
		MSAE	RMSE	MSAE	RMSE	MSAE	RMSE	MSAE	RMSE	MSAE	RMSE
Gross Domestic Product	RW	**0.1253**	**0.1602**	**0.4721**	**0.5165**	**0.5021**	**0.5441**	**0.3817**	**0.4298**	**0.2072**	**0.2439**
	S+SR	2.0019	2.0049	1.9710	2.0788	0.6945	0.6946	1.1735	1.1742	1.4686	1.5782
Real Domestic Absorption	RW	**0.2088**	**0.2308**	**0.4116**	**0.4381**	**0.4933**	**0.5290**	**0.1708**	**0.2111**	**0.0356**	**0.0486**
	S+SR	1.8820	1.8921	1.5431	1.7768	0.8954	0.9046	1.4891	1.4900	1.9937	2.1452
Manufacturing Output	RW	**3.4917**	**4.1054**	**1.0588**	**1.1283**	**0.7100**	**0.8119**	**1.7710**	**2.0112**	**1.2386**	**1.2782**
	S+SR	6.9592	7.5534	5.0488	5.8494	3.1939	3.5267	3.0836	3.1884	5.0864	5.2416
Industrial Output	RW	**1.9328**	**2.5447**	**1.0534**	**1.1258**	**0.6091**	**0.7348**	**1.3244**	**1.3649**	0.8397	0.8662
	S+SR	3.9934	4.4883	5.3787	5.6776	0.8655	1.0023	2.0031	2.0460	**0.4584**	**0.5631**
Gross Capital Formation	RW	**1.4414**	**1.6679**	**0.7282**	**0.7811**	**0.8325**	**0.9382**	**0.7107**	**0.9314**	**0.6983**	**0.7580**
	S+SR	5.4728	5.6491	10.1342	10.1414	8.5901	8.6033	13.7890	14.7672	4.2670	4.3030
Consumption	RW	**0.5114**	**0.5206**	0.4839	0.4858	**0.0878**	**0.1201**	0.6712	0.6877	0.2740	0.2788
	S+SR	0.7642	0.7642	0.4343	0.4523	1.3760	1.4225	**0.5551**	**0.5753**	0.5063	0.5467

Root mean square errors and mean squared absolute errors were calculated using the parameters of recursive OLS regressions estimated from 1987. The two models reported are:
Random Walk Model: $\Delta y_t = \xi_o + \xi_1 \Delta y_{t-1} + \varepsilon$, Spread + Short Rate Model: $\Delta y_t = \lambda_o + \lambda_1 S_t + \lambda_2 r_t + \varepsilon$.
The abbreviations used in the Table are: Random Walk = RW; Spread = S; Short Rate = SR. The **boldfaced** figures indicate the superior model among the two in each case.

The random-walk model delivered superior forecasts than the spread and short rate model in 28 of the 30 cases considered! The spread plus short rate model fared best in only two of the 30 cases. For growth in total output, the past growth in output itself provided a more reliable basis for out of sample forecasting than information contained in the spread plus short rate. The same is true of manufacturing output and total expenditure. For future growth in industrial output, with the exception of the five-year horizon, where current spread plus short rate model proved superior, its own past growth is also the best predictor.

4.7 POLICY IMPLICATIONS

How could the central bank use the information content of yield curve? We address this question in the context of three basic conditions: stability, predictability, and controllability[49]. The first condition implies that the relationship between the yield curve and non-financial activity needs to be stable. Second condition states that the yield curve should possess leading indicator properties with respect to non-financial activity. That is, observable developments of the yield curve must provide reliable 'advance knowledge' of non-financial activity. Finally, controllability implies that the central bank must be able to control the yield curve precisely and fairly quickly. The third condition is necessary only if the central bank wishes to use the yield curve either as an instrument or an intermediate target for monetary policy. Taken together, these conditions determine whether or not the central bank can make any practical use of the information content of the slope of the yield curve in any way.

To a large extent, because the central bank can only determine the short-term rate, the slope of the yield curve is not directly controllable by the central bank. This precludes using the slope of the yield curve as a policy instrument (Bernanke and Blinder, 1992). However, the stability of the relationship between the yield spread and future non-financial activity might suggest that the central bank could still use the slope of the yield curve as an information variable[50]. Even then, the central bank should be cautious in using the yield curve as an information variable for policy purposes. Although the empirical evidence indicates a positive correlation between the yield slope and non-financial activity, this correlation may reflect a variety of economic phenomena at different points in time. The policy clue from any given movement in the slope is not necessarily obvious. For example, a steepening of the slope may reflect the expectation of an increase in capital productivity, reflected in higher real interest rates and a subsequent increase in activity. Monetary tightening may or may not be warranted in this case, as the appropriate decision will be determined by the current state of the business cycle. On the other hand, the positive correlation may reflect the expectation of a future monetary tightening by a credible monetary policymaker. In which case, no immediate policy response is warranted. This possibility of multiple valid theoretical explanations of a single observed relationship corroborates the fact that the response of the term structure is highly sensitive to the nature of the underlying shocks impinging on the economy[51].

There are also reasons why central banks should be cautious in using the yield curve for monetary policy purposes. The information content is largest in countries where short-term interest rates are easiest to predict[52]. Since predictability can be a manifestation of a credible monetary policy, regime shifts can destroy this credibility (especially if regime shifts occur frequently), with consequences for the empirical validity of the positive correlation. Similarly, it is clearly possible for the same central bank to pursue identical policies at different points in time, but induce different expectations and consequent reactions from economic agents because of differences in its credibility at the different points. The implication is that the usefulness of information content of the yield curve will vary over time.

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[49] See Shigehara (1996) for more detailed discussion.
[50] See Friedman (1993, 1994).
[51] Turnovsky (1985, 1989) and McCallum (1994).
[52] Gerlach and Smets (1995)

Consequently, the information content of the slope of the yield curve will be of more practical value to policymakers only when it is used in combination with information available on other variables in the economy at any point in time.

When used in this way, the slope can be a very strong indicator for informing policymakers judgement about the best courses of policy actions, even when the slope cannot be used as a policy instrument or an intermediate target.

4.8 SUMMARY AND CONCLUSION

We find that the term-structure spread does predict real activity (measured as real GDP) in Nigeria quite well. The in-sample *predictive power* of the spread is comparable to that found for OECD economies (e.g. in Estrella and Hardouvelis (1991), Caporale (1994)). The predictive power of the term-structure spread is stronger for future growth in real expenditure, measured as real domestic absorption (RLDA) and its components, than it is for real output growth, measured as real GDP and its components. The spread even has a higher predictive power for future growth in real gross domestic Gross Capital Formation than it has for total expenditure, making Gross Capital Formation the most closely associated with variations in the spread in the Nigerian context. The spread also contains considerable exclusive information on consumer spending in Nigeria.

Another model in which economic activity is regressed against the spread and short-term rate together confirms that the explanatory power of the spread for future real activity stem entirely from the demand side. In the presence of the short rate, the spread can no longer explain any of the variations in supply side measures of real activity. Conversely, the short-term rate has no marginal predictive power for future growth in real consumption in the presence of the spread, which is still well predicted by the spread in the combined model. Out-of-sample forecast results suggested the random walk model provided better out of sample forecasts of all the other variables than spread or spread plus short rate model.

The spread however has absolutely no predictive content for real activity in the period before 1985. Its information content appears confined to the post liberalization/structural adjustment period when interest rates reflected relative scarcity of funds, exchange rate and goods prices were fully liberalized, and the macro-economy entered a turbulent phase. 1960 to 1985 was a largely tranquil phase in the economy, when the future course of economic activity was probably shaped by development plans (funded by export earnings or foreign debt) that offered huge subsidies for credit, production inputs, and numerous consumer items.

Finally, we note a number of reasons why the practical usefulness of information content of the slope of the yield curve for policy purposes will vary over time. Consequently, the information content of the slope of the yield curve will be of practical value to the central bank only when it is used in combination with information available on other key variables in the economy at any given point in time. It is only in this way that the slope can be a very strong indicator for informing policymakers judgment about the best courses of policy actions, even when the slope cannot be used as a policy instrument or an intermediate target.

V. DEMAND FOR NARROW MONEY (M1) IN NIGERIA

This Chapter tests hypotheses about demand for M1 and estimates the long and short run elasticities of the model in line with the steps laid out in section 2.6 to 2.10. We begin with a step-by-step specification search for a demand function for narrow money, M1, in section 5.1. The specification search involved a permutation of rival measures of real activity and interest rates to see which ones are cointegrating combinations in the Engle Granger sense. The outcome of the OLS search is presented in section 5.2. Section 5.3 presents JML tests of the hypothesis of cointegration on the uncovered vector. Section 5.4 derives Wickens-Breusch ARDL estimates of the long run elasticities. Specification tests are undertaken in section 5.5. The short run responses are derived in sections 5.6 to 5.10, using the Wickens-Breusch ECMs.

5.1. E-G OLS Searches for Cointegrating M1 Vector

The equation estimated for M1 is:

$$\frac{m1^{d}}{P} = f(y, r_{qm}^{nig}, r_{tbr}^{nig}, r_{qm}^{uk}, \pi, e) \qquad \dots (5.1)$$

Where,

$m1^{d}$ = desired stock of demand deposits (equals actual only in equilibrium);

P = general price level;

y = real expenditure;

r_{qm}^{nig} = Rate on quasi-money in Nigeria;

r_{tbr}^{nig} = Rate on Treasury bills in Nigeria;

r_{qm}^{uk} = Rate on quasi-money in the UK.

π = rate of inflation.

e = exchange rate depreciation:

The double logarithmic form of (5.1) is:

$$\log\left(\frac{m1^d}{P}\right) = \alpha_0 + \alpha_1 \log y + \alpha_3 \log r_{qm}^{nig} + \alpha_4 \log r_{tbr}^{nig} + \alpha_5 \log r_{qm}^{uk} + \alpha_6 \pi + \alpha_7 \log e + \mu \ \ldots \ (5.2)^{53}$$

Table 5.1a presents estimates using gross domestic product and its deflator as the transaction and price level variables while Table 5.1b presents estimates using domestic absorption and its deflator.

In Table 5.1a, the price level is defined as the GDP deflator (DEF), while the rate of inflation is the first difference of the GDP deflator (ΔlogDEF or π_{DEF}), and nominal M1 is deflated by the GDP-deflator to define real M1.

Table 5.1a: Specification Searches for Nominal and Real M1: Real-GDP as Scale Variable

	1.	2.	3.	4.	5.	6.	7.
Dependent Variable	Log M1	Log M1	Log M1	Log M1	Log M1	Log M1	Log (M1/DEF)
CONSTANT	-11.9 (-5.9)***	-11.8 (-6.1)***	-13.6 (-7.0)***	-6.46 (-3.5)***	-3.6 (-3.0)***	-3.5 (-2.9)***	-4.7 (-5.7)***
LOGGDP	1.41 (7.5)***	1.40 (7.8)***	1.7 (8.7)***	0.998 (5.4)***	0.76 (6.4)***	0.76 (6.4)***	0.9 (13.3)***
LOGGDPDEF	1.1 (26.0)***	1.1 (27.3)***	0.93 (13.5)***	1.03 (17.4)***	1.07 (28.3)***	1.05 (28.3)***	-
LOGGDPDEF	-	-1.81 (-3.9)***	-1.5 (-3.3)***	-1.03 (-2.6)***	-0.46 (-1.8)*	-	-
Log[tdr3m/(1+tdr3m)]	-	-	0.3 (3.4)***	1.4 (8.8)***	0.76 (6.7)***	0.8 (7.0)***	0.8 (7.4)***
Log[tbr/(1+tbr)]	-	-	-	-1.3 (-7.8)***	-0.48 (-4.0)***	-0.5 (-4.1)***	-0.47 (-4.0)***
LOGTOTADJ	-	-	-	-	1.31 (14.2)***	1.3 (14.6)***	1.3 (14.4)***
CRDW	0.161	0.187	0.206	0.406	0.664	0.73829	0.7327
Adj. R^2	0.9793	0.9805	0.9823	0.9876	0.9950	0.9949	0.9509
F-ratio	3379.1 [0.00]	2438.3 [0.00]	1971.4 [0.00]	2269.0[0.00]	4689.2[0.00]	5534.8[0.00]	688.4 [0.00]
σ	0.30184	0.2887	0.27826	0.23261	0.14824	0.14946	0.14995
LL	-30.32	-23.2217	-17.4391	8.707	73.6563	71.9586	70.98
SBC	-37.78	-33.1474	-29.8462	-6.181	56.2863	57.0701	56.568
T[1960II-95IV]	143	143	143	143	143	143	143
N	3	4	5	6	7	6	5
ADF [I], (I=0 ... 4)	-2.1099 [0]	-2.1614 [0]	-2.5902 [0]	-3.828 [0]	-5.0920 [0]	-5.483 [0]**	-5.5039 [0]**
ADF 95% crit. Val.	-3.8037	-4.1790	-4.5185	-4.829	None	-4.8294	-4.5185
Cointegrated?	No	No	No	No	?	Yes	Yes

All variables are expressed in logarithms. ' ' implies first differences of the logarithms of the levels of the corresponding variables. Figures in parentheses are t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. '*' signifies 10% level of significance; '**', 5%; and '***', 1%. '-' Implies the corresponding variable(s) not included. σ = Standard error of regression; LL = Maximum of Log-likelihood; T = Number of observations; N= number of series for which the null of no-co-integration is being tested. The 95% critical values for the ADF$_i$ statistics, [*i*] *(i=0 ... 4)*, where *i* is the number of lags in the ADF regressions, depend on both T and N based on the response surface estimates given by MacKinnon (1991). The specific number of lags used in each case is indicated in brackets. Again, '**', indicates significance of the ADF statistic in rejecting the null of no co-integration.

Column 1 of Table 5.1a tests for possible co-integration between nominal M1, real GDP, and the GDP-deflator, all of which are individually non-stationary (I(1)) series. This reduces to a question of *whether the inverse of M1-velocity is stationary.* ADF statistic of –2.1099 (critical value of –3.8037) suggests there is no co-integration. Thus necessitating the search for which opportunity cost should be added to these variables to define a stable long run relation of demand for M1.

[53] For estimation purposes, alternative scale variables are substituted for y, alternative deflators are substituted for P, and all interest rates, r, are expressed as r/(1+r).

Column 2 tests for the possibility that the *addition of the inflation rate alone* will result in co-integration (Arrau et al (1995))[54]. Again, the ADF statistic of -2.1614 (-4.1790) suggests that there is no co-integration. The estimated coefficient of the inflation rate of −1.81 is statistically significant at the 1% level and is therefore retained for the time being while additional variables are introduced into the vector in subsequent columns.

Column 3 tests for the possibility that the addition of the *3-month time deposit rate alone* to the model in column 2 will result in co-integration. Again, the ADF statistic of −2.5902 (-4.5185) suggests that there is no co-integration. The coefficient of the 3-month time deposit rate is 0.32, and is also significant at the 1% level, like all the other variables.

Column 4 tests for the possibility that the addition of a second nominal interest rate, the *3-month Treasury bill rate*, will result in co-integration. Again, the ADF statistic of −3.828 (-4.8294) suggests that there is no co-integration. All the five explanatory variables, especially both interest rates and the rate of inflation, are significant at the 1% level. The opposite signs in the estimated responses of the demand for M1 for the two interest rates is noteworthy.

Column 5 tests for the possibility that a modification to the scale variable used will result in co-integration. *Terms-of-trade adjustment* is thus added as an independent variable bringing the number of independent variables to six. No critical value of the ADF is available for a seven-variable vector. Note however, that the rate of inflation becomes statistically significant only at the 10% level with the addition of the terms of trade adjustment while all the other five explanatory variables remain significant at the 1% level. Notice also that both the magnitude and statistical significance of the coefficient of the inflation rate had dwindled steadily with the inclusion of each additional explanatory variable from columns 3 to 5, the level of significance dropped most sharply in column 5.

An important point here is that the inflation rate appears to be the red herring in the long run money-demand model in the Nigerian context over the sample period. It is highly significant in

[54] Note that the inflation rate is stationary (I(0)) series while the other variables are non-stationary (I(1)) series.

the absence of the 'correct variables', and could lead the unwary down the wrong path. The inflation rate is probably a spurious regressor and is dropped from the model. The re-estimated equation is presented in **Column 6.** The ADF statistic of –5.483 (-4.8294) suggests that *there is co-integration.*

Three points are noteworthy here:

i. GDP is an inappropriate proxy for the scale variable[55];

ii. Inflation rate does not belong to the long run demand for money model;

iii. Two domestic interest rates belong to the long run relation for M1 in Nigeria.

Notice that the coefficient of the price level, GDP deflator in this case, is either 1 or very close to unity in columns 1 to 6, which are all models of nominal M1 balances. The hypothesis that nominal money balances is homogeneous of degree one in prices is thus consistent with the data. **Column** 7 imposes the implied zero-homogeneity in prices on real-M1 balances, i.e., $\alpha_2=0$ from equation 5.1. The real-M1 model is revealed by the ADF statistic of –5.5039 (-4.5185) to be cointegrated and this confirms that the restriction is data-consistent (M1 is deflated by the GDP deflator in column 7).

Inspecting the various other statistics reported for each of the columns in Table 5.1a besides the ADF statistics supports the claim that columns 1 to 4 probably misspecifies the model of interest. Although each step from 1 to 4 reduces the standard error of the equation as reflected in the steady decline in σ, and the steady rise in LL and SBC. Columns 5 to 7 appear to be adequate reflections of the underlying information in the data and each step from columns 5 to 7 also improved the model. Specifically, σ is minimized (and LL maximized) in 5 where the 'correction of the error in the scale variable' is effected. SBC is maximized in 6 when the inflation rate was dropped from the long run model. Column 7 represents a gain in theory-consistency and parsimony, rather than in statistical fit.

[55] GDP leaves out terms of trade adjustment and its use could amount to misspecification of the scale variable if terms-of-trade-adjustment influence money demand. The terms of trade adjustment is I(1).

The Engle-Granger static OLS specification search thus leaves us with a model for real M1 in which the nominal time deposit rate and Treasury bill rates show up as the relevant interest rates. Apart from these two interest rates, the scale variable is the only other information needed to define the co-integrating vector for real-M1.

While the objective at this stage is to test the hypothesis about the existence of equilibrium relations rather than estimate the long run equilibrium elasticities, a few comments on the estimated long run responses can now be made in passing[56]. The estimated income elasticity, coefficient of the GDP, is significantly greater than unity in columns 1-3 where both the scale variable and opportunity costs were misspecified. It drops to unity in column 4, when opportunity cost is specified by the inclusion of the two interest rates together. Finally, it drops below unity in columns 5 to 7 when the correction for the scale variable is done. It therefore remains consistent with the a priori expectation ($0.5 \leq \alpha_1 \leq 1$) in columns 4 to 7, but not in columns 1-3. Note for the time being that the elasticity of M1 demand with regard to the terms of trade adjustment is 1.3 in columns 5-7, and it is slightly more statistically significant than the elasticity of M1 to GDP in the model for real-M1, the final column. The coefficient of the time deposit rate is positively signed (α_3=0.8), suggesting that M1 and time deposits are long-run complements. The coefficient of the Treasury bill rate however, is negatively signed (α_4=-0.5), suggesting that M1 and government securities are substitutes.

The GDP proved an inadequate scale variable and the terms of trade adjustment had to be used as an additional explanatory variable: a second scale variable in actual fact. While a vector of interest rates is admissible into the money demand framework, theory suggests only one scale variable. We therefore now attempt to express the relation in column 7 in such a way that only one scale variable is used rather than two. This should achieve a higher degree of theory consistency (even if this has to be done at the expense of statistical fit). Since the central

[56] The sizes of the estimated long-run responses of M1 to transaction scale and interest rates are discussed in greater detail Chapter eight.

postulation of theory at this stage is about long run stability of the money demand function, presence of co-integration, not some absolute statistical criteria, is taken as sufficient for fulfilling the requirement of theory. It must also be borne in mind that the fact that subsequent specification searches will involve a change of the scale variable and the deflator must mean that the two stages are not as directly comparable as the successive columns of Table 5.1a.

Table 5.1b explores the possibility of having only one scale variable by using the sum of GDP and terms of trade adjustment, the real domestic absorption (RLDA) as the relevant scale variable. In that Table, the price level is the domestic absorption deflator (DAD), and the rate of inflation is the first difference of the domestic absorption deflator (ΔlogDAD or π_{DAD}). Finally, nominal M1 is deflated by the domestic absorption deflator to define real M1 (log(m1/DAD).

Table 5.1b: Specification Searches for M1: Real Domestic Absorption as Scale Variable

	8.	9.	10.	11.	12.	13.	14.
Dependent Variable	log M1	log (M1/DAD)	log (M1/DAD)	Log (M1/DAD)	log (M1/DAD)	log (M1/DAD)	Log (M1/DAD)
CONSTANT	-16.1 (-22.24)***	-16.7 (-30.88)***	-11.5 (-14.04)***	-11.6 (-14.23)***	11.5 (13.99)***	-13.9 (-20.05)***	-15.1 (-23.82)***
LOGDA	1.79 (26.73)***	1.85 (39.37)***	1.44 (21.08)***	1.45 (21.23)***	1.44 (21.03)***	1.66 (30.51)***	1.75 (35.05)***
LOGDAD	1.03 (52.83)***	-	-		-	-	-
ΔLOGDAD	-	-	-	-0.55 (1.97)*	-	-	-
Log[tdr3m/(1+ tdr3m)]	-	-	0.88 (6.03)***	0.86 (5.92)***	0.88 (6.03)	0.20 (5.81)***	-
Log[tbr/(1+tbr)]	-	-	-0.74 (-4.77)***	-0.69 (-4.48)***	-0.74 (-4.7498)	-	0.17 (4.50)***
ΔLOGER	-	-	-	-	--0.062 (-0.56)	-	-
CRDW	0.285	0.282	0.459	0.399	0.44	0.3436	0.325
Adj. R^2	0.9874	0.9155	0.9403	0.94	0.94	0.9310	0.9252
F-ratio	5621.9[0.00]	1550.1[0.00]	746.3[0.00]	572.3[0.00]	557.1[0.00]	959.4[0.00]	879.2[0.00]
σ	0.23497	0.2355	0.1978	0.1958	0.1983	0.2126	0.2214
LL	5.7416	4.9032	30.8487	32.82	31.00	20.03	14.23
SBC	-1.7132	-0.067	20.922	-4.48	18.60	12.58	6.79
T	144 [19601-95IV]	144[19601-95IV]	144[19601-95IV]	143[1960II-95IV]	144[1960II-95IV]	144[19601-95IV]	144[19601-95IV]
N	3	2	4	4	4	3	3
ADF [I], (I=0 ... 4)	-2.3145[1]	-2.3641[1]	-4.1989[0]	-3.7965[0]	-4.0995	-2.53[1]	-2.4316
ADF 95% crit. Val.	-3.8037	-3.3811	-4.1790	-4.1790	-4.1790	-3.8041	-3.8041
Cointegrated?	No	No	Yes	No	No	No	No

All variables are expressed in logarithms, and 'Δ' implies first differences of the logarithms of the levels of the corresponding variables. Figures in parentheses are t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. '*' signifies 10% level of significance; '**', 5%; and '***', 1%. '-' Implies the corresponding variable(s) not included. σ = Standard error of regression; LL = Maximum of Log-likelihood; T = Number of observations; N= The number of series for which the null of no-co-integration is being tested. The 95% critical values for the ADF_i statistics, [*i*] *(i=0 ... 4)*, where *i* is the number of lags in the ADF regressions, depend on both T and N based on the response surface estimates given by MacKinnon (1991). The specific number of lags used in each case is indicated in brackets. Again, '**', indicates significance of the ADF statistic in rejecting the null of no co-integration.

Column 8 tests for possible co-integration between nominal M1, real domestic absorption, and the domestic absorption deflator, all of which are individually non-stationary (I(1)) series. This, like column 1 of Table 5.1a, reduces to a question of *whether the inverse of M1-is stationary,* if defined in terms of domestic absorption rather than real GDP. The calculated ADF statistic of –1.7132 (critical value of -3.8037) suggests there is no co-integration. Notice that the coefficient of the price level remains unity in column 8, even with the change in the proxy for the price level from GDP deflator to domestic absorption deflator to be consistent with the switch in scale variable.

Column 9 imposes the implied zero-homogeneity in prices on real-M1 balances, i.e., $\alpha_2=0$ from equation 6.1. The result in column 9 once again confirms the absence of a bivariate co-integration (ADF=-2.3641(-3.3811)) between real balances and real domestic absorption. This necessitates a search for opportunity cost variables that should be added to real M1 and the scale variable to define a stable long run relation of demand for M1. Columns 10 to 14 address this issue. **Column 10** takes a cue from column 7 and tests the hypothesis that only the two interest rates need to be added to the real domestic absorption to achieve co-integration. The ADF test statistic of –4.1989 (-4.1790) does reveal that this hypothesis is plausible.

Column 11 includes the inflation rate to test the hypothesis that this variable should belong to the long run model, while **column 12** does the same for the official exchange rate depreciation. The results show that the property of co-integration is lost if either of these variables is added to the model, in spite of the fact that the variables are themselves individually I(0). ADF statistic is –3.7965 (-4.1790) in column 11 and –4.0995 (-4.1790) for column 12, the critical value in each of the two cases is the same as the one in column 10 because the number of non-stationary series remains 4. Columns 13 and 14 checks whether either of the two interest rates can also be dropped without hampering the long run stability of the remaining variables in the relation uncovered in column 10. The results show that the co-integrating property is lost if any of the two interest rates is excluded, the ADF statistics are –2.53 (-3.8041) in column 13 and –2.4316 (-3.8041). This confirms that the relation in column 10 defines a valid cointegrating vector to which no additional variable needs to be added ($\alpha_5=\alpha_6=\alpha_7=0$ in the case of M1 in equation 5.1), and from which no variable can be removed, without losing the property of cointegration. By the rank condition, if it is possible to exclude any variable and still have cointegration among the remaining variables, then the excluded variable does not belong to the cointegrating relation. That variable must be excluded even if the variable appears to be statistically significant and statistics, such as the ADF tests, suggest that the model that includes that variable is cointegrated. On the whole, the evidence suggests that column 10 actually uncovers what Davidson (1998) refers to as 'irreducible cointegrating vector', a property that is required to satisfy the rank condition of co-integration. This seems sufficient to lay to rest any further debate about what other variable should belong to the long run relation for real-M1 balances in Nigeria over the current sample period. Based on this finding for M1, we subsequently adopt Real Domestic Absorption (RLDA) as the scale variable for COB and DD estimations since M1 = COB + DD.

5.2. Summary of the E-G Results for M1

Over the 1960Q1-1995Q4-sample period, Engle-Granger static OLS specification search recovered a four-variable cointegrating vector for real-M1 as follows:

$$\log\left(\frac{\hat{m}1}{p}\right) = \underset{(-14.04)}{-11.5} + \underset{(21.08)}{1.44}\log\left(\frac{y}{p}\right) + \underset{(6.03)}{0.88}\log r_{tdr3m}^{nig} - \underset{(-4.77)}{0.74}\log r_{tbr}^{nig} \qquad (5.3)$$ [57] [58]

Adj. R^2=0.9403; CRDW=0.46; F-ratio=746.3[0.00]; σ=0.1978; LL=30.8487; SBC=20.922; T=144[19601-95IV]; N=4; ADF [i], (i=0 ... 4)=-4.1989[0]; ADF 95% critical value=-4.1790; Cointegrated? **Yes.**

Our Engle-Granger static OLS specification search thus finally leaves us with a cointegrating vector with four variables for the demand for real-M1 in Nigeria over the 1960Q1-95Q4 sample

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[57] All variables are expressed in logarithms. Figures in parentheses are t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. '*' signifies 10% level of significance; '**', 5%; and '***', 1%. σ = Standard error of regression; LL = Maximum of Log-likelihood; T = Number of observations; N= The number of series for which the null of no-co-integration is being tested. The 95% critical values for the ADF_i statistics, [*i*] *(i=0 ... 4)*, where *i* is the number of lags in the ADF regressions, depend on both T and N based on the response surface estimates given by MacKinnon (1991). The specific number of lags used in each case is indicated in brackets. Again, '**', indicates 95% level of confidence in the rejection of the null of no co-integration by the ADF statistic.

[58] The model estimated from the semi-log version of equation 5.3 is:

$$\log\left(\frac{\hat{m}1}{p}\right) = \underset{(-19.9)}{-14.4} + \underset{(25.967)}{1.648}\log\left(\frac{y}{p}\right) + \underset{(3.66)}{9.66}\, r_{tdr3m}^{nig} - \underset{(-3.16)}{8.75}\, r_{tbr}^{nig}$$

Adj. R^2=0.924; CRDW=0.42; F-ratio=580.5[0.00]; σ=0.2233; LL=13.5770; SBC=3.6374; T=144[19601-95IV]; N=4; ADF [i], (i=0 ... 4)=-2.8811[0]; ADF 95% critical value=-4.1784; Cointegrated? No.
The presence of cointegration in the double-log form and the absence thereof in the semi-log form suggest that the former is the better representation of the long run relationships among the variables. Also, non-nested test of the semi-log against the double log form delivers SBC of -13.0554 against the semi-log form, suggesting the double log form encompasses the semi-log form.

period: real M1 is determined by real activity (domestic absorption) and two nominal interest rates (time deposit and Treasury bill rates). There is a stable long-run relation between real-M1 and only three other variables in Nigeria. The above result from Engle-Granger (E-G) single-equation static ordinary least squares (OLS) regression clearly suggests a rejection of the null of non-cointegration between real-M1 with real activity and interest rates. Since this method is known to have a tendency to suggest absence cointegration when one is present, the finding of cointegration within this framework is strong evidence indeed.

But one should still note that there is a lot of uncertainty about the reliability of co-integration tests in finite samples when the true model is unknown. The E-G result also does not tell us all that we would like to know about the cointegrating vector. There is a possibility that the vector is not unique: there might be more than one cointegrating relationship among the four variables in the vector. This needs to be ascertained. It is also not clear which of the four variables in the vector is the endogenous variable. The E-G static OLS technique is ill-suited for these excercises. All these necessitate the application of Johansen-Juselius Maximum Likelihood (JML) vector autoregression technique to the vector identified from the static OLS search in this section.

5.2: Granger Causality Tests for the M1 Cointegrating Vector

	$\sum_{i=1}^{4} \Delta lrlda_{t-i}$	$\sum_{i=1}^{4} \Delta ltbr_{t-i}$	$\sum_{i=1}^{4} \Delta ltdr3m_{t-i}$	$\sum_{i=1}^{4} \Delta ldad_{t-i}$	$\sum_{i=1}^{4} \Delta lm1_{t-I}$	ECM
$\Delta lrlm1_t$	3.3*[2]	10.8***[3]	19.8***[4]	6.0***[2,4]	12.4***[1.3,4]	13.2***
$\Delta lrlda_t$	5.7***[2,3]	...	5.9**[2]	4.5**[4]	...	...
$\Delta ltbr_t$	...	...	...	...	...	...
$\Delta ltdr3m_t$	...	...	...	...	...	...

The numbers reported are F statistics. The numbers in brackets indicate the specific lag(s) that are significant. Significance at 1 per cent level is indicated by, '***'; '**', implies 5 per cent level, and, '*', 10 per cent. Note that ΔlogDAD and ΔlogM1 are entered separately with the same lags in this regression. Using ΔlogM1 rather than ΔlogRLM1 is the correct thing to do as it also enables us to isolate the impact of observable changes in the nominal money stock on 'unobservable' desired holding of real-balances.

Table 5.1c presents the results of Granger causality tests on the E-G cointegrating vector for M1. The error-correction term, ECM_{t-1} (one period lagged residuals from the vector for real-M1) is only statistically significant in explaining changes in real-M1. Changes in real-M1 could therefore rightly be treated as the endogenous variable in a single-equation error-correction model (SEECM) framework. Exogeneity assertions are usually made to allow the analysis of one set of variables without having to specify how a second set is determined. Different notions of exogeneity are required depending on the purpose of analysis. The insignificance of the ECM in the equations for the changes in other variables shows that they can be rightly regarded as weakly exogenous for real-M1. Weak exogeneity is required for valid statistical inference.

Beyond the causal influence of the disequilibrium error, causality also runs from the lagged values of the different variables to one another. The absence of reverse causation from real-M1 to any of the other explanatory variables is noteworthy in this regard. Strong exogeneity, which is relevant in forecasting models, requires the absence of reverse causation from the dependent variable to any of the weakly exogenous explanatory variables. The dynamic models for real-M1 derived from the above cointegrating vector, will therefore be well suited for out-of-sample forecasting. Our interest in constructing M1 demand models centers more on conditional policy inferences rather than on forecasting. Strong exogeneity is not relevant to this pursuit. The relevant attribute is super exogeneity, which requires that the dynamic model be structurally stable with constant parameters. Since the Granger causality tests are conducted within reduced form models, we shall return to stability and constancy requirements after constructing the structural models in the sections that follow.

5.3. JML Results for M1

The JML tests are preceded by a test for the optimal order of the VAR, conducted in the context of an unrestricted VAR model with eight lags.

TABLE 5.3a: SELECTING THE ORDER OF THE VAR MODEL

Test Statistics and Choice Criteria for Selecting the Order of the VAR Model are based on 136 observations from 1995Q4. Lag length used for testing is VAR=8. List of variables included in the unrestricted VAR: LOG (M1/DAD), LOG(RLDA), LOG(TDR3M), and LOG(TBR). List of deterministic and/or exogenous variables: CONSTANT		
Order of Lag in the VAR(p)	AIC	SBC
p =0	-115.73	-122.97
p =1	**631.47*****	**588.00*****
p =2	623.28	543.59
p =3	615.13	499.22
p =4	604.25	452.12
p =5	601.24	412.88
p =6	591.59	367.01
p =7	584.78	323.97
p =8	578.08	281.05

AIC=Akaike Information Criteria; and, SBC=Schwarz Bayesian Criterion.

From Table 5.3a, both AIC and SBC suggest the optimal order of this VAR is 1. Hence, the test for co-integration is based on a VAR of order 1. Co-integration is tested with restricted intercepts and no trends in the underlying VAR. 143 observations from 1960Q2 to 1995Q4 were used with a VAR of order 1. The list of variables included in the vector is: log(M1/DAD), log(RLDA), log(TDR3M), and log(TBR), and INTERCEPT.

TABLE 5.3b: DETERMINISTIC COMPONENTS IN THE COINTEGRATING RELATIONS

Assumptions	AIC	SBC	HQC
Case 1: No intercept, and no deterministic trends in the VAR	648.4538 (r=1)	641.6691 (r=0)	644.2400 (r=1)
Case 2: Restricted intercept, and no deterministic trends in VAR***	653.7261 (r=3)	**641.6691 (r=0)**	**645.1703*** (r=2)**
Case 3: Unrestricted intercept, and no deterministic trends in VAR	653.7703 (r=2)	634.5782 (r=0)	644.1387 (r=2)
Case 4: Unrestricted intercept, and restricted deterministic trends in VAR	**654.3269 (r=4)**	634.5782 (r=0)	641.7453 (r=2)
Case5: Unrestricted intercept and deterministic trend in VAR	**654.3269 (r=4)**	625.0395 (r=0)	639.8794 (r=4)

AIC=Akaike Information Criteria; SBC=Schwarz Bayesian Criterion, HQC=Hannan-Quin Criterion.

TABLE 5.3c: LR TEST BASED ON MAXIMAL EIGENVALUE OF THE STOCHASTIC MATRIX

NULL	*ALTERNATIVE*	*STATISTIC*	*95%CRITICAL VALUE*	*90% CRITICAL VALUE*
r=0	r≥1**	31.84	28.2700	25.8000
r≤1	r≥2*	20.0157	22.0400	19.8600
r≤2	r≥3	8.2562	15.8700	13.8100
r≤3	r≥4	3.2420	9.1600	7.5300

TABLE 5.3d: LR TEST BASED ON TRACE OF THE STOCHASTIC MATRIX

NULL	*ALTERNATIVE*	*STATISTIC*	*95%CRITICAL VALUE*	*90% CRITICAL VALUE*
R=0	r≥1**	63.3561	53.4800	49.9500
r≤1**	r≥2	31.5139	34.8700	31.9300
r≤2	r≥3	11.4983	20.1800	17.8800
r≤3	r≥4	3.2420	9.1600	7.5300

The list of eigenvalues in descending order is: 0.19962, 0.13062, 0.056101, 0.022417, and 0.0000. Using a VAR (1), the maximal eigenvalue of the stochastic matrix of the JML test suggests that the null of r = 0 can be rejected in favour of the alternative hypothesis of the rank of the cointegrating vector being equal to one at the 95% level of confidence. The hypothesis that r = 2 can be rejected on the basis of the maximal eigenvalue at the 95% level but not at the 90% level. These can be found in Table 5.3c. In Table 5.3d, evaluation of the hypotheses that r equals 0, 1, or 2 based on the trace of the stochastic matrix rejects rank of 0 and 2 in favour of rank of 1 at both 95 and 90% levels of significance. Table 5.3b presents the results of the three data-based information criteria on the choice of the rank of the CV. SBC value is maximized for r=0, suggesting there is no cointegrating combination among the variable. HQC value is maximized for r=2, suggesting two cointegrating vectors, and AIC is maximized for r=4. Since the maximal eigenvalue and the trace of the stochastic matix both strongly reject rank not equal to 1 in Tables 5.3c and 5.3d, we accept r=1 in spite of the inconclusiveness of the choice criteria.

Log(M1/DAD)=1.42log(RLDA)+1.22log(tdr3m/(1+ tdr3m))-1.25log(tbr/(1+tbr)) ... (5.4)

$$\Delta \log\left(\frac{\hat{m}}{p}\right) = \underset{(-5.44)}{-2.61} - \underset{(-5.46)}{0.57}\, ECT \qquad \text{... (5.5)}$$

R^2 = 0.1744; $\bar{R}^2$ = 0.16854; σ = 0.10504; DW = 2.3215; Equation Log-Likelihood = 120.34; F-Ratio$_{(1,141)}$ = 29.78 (0.381); SBC = 115.3775; Residuals serial correlation, LM$(\chi^2)_4$ = 14.3679 (0.006)*; RESET functional form LM$(\chi^2)_1$ = 0.11276 (0.737); Jarque-Bera error non-normality LM$(\chi^2)_2$ =66.15 (0.00)*; Heteroscedasticity LM$(\chi^2)_1$ =0.28276 (0.595);

The JML results therefore confirm that there is a valid co-integrating relationship between real M1, real activity, and two interest rates, TDR3m and TBR. Moreover, the results also suggest the absence of multiple co-integrating relations among these variables. Subsequent estimation is based on the assumption that a unique co-integrating relationship exists between real M1 and the other variables. The estimates of the long run coefficients of the vector are presented in equation 5.4 and the associated ECM is presented in equation 5.5. Examining the error-correction mechanism associated with the assumed long run relations in equation 5.3 establishes the validity of normalising the vector on real M1. The negative sign and statistical significance of the error-correction term with a t-ratio of -5.4575 in the equation for Δlog(M1/DAD) provides a strong confirmation that the vector is a valid co-integrating relationship and also reveals that it is appropriate to treat LOG(M1/DAD) as the endogenous variable in the model.

5.4. ARDL Estimation of M1 Models

Auto-regressive distributed lag estimation was based on the following augmented auto-regressive distributed lag ARDL ($p, q_1, q_2, \ldots q_k$) model:

$$\phi(L,p)y_t = \sum_{i=1}^{k} \beta_i(L,q_i)x_{it} + \delta' w_t + u_t \qquad \text{... (5.6)}$$

Where,

$$\phi(L,p) = 1 - \phi_1 L - \phi_2 L^2 - \ldots - \phi_p L^p \qquad \text{... (5.7)}$$

$$\beta_i(L,q_i) = \beta_{i0} + \ldots + \beta_{iq_i} L^{q_i}, \quad i = 1,2,\ldots,k, \qquad \text{... (5.8)}$$

L is a lag operator such that $Ly_t = y_{t-1}$, and $\mathbf{w}_t$ is a $s \times 1$ vector of deterministic variables such as the intercept term, seasonal dummies, time trends, or exogenous variables with fixed lags[59].

Computation involves estimation of (5.7) by OLS for all possible values of p = 0,1,2... m, q_i = 0, 1, 2, . . . m, i = 1, 2, . . . k; giving a total of $(m + 1)^{k+1}$ different ARDL models.

Computation was based on a maximum lag, m, of 8 quarters for all variables ($p=q_i=8$)[60]. All the models were estimated on the same sample period, namely $t = m+1$, m + 2... n. Models selected by each of the four information criteria (from the $(m+1)^{k+1}$ ARDL models that were estimated) are presented in Table 5.4a.

[59] See Pesaran and Shin (1995).

[60] Wickens and Bruesch (1988) noted that, for non-stationary series, it is not important to specify the lag length correctly as long as congruency requirements are satisfied at the chosen lag (p 204).

The ARDL ($\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3$) models selected by the different choice criteria are indicated in row 1. The variables in the ARDL equations are log (M1/DAD) as the dependent variable; and, log (RLDA), log (TDR), and log (TBR) as the three explanatory variables. The number of observations is 136 over 1960Q1-1995Q4-sample period. Both the $\overline{R}^2$ criterion and the AIC picked an ARDL (**5, 8, 8, 5**) model, while SBC picked ARDL (**2, 0, 0, 0**) and HQC ARDL (**8, 0, 0, 5**). The long-run responses of y_t to unit changes in x_{it} were estimated by

$$\hat{\phi}_i = \frac{\hat{\beta}_i(1,\hat{q}_i)}{\hat{\phi}(1,\hat{p})} = \frac{\hat{\beta}_{i0} + ... + \hat{\beta}_{i\hat{q}_i}}{1-\hat{\phi}_1 - \hat{\phi}_2 - ... - \hat{\phi}_{\hat{p}}}, \qquad i = 1, 2... k \qquad ... \quad (5.9),$$

where $\hat{p}$ and $\hat{q}_i, i = 1, 2, ..., k$ are the selected (estimated) values of p and $q_i, I = 1, 2, ..., k$. Similarly, the long-run coefficients associated with the deterministic/exogenous variables with fixed lags are estimated by

$$\hat{\psi} = \frac{\hat{\delta}(\hat{p},\hat{q}_1,\hat{q}_2,...,\hat{q}_k)}{1-\hat{\phi}_1 - \hat{\phi}_2 - ... - \hat{\phi}_{\hat{p}}} \qquad ... \ (5.10)$$

Where $\hat{\delta}(\hat{p},\hat{q}_1,\hat{q}_2,...,\hat{q}_k)$ denote the OLS estimates of the asymptotic standard errors of $\hat{\theta}_1,\hat{\theta}_2,...,\hat{\theta}_k$, and $\hat{\psi}$ are computed using Bewley's (1979) regression approach. This will yield the same result as applying the Δ-method to (5.9) and (5.10). To derive the Δ-method, let $\phi = \phi(\theta)$ be a $r \times 1$, first-order, differentiable function of the $k \times 1$ parameter vector, θ, of an econometric model; suppose also that $\Phi(\theta) = \partial\phi \ (\theta) \ \partial \ \theta'$ is a $r \times k$ matrix of rank $(r \le k)$. Then the estimator of ϕ and the estimator of its asymptotic variance would be given by

$$\hat{\phi} = \phi(\hat{\theta}) \qquad ... \ (5.11), \text{and,}$$

$$\hat{V}(\phi) = \hat{\sigma}^2 \left[\frac{\partial\phi(\theta)}{\partial\theta'}\right]_{\theta=\hat{\theta}} \hat{V}(\hat{\theta}) \left[\frac{\partial\phi(\theta)}{\partial\theta'}\right]'_{\theta=\hat{\theta}} \qquad ... \ (5.12)$$

Where $\hat{\theta}$ represents the estimator of θ and $\hat{\sigma}^2\hat{V}(\hat{\theta})$ is the estimator of the variance matrix of $\hat{\theta}$. This procedure for estimating the variance of $\hat{\phi}$ is the Δ-method (see Serfling (1980)). These long run coefficients are the ones used in the ECMs associated with each of the ARDL models.

Table 5.4b presents the long run responses corresponding to these models. With reference to our a priori expectations for equation (5.3), the estimated long run income elasticity of M1 is correctly signed but large in all the four cases. In three of the four models, both the own rate and the opportunity cost effects are present, the exception being the HQC ARDL (**8, 0, 0, 5**) in which there is an opportunity cost effect, but no own rate effect.

It is also only in this case that the estimated interest elasticity is significant at the 5% level, in all other cases, the significance level is notably 10% for own rate and the opportunity cost alike. In contrast, the income elasticity is significant at the 0.5% level in all cases. Besides the level of statistical significance, the estimated long-run responses of money to the own rate and opportunity cost variables are high.

Table 5.4a: ARDL Estimates of M1 {LOG [RLM1], LOG [RLDA], LOG [TDR3M], LOG [TBR]}

	1	2	3
Method	$\bar{R}^2$ = AIC	SBC	HQ
ARDL ($\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3$)	(5, 8, 8, 5)	(2, 0, 0, 0)	(8, 0, 0, 5)
Constant	-3.28 (-3.77) ***	-3.1361 (-4.95)***	-3.4429 (-5.3)***
$Log(M1/DAD)_{t-1}$	0.713 (7.83)***	0.6089 (7.14)***	0.6565 (7.62)***
$Log(M1/DAD)_{t-2}$	0.0438 (0.4)	0.1771 (2.23)**	0.0836 (0.85)
$Log(M1/DAD)_{t-3}$	-0.0830 (-0.86)	...	0.0266 (0.28)
$Log(M1/DAD)_{t-4}$	0.3151 (3.1)***	...	0.2337 (2.4)**
$Log(M1/DAD)_{t-5}$	-.2098 (-2.37)**	...	-0.3257 (-2.9)***
$Log(M1/DAD)_{t-6}$	...	...	0.0446 (-0.37)
$Log(M1/DAD)_{t-7}$	...	...	-0.1322 (-1.1)
$Log(M1/DAD)_{t-8}$	...	...	0.3004 (3.4)***
$Log(RLDA)_t$	0.3159 (1.06)	0.3579 (5.15)***	0.3731 (5.5)***
$Log(RLDA)_{t-1}$	-0.5982 (1.14)	...	...
$Log(RLDA)_{t-2}$	-0.71627 (-1.39)	...	...
$Log(RLDA)_{t-3}$	0.2149 (0.44)	...	...
$Log(RLDA)_{t-4}$	-0.8654 (-1.9)*	...	...
$Log(RLDA)_{t-5}$	1.5894 (3.3)***	...	...
$Log(RLDA)_{t-6}$	-0.9838 (-1.86)*	...	...
$Log(RLDA)_{t-7}$	-0.3938 (-0.74)	...	...
$Log(RLDA)_{t-8}$	0.61089 (2.02)**	...	...
$Log[tdr3m/(1+ tdr3m)]_t$	-.080566 (0.58)	0.1632 (1.61)	0.1261 (1.3)
$Log[tdr3m/(1+ tdr3m)]_{t-1}$	0.0136 (0.8)	...	...
$Log[tdr3m/(1+ tdr3m)]_{t-2}$	0.1288 (0.78)	...	...
$Log[tdr3m/(1+ tdr3m)]_{t-3}$	0.1636 (1.03)	...	...
$Log[tdr3m/(1+ tdr3m)]_{t-4}$	0.0865 (0.52)	...	...
$Log[tdr3m/(1+ tdr3m)]_{t-5}$	-0.036103 (-0.23)	...	...
$Log[tdr3m/(1+ tdr3m)]_{t-6}$	-0.2560 (1.9587)*	...	...
$Log[tdr3m/(1+ tdr3m)]_{t-7}$	0.3475 (2.5859)**	...	...
$Log[tdr3m/(1+ tdr3m)]_{t-8}$	-0.19952 (-2.0160)**	...	...
$Log[tbr/(1+tbr)]_t$	0.0005 (0.0.004)	-0.1703 (-1.67)*	-0.1626 (-1.45)
$Log[tbr/(1+tbr)]_{t-1}$	0.0642 (0.47)	...	0.0752 (0.69)
$Log[tbr/(1+tbr)]_{t-2}$	-0.0258 (-0.19)	...	0.064720 (0.60)
$Log[tbr/(1+tbr)]_{t-3}$	-0.4273 (-3.18)***	...	-0.37956 (-3.53)***
$Log[tbr/(1+tbr)]_{t-4}$	0.4081 (2.9)***	...	0.49412 (4.4)***
$Log[tbr/(1+tbr)]_{t-5}$	-0.-2077 (1.72)*	...	-0.2520 (-3.17)***
$Log[tbr/(1+tbr)]_{t-6}$	...	...	...
$Log[tbr/(1+tbr)]_{t-7}$	...	...	...
$Log[tbr/(1+tbr)]_{t-8}$	...	...	...
R^2	0.9904	0.9835	0.9887
$\bar{R}^2$	0.9885	0.9829	0.9871
σ	0.08577	0.10457	0.09060
LL	159.99	117.167	142.673
AIC	127.99	111.167	125.673
SBC	84.30	102.429	100.9158
DW	2.01	2.05	1.8412
Normality: T_{JB}, LM $(\chi^2)_2$:	0.6996[0.966]	22.9[0.000]***	0.4061[0.816]
5th-order Auto-correlation: T_{ARMA}, LM $(\chi^2)_5$	4.8462[0.435]	12.11[0.033]**	7.8895[0.162]
4th-order ARCH: T_{ARCH}, LM $(\chi^2)_4$	6.6898[0.153]	11.75[0.019]**	1.8734[0.759]
Heteroscedasticity: T_{WHET}, LM $(\chi^2)_1$,	0.0264[0.871]	0.0398(0.842]	0.1336[0.715]
Functional form: T_{RESET}, LM $(\chi^2)_1$	0.1269[0.722]	0. 8702[0.351]	0.4321[0.511]

Figures in parentheses are the t-ratios of the corresponding estimates. Figures in square brackets after the diagnostic statistics indicate their levels of significance. In all cases, '*' signify 10% level of significance; '**', 5%; and '***', 1%.

Table 5.4b: Associated Long run coefficients of M1 Models

METHOD	$\overline{R}^2$ = AIC	SBC	HQ
ARDL ($\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3$)	(5, 8, 8, 5)	(2, 0, 0, 0)	(8, 0, 0, 5)
Constant	-14.8280 (-6.55)***	-14.6543 (6.46)***	-17.0631 (-6.4)***
$Log(RLDA)_t$	1.6726 (8.94)***	1.6726 (0.8.95)***	1.8488 (8.69)***
$Log[tdr3m/(1+tdr3m)]_t$	0.75822 (1.67)*	.76260 (0.1.85)*	0.6248 (1.55)
$Log[tbr/(1+tbr)]_t$	-0.84973 (-1.8)*	-.79590 (-1.85)*	-0.7936 (-1.96)**

Figures in parentheses are t-ratios of the corresponding estimates. '*' signifies 10% level of significance; '**', 5%; and '***', 1%.

The own rate elasticity is about 0.76 in all the three cases where it is present. The cross price elasticity is about –0.85 in the AIC and $\overline{R}^2$ models and -0.80 in the SBC and HQC models.

5.5. Congruence

While the choice criteria are based primarily on considerations about 'statistical fit' and 'parsimony', the initial concern in the general-to-specific modelling strategy is to isolate a 'congruent' general model. A model is regarded as congruent at this stage if it passes standard diagnostic tests. Thus this first stage relates only to the identification of a generalized unrestricted model (GUM). The intermediate stages in this strategy will involve the use of economic and statistical information to *reduce* the GUM until a parsimonious representation of the *underlying* economic relationships are derived at the final stage (Hendry (1995) and Ericsson (1998)). We will therefore now concentrate on assessing the congruency of the alternative models thrown up by the different choice criteria in Table 5.4a.

Gerrard and Godfrey (1998) warned that not all of the standard diagnostic tests have asymptotic validity in ARDL models with non-stationary variables and stationary residuals. Gerrard and Godfrey's point related to which of the tests remain asymptotically valid and which lack a theoretical underpinning in the light of McAleer's (1994) remarks that test statistics that involve transformations of I(1) regressors will have non-standard asymptotic distributions (p 223). The tests are:

T_{JB} : Jarque–Bera (1987) test for non-normality, LM $(\chi^2)_2$

T_{ARMA} : Godfrey (1987) test for 5th-order auto-correlation LM $(\chi^2)_5$

T_{ARCH} : Engle (1982) test for 4th-order ARCH[61], LM $(\chi^2)_4$

T_{WHET} : White (1980) test for heteroscedasticity LM $(\chi^2)_1$,

T_{RESET} : Ramsey (1969) RESET functional form test with squared fitted value, LM $(\chi^2)_1$

Gerrard and Godfrey demonstrated that McAleer's (1994) remarks invalidate the use of T_{WHET} test for heteroscedasticity and the RESET test for functional form in assessing ARDL models and their associated long run responses in the presence of I(1) regressors. The same applies to the Engle-Granger static OLS regression and the Engle-Granger ECM, in spite of their widespread use in published empirical work. Non-normality, ARCH and auto-correlation tests can still be applied to the ARDL and, except in the case of the auto-correlation test, also to the Engle-Granger ECM.

Table 5.5a: Summary of the findings of Gerrard and Godfrey (1998)

	1	2	3	4
Test	Problem	ARDL	E-G ECM	W-B ECM
T_{JB} , LM $(\chi^2)_2$	Normality	Valid	Reliable	Reliable
T_{ARMA} , LM $(\chi^2)_5$	5th-order Auto-correlation	Valid, if cointegrated	Unreliable	Reliable
T_{ARCH} , LM $(\chi^2)_4$	4th-order ARCH	Valid	Unreliable	Reliable
T_{WHET} , LM $(\chi^2)_1$,	Heteroscedasticity	Not valid	Reliable	Reliable
T_{RESET} , LM $(\chi^2)_1$	Functional form	Not valid	Unreliable	Reliable

The issue in column 3 with regard to the relevance of diagnostic test to the full ARDL models has to do with the theoretical problem of asymptotic validity. Issues in columns 3 and 4 however have to do with reliability of tests in finite samples (Gerrard and Godfrey (1998).

Consequently, a complete set of asymptotically valid tests for an ARDL model with integrated variables can only be obtained in two stages that involve: estimating the full Wickens–Breusch-type ARDL to derive estimates of long-run parameters; using the estimated parameters to form the ECM implied by the ARDL model. Misspecification tests can then be applied to this 'Wickens–Breusch ECM'. These misspecification tests provide the evidence with which to judge the data consistency of the ARDL model and the corresponding long-run responses.

[61] Auto-regressive conditional heteroscedasticity

Thus, each of the full ARDL models in Table 5.4a are assessed on the basis of the diagnostics computed from their associated ECM which are presented later in Table 5.6a[62]. The long run responses presented in Table 5.4b are the ones used for deriving the 'Wickens-Breusch ECMs' in Table 5.6a. It might be worth noting that since only T_{WHET} and T_{RESET} are not valid in evaluating the full ARDL in Table 5.4a, each of the remaining three tests T_{JB}, T_{ARMA}, or T_{ARCH} still provide a valid misspecification check.

5.6. Wickens-Breusch Error Correction Models for M1

The error correction models associated with the ARDL ($\hat{p}$, $\hat{q}_1$, $\hat{q}_2$, ... , $\hat{q}_k$) model were obtained by writing equation (5.5) in terms of the lagged levels and the first differences of y_t, x_{1t}, x_{2t}, . . ., x_{kt}, and $\mathbf{w}'$.

First, note that

$$y_t = \Delta y_t + y_{t-1}$$

$$y_{t-s} = y_{t-1} - \sum_{j=1}^{s-1} \Delta y_{t-j}\,, \qquad s = 1, 2, \ldots, p$$

And similarly,

$$\mathbf{w}_t = \Delta \mathbf{w}_t + \mathbf{w}_{t-1}$$

$$x_{it} = \Delta x_{it} + x_{i,t-1}$$

$$x_{i,t-s} = x_{i,t-1} - \sum_{j=1}^{s-1} \Delta x_{i,t-j}\,, \qquad s = 1, 2, \ldots, q_i,$$

Substituting these relations into (5.6);

$$\Delta y_t = -\phi(1,\hat{p}) EC_{t-1} + \sum_{i=1}^{k} \beta_{i0} \Delta x_{it} + \delta' \mathbf{w}_t \qquad \ldots (5.13)$$

[62] This justifies the derivation of error correction models even when interest is purely on estimating long run responses associated with the ARDL models. The diagnostics associated with the corresponding ECM must be computed to assess the validity of the estimated long-run coefficients (Gerrard and Godfrey (1998).

Table 5.6a: Error Correction Models for M1

METHOD	$\bar{R}^2$=AIC	SBC	HQ
ARDL ($\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3$)	(5, 8, 8, 5)	(2, 0, 0, 0)	(8, 0, 0, 5)
Constant	0.017 (1.5)	0.039 (3.6)***	0.024 (1.895)*
ΔLog(M1/DAD)$_{t-1}$	0.32 (1.9)*	0.6 (3.6)***	0.19 (1.13)
ΔLog(M1/DAD)$_{t-2}$	-0.107 (-1.06)	-0.049 (-0.57)	-0.08 (-0.84)
ΔLog(M1/DAD)$_{t-3}$	-0.05 (-0.57)	...	0.034 (0.36)
ΔLog(M1/DAD)$_{t-4}$	0.25 (2.9)***	...	0.428 (5.17)***
ΔLog(M1/DAD)$_{t-5}$	...	...	-0.10 (-1.0)
ΔLog(M1/DAD)$_{t-6}$	...	...	0.105 (1.1)
ΔLog(M1/DAD)$_{t-7}$	...	...	-0.19 (-2.0)**
ΔLog(DAD)$_t$	-0.87 (-6.7)***	-0.958 (-7.0)***	-0.94 (-6.6)***
ΔLog(DAD)$_{t-1}$	0.48 (2.75)***	0.341 (2.0)**	0.405 (2.27)**
ΔLog(DAD)$_{t-2}$	-0.25 (-1.4)	-0.24 (-1.52)	-0.034 (-0.2)
ΔLog(DAD)$_{t-3}$	-0.1 (-0.57)	...	-0.227 (-1.3)
ΔLog(DAD)$_{t-4}$	0.39 (2.35)**	...	0.5 (2.6)**
ΔLog(DAD)$_{t-5}$	...	...	-0.107 (-0.55)
ΔLog(DAD)$_{t-6}$	...	...	0.32 (1.55)
ΔLog(DAD)$_{t-7}$	...	...	-0.371 (-2.0)**
ΔLog(RLDA)$_t$	0.05 (0.2)	0.0587 (0.26)	0.22 (0.87)
ΔLog(RLDA)$_{t-1}$	0.66 (2.3)**	...	...
ΔLog(RLDA)$_{t-2}$	-0.2 (-0.6)	...	...
ΔLog(RLDA)$_{t-3}$	-0.01 (-0.3)	...	...
ΔLog(RLDA)$_{t-4}$	-0.54 (-2.1)**	...	...
ΔLog(RLDA)$_{t-5}$	1.3 (4.6)***	...	...
ΔLog(RLDA)$_{t-6}$	-0.7 (-2.1)**	...	...
ΔLog(RLDA)$_{t-7}$	-0.058 (-0.23)	...	...
ΔLog[tdr3m/(1+ tdr3m)]$_t$	-0.20 (-1.7)*	-0.063 (-0.27)	-0.12 (-1.0)
ΔLog[tdr3m/(1+ tdr3m)]$_{t-1}$	-0.06 (-0.52)	...	...
ΔLog[tdr3m/(1+ tdr3m)]$_{t-2}$	-.03 (-0.25)	...	...
ΔLog[tdr3m/(1+ tdr3m)]$_{t-3}$	0.12 (1.09)	...	...
ΔLog[tdr3m/(1+ tdr3m)]$_{t-4}$	-0.02 (-0.17)	...	...
ΔLog[tdr3m/(1+ tdr3m)]$_{t-5}$	0.066 (0.68)	...	...
ΔLog[tdr3m/(1+ tdr3m)]$_{t-6}$	-0.24 (-2.7)***	...	...
ΔLog[tdr3m/(1+ tdr3m)]$_{t-7}$	0.19 (2.1)**	...	...
ΔLog[tbr/(1+tbr)]$_t$	0.03 (0.32)	-0.078 (-0.7)	-0.009 (-0.08)
ΔLog[tbr/(1+tbr)]$_{t-1}$	0.13 (1.3)	...	0.082 (1.13)
ΔLog[tbr/(1+tbr)]$_{t-2}$	0.1 (1.02)	...	0.11 (1.47)
ΔLog[tbr/(1+tbr)]$_{t-3}$	-0.28 (-2.9) ***	...	-0.25 (3.4)***
ΔLog[tbr/(1+tbr)]$_{t-4}$	0.23 (2.11.8)**	...	0.19 (2.2)**
ΔLog[tbr/(1+tbr)]$_{t-5}$	...	...	
ΔLog[tbr/(1+tbr)]$_{t-6}$	...	...	...
ΔLog[tbr/(1+tbr)]$_{t-7}$	...	...	...
ECM	-0.46 (2.57)**	-0.865 (-4.89)***	-0.33 (1.9)*
R^2	0.6995	0.4675	0.5767
$\bar{R}^2$	0.6091	0.429	0.489
σ	0.07286	0.088	0.083
LL	180.3	141.69	157.18
AIC	148.3	131.69	133. 18
SBC	101.82	117.16	98.32
DW	1.97	2.01	1.98
Normality: T_{JB}, LM $(\chi^2)_2$:	2.71[0.257]	11.9[0.003]***	2.3[0.314]
5th-order Auto-correlation: T_{ARMA}, LM $(\chi^2)_5$	2.2094[0.819]	15.62[0.008]***	7.8680[0.164]
4th-order ARCH: T_{ARCH}, LM $(\chi^2)_4$	6.6917[0.153]	10.69[0.030]**	3.5041[0.477]
Heteroscedasticity: T_{WHET}, LM $(\chi^2)_1$,	0.04[0.841]	0.1(0.725]	0.4[0.525]
Functional form: T_{RESET}, LM $(\chi^2)_1$	0.16[0.686]	1.285[0.257]	0.07[0.789]

Figures in parentheses are standard errors of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. In all cases, '*' signify 10% level of significance; '**', 5%; and '***', 1%. Note that Δlog(DAD) is entered separately in addition to, and with the same lag with Δlog(M1/DAD) in these regressions. The restriction of zero price elasticity of real balances applicable to the long-run relationships is not necessarily applicable to the short run adjustments. Including Δlog(DAD) relaxes that restriction by allowing for a non-zero real balance effect in the short run. Once Δlog(DAD) is included, either Δlog(M1/DAD) or Δlog(M1) produces identical initial models. Using Δlog(M1) rather than Δlog(M1/DAD) enables us to isolate the impact of changes in the nominal money stock on desired holding of real money stock..

$$-\sum_{j=1}^{\hat{p}-1}\phi_j^{*}\Delta y_{t-j}-\sum_{i=1}^{k}\sum_{j=1}^{\hat{q}_i-1}\beta_{ij}^{*}\Delta x_{i,t-j}+u_t$$

Where EC_t is the correction term defined by $\qquad EC_t = y_t - \sum_{i=1}^{k}\hat{\theta}_i x_{it} - \hat{\psi}'\,\mathbf{w}_t$

$\phi(1,\hat{p}) = 1-\hat{\phi}_1-\hat{\phi}_2-\ldots-\hat{\phi}_{\hat{p}}$, it measures the quantitative importance of the error correction term.

The remaining coefficients, ϕ_j^{*} and β_{ij}^{*}, relate to the short-run dynamics of the model's convergence equilibrium. These are given by

$$\phi_1^{*} = \phi_{\hat{p}}+\phi_{\hat{p}-1}+\ldots+\phi_3+\phi_2$$

$$\phi_2^{*} = \phi_{\hat{p}}+\phi_{\hat{p}-1}+\ldots+\phi_3$$

$$\vdots$$

$$\phi_{\hat{p}-1}^{*} = \phi_{\hat{p}}$$

And similarly,

$$\beta_{i1}^{*} = \beta_{i,\hat{q}_i}+\beta_{i,\hat{q}_i-1}+\ldots+\beta_{i,3}+\beta_{i,2}$$

$$\beta_{i2}^{*} = \beta_{i,\hat{q}_i}+\beta_{i,\hat{q}_i-1}+\ldots+\beta_{i,3}$$

$$\vdots$$

$$\beta_{i,\hat{q}_i-1}^{*} = \beta_{i,\hat{q}_i}$$

The estimates ϕ_i and $\hat{\psi}$ are already computed using relations (5.9) and (5.10).

The estimates of the parameters of the error correction model (ECM) (5.13) are obtained from the coefficient estimates of the ARDL model using the above relations. The standard errors of these estimates are also obtained using the variance formula (5.12), and allow for possible non-zero co-variances between the estimates of the short-run and the long-run coefficients. Note that the co-variances of the short-run and long run coefficients are asymptotically non-correlated only in the case where it is known that the regressors are I (1) and that they are not cointegrated among themselves.

5.7. Model Selection

Again, the results are for the estimates of ARDL (p, q_1, q_2, q_3) models with four variables [Log (M1/DAD), Log (RLDA), Log (TDR), and Log (TBR)], and 136 quarterly observations over 1960Q1-1995Q4-sample period. The following can be seen from the error correction models presented in Table 5.6a:

ARDL (**5, 8, 8, 5**) model suggested both by $\bar{R}^2$ criterion and AIC is congruent;

ARDL (**2, 0, 0, 0**) model suggested by SBC is incongruent as it fails T_{JB}, T_{ARMA}, and T_{ARCH} ;

ARDL (**5, 8, 8, 5**) ARDL (**8, 0, 0, 5**) model suggested by HQC is congruent.

The ARDL (**2, 0, 0, 0**) model suggested by SBC can be discarded at this stage for two reasons. First, it fails to satisfy at least three of the important congruency requirements and as such amounts to an inadequate representation of the data generating process. Second, ARDL (2, 0, 0, 0) is nested within the two models selected by the other criteria [ARDL (5, 8, 8, 5) and ARDL (8, 0, 0, 5)], nothing is lost by dropping its restrictive representation. The other two however appear to provide valid representations of the DGP based on the conventional statistics. However, the fact that both [ARDL (**5, 8, 8, 5**) from $\bar{R}^2$ criterion and AIC, and ARDL (**8, 0, 0, 5**) from HQC] models are non-nested raises a further problem of selecting which of the two captures the DGP better than the other. A comparison of the two follows.

A summary of the main features of the two models from Table 5.6a is presented in Table 5.7a to facilitate comparison. Clearly, Table 5.7a shows that ARDL (5, 8, 8, 5) from $\bar{R}^2$ criterion and

AIC has much higher explanatory power, much higher $\bar{R}^2$, LL, AIC, SBC and much lower standard error, σ, than ARDL (8, 0, 0, 5) from HQC on every single statistic.

Table 5.7a: Summary Statistics for Two Congruent Models

MODEL	$\bar{R}^2$ =AIC	HQC
ARDL (p, q_1, q_2, q_3)	(5, 8, 8, 5)	(8, 0, 0, 5)
R^2	0.6995	0.5767
$\bar{R}^2$	0.6091	0.489
σ	0.07286	0.083
LL	180.3	157.18
AIC	148.3	133. 18
SBC_λ	101.82	98.32

More direct comparison of the two equations through simple non-nested tests follows. Let the log of maximized log likelihood functions of model 1 and model 2 be LL1 and LL2 respectively, and,

k= number of estimated coefficients,

n = number of observations used in estimation.

The Akaike Information Criteria (AIC) for the choice between the two is computed as:

$$AIC\ (model\ 1{:}model\ 2) = LL1 - LL2 - (k1 - k2).$$

Model 1 is preferred to model 2 if AIC (model 1:model 2)>0, otherwise model 2 is preferred to model 1. The Schwarz Bayesian Information Criteria (SBIC) for the choice between model 1 and model 2 is computed as:

$$SBIC\ (model\ 1{:}model\ 2) = LL1 - LL2 - 0.5(k1 - k2)\log(n).$$

Model 1 is preferred to model 2 if SBIC (model 1:model 2)>0, otherwise model 2 is the preferred model (Pesaran and Pesaran, 1997).

Table 5.7b: Choice Criteria for the two M1 Models

MODELS	AIC	SBC	PREFERRED MODEL
ARDL (5, 8, 8, 5) versus ARDL (8, 0, 0, 5)	15.125	3.504	ARDL (5, 8, 8, 5)

ARDL (5, 8, 8, 5) is model 1, and ARDL (8, 0, 0, 5) is model 2.

The results presented in Table 5.7b confirm that the two models are different, i.e. non-nested, and ARDL (5, 8, 8, 5) is a better representation of the data than ARDL (8,0,0,5). We will therefore also discard ARDL (8,0,0,5) at this stage and concentrate only on (5, 8, 8, 5) in subsequent analyses of demand for M1.

5.8. Reparameterization of the Lag Structure

As we proceed to find a parsimonious representation for ARDL (5, 8, 8, 5), an important consideration is the fact that economic theory does not restrict the lag polynomials $\phi(L, p)$ and $\beta_i(L, q_i)$ in any of the ARDL $(\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3)$ estimable from equation **(3)**. Any pattern of lags is consistent with the behaviour of economic agents. (Hendry (1995) demonstrated that $\beta_i(L, q_i)\, x_t$ is invariant to linear transformations such as:

A first difference over one period, which generates a sign switch in levels

$$\alpha\Delta x_t = \alpha x_t - \alpha x_{t-1}$$

An average growth, which generates a gap

$$\alpha\left\{\frac{1}{2}(\Delta x_t + \Delta x_{t-1})\right\} = \frac{1}{2}x_t + 0.x_{t-1} - \frac{1}{2}\alpha x_{t-2} = \alpha\left(\frac{1}{2}\Delta_2 x_t\right);$$

A second difference which, reflects an acceleration

$$\alpha\Delta^2 x_t = \alpha x_t - 2\alpha x_{t-1} + \alpha x_{t-2};$$

A multi-period first difference which produces an average first difference

$$\alpha\Delta_4 x_t = \alpha\Delta x_t + \alpha\Delta x_{t-1} + \alpha\Delta x_{t-2} + \alpha\Delta x_{t-3} = \alpha\sum_{i=0}^{3}\Delta x_{t-i};$$

A difference plus acceleration

$$\alpha\Delta x_t + \beta\Delta^2 x_t = (\alpha + \beta)\Delta x_t - \beta\Delta x_{t-1};$$

Which in terms of the levels of the variables

$$(\alpha + \beta)x_t - (\alpha + 2\beta)x_{t-1} + \beta x_{t-2}$$

A level and a difference, which can induce apparent sign changes on lag order switches.

$$\alpha\Delta x_t + \beta x_{t-1} = \beta x_t + (\alpha - \beta)\Delta x_t;$$

and so on. These special cases derive from the fact that polynomials are invariant to linear transformations such as:

$$\phi(L) = \sum_{i=0}^{n} \phi_i L^i = \sum_{i=0}^{n} \lambda_i (1-L)^i = \varsigma_0 + \sum_{i=1}^{n} \varsigma_i (1-L^i) = \zeta_0 + \sum_{i=1}^{n-1} \zeta_i (1-L)L^i.$$

Thus almost any coefficient pattern is conceivably consistent with economic agents' behavior. This suggests the usefulness of commencing from relatively unconstrained lag structures such as in the *generalized unrestricted models* (or GUMs) represented by any of columns 1 to 4 in Table 5.4a or 5.6a. The GUM necessarily spreads whatever is to be explained across a large number of lags, some of which probably do not affect or explain behavior. Similar issues arise for $\phi(L, p)$, for which the first transform is into an ECM, with the remaining effects of the dependent variable expressed as differences and functions of differences.

5.9. Model Reduction

Reduction or model discovery therefore involves transforming the unconstrained lags in the GUM into parameterizations that isolate data functions that reflect behavior and eliminating those that do not. One way of doing this is to eliminate lags that are not statistically significant at the 5 per cent level. The other is to transform variables and lags to highlight relevant features and then eliminate irrelevant functions of variables after those transformations. Helpful techniques include transforming variables into levels and changes, or simple moving averages, or spreads (say between two interest rates), or ECMs. Taking the ECM corresponding to the ARDL **(5, 8, 8, 5)**[63] from Table 5.6a, re-presented here as Table 5.9a, as the starting point, the first step is to do a stepwise elimination of lags that are statistically insignificant at the 10% level.

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[63] ARDL (5, 8, 8, 5) in levels corresponds to an ECM (4, 7, 7, 4) in first differences, plus another four lags on ΔLog(DAD). This produces 26 lags in all. Adding the contemporaneous changes in real activity, two interest rates, and ΔLog(DAD), plus the ECM and a constant implies that the total number of freely estimated parameters in this ECM is 32.

Table 5.9a: Full Equilibrium Correction Model for $\Delta Log(M1/P)_t$

VARIABLES	ESTIMATED COEFFICIENTS
Constant	0.174 (1.5358)
$\Delta Log(M1)_{t-1}$	0.32 (1.8809)*
$\Delta Log(M1)_{t-2}$	-0.107 (-1.0576)
$\Delta Log(M1)_{t-3}$	-0.05 (-0.5731)
$\Delta Log(M1)_{t-4}$	0.25 (2.9217)***
$\Delta Log(DAD)_t$	-0.87 (-6.6929)***
$\Delta Log(DAD)_{t-1}$	0.1647 (2.7515)***
$\Delta Log(DAD)_{t-2}$	-0.1448 (-1.4139)
$\Delta Log(DAD)_{t-3}$	-0.0467 (-0.5732)
$\Delta Log(DAD)_{t-4}$	0.1422 (2.3494)**
$\Delta Log(RLDA)_t$	0.05 (0.2083)
$\Delta Log(RLDA)_{t-1}$	0.6 (2.3341)**
$\Delta Log(RLDA)_{t-2}$	-0.2 (-0.6359)
$\Delta Log(RLDA)_{t-3}$	-0.01 (-0.0284)
$\Delta Log(RLDA)_{t-4}$	-0.54 (-2.1008)**
$\Delta Log(RLDA)_{t-5}$	1.3 (4.6367)***
$\Delta Log(RLDA)_{t-6}$	-0.7 (-2.1373)**
$\Delta Log(RLDA)_{t-7}$	-0.06 (-0.2250)
$\Delta Log[tdr3m/(1+tdr3m)]_t$	-0.19 (-1.6674)*
$\Delta Log[tdr3m/(1+tdr3m)]_{t-1}$	-0.063 (-0.5190)
$\Delta Log[tdr3m/(1+tdr3m)]_{t-2}$	-.03 (0.-0.2515)
$\Delta Log[tdr3m/(1+tdr3m)]_{t-3}$	0.12 (1.0868)
$\Delta Log[tdr3m/(1+tdr3m)]_{t-4}$	-0.02 (-0.1768)
$\Delta Log[tdr3m/(1+tdr3m)]_{t-5}$	0.066 (0.6767)
$\Delta Log[tdr3m/(1+tdr3m)]_{t-6}$	-0.23 (-2.6925)***
$\Delta Log[tdr3m/(1+tdr3m)]_{t-7}$	0.19 (2.0754)**
$\Delta Log[tbr/(1+tbr)]_t$	0.03 (0.3243)
$\Delta Log[tbr/(1+tbr)]_{t-1}$	0.13 (1.3393)
$\Delta Log[tbr/(1+tbr)]_{t-2}$	0.10 (1.0227)
$\Delta Log[tbr/(1+tbr)]_{t-3}$	-0.277 (-2.8869) ***
$\Delta Log[tbr/(1+tbr)]_{t-4}$	.023 (2.0746)**
ECM	-0.46 (0.-2.5721)**
F	
R^2	0.6995
$\bar{R}^2$	0.6091
σ	0.07286
LL	180.3
AIC	148.3
SBC	101.82
DW	1.97
Normality: T_{JB}, LM $(\chi^2)_2$:	2.71[0.257]
5th-order Auto-correlation: T_{ARMA}, LM $(\chi^2)_5$	2.209[0.819]
4th-order ARCH: T_{ARCH}, LM $(\chi^2)_4$	6.692[0.153]
Heteroscedasticity: T_{WHET}, LM $(\chi^2)_1$,	0.040[0.841]
Functional form: T_{RESET}, LM $(\chi^2)_1$	0.160[0.686]
$F_{(31,103)}$	7.73(0.000)

Figures in parentheses are the t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. In all cases, '*' signify 10% level of significance; '**', 5%; and '***', 1%. Note that Δlog(DAD) is entered separately in addition to, and with the same lag with Δlog(M1/DAD) in these regressions. The restriction of zero price elasticity of real balances applicable to the long-run relationships is not necessarily applicable to the short run adjustments. Including Δlog(DAD) relaxes that restriction by allowing for a non-zero real balance effect in the short run. Once Δlog(DAD) is included, using either Δlog(M1/DAD) or Δlog(M1) on the right hand side produces identical initial models. Using Δlog(M1) rather than Δlog(M1/DAD) enables us to isolate the impact of changes in the nominal money stock on desired holding of real money stock.

The reduced ECM, presented in Table 5.9b, has only 15 lags that are significant at least at the 10% level. The test of the hypothesis that all the 16 lags and the constant (17 variables) eliminated from the initial ECM contain no additional information is reported in the final row of Table 5.9b (variable deletion Test LM $(\chi 2)_{17}$=10.55[0.879]).

This is supported by the drop in the standard error of the regression, σ, from 0.07286 in the full ECM to 0.07030 in the reduced ECM; and a rise in $\bar{R}^2$ from 0.6091 in the full ECM to 0.6360 in the reduced ECM.

Table 5.9b: Reduced ECM

VARIABLES	ESTIMATED COEFFICIENTS
ΔLog(M1)$_{t-1}$	0.3948 (4.5214)***
ΔLog(M1)$_{t-4}$	0.3235 (4.9455)***
ΔLog(DAD)$_t$	-0.8088 (-8.2042)***
ΔLog(RLDA)$_{t-1}$	0.5035 (2.4598)**
ΔLog(RLDA)$_{t-4}$	-0.6009 (-2.8410)***
ΔLog(RLDA)$_{t-5}$	1.2579 (5.2284)***
ΔLog(RLDA)$_{t-6}$	-0.8431 (-3.5812)***
ΔLog[tdr3m/(1+ tdr3m)]$_t$	-0.1350 (-1.8948)*
ΔLog[tdr3m/(1+ tdr3m)]$_{t-6}$	-0.2127 (-3.0215)***
ΔLog[tdr3m/(1+ tdr3m)]$_{t-7}$	0.2306 (3.2095)***
ΔLog[tbr/(1+tbr)]$_{t-1}$	0.1049(1.7412)*
ΔLog[tbr/(1+tbr)]$_{t-2}$	0.1083(1.8053)*
ΔLog[tbr/(1+tbr)]$_{t-3}$	-0.2125(-3.5717)***
ΔLog[tbr/(1+tbr)]$_{t-4}$	0.2553 (4.2139)***
ECM	-0.5572 (-5.5462)***
F	
R^2	0.6740
$\bar{R}^2$	0.6360
σ	0.07030
LL	174.81
AIC	159.81
SBC	138.03
DW	1.89
Normality: T_{JB}, LM $(\chi^2)_2$:	1.06[0.587]
5th-order Auto-correlation: T_{ARMA}, LM $(\chi^2)_5$	3.676[0.597]
4th-order ARCH: T_{ARCH}, LM $(\chi^2)_4$	6.3145[0.177]
Heteroscedasticity: T_{WHET}, LM $(\chi^2)_1$,	0.1799[0.671]
Functional form: T_{RESET}, LM $(\chi^2)_1$	0.1248[0.724]
$F_{(14,120)}$	17.72[0.000]***
Variable Deletion Test LM $(\chi^2)_{17}$	10.55[0.879]

Figures in parentheses are standard errors of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. '*' signifies 10% level of significance; '**', 5%; and '***', 1%. Δlog(DAD) is entered separately in addition to, and with the same lag with Δlog(M1/DAD) in this regression.

There is also a very sharp improvement in the SBC_{λ} from 102 to 138. The fact that the eliminated lags could be regarded as nuisance parameters is buttressed by the fact that many of the remaining variables, the ECM for example, became more significant than they were in the initial ECM. Only the contemporaneous change in the deflator (Δlog(DAD)) is significant in the reduced ECM, lags 1 to 4 were among those eliminated in the transition from the full ECM to the reduced ECM. Only two lags (1 and 4) of nominal M1, four of RLDA (1, 4, 5, and 6), three of TDR3M (0, 6, and 7), four of TBR (1-4), enter the reduced model along with the ECM and Δlog(DAD).

Of the retained variables, the contemporaneous change in the three-month time deposit rate, lags 1 and 2 of the change in the three-month Treasury bill rate are significant at the 10% level. Lag 1 of the change in real activity is significant at 5% level. All the remaining variables are significant at the 1% level, especially the ECM, Δlog(DAD), and the remaining lags of Δlog(M1). All the reported model design diagnostic statistics show that the reduced ECM is congruent. The statistical properties of this estimation at this stage can be considered as encouraging. Apart from the general high significance of the coefficients, the overall $\bar{R}^2$ value of 0.64 is substantial with a minimal standard error of residual of only 0.07 and DW of 1.89.

Making economic sense of the reduced ECM (Table 5.9b) is however a difficult, if not an impossible, task. The coefficients of the lags of RLDA, TDR3M, and TBR that enter the reduced ECM have mixed signs and vary very widely in magnitude, and there is some variation in the levels of statistical significance of the different lags. For RLDA, the signs of the coefficients alternate between positive and negative, from -0.84 to 1.25. It is not clear from the magnitudes of the coefficients if there are scale economies in real money holding or not. Two of the lags (0 and 6) of TDR3M have negative sign (-0.14 and -0.21 respectively), while lag 7 is positive (0.23). It is therefore not too clear from this equation whether there is complementarity or substitutability between narrow money and time deposit in the short-run. Similarly, of the 4 lags of TBR that entered the reduced ECM, only lag (3) has the expected negative sign (-0.21), while others are positive, ranging from 0.10 to 0.26. TDR3M (0) and TBR (1 and 2), are significant at the 10% level, RLDA (1) at the 5% level, and the remaining coefficients are significant at the 1% level.

5.10. Parsimony

From the reduced ECM, we proceed to recover the parsimonious model. The mix in the signs of the coefficients is resolved in the final ECM. Although the statistical fit declined slightly, the model however remains very robust. This transition, from the reduced ECM (Table 5.9b) to the final parsimonious version (Table 5.10a), involves transformations on the retained lags through introduction of acceleration effects (second differences or Δ^2) for consecutive lags, and dropping one of the two lags if it becomes insignificant in the presence of the second difference; or, mixed dating (such as estimating a single coefficient for $[\Delta\log(RLDA)_{t-1}-\Delta\log(RLDA)_{t-4}]$ and $\{\Delta\log[tbr/(1+tbr)]_{t-3}-\Delta\log[tbr/(1+tbr)]_{t-4}\}$ rather than separate coefficients for the two different lags of the same variables as in the reduced ECM); and, dropping insignificant lags after acceptable transformations to achieve parsimony and isolate data functions that reflect behavior. Acceptability here is judged by the impact of each transformation on the explanatory power of the model. Re-parameterizations that result in a marked decline in the explanatory power of the model (based on $\overline{R}^2$, σ and SBC_λ) are not acceptable, while those that result in negligible or no drop in explanatory power but reveal relevant features of underlying economic behavior are acceptable.

The resulting model for M1 is presented in Table 5.10a. The statistical estimates of the model are generally robust. The standard error of residual is significantly small (0.07), indicating that it satisfies the additive stability property. The value of the adjusted R-square also shows that over 62 per cent of the variations in the M1 are explained in the short-run, i.e., within the quarter. The estimated coefficients are all equally significant at 5 per cent conventional level, confirming the existence of multiplicative stability. The dynamic stability of the model is affirmed by the highly significant error correction term (with t-ratio of 5.55), which is also correctly signed. The coefficient of ECM is -0.56, which implies that any disequilibrium in narrow money is corrected within two quarters (i.e. within 6 months).

The variables enter the equation mostly the first differences, except the transaction variable and own rate (TDR), which also enter at second difference. Other variables that enter the final parsimonious short run model include the endogenous variable M1 lagged one and four periods; the first difference of the deflator (DAD current period); income lagged five quarters; opportunity cost variable lagged four period.

Table 5.10a: Final ECM

VARIABLES	ESTIMATED COEFFICIENTS
$\Delta Log(M1)_{t-1}$	0.40 (4.8119)***
$\Delta Log(M1)_{t-4}$	0.36 (5.7977)***
$\Delta Log(DAD)_t$	-0.80 (-8.1961)***
$[\Delta Log(RLDA)_{t-1} - \Delta Log(RLDA)_{t-4}]$	0.47 (3.0638)***
$\Delta^2 Log(RLDA)_{t-5}$	1.0 (5.1512)***
$\Delta^2 Log[tdr3m/(1+tdr3m)]_{t-6}$	-0.23 (-4.3807)***
$\{\Delta Log[tbr/(1+tbr)]_{t-3} - \Delta Log[tbr/(1+tbr)]_{t-4}\}$	-0.23 (-5.1604)***
ECM	-0.56 (-5.5857)***
F	
R^2	0.6389
$\bar{R}^2$	0.6190
σ	0.0719
LL	167.90
AIC	159.90
SBC	148.03
DW	1.84
Normality: T_{JB}, LM $(\chi^2)_2$:	0.9242[0.630]
5^{th}-order Auto-correlation: T_{ARMA}, LM $(\chi^2)_5$	6.8332[0.233]
4^{th}-order ARCH: T_{ARCH}, LM $(\chi^2)_4$	5.0748[0.280]
Heteroscedasticity: T_{WHET}, LM $(\chi^2)_1$,	0.0060[0.938]
Functional form: T_{RESET}, LM $(\chi^2)_1$	0.0105[0918]
$F_{(7,127)}$	32.0965[0.000]***
Predictive Failure LM $(\chi^2)_{40}$	49.4112[.146]
Chow's Structural Stability Test LM $(\chi^2)_8$	6.2365[.621]

All the variables in the model are significant. The first and the fourth lags of changes in narrow money affect the behaviour of demand for narrow money with elasticities of 0.40 and 0.36 respectively. The rate of inflation (ΔDAD), has a significant elasticity of 0.80 and is correctly signed, being negative in relation to change in real M1 balances, Δ(M1/DAD). The estimated transaction elasticity at lag 5 is exactly unity, rightly signed and statistically significant, implying that a 1 per cent change in M1 follows a 1 per cent change in income in the short run. Likewise the response of money to the change in the growth in real activity between first and fourth quarter is 0.47 and is positively signed. Coincidentally, the net short-run elasticities of the changes in the two interest rates are both -0.23 for M1, and statistically significant, the treasury bill rate being more significant than the time deposit rate.

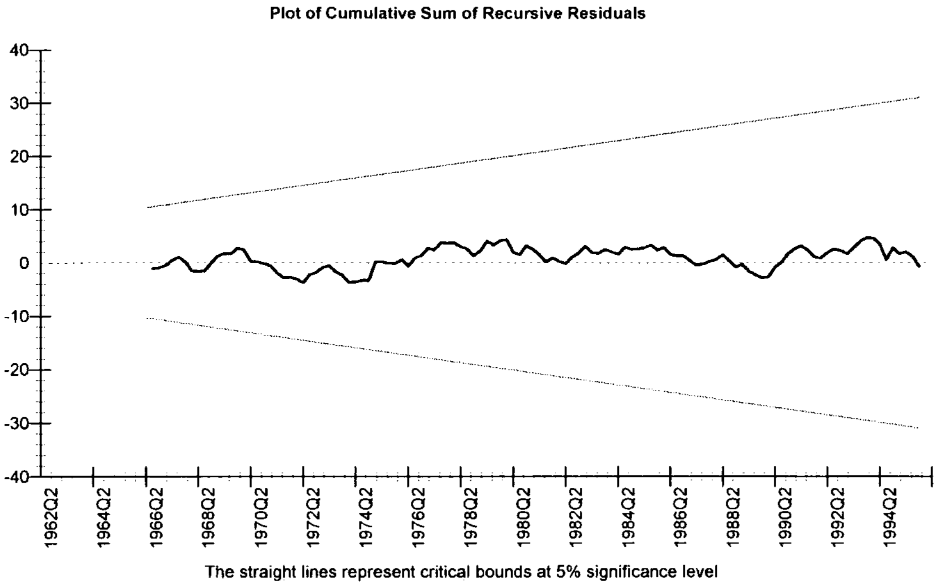
Thus in Table 5.10a, the four lags of real activity from Table 5.9b are replaced by one mixed-dated difference ($[\Delta\log(RLDA)_{t-1}-\Delta\log(RLDA)_{t-4}]$) and one second difference $\Delta^2\log(RLDA)_{t-5}$; similarly, lags five and six of the 3-month time deposit rate can be expressed as a second difference at lag five; while, lags three and four of the Treasury bill rate are represented by a mixed-dated lag effect, $\{\Delta\log[tbr/(1+tbr)]_{t-3}-\Delta\log[tbr/(1+tbr)]_{t-4}\}$[64]. With these transformations, the contemporaneous change in the three-month time deposit rate, and lags 1 and 2 of the change in the three-month Treasury bill rate became insignificant at the 10% level, and were eased out of the model.

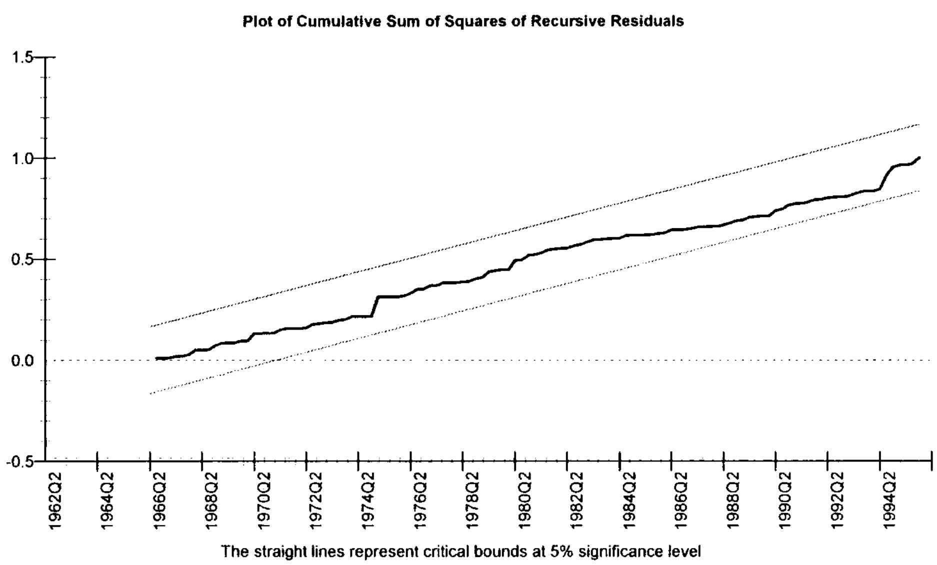
The final ECM (Table 5.10a) has only eight freely estimated parameters, compared to 15 in the reduced ECM of Table 5.9b. Although there is an increase in σ from 0.0703 to 0.0719 and a drop in $\bar{R}^2$ from 0.636 to 0.619, the SBC_{λ} improved from 138 in the reduced ECM to 148 in the final ECM. This suggesting that additional information gained outweighs the apparent loss of statistical 'fit', and that the net impact of the transformation is a more parsimonious representation of the underlying economic relationship. More importantly, it is now more

[64] See Ericsson (1998) for a discussion of mixed dating.

straightforward to make economic sense of the elasticities of M1 with regard to each of the explanatory variables in the model. Each of the two interest rates and the inflation rate now has *only one* estimated short run multiplier, thereby eliminating the sign switches uncovered in the reduced ECM.

Past growth in transactions and actual money stock exert positive effects on desired real money holding in line with *a priori* expectations. Both interest rates and the inflation rate exert a negative impact on real money holding, suggesting that narrow money holders treat time deposits, Treasury bills and real assets as substitutes to money holding in the short run.

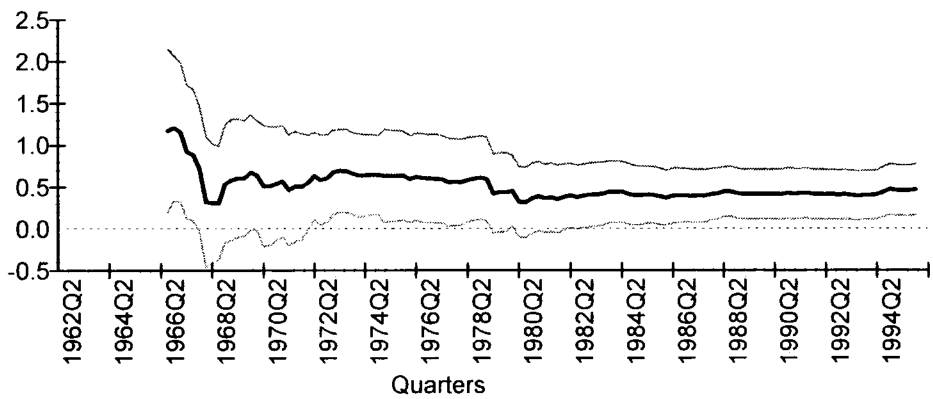




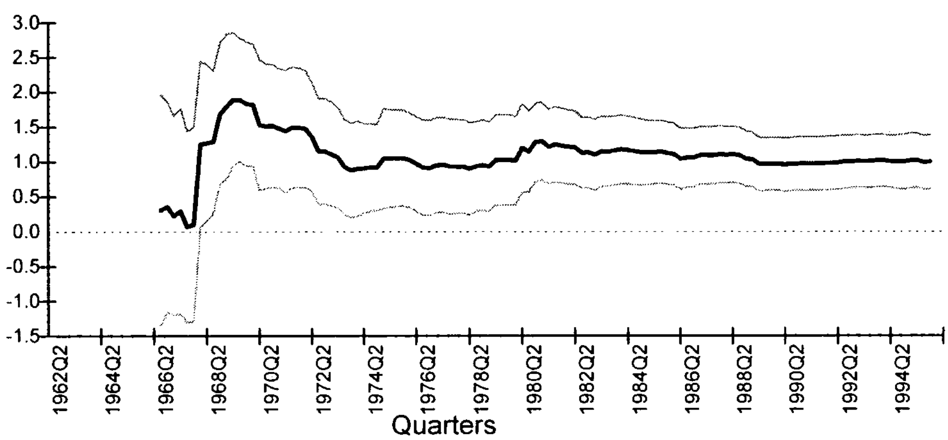
The short run relation is of course constrained by the fact that in the long run inflation is irrelevant to the decision to hold narrow money, as summarized in the equilibrium correction term. Further details about the long-run elasticity of M1 with regard to the two interest-rates are discussed in chapters seven and eight. As such, the issues about time deposits and M1 being long run complements and Treasury bills and M1 being long-run substitutes will be discussed in greater detail in Chapter eight.

The final ECM remains congruent as revealed by the reported diagnostics. More importantly the model exhibits structural stability as revealed by the Chow test (Chow's Structural Stability Test LM $(\chi^2)_8$ = 6.2365[.621]) and plots of Sargan's CUSUM and CUSUMSQ of the recursive residuals for the final model above reveal no significant break in the equation.

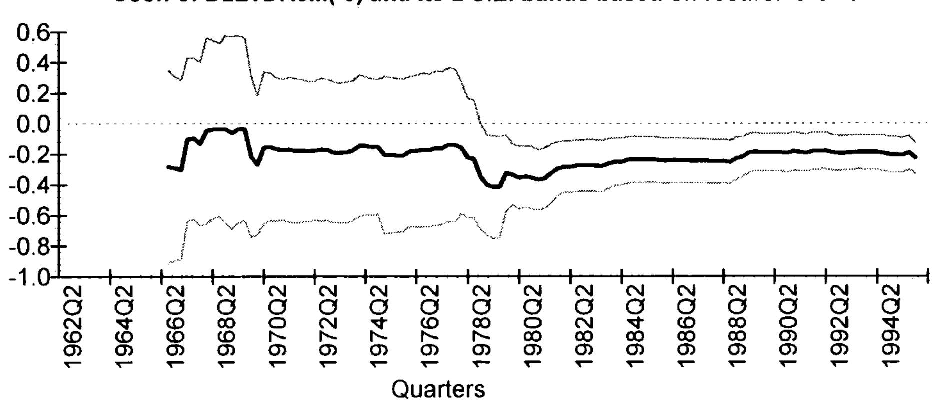
Coef. of D4LRLDA and its 2 S.E. bands based on recursive OLS



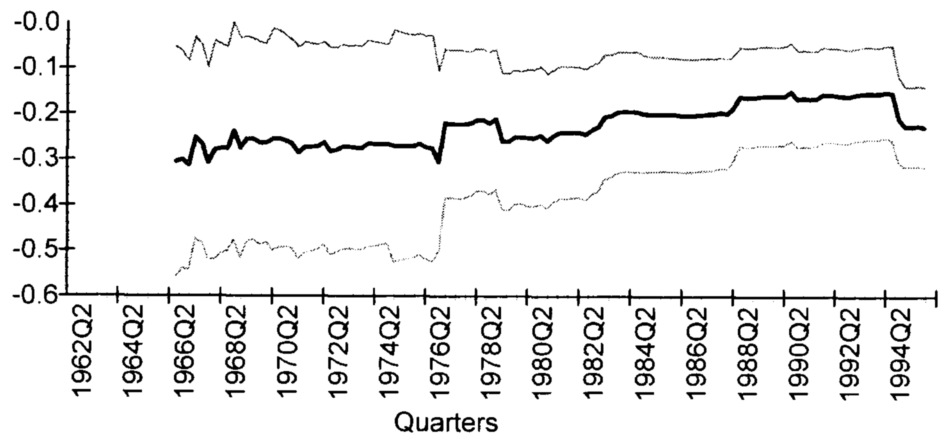
Coef. of D2LRLDA(-5) and its 2 S.E. bands based on recursive OLS



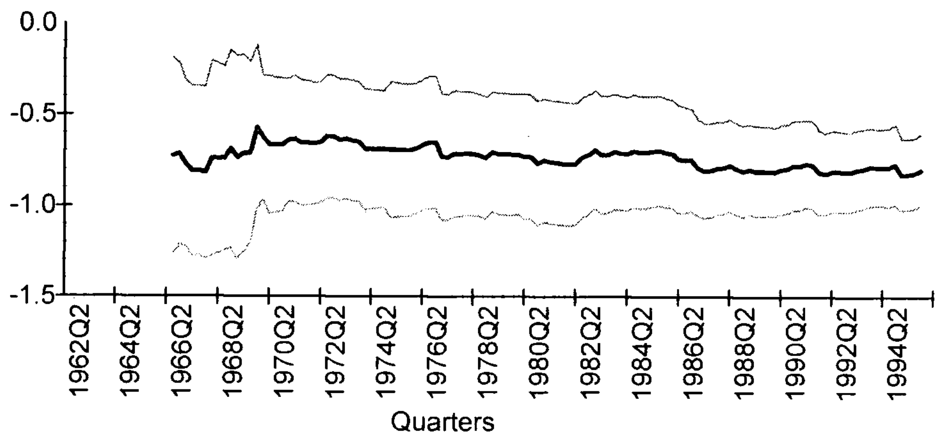
Coef. of D2LTDR3M(-6) and its 2 S.E. bands based on recursive OLS



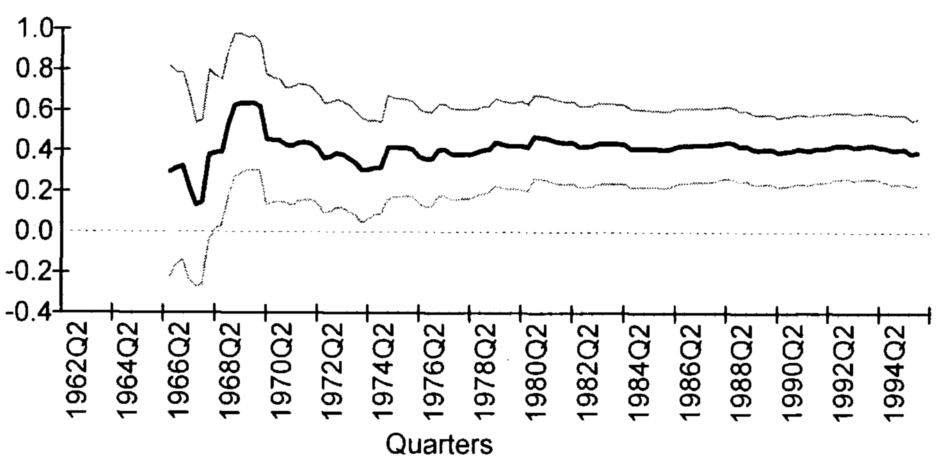
Coef. of D34LTBR and its 2 S.E. bands based on recursive OLS

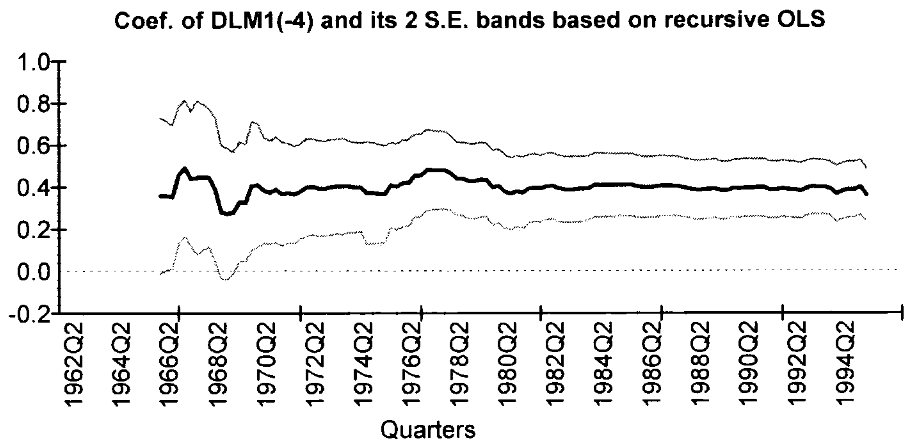


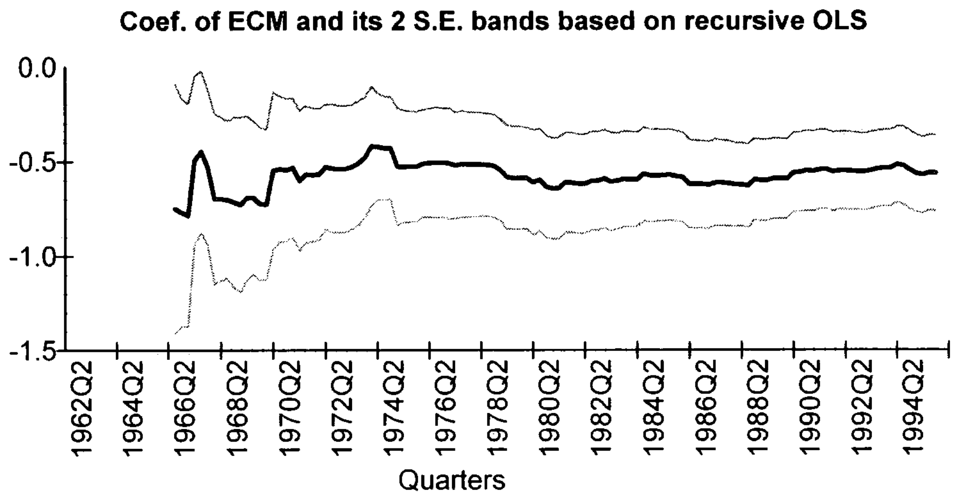
Coef. of DLDAD and its 2 S.E. bands based on recursive OLS



Coef. of DLM1(-1) and its 2 S.E. bands based on recursive OLS







It also exhibits parameter constancy as revealed by the in-sample predictive stability test (Predictive Failure LM $(\chi^2)_{40}$ = 49.4112[.146]) and the recursive plots of the estimates of each of the eight parameters.

Combining the structural stability and parameter constancy of the explanatory variables with the fact that they are weakly exogenous (established from the uniqueness of the underlying co-integrating vector) suggests that the model may indeed be useful for drawing policy inferences. This assertion approaches a truism when one recalls that both interest rates included in the model have been frequent subjects of regulation through ceilings and floors from 1970 to 1987, in 1991, and from February 1994 until the end of the sample[65].

[65] Full details can be found in section 3.3.

VI. DEMAND FOR DEMAND DEPOSITS (DD) IN NIGERIA

As in the previous Chapter, this Chapter tests hypotheses about DD demand and estimates the long and short run elasticities of the model in line with the steps laid out in section 2.6 to 2.10. We present the outcome of the OLS specification search in section 6.1. Section 6.2 presents JML tests of the hypothesis of cointegration on the DD vector. Section 6.3 presents the Wickens-Breusch ARDL estimates of the long-run responses, model diagnostics, and the short run responses.

6.1. OLS RESULTS FOR DEMAND DEPOSITS

Similar Engle-Granger cointegrating searches recovered the following five-variable cointegrating vector for demand deposits in Nigeria:

$$\frac{\mathrm{dd}^{d}}{P} = f(y, r_{qm}^{nig}, r_{tbr}^{nig}, r_{qm}^{uk}) \tag{6.1}$$

Where,

dd^{d} = desired stock of demand deposits (equals actual only in equilibrium);

P = general price level; y = real expenditure;

r_{qm}^{nig} = Rate on quasi-money in Nigeria;

r_{tbr}^{nig} = Rate on Treasury bills in Nigeria;

r_{qm}^{uk} = Rate on quasi-money in the UK.

The double logarithmic form of (6.1) is:

$$\log\left(\frac{dd^{d}}{P}\right) = \alpha_0 + \alpha_1 \log y + \alpha_3 \log r_{qm}^{nig} + \alpha_4 \log r_{tbr}^{nig} + \alpha_5 \log r_{qm}^{uk} + \mu \tag{6.2}$$

The alternative cointegrating vector for DD is:

$$\frac{\mathrm{dd}^{d}}{P} = f\left(y, r_{qm}^{nig}, r_{tbr}^{nig}, \frac{r_{qm}^{nig}}{r_{qm}^{uk}}\right) \tag{6.1'}$$

Where, $\frac{r_{qm}^{nig}}{r_{qm}^{uk}}$ = ratio of time deposit rates in Nigeria and the UK. In double logarithmic form, (6.1') also yields:

$$\log\left(\frac{dd^d}{P}\right) = \alpha_0 + \alpha_1 \log y + \alpha_3 \log r_{qm}^{nig} + \alpha_4 \log r_{tbr}^{nig} + \alpha_5 \log\left(\frac{r_{qm}^{nig}}{r_{qm}^{uk}}\right) + \mu \qquad (6.2')$$

The difference between the two is that the differential between deposit rates in Nigeria and UK is used in place of the UK deposit rate. Estimates of equation 6.2 and 6.2' are presented in Tables 6a(i) and 6a(ii). Table 6a(i) defines demand deposits in nominal terms, with the price level as one of the explanatory variables.

Table 6a(i): ENGLE-GRANGER MODELS FOR *NOMINAL* DEMAND DEPOSITS IN NIGERIA

$\text{Log}\,(dd^d) = \alpha_0 + \alpha_1 \log y + \alpha_2 \log P + \alpha_3 \log r_{qm}^{nig} + \alpha_4 \log r_{tbr}^{nig} + \alpha_5 \log r_{qm}^{uk} + \mu \ldots (2)$		
	1.	2.
Dependent Variable	*log (dd)*	log (dd)
Model:	$dd = f(rlda, dad, r_{tdr3m}^{nig}, r_{tbr}^{nig}, r_{tdr3m}^{uk})$	$dd = f(rlda, dad, r_{tdr3m}^{nig}, r_{tbr}^{nig}, \frac{r_{tdr3m}^{nig}}{r_{tdr3m}^{uk}})$
Constant	-15.53 (-15.06)	-15.48 (-15.03)
log (rlda)	1.8986 (20.1354)	1.8939 (20.11)
log (dad)	0.82 (22.65)	0.83 (22.69)
$\log(r_{tdr3m}^{nig})$	1.08 (6.85)	1.27 (8.2)
$\log(r_{tbr}^{nig})$	-0.67 (-4.02)	-0.66 (-3.96)
$\log(r_{tdr3m}^{uk})$	0.1898 (3.8716)	-
$\log(r_{tdr3m}^{nig}/r_{tdr3m}^{uk})$	-	-0.18 (-3.97)
Adj. R^2	0.99127	0.99131
F-ratio	3247.3	3264
σ	0.21004	0.2095
Mean of dep. Var.	7.3817	7.3817
LL	23.441	23.811
AIC	17.441	17.811
SBC	8.5318	8.9016
T	144	144
N	6	6
CRDW	0.67151	0.67213
ADF [I], (I=0 ... 4)	AIC=SBC=HQ=-5.2794[0]**	AIC=SBC=HQ=-5.2826 [0]**
ADF 95% crit. Val.	-4.8285	-4.8285
Cointegrated?	**Yes**	**Yes**

Figures in parentheses are t-ratios of the corresponding estimates. '*' signifies 10% level of significance; '**', 5%; and '***', 1%. '-' Implies the corresponding variable(s) not included. σ = Standard error of regression; LL = Maximum of Log-likelihood; T = Number of observations; N= The number of series for the null of non-co-integration is being tested. The 95% critical values for the ADF_i statistics, [*i*] *(i=0 ... 4)*, where *i* is the number of lags in the ADF regressions, depend on both T and N based on the response surface estimates given by MacKinnon (1991). The specific number of lags used in each case is indicated in brackets. Again, '**', indicates significance of the ADF statistic in rejecting the null of no cointegration. The decision on which lag of the ADF tests should be used is based on the lag that maximizes the value of an information criterion: the three used are Akaike Information Criteria (AIC), Schwarz Bayesian Criteria (SBC), and Hannan-Quinn Criteria (HC).

Estimation of the model with the nominal aggregate permits assessment of the value of α_2, the price elasticity of demand deposits. This estimated value is about 0.8 in the estimates of 2 and 2' in Table 6a(i). Both equations are cointegrated.

Table 6a(ii): OLS MODELS FOR *REAL* DEMAND DEPOSITS IN NIGERIA

$\text{Log}\,(\frac{dd^d}{P}) = \alpha_0 + \alpha_1 \text{log}y + \alpha_3 \text{log}\, r_{qm}^{nig} + \alpha_4 \text{log}\, r_{tbr}^{nig} + \alpha_5 \text{log}\,(\frac{r_{qm}^{nig}}{r_{qm}^{uk}}) + \mu \ldots (2')$		
	3.	4.
Regressand	log (dd/dad)	log (dd/dad)
Model:	$dd/dad = f(rlda, r_{tdr3m}^{nig}, r_{tbr}^{nig}, r_{tdr3m}^{uk})$	$dd/dad = f(rlda, r_{tdr3m}^{nig}, r_{tbr}^{nig}, \frac{r_{tdr3m}^{nig}}{r_{tdr3m}^{uk}})$
Constant	-13.738 (-13.27)	-13.7 (-13.31)
Log (rlda)	1.6348 (19.78)	1.6340 (19.91)
$\text{Log}\,(r_{tdr3m}^{nig})$	0.94 (5.60)	1.21 (7.31)
$\text{Log}\,(r_{tbr}^{nig})$	-0.83 (-4.72)	-0.81 (-4.61)
$\text{Log}\,(r_{tdr3m}^{uk})$	0.283 (5.87)	-
$\text{Log}\,(r_{tdr3m}^{nig} / r_{tdr3m}^{uk})$	-	-0.269 (-6.01)
Adj. R^2	0.94756	0.94808
F-ratio	647	654
σ	0.22664	0.22550
Mean of dep. Var.	3.8872	3.8872
LL	11.9717	12.6945
AIC	6.9717	7.6945
SBC	-.45282	0.26998
T	144	144
N	5	5
CRDW	0.5457	0.55011
ADF [i], (I=0 … 4)	AIC=SBC=HQ=-4.6171 [0]**	AIC=SBC=HQ=-4.6391 [0]**
ADF 95% crit. Val.	-4.5177	-4.5177
Cointegrated?	**Yes**	**Yes**

Figures in parentheses are t-ratios of the corresponding estimates. '*' signifies 10% level of significance; '**', 5%; and '***', 1%. '-' Implies the corresponding variable(s) not included. σ = Standard error of regression; LL = Maximum of Log-likelihood; T = Number of observations; N= The number of series for the null of non-co-integration is being tested. The 95% critical values for the ADF$_i$ statistics, [*i*] *(i=0 … 4)*, where *i* is the number of lags in the ADF regressions, depend on both T and N based on the response surface estimates given by MacKinnon (1991). The specific number of lags used in each case is indicated in brackets. Again, '**', indicates significance of the ADF statistic in rejecting the null of no co-integration. The decision on which lag of the ADF tests should be used is based on the lag that maximizes the value of an information criterion: the three used are Akaike Information Criteria (AIC), Schwarz Bayesian Criteria (SBC), and Hannan-Quinn Criteria (HC).

Table 6a(ii) implicitly restricts α_2 to unity by using real demand deposits as the dependent variable and excluding the price level from the right hand side. The restriction has no impact on the long run equilibrium relationships in 6.2', as the results in both columns remain cointegrated.

We note the decline in all measures of statistical fit in Table 6a(ii) in comparison with Table 6a(i). However, since theory is about desired demand for real-money balances, the loss in statistical fit is not as important as the theory consistence implied by the fact that the restriction of α_2 to unity is compatible with cointegration. Hence it is the restricted version that will be maintained in the subsequent stages of the modelling.

Turning to the choice between equations 6.2 and 6.2', both define cointegrating relationships for desired holding of real demand deposits in Nigeria, but equation 6.2' provides a slightly better fit than 6.2 as both Tables 6a(i) and 6a(ii) reveal. The second column of both tables provides a slightly better fit than the first in both tables, suggesting that introducing the foreign interest differential is the more suitable way of incorporating the effect of the foreign deposit rate into the model. Qualitatively, the negative sign on the differential makes it more readily interpretable as capturing a plausible net-substitution effect between demand deposits and foreign deposits, while the positive sign on the foreign deposit rate would have been a bit more difficult to interpret. Apart from the difference in signs, the magnitudes of the estimated elasticities are quite similar for the differential and the foreign rate. It is the differential that is used in subsequent modelling of demand deposits. Our Engle-Granger static-OLS specification searches thus leave us with a cointegrating vector with five variables for the demand for real-DD in Nigeria over 1960Q1-1995Q4[66]. The desired holdings of real-DD are determined by levels of real domestic absorption, time deposit and Treasury bill rates, and deposit rate differential between Nigeria and

[66] The model estimated from the semi-log version of this model:

$$\log\left(\frac{\hat{dd}}{p}\right) = \underset{(-23.53)}{-19.35} + \underset{(27.9)}{2.0}\log\left(\frac{y}{p}\right) + \underset{(3.34)}{10.37}\, r^{nig}_{tdr3m} - \underset{(-1.81)}{6.39}\, r^{nig}_{tbr} - 0.147\,(r^{nig}_{tdr3m} / r^{uk}_{tdr3m})$$

Adj. R^2=0.9344; CRDW=0.4779; F-ratio=510.46[0.00]; σ=0.2534; LL=-4.11; SBC=-16.14; T=144[19601-95IV]; N=5; ADF [i], (i=0 ... 4)=-3.1630[0]; ADF 95% critical value=-4.5177; Cointegrated? **No.**
The presence of cointegration in the double-log form and the absence thereof in the semi-log form suggest that the former is the better representation of the long run relationships among the variables. Also, non-nested test of the semi-log against the double log form delivers SBC of −16.8554 against the semi-log form, suggesting the double log form encompasses the semi-log form.

the UK. We can therefore conclude that there is a stable long-run relation between real-DD and a few other variables in Nigeria: only four variables.

Results from Engle-Granger (E-G) single-equation static OLS regression thus clearly suggest the presence of a cointegrating relation between DD (nominal or real), real activity and interest rates. Again, since this method is known to have a tendency to suggest absence of cointegration when one is present, the finding of cointegration for DD within this framework is fairly strong evidence.

Table 6b: Granger Causality Tests for the DD Cointegrating Vector

	$\sum_{i=1}^{4} \Delta lrlda_{t-i}$	$\sum_{i=1}^{4} \Delta ltbr_{t-i}$	$\sum_{i=1}^{4} \Delta ltdr3m_{t-i}$	$\sum_{i=1}^{4} \Delta ldad_{t-i}$	$\sum_{i=1}^{4} \Delta ldd_{t-i}$	$\sum_{i=1}^{4} \Delta lrdiff_{t-i}$	ECM_{t-1}
$\Delta lrldd_t$	2.8*[3]	4.6**[1,3]	8.1***[1,4]	10.8***[3]	8.6***[4]	...	29.5***
$\Delta lrlda_t$	4.3**[2,3]	...	5.0**[2]	...	6.0**[4]	...	...
$\Delta ltbr_t$	...	...	....	...	...	...	...
$\Delta ltdr3m_t$	...	...	...	...	...	...	...
$\Delta lrdiff_t$	...	7.2***[1,2,3]	6.0***[1,2,3]	6.9***[4]	...	5.8**[1]	...

The numbers reported are F statistics. The numbers in brackets indicate the specific lag(s) that are significant. Significance at 1 per cent level is indicated by, '***'; '**', implies 5 per cent level, and, '*', 10 per cent. Note that ΔlogDAD and ΔlogDD are entered separately with the same lags in this regression. Using ΔlogDD rather than ΔlogRLDD is the correct thing to do as it also enables us to isolate the impact of observable changes in the nominal money stock on 'unobservable' desired holding of real-balances.

Table 6b presents the results of Granger causality tests on the E-G cointegrating vector for DD. The error-correction term, ECM_{t-1} (one period lagged residuals from the vector for real-DD) is only statistically significant in explaining changes in real-DD. Changes in real-DD could therefore rightly be treated as the endogenous variable in a single-equation error-correction model (SEECM) framework. Exogeneity assertions are usually made to allow the analysis of one set of variables without having to specify how a second set is determined. Different notions of exogeneity are required depending on the purpose of analysis. The insignificance of the ECM in the equations for the changes in other variables shows that they can be rightly regarded as weakly exogenous for real-DD. Weak exogeneity is required for valid statistical inference.

Beyond the causal influence of the disequilibrium error, causality also runs from the lagged values of the different variables to one another. The reverse causation between real-DD and real domestic absorption is noteworthy in this regard. Strong exogeneity, which is relevant in forecasting models, requires the absence of reverse causation from the dependent variable to any of the weakly exogenous explanatory variables. The dynamic models for real-DD derived from the above cointegrating vector, will therefore be ill suited for out-of-sample forecasting.

Most often however, interest in constructing money demand models center on conditional policy inferences rather than on forecasting. Strong exogeneity is irrelevant to this pursuit, and the reverse causation therefore is of no consequence. The relevant attribute for policy inferences is super exogeneity, which requires that the dynamic model be structurally stable with constant parameters. Since the Granger causality tests are conducted within reduced form models, we shall return to stability and constancy requirements after constructing the structural models in the sections that follow.

6.2. JML RESULTS FOR DEMAND DEPOSITS

The E-G results however do not tell us all that we would like to know about the cointegrating vector. There is a possibility that the vector is not unique: there might be more than one cointegrating relationship among the five variables in the vector. This needs to be ascertained. It is also not clear which of the five variables in the vector is the endogenous variable. The E-G static OLS technique is ill-suited for these excercises.

Lag Order of the VAR

This necessitates the application of Johansen-Juselius Maximum Likelihood (JML) vector autoregression technique to the vector identified from the static OLS search in this section.

We precede the JML tests with a test for the optimal order of the VAR based on two information criteria, the Akaike Information Criteria (AIC) and the Schwarz Bayesian Criterion (SBC)[67]. The result of the test for the optimal order of the VAR, p, conducted in the context of an unrestricted VAR model with eight lags, is reported in Table 6c. From this Table, both AIC

[67] In the event of a conflict between the two, Gonzalo and Pitarakis (1999a) showed that AIC is the more reliable one for determining the optimal lag length of the unrestricted VAR even in large dimensional systems.

and SBC are maximized at the first lag, both suggesting that the optimal order of this VAR is 1,. Hence, the test for co-integration of the demand deposits model is based on VAR (1).

TABLE 6c: SELECTING THE ORDER OF THE VAR MODEL

Test Statistics and Choice Criteria for Selecting the Order of the VAR Model are based on 136 observations from 1995Q4. Lag length used for testing is VAR=8. List of variables included in the unrestricted VAR: log (DD/DAD), log(RLDA), log(TDR3M), log(TBR), and log(TDR3M/TDR3MUK. List of deterministic and/or exogenous variables: CONSTANT		
Order of Lag in the VAR(p)	AIC	SBC
p =0	-115.73	-122.97
p =1	**631.47*****	**588.00*****
p =2	623.28	543.59
p =3	615.13	499.22
p =4	604.25	452.12
p =5	601.24	412.88
p =6	591.59	367.01
p =7	584.78	323.97
p =8	578.08	281.05

AIC=Akaike Information Criteria; and, SBC=Schwarz Bayesian Criterion.

Deterministic components

We now proceed to test assumptions about the presence or otherwise of deterministic trends in the cointegrating relations. Five possible cases are tested in Table 6d. The values of the AIC, SBC, and HQC are all maximized for Case 2: restricted intercept and no deterministic trends in VAR. This suggests that the only deterministic component in the vector is the intercept in the cointegrating relation. It also suggests the absence of any other deterministic trend (either linear or quadratic) from the *cointegrating relations* or *in any of the individual time series* defining the cointegrating vector.

TABLE 6d: DETERMINISTIC COMPONENTS IN THE COINTEGRATING RELATIONS

Assumptions	AIC	SBC	HQC
Case 1: No intercept, no trends in the VAR	629.3847 (r=2)	618.9962 (r=0)	622.8793 (r=1)
Case 2: Restricted intercept, no trends in VAR	**633.2832 (r=2)**	**618.9962 (r=0)**	**623.5811*** (r=1)**
Case 3: Unrestricted intercept, no trends in VAR	632.5935 (r=2)	609.7506 (r=0)	620.2288 (r=2)
Case 4: Unrestricted intercept, restricted trends in VAR	631.2106 (r=2)	609.7506 (r=0)	618.4644 (r=1)
Case5: Unrestricted intercept and trend in VAR	631.1125 (r=5)	599.3069 (r=0)	614.2655 (r=2)

AIC=Akaike Information Criteria; SBC=Schwarz Bayesian Criterion, HQC=Hannan-Quin Criterion.

The presence of a non-zero intercept in the cointegrating vector makes sense as the intercept is usually needed, at least to account for the units of measurements of the variables. JML cointegration tests are therefore based on the assumptions that intercepts are restricted to lie within the cointegrating space, and there are no deterministic trends in the underlying VAR (1) or in any of the individual variables.

The cointegrating rank

In testing for the cointegrating rank, 143 observations from 1960Q2 to 1995Q4 were used with a VAR of order 1. The list of variables included in the vector is: log(dd/dad), log(rlda), log(tdr3m), log(tbr), log(tdr3m/uktdr3m), and intercept. The list of eigenvalues in descending order is 0.26329, 0.16166, 0.067504, 0.052682, 0.027636, and 0.0000. Note that while the maximized values of the three information criteria reported 5.3d are agreed on the nature of the intercept and trend components of the VAR, as already discussed, they do not necessarily agree on the cointegrating rank of the vector: AIC suggest a rank of 2, SBC suggests a rank of 0, while HQC suggest a rank of 1. Since the reliability of the JML Langrange Ratio (LR) tests are sensitive to assumptions about the trend and intercept components, it is important to address this conflicting suggestions about the rank of the cointegrating vector by the three choice criteria. Gonzalo and Pitarakis (1999b) has examined the asymptotic and finite sample properties of choice-criteria approaches to estimation of the cointegrating rank in the JML framework. They uncovered a marked deterioration of the ability of the AIC and SBC to correctly determine the cointegrating rank as system dimension increases to the range of $n \geq 5$ (n = number of variables in the vector), with moderate sample sizes of $T \leq 150$. They demonstrated that 'the AIC or any other constant penalty criterion will persistently over-rank, especially as system dimension increases' (p. 224-225). They also demonstrated the fact that SBC ' will be unable to move away from $r=0$ as $n \geq 5$ even if sufficiently large sample is available. On the contrary, they showed that the 'HQ criterion turns out to be the only criterion able to achieve reasonable results even under a large dimensional system' (p. 226). With a five-variable vector in Table 7d, the AIC and SBC both appear to conform to the findings of Gonzalo and Pitarakis (1999b), and neither will therefore be relied upon in determining the appropriate intercept/trend properties of the cointegrating vector under investigation nor in determining the cointegrating rank. Only the HQC will be used for both purposes, as recommended by Gonzalo and Pitarakis (1999b).

TABLE 6e: LR TEST BASED ON MAXIMAL EIGENVALUE OF THE STOCHASTIC MATRIX

NULL	*ALTERNATIVE*	*STATISTIC*	*95%CRITICAL VALUE*	*90% CRITICAL VALUE*
R=0	r≥1	40.9456	34.4000	31.7300
R≤1	r≥2	23.6284	28.2700	25.8000
R≤2	r≥3	9.3654	22.0400	19.8600
R≤3	r≥4	7.2521	15.8700	13.8100
R≤4	r≥5	3.7554	9.1600	7.5300

TABLE 6f: LR TEST BASED ON TRACE OF THE STOCHASTIC MATRIX

NULL	*ALTERNATIVE*	*STATISTIC*	*95%CRITICAL VALUE*	*90% CRITICAL VALUE*
r=0	r≥1	84.9469	75.9800	71.8100
R≤1	r≥2	44.0013	53.4800	49.9500
R≤2	r≥3	20.3728	34.8700	31.9300
R≤3	r≥4	11.0075	20.1800	17.8800
R≤4	r≥5	3.7554	9.1600	7.5300

Using a VAR (1), the maximal eigenvalue of the stochastic matrix in Table 6e suggests that the null of r=0 can be rejected in favour of the alternative hypothesis of r=1 at the 95% level of confidence. Also, the hypothesis that r=2 can be rejected on the basis of the maximal eigenvalue at both the 95% and 90% levels of confidence, in favour of r=1.

TABLE 6g: ESTIMATED AND NORMALIZED CO-INTEGRATED VECTORS

VECTOR	*ESTIMATE*	*NORMALIZED*
LOG(DD/DAD)	0.32185	-1.0000
LOG(RLDA)	-0.38991	1.2115
LOG[TDR3M/(1+ TDR3M)]	-0.92301	1.8679
LOG[TBR/(1+TBR)]	0.84575	-2.6278
LOG(TDR3M/UKTDR3M)	0.0.10506	-0.3264
INTERCEPT	2.9481	-9.1600

Similarly, evaluation of the hypotheses that r equals 0, 1, or 2 based on the trace of the stochastic matrix in Table 6f rejects r=0 and r=2 in favour of rank of r=1 at both 95 % and 90% levels of confidence. The maximal value of HQC reported in Table 6f confirms r=1 suggested by both the maximal eigenvalues in Table 6e and trace of the stochastic matrix in Table 6f. We therefore accept the proposition that there is a single co-integrating vector for the five variables. The JML results therefore confirm that there is a valid co-integrating relationship between real-DD, real activity, two interest rates: TDR3m and TBR, and one interest rate differential. Moreover, the results also suggest the absence of multiple co-integrating relations among these variables. Subsequent estimation is based on the assumption that a unique co-integrating relationship exists between real DD and the other variables. The estimates of the long run coefficients are presented in Table 6g.

TABLE 6h: ECM FOR VARIABLE LOG(DD/DAD) ESTIMATED BY OLS BASED ON CV (VAR(1))

Dependent Variable: Δ log(DD/DAD)		
Regressor	*Coefficient*	*T-Ratio[Prob.]*
ECM	*-0.50214*	*-3.6167[.000]*
R^2 *= 0.081744;* $\bar{R}^2$ *= 0.081744;* σ *= 0.13884; DW = 2.3123; Equation Log-Likelihood = 74.9387;*		
SBC = 72.4898; Residuals serial correlation, LM $(\chi^2)_4$ = 8.9610 (0.062)*; RESET functional form LM $(\chi^2)_1$ = 0.19689 (0.657);		
Jarque-Bera error non-normality LM $(\chi^2)_2$ = 10.1250 (0.06)*; Heteroscedasticity LM $(\chi^2)_1$ =0.075742 (0.783);		

Examining the error-correction mechanism associated with the above long run relations in Table 6h establishes the validity of normalising the vector on real DD. The negative sign and statistical significance of the error-correction term with a t-ratio of –3.6167 in the equation for Δ log(DD/DAD) confirms that the vector is a valid co-integrating relationship and that it is appropriate to treat LOG(DD/DAD) as the endogenous variable in the model.

ARDL RESULTS ON DEMAND DEPOSITS

TABLE 6i: ARDL ESTIMATES FOR DD

Method	$\bar{R}^2$ =AIC
ARDL ($\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3, \hat{q}_4$)	(6, 9, 3, 7, 9)
Constant	-5.8 (-4.38)***
$Log(DD/DAD)_{t-1}$	0.5 (5.2)***
$Log(DD/DAD)_{t-2}$	0.13 (1.27)
$Log(DD/DAD)_{t-3}$	0.0027 (0.025)
$Log(DD/DAD)_{t-4}$	0.21 (1.86)*
$Log(DD/DAD)_{t-5}$	-0.03 (-0.27)
$Log(DD/DAD)_{t-6}$	-0.21 (-2.27)**
$Log(RLDA)_t$	0.47 (2.09)**
$Log(RLDA)_{t-1}$	0.26 (0.87)
$Log(RLDA)_{t-2}$	-0.13 (-0.45)
$Log(RLDA)_{t-3}$	-0.5 (1.75)*
$Log(RLDA)_{t-4}$	-0.07 (-0.24)
$Log(RLDA)_{t-5}$	0.54 (1.92)*
$Log(RLDA)_{t-6}$	-0.01 (0.04)
$Log(RLDA)_{t-7}$	-0.53 (1.88)*
$Log(RLDA)_{t-8}$	0.3 (1.07)
$Log(RLDA)_{t-9}$	0.36 (1.6)
$Log[tdr3m/(1+ tdr3m)]_t$	0.13 (0.67)
$Log[tdr3m/(1+ tdr3m)]_{t-1}$	-0.12 (-0.47)
$Log[tdr3m/(1+ tdr3m)]_{t-2}$	0.14 (0.57)
$Log[tdr3m/(1+ tdr3m)]_{t-3}$	0.39 (1.9)*
$Log[tbr/(1+tbr)]_t$	-0.32 (-1.9675)*
$Log[tbr/(1+tbr)]_{t-1}$	0.28 (1.49)
$Log[tbr/(1+tbr)]_{t-2}$	-0.08 (0.42)
$Log[tbr/(1+tbr)]_{t-3}$	-0.61 (-3.46)***
$Log[tbr/(1+tbr)]_{t-4}$	0.42 (2.77)***
$Log[tbr/(1+tbr)]_{t-5}$	-0.33 (-2.09)**
$Log[tbr/(1+tbr)]_{t-6}$	-0.16 (-0.99)
$Log[tbr/(1+tbr)]_{t-7}$	0.23 (1.94)*
$Log\ [tdr3m/uktdr3m]_t$	0.008 (0.12)
$Log\ [tdr3m/uktdr3m]_{t-1}$	-0.15 (-1.59)
$Log\ [tdr3m/uktdr3m]_{t-2}$	0.15 (1.52)
$Log\ [tdr3m/uktdr3m]_{t-3}$	-0.078 (-0.8)
$Log\ [tdr3m/uktdr3m]_{t-4}$	-0.02 (-0.25)
$Log\ [tdr3m/uktdr3m]_{t-5}$	0.03 (0.34)
$Log\ [tdr3m/uktdr3m]_{t-6}$	-0.068 (-0.78)
$Log\ [tdr3m/uktdr3m]_{t-7}$	0.033 (0.39)
$Log\ [tdr3m/uktdr3m]_{t-8}$	0.05 (0.61)
$Log\ [tdr3m/uktdr3m]_{t-9}$	-0.14 (-2.3)**
R^2	0.99021
$\bar{R}^2$	0.98634
α	0.11314
LL	125.6433
AIC	86.6433
SBC	29.9958
DW	1.95
Normality: T_{JB}, LM $(\chi^2)_2$:	1.6073 [0.448]
5th-order Auto-correlation: T_{ARMA}, LM $(\chi^2)_5$	3.4875 [0.625]
4th-order ARCH: T_{ARCH}, LM $(\chi^2)_4$	1.6579 [0.798]
Heteroscedasticity: T_{WHET}, LM $(\chi^2)_1$,	0.32372 [0.569]
Functional form: T_{RESET}, LM $(\chi^2)_1$	0.22216 [0.637]

Figures in brackets after the diagnostic statistics indicate their levels of significance. Figures in parentheses are standard errors of the corresponding estimates. In all cases, '*' signify 10% level of significance; '**', 5%; and '***', 1%.

We now move on to the Wickens-Breusch ARDL method of estimating the long run elasticities. ARDL computations for the DD models were based on a maximum lag, m, of 9 quarters for all variables (p=q_i=9)[68]. All the models were estimated on the same sample period, namely $t = m + 1$, m + 2... n. The model selected (from the $(m+1)^{k+1}$ ARDL models that were estimated) is presented in Table 6i. The variables in the ARDL equations are log (DD/DAD) as the dependent variable; and, log (rlda), log (r^{nig}_{tdr3m}), and log (r^{nig}_{tbr}) and log ($\frac{r^{nig}_{tdr3m}}{r^{uk}_{tdr3m}}$) as the four explanatory variables. The number of observations is 135 over the 1960Q1-1995Q4-sample period. ARDL $(\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3, \hat{q}_4)$, (6, 9, 3, 7, 9), model was selected by both $\bar{R}^2$ and AIC criteria. The SBC picked ARDL (1, 0, 0, 0, 0) and HQC ARDL (2, 0, 0, 0, 0), which are not only incongruent but also nested in ARDL (6, 9, 3, 7, 9), which, by contrast, is also congruent, and is therefore the only one taken further into subsequent analyses. The long-run responses of y_t to unit changes in x_{it} are presented in Table 6j. With reference to our *a priori* expectations for equation (6.2'), the estimated long run income elasticity of DD is correctly signed but too large, while both the own rate and the opportunity cost effects are present.

Table 6j: Associated long run coefficients of dd model

Method	$\bar{R}^2$ =AIC
ARDL $(\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3, \hat{q}_4)$	(6, 9, 3, 7, 9)
Constant	-14.11 (7.7)***
Log(RLDA)$_t$	1.66 (11.57)***
Log[tdr3m/(1+ tdr3m)}	1.34 (4.28)***
Log[tbr/(1+tbr)}	--0.97 (-2.9)***
Log[tdr3m/(uktdr3m)}$_t$	-0.45 (4.79)***

Figures in parentheses are standard errors of the corresponding estimates. '*' signifies 10% level of significance; '**', 5%; and '***', 1%.

6.4. Wickens-Breusch ECM for DD

The ECM corresponding to the ARDL (6, 9, 3, 7, 9) is presented in Table 6k as the starting point in the general-to-specific (GTS) search for a congruent dynamic model.

[68] Congruency requirements were satisfied at this lag (see Wickens and Bruesch (1988)).

TABLE 6k: INITIAL ERROR CORRECTION MODEL FOR DD

Method	$\bar{R}^2$ =AIC
ARDL ($\hat{p}$, $\hat{q}_1$, $\hat{q}_2$, $\hat{q}_3$, $\hat{q}_4$)	(6, 9, 3, 7, 9)
Constant	0.35 (1.96)*
Δlog(DD)$_{t-1}$	0.033 (0.21)
Δlog(DD)$_{t-2}$	-0.13 (-1.2)
Δlog(DD)$_{t-3}$	-0.11 (-1.1)
Δlog(DD)$_{t-4}$	0.18 (1.8)*
ΔLog(DD)$_{t-5}$	0.11 (1.1)
ΔLog(DAD)$_t$	-1.067 (-5.4)***
ΔLog(DAD)$_{t-1}$	0.49 (1.94)*
ΔLog(DAD)$_{t-2}$	-0.14 (-0.67)
ΔLog(DAD)$_{t-3}$	-0.41 (-2.04)**
ΔLog(DAD)$_{t-4}$	0.29 (1.23)
ΔLog(DAD)$_{t-5}$	-0.093 (0.42)
ΔLog(RLDA)$_t$	0.25 (1.11)
ΔLog(RLDA)$_{t-1}$	0.59 (2.53)***
ΔLog(RLDA)$_{t-2}$	0.35 (1.48)
ΔLog(RLDA)$_{t-3}$	-0.35 (-1.6)
ΔLog(RLDA)$_{t-4}$	-0.20 (-0.90)
ΔLog(RLDA)$_{t-5}$	0.44 (2.1)**
ΔLog(RLDA)$_{t-6}$	-0.06 (-0.27)
ΔLog(RLDA)$_{t-7}$	-0.28 (-1.35)
ΔLog(RLDA)$_{t-8}$	0.34 (1.658)
ΔLog[tdr3m/(1+ tdr3m)]$_t$	-0.18 (-0.96)
ΔLog[tdr3m/(1+ tdr3m)]$_{t-1}$	-0.23 (1.26)
ΔLog[tdr3m/(1+ tdr3m)]$_{t-2}$	-.-0.75 (-0.40)
ΔLog[tbr/(1+tbr)]$_t$	-0.20 (1.29)
ΔLog[tbr/(1+tbr)]$_{t-1}$	0.30 (1.99)**
ΔLog[tbr/(1+tbr)]$_{t-2}$	0.25 (1.73)*
ΔLog[tbr/(1+tbr)]$_{t-3}$	-0.22 (-1.9) *
ΔLog[tbr/(1+tbr)]$_{t-4}$	.024 (2.07)**
ΔLog[tbr/(1+tbr)]$_{t-5}$	0.02 (0.15)
ΔLog[tbr/(1+tbr)]$_{t-6}$	-0.15 (-1.3)
ΔLog[tdr3m/uktdr3m)]$_t$	0.055 (0.90)
ΔLog[tdr3m/(uktdr3m)]$_{t-1}$	-0.13 (-2.05)**
ΔLog[tdr3m/(uktdr3m)]$_{t-2}$	0.06 (1.01)
ΔLog[tdr3m/(uktdr3m)]$_{t-3}$	-0.01 (-0.18)
ΔLog[tdr3m/(uktdr3m)]$_{t-4}$	-0.036 (-0.66)
ΔLog[tdr3m/(uktdr3m)]$_{t-5}$	0.075 (1.37)
ΔLog[tdr3m/(uktdr3m)]$_{t-6}$	-0.053 (-0.98)
ΔLog[tdr3m/(uktdr3m)]$_{t-7}$	0.037 (0.66)
ΔLog[tdr3m/(uktdr3m)]$_{t-8}$	0.091 (1.67)
ECM	-0.43 (2.36)**
R^2	0.62477
$\bar{R}^2$	0.46338
α	0.10614
LL	134.89890
AIC	93.8989
SBC	34.4931
DW	1.9271
Normality: T_{JB} , LM $(\chi^2)_2$:	0.77658 [0.678]
5th-order Auto-correlation: T_{ARMA} , LM $(\chi^2)_5$	7.2163 [0.205]
4th-order ARCH: T_{ARCH} , LM $(\chi^2)_4$	1.7272 [0.786]
Heteroscedasticity: T_{WHET} , LM $(\chi^2)_1$,	0.0020948 [0.963]
Functional form: T_{RESET} , LM $(\chi^2)_1$	1.2699 [0.260]

Figures in parentheses are t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. In all cases, '*' signify 10% level of significance; '**', 5%; and '***', 1%. Note that Δlog (DAD) and Δlog (DD) are entered separately with the same lags in this regression. The restriction of zero price elasticity of real balances applicable to l.h.s variable, unobserved 'desired' money stock, and not to the r.h.s variables, Δlog (DAD), or the observed rate of inflation, and Δlog (DD), the observed change in the log of nominal money stock. Once Δlog (DAD) is included, using either Δlog (DD/DAD) or Δlog (DD) on the r.h.s. produces similar initial models, but different dynamic adjustment paths. Using Δlog (DD) rather than Δlog (DD/DAD) is the correct thing to do as it also enables us to isolate the impact of observable changes in the nominal money stock on 'unobservable' desired holding of real-balances.

This model has 41 freely estimated parameters. 134 quarterly observations from 1963Q1 to 1995Q4 were used in estimation. The explanatory power of the model of 0.625 drops to 0.464

after adjusting for the degrees of freedom lost in estimating the 41 parameters[69]. The value of the Schwarz Bayesian Criteria for this model is only 34.49.

6.5. The Reduced Model

The first step in the GTS search involves a stepwise elimination of variables or lags that are statistically insignificant at the 10% level. The reduced ECM, presented in Table 6l, has only 21 variables/lags that are significant at the 10% level, and these include the constant term. The test of the null hypothesis that all the 20 variables eliminated from the initial ECM contain any useful additional information is reported in the final row of Table 6l (variable deletion Test LM $(\chi^2)_{20}$=17.25[0.636]). This clearly shows that the null hypothesis can safely be rejected. The reduced ECM, presented in Table 6l, has only 20 lags that are significant at least at the 10% level. The test of the hypothesis that all the 20 lags eliminated from the initial ECM contain no additional information is reported in the final row of Table 6l (variable deletion Test LM $(\chi 2)_{17}$=17.25[0.636]). This is supported by the drop in the standard error of the regression, σ, from 0.10614 in the full ECM to 0.10316 in the reduced ECM, a rise in $\bar{R}^2$ from 0.46338 in the full ECM to 0.49308 in the reduced ECM. There is also a very sharp improvement in the SBC_λ from 34.49 to 74.24. The fact that the eliminated lags could be regarded as nuisance parameters is buttressed by the fact that many of the remaining variables, the ECM for example, became more significant than they were in the initial ECM. Three lags (2, 3, and 4) of nominal DD, four of DAD (0, 1, 3, and 4), five RLDA (1, 2, 5, 7, and 8), five of TBR (0, 2, 3, 4, and 6), two of TDR3M (1, and 8), enter the reduced model along with the ECM. This is supported by the very sharp improvement in the SBC_λ from 34.49 to 74.24 that resulted from excluding the deleted variables from the model.

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[69] ARDL (6, 9, 3, 7, 9) in levels correspond to an ECM (5, 8, 2, 6, 8) in first differences, plus another five lags on Δlog (DAD). This produces 34 lags in all. Adding the contemporaneous changes in real activity, three interest rates, and Δlog(DAD), plus the ECM and a constant implies that the total number of freely estimated parameters in this ECM is 41.

TABLE 61: THE REDUCED ERROR CORRECTION MODEL FOR DD

Method	$\bar{R}^2$=AIC
ARDL ($\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3, \hat{q}_4$)	(6, 9, 3, 7, 9)
Constant	0.40 (2.7)**
ΔLog(DD)$_{t-2}$	-0.17 (-1.98)**
ΔLog(DD)$_{t-3}$	-0.16 (-1.91)*
ΔLog(DD)$_{t-4}$	0.14 (1.69)*
ΔLog(DAD)$_t$	-1.0 (-6.0)***
ΔLog(DAD)$_{t-1}$	0.42 (2.44)**
ΔLog(DAD)$_{t-3}$	-0.38 (-2.37)**
ΔLog(DAD)$_{t-4}$	0.37 (1.94)*
ΔLog(RLDA)$_{t-1}$	0.57 (3.05)***
ΔLog(RLDA)$_{t-2}$	0.40 (2.17)**
ΔLog(RLDA)$_{t-5}$	0.40 (2.2)**
ΔLog(RLDA)$_{t-7}$	-0.32 (-1.78)*
ΔLog(RLDA)$_{t-8}$	0.34 (1.87)*
ΔLog[tbr/(1+tbr)]	-0.3 (-3.2)***
ΔLog[tbr/(1+tbr)]$_{-2}$	0.18 (1.99)**
ΔLog[tbr/(1+tbr)]$_{-3}$	-0.23 (-2.48)**
ΔLog[tbr/(1+tbr)]$_{-4}$	.21 (2.15)**
ΔLog[tbr/(1+tbr)]$_{-6}$	-0.16 (-1.77)*
ΔLog[tdr3m/(uktdr3m)]$_{-1}$	-0.12 (-2.46)**
ΔLog[tdr3m/(uktdr3m)]$_{-8}$	0.089 (1.89)*
ECM	-0.39 (3.85)***
R^2	0.56931
$\bar{R}^2$	0.49308
α	0.10316
LL	125.6637
AIC	104.6637
SBC	74.2364
DW	1.908
Normality: T_{JB}, LM $(\chi^2)_2$:	1.4653 [0.481]
5th-order Auto-correlation: T_{ARMA}, LM $(\chi^2)_5$	5.3242 [0.374]
4th-order ARCH: T_{ARCH}, LM $(\chi^2)_4$	1.5785 [0.813]
Heteroscedasticity: T_{WHIT}, LM $(\chi^2)_1$,	0.7115 [0.399]
Functional form: T_{RESET}, LM $(\chi^2)_1$	1.3638 [0.2430]
Variable deletion Test LM $(\chi^2)_{20}$	17.25[0.636]

Figures in parentheses are t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. In all cases, '*' signify 10% level of significance; '**', 5%; and '***', 1%. Note that Δlog (DAD) and Δlog (DD) are entered separately with the same lags in this regression. The restriction of zero price elasticity of real balances applicable to l.h.s variable, unobserved 'desired' money stock, and not to the r.h.s variables, Δlog (DAD), or the observed rate of inflation, and Δlog (DD), the observed change in the log of nominal money stock. Once Δlog (DAD) is included, using either Δlog (DD/DAD) or Δlog (DD) on the r.h.s. produces similar initial models, but different dynamic adjustment paths. Using Δlog (DD) rather than Δlog (DD/DAD) is the correct thing to do as it also enables us to isolate the impact of observable changes in the nominal money stock on the 'unobservable' desired holdings of real-balances being modelled.

There is also a fall in the standard error of the regression, σ, from 0.10614 in the full ECM to 0.10316 in the reduced ECM, and a rise in $\bar{R}^2$ from 0.464 in the full ECM to 0.493 in the reduced ECM. Changes in tdr3m were dropped, lags of the deposit rate differential dropped from nine to two, treasury bill rate from seven to five, nominal money from five to three, real activity from nine to five, and inflation rate from six to four in the transition to the reduced ECM.

All the reported model design diagnostic statistics show that the reduced ECM is congruent.

6.6. The Parsimonious Model

The transition from the reduced ECM (Table 6l) to the parsimonious version (Table 6m) involves transformations on the retained lags through introduction of acceleration effects (second differences or Δ^2) for consecutive lags, and dropping variables that are not significant at the 5% level.

TABLE 6m: PARSIMONIOUS ERROR CORRECTION MODEL FOR DD

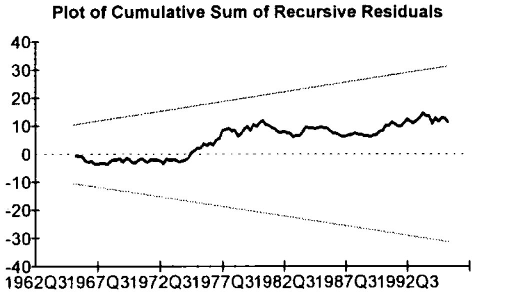
Method	$\bar{R}^2$ =AIC
ARDL ($\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3, \hat{q}_4$)	(6, 9, 3, 7, 9)
Constant	0.044 (3.44)***
ΔLog(DD)$_{t-2}$	-0.23 (-2.9)***
ΔLog(DAD)$_t$	-.6 (-3.2)***
Δ^2Log(DAD)$_t$	-0.49 (-2.8)***
Δ^2Log(DAD)$_{t-3}$	-0.31 (-2.18)**
ΔLog(RLDA)$_{t-1}$	0.0.43 (2.35)**
ΔLog(RLDA)$_{t-2}$	0.37 (2.01)**
ΔLog(RLDA)$_{t-5}$	0.40 (2.2)**
ΔLog[tbr/(1+tbr)]$_t$	-0.27 (-2.9)***
Δ^2Log[tbr/(1+tbr)]$_{t-3}$	-0.15 (-2.18)**
ΔLog[tdr3m/(uktdr3m)]$_{t-1}$	-0.11 (-2.34)**
ECM	-0.38 (3.57)***
R^2	0.49039
$\bar{R}^2$	0.44445
α	0.10799
LL	114.391
AIC	102.391
SBC	85.0039
DW	1.9869
Normality: T_{JB} , LM $(\chi^2)_2$:	0.27324 [0.872]
5th-order Auto-correlation: T_{ARMA} , LM $(\chi^2)_5$	4.4824 [0.482]
4th-order ARCH: T_{ARCH} , LM $(\chi^2)_4$	1.9777 [0.740]
Heteroscedasticity: T_{WHET} , LM $(\chi^2)_1$,	0.074409 [0.785]
Functional form: T_{RESET} , LM $(\chi^2)_1$	0.18304 [0.669]
Predictive Failure LM $(\chi^2)_{40}$	44.1276 [0.301]
Chow's Structural Stability Test LM $(\chi^2)_{12}$	8.8787 [0.713]

Figures in parentheses are t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. In all cases, '*' signify 10% level of significance; '**', 5%; and '***', 1%. Note that ΔLog (DAD) and ΔLog (DD) are entered separately with the same lags in this regression. The restriction of zero price elasticity of real balances applicable to l.h.s variable, unobserved 'desired' money stock, and not to the r.h.s variables, ΔLog (DAD), or the observed rate of inflation, and ΔLog (DD), the observed change in the log of nominal money stock. Once ΔLog (DAD) is included, using either ΔLog (DD/DAD) or ΔLog (DD) on the r.h.s. produces similar initial models, but different dynamic adjustment paths. Using ΔLog (DD) rather than ΔLog (DD/DAD) is the correct thing to do as it also enables us to isolate the impact of observable changes in the nominal money stock on the 'unobservable' desired holdings of real-balances being modelled.

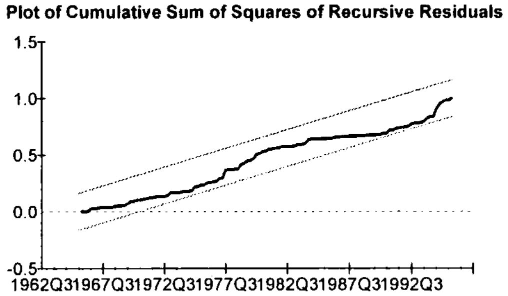
As before, any reparameterization that result in a marked decline in the explanatory power of the model (based on $\bar{R}^2$, σ, and SBC_λ) is not admissible, while those that result in negligible or no drop in explanatory power but reveal relevant features of underlying economic behaviour are admissible.

The final (parsimonious model is reported in Table 6m, an ECM with only 11 freely estimated parameters, compared to 21 in the reduced ECM of Table 6l. There is an increase in σ from 0.10316 to 0.10799 and a drop in $\bar{R}^2$ from 0.493 to 0.445. The SBC_λ however improved from 74 in the reduced ECM to 85 in the final ECM, suggesting that additional information outweighs the loss of statistical 'fit', and that the net impact of the foregoing data transformations has been to achieve a more parsimonious representation of the underlying economic relationship. More importantly there is an increase in the economic interpretability of the model as all the remaining inflation, real activity and interest rate variables have economically meaningful signs, in contrast to the sign switches that were observed in the reduced ECM of Table 6l.

Past growth in income exerts positive effects on real money holding in line with *a priori* expectations. Just as changes in the Treasury bill rate, foreign deposit rate differential and the inflation rate exert negative impacts on real money holding. These suggest that holders of demand deposits treat Treasury bills, local time deposits, foreign time deposits and real assets as substitutes to demand deposits in the short run.

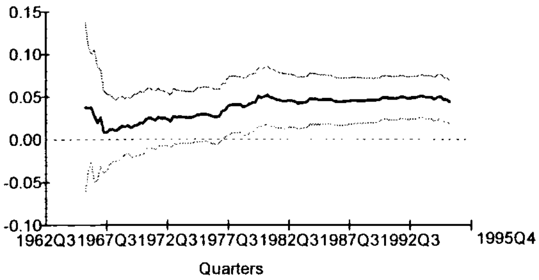


The straight lines represent critical bounds at 5% significance level

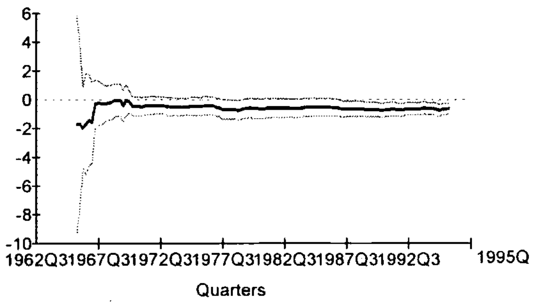


The straight lines represent critical bounds at 5% significance level

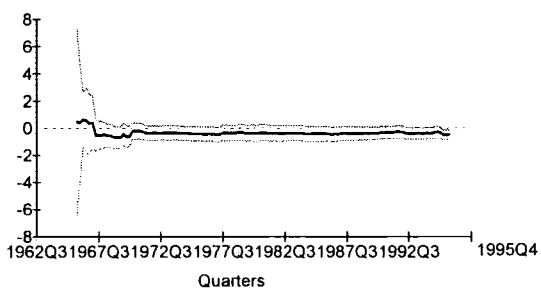
Coef. of CONSTANT and its 2 S.E. bands based on recursive OLS



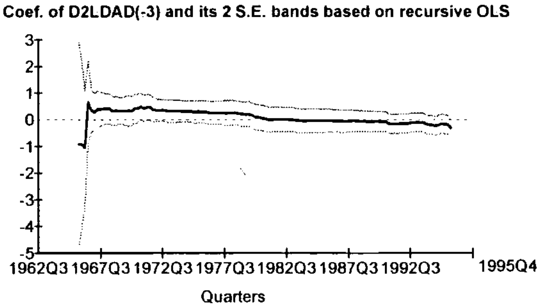
Coef. of DLDAD and its 2 S.E. bands based on recursive OLS



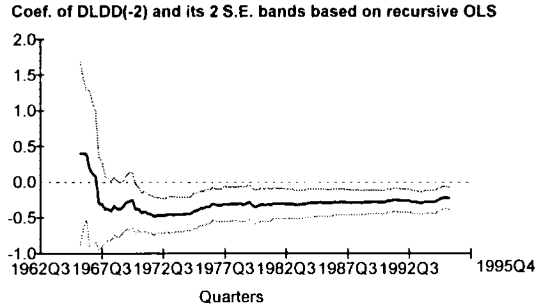
Coef. of D2LDAD and its 2 S.E. bands based on recursive OLS



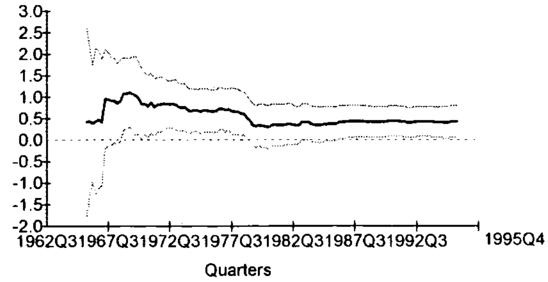
Coef. of D2LDAD(-3) and its 2 S.E. bands based on recursive OLS



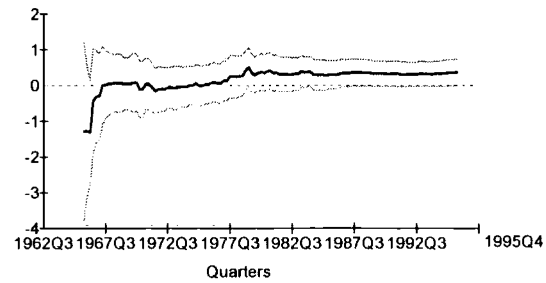
Coef. of DLDD(-2) and its 2 S.E. bands based on recursive OLS



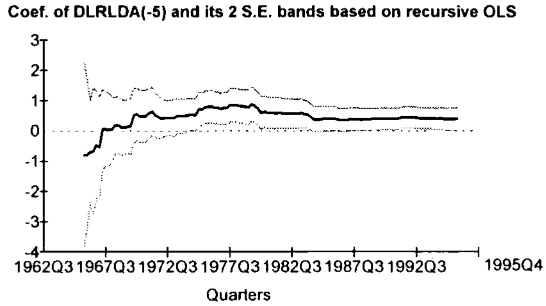
Coef. of DLRLDA(-1) and its 2 S.E. bands based on recursive OLS



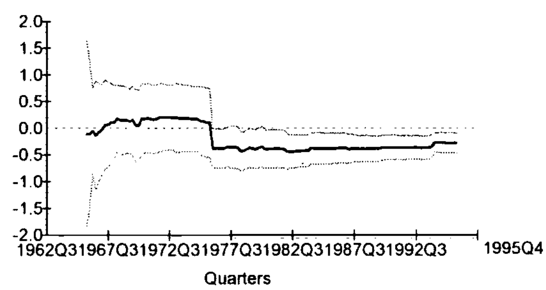
Coef. of DLRLDA(-2) and its 2 S.E. bands based on recursive OLS



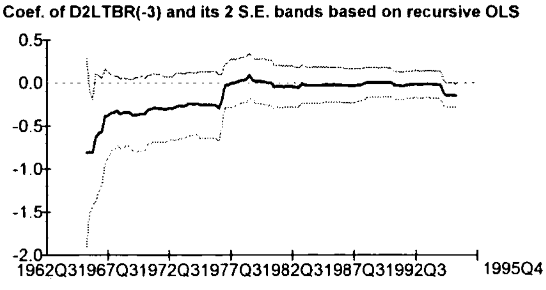
Coef. of DLRLDA(-5) and its 2 S.E. bands based on recursive OLS

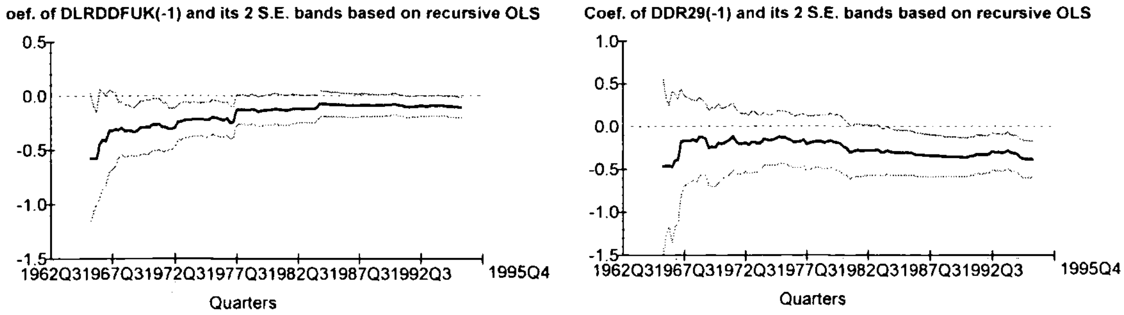


Coef. of DLTBR and its 2 S.E. bands based on recursive OLS



Coef. of D2LTBR(-3) and its 2 S.E. bands based on recursive OLS





As for M1, the short run relation for DD is of course constrained by the fact that in the long run inflation is irrelevant to the decision to hold DD, as summarized in the equilibrium correction term. Details about the long-run elasticity of DD with regard to the two interest-rates are discussed in chapters seven and eight. As such, the issues about time deposits and DD being long run complements and Treasury bills and DD being long-run substitutes will also be discussed in greater detail in Chapter eight.

The final model remains congruent as revealed by the reported diagnostics. The model also exhibits structural stability as revealed by the Chow test (Chow's Structural Stability Test LM $(\chi^2)_{12}$ = 8.8785[0.713]) and plots of Sargan's CUSUM and CUSUMSQ tests. The model also exhibits parameter constancy as revealed by the in-sample predictive stability test (Predictive Failure LM $(\chi^2)_{40}$ = 44.1276[0.301]) and the recursive plots of the estimates of each of the twelve coefficients. Combining the structural stability and parameter constancy of the explanatory variables with the fact that they are weak exogenous (established from the uniqueness of the underlying co-integrating vector) suggests that the model may indeed be useful for drawing policy inferences. This assertion approaches a truism when one recalls the well known fact that both interest rates included in the model have frequently been subjects of official intervention through ceilings and floors from 1970 to 1987, in 1991, and from February 1994 till the end of the sample. The model is therefore suitable for inferences about how demand for DD would respond should there be changes in the explanatory variables.

VII. FURTHER SPECIFICATION SEARCHES

7.1. The Problem

The tendency to treat outside money, inside money and quasi money alike as if they can be explained by the transactions money demand function in extant studies has been noted in Chapter three. This Chapter examines the appropriateness or otherwise of applying the transactions demand framework across the aggregates available for Nigeria. The five aggregates that have been modelled in extant literature are currency outside banks (COB), demand deposits (DD), narrow money (M1= COB+DD), Quasi Money (QM), and Broad Money (M2), which is the sum of M1 and QM. A sixth aggregate that has not been modelled is the monetary base (MB[70]).

In the transactions' framework, the monetary aggregate is assumed endogenous while transaction and opportunity-cost variables are assumed to be at least weakly exogenous. Since the five aggregates are conceptually different, there is little or no reason to expect them to yield results that are sufficiently qualitatively similar to expect the transactions' model to capture the behavior of each and every one. The three basic components of money held by the non-bank public in Nigeria are currency outside banks (COB), demand deposits (DD), and quasi-money (QM). COB is *outside money* injected by government fiat as paper-notes and metal coins. Thus, they are held as private sector asset that does not have any corresponding private sector liability. DD is *inside money* created by the private sector through the interaction of commercial banks and the non-bank public. Thus they are private sector assets with corresponding liabilities in the private sector. Though *Quasi-money* is also inside money, the complication is that it is probably as much

[70] Monetary Base (MB) is the sum of COB and bank reserves (BR). It is quite understandable that this aggregate is not often modelled money demand framework. BR is the sum of cash in the banks' vaults (VC) and the cash reserves (CR) held by the banks with the central bank, modelling MB might conflate demand for money by the non-bank public with demand for reserves by banks. Primary interest in money demand modelling is the behaviour of the non-bank public. Understanding the reserves holding behaviour of banks is more relevant to analysis of money supply processes.

'savings' as it is 'money'. Consequently, how to model it remains an open empirical question: whether we should expect it to behave more like money or more like savings.

Since cash and cheques are both instruments of payment, COB and DD holdings are predominantly driven by the transactions' motive. But the fact that one is outside money and the other is inside money raises the issue of whether we could rightly expect each to respond endogenously to changes in real activity and opportunity costs.

The speculative motive is expected to be a stronger driver of the demand for quasi-money than the transaction's motive. At least the case for modelling it in the transactions' framework is considerably weaker than for COB and DD. As for M1, if COB and DD exhibit different relationships with real activity, the point becomes, which of the two dominates in determining the relationship between M1 and the explanatory variables? For M2, the issue is similarly whether it is M1 or QM that has the dominant attribute.

7.2 Issues

These considerations raise the following important questions:

i. Which of the available aggregates are appropriately modelled within the transactions' demand framework? In other words, which ones do the *cash holding decisions of the non-bank public endogenously determine*?

ii. Which of the available aggregates would be *inappropriate* to model within the transaction's demand framework? Two sub-groups can be identified here:

    - Which of the monetary aggregates are *not endogenous* with regards to real activity? Is it possible to find that some of the aggregates are exogenous for real activity, in line with the large and growing literature on Granger-causality/exogeneity running from money to economic activity[71]. These would be aggregates that are probably *exogenously determined by the monetary policy decisions of the central bank*.

[71] See Caporale et al (1998) and Hayo (1999) respectively for useful summaries of testable hypotheses and alternative testing strategies. Both present interesting results on OECD countries. Azali and Matthews (1999) modelled Malaysian data.

- Is it possible to find some broad monetary aggregates that are also Granger caused by narrow monetary aggregates, such as base money, in line with recent literature on the money multiplier[72]? These would be aggregates that are somewhat *determined by the interaction of banks and the non-bank public*, for any given stock of the narrow aggregates.

Since the objective of this study is to model transactions' demand for money in Nigeria, aggregates that are *more likely to be appropriately modelled within rival approaches* such as the Granger-causality or the money multiplier frameworks[73] *will merely be identified.* We leave the detailed modelling of such for other studies to enable us focus on the task of building interpretable models of transactions' demand for money in Nigeria.

The issues examined in this Chapter can therefore be summarized as follows:

i. Are outside money aggregates like currency outside bank (COB) and monetary base (MB) determined by real activity and interest rates as previous studies implied.
ii. Can the relationship between inside money (demand deposits) and real activity in Nigeria be captured by transactions' demand functions employed in previous studies?
iii. What are the significant qualitative and/or quantitative differences in the relations of outside and inside money aggregates to real activity in Nigeria?
iv. If the two components of narrow money are related to real economic activity in qualitatively and quantitatively different ways, which of the two sub-components has a dominant property when both are added to define M1?
v. Could quasi-money also be explained by a transaction demand function?
vi. What about broad money (M2)?

7.3. Approaches

Since all the relevant variables have been shown to be integrated of order 1, or I (1) in Chapter three, the approach adopted for the specification tests is to check for the presence of a bivariate cointegrating relationships between real activity and each of the six measures of money available.

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[72] Agung and Ford (1999), Ford and Morris (1996), Smant (1998) are some of the very useful applications of the multiplier analysis. Agung and Ford modelled Taiwanese data, while Smant studied the G4 and Netherlands, Ford and Morris used UK data. Nwaobi (1999) is a related reading on Nigeria.

[73] Or the asset demand framework in which the attribute of interest is the store of wealth/store of value function, which numerous other domestic and foreign financial instruments can perform much better than money and quasi-money. Numerous money market and capital market instruments, and even foreign currencies might well be better stores of value. Primary interest in this study is the means of payment function.

The case for adding interest rates to the vector is weakened if cointegration is present in the bivariate relationship, since interest rates are also known to be I (1)[74]. In the absence of bivariate cointegrating relations, we proceed to add interest rates to the vectors and then test for the presence of cointegration. If cointegration is found, the vector is deemed suitable for the transactions' framework.

7.4. Results

Bivariate cointegration with real activity was found in only one of the six cases: monetary base (MB) was cointegrated with real activity. Other measures were not cointegrated with real activity.

Table 7.1: Inverse of the Transactions' velocity of money

	1.	2.	3.	4.	5.	6.
MEASURE:	LRLMB	LRLCOB	LRLDD	LRLQM	LRLM1	LRLM2
	1960Q1-95Q4	1960Q1-95Q4	1960Q1-95Q4	1960Q1-95Q4	1960Q1-95Q4	1960Q1-95Q4
CONSTANT	-15.84*(-27.82)	-12.90*(-27.16)	-22.09*(-33.40)	-22.41*(-27.32)	-16.67*(-30.70)	-17.94*(-30.32)
LRLDA	1.73*(35.14)	1.46*(35.30)	2.26*(39.31)	2.30*(32.31)	1.85*(39.17)	2.0*()38.90
ADJ. R2	0.9053	0.8970	0.9152	0.8794	0.9147	0.9136
SBC	6.7947	18.5290	-29.1091	-60.1075	-0.7280	-13.1377
CRDW	0.5844	0.4221	0.3530	0.1363	0.3329	0.2254
DF (l)	-4.4666(0)	-2.4722(4)	-2.4241(1)	-2.2815(0)	-2.5206(1)	-1.9577(1)
95% DF crit. val.	-3.3860	-3.3811	-3.3811	-3.3811	-3.3811	-3.3811
Cointegrated?	YES	NO	NO	NO	NO	NO

We therefore suggest that it will be inappropriate to model MB in the transactions demand framework. MB might be better suited for Granger causality tests in which the interest is to see if changes in outside money have neutral or non-neutral effects on real activity, size of the impact, length and variability of the impact, etc. Since this aggregate is outside money, we consider these empirical results to be reasonable. Bivariate cointegration with real activity is absent in the remaining five cases (COB, DD, M1, QM, M2). We therefore proceeded to add interest rates to the vectors. COB has no meaningful cointegrating form within the money demand framework. Details of the COB specification searches are provided in Appendix 1. We merely note here that, being outside money, COB, like MB, might be better suited for supply side Granger causality tests[75].

74 Term spreads for Nigerian Treasury bill and time deposit rates are stationary but spreads between interest rates on different assets of the same maturity remain I (1).

75 Ford and Morris (2000) actually used COB as their definition of high-powered money.

We found cointegrating relationships for DD and M1, as already reported in Chapters 5 and 6, but also summarized here in tables 7.2a and 7.2b. It has already been demonstrated in Chapters 5 and 6 that DD and M1 are endogenous in these vectors, not real activity or the interest rates. Since DD is inside money, which is created by the interaction of the non-bank public and private banks, endogeneity seems to be more intuitively plausible, and as such the quantitative evidence made sense.

Table 7.2a: EG-OLS Cointegration Tests Results for DD

	1.
MEASURE:	LRLDD
CONSTANT	-13.70 (-13.32)***
LogRLDA	1.63 (19.92)***
Log[tdr3m/(1+ tdr3m)]	1.21 (7.32)***
Log[tbr/(1+tbr)]	-0.81 (-4.61)***
Log[tdr3m/uktdr3m]	-0.27 (-6.02)***
ADJ. R^2	0.9481
SBC	0.3134
CRDW	0.5501
DF	-4.6398(0)
95% CRIT.VALUE for DF	-4.5177
Cointegrated?	YES

Table 7.2b: EG-OLS Cointegration Tests Results for M1

	1.
MEASURE:	LRLM1
CONSTANT	-11.58 (-13.51)***
LRLDA	1.44 (20.25)***
Log[tdr3m/(1+ tdr3m)]	0.86 (5.77)***
Log[tbr/(1+tbr)]	-0.73 (-4.67)***
ADJ. R^2	0.9366
SBC	16.6325
CRDW	0.4583
DF	-4.2068(0)
95% CRIT.VALUE for DF	-4.1782
Cointegrated?	YES

Chart 7.1a: Savings and Time Deposit (% of Total Bank Deposits)

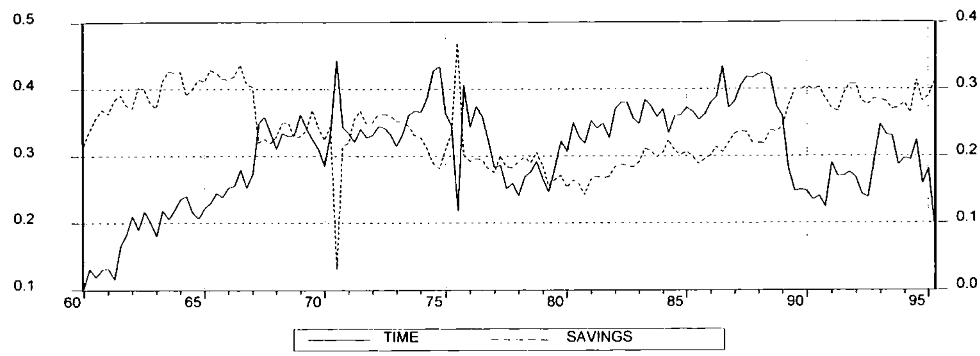
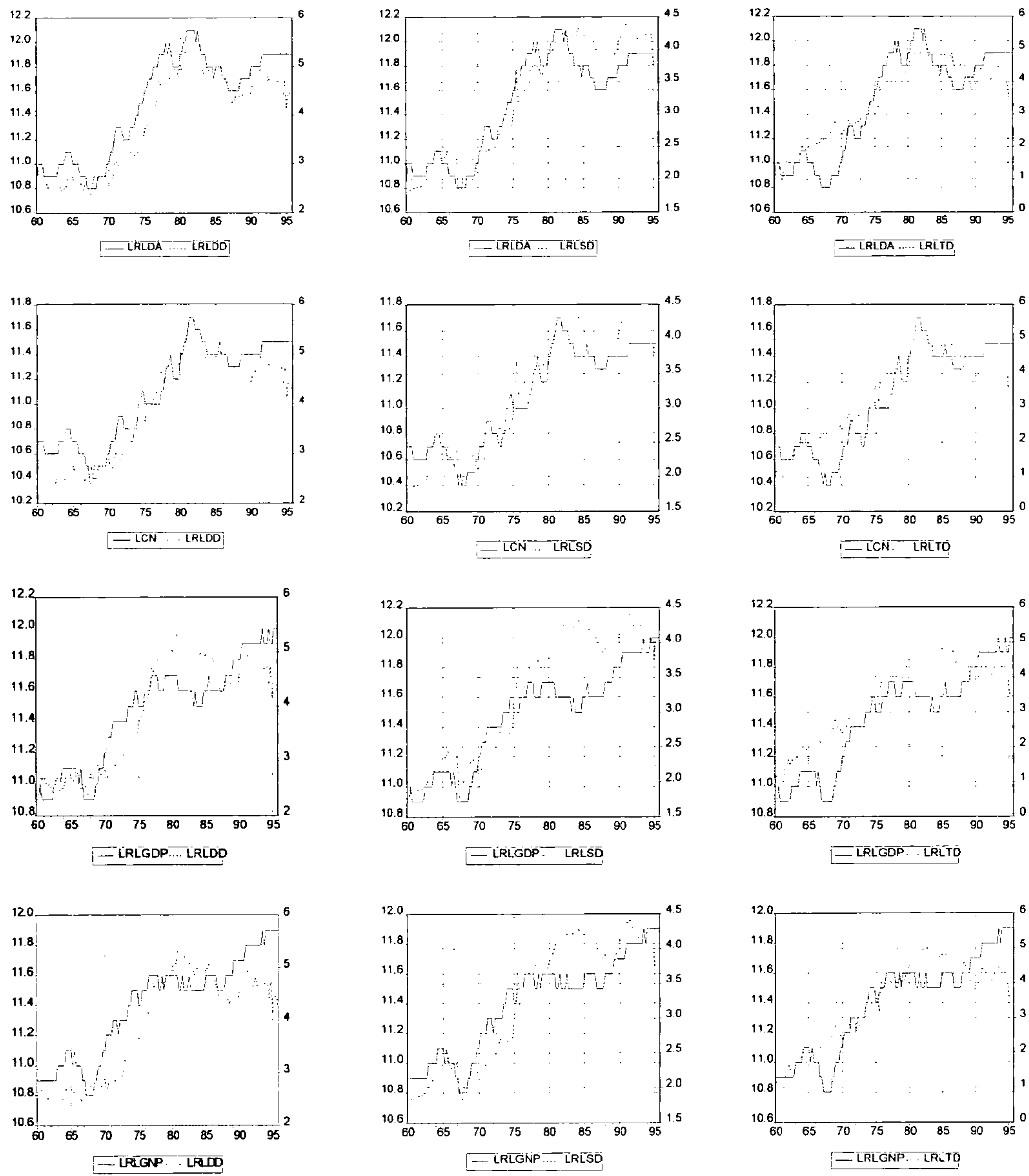


Chart 7.1b



We also note that it appears that the endogeneity property of DD is dominant in M1. This is also intuitively plausible since the private sector can select their currency deposit ratios by adjusting their DD holdings for given levels of COB, thus making M1 endogenous while its other component, COB, could well be exogenous. We therefore conclude that DD and M1 can be appropriately modelled within the transactions demand framework, as Chapters 5 and 6 already made clear.

None of the frameworks seemed capable of explaining QM in Nigeria. As a clue, we suggested that savings and time deposits, the two components of QM, be modelled separately. Chart 7.1a reveals sharp contrasts in the behaviour of the two over most of the sample period, suggesting that adding the two might indeed suppress information about the relationships between each of them and the explanatory variables.

Further, Chart 7.1b plots each of the three deposits (DD, SD, and TD) along with the four proxies for real activity. It seems clear from the first row of the charts that savings deposits, like demand deposits, had a close association with total expenditure (real domestic absorption) over the sample period.

Table 7.3a: Monetary Base as Explanatory Variable in the Money Multiplier Model

	1.	2.	3.	4.	5.
	COB	DD	QM	M1	M2
CONSTANT	7.62(0.02)	1235.1*(3.21)	1617*(3.95)	1244.6*(2.11)	2857.2*(3.29)
MB	0.76*(61.47)	0.80*(52.18)	1.05*(64.20)	1.57*(66.49)	2.62*(75.35)
ADJ. R^2	0.97	0.9548	0.9697	0.9716	0.9778
SBC	-1236.2	-1264.1	-1272.0	-1319.4	-1369.9
CRDW	1.2057	1.4598	1.2072	1.4289	1.3952
DF(I)	-9.6628(2)	-3.0003(3)	-2.9323(2)	-4.9603(2)	-8.0400(0)
95% Crit. val. For DF	-3.3860	-3.3860	-3.3860	-3.3860	-3.3860
Cointegrated?	YES	NO	NO	YES	YES

The same cannot be said about time deposits that seemed to move rather independently of real activity over the sample. It is probable that, once they are added up as QM, time deposits dominate savings deposits, explaining the already noted weak association between QM and real activity. More could well be learnt if the behaviour of each is modelled separately. Whether information is gained or lost by lumping both together as QM will become evident from that line of research. If this line is pursued, meaningful models might be recoverable for one or both of these interest-bearing deposits, with the possibility that the resulting models will provide further clues on how to proceed afterwards[76]. We leave the pursuit of these to future studies. Regression of M2 on base money showed that the two are cointegrated (see Tables 7.3). This suggests that the money multiplier framework might be a more fruitful way of investigating the behaviour of M2. Again, we merely identify this as a possible way of modelling M2, and leave the task of finding out whether meaningful models can be recovered for this aggregate in that setup to future studies.

[76] A likely outcome is that a new aggregate such as M1+ may be defined as the sum of M1 and savings deposits, if savings deposit is found to have meaningful empirical representation as money demand model. It might be possible then to model M1+ even if M2 still does not fit the transactions' demand mould.

The findings of this Chapter can be summed up as in the following Table:

Table 7.4: Empirical Characteristics of the Different Measures of Money

Type of money:	Measured as:	Relation with real activity	Implications
Outside money	MB	• Cointegrated with real activity alone.	• Forecloses the addition of interest rates in transactions' demand for money style. • Raises the possibility of fruitful research on causal relations between MB and real activity.
Outside money	COB	• Not cointegrated with real activity alone. • Addition of interest rates in transactions' demand for money style yielded no fruitful result in Appendix 1.	• Raises the possibility of fruitful research on causal relations between COB and real activity.
nside oney	DD	• DD was not cointegrated with real activity alone. • Introduction of other I (1) variables to obtain transactions' demand style resulted in cointegration.	• Introduction of interest rates resulted in cointegration in both the E-G and JML approaches. • WB-ARDL estimators were used to recover meaningful long run and short run demand for money models.
Narrow money	M1: (Sum of COB and DD)	• M1was not cointegrated with real activity alone. • Introduction other I (1) variables to obtain transactions' demand style resulted in cointegration.	• Introduction of interest rates resulted in cointegration in both the E-G and JML approaches. • WB-ARDL estimators were used to recover meaningful long run and short run demand for money models.
Quasi money	QM: (Sum of Time and savings deposits).	• QM was not cointegrated with real activity. • Addition of interest rates still did not result in cointegration	• Since the two components of QM, time deposits and savings deposits do not necessarily behave in the same way, A fruitful area for further research is to model time and savings deposits separately and see what clues can be derived for modelling QM itself.
Broad money	M2: (Sum of M1 and QM)	• M2 was not cointegrated with real activity. • Addition of interest rates to the vector still did not result in cointegration. • However, M2 was cointegrated with MB, suggesting the empirical plausibility of money multiplier links between base money and M2.	• It seems doubtful that the transaction demand framework is appropriate for M2 demand in Nigeria • Money multiplier model might be a more fruitful way of modelling M2. • Alternatively, an asset demand framework might prove fruitful. • Modelling the two components of QM separately might be a useful prelude to this exercise.

VIII. Interpretation of the Empirical Results

We set out to model non-bank publics' desired holdings of five different measures of money in the Nigerian economy. These are currency outside banks (COB); demand deposits (DD); narrow money (M1); quasi money (QM); broad money (M2). We recovered interpretable empirical money demand models for only two of the five measures: M1 and DD.

No meaningful empirical money demand models could be recovered for COB, QM or M2, although we identified rival modelling frameworks that might be fruitfully explored to model COB and M2 in Nigeria in Chapter seven. We show some initial empirical results, which suggest that fruitful further research is feasible on COB and M2. We however leave detailed modelling within the indicated frameworks to other studies. None of the frameworks seemed capable of explaining QM in Nigeria. Our purpose in this Chapter is to see what lessons might be learnt from a comparison of the qualitative and quantitative attributes of the models recovered for each of M1 and DD in Chapters five and six.

8.1. Qualitative Attributes

The models recovered for M1 and DD conformed to this general specification:

$$\log\left(\frac{m}{p}\right)^{d} = \alpha_0 + \alpha_1 \log y + \alpha_2 \log P + \alpha_3 \log r_m + \alpha_4 \log r + \alpha_5' \log \left(\frac{r}{r_f}\right) + \mu \quad \text{... (8.1)}$$

Only one cointegrating relation was discovered for each of DD and M1 within the above framework. Each of the two cointegrating vectors was found to be unique, with the monetary aggregate being the endogenous variable. As such, the equilibrium and dynamic relations could be estimated within the framework of the auto-regressive distributed lag single-equation error correction modelling (ARDL-SEECM). The full sample EG-OLS and WB-ARDL long run results for DD and M1 are reproduced in Table 8.1. The EG-OLS results reported earlier in Tables 7.2a and 7.2b are reproduced here to facilitate comparison with the ARDL and interpretation of the results. E-G OLS estimates are known to be prone to omitted dynamics bias, as such we are not leaning too strongly on them for interpretation of the results. We present them only for comparative purposes, especially for impressionistic assessment of how the EG-OLS estimates compare with the ARDL estimates. The ARDL approach that corrects the omitted dynamics problem is more demanding on degrees of freedom to be feasible in the split sample estimations.

Table 8.1 Summary of the long-run estimates

		LOG(DD/P)		LOG(M1/P)	
		EG-OLS	ARDL	EG-OLS	ARDL
Constant	$\hat{\alpha}_0$	−13.7 (−13.31)	−14.1 (−7.71)	−11.5 (−14.04)	−14.8 (−6.55)
Log y	$\hat{\alpha}_1$	1.63 (19.91)	1.66 (11.57)	1.44 (21.08)	1.68 (8.94)
Log P	$\hat{\alpha}_2$	...	...	...	...
$\log r^{nig}_{tdr3m}$	$\hat{\alpha}_3$	1.21 (7.31)	1.34 (4.28)	0.88 (6.03)	0.75 (1.67)
$\log r^{nig}_{tbr}$	$\hat{\alpha}_4$	−0.81 (−4.61)	−0.97 (−2.9)	−0.74 (−4.77)	−0.85 (−1.8)
$\log r^{uk}_{tdr3m}$	$\hat{\alpha}_5$	...	...	...	...
$\log\left(\frac{r^{nig}_{tdr3m}}{r^{uk}_{tdr3m}}\right)$	$\hat{\alpha}_5'$	−0.269 (−6.01)	−0.45 (−4.79)	...	...
$\bar{R}^2$		0.94808	0.98634	0.9403	0.9885
σ		0.22550	0.11314	0.1978	0.08577
LL		12.6945	125.6433	30.8487	159.99
SBC		0.26998	29.9958	20.922	84.30
DW		0.55011	1.95	0.46	2.01
T_{JB}, LM $(\chi^2)_2$:		...	1.6073 [0.448]	...	0.6996[0.966]
T_{ARMA}, LM $(\chi^2)_5$		...	3.4875 [0.625]	...	4.8462[0.435]
T_{ARCH}, LM $(\chi^2)_4$		...	1.6579 [0.798]	...	6.6898[0.153]
T_{WHET}, LM $(\chi^2)_1$,		...	0.32372 [0.569]	...	0.0264[0.871]
T_{RESET}, LM $(\chi^2)_1$		...	0.22216 [0.637]	...	0.1269[0.722]

The estimated long-run relation for DD has the form:

$$\log\left(\frac{dd}{p}\right)^{d} = \alpha_0 + \alpha_1 \log y + \alpha_3 \log r_m + \alpha_4 \log r + \alpha_5' \log\left(\frac{r}{r_f}\right) + \mu \quad \ldots \qquad (8.2)$$

That is, $\alpha_4 < 0$, and $\alpha_5' < 0$, and $\left(\frac{r}{r_f}\right)$ is the differential between three month deposit rates in Nigeria and the UK.

The estimated long run relation for M1 has the form:

$$\log\left(\frac{m1}{p}\right)^{d} = \alpha_0 + \alpha_1 \log y + \alpha_3 \log r_m + \alpha_4 \log r + \mu \quad \ldots \qquad (8.3)$$

i.e. $\alpha_4 < 0$, but $\alpha_5' = 0$, where r is the three month Treasury bill rate. $\alpha_2 = 0$ in both cases, suggesting the absence of money illusion in money holding for all the aggregates. It also confirms that it is correct to specify the dependent variable as real-balances, rather than nominal, in both cases.

Also note that the finding that $\alpha_3 > 0$ and $\alpha_4 < 0$ in these vectors imply that both 'own' and 'cross price' effects are significant in both relations. Deletion of any of the two domestic interest rates in the long run models led to loss of the cointegrating relationships. Not only is a meaningful cross rate effect recovered only when the own rate is allowed for, both must be included for cointegration to occur. The main difference between the cointegrating vector for M1 and the one for DD is that $\alpha_5' < 0$ in the DD equation, while $\alpha_5' = 0$ in the M1 equation. Thus, demand deposit is negatively influenced by the difference between local and foreign time deposit rates, while M1 is not.

8.2. Quantitative Attributes

❒ *Additive stability:*

The ARDL estimates of the long run *equations* for both DD and M1 are additively stable. The standard errors of the equations are small and the adjusted R^2 are very high, at approximately 0.99 in both cases. There is therefore relatively low level of uncertainty surrounding the predictability of the money demand shifts.

❒ *Multiplicative stability:*

The long run model for demand deposits however exhibited a much higher degree of multiplicative stability than the one for M1 in the sense that the long run responses of DD to real activity and the three interest rates are all significant at the one percent level. Only the long run response of M1 to real activity is significant at this level; its responses to the two interest rates are only significant at the 10% level[77]. This suggests that policy makers will have a lower level of uncertainty about the long run responses of DD to changes in its determinant than they would have about M1, and may therefore pay a closer attention to what is happening to the demand for DD.

❒ *The long run estimates:*

The results conformed broadly to the general hypotheses under test. The long run transactions' responses of the demand for DD and M1 were as large as 1.6. The estimated long-run responses of both M1 and DD to the scale variable significantly exceeded unity. 1.66 for DD and 1.68 for M1 based on the ARDL estimates. The OLS estimates were 1.63 and 1.44 for DD and M1 respectively. These estimates suggest that both DD and M1 were luxury goods, as there were more than proportionate increases in money holding for every unit change in total transaction.

[77] Another indication of stronger links between DD and interest rates than COB and interest rates.

Both DD and M1 responded positively to the time deposit rate and negatively to Treasury bill rate. This suggests substitutability between Treasury bills and money, and complementarity between time deposits and money in Nigeria[78].

DD responded negatively to the foreign interest differential. This corroborates the fact that foreign interest-differential explains the high increase in the outflow of cross border inter-bank deposits relative to inflow.

Table 8.2: Long-run Elasticities from Previous studies of demand for DD and M1 in Nigeria

S/N	STUDY	MODEL	η_Y	η_P	η_{RG}	η_{RD}	η_{RF}	η_E	
DD									
1.	Teriba (1974)	Static OLS and PA	2.057(1.97)		0.75(0.46)	-0.70(-0.73)			R2=0.900; Dw=1.96

S/N	STUDY	MODEL	η_Y	η_P	η_π	η_{RD}	η_{RF}	η_E	
M1									
1.	Tomori(1972)	Static OLS	2.07(0.49)			-0.038(-1.19)			R^2=0.829
2.	Teriba (1974)	Static OLS	0.389(2.45)			-0.259(-0.56)			R2=0.9060; SE=0.1347
3.	Ojo (1974a, b)	Static OLS	0.44(0.29)		-1.07(0.70)				R2=0.953; DW=0.95
4.	Ajayi(1974)	Static OLS	0.14(2.10)			0.0039(0.25)			R2=0.807; DW=1.709
5.	Iyoha (1976)	Static OLS	0.027(0.71)			-4.09(-0.7)			R2=0.97; DW=0.77
6.	Fakiyesi (1979)	Static OLS	1.14(0.11)	1.54(0.3)					R2=0.98; DW=2.141 F=1769
7.	Arize et al. (1990)	PA	0.23(3.11)		0.10(0.15)		-0.001(1.4)		R2=0.97; SE=0.12
8.	Oresotu & Mordi (1992)	PA	1.86(5.9)		-0.016(1.8)	-0.019(1.19)		0.009(1.88)	R^2=0.9762; SE=0.0424; F=199.642; DW=1.701
9.	Arrau et. al. (1995)	Static OLS	0.19(1.15)		-0.89(-1.50)				R2=0.17; DW=0.63
10.	Hassan et al. (1995)	PA	1.73(2.04)		-0.011(-3.04)			-0.34(-8.76)	R2=0.68; SSE=2.12; F=109.08
11.	Moser (1997)	E-G	1.05(0.12)			-0.01(0.00)		-0.36(0.04)	

[78] An alternative pursued was to substitute the spread for the two domestic rates in the regressions in Table 8.1. Doing this imposes an equality restriction on the coefficients of the two domestic rates. This often led to a loss of cointegration and non-nested tests showed that the reported unrestricted alternative is better. While the regression for M1 was cointegrated, with a positive sign on the spread, the regression for DD was not cointegrated with a negative sign on the coefficient of the spread. The point that must not be lost is that such a restricted specification will be inappropriate in an environment that is prone to regime shifts in credit markets. The unrestricted model will be more robust to such regime shifts.

Table 8.2 presents a summary of the long run elasticities from the demand for DD and M1 in previous studies on Nigeria. Teriba (1974) is the only previous attempt at modelling demand deposit in Nigeria. Using a double log specification and static-OLS method with annual data for 1958-1972 sample period, the explanatory variables in the study were GNP, GNP deflator, rates on long-term bond, treasury bills, time deposit and savings deposit. The study documented the high income-elasticity of demand deposits in Nigeria. The long run income elasticity of DD was approximately 2. The study also established roles for both treasury bills and deposit rates as the relevant domestic opportunity costs in the demand deposit model for Nigeria, with the two rates having opposite signs. The interest elasticity of DD was 0.75 for the treasury bills rate and -0.71 for the deposit rate. While the income elasticity was significant, the interest rates were not statistically significant. There have been eleven previous studies on the demand for M1 in Nigeria. Long-run income elasticity of M1 had ranged from 0.0266 to 2.07. Six of the studies found roles for the domestic interest rate, while the remaining five used the rate of inflation. The interest elasticity of M1 has tended to be negative with values and less than unity, with a couple of exceptions. Arize et al (1990) found foreign interest rate to be inversely related to the demand for M1, while about three other authors found roles for devaluation with mixed results.

❒ *Dynamic stability:*

The equations for both DD and M1 are dynamically stable, given the fact that these ARDL estimates are for cointegrated vectors.

$$\Delta\log\left(\frac{\hat{dd}}{P}\right) = \underset{(3.44)}{0.04} - \underset{(-3.2)}{0.6}\,\Delta\log P_t - \underset{(-2.8)}{0.49}\,\Delta^2\log P_t - \underset{(-2.18)}{0.31}\,\Delta^2\log P_{t-3}$$

$$+\underset{(2.35)}{0.43}\,\Delta\log y_{t-1} + \underset{(2.01)}{0.37}\,\Delta\log y_{t-2} + \underset{(2.2)}{0.4}\,\Delta\log y_{t-5}$$

$$-\underset{(-2.9)}{0.27}\,\Delta\log(r^{nig}_{tbr})_t - \underset{(-2.18)}{0.15}\,\Delta^2\log(r^{nig}_{tbr})_{t-3} - \underset{(-2.34)}{0.1}\,\Delta\log\left(\frac{r^{nig}_{tdr3m}}{r^{uk}_{tdr3m}}\right)_{t-1}$$

$$-\underset{(2.9)}{0.23}\,\Delta\log dd_{t-2} - \underset{(-3.57)}{0.38}\,ECT \qquad \ldots (8.4)$$

$\bar{R}^2$ =0.45; σ=0.10799; LL=114.391; AIC=102.391; SBC =85.0039; DW=1.9869;

T_{JB}, LM $(\chi^2)_2$: 0.27324 [0.872]; T_{ARMA}, LM $(\chi^2)_5$: 4.4824 [0.482]; T_{ARCH}, LM $(\chi^2)_4$: 1.9777 [0.740];

T_{WHET}, LM $(\chi^2)_1$,: 0.074409 [0.785]; T_{RESET}, LM $(\chi^2)_1$: 0.18304 [0.669];

Predictive Failure LM $(\chi^2)_{40}$: 44.1276 [0.301];

Chow's Structural Stability LM $(\chi^2)_{12}$: 8.8787 [0.713]

$$\Delta\log\left(\frac{\hat{m}1}{P}\right) = -\underset{(-8.2)}{0.8}\,\Delta\log P_t + \underset{(3.06)}{0.47}\{\Delta\log y_{t-1} - \Delta\log y_{t-4}\} + \underset{(5.15)}{1.0}\,\Delta^2\log y_{t-5}$$

$$-\underset{(-4.38)}{0.23}\,\Delta^2\log(r^{nig}_{tdr3m})_{t-6} - \underset{(-5.16)}{0.23}\{\Delta\log(r^{nig}_{tbr})_{t-3} - \Delta\log(r^{nig}_{tbr})_{t-4}\}$$

$$+\underset{(4.8)}{0.4}\,\Delta\log ml_{t-1} + \underset{(5.8)}{0.36}\,\Delta\log ml_{t-4} - \underset{(-5.59)}{0.56}\,ECT \qquad \ldots (8.5)$$

$\bar{R}^2$ =0.6190; σ=0.0719; LL=167.9; AIC=159.9;SBC =148.03; DW=1.84;

T_{JB}, LM $(\chi^2)_2$:=0.9242[0.630] T_{ARMA}, LM $(\chi^2)_5$=6.8332[0.233]; T_{ARCH}, LM $(\chi^2)_4$=5.0748[0.280];

T_{WHET}, LM $(\chi^2)_1$,=0.0060[0.938]; T_{RESET}, LM $(\chi^2)_1$=0.0105[0.918]; Predictive Failure LM $(\chi^2)_{40}$=49.4112[0.146];

Chow's Structural Stability LM $(\chi^2)_8$=6.2365[0.621].

The dynamic stability of both models is further confirmed by the WB-ECM reported in equations 8.4 and 8.5[79]. Equation 8.5 (for ΔM1) however has a better explanatory power, i.e., more additively stable, than equation 8.4 (for ΔDD). This means that there is a lower

79 ΔlogP and ΔlogM are entered separately with the same lags in these regressions. The restriction of zero price elasticity of real balances applicable to unobserved 'desired' money stock, does not necessarily apply to the observed change in the log of nominal money stock, ΔlogM. Once Δlog P is included, using either Δlog (M/P) or ΔlogM on the r.h.s produces similar initial models. But this choice implies different dynamic adjustment paths. Using ΔlogM rather than Δlog(M/P) is the correct thing to do as it also enables us to isolate the impact of observable changes in the nominal money stock on the 'unobservable' changes in desired holdings of real-balances being modelled.

level of uncertainty about the dynamic adjustment of ΔM1 compared to ΔDD, in spite of the fact that the equilibrium estimates of DD are more predictable than that of M1.

Thus if policy makers are interested in understanding the short-run adjustment of money holding, they will be better off relying on the ΔM1 model. But if what they care about are the long run responses, the ΔDD model reveals more. These assertions derive from the fact that the dynamic model for ΔM1 has higher levels of additive and multiplicative stability than the ΔDD model. The adjusted R^2 for M1 ECM is much higher, about 0.62, compared to 0.45 for DD ECM. All the eight coefficients in the M1 ECM are significant at the 1% level, while only five of the 12 coefficients in the DD ECM are significant at this level, the remaining seven are however still significant at the 5% level. The speed of adjustment of M1 back to equilibrium is faster and also less uncertain than for DD going by the coefficient of the error-correction term (ECT) of -0.56 with a t-ratio of about 5.6 for Δ(M1/DAD), compared with -0.38 and t-ratio of about 3.6 for Δ(DD/DAD). Thus while M1 will readjust to equilibrium in a little over five months (less than two quarters), it will take nearly eight months (close to three quarters) for DD to do the same. Finally M1 model has the added advantage of combining all these strong attributes of stability and dynamic reliability, which makes the model especially suitable for policy inferences, with the absence of reverse causation from the dependent variable to any of its explanatory variables. Which means that policy makers have the added luxury of being able to rely on the M1 model for out of sample forecasting. DD model is ill suited to forecasting because of reverse Granger causality from DD to real activity.

The foregoing goes to indicate that adjustment of the currency-deposit ratio (within M1) through adjustments in DD holdings, is the main way in which money holders accommodate exogenous changes in COB, making the M1 error-correction model capture more of the dynamic adjustments than DD. If we are concerned with what happens in equilibrium, when all the adjustments are complete, however, the DD model however remains the more reliable guide.

❒ *Structural Invariance/Parameter Constancy*

Models for DD and M1 have both been demonstrated in chapters five and six to be the structurally stable with constant underlying parameters. The models could therefore be useful for drawing policy inferences about how demand for DD and M1 would respond should there be changes in the explanatory variables.

IX. STYLIZED FACTS ABOUT MONEY DEMAND IN NIGERIA

This Chapter concludes the thesis by summing up the answers to the questions posed in Chapter one as the stylized facts on transactions' demand for money in Nigeria.

Q1. *For which of the six monetary aggregates* in Nigeria can the assumed long run equilibrium relationship between the variables in the transaction demand framework be shown to exist?

Ans. 1. The assumed long run equilibrium relations were established to hold for only two of the six monetary aggregates available for Nigeria: inside money (DD) and narrow money (M1). These are presented in Chapters five to eight.

The relations did not hold for outside money: currency outside banks (COB) and Base Money (BM). Base money had a bivariate cointegrating relation with real activity, and seem better suited for granger causality tests from money to real economic activity. COB had no bivariate equilibrium relationship with real activity, but did not fit into the transactions demand mould either. Appendix 1 provides details of the behaviour of COB.

The assumed relations also did not hold for quasi-money (QM). We noted marked differences in the behavior of the two components of QM, savings deposit and time deposits, and suggested that these be modelled separately first. The results from that stage should give some clues on how to proceed with the modelling of interest bearing bank deposits in Nigeria.

By extension, the assumed relations did not hold for broad money (M2). We however identified the money multiplier approach as a potentially useful way of modelling M2. Since banks also have a role in the determination of M2, apart from the non-bank public, this role could possibly be accounted for within the money multiplier approach.

Q2. *Are domestic interest rates informative in Nigeria?*

Ans. 2. The evidence presented in Chapter four demonstrates that domestic interest rates are about as informative on future growth in real activity in Nigeria as they have been shown to be elsewhere. From the results in Chapters five and six, especially Section 5.1, domestic interest rates clearly play the hypothesized role in money demand models in Nigeria.

Q3. *If the assumed equilibrium relationships did in fact exist in Nigeria, among which alternative measures of the variables do they exist, given the proliferation of proxies for transactions, the price level, and opportunity cost variables?*

Ans. 3. The assumed relations hold among money, total domestic expenditure, its deflator and two domestic interest rates, and, only in the case of DD, the domestic-foreign deposit rate differential. The two domestic interest rates that entered the relations were the three-month time deposit rate and the Treasury bill rate. The time deposit rate mimicked the 'own rate' of money in the equation, while the treasury bills rate captured the domestic 'cross-price effect', representing the domestic opportunity cost of money holding[80]. Deletion of any of the two domestic interest rates in the long run models led to loss of the cointegrating relationships. Not only is a meaningful cross rate effect recovered only when the own rate is allowed for, both must be included for cointegration to occur. We therefore documented significant 'own' and 'cross price' effects in the long run relations. On the contrary, the rate of inflation, which has been favoured over interest-rates by some authors, had no place in the long run demand for money models recovered in this study. Depreciation of the exchange rate also plays no role whatsoever in models. Rather, it is foreign interest rate differential

[80] See Klein (1974).

that exerts a significant influence of demand for deposits in Nigeria, suggestive of the presence of portfolio substitution effects rather than currency substitution effects.

Q4. *What are the signs, magnitudes and other characteristics of the long run responses of money demand to its determinants over the full sample and the sub-samples? What is the structure of the dynamic adjustment and how fast is the speed with which the relationships converge back to equilibrium following a shock? What are the implications of the findings for monetary policy?*

Ans. 4. The results conformed broadly to the general hypotheses under test .The long run transactions' responses of the demand for DD and M1 were as large as 1.6. The estimated long-run responses of both M1 and DD to the scale variable significantly exceeded unity. 1.66 for DD and 1.68 for M1 based on the ARDL estimates. The OLS estimates were 1.63 and 1.44 for DD and M1 respectively. These estimates suggest that both DD and M1 were luxury goods, as there were more than proportionate increases in money holding for every unit change in total transaction. Both DD and M1 responded positively to the time deposit rate and negatively to Treasury bill rate. This suggests substitutability between Treasury bills and money, and complementarity between time deposits and money in Nigeria. DD responded negatively to the foreign interest differential. This corroborates the fact that the foreign interest-differential explains the high outflow of cross border inter-bank deposits relative to inflow. M1 was not influenced by the differential at all.

The long-run *equations* for both DD and M1 are additively stable. As such, policy makers' have a low level of uncertainty about the shifts in money demand functions for both M1 and M2. Policy makers will however have a lower level of uncertainty about the long run responses of DD to changes in its determinant than they would have about M1. The long run model for demand deposits however exhibited a much higher degree of multiplicative stability than the one for M1 in the sense that the long run responses of DD to real activity and the three interest rates are all significant at the one percent level. Only the long run response of M1 to real activity is significant at this level; its responses to the two interest rates are only significant at the 10% level. In the short-run, while both models remain stable, the level of uncertainty is higher for DD than for M1. In the short run, the higher additive and multiplicative stability of ΔM1 model than the ΔDD model means that there is a lower level of uncertainty about the dynamic adjustment of ΔM1 compared to that of ΔDD. This is in spite of the fact that the equilibrium estimates of DD are more predictable than that of M1. Thus if policy makers are interested in understanding the short-run adjustment of money holding, they will be better off relying on the ΔM1 model. But if what they care about are the long run responses, the DD model reveals more. The speed of adjustment of M1 back to equilibrium is also faster and less uncertain than the one for DD. Finally, M1 model has the added advantage of combining all these strong attributes of stability and dynamic reliability, which makes the model especially suitable for policy inferences, with the absence of reverse causation from the dependent variable to any of its explanatory variables. Which means that policy makers have the added luxury of being able to rely on the M1 model for out of sample forecasting. DD model is ill suited to forecasting because of reverse Granger causality from DD to real activity. The foregoing goes to confirm that adjustment of the currency-deposit ratio (within M1) through adjustments in DD holding, is the main way in which money holders accommodate exogenous changes in COB. This makes the M1 error-correction model capture more of the dynamic adjustments than DD. With respect to what happens in equilibrium once all the adjustments are completed, the DD model however remains the more reliable guide. Having noted the long run and short run tradeoffs that the two models present for policy makers, it must be stated that both models will be useful for drawing such policy inferences about how demand for DD and M1 would respond should there be changes in the explanatory variables. This is because both exhibit structural stability and parameter constancy in the face of major regime shifts in the individual variables and government policies.

Q5. *Finally, in what directions would further research be useful?*

Ans. 5. This study is only able to uncover some of the main attributes of demand for inside money (DD) and narrow money (M1) using the transactions' demand framework for 1960Q1-1995Q4.

We have demonstrated that the transactions' framework is ill suited for modelling outside money (currency outside banks and the monetary base inclusive). We suggested tests of the causal links from outside money to real activity as a more appropriate framework that other studies might wish to use for exploring the relationship between outside money and real activity in Nigeria.

We are unable to make any categorical statement on Quasi-money, as it is clear that its two components, savings deposits and time deposits, are sufficiently dissimilar in their evolution over the sample period to weaken the case for summing them up to define QM. Information about the relationship of the two interest bearing deposits with real activity and interest rates is most likely suppressed in the process of summing them. The two often moved in opposite directions, such that summing them would weaken the relationships between the sum and the explanatory variables in a transactions' demand for money model.

This appeared to be the problem with QM, and by extension, M2. We suggest that future studies should consider modelling savings and time deposits separately. It might well be that one of them (probably savings deposit) could be fruitfully analyzed within the transactions' demand framework, in which case it could be added to M1 to define M1+ as the broadest aggregate that is primarily driven by the transactions' motive. Policy makers will benefit from an understanding of the long and short run properties of such an aggregate. The other component (probably time deposit) might be more appropriately modelled in a portfolio demand framework by future studies, if the speculative motive dominates the holdings of this type of deposit.

But that will still not answer the question posed by Buiter and Armstrong (1978) about whether it will be useful to go on and sum the transactions demand function with the speculative demand function and expect to get a well behaved empirical model for total money demand in the economy. As the areas identified for further research on the components of quasi-money are likely to define a medium to long term research on money demand in Nigeria, we have also suggested that other studies can use the money multiplier approach to gain an understanding of M2 in the near term.

APPENDIX 1: DEMAND FOR CURRENCY OUTSIDE BANK

A2.1. E-G RESULTS FOR CURRENCY OUTSIDE BANK (COB)

For the 1960Q1-1995Q4-sample period, Engle-Granger static OLS specification search uncovered a four-variable *near co-integrating vector* for real-COB as follows:

$$\frac{COB^d}{p} = f(y, r_{qm}^{nig}, r_{tbr}^{nig}) \tag{A2.1}$$

Where,

COB^d = desired nominal stock of Currency Outside Bank (equals actual only in equilibrium)

P = general price level;

y = real expenditure;

r_{qm}^{nig} = Rate on quasi-money in Nigeria;

r_{tbr}^{nig} = Rate on Treasury bills in Nigeria;

The double logarithmic form of (6.1) is:

$$\log\left(\frac{COB^d}{P}\right) = \alpha_0 + \alpha_1\log + y\ \alpha_3\log r_{qm}^{nig} + \alpha_4\log r_{tbr}^{nig} + \mu \tag{A2.2}$$

The estimated equation is:

$$\log\left(\frac{COB}{p}\right) = \underset{(-11.86)}{-9.07} + \underset{(18.33)}{1.17}\log\left(\frac{y}{p}\right) + \underset{(3.84)}{0.51}\log r_{tdr3m}^{nig} - \underset{(-2.54)}{0.36}\log r_{tbr}^{nig} \tag{A2.3}$$ [81]

Adj. R^2=0.9202; CRDW=0.54; F-ratio=550.5[0.00]; σ=0.1822; LL=42.88; SBC=32.94; T=144[19601-95IV]; N=4; ADF [i], (i=0 ... 4)=-3.1053[4]; ADF 95% critical value=-4.1784[82].

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[81] Figures in parentheses are t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. The reader should note that, '*' signifies 10% level of significance; '**', 5%; and '***', 1%. Also, '-' implies the corresponding variable(s) not included. σ = Standard error of regression; LL = Maximum of Log-likelihood; T = Number of observations; N= The number of series for which the null of no-co-integration is being tested. The 95% critical values for the ADF_i statistics, [*i*] *(i=0 ... 4)*, where *i* is the number of lags in the ADF regressions, depend on both T and N based on the response surface estimates given by MacKinnon (1991). The specific number of lags used in each case is indicated in brackets. Again, '**', indicates 95% level of confidence in rejecting the null of no co-integration by the ADF statistic.

TABLE A2a: SELECTING THE ORDER OF THE VAR MODEL

Test Statistics and Choice Criteria for Selecting the Order of the VAR Model are based on 136 observations from 1995Q4. Lag length used for testing is VAR=8. List of variables included in the unrestricted VAR: LOG (COB/DAD), LOG(RLDA), LOG(TDR3M), and LOG(TBR). List of deterministic and/or exogenous variables: CONSTANT		
Order of Lag in the VAR(p)	AIC	SBC
p =0	-14.3216	-20.1469
p =1	**624.2652** ***	**595.1386** ***
p =2	614.8718	562.4440
p =3	608.0887	532.3597
p =4	608.2063	509.1761
p =5	611.3433	489.0117
p =6	605.7546	460.1219
p =7	600.9690	432.0351
p =8	597.5597	405.3245

AIC=Akaike Information Criteria; and, SBC=Schwarz Bayesian Criterion.

TABLEA2b: DETERMINISTIC COMPONENTS IN THE COINTEGRATING RELATIONS

Assumptions	AIC	SBC	HQC
Case 1: No intercept, and no deterministic trends in the VAR	638.1180 (r=1)	**630.6935 (r=0)**	633.9041 (r=1)
Case 2: **Restricted intercept, and no deterministic trends in VAR*** **	646.7851 (r=2)	**630.6935 (r=0)**	**638.3574*** (r=2)**
Case 3: Unrestricted intercept, and no deterministic trends in VAR	646.6824 (r=2)	624.6417 (r=1)	637.0508 (r=2)
Case 4: Unrestricted intercept, and restricted deterministic trends in VAR	**647.4111 (r=4)**	623.5342 (r=0)	635.1820 (r=2)
Case5: Unrestricted intercept and deterministic trend in VAR	**647.4111 (r=4)**	616.3738 (r=1)	632.9636 (r=4)

AIC=Akaike Information Criteria; SBC=Schwarz Bayesian Criterion, HQC=Hannan-Quin Criterion.

TABLE A2c: LR TEST BASED ON MAXIMAL EIGENVALUE OF THE STOCHASTIC MATRIX

NULL	*ALTERNATIVE*	*STATISTIC*	*95%CRITICAL VALUE*	*90% CRITICAL VALUE*
R=0	r≥1**	36.96	27.4200	24.9900
r≤1	r≥2*	21.4901	21.1200	19.0200
r≤2	r≥3	5.0151	14.8800	12.9800
r≤3	r≥4	1.6407	8.0700	6.5000

Given this vector, a stable long-run relation between desired real-COB balances and the three variables: real activity (domestic absorption) and two nominal interest-rates (time deposit and Treasury bill rates) cannot yet be said to exist or not. The earlier noted tendency of the EG tests to reject cointegration in cases where one exists explains this.

[82] The values of the three information criteria (AIC, SBC, and HQC) computed along with the ADF tests suggest lag four as the optimal lag for the ADF tests (as the AIC, SBC, and HQC values are all maximized at lag four). The statistic suggests no co-integration at this lag. However, there is evidence of co-integration

TABLE A2d: LR TEST BASED ON TRACE OF THE STOCHASTIC MATRIX

NULL	*ALTERNATIVE*	*STATISTIC*	*95%CRITICAL VALUE*	*90% CRITICAL VALUE*
R=0	r≥1**	65.1010	48.8800	45.7000
R≤1**	r≥2	28.145931	31.5400	28.7800
r≤2	r≥3	6.6558	17.86002	15.7500
r≤3	r≥4	1.6407	8.07009	6.5000

TABLE A2e: ESTIMATED AND NORMALIZED CO-INTEGRATED VECTORS

VECTOR	*ESTIMATE*	*NORMALIZED*
LOG(COB/DAD)	0.44204	-1.0000
LOG(RLDA)	-0.51567	1.1665
LOG(TDR3M/(1+TDR3M))	-0.33745	0.76339
LOG(TBR/(1+TBR))	0.31652	-0.71603

TABLE A2f: ECM FOR VARIABLE LOG(DD/DAD)

Dependent Variable: Δ Log(DD/DAD)		
Regressor	Coefficient	T-Ratio[Prob.]
Intercept	-2.7923	-6.0663[.000]
Ecm(-1)	-0.67681	-6.0895[.000]
R^2 = 0.20823; $\overline{R}^2$ = 0.20262; σ = 0.11114; DW = 2.1208; Equation Log-Likelihood = 112.261; SBC = 107.2986; Residuals serial correlation, LM$(\chi^2)_4$ = 23.2511 (0.000)*; RESET functional form LM$(\chi^2)_1$ = 5.7564 (0.016); Jarque-Bera error non-normality LM$(\chi^2)_2$ =18.3999 (0.000)*; Heteroscedasticity LM$(\chi^2)_1$ =0.96805 (0325);		

Further investigation within the JML framework is needed to clarify this. As before, the JML tests are preceded by a test for the optimal order of the VAR, conducted in the context of an unrestricted VAR model with eight lags.

From Table A2a, both AIC and SBC suggest the optimal order of this VAR is 1. Hence, the test for co-integration is based on a VAR of order 1.

Co-integration is tested with unrestricted intercepts and no trends in the underlying VAR. 143 observations from 1960Q2 to 1995Q4 were used with a VAR of order 1. The

at lag zero (ADF [0]=-4.7496), but this lag is not indicated at the optimal lag by any of the three information criteria.

list of variables included in the vector is: LOG(COB/DAD), LOG(RLDA), LOG(TDR3M), and LOG(TBR), and INTERCEPT.

Using a VAR (1) the maximal eigenvalue of the stochastic matrix of the JML test suggests that the null of r = 0 cannot be rejected in favour of the alternative hypothesis of the rank of the non cointegrating vector being equal to one at the 95% level of confidence. The hypothesis that r = 2 can equally not be rejected on the basis of the maximal eigenvalue at both the 95% and 90% levels of sifgnificance.

However the evaluation of the hypotheses that r equals 0, 1, or 2 based on the trace of the stochastic matrix rejects rank of 0 and 2 in favour of rank of 1 at both 95 and 90% levels of significance. We therefore work on the assumption that there is only one cointegrating vector, details of which are as follows:

Again, like the E-G results, the ARDL estimates for COB are far from satisfactory. As many as 17 quarters lag were required, compared to only eight or nine quarters in the models for M1 and DD. The diagnostic tests also reveal auto-correlated and ARCH errors.

TABLE A2g: Full ARDL Model for Log(COB/DAD)

VARIABLES	ESTIMATED COEFFICIENTS
Constant	-2.3972 (-2.7103)
$Log(COB/DAD)_{t-1}$	0.70612 (6.5266)*
$Log(COB/DAD)_{t-2}$	0.12803 (0.95941)
$Log(COB/DAD)_{t-3}$	-0.17641 (-1.3002)
$Log(COB/DAD)_{t-4}$	0.045084 (0.3317)***
$Log(COB/DAD)_{t-5}$	-0.14848 (-1.0557)
$Log(COB/DAD)_{t-6}$	0.18411 (1.2628)
$Log(COB/DAD)_{t-7}$	-0.091314 (-0.6234)
$Log(COB/DAD)_{t-8}$	0.36000 (2.4528)
$Log(COB/DAD)_{t-9}$	-0.17010 (-1.1492)
$Log(COB/DAD)_{t-10}$	-0.21423 (-1.4722)
$Log(COB/DAD)_{t-11}$	0.16385 (1.1250)
$Log(COB/DAD)_{t-12}$	0.12795 (0.8580)
$Log(COB/DAD)_{t-13}$	-0.17718 (-1.1739)
$Log(COB/DAD)_{t-14}$	-0.16410 (-1.0845)
$Log(COB/DAD)_{t-15}$	0.15238 (1.0295)
$Log(COB/DAD)_{t-16}$	0.18161 (1.2226)
$Log(COB/DAD)_{t-17}$	-0.21979 (-2.0959)
$Log(RLDA)_{t}$	0.18795 (0.9682)
$Log(RLDA)_{t-1}$	0.14536 (0.5647)
$Log(RLDA)_{t-2}$	0.037839 (0.1458)
$Log(RLDA)_{t-3}$	0.025882 (0.1024)
$Log(RLDA)_{t-4}$	-0.17081 (-0.70431
$Log(RLDA)_{t-5}$	0.087896 (0.4288)
$Log[tdr3m/(1+tdr3m)]_{t}$	-0.013052 (-0.0760)
$Log[tdr3m/(1+tdr3m)]_{t-1}$	0.24191 (1.1397)
$Log[tdr3m/(1+tdr3m)]_{t-2}$	-0.042997 (-0.1946)
$Log[tdr3m/(1+tdr3m)]_{t-3}$	-0.24525 (-1.1173)
$Log[tdr3m/(1+tdr3m)]_{t-4}$	0.13993 (0.6614)
$Log[tdr3m/(1+tdr3m)]_{t-5}$	0.24379 (1.3753)
$Log[tbr/(1+tbr)]_{t}$	-0.039650 (-0.2623)
$Log[tbr/(1+tbr)]_{t-1}$	-0.18244 (-1.0631)
$Log[tbr/(1+tbr)]_{t-2}$	0.025010 (0.1432)
$Log[tbr/(1+tbr)]_{t-3}$	-0.096983 (-0.5432)
$Log[tbr/(1+tbr)]_{t-4}$	0.44612 (2.5360)
$Log[tbr/(1+tbr)]_{t-5}$	-0.24090 (-1.3816)
$Log[tbr/(1+tbr)]_{t-6}$	-0.14002 (-1.0281)
$Log[tbr/(1+tbr)]_{t-7}$	-0.20160 (-1.4765)
$Log[tbr/(1+tbr)]_{t-8}$	0.043657 (0.9576)
$Log[tbr/(1+tbr)]_{t-9}$	0.17777 (1.0728)
$Log[tbr/(1+tbr)]_{t-10}$	0.063470 (0.3626)
$Log[tbr/(1+tbr)]_{t-11}$	0.032767 (0.1864)
$Log[tbr/(1+tbr)]_{t-12}$	-0.12410 (-0.7077)
$Log[tbr/(1+tbr)]_{t-13}$	-0.029387 (-0.1766)
$Log[tbr/(1+tbr)]_{t-14}$	0.17048 (1.1032)
$Log[tbr/(1+tbr)]_{t-15}$	0.022557 (0.1551)
$Log[tbr/(1+tbr)]_{t-16}$	-0.090160 (-0.6238)
$Log[tbr/(1+tbr)]_{t-17}$	-0.16054 (-1.4403)
F	132.2961[.000]
R^2	0.98745
$\bar{R}^2$	0.97999
σ	0.087539
LL	159.2716
AIC	111.2716
SBC	43.0111
CRDW	2.0589
T_{JB}, LM $(\chi^2)_2$:	3.9578[.138]
T_{ARMA}, LM $(\chi^2)_5$	11.4913 [0.042]
T_{ARCH}, LM $(\chi^2)_4$	9.9340 [0.042]
T_{WHET}, LM $(\chi^2)_1$,	1.9236[.165]
T_{RESET}, LM $(\chi^2)_1$	1.8528[.173]

Figures in parentheses are the t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. In all cases, '*' signify 10% level of significance; '**', 5%; and '***', 1%.

Table A2l: Full Equilibrium Correction Model for

ΔLog(COB)$_t$

VARIABLES	ESTIMATED
Constant	0.0129(0.7459)
ΔLog(RLDA)$_t$	-0.0338(-0.1585)
ΔLog(RLDA)$_{t-1}$	0.2133(0.9260)
ΔLog(RLDA)$_{t-2}$	0.2685(1.1328)
ΔLog(RLDA)$_{t-3}$	0.1833(0.7445)
ΔLog(RLDA)$_{t-4}$	0.0031(0.0122)
ΔLog[tdr3m/(1+ tdr3m)]$_t$	-0.2562(-1.3868)
ΔLog[tdr3m/(1+ tdr3m)]$_{t-1}$	0.3253(1.7001)**
ΔLog[tdr3m/(1+ tdr3m)]$_{t-2}$	-0.0953(-0.4676)
ΔLog[tdr3m/(1+ tdr3m)]$_{t-3}$	-0.1628(-0.8838)
ΔLog[tdr3m/(1+ tdr3m)]$_{t-4}$	0.0626(0.3351)
ΔLog[tbr/(1+tbr)]$_t$	0.1329(0.8436)
ΔLog[tbr/(1+tbr)]$_{t-1}$	-0.1454(-0.8971)
ΔLog[tbr/(1+tbr)]$_{t-2}$	0.1031(0.6012)
ΔLog[tbr/(1+tbr)]$_{t-3}$	-0.1765(-1.0685)
ΔLog[tbr/(1+tbr)]$_{t-4}$	0.2827(1.6618)**
ΔLog[tbr/(1+tbr)]$_{t-5}$	0.0061(0.0438)
ΔLog[tbr/(1+tbr)]$_{t-6}$	0.0451(0.3730)
ΔLog[tbr/(1+tbr)]$_{t-7}$	-0.1707(-1.5091)
ΔLog[tbr/(1+tbr)]$_{t-8}$	0.0431(0.3409)
ΔLog[tbr/(1+tbr)]$_{t-9}$	-0.0085(-0.0664)
ΔLog[tbr/(1+tbr)]$_{t-100}$	0.0977(0.7697)
ΔLog[tbr/(1+tbr)]$_{t-11}$	0.0475(0.3670)
ΔLog[tbr/(1+tbr)]$_{t-12}$	-0.0497(-0.4070)
ΔLog[tbr/(1+tbr)]$_{t-13}$	-0.0061(-0.0518)
ΔLog[tbr/(1+tbr)]$_{t-14}$	0.041(0.3514)
ΔLog[tbr/(1+tbr)]$_{t-15}$	0.0811(0.7562)
ΔLog[tbr/(1+tbr)]$_{t-16}$	-0.0637(-0.5809)
ΔLog(DAD)$_t$	-0.6565(-3.1068)***
ΔLog(DAD)$_{t-1}$	-0.3115(-0.9761)
ΔLog(DAD)$_{t-2}$	0.1096(0.5166)
ΔLog(DAD)$_{t-3}$	0.2177(1.0203)
ΔLog(DAD)$_{t-4}$	0.2536(0.9214)
ΔLog(DAD)$_{t-5}$	-0.0306(-0.1235)
ΔLog(DAD)$_{t-6}$	-0.0275(-0.1099)
ΔLog(DAD)$_{t-7}$	-0.1776(-0.7353)
ΔLog(DAD)$_{t-8}$	-0.4274(-1.6608)**
ΔLog(DAD)$_{t-9}$	0.2695(1.0630)
ΔLog(DAD)$_{t-10}$	0.239(0.9932)
ΔLog(DAD)$_{t-11}$	0.0044(0.0180)
ΔLog(DAD)$_{t-12}$	-0.3258(-1.3675)
ΔLog(DAD)$_{t-13}$	-0.0133(-0.0550)
ΔLog(DAD)$_{t-24}$	-0.0558(-0.2224)
ΔLog(DAD)$_{t-15}$	0.3431(1.3750)
ΔLog(DAD)$_{t-16}$	-0.4015(-1.6311)
ΔLog(COB)$_{t-1}$	0.452(1.6589)**
ΔLog(COB)$_{t-2}$	0.0949(0.7850)
ΔLog(COB)$_{t-3}$	-0.0774(-0.7004)
ΔLog(COB)$_{t-4}$	0.12(1.0344)
ΔLog(COB)$_{t-5}$	-0.1226(-1.0986)
ΔLog(COB)$_{t-6}$	0.0409(0.3248)
ΔLog(COB)$_{t-7}$	-0.111(-0.9807)
ΔLog(COB)$_{t-8}$	0.1678(1.2588)
ΔLog(COB)$_{t-9}$	-0.1402(-0.9019)
ΔLog(COB)$_{t-10}$	-0.0208(-0.1515)
ΔLog(COB)$_{t-11}$	0.1607(1.2071)
ΔLog(COB)$_{t-12}$	0.399(2.8332)**
ΔLog(COB)$_{t-13}$	-0.2044(-1.2412)
ΔLog(COB)$_{t-24}$	-0.2496(-1.8531)**
ΔLog(COB)$_{t-15}$	0.1088(0.7644)
ΔLog(COB)$_{t-16}$	-0.0328(-0.2380)
ECM	-0.7105(-2.3570)***
F	3.3092
R^2	0.75927
$\bar{R}^2$	0.5298
σ	0.0856
LL	173.6751
AIC	111.6751
SBC	23.7504
CRDW	2.0484
T_{JB}, LM $(\chi^2)_2$:	31.0366[.000]
T_{ARMA}, LM $(\chi^2)_5$	5.8422[.211]
T_{ARCH}, LM $(\chi^2)_4$	
T_{WHET}, LM $(\chi^2)_1$,	0.98510[.321]
T_{RESET}, LM $(\chi^2)_1$	1.3981[.237]

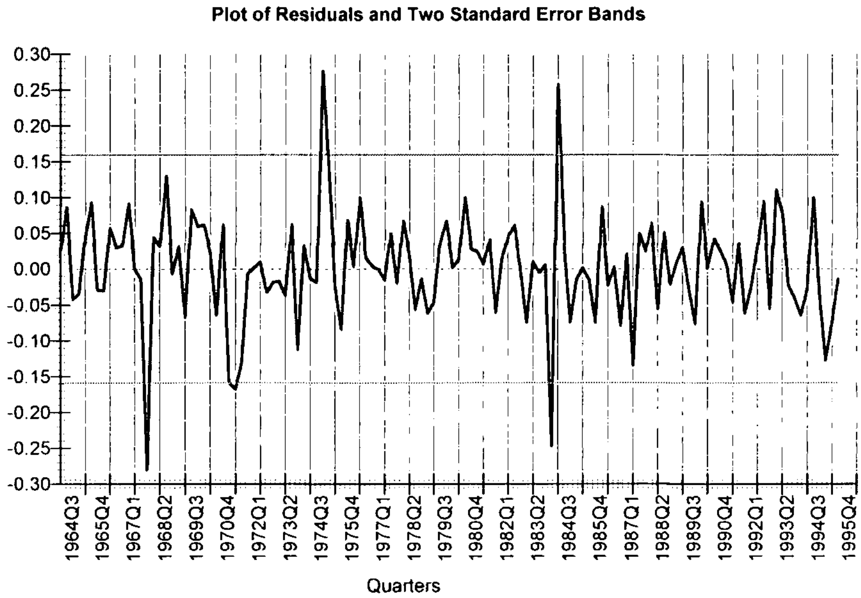
Figures in parentheses are the t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. In all cases, '*' signify 10% level of significance; '**', 5%; and '***', 1%. Note that Δlog(DAD) is entered separately in addition to, and with the same lag with Δlog(COB) in this regression. The restriction of zero price elasticity of real balances applicable to the long-run relationships is not necessarily applicable to the short run adjustments. Including Δlog(DAD) relaxes that restriction by allowing for a non-zero real balance effect in the short run. Once Δlog(DAD) is included, using either ΔLog(COB/DAD) or Δlog(COB) on the right hand side produces identical initial models. Using Δlog(COB) rather than Δlog(COB/DAD) enables us to isolate the impact of changes in the nominal money stock on desired holding of real money stock.

Table A2m: Reduced ECM FOR COB

Method	$\bar{R}^2$ =AIC
ADL ($\hat{p}, \hat{q}_1, \hat{q}_2, \hat{q}_3$)	**(17, 5, 5, 17)**
~~ΔLRLDA(-2)~~	0.36(2.51)**
ΔLRLDA(-3)	0.38(2.61)***
ΔLTBR(-3)	-0.22(-3.07)***
ΔLTBR(-4)	0.17(2.32)***
ΔLDAD	-0.681(-5.61)***
ΔLDAD(-3)	0.45(4.04)**
ΔLCOB(-1)	0.19(1.91)***
ΔLCOB(-7)	-0.29(-3.49)***
ΔLCOB(-8)	0.23(2.82)***
ΔLCOB(-11)	0.22(2.59)**
ΔLCOB(-12)	0.34(4.05)**
ΔLCOB(-13)	-0.24(-3.02)***
ΔLCOB(-14)	-0.20(-3.04)***
ECM	-0.43(-3.37)***
R^2	0.63637
$\bar{R}^2$	0.59416
σ	0.079485
LL	147.6897
AIC	133.6897
Variable deletion Test LM $(\chi^2)_{48}$	42.5862 [.694]
SBC	113.8357
CRDW	2.0472
Normality: T_{JB} , LM $(\chi^2)_2$:	**54.7279[.000]***
5th-order Auto-correlation: T_{ARMA} , LM $(\chi^2)_5$	3.3409[.502]
4th-order ARCH: T_{ARCH} , LM $(\chi^2)_4$	
Heteroscedasticity: T_{WHET} , LM $(\chi^2)_1$,	0.043951[.834]
Functional form: T_{RESET} , LM $(\chi^2)_1$	0.13510[.713]
Variable deletion Test LM $(\chi^2)_{20}$	

Figures in parentheses are t-ratios of the corresponding estimates. Figures in brackets after the diagnostic statistics indicate their levels of significance. In all cases, '*' signify 10% level of significance; '**', 5%; and '***', 1%. Note that Δlog (DAD) and Δlog (COB) are entered separately with the same lags in this regression. The restriction of zero price elasticity of real balances applicable to l.h.s variable, unobserved 'desired' money stock, and not to the r.h.s variables, Δlog (DAD), or the observed rate of inflation, and Δlog (COB), the observed change in the log of nominal money stock. Once Δlog (DAD) is included, using either Δlog (COB/DAD) or ΔLog (COB) on the r.h.s. produces similar initial models, but different dynamic adjustment paths. Using Δlog (COB) rather than Δlog (COB/DAD) is the correct thing to do as it also enables us to isolate the impact of observable changes in the nominal money stock on the 'unobservable' desired holding of real-balances being modelled.

The Full Equilibrium Correction Model for lags of log(COB) is presented in Table A2l. This estimate provides the starting point to generate the reduced ECM and subsequently the final ECM. The coefficients are generally less than unity for all the variables. The model has only 8 (eight) variables significant at 10 percent (of which six are significant at 5%) including the EC variable. In this full model, none of the real activity variables was significant at 10% or below. The coefficient of the error correction term indicates that about three-quarters of any deviation from the equilibrium point is corrected within one quarter of a year. Both the R-square and the Adjusted R-square appear to be strong, having 0.75 and 0.51 values respectively. The diagnostic tests indicate the presence of non-normality.



The non-normality of the residuals of the reduced ECM for COB renders the model un-interpretable. This necessitated the plotting of the residuals and the two standard error bands as above. The plot reveals the following clues:

- Three outliers (when the residual exceeded the standard error bars) can be identified over the 1960Q1 to the 1995Q4 sample-period.
- The first happened around 1967/68 and coincides with the outbreak of the Nigerian civil war;
- The second happened in 1974 and coincides with the onset of the oil-boom;

- The third and the last happened around 1984 and coincides with the sudden change (within a couple of months) of Naira notes by a new military government to check counterfeiting.

Each of the associated events probably can individually or collectively be responsible for the residual non-normality. Dummies for each of the three shocks were included, but the residual non-normality persisted. Consequently, we are unable to recover any well-behaved model for COB for Nigeria that can be compared with models already derived for M1 and demand deposits. Chapter seven probes why this problem might arise a little further.

Appendix 2: Types and Sources of Data

A3.1 Money Stock

Detailed information on the various monetary aggregates in Nigeria are available from the Central Bank of Nigeria (CBN). These were published in monthly frequency from 1960-90, but only for the last month in each quarter from 1991 to date.

A3.2. Real Economic Activity and Relevant Deflators

Annual data on various measures of production and expenditure aggregates and relevant deflators for Nigeria are available from the World*Data 1995 (World Bank Data on CD-ROM). IFS quarterly series are only available on relatively narrow indices of manufacturing and industrial production, and only for the later part of the sample period. The annual series on the broader measures of economic activity and prices are therefore interpolated to generate quarterly series that can be used along with the more readily available high frequency data on interest rates.

A3. 3. Interest Rates:

The sources of data on interest rates in Nigeria are the various publications of the Central Bank of Nigeria such as the monthly *Economic and Financial Review January* and *Annual Report and Statement of Accounts (1960 to date),* as well as the *Statistical Bulletin* (providing data from 1970 to date). Comparable data on interest rates in the United States are available from the *International Financial Statistics,* published by the International Monetary Fund. Interest Rates data are available in monthly frequency from both sources from 1960-1990. While US monthly series are available to date, only quarterly series are available from the Central Bank of Nigeria after 1990.

A3.4. Exchange Rates

Official rate is available on a monthly basis from CBN from 1960 to date. Parallel market rates are only available on a monthly basis from 1976 to date from *Picks Currency Yearbook.*

A3.5. Temporal Aggregation

The interpolated series on real activity and the corresponding deflators are quarterly averages. The ideal practice would be to transform the monthly series on money, interest rate and exchange rate into quarterly averages. The fact that monthly data are only available for the 1960-90 period implies that this cannot be done for the full sample. The money, interest rate and exchange rate series are therefore end of quarter series to permit the analysis of the full sample covering 1960 to 1995.

A3.6. Method of Interpolation

The method of interpolation used is the one proposed by Goldstein and Khan (1976) that if x_{t-1}, x_t, and $x_{t+1}$are three successive annual observations of a flow variable x (t), the quadratic function passing through the three points is such that:

$$\int_0^1 (as^2 + bs + c)\, ds = x_{t-1}$$

$$\int_1^2 (as^2 + bs + c)\, ds = x_t$$

$$\int_2^3 (as^2 + bs + c)\, ds = x_{t+1}$$

Integrating and solving for a, b, and c gives

$$a = 0.5\, x_{t-1} - 1.0\, x_t + 0.5\, x_{t+1}$$

$$b = -2.0\, x_{t-1} + 3.0\, x_t - 1.0\, x_{t+1}$$

$$c = 1.8333\, x_{t-1} - 1.1666\, x_t - 0.333\, x_{t+1}$$

The first two quarterly figures within any year can be interpolated by

$$\int_{1}^{1.25} (as^2 + bs + c)\, ds = 0.0548\, x_{t-1} + 0.2343\, x_t - 0.0390\, x_{t+1}$$

$$\int_{1.25}^{1.50} (as^2 + bs + c)\, ds = 0.0077\, x_{t-1} + 0.2657\, x_t - 0.0235\, x_{t+1}$$

and corresponding formulas give the third and fourth quarter interpolation. Multiplication by 4 expresses the interpolated series at annual rates. This method was used to interpolate real aggregates and their deflators.

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