AN ESTIMATION OF THE DEMAND FOR REAL MONEY IN SOUTH AFRICA, WITH THE APPLICATION OF COINTEGRATION AND ERROR CORRECTION MODELLING OVER THE PERIOD 1965:02 TO 1996:04.

By

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DECLARATION

I wish to acknowledge that this thesis, except where specifically indicated to the contrary in the text, is entirely my own work and has not been submitted at any other university.

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Annabel M. Reinhardt

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CHAPTER ONE

INTRODUCTION

In the South African context there has not been much attempt made to model the real demand for money on a wealth variable within the last thirty years. This thesis seeks to correct for this lacuna by following the suggestion of Hurn and Muscatelli (1992, p.168) of including a wealth variable into the estimation of the demand for real money in South Africa so as to be able to determine whether the results improve with this inclusion. In particular there has been a trend in the studies done on the South African demand for money for the interest rate elasticities to have the incorrect sign, thereby exhibiting a positive relationship instead of the negative one expected by the theory. Consequently an estimated function with the correct theoretical relationship between the demand for money and the interest rate would be a welcome result.

The analysis of the demand for money has recently seen that "*it is the application of new econometric techniques rather than advances in theoretical monetary economics which has provided the most informative research findings in recent years*"(Taylor, 1991, p.1). These techniques of cointegration and error correction modelling have allowed greater empirical analysis to be made into the traditional theories by providing new methods for incorporating the short-run dynamics into the long-run function, whilst also being able to correct for the disequilibrium experienced in the short-run. In South Africa Naudé (1992) has estimated an error correction model for the demand for nominal money using very narrowly defined money, but did not attempt to apply an error correction representation to broadly defined money, nor specifically to incorporate the method of cointegration into the analysis. The studies of Hurn (1991) and Hurn and Muscatelli (1992) on the other hand have not made use of error correction modelling. Instead the focus of their analysis has been on using the method of cointegration to model the long-run properties of the demand for money, with the result that the short-run disequilibrium of money demand has not been incorporated into these analyses. The present study seeks to combine the two methods of cointegration and error correction modelling in the estimation of a function for the South African demand for real money, arguing that it is only by including both the short-run and the long-run properties of the demand for money into the analysis that the true nature of the demand for money can be discerned.

This estimation procedure is in accordance with those currently being used in the literature where the long-run money demand function is estimated first by using the method of cointegration and then, consequent on a cointegrating relationship being found between the variables, the short-run dynamics are accounted for by use of the error correction model (Engle and Granger (1987); Hendry and Ericson (1991)). This error correction model is also able to capture and correct for any deviations from the long-run equilibrium experienced in the previous period. Wong and Kennedy (1992) and the Deutsche Bundesbank Monthly Report (1995) have followed this two-stage estimation procedure of Engle and Granger (1987) involving the use of cointegration and error correction modelling, and have used the general-to-specific approach to modelling to provide the final estimate of the error correction model. The advantage's of this is that the error correction model is first estimated with numerous lagged values of all the explanatory variables including the dependant variable. Then through testing-down procedures involving tests of significance on the estimated coefficients the model is pared down to a specific form so that in effect the data then determines the specification of the model. This general-to-specific approach to modelling has also been used by Hendry (1979), Hendry and Richard (1982) and Hendry and Richard (1983).

The results obtained in the present analysis suggest that there is a stable long-run function for the demand for real money balances in South Africa due to cointegrating relationships being obtained for the variables. The finding of a negative interest elasticity of the demand for money is particularly pleasing, with the models also not violating any of the other theoretical expectations of positive relationships between the demand for money and the income and wealth variables.

Further the short-run demand for money has been found to follow a random walk meaning that each previous observation exerts its full influence on the next observation with the result that the series is non-stationary. This result is in accordance with the theory of Miller and Orr (1966) who hypothesize that the demand for money is characterized by the existence of a stable long-run level of money holdings with upper and lower boundary levels (or bands) within which the short-run demand for money follows a random walk. Milbourne (1983, p.686) also supports this theory, arguing that the movements in the demand for money are determined by the short-run movements in the level of money holdings, providing that an equilibrium or desired level (or bands) of money holdings exists, while the long-run determines the actual level of these bands (Hendry and Ericson, 1991, p.23).

Estimations which make use of error correction models are consistent with this theory as the error correction terms show a decreasing structure of values of the coefficients over time which means that the short-run disequilibria are constantly being moved in line with the long-run or equilibrium level of money holdings as smaller and smaller adjustments need to be made over time with the smallest correction of all being made in the present period. This dampening effect which the error correction mechanism has on the short-run movements of the demand for money ensures that they always return to the long-run levels (or bands) of money holdings when there is any deviation.

The inclusion of the wealth variable amongst the regressors of the function for the demand for real balances improved the results obtained in the cointegrating equations, showing that wealth does have significant explanatory power on the level of money holdings. A further major finding is that the wealth variable also significantly improves the results obtained in the error correction models and therefore points towards a significant contribution to the understanding of the short-term nature of the demand for real balances in South Africa as well. In fact the inclusion of a wealth variable causes the signs of the interest rate coefficients to become theoretically consistent which further implies that using a wealth variable as a regressor gives a more correct specification for the demand for broadly defined real money balances in South Africa.

The theoretical issues upon which the model is built are reviewed in chapter two in order to give an indication of the variables for inclusion in the model and the expected relationships between these variables. Other issues surrounding the demand for money are examined as well, including the issue of the use of real and nominal balances, the stability of the function and the definition of money and of the concept of the demand for money.

Chapter three provides an overview of the literature involving the empirical estimation of the demand for money function in South Africa in order to establish precedents, examine previous problems and successes, and ascertain the existing empirical position of money demand analyses. The issues which are highlighted are those that are of relevance to the present study, with emphasis being placed on the variables used in the specifications of the money demand functions.

Chapter four presents the specification of the model that is used in this study, with the issues raised in chapters two and three providing the theoretical and empirical basis. All the variables which are used in the analysis are defined and explained in this chapter and, where necessary, reasons are put forward for the figures used to measure them. The concepts of non-stationarity, cointegration and error correction modelling are defined and explained in full in this chapter, and the estimation procedure to be used in chapter five is considered in detail.

Chapter five presents the estimations and the results of the application of cointegration and error correction modelling to the model specified in chapter four. The results of the final estimations are then examined for

(a.) the existence of a negative relationship between the interest rates and the demand for money
(b.) whether the inclusion of the wealth variable leads to improved results
(c.) whether the use of the estimation techniques of cointegration and error correction modelling aid in providing an analysis of the demand for money which incorporates both the short and long-run nature of the demand for real balances in South Africa.

Chapter six provides the conclusion, and in doing so summarises the results, and assesses the implications of these results.

CHAPTER TWO

THEORETICAL ISSUES SURROUNDING ON THE DEMAND FOR MONEY

2.1. Introduction

When initially formulating empirical models it is the underlying theory that is customly relied on to construct the specifications, and once the empirical estimates are obtained they are assessed on the terms of their consistence with this theory. As a result, it is crucial to review all the pertinent economic theory surrounding the subject before proceeding with the actual estimation of the model. This ensures that the initial specification that the model is built on will then include valid relationships between the variables, while also providing a basis for the inclusion of the variables themselves.

To this aim this chapter presents the transaction and asset demand theories in sections (2.4.1.) and (2.4.2.), the buffer stock theory in section (2.4.3.), with the inflationary effects on the demand for money and the demand for money in the open market being reviewed in section (2.4.4.). Lastly issues pertaining to the stability of the demand for money are addressed in section (2.5.).

Before reviewing the theory however it would be useful to initially provide a section that deals with the definition of the demand for money, and one which explains and distinguishes between real and nominal money balances. Section (2.2.) and (2.3.) below attempt to do this, thereby providing greater clarity to the subsequent analysis.

2.2. The Definition of the Demand for Money

Money is defined by Friedman (1956, p.5) *"as claims or commodity units that are generally accepted in payment of debts at a fixed nominal value"*. Many narrower definitions of money can be drawn by limiting it just to currency, or broadening it to include demand deposits and savings, cheque and transmission accounts, and short, middle-term and long-term time (or fixed) deposits. The actual demand for money can then be defined as the level (or stock) of money that any one individual, or the aggregate of all individuals in the private sector, desires to hold at a point in time. At equilibrium this demand for money would then equal the supply of money which in turn equals the optimum, or desired, level of money balances. In contrast when the demand for money is in disequilibrium then the actual level of money that is demanded by individuals is different from their desired or equilibrium levels of money balances.

The theory of supply and demand typically points to an equilibrium relationship between these variables in the long-run (Vane and Thompson, 1994, p.77-79), with any disequilibrium that is experienced being essentially short-run in nature so that the demand for money will always tend in the long-run to move back to its equilibrium level[1]. This is of considerable significance to the present analysis as the estimation of a money demand function for South Africa would then need to take cognisance of both the short and long-run nature of money because it is solely by incorporating both the long-run equilibrium, and short-run disequilibrium into the analysis, that the demand for money can then be genuinely understood (Santomero and Seater, 1981, p.566).

The error correction model reviewed in chapter four, section (4.4.5.), provides an empirical estimation technique for dealing with the disequilibria experienced in the short-run through the introduction of a term that is able to capture the extent of, and then correct for, the short-run

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[1] The short-run is usually taken as the period of time during which the inputs of a factor cannot be changed (see Lipsey, 1989, p.790). In terms of the demand for money this then means that the disequilibrium will be experienced in the short-run. When the demand for money is in equilibrium however then the time period is know as the long-run, so that the terms equilibrium and long-run can then be used synonymously (Chow, 1966, p.111).

deviation of the demand for money from its long-run equilibrium. The actual short-run dynamics of money demand are also captured by the error correction model through its ability to relate changes that occur from one time period to the next in the level of money demanded to the changes or short-run movements of the variables that explain the demand for money. A more detailed explanation on the workings of the error correction model is provided in chapter four, section (4.4.5.).

2.3. Real and Nominal Money Balances

The difference between nominal and real money can be seen to essentially involve the unit of measurement used. This is because nominal money balances refer to the actual nominal number of units of money in circulation while real money balances are the value of this money in terms of its purchasing power of goods and services (Barro, 1993, p.67).

Friedman (1959, p.330) argues that the nominal stock of money is determined by the monetary authorities, and not by non-bank[2] holders of money; while the real stock of money is determined by the (non-bank) holders of money. In South Africa the Reserve Bank is the monetary authority which controls the amount of nominal money that is demanded and it does so by adjusting the monetary policy instruments and tools at its disposal so that the amount of money demanded equals the amount of nominal money which the Reserve Bank wishes to supply. One of the ways in which this can occur is through the Reserve Bank's discount policy where the cost of obtaining credit is raised through an increase in the discount rate, which causes the cost of credit to become more expensive and hence less attractive. In this way the monetary authorities can decrease the demand for credit and hence indirectly exert some control over the quantity of money.

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[2] Non-bank here should perhaps rather read non-(Reserve) Bank, as the non-bank holders of money alluded to here include commercial, merchant and other banks besides private individuals, but not the reserve bank or any other monetary policy maker.

Another means the Reserve Bank employs in controlling the level of money demanded is through the informal agreement between the Reserve Bank and clearing banks on the 'price' of money. This is possible as the clearing banks prime overdraft rate (the lowest and only rate at which a clearing bank will lend on overdraft) is linked to the Bank rate at a level which exceeds the Bank rate by between 2,5 and 3,5 % (Fourie, Falkena and Kok, 1992, p.57 and p.321-22; Falkena *et al*, 1991, p. 477). By increasing the Bank rate the monetary authorities can decrease the demand for credit by making credit more expensive and hence indirectly exert some control over the quantity of money that is demanded. The market rates of interest are then influenced by the Reserve Bank's lead when the Bank Rate is raised or lowered because, as the commercial banks borrow from the Reserve Bank at the bank rate, increases or decreases in the bank rate will cause the commercial banks to increase their rates at which they lend, so that these changes in the cost of credit are then passed on into the market.

It can therefore be seen that non-Bank holders of money are unable to influence the nominal amount of money demanded in the South African economy as it is surmised that they cannot directly influence the monetary policies of the Reserve Bank. On the other hand the level of real money demanded can be controlled by non-Bank holders of money. This is because when these agents desire to hold less real money, they are able to do so on an aggregate level by increasing their level of expenditure on goods and services which then causes the prices of these goods and services to rise. This will then decrease the amount of goods and services that a fixed nominal amount of money can buy, thereby decreasing the real value of money, so the amount of real money demanded decreases even though the nominal amount demanded remains unaltered.

The demand for money is therefore a demand for real balances as individuals are interested in the purchasing power of their money and not about how many units of currency they hold (Spencer, 1985, p. 495; Hafer and Thornton, 1986, p. 540). This is because the demand for real money balances remains unchanged when the price level increases as individuals will conceivably still demand the same number of goods and services as before, but the demand for nominal money balances increases to pay for the general price level increase of all goods and services. An alternative way of looking at the differences between real and nominal money balances is that real money balances are just nominal money balances (M) deflated by the price level (P), or M/P. In other words nominal money is divided (deflated) by a suitable price index such as the CPI (Consumer Price Index) or GDP(Gross Domestic Price) deflator in order to remove the price factor (inflation is adjusted for) so that the demand for money can be measured in real terms by the amount of goods and services that it can buy. A demand for money function that is specified in its nominal form should be divided through by the price level in order to obtain the real specification (Milbourne, 1983, p. 634).

Individuals whose real behavior, including the demand for real money balances is affected by changes in the price level are said to be suffering from 'money illusion'. This means that these individuals are not taking into account the real value of their money balances as they do not look at what they can purchase but rather at the nominal amount of money they have. When an individual is affected by money illusion then the specification of his demand function is in nominal terms.

The empirical evidence on the demand for money shows a large support for the estimation of the demand for money being a demand for real balances and not nominal balances. Gupta and Moazzami (1990, p. 7) in examining whether the adjustment of actual to desired (equilibrium) money balances is real or nominal for eleven Asian countries found that a nominal adjustment should be used in the error correction models. Simmons (1992, p.30) however, in using the error correction mechanism to estimate specifications of the demand for money functions of five African developing countries, uses a real adjustment mechanism and obtains stable money demand functions for each country. Haug and Lucas (1996); Choudry (1995); Huang (1994), Hofman and Tahiri (1994) Lim (1993); Psaradakis (1993); Montecelli and Strauss-Kahn (1993); Arestis and Demetriades (1991), and Bahmani-Oskooee (1991) have concluded that a real adjustment should be used in the error correction models.

Turning to the work done on the South African demand for money, the recent estimations of Travlas(1989), Hurn(1991) and Hurn and Muscatelli(1992) have specified the money demand function in real terms and have obtained very good results (see chapter three for the review on the South African literature). In contrast Whittaker (1985) and Courakis have not obtained results as good with the use of nominal specifications although Naudé(1992) has successfully used a nominal specification to model the demand for very narrowly defined money (currency) with the aid of the error correction technique mentioned above.

The inclusion of a wealth variable amongst the regressors of the money demand function as mentioned before has been done as a result of the suggestion by Hurn and Muscatelli (1992) that it might improve the results when the more broadly defined monetary aggregate, M3, is used as the dependant variable. (Regressions run on M1 and M2 have been done to test whether the inclusion of wealth improves the results as well.) In the present analysis therefore the demand for money has been specified in real terms as follows the study Hurn and Muscatelli (1992).

The actual specification of the relationships of the variables included in this model as well as the basis for the inclusion of these variables has been derived from the economic theory on the demand for money which is reviewed next in the section below.

2.4. The Theory of the Demand for Money

The theory on the demand for money has arisen largely from the functions that money serves as a universally acceptable means (media) of exchange and as a store of value (see Jevons, 1875; Clower, 1976; Jones, 1976). The function of money as a media of exchange serves as the basis to the theory of the transaction models (Clower, 1976, p.3, Jones, 1976, p.758), of which the inventory models assume the levels of transactions to be known, whilst the precautionary demand models treat net inflows of money as uncertain. Money's function as a store of value or wealth (Jevons, 1875, p.38) on the other hand led to the speculative motive of holding money and later the asset/portfolio theories. These two theories on the transaction demand for money and the speculative or asset demand for money contain many differences and, as a result, have been the center of serious debate in the literature surrounding the demand for money.

2.4.1. The Transaction Demand for Money

Early contributions to the money demand analysis were made by the Cambridge economist, Pigou (1917, p. 42) who is largely responsible for reformulating Fisher's quantity theory of money as a theory of the demand for money. Taking the quantity theory identity of Fisher (1911, p.24-29), ie $MV \equiv PT$ where M is the quantity of (nominal) money in circulation, P the aggregate price level, V the velocity of money in circulation, T the level of trade (and hence income) and where V is determined by the individuals need for money in order to make payments (transactions), Pigou shifted the focus to the individuals desired demand for money, ie $M^d = kPT$ where T is, as above, the total resources transacted, k is the proportion of these resources kept in the form of money and M^d is the desired or equilibrium level of (nominal) money demanded (Laidler, 1969, p.48). Pigou recognised that k could depend on other variables such as wealth (financial assets) and interest rates, but regarded the level of transactions as the chief determinant of the demand for money (Cuthbertson and Barlow, 1991, p. 16).

Keynes (1936, p.170) developed the Cambridge school's analysis of the demand for money further by separating the specific motives that led people to hold money. In order to compensate for the lack of synchronisation between the receipt of income and its expenditure, Keynes argued that a transactionary motive for holding money arises that is approximately proportional to the routine level of transactions and to the level of income (see Keynes, 1936, p.172).

Keynes (1936, p.196) also argued that a second motive, the precautionary motive for holding money, exists in conjunction with the transaction motive as a result of the need to have an additional level of money balances to meet exigent payments in sudden or unpredictable circumstances. Keynes (1936, p.171) surmised that this precautionary motive for holding money is similar to the transaction motive in that the amount of money held is mainly dependent on the level of income, the uncertainty of the timing between the receipts and expenditure of money, and the cost of and ability to acquire money at the actual time that it is to be spent (see Keynes, 1936, p.196 and Pierce and Tysome, 1985, p.46).

Keynes (1936, p.171) assumed that both the transaction and the precautionary demand for money are not very sensitive to changes in the interest rate. By this Keynes did not mean that the opportunity cost of holding money does not affect the demand for money, but rather that a third motive, the speculative motive, accounts for the sensitivity of the demand for money to the level of interest rates (see section 2.4.2.) while the transaction and precautionary motives are instead determined by the level transactions and hence income as mentioned above.

Keynes did not provide any specific empirical measures of the strengths of the interest and income elasticise of the transaction and precautionary demand for money, partly because of the minor role that he felt interest rates were likely to play in influencing these types of money holdings. Also he did not feel that a specific empirical relationship existed between the level of income and the demand for transactionary and precautionary balances, arguing instead that the level of money held for transaction purposes was "*more or less proportionately*" (Keynes, 1936, p.171-172) equal to the level of income.

A formal empirical statement of the transaction demand for money was provided by Baumol (1952, p.545) within the framework of the inventory-theoretic approach. This approach was initially used to determine the level of inventories that a firm should have on hand, but Baumol adapted it to determine the individuals's demand for money as the he felt that the individual's level of money holdings is "(the) *holder's inventory of the medium of exchange, and like an inventory of a commodity* ... (can be traded)... *as it's possessors part of a bargain in an exchange* " (Baumol, 1952, p. 545).

Baumol (1952, p. 545-6) made the following simplifying assumptions to the transaction demand analysis: (1) all future transactions are known with certainty and occur uniformly over time; 2) the individual pays out (T) amount of cash per period as payments for transactions and his income per period is also assumed to be (T); (3) the individual incurs an opportunity cost of holding money which is measured by the rate of interest (I) over each period; (4) the individual withdraws (or borrows) cash in fixed amounts paced evenly throughout the period to meet his payments and spends all of the money received before withdrawing more; and (5) incurs a constant brokerage fee of (b) each time he makes a withdrawal. The individual will therefore make T/C number of withdrawals so that the total brokerage fee is b(T/C). As the individual is assumed to spend all his money in a constant stream before drawing out C amount of cash again, the average cash holding at any one time will equal C/2 and so the individuals loss in terms of interest foregone is I(C/2).

Further the individual is assumed to want to minimize the total costs of holding money, namely the sum of the brokerage fees, b(T/C) and interest foregone, I(C/2). By minimizing these total costs Baumol (1952, p.547) obtained a function positively relating the level of cash withdrawals to the square root of the brokerage charge and the level of income and inversely relating cash withdrawals to the square root of the interest rate, where

$$C = [2bT/ I]^{1/2} \qquad (2.1)$$

As the individuals demand for money (M^d) at any one time is just the same as his average cash holdings, C/2, at that time, the transactionary demand for money can be empirically stated as follows

$$M^d = C/2 = [\, bT/ 2I \,]^{1/2} \qquad (2.2)$$

At the beginning of the chapter in section (2.3.) it was stated that the demand for money is a demand for real balances. Consequently the inventory theory on the transaction demand for money is devoid of any money illusion as equation (2.2.) above shows that the real demand for money does not change when prices increase (Dornbusch and Fischer, 1990, p.361). This can be seen by the situation where a doubling of all prices, so that both nominal income (T) and the brokerage fee (b) (which is also a nominal value) will then double, causes the demand for nominal money (M^d) to double by causing the monetary units which M^d is measured in to double in number (Baumol, 1952, p.547). The demand for real balances is unaffected however as the actual amount of goods and services that the new nominal level of money demand can buy is still equal to the amount that the previous level of nominal money demand could buy before the doubling of all prices.

Simplifying (2.2.) into a linear form through the use of logarithms gives us

$$\ln(M^d) = 0.5\ln(b/2) + 0.5\ln(T) - 0.5\ln(I) \qquad (2.3)$$

where the transaction demand for money depends positively on the level of income and brokerage fees and negatively on the interest rate. The income elasticity is 0.5 which means that an increase in the real income level raises the demand for real money balances by less than the actual increase in the income level, implying the existence of economies of scale (Baumol, 1952, p.551). This means that a one percent increase in the level of real income causes the level of real money balances to rise by half a percent so that when an individuals income increases he or she then holds proportionately less money. Dornbusch and Fischer (1990, p.360) explains this as being due to the occurrence of better cash management at higher levels of income as a result of the individual paying lower brokerage fees per transaction in terms of the cost of each unit of cash transacted which then enables more frequent transactions, as they cost comparatively less per unit of cash due to their increased sizes, and hence lower levels of money being demanded at any one time. The interest elasticity of -0.5 also implies that an increase in the nominal interest rate causes a decrease in the demand for real balances that is proportionately less in absolute value than the initial increase in the rate of interest.

Baumol's inventory model can also be extended quite easily to include interest payments on money (R) (from Cuthbertson and Barlow, 1991, p.17) where

$$M^d = C/2 = [\ (b/2)T/\ (I - R)]^{\frac{1}{2}} \qquad (2.4)$$

or

$$\ln(M^d) = 0.5[\ln(b/2) + \ln(T) - \ln(I - R)] \qquad (2.5)$$

where the transactions demand for money depends positively on its own interest rate and negatively on the opportunity cost of holding transactionary balances (I). The income elasticity is still 0.5, but the interest elasticity of the demand for money becomes - I/2(I - R) with the relative interest elasticity being -0.5. The difference between the interest elasticity of the demand for money and the relative interest elasticity is that by including moneys own interest rate (R) in the money demand function, the resultant relative interest variable (I - R) becomes a measure of the opportunity cost of holding money which bears a rate of return and the relative interest elasticity measures the responsiveness of the demand for money to a change in the relative interest rate. The interest elasticity on the other hand measures the responsiveness of the demand for money to changes in the interest rate including changes in money's own rate of interest.

Tobin (1956, p.241), taking a different approach to Baumol, set about analysing the interest elasticity of the transaction demand for money. He introduced the scenario where individuals are able to hold their transaction balances in the form of interest bearing assets (with higher yields of return than cash), and then are able to convert these assets into cash just before a payment needs to be made. The individual then pays two fixed brokerage fees (2b), one to convert his cash into bonds and the other to convert his bonds back into cash.

Of course the opposite situation could exist where the interest earnings on the assets are high enough to make it worthwhile incurring numerous brokerage fees, so that the individuals average cash holdings at any time are zero, and his holdings of other assets are on average T/2. If, however, the interest earnings on the bonds do not exceed the cost of buying and then later selling these bonds ($r < 2b$), the individual will have no incentive to hold assets, so that a corner solution arises where the individual's demand for money is interest inelastic and directly proportional to the lump-sum receipt or income received at the beginning of each period.

By combining Baumol's square root solution to money demand with Tobin's corner solution, Barro (1976, p.85) introduced integral constraints to Baumol's inventory model with the assumption that individuals withdraw cash in integer amounts, as opposed to Baumol's model where it was assumed that any number of transactions, such as 1.75, could be made. The implication of limiting the number of transactions to the realistic values of whole positive numbers is that the income elasticity of the demand for real money then ranges from 0.5 to 1. This is because, given that the lowest number of withdrawals any individual can make is one, certain individuals who are to poor to invest part of their income in bonds, as they can't afford additional brokerage charges, will make the one obligatory withdrawal at the beginning of the month and then spend all their income without investing any during that period, resulting in an income elasticity of 1 (and an interest elasticity of 0). It can therefore be seen that the income elasticity can conceivably range between 0.5 and 1, and the interest elasticity between -0.5 and 0.

This result should not be very surprising when applied to South Africa as a large proportion of this country's individuals receive very low incomes, incomes that often are not even sufficient to cover all their needs and so they cannot even think of investing any of this income in interest earning assets. Their demand for money will therefore be likely to be a corner solution with an income elasticity close to 1, and interest elasticity of close to 0.

When the assumption that all receipts and payments of income are known with perfect foresight is relaxed a certain degree of uncertainty enters the model causing individuals to hold precautionary balances in order to be able to make the unforseen transactions. The optimal precautionary balance to hold involves the balancing of interest lost (Mr) (Dornbusch and Fischer, 1990, p.363) against the cost of being illiquid or the brokerage fee (b), times the probability of being illiquid (p), where the probability distribution of receipts and payments is assumed to be known. The total expected cost (TC) will therefore be the interest lost plus the cost of the likelihood of incurring the brokerage fee, or

$$\mathrm{TC} = Mr + pb \tag{2.6.}$$

in mathematical form. By substituting s^2/M^2 for p (the probability of being illiquid) where s^2 is the variance of net expenditures or payments and M is money holdings[3], and then minimizing the total expected costs of cash management, Whalen (1966, p.318) obtained an equation for the optimal or desired level of precautionary cash holdings. This equation

$$M = (2s^2 b/r)^{1/3} \tag{2.7.}$$

positively relates the precautionary demand for real balances to the cube root of the brokerage fee, and inversely relates it to the cube root of the rate of return on bonds. By expressing this equation (2.7.) in natural logarithmic form

$$\ln M = 0.3\ln 2 + 0.3\ln s^2 + 0.3\ln b - 0.3\ln r \tag{2.8.}$$

it is possible to obtain the relevant income and interest elasticities for the precautionary demand for

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[3] The term s^2/M^2 shows the probability of being illiquid as the variance of net expenditures or payments (s^2) divided by the square of money holdings gives the amount that the payments (or transactions) will tend to vary from the mean or expected level, or in other words shows how often the level of payments will not be equal to the level of money that is held.

money as well. The interest elasticity is then accordingly - 0.3 and the variance of the income elasticity is 0.3. The reason for the difference in the income and interest elasticities obtained here and those previously obtained in the Baumol-Tobin model, is due to the use of a 'cube root rule', as opposed to Baumol's square root rule, to express the uncertainty between the timing of receipts and payments[4].

Miller and Orr (1966, p.418) derive a similar precautionary demand model by also discarding the previous assumptions that individuals demand the same fixed amount of money (T) in each period. They argue that as receipts and payments of income are not perfectly synchronised, individuals prefer instead to allow their cash balances to fluctuate randomly, converting bonds into money when these stochastic variations in the level of cash balances reach a certain minimum, and substituting money for bonds when cash holdings exceed some upper boundary limit. The individuals demand for money is therefore not deterministic, as perceived in the Baumol model, but is instead "*generated by a stationary random walk*"[5] (Miller and Orr, 1966, p.418). What this then means is that individuals tend to demand the same average or mean level of real balances in the long-run (assuming that all other factors remain constant), while in the short-run the particular amount they demand at any one time varies from the mean by not more than a certain fixed or constant value, hence the upper and lower boundary limits mentioned above within which the demand for money is seen to follow a random walk or path. This theoretical explanation is of extreme interest to the current analysis as it gives theoretical underpinning to the use of the technique of cointegration and the application of the error correction model which is employed here in analysing the demand for money and subsequently will be returned to in chapter four and five.

Miller and Orr (1966, p.425) derive the following model for the firms long-run average demand for

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[4] The cube root relationship stems from the minimization of s^2/M^2 where Tchebycheff's theorem was used to derive s^2/M^2, or the probability of illiquidity, in order to empirically express the uncertainty between the timing of receipts and payments. See Whalen (1966, p. 317) and Duncan (1959, p. 104-106) for further explanation of the mathematical and statistical reasoning involved.

[5] A time series which, although generated by a stochastic (or random) process, has a constant mean (or average), variance and autocovariance over time is said to follow a stationary walk. For further explanation see chapter 4, where the meaning and implications of stationarity is explained in greater detail.

real balances

$$M = 4/3(3m^2\gamma t/4r)^{1/3} \qquad (2.9.)$$

where the demand for money (M) is positively related to the cube root of the transfer costs (γ), the frequency of transactions (t) and the amount that cash balances are expected to increase or decrease by (m), and inversely related to the cube root of the interest rate. The term m^2t is the variance of the daily change in cash balances (σ^2) and represents the lack of synchronization that typically exist between the flow of receipts and expenditures of money. Further the term (γ), which denotes the transfer costs involved in transferring between cash and bonds, includes, at the very least, brokerage fees, bank service costs, postage, cost of time, information and communications involved, and can also include the purchase cost when the context in which the model is being applied is broadened to include a choice alternative portfolio assets (see below).

Expressing (2.7.) in logarithms gives

$$\ln M = \ln 4/3 + 0.3\ln(3\gamma/4) + 0.3\ln(m^2t) - 0.3\ln(r) \qquad (2.10.)$$

where it can be seen that the elasticity of the variance of income with respect to the demand for money is 0.3 and the interest elasticity of demand is -0.3. The actual income elasticity of the demand for money ranges from 0.33 to 0.67 (Coghlan, 1980, p. 92), but as we are examining the uncertainty between the timing of receipts and payments of money (the precaution demand for money) it is the variance, and not the level, of transactions that is of interest.

Miller and Orr (1968, p.747) also examined the affects of portfolio alternatives on the precautionary demand for money by including two further assets (besides cash) in the model: a low cost (in terms of brokerage fees and purchase price), low risk, low return asset termed shorts (for short-term), and a second class of assets called longs (longer-term capital investments) which include all other types of securities which do not have lower risk, lower costs or a lower rate of return than the shorts. Cash is then converted into shorts when the cash balance reaches an upper boundary limit (h), and shorts are converted into cash when the lower boundary limit (0) is reached.

Similarly transfers of shorts into longs are made when a transfer from cash holdings would put the balance of short-term assets above the upper boundary (H), and transfers from longs to shorts are made when a transfer from short-term assets into cash would cause the balance of 'shorts' to reach the lower boundary limit (0). As a result "*the cash balance and the shorts holding will perform random walks on the intervals (0,h) and (0,H) respectively*" (Miller and Orr,1968, p.748) meaning that demand for money is not generated by a deterministic trend, but is instead generated by a random or stochastic walk as described above in the Miller-Orr model.

The actual level of trading in longs or capital investments will depend on the upper and lower limits that the holdings of short-term assets are allowed to reach, and so are independent of the upper and lower limits that are set on the holding of cash balances and therefore the level of assets held in the shorts account is independent from the level of cash held in the cash account. This means that the initial predictions of the Miller-Orr model on the demand for money are unaffected by the extensions, so that the transaction (income) variable of the demand for money is still the variance of the cash flows and the income and interest demand elasticities are still -0.3 and +0.3 respectively.

In this way Miller and Orr have taken into account the short-term movements of the demand for money by arguing that they fluctuate, or follow a random walk, between some stable upper and lower boundary level determined by the long-term level of money holdings.

In respect to the opportunity cost of holding money, Miller and Orr argue that the relevant measure is the 'long' interest rate as it is assumed (in their model) to be higher than the interest rate paid on short term assets, and so is the one that therefore quantifies the greatest earning opportunity that is foregone by holding cash. This is not to say that they don't recognise the relevance of the high substitutability between short-term assets such as three month treasury bills and cash, but that rather they believe that the benefits, or returns, deriving from this close substitutability is more appropriately represented by the low transfer costs (ie the brokerage fees and the purchase price) of these short-term assets, than by the low interest earnings of these assets representing the opportunity cost foregone by holding cash.

Further work has also been done on the Miller-Orr precautionary model by Milbourne (1986). Milbourne (1986, p.507) examines the impact which financial innovation has had on narrowly and more broadly defined money, M1 and M2 respectively, within the framework of the Miller-Orr model[6]. He found that the demand for M1 (narrowly defined money) was not influenced by the introduction of interest earning assets that provide a safe store of value into the market such as money market mutual funds[7] (see Cuthbertson and Barlow, 1991, p.20). This finding supports the assumption that money is held under the precautionary model for the purpose of immediately meeting unexpected transactions, and not in order to provide a safe store of value for the wealth (see section 2.4.2.), as the advent of interest bearing assets, which provide a reliable store of value, do not affect the level of individuals precautionary balances of narrowly defined money, M1, proving that individuals desire to hold a certain amount of cash no matter what.

More broadly defined money, M2 here, does become sensitive to the introduction of alternative capital safe assets implying that broadly defined money tends to be more sensitive to (or serve the function of) providing a reliable store of value for wealth, whilst more narrowly defined money (M1) is used more for transactionary and precautionary purposes[8].

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[6] M1 is defined here as notes, coins and checkable deposits while M2 includes savings and fixed deposits as well as some other interest earning assets.

[7] Money market mutual funds are interest earning assets that require at minimum 24 hours of written notice to convert the funds into liquidity (see Guardbank, 1997, p.13 for more information).

[8] The insensitivity of the demand for M1 to the interest assets also implies that the interest rate of the capital safe interest earning asset used here would not provide a reliable measure of the opportunity cost of holding narrowly defined money (M1). This is an important point when attempting to find a measure of the opportunity cost of holding money for inclusion in the demand for money equation.

Milbourne also found that a fall in the brokerage fees (or transaction costs of converting assets into money and vice versa) affected M1 more strongly than M2, which again supports the assertion that narrowly defined money is used more for transactionary and precautionary purposes hence the sensitivity of M1 to higher transaction costs, whilst demand for the more broadly defined M2 is less responsive to these changes on the whole due to its additional function of maintaining the value of the individuals wealth.

To summarise this section the following conclusions can be drawn from the theory. Precautionary models are based on the transaction motive for holding money, namely where the demand for money depends on the level of transactions (or income received). These transactions are either assumed to be known with complete certainty (the transaction motive) or else additional unexpected transactions over and above the routine level are assumed to occur (the precautionary motive for holding money). The level of income is assumed to be positively related to the demand for money and the income elasticity is assumed to range from 0.5 to 1, with specific values depending on the absence or presence of integer constraints (ie where individuals may only withdraw cash in integer amounts), brokerage fees and the individual's level of income.

(I). When integer constraints are absent, and brokerage fees and income levels are not extreme (as in the Baumol-Tobin transaction demand model), then the income elasticity of the demand for money will be 0.5, which means that a one percentage increase in the level of income will cause the demand for money to rise by 0.5 per cent. The demand for money is not directly proportional to the level of income as predicted by Keynes and instead exhibits certain economies of scale of cash management (Dornbusch and Fischer, 1990, p.360). Further the model predicts that as an individual's level of income increases the individual will hold a lower proportion of money to income (expenditure) than an individual with a lower income level.

(II). When certainty still prevails, but the brokerage costs become to high for the individual or the individuals level of income becomes to low (and integer constraints[9] are present) then the individual will have an income elasticity of 1 as the individual needs to spend all his income and cannot afford to invest any. That is there are constant returns to scale in the individuals cash management as a one percentage increase in income results in a 1 percent increase in the demand for money.

(III). However when uncertainty exists about the timing of receipts and payments, then the elasticity of the variance of income with respect for the demand for money is approximately 0.3, while the actual income elasticity ranges between 0.33 and 0.67 such that a 1 percentage increase in the level of income causes an increase in the demand for money anywhere from about 0.3 to 0.6 per cent meaning that the demand for cash balances fluctuates randomly and is no longer fixed at a certain level. The reason why these fluctuations occur is that it is possible for people to borrow and lend money when payments don't match receipts, even in the very short-run. The effect that the variability of income has on the demand for money then becomes important and so the precautionary model postulates that the demand for money is stochastic as the demand for money typically experiences random movements in the short-run from its long-run or equilibrium value. The elasticity of the variance of income with respect to the demand for money gives some theoretical predictions on the short-run dynamics of the demand for money whilst also incorporating the long-run (equilibrium) level of money demand into the theory by postulating a stable band, or upper and lower limits, of long-run money holdings within which the short-run demand for money follows a random walk.

As the transaction motive for holding money is based on the tenet that the individual withdraws a certain amount of money at the beginning of each time period in order to pay for all his necessary transactions, the correct income variable to use is current or measured income (Chow, 1966, p.111), where current income is the individuals income for one period. Further as current income is assumed

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[9] The presence or absence of integer constraints do influence the real demand for money for while the real demand for money is for a flow of goods and services, this flow is constrained by the level of income that is received and hence is affected by whether there are integer constraints or not on income.

to be used only for the purpose of expenditures and interest earning assets are seen as alternatives to money in the transaction and precautionary models, money is then narrowly defined.

As the individual's transaction demand for money depends on current income, the correct interest rate to use would then be a measure of the short-run ('current') opportunity cost of holding money or the short-term interest rate, when measuring the opportunity cost of holding money in a given period.

The opportunity cost of holding money is also assumed to be negatively related to the demand for money, with the interest elasticity ranging from 0 to - 0.5, depending again on integer constraints, brokerage fees and the level of income of the individual.

(I). In the Baumol-Tobin model where it is assumed that the timing of receipts and payments are known with certainty, integer constraints are absent and brokerage fees and income levels are not extreme, the interest elasticity of the demand for money is - 0.5

(II). When certainty still prevails, but the individuals level of income becomes to low or the brokerage costs become to high to afford more than the one obligatory withdrawal of money due to the presence of integer constraints, then the individual will have an interest elasticity of 0.

(III). When there is uncertainty about the timing of receipts and payments as in the precautionary models such as the Miller and Orr model where the demand for money is assumed to follow a stationary random walk, the interest elasticity becomes - 0.3.

2.4.2. The Asset Demand for Money

Whilst the transaction and precautionary motives for holding money are based on money's function as a medium of exchange, the speculative or asset motive for holding money reviewed in this section arises directly from money's function as a store of value.

The Cambridge economists, Marshall (1923, p.16) and Pigou (1917, p.47), believed that one of the main reasons for holding money was the measure of security that money as a store of value can provide against the uncertain nature of the future (see Laidler, 1969, p.52). Keynes (1936, p.168) adapted this line of reasoning into his third and last motive for holding money, the speculative motive, by narrowing down the focus of the argument from the effect that general uncertainty about the future has on the demand for money, to the effect that uncertainty about the future rate of interest has on the level of money holdings. By this Keynes (1936, p.172) did not mean that individuals were uncertain what the interest rate would be in the future, but rather that individuals have differing opinions of the future level of the interest rate which gives rise to the speculative motive of attempting to "*secur*(e) *profit from knowing better than the market what the future will bring forth*" (Keynes, 1936, p.170).

Under the speculative motive Keynes assumed that individuals can hold their wealth either in the form of money, which earns little or no interest but is a secure capital asset, or as bonds, which earn a fixed return but are riskier assets as their price tends to vary inversely with the rate of interest (Cuthbertson and Barlow, 1991, p.16)[10]. Because the value of bonds decline when the interest rate rises, individuals who hold bonds when the interest rate rises make capital losses. Alternatively, individuals who hold bonds when the interest rate falls, make capital gains as a result of the increase in the price or value of the bonds[11].

Keynes further assumed that each individual perceives a “normal” level of the interest rate, so that when the current interest rate deviates from this “normal” rate the individual then expects the interest rate to return to the normal level in the future (see Newlyn, 1962, p.58 and Pierce and Tysome, 1985,

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[10] Bearing in mind that the interest rate on an asset is just a percentage of the value or price of that asset, the inverse relationship between bond prices and the interest rate can be explained as follows: when the market interest rate rises the yield on the bond (or coupon rate) must rise as well to reflect the increased level of interest rates in the market (ie the interest rate or coupon rate of the bond is part of the market interest rates). However the bond's interest return is fixed in monetary units, so the only way to reflect the increased return on interest bearing assets is for the bond to decrease in value, so that the bonds fixed rate of return becomes equal to a higher percentage of the bond.

[11] This is again because the bond's interest return is fixed in monetary units, so that the only way to reflect the now lower returns on interest bearing assets is for the bond to increase in value, so that the bonds fixed rate of return becomes equal to a lower percentage of the bond's value.

p.47-48). This knowledge enables the individual to predict future movements of interest rates and the future bond prices. The individual will then try to avoid making capital losses by substituting bonds for money when he or she believes the interest rate will rise in the future; and seek to make a capital gain by converting money into bonds when he or she believes that a fall in the level of interest rates is imminent.

As a result, Keynes predicted that individuals will not diversify their portfolios, but will rather hold all their wealth either in the form of money or in the form of bonds and substitute one for the other according to their beliefs about the future level of the rate of interest and hence the future prices of bonds. Nominal interest rates however were low in Keynes's time and changes in the interest rate were not usually very big so that the interest rate would tend to have a certain average or "normal" level, whilst nowadays interest rates in South Africa have, over the last thirty years (see appendix A), have in fact been trending upwards and so do not tend to have a "normal" level which they return to.

Tobin (1958, p.66) also disagreed with this prediction of Keynes, arguing instead that individuals do hold diversified portfolios of both risky assets, which have variable returns, and money (narrowly defined as cash) which earns no interest and is assumed to be a safe store of value. This is because, in reality, each individual is not firmly convinced about what the level of interest rates will be in the future, and is therefore also uncertain about what the future capital value of bonds will be so that an inherent risk is then involved in the holding of bonds. As a result Tobin argued that individuals will maximise their utility by trading off risk and return subject to their wealth constraints (see also Markowitz, 1952, 1987, Feldstein, 1969) so that the interest rate (return), the risk of holding bonds, and the level of the individual's wealth determine the degree of diversification of assets in individuals' portfolios.

Nowadays however, with the advent of large institutional investors who offer capital safe interest earning assets that are immediately, or virtually immediately, convertible into cash, individuals tend not to hold cash as a safe store of value as they can earn interest by investing in these institutions riskless assets instead (Pierce and Tysome, 1985, p. 66). The effect of these interest earning capital safe assets on the level of transactionary and precautionary balances has not been large (see Milbourne's (1986) results reviewed in section (2.4.1.), p.21-22), as that on speculative or asset balances, but the use of credit cards and retail chain cards that enable individuals to buy on credit have reduce the need to hold cash and check accounts (narrowly defined money), and hence have reduced the transactionary and precautionary demand for narrowly defined money.

In spite of these criticisms however, Keynes's speculative motive for holding money does provide a significant contribution to the analysis of the demand for money by recognising the sensitivity that the total demand for money displays to the rate of interest. As noted earlier, the previous writers such as the Cambridge economists, viewed the income level as the chief determinant of the demand for money, thereby neglecting the effect of the interest rate on the demand for money.

An alternative line of reasoning to that of Keynes's analysis was developed by Friedman (1956) and the other Modern Quantity Theorists from the Cambridge version of the quantity theory. Instead of analysing the motives that lead people to hold money, the Modern Quantity Theorists accept that people do hold (demand) money, and then proceed to analyse the factors that determine the quantity of money which individuals hold under different circumstances (Laidler, 1969, p.56-57).

Friedman (1956, p.4), in his restatement of the quantity theory, argues that money is one type of asset in which wealth can be held and, as a result, the demand for money should then be analysed in the same way as the demand for any other durable good or asset - by basing it on the assumptions of consumer choice theory where consumption is a function of permanent income (defined as consisting of all the individuals past current incomes, as well as the individual's level of human and nonhuman wealth, and all possible future incomes), and permanent income is in turn a function of the interest rate[12]. Under the assumptions of consumer choice theory the demand for money depends on the individuals total wealth, which is his budget constraint; the return on money and the opportunity cost

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[12] Permanent income (PI) is seen as equaling consumption in the first period (C_1) plus the previous periods consumption discounted by one plus the real rate of interest $(1 + R)$ or $C_1 + C_1/(1 + R) = PI = Y_1 + Y_1/(1 + R)$ or permanent income is function of the level of disposable income (Y) or the level of consumption and inversely related to the nominal interest rate (R) Barro (1993, p. 278) .

of holding other assets; and the tastes and preferences of the wealth holders (Friedman, 1956, p.4). The individual is further assumed to divide his total wealth amongst his assets in a manner that maximises his utility subject to the constraints he suffers on substituting one form of wealth for another.

Total wealth is broadly defined by the modern quantity theorists to include all types of assets that yield a flow of income, or a flow of consumable services which can be exchanged for income. Included in this definition is the productive capacity of peoples own bodies, (human wealth) because people are able to produce goods and services that can be exchanged for income. Human wealth cannot however be bought or sold on markets as nonhuman wealth (such as bonds, equities, tangible nonhuman goods and money) can, barring the existence of slavery. Because of this limitation on the substitution between human and nonhuman wealth, Friedman suggested that the ratio of nonhuman to human wealth, or more specifically of the ratio of the income from nonhuman wealth to the income from human wealth, be included in the demand for money function.

Alais (1947, p.238-41), and later Friedman (1956, p.4), surmise that money, just like any other asset, yields a flow of services to the holder. These services arise, to a large extent, as a result of the convenience that money offers the holder through its function as a medium of exchange. Alais argues that no price is directly paid for this service that money yields, with the cost coming indirectly from the amount of interest that is forgone by not investing in alternative interest bearing assets. Thus the Modern Quantity Theorists can be seen to consider the opportunity cost of holding money to be the return (rate of interest) of all other forms of wealth, as well as the possible capital gains or losses of these assets.

Alais also noted that the value of the services rendered by money, relative to the services of other assets, tend to decrease as more money is held. A diminishing marginal rate of substitution therefore exists between the services of money and the services that other assets offer (Laidler, 1969, p.59), so that the demand for money falls (rises) when the return on any of the other assets (the opportunity cost of holding money) rises (falls). The actual rate of interest chosen to represent the opportunity cost of holding money is argued by Friedman to be one which is representative of the movements of the rates of return on the various assets, providing these rates move together.

The actual amount of service in terms of purchasing power that one nominal unit of money can provide the holder will depend on the quantity of goods and services that the unit of money is able to buy (ie its real value). The general price level (cost of these goods and services) is seen by the Modern Quantity Theorists to determine the real return of a nominal unit of money (Pierce and Tysome, 1985, p.68) as the real value of money holdings falls (rises) when the price level rises (falls). The expected rate of change of the price level can then in fact be interpreted as the expected rate of return to money holdings because the higher (lower) the expected level of inflation (or the expected rate of return to money holdings), the more (less) nominal money will be demanded (see Laidler, 1969, p.60). Friedman also identified inflation as the own rate of return of money and therefore included the expected rate of change of the price level in his money demand function.

The demand for money was seen to be a demand for real balances by the Modern Quantity Theorists because, as money is seen to provide the holder a flow of services through its purchasing power, they argued that the demand for money is determined in units of constant purchasing power, which means that the demand for money relevant to the analysis is then the demand for real balances. The demand for real money (M/P) is specified by Friedman as a stable function of, among other variables, the nominal interest rates on bonds and equities (R), real income (Y/P) and total wealth (w) or

$$M/P = f(R, Y/P, w\ldots.) \qquad (2.11.)$$

where income (Y) here is permanent income. Mathematically an individuals permanent income is similar to the expected value (Nerlove, 1958, p.98) of the individuals income, given a probability distribution of all measured income levels over his entire life.

The literature on the demand for money in the sixties tends to agree with Friedman's assertion that wealth and permanent income are the relevant long-run constraints on the broad definition of money (see also Friedman, 1957, p. 9-10). Notably, Meltzer (1963, p.222) favoured using wealth (as opposed to current and permanent income) as a long-run constraint on the demand for money whilst Chow (1966, p.113) found wealth and permanent income to be the more appropriate income variables to use in the long-run, as opposed to current income. Friedman (1959, p.349) found, as a result of money being regarded as an asset, that the more wealth that an individual has, the more money will be demanded, ie that money is a luxury good and the income elasticity of the demand for money is therefore greater than one. Further Dornbusch and Fischer (1990, p. 278-279) notes that the permanent-income theory of consumption, or consumer choice theory, upon which Friedman bases his analysis of the demand for money has, in the long-run, a very stable consumption income ratio but in the short-run this consumption income ratio is subject to random fluctuations. In Friedman's permanent income theory of consumption it is assumed that consumption is a function of permanent income (defined as consisting of all the individuals past current incomes, as well as the individual's level of human and nonhuman wealth, and all possible future incomes), and permanent income is in turn a function of the interest rate. Under the assumptions of consumer choice theory the demand for money will then depend on the individuals total wealth, which is his budget constraint; the return on money and the opportunity cost of holding other assets; and the tastes and preferences of the wealth holders (Friedman, 1956, p.4)).

To summarise the following conclusions can be drawn from the theory. The asset motive for holding money places a greater emphasis on real wealth or (real) permanent income as the determinant of the demand for money than on current income (Chow, 1966, p.111) as the speculative motive does. Wealth is seen as consisting of human capital (the present value of all future earnings) as well as nonhuman wealth (that which can be converted into money) whereas Keynes speculative motive does not provide such a broad definition.

In the speculative model a broad definition of money is normally used as narrowly defined money is typically not held at all due to the fact that there are so many alternative financial assets which are equally secure, but provide a higher rate of return. The asset model tends to define money as that which is generally accepted as payment for goods and services as well as an asset which yields its holder a flow of services. The more wealth an individual has, the more money will be demanded under Friedman's permanent-income hypothesis so that money is a luxury good, meaning that the income / wealth elasticity of the demand for money under the asset model will be greater than or equal to one.

With the advent of ATM's, check accounts, credit cards and all other means of converting an individuals wealth into instant liquidity, the transaction motive for holding cash, defined as the desire to hold a certain fixed amount of cash at the beginning of the period in order to make payments throughout that period, has nowadays become largely redundant. The stable or fixed demand for cash balances proposed by this transaction motive have therefore also by and large fallen away because of individuals withdrawing cash as and when they need it, or otherwise paying on credit or with checks. Sprenkle (1969, p. 847) found transaction motive for holding money to be particularly useless in estimating the demand for cash in large firms as they explained only a very small proportion of the cash balances held, leading him to conclude that money was demanded for purposes other than that proposed in the transaction motive.

On the other hand, the precautionary model, with its proposed variable demand for money is the motive which best explains the current fluctuations of money demand, as individuals typically hold money to maintain a certain level of liquidity for the purpose of meeting various contingencies that might arise. However this does not mean that Brunner and Meltzer's (1968, p. 1239) and Chow's (1966, p. 113 and p.127) views on the long-run demand for money should be disregarded but rather that the theory of stochastic fluctuations of money in the short-run within certain long-run upper and lower limits as proposed in the precautionary model is more valid than the concept of a fixed flow as in the transaction motive.

The idea of short-run random fluctuations moving away from and towards the long run (equilibrium) value of money demand is also an appropriate model for the motive where money is held as asset. This is because a certain desired or equilibrium level of money holdings exists in the long-run under the asset motive for holding money, but in reality in the short-run the actual level of the demand for money does not equal the desired level due to the existence of certain constraints which prevent the immediate adjustment of actual balances to the desired levels. These short-run disequilibriums or stochastic fluctuations from the equilibrium value are best modeled by the theory of precautionary demand for money. However this does not mean that the asset motive for holding money is invalid, in fact the transaction and asset theories complement one another as theories as money is demanded both for its function as a medium of exchange in transactions and as an asset to store value, but rather that the movements of money explained in the precautionary model is closest to the dynamics that are experienced in the demand for money in reality.

Friedman (1957, p.16) also recognised the precautionary motive for holding money and saw it being closely related to wealth, due to the desire of the individual to hold wealth (or precautionary balances) to meet any emergencies that might arise such as unexpectedly low receipts of money level of income. As mentioned above the question of whether the demand for money and permanent-income do in fact follow a random walk in the short-run as respectively suggested by Miller and Orr(1966) and Friedman (1957) will be answered in the estimations in chapter five.

The next three sections are included so as to give an overall view on some of the other theories on the demand for money, as well as to provide some theory on the role of inflation and exchange rates in the demand for money.

2.4.3. Buffer Stock Models

Central to the theory of buffer stock models is the role that money plays as a shock absorber to unanticipated changes in the level of cash balances. More specifically the necessity for holding a buffer stock of money arises firstly as a result of the existence of time lags in portfolio transfers (the substitution between money and bonds), so that a buffer stock of money becomes necessary in order to protect the individual from 'running out' of cash. There is also assumed to be a cost involved in finding a buyer for the agents non-monetary assets when he or she wishes to convert them into money. Agents therefore tend to hold a buffer stock of money in order to reduce brokerage costs and to prevent the holder from being suddenly illiquid when unexpected changes in prices or income levels occur (Laidler, 1984, p.19). This buffer also reduces the agents costs, in terms of time and money, of obtaining and using information, as well as providing the agent with a certain grace period before having to make adjustments to levels of employment, investment and output (Laidler, 1984, p.19) due to having a certain amount of 'spare' money.

The conventional form of the money demand equation therefore often contains a buffer stock term which captures the difference between the anticipated or desired level of the money stock, and the actual money stock. The buffer stock term is written as

$$\alpha(m_t - m^a_t) + u^a_t \qquad (2.12.)$$

where $m_t^a = gz_t$ and $m_t = gz_t + v_t$, $0 < \alpha < 1$, and z_t represents a set of variables that exert considerable influence on the money stock and g represents the parameters to be estimated. The variable m_t^a represents the anticipated money supply, and m_t is the actual money supply. The coefficient of the buffer stock term, α, is the adjustment coefficient of the partial adjustment model, and shows the rate at which the demand for money adjust towards the equilibrium level, ie the rate at which the individual adjusts his expenditures in order to reach a desired level of money holdings (Laidler, 1984, p.20).

The inclusion of this buffer stock term is important as it allows for the estimation of the short-run money demand function, as it is in the short-run that the actual level of money holdings may not be equal to its long-run or desired level (Gujarati, 1988, p.518). As will be reviewed in section (3.4.) Travlas (1989) has used this model to estimate the South African money demand function with some successful results.

2.4.4. The Demand for Money in the Open Economy and Inflationary Effects on the Demand for Money

As the purpose of this analysis is to focus on the demand for money and not particularly on the relationship between the demand for money and the exchange rates, the demand for money in the open market can be dealt with through the Mundell-Fleming model (Blanchard and Fischer, 1989, p.538). A reason for this is that only until fairly recently have there been any easing of exchange controls and until the last couple of years there have been heavy restrictions on domestic residents in South Africa have holding external assets. Consequently for the data set as a whole, running as it does from the second quarter of 1965 to the fourth quarter of 1997, virtually the entire period suffered from these restrictions. The effects of the exchange rate can be incorporated indirectly into the money demand function through the interest rate with the use of the Mundell-Fleming model (Blanchard and Fischer, 1989, p.538) as follows. Using the IS-LM model[13]

$$M/P = L(Y, I) \qquad (2.13.)$$

it is possible to take the inverse,

$$I = L^{-1}(M/P, Y) \qquad (2.14.)$$

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[13] See Vane and Thompson (1992, p.77-78) for a discussion of the IS-LM.

where M/P is the real quantity of money, I is the nominal (domestic) interest rate, L the demand for money and *Y* the real level of output. If e is the nominal exchange rate, ie the price of foreign currency in terms of the domestic currency, I' the foreign interest rate and the expected domestic interest rate equals the foreign interest rate then the following result can be obtained where

$$I = I' + \frac{(de/dt)^*}{e} \qquad (2.15.)$$

Source: Blanchard and Fischer (1989, p.538).

What this equation means is that if the price of foreign currency rises relative to the price of the domestic currency then the domestic interest rate will fall and, relating this to the theory on the inverse relationship between the demand for money and the rate of interest, the demand for money will increase (the domestic money is becoming cheaper). That is, the demand for (domestic) money rises when the price of foreign currency rises, which is captured by a fall in the domestic interest rate, ie domestic interest rates also include the effects of exchange rate changes.

The effects of expected inflation can be included in the analysis by specifying the demand for money function as a demand for real balances with the nominal as the opposed to the real interest rate as the regressor. The explanation for this can be given by referring to Barro's (1993, p.174) analysis on real and nominal interest rates. He defines the real rate of interest as the nominal rate of interest divided by the inflation rate or,

$$(1 + r) = (1 + I)/(1 + p^{\circ}_{e}) \qquad (2.16.)$$

where I is the nominal rate of interest, r is the real rate of interest and p°_{e} is the expected rate of inflation. Equation (2.16.) can easily be converted to

$$(1 + r)(1 + p^{\circ}_{e}) = (1 + I) \qquad (2.17.)$$

which then simplifies to

$$I = r + p^{\circ}_{e}, + r\, p^{\circ}_{e} \qquad (2.18.)$$

As the term ($r\, p^{\circ}_{e}$), is equal to a negligible amount when inflation rates are not excessive (below 20% see (Barro, 1993, p.174), the term ($r\, p^{\circ}_{e}$) can be excluded in a country such as South Africa where the inflation rate has not risen above this 20% level (see appendix A for the CPI index over the estimation period) so that the real rate of interest can then be approximated by

$$r \approx I - p^{\circ}_{e} \qquad (2.19.)$$

where ≈ means approximately equal to (Barro, 1993, p.174). By rearranging the above equation it is then possible to see that the nominal rate of interest can be given as

$$I = r + p^{\circ}_{e} \qquad (2.20)$$

where (r) is the real rate of interest, (I) is the nominal interest rate and (p°_{e}), is the expected rate of inflation which means then that the nominal rate of interest equals the real rate plus the expected rate of inflation.

Bailey (1956, p.93) in examining the welfare cost of inflationary finance found that a tax in effect equal to that of an excise tax is levied on the holdings of cash balances. That is, when the government increases the money supply to provide revenue for fiscal spending, the inflation rate rises, thereby increasing the cost of holding cash balances as a result of the rise in the nominal interest rate. (The nominal interest rate (I) increases because it is determined by the sum of the real interest rate (r) and the inflation rate (π) or $I = r + \pi$). Cagan (1956, p.25) disagreed with Baily's findings, and instead found that in ordinary inflations real cash balances (ie the demand for money) tended to rise however instead of decline as a result of the fact that it is the nominal, and not the real, amount of money that individuals want to hold which affected by the price level. He identified the real demand for money as being positively determined by real income and wealth in real terms and negatively determined by the expected returns from all forms of wealth, including money.

The theories reviewed so far in section (2.4.) have all pointed to the inclusion of interest rates and some measure of wealth and/or income in a specification for the demand for money. The relationship is postulated to be positive between the demand for money and income/ so that an increase in income/wealth will cause the demand for money to increase, whilst a negative relationship exists between the demand for money and the interest rates as they measure the opportunity cost of holding money. The next issue that needs to be addressed is that pertaining to the stability of the demand for money function.

2.5. The Question of Stability

A function is stable when it is unchanging over time meaning that when it is estimated over two (or more) separate periods in time the same estimates for the regression coefficients are obtained. Two issues that are relevant to the stability of money demand functions are the neutrality of money and the superneutrality of money. Money is said to be neutral when a once off change in the aggregate quantity of money influences the nominal variables in the money demand function but leaves the real variables unaffected (Barro, 1993, p.136). This can be explained by looking at the situation that arises when the money stock doubles: when the level of money stock is doubled the price level will double, as will the level of consumption/ income, but the level of real money balances will remain unchanged.

Superneutrality occurs when the real variables in the money demand function are also unaffected by the change in the money stock so that even if constant changes occur in the level of money, the real variables are unchanged. Although money has been seen to be neutral where the demand for real balances is unaffected by changes in the price level (via changes in the money stock), money has not proved to be superneutral which means that the variations in the path of money do have real effects (Barro, 1993, p.206) on other variables. Because of this effect that money has on other variables, the demand for money is very important to policy makers as changes in the real level of money causes changes in other real variables. Therefore for policy makers to be able to effectively carry out the desired changes through their policies they need to be able to accurately predict what effect any change in the level of money stock will have on other variables so as to be able to accurately include these effects into the consequences their policies will have.

These problems of policy makers can be solved by estimating a stable specification of the money demand function which would then enable policy makers to make reliable, accurate predictions about the effect that proposed changes in monetary policy will have on the economy. Judd and Scadding (1982, p.993) notes three points that are necessary for a money demand function to be stable:

(1.) a high degree of predictability as measured by the statistical criterion of forecasting accuracy, goodness-of-fit and accurately estimated parameters.

(2.) parsimony, which means that the model contains a few crucial explanatory variables determining virtually all of the variations in the demand for money, with the remaining minor influences being captured to the error term.

(3.) These explanatory variables should be highly representative of spending and economic activity in the real sector.

Empirical evidence on estimated money demand functions also gives an indication of the necessary attributes for a stable function. In the U.S.A. before 1973, money demand functions appear to be stable, but those estimated after 1973 have tended to be unstable[14]. In particular Laidler (1971, p.90-91) and Goldfeld (1976, p.685) find stable money demand functions before 1973 while Enzler, Johnson and Paulus (1976, p.261) and Goldfeld (1976, p.683) show that after 1973 the demand for money function tends to shift over time. This shift was ascribed by Judd and Scadding to certain financial and monetary changes occurring at the time, namely adjustments in the regulations on interest rate ceilings, innovations in the short-term financial markets and increases in post-war inflation and interest rates. Goldfeld and Enzler *et al* also found that the 'conventional' specifications of the money demand equations being used tended to regularly overpredict the demand for actual money balances, leading them to believe that misspecification errors had occurred. Two sources of instability in money demand functions can therefore be identified, misspecification errors and the failure to incorporate the dynamic components of money demand into the function.

2.6. Conclusion

The purpose of this chapter has been to review the theoretical issues surrounding the demand for money in order to provide a base for the specification of a function for the demand for money in South Africa. In particular the relationships between the variables and the reasons for the inclusion of variables themselves has been dwelt on.

The chapter began by examining whether the demand for money is for real or nominal balances by looking at the theories and evidence surrounding this issue. The recent evidence, both theoretical and

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[14] see Judd and Scadding (1982, p.994), Laumas and Spencer (1980, p.455), Hwang (1981, p.235), Hafer and Hein (1982).

practical points to the use of real balances, a result which makes sense as people generally are, in the end, not concerned with the amount of nominal units of money that they have but rather with what their money can give them in terms of goods and services, security or just a sense of achievement which is the real value of money.

The last section has addressed the question of stability in regards to the demand for money function. The theories surrounding this issue have suggested a number of features for the model to be stable. Most importantly the problems of misspecification errors and the failure to incorporate the dynamic or short-run components of money demand have proved to be the biggest problems in causing unstable money demand functions. Other characteristics indicative of a stable money demand are parsimony, inclusion of explanatory variable(s) that are highly representative of spending and economic activity in the real sector, and a high degree of predictability in the model as measured by the statistical criterion of forecasting accuracy, goodness-of-fit and accurately estimated parameters.

The following chapter, chapter three, seeks to examine the analyses which have already been conducted in this country over the period under review with the goal of providing further insight into the specification of a suitable function for the demand for money in South Africa over the period 1965:02 to 1996:04.

CHAPTER THREE

SOUTH AFRICAN LITERATURE REVIEW

3.1. Introduction

The development of the analysis of the South African demand for money has largely mirrored the path of studies in the rest of the world. While the aim of specifying a stable money demand function has remained the same, improvements have been made through the increasing sophistication of the econometric methods employed in the estimations. Initially simple log-linear functions, such as those proposed by Keynes (1936), Baumol (1952), Tobin (1952), Walen (1966) and Friedman (1956) in chapter two, were used to model the demand for money where logarithms are used to linearly relate money demand to the interest rate, some measure of income, and sometimes a price variable. This simple function however failed to take into account the need for the model to capture the short-run adjustment to the long-run equilibrium. This omission led to the use of partial and stock adjustment models, and, to a lesser extent, the buffer stock model.

Lately however the preferred estimation technique has been the use of cointegration, which enables the estimation of a stable long-run money demand function, or error correction modelling, which is able to account for the short-run movements of money demand and also provide a term to correct for the disequilibrium experienced in the short-run, by correcting for any deviation from the long-run (equilibrium) level. These techniques of cointegration and error correction modelling have not been specifically combined in the estimation procedure of any of the available studies done on the South African demand for money. Instead either one or the other of these two techniques have been used separately in the analysis. This gap in the applied work is consequently one of the reason for the estimation procedure used in the present analysis as it is felt that valuable insights into the nature of the South African demand for money can be gained by employing the method of cointegration, to estimate the long-run function, and then applying an error correction representation to the cointegrating equation to take the short-run dynamics into account. The purpose of this chapter is to provide some empirical perspectives on the estimations of the South African money demand function to ascertain which variables have been successfully used, as well as the most appropriate measures of the variables and the relevance of the results that were obtained.

This chapter is divided into four parts, the first section reviews the results obtained with the specification of a simple linear function, the next section reviews the South African literature using partial and stock adjustment models, section (3.4.) reviews the buffer stock model and section (3.5.) the more recent studies involving the use of cointegration and the error correction models.

3.2. The Linear Function

The South African money demand studies for the period coinciding with the length of the data set (1965:02 to 1996:04) begins with Heller (1966) who sought to estimate a stable money demand function for the period 1918-1955. The variables he employs in his analysis are money, broadly defined to include coins, notes and demand, fixed and savings deposits; current income measured by GNP, interest rates measured by the rate on twelve month fixed deposits or alternatively by the union treasury bill rate, a wealth variable which he does not, to the great disappointment of this study, define nor is it possible to obtain the definition of these figures from the original source. He also includes the general price level, measured by the implicit wealth deflator (and also unobtainable).

Heller (1966, p.335-340) makes use of the following simple logarithmic function

$$M = a + bY + bW - bR + bP\ ut \qquad (3.1.)$$

where M is nominal money, Y is the nominal GNP, W is a nominal measure of wealth and R is the interest rate variable. Running equation (3.1.) three times, and excluding the wealth variable from the regression in the second estimation and GNP from the third, he finds that the current income, as measured by GNP, exhibited the most stability as the value of its estimated coefficient only altered slightly when the wealth variable was included in the money-demand equation, whilst wealth on the other hand was highly unstable as its value changed significantly when GNP was included in the regression. Similarly he found that the inclusion of the general price level in the model significantly increased the explanatory power of the model, which is to be expected as he uses a nominal measure of money, and that the interest rate which performed best overall was the interest rate on 12 month fixed deposits.

In order to examine the stability of the demand for money function, Heller divided the period under analysis into three sub-periods and employed three different definitions of money in each period. He found that only the narrowly defined money equation in the first period was significant, and concluded that the demand for money equations did not have the same degree of stability in the short run as that exhibited in the long run. This conclusion is in fact erroneous as the above method shows that it is the money demand function itself that is unstable, as the parameter values changed significantly in the regressions for each period. The linear function estimated by Heller for the long-run demand for money is therefore misspecified due to the existence of instability in the parameters.

Maxwell (1971) also concluded that Heller had not estimated a stable long-run function for money arguing that the log-linear function of Heller could not be fitted over both the pre- and post-war period as money, broadly defined to include savings deposits, would differ in the different period as a result of a high degree of forced savings during World War Two and of the swift growth of the financial sector after the War. In order to prove that the linear function of Heller's represents a misspecification, Maxwell estimated a linear function expressing the variables in logarithmic form as Heller did for the demand for money over the years for the same time period that Heller used (1918-1960).

Following Heller's method he regressed the real money stock, both narrowly and then broadly defined, against the interest rate (defined as the rate of interest on twelve month fixed deposits) and current income (Gross Domestic Product) first, and then against the interest rate and permanent income (weighted average of current incomes as defined by Friedman in section (2.4.2.), and lastly against wealth and the interest rate for the whole period. He found that the permanent income model using the income variable was the model which proved to have the best explanatory powers. Further the interest elasticity was significant and displayed the negative sign expected by theory.

However an extremely low Durbin-Watson statistic was obtained for all the regressions which indicated a possible misspecification of the functional form through the identification of serial correlation of the error terms. To check this possibility of misspecification, Maxwell then estimated the logarithmic function of the demand for money over the two sub periods (pre- and post-war periods) by running two separate regressions, one for each sub-period. The results for the two periods were substantially different, that is a separate regression was necessary for each sub-period in order to determine that period's money-demand which provided confirmation of the existence of a parametric shift in the money demand function over the whole period. Next, Maxwell checked to see if the inclusion of a price variable could improve the regression, or in other words, he checked if the function works better when fitted in nominal terms. The results obtained did not differ significantly from the previous results however, although the price variable itself was significant. Maxwell therefore took this to be proof that the previous results were not a consequence of the misspecification of the function due to being expressed in real variables but of the linear functional form employed.

Stadler (1981, p.145-152) also initially made use of a log-linear model of real money balances regressed on real income and the interest rate, but alternatively used money both broadly and then narrowly defined, and two types of interest rates (the rate on three month bankers acceptances and the rate on company stock debentures). Stadler therefore did not specify a variable, as such, to represent permanent income but preferred instead to let the interest rate reflect the demand for idle balances. The data which he used to estimate his results came from the period 1965-1979.

Unlike Heller (1966) and Maxwell(1971), Stadler found the coefficient of the interest rate to consistently have the incorrect sign. Further the demand for money was on the whole interest inelastic as the interest rate was insignificant in explaining the demand for money. These results are heavily in contradiction with Maxwell's results, who found money to be interest elastic. However it must be remembered that Maxwell analyzed the period of 1918 to 1960 whilst Stadler was looking at the years from 1965 to 1979 and, as Stadler notes, the pre-war elasticities estimated by Maxwell where much higher than the post-war elasticities, and so the lack of relationship between the interest rate and the demand for money in the next period could be seen as a continuation of the trend begun in the years examined by Maxwell. This empirical result is supported theoretically by Marty (1961, p.59-60), in a criticism of the Gurley and Shaw hypothesis on interest elasticity. Marty shows that an increased number of substitutes for currency would cause those who are highly sensitive to the interest rates being offered, to place all their currency into the higher interest earning deposits, and then leave it there, causing the market interest elasticity to be lower than it was initially[15].

The one exception to the prevalence of the interest inelasticity in Stadler's results was where a long-term interest rate was regressed against broadly defined money stock, but the relationship still remained incorrectly, positive. Possible explanations for this positive correlation between money-demand and the interest rate put forward by Stadler, includes the fact that the broad definition of money encompasses interest bearing deposits, and so a rise in the interest rate would then be expected to increase the demand for these deposits. The fact that narrow money is interest inelastic he explained as a result of the increase in liquid assets which, as alternatives to narrow money, are more attractive stores of value given the inflation levels in that period. Thus all narrow money held would be solely for transaction purposes which, by definition, is interest inelastic.

The Durbin-Watson Statistic also indicated a possible misspecification of the function. As a result of the lack of significance of the interest rate variable, Stadler decided to drop it from his specification, and instead include the price level. The resultant price elasticity was less than unity contrary to theoretical expectations of a price elasticity of zero, ie that the price variable was not a significant

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[15] Cagan and Swartz (1975) and Darrat and Webb (1986) also find evidence to contradict Gurley and Shaws hypothesis.

explanatory variable in the demand for money equation (see the transactionary, precautionary, speculative and asset demand theories in the previous chapter). This value of the price elasticity of the demand for real balances was also exhibited in the results obtained by Heller in his earlier study. When Heller replaced the price variable with an inflation variable, inflation was not found to significantly contribute to the determination of the demand for money and so this implied that consumers appeared to be reacting to the change in the level of prices as opposed to the rate at which prices changed, and as a result this outcome appeared suspect.

The failure of the linear model to actually provide a stable specification for the long-run demand for money is mostly due to the fact that it does not take into account the actual short-run nature of the demand for money holdings as it provides no means for the adjustment between the actual and the desired or equilibrium level of balances to occur. As noted above, failure to take into account the nature of the short-run movements of money will result in a false regression being obtained which appears to give indication of a meaningful relationship between the regressors, typified by high R^2 values (obtained by both Heller (1966, p. 338) and Maxwell (1971, p.18) showing a good relationship between the dependant variable and the explanatory variables, when in actual fact the opposite is true (section (4.4.1.) explains this concept of false or spurious regressions in more depth). To attempt to correct for these short-comings Maxwell next madè use of a lagged stock adjustment to model the long-run demand for money.

3.3. The Partial (Stock) Adjustment Models

Using the same variables as in his estimation of the linear demand model Maxwell ran the following lagged stock adjustment model[16] of the form

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[16] This model is actually an autoregressive model as in equilibrium, ie where the amount of money demanded equals the amount supplied equals the optimum amount of money, ie $M^d_t = M^s_t = M^*_t$, then $M^*_t = M^*_{t-1}$ so when imposing this condition that 3.1. becomes

$$l_nM_t = \alpha_0 + \alpha_2 l_n r_t + \alpha_2 l_n A_t \qquad (3.1.1)$$

$$l_nM_t = \alpha_0 + \alpha_1 l_nM_{t-1} + \alpha_2 l_nr_t + \alpha_2 l_nA_t \qquad (3.2.)$$

to represent the money demand function. This mechanism yielded better results than the previous linear model used for the period as a whole as there were no indications that the function was misspecified, with the Durbin Watson statistic showing that no autocorrelation was present. A parametric shift in the function was still evident from the F-test and when this regression was run separately over the two sub-periods, the results were again markedly different. That is, the lagged stock adjustment model gave the best results for the pre-war period, but gave poor results for the post-war period. Reasons advanced by Maxwell for this phenomenon was that the high rate of economic growth and rapidly expanding secondary and tertiary sectors brought about a rapid growth of near banks. These institutions provided a whole new spectrum of liquid assets that were superior to M1[17] as a store of money in that they offered interest and a certain level of security, eg cheque and transmission deposits. A significant conversion from the holding of currency to deposits therefore occurred, with a direct result of M1's decline as a store of value being that the transactions motive then became relatively more important in determining the level of holdings of M1. Also, Gurley and Shaw (1955, p.520) noted that the growth of these near banks actually caused the demand for money to become more interest elastic, through the individuals greater awareness of the opportunity cost of holding money as a result of the increased choice of, and competitiveness for, the provision of these liquid assets.

Maxwell decided that it was not possible in his analysis to find a function which would be appropriate for both the pre- and post-war periods, and so adopted the lagged stock adjustment model for the pre-war period, while for the post-war period he found the most successful functional form to be a linear time trend. He therefore concluded that the demand function was not stable in the long-run as it had undergone a significant parametric shift between the pre- and post-war periods.

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[17] Defined by Maxwell as note, coins and demand deposits.

Stadler also decided to estimate a new model, using the partial adjustment hypothesis postulated by Nerlove (1958, p.15-18) as he felt that past empirical[18] and theoretical studies (see section 2.4.3.) pointed to the presence of lags in the money demand equation. That is, he believed that the demand for money depends, among other things, on its value in the previous period. This can be seen by assuming a desired level of money holdings, M^*_t, which individuals would like to hold, and which does not always equal the actual level of money-demand, M_t. The reason for this assumption is that as the demand for money is determined by factors such as income, prices, expectations, etc, it changes over time as these determining factors change, and as individuals are not always able to instantaneously adjust their desired level of money holdings to the changes, the desired level of money balances diverges from the actual money balances. This divergence between the desired and actual money balances causes the change in money demand for one period to be only a fraction, g, of the desired change, or

$$M_t - M_{t-1} = g(M^*_t - M_{t-1}) \qquad (3.3.)$$

where $0 < g < 1$. The question arises here whether the adjustment in the demand for money is real or nominal. Chow (1966) assumes that the adjustment is real, an assumption which has been criticised by White (1978, p.567-8) who believes that the adjustment process is nominal. Fair (1987) and Gupta and Moazzami (1990) examined the performance of both the real and nominal adjustment processes for 27 countries and 11 Asian countries respectively and found that the nominal adjustment process is be empirically superior to the real adjustment process).

Stadler also included expected income instead of observed income in the money demand function by first using the following hypothesis to form income expectations

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[18] See Maxwell(1971) (reviewed above).

$$Y^*_t - Y^*_{t-1} = k(Y_t - Y^*_{t-1}) \qquad (3.4.)$$

where $0 < k < 1$. That is, Y^*_t is expected income, and in each time period expectations are updated by a fraction, k, of the current value of income, Y_t, and the previous expected value of income, Y^*_{t-1}. This hypothesis, known as the adaptive expectation, progressive expectation or error learning hypothesis (Gujarati, 1995, p.596), gained widespread recognition through the works of Cagan(1965, p.33-77) and Friedman(1957). What this hypothesis is representing is that expectations about future income (income levels in the next period) are formed by some fraction of the difference between the actual income level in this period and the expectation of the level of income in this period which was formed in the previous period. Some fraction(k) of the previous error made in estimating expected income levels in the past is therefore taken into account when next forming expectations of income levels. The partial adjustment mechanism is therefore used to show the short-run adjustment to the long run (equilibrium) level.

Stadler used the adaptive expectations hypothesis to obtain expected income and then regressed real money-demand on expected income (as opposed to observed income) by combining equation (3.3.) with the following log- linear money-demand equation

$$M_t = b_0 + b_1 Y^*_t + b_2 P_t \qquad (3.5.)$$

to obtain

$$M_t = kb_0 + kb_1 Y_t + b_2 P_t - b_2(1 - k)P_{t-1} - (1 - k)M_{t-1} \qquad (3.6.)$$

also expressed in logarithms. The estimates for the coefficient of the expected income variable performed better than the one obtained earlier for observed income, as did the estimates for price, but there was a high presence of multicollinearity in the model. That is, three of the variables, Y_t, P_t and P_{t-1}, are co-linear (intercorrelated with each other) giving rise to the possible consequences of multicollinearity: a greater likelihood of not including relevant variables in the equation through wider confidence intervals, insignificant t ratio's and high R^2 values. For this reason then, as Stadler notes, one should not rely to heavily on the estimated model.

An important point arising from this analysis however is the fact that Stadler finds absolutely no discernable relationship between the demand for money and the interest rate. Kantor (1979, p.75) and the Franzsen Commission (1970) noted the apparent lack of sensitivity of the demand for credit[19] (especially hire purchase finance) to the interest rate but found other types of financial demands to be more interest elastic. An explanation given by the Franzsen Commission (1970, p.158) for the interest inelasticity of hire purchase credit is the increased level of spending occurring as a result of individuals perceptions that it is better to spend now (even on credit if they have to) as opposed to later, because goods and services are becoming more and more expensive due to the high rate of inflation experienced since the second world war.

Contogiannis and Shahi (1982, p.26-34), in an extension of the work done by Stadler, examined the period 1965-1980. They felt that certain aspects of the demand for money function had received insufficient attention, namely price expectations which they introduced in the form of adaptive expectations used by Stadler to form expectations of income levels. By introducing the price variable into their analysis, their aim was to provide an alternative variable to measure the opportunity cost of holding money instead of the traditionally used interest rates. They used the adaptive expectations

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[19] Credit here refers to the purchase of goods on credit, but in effect money is being bought on credit with which to purchase these goods, and as such, a rate of interest is levied on the money being borrowed. There is therefore a demand for this type of money as well, and a broad definition of the term 'money' would include hire purchase credit. Thus the demand for credit can be seen as an indication of the demand for a certain type of money.

process to form the price expectations as follows

$$P^*_t - P^*_{t-1} = \delta(P_t - P^*_{t-1}) \qquad (3.7.)$$

where δ is the coefficient of price expectations representing the fraction of the difference between P_t (current prices) and P^*_{t-1} (the previous expected prices) by which expectations are updated in each period. As Shaw(1984, p.25) points out this means that agents are in effect learning from their mistakes by 'adapting' their current expectations of future prices as a result of what their past experiences were. (P^*_t being the expected price level in period t). Contogiannis and Shai incorporated these adaptive price expectations[20] into the partial adjustment model estimated by Stadler (that is they replaced observed prices with expected prices in the money-demand function), and then estimated the model using first a narrow and then a broad definition of money.

They also made use of current income (GDP) in their logarithmic real money demand function, as did Stadler in order to maintain the continuancy, and their results yielded an income elasticity in excess of one, with the correct sign. The expected price level was highly significant as an explanatory variable, and the price elasticity was negative 0.5. When interest rates were included in the function they were also found to be statistically insignificant (as in Stadler's analysis).

Courakis (1984, p.1-39) comes to the same conclusion as Stadler, and Contogiannis and Shai, on the importance of expectations in determining the demand for money; and also on the possibility of the desired money stock adjusting to changes in the actual money stock, with a time lag. However he disagreed with the assumption made by these earlier studies on unitary income and price expectations

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[20] Adaptive expectations are not rational however as systematic errors are carried through because individuals are assumed to form their present expectations systematically from past expectations and experiences. Expectations are never completely revised so that the adjustment is never complete, that is the error itself is not taken into account, further than just adjusting expectations either up or down in the subsequent period if they were under- or over-estimated respectively in the previous period. Under rational expectations however individuals are assumed to use all information available to them when forming expectations.

(ie. $k = 1$, $\delta = 1$, where k and δ are the expectation coefficients in equations (3.3.) and (3.6.)), and on the income and price expectation coefficients equaling one another (ie. that $k = \delta$). Both Stadler, and Contogiannis and Shai therefore assumed income and price expectations to be unitary and equal. Stadler treated price expectations as unitary (that is observed prices equaled the expected prices, $P_t = P^*_t$) by not including price expectations in his model and using observed prices instead. Combining adaptive expectations for income with the partial adjustment hypothesis of desired money balances to changes in actual money balances, Stadler obtained equation (3.6.) where income expectations are assumed to be unitary, $Y_t = Y^*_t$. Courakis criticised Stadler's assumption of unitary income expectations because he felt that none of these assumptions can be made *a priori*, and also because it is not realistic to expect the expectation formation process for real income and the price level to have the same coefficient when they are two entirely different variables with different determinants, or in other words for expected price and income levels to equal current observed price and income levels. Instead he felt that it would be more reasonable to test for the these two assumptions after estimating the parameters of the nominal money-demand equation.

Courakis therefore felt that the previous two papers had not sufficiently analysed the problem at hand, namely the demand for money in South Africa over the period 1960 - 1980, and so sought to provide a more reliable and extensive examination of the subject. To this end he estimated a money demand equation (for narrowly defined money, M1) by combining the approaches of Stadler (1981) and Contogiannis and Shai (1982). He did this through solving equations (3.3.) and (3.6.) for expected income and expected prices respectively, and then substituted into the following logarithmic money demand function expressed by Friedman (1959, p.111-139) where

$$M_t = \alpha_0 + \alpha_1 Y^*_t + \alpha_2 P^*_t \qquad (3.8.)$$

to obtain

$$M_t = \delta k\alpha_0 + k\alpha_1 Y_t - k(1 - \delta)\alpha_1 Y_{t-1} + \delta\alpha_2 P_t + \delta(1 - k)\alpha_1 P_{t-1}$$
$$+ (2 - k - \delta)M_{t-1} - (1 - k)(1 - \delta)M_{t-2} \qquad (3.9.)$$

In estimating the results for this logarithmic money-demand function(3.8.) using South African data over the period 1965-1980, Courakis found, through the use of the Chi-squared test, that the hypotheses of unitary income expectations and equal expectation coefficients for real income and the price level (found by the previous two papers mentioned) to be false. The expectation processes generating price and income expectations did not correspond to the *a priori* assumptions which formed part of the econometric standards applicable in the previous economic literature on South Africa. Moreover the estimates obtained for δ, the price expectation coefficient, was greater than unity, and so inconsistent with the adaptive expectations process used to form these price expectations, an important point as it implied functional misspecification.

Further Courakis found that the elasticities of demand with respect to the permanent price level were not what he had expected given the literature in other countries, and that the permanent income elasticities were greater than one which he believed indicated possible misspecification of the function through the omission of relevant variables, as Friedman (1957) holds that the income elasticity will be less than one.

Courakis decided to seek a more general specification of the money-demand function to counter this possible functional misspecification through either including more determinants in the function[21], making use of alternative expectation processes to form price and income expectations[22] , or through

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[21] Courakis does not give his theoretical reasons for embarking on theses changes but Gujarati (1988, p.356) notes that a researcher typically starts with a possible model which may not be the correct one, but does provide a starting point. After running the regression analysis, the researcher checks to see if the results support the a priori theoretical expectations. When it does not the researcher begins to change the model, and the case of possible exclusion of relevant variables is one of the possible causes of specification bias (the possibility of misspecification arising from inclusion of irrelevant variables is precluded here by the absence of multicollinearity, see above for explanation on multicollinearity).

[22] The third cause of model misspecification is by using the incorrect functional form (Gujarati, 1988, p.357). Thus by using alternative means of forming price and income expectations, the adjustment of actual to desired money balances will in effect give rise to other sub-functions used to form these variables.

finding other possible ways to depict actual money balances adjusting to their desired levels. Consequently, Courakis included interest rates and expected inflation as additional determinants of the demand for money to give the following log-linear function

$$M_t = \alpha_0 + \alpha_1 Y^*_t + \alpha_2 P^*_t + \alpha_3 R^*_t + + \alpha_4 X^*_t \qquad (3.10.)$$

where R^*_t is the permanent or expected interest rate, such that

$$R^*_t = \mu R_t + (1 - \mu) R^*_{t-1} \qquad (3.11.)$$

and $X^*_t \equiv P^*_t - P^*_{t-1}$ is expected inflation. Courakis's rationale for including interest rates was that as a measure of the opportunity costs of holding money, interest rates are the most conspicuous omission from the money-demand equation. The reason for initially omitting these interest rates in the analysis is that Courakis sought to mirror the work done by Stadler and Contogiannis and Shai (who omitted interest rates[23]) in order to improve and add to their findings. Courakis, using the same data for interest rates as Stadler did, included them as levels (assumed they were levels but did not give a reason why) and not as logarithms, and as a result found that the responses of the interest rates were significant and conformed to theoretical expectations, (see section 2.4.).

Courakis felt that inflation expectations also needed to be re-examined as Contogiannis and Shai had made an error in treating the expected price level as a measure of the expected rate of inflation (and also in using real as opposed to nominal measures of the money stock in their money demand

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[23] These previous researchers incorporated interest rates as a result of the fact that the broad definition of money used encompasses interest bearing deposits and so the interest rate would be money's own interest rate as opposed to the opportunity cost of holding money (see section 3.1. above).

equation when price expectations ($P^*_t = \delta P_t + (1 - \delta)P^*_{t-1}$) equation (3.7.)) were among the determinants). The results from this new, corrected money demand function showed the interest rate to be significant, as noted, and expected inflation to be even more significant than the interest rate.

Next he made use of the following adjustment mechanism of actual (nominal) money balances to desired (nominal) money balances as it was more flexible

$$M_t = gM^*_t + (1 - g)M_{t-1} + \Phi(M^*_t - M_{t-1}) - (M^*_{t-1} - M_{t-2})$$

(3.12.)

where M^*_t is the desired level of money balances, which Courakis uses to replace M_t in equation (3.9), M_t being the actual level of money balances. In re-estimating the equation, Courakis found evidence of serially correlated error terms. That is, there was evidence that the error terms of one observation were related to the error terms of other observations, giving rise to the possible consequences of serially correlated disturbance terms: insignificant t and F tests causing a greater likelihood of not including relevant variables in the equation, the R^2 values are overestimated giving the illusion that the model fits the data better than it really does, possible consequences which cast severe doubt on the validity of the model.

As a result therefore Courakis examined the structure of the error terms, and found that part of the problem occurred as a result of the exclusion of variables contributing to the seasonal variation in the demand for money and part of the problem was due to the omission of other relevant explanatory variables. Courakis did not precisely establish which variables these were through empirical testing, but instead just gave some examples of the variables that could possibly be included, namely changes in the payments mechanism and in savings habits.

Courakis made allowance for these ignored and omitted factors, ie serial correlation, opportunity costs etc. by re-estimating the following double-log money demand function

$$M_t = a_0 + \Sigma^{w-1}{}_{w=0} a_{yw} Y_{t-w} + a_y Y^{\wedge}{}_{wt} + a_y Y^{\sim}{}_0 (1 - g)^t + \Sigma^{n-1}{}_{v=0} a_{pv} P_{t-v}$$

$$+ a_p P^{\wedge}{}_n + a_p P^{\sim}{}_0 (1 - \delta)^t + \Sigma^{s-1}{}_{\sigma=0} a_{\sigma r} R_{t-\sigma} + a_r R^{\wedge}{}_{st} - a_r R^{\sim}{}_0 (1 - \mu)^t$$

$$+ \Sigma^{J}{}_{j=0} a_{mj} M_{t-j} + \epsilon^t$$

(3.13.)

where $Y^{\wedge}$, $P^{\wedge}$, $R^{\wedge}$ are Koyck terms[24] of the permanent income, price and interest variables respectively for the first period, and $Y^{\sim}$, $P^{\sim}$, $R^{\sim}$ are the Koyck terms for the next period, and so have less of an impact than the first set of Koyck components on the demand for money (the terms relating to the following period would have an even smaller effect on the demand for money, and so on). Upon estimating this regression Courakis found that the Koyck terms could be omitted as the hypothesis that the expectations can be modeled by a Koyck procedure was statistically rejected.

Courakis found interest rates to be statistically significant however, irrespective of the nature of the expectation process used, and the inclusion of the lagged value of the dependent variable (narrowly defined money) was also significant, when the lags were of a higher order than two. Further the elasticity of real income decreased to less than one, as predicted by Friedman (1956, p.58) in the Quantity Theory, and the price elasticity became less than or close to unity. The best functions, where the qualifying criteria was adherence to theoretical expectations and the minimization of the residual sum of squares, was equation (3.12) with, and without, the Koyck terms. These two specifications were found to approximate the actual movement of the South African demand for narrow money very

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[24] Koyck terms are variables included in the distributed lag model but which are assumed to decline geometrically so that each previous value is less than the one preceding it, so that observations in the distant past have less impact than those in the immediate past (Gujarati, 1988, p.513). For example we would expect current and recent income levels to affect the demand for money more strongly than income levels in the distant past.

closely, and without any structural breaks, ie that the long-run demand for money was relatively stable over the period analysed by Stadler, and Contogiannis and Shahi.

Whittaker (1985, p.184-196) agrees with Courakis on the numerous shortcomings manifest in the previous works of Stadler, and Contogiannis and Shahi, but felt nevertheless that Courakis did not come any closer to identifying the correct functional form, or the parameters of the South Africa money-demand function. Whittaker also felt that Courakis did not manage to support, or repudiate any of the relationships proposed by the theory on the demand for money. Whittaker specifically criticised Courakis's use of the Chi-squared test as he felt that the number of observations in Courakis's data set (20) was insufficient for the test to perform properly (as the confidence intervals are to wide leading to greater acceptance of variables), where Courakis defined the degrees of freedom, *n*, to be the number of free coefficients estimated in each circumstance and *n* ranged from 1 to 3. Whittaker suggested that the F-test be used instead which gave lower confidence levels for the rejection of the functions restricted by unitary and/or equal expectation coefficients.

Whittaker then set out to test the robustness of Courakis's best (statistically superior) money demand equation, equation (3.12.). Accepting that the Koyck terms in equation (3.12.) were statistically insignificant, Whittaker omitted them, obtaining the following logarithmic function

$$M_t = a_0 + \Sigma^6{}_{w=0} a_{yw} Y_{t-w} + \Sigma^6{}_{v=0} a_{pv} P_{t-v} + \Sigma^6{}_{\sigma=0} a_{\sigma r} R_{t-\sigma}$$

$$+ \Sigma^7{}_{j=0} a_{mj} M_{t-j} + \epsilon^t$$

(3.14.)

which he proceeded to estimate over different time periods and data series, in order to test how it stood up to different conditions. The parameter values he obtained proved to be different for each data set used, and markedly different to those obtained by Courakis, as well as having large standard deviations and appearing to be unstable. Further, by running the Chow test for stability Whittaker found that the parameters were not constant (appropriate) for the entire set of observations.

Whittaker also criticised Courakis's choice of GDP as a measure of income, as he felt GDE(Gross Domestic Expenditure) was more appropriate when dealing with the narrow demand for money, as a result of the fact that in South Africa most incomes tend to be paid in the form of broadly defined money, while narrowly defined money (currency and demand deposits (M_1)) is more often used for expenditure. He also felt that the rate for three month bankers acceptances (BA) would be a better measure of the opportunity cost of holding money than the treasury bill (TB) rate, arbitrarily selected by Courakis. This was because most of the treasury bills have at some stage been held by the Reserve Bank or National Finance Corporation, and as a result the BA rate is perhaps a more appropriate measure of the market cost of short-term credit. However when the BA rate is used instead of the TB rate the interest rate coefficient becomes positive and statistically insignificant. As a result Whittaker felt that the theoretical relationship (see chapter 2) between money-demand and the interest rate was not supported, which was in accordance with the previous findings of Stadler and Contogiannis and Shahi. Thus Whittaker felt that the parameters were sensitive to the structure of the model, the data series used and the time period under analysis, and as a result he found the demand for money(M1) function estimated by Courakis to be unstable.

3.4. The Buffer Stock Model

Travlas (1989, p.1-13) believed that this particular criticism of Whittaker's (about Courakis's study) could be countered through the use of the buffer stock model, where money supply shocks are one of the determinants of real money balances. That is, in the buffer stock model, money is assigned the role of a buffer or shock absorber which allows individuals (temporary) relief from having to make adjustments (in terms of employment levels, investments etc) to shocks in the money supply, reducing the costs of obtaining and assimilating information attendant on these adjustments (see section 2.4.3).

Travlas then set out to test the performance of the buffer stock model (equation 3.16.) against the conventional money demand equation which he defined as follows

$$m_t - p_t = a_0 + a_1y_t + a_2r_t + a_3(m_{t-1} - p_{t-1}) + u_t \tag{3.15.}$$

where m_t is the logarithm of the nominal money stock, p_t is the logarithm of the price index, y_t the logarithm of income or wealth, r_t the logarithm of the opportunity cost of holding money and u_t is the error term. The lagged dependent variable includes the costs of adjustment and the permanent values of the other determinants. This model, estimated in its various derivations by the preceding literature, has often been unstable, a problem which Travlas sought to counter through making use of the following buffer stock model

$$\begin{aligned} m_t - p_t = a_0 + a_1y_t + a_2r_t + a_3(m_{t-1} - p_{t-1}) \\ + a_4(m_t - m^a_t) + u^a_t \end{aligned} \tag{3.16.}$$

where $m_t^a = gz_t$ and $m_t = gz_t + v_t$, and z_t represents a set of variables that exert considerable influence on the money stock such as macro-economic disturbances or 'shocks' and also the lack of synchronization of payments and receipts. The variable m_t^a represents the logarithm of the anticipated money supply, and g represents the parameters of z_t to be estimated.

In estimating these models Travlas used South African data over the period 1977- 1987. He tested two opportunity cost variables, the long-term government bond rate, and the treasury bill rate, while the deposit rate was used for measuring money's own rate. He used real GDP as a measure of income and M3 as a measure of money, corrected for seasonality. Equation (3.15.) results were very poor, with GDP, the treasury bill rate and the deposit rate all proving to be statistically insignificant, although the coefficients of the treasury bill and deposit rates were negative and positive respectively, as predicted by the theory (see chapter 2). The only significant variable was the lagged dependent variable. The Chow test, with the period split in half (1977:04 to 1983:03 and 1982:04 to 1987:03) gave evidence of a structural break occurring between these periods, indicating a very unstable function. In order to find a regression which gave a more stable function for the demand for money Travlas then ran the regression a number of times with alternative variations on the explanatory variables.

To test for inflationary expectations, Travlas formed an expected inflation series through using a polynomial lag structure of past inflation rates, and then included these (adaptive) inflationary expectations in the model (3.15.), but they also proved to be insignificant. Travlas then replaced the treasury bill rate with the long-term government bond rate which caused the results to improve, as the variables all were statistically significant, but the Chow test still indicated that the function was unstable, although not by as much as the treasury bill specification. The inflationary expectations were again insignificant when included in this equation (long-term government bond equation). Finally substituting the treasury bill rate in place of the deposit rate, also gave an unstable regression.

Travlas then estimated the buffer stock model, equation(3.16.). All the parameters proved to be significant, particularly the money shock term, which is a series derived from the difference between the actual money supply and an anticipated money supply series. The Chow statistic showed the buffer stock function to be stable. Travlas found one problem with the buffer stock model specification however, namely that nominal money stock, m_t, in the monetary shock term may be correlated with the dependent variable's numerator m_t. Travlas set about to correct this by using the monetary base to replace the money supply in the monetary shock term as he felt that changes in the monetary base are likely to occur before changes in M3 which lessens the correlation between the real money balances and the first component of the monetary shock term. Although not as highly significant as before, the 'new' monetary base term in this alternative specification of equation (3.16.)

proved to still be significant. By alternatively making use of instrumental variables to form a series for m_p and then re-estimating equation (3.16.) using this version of the monetary shock term, Travlas found that the specification performed even better, as the monetary shock term became highly significant, whilst the Chow statistic indicated that this specification of the demand for money function was the most stable of all.

The buffer stock model relies on exogenous shocks to the money supply which in turn then influence the demand for real money balances; however if the money supply is endogenous to the interest rate, then the buffer stock model would obviously not be applicable in South Africa. For this reason, Travlas examined the exogenity of the money supply and the interest rates using the Granger procedure and found that interest rates did not determine the money supply, that is the money supply was not endogenous to the rate of interest, but rather that the money supply tended to determine the level of interest rates. Travlas concluded that a stable specification for the demand for money as proxied by M3 did appear to exist.

A possible criticism here however is the shortage of the data, merely 11 years of quarterly observations makes for a very small data set, and therefore it is easier to fit a stable function over this as opposed to a much longer period, where there are likely to be more influences on the demand for money.

3.5. Summary of the South African Money Demand Studies before the Use of Cointegration and Error Correction Modelling

The literature on the South African demand for money in this section started with Heller's work in 1966, although the actual study of Heller covers the period from 1918 to 1955, and ended with Travlas (1989) whose analysis comprised the period 1977 to 1987. Therefore almost eighty years of the South African demand for money have been reviewed without common consensus being reached on the exact specification of the demand for money function.

Heller (1966), Maxwell (1971), Courakis (1984) and Travlas (1989) all found the interest rate, as a proxy of the opportunity cost of holding money, to be significant explanatory variables in determining the demand for money, and to be negatively related to money demand as predicted by theory. Both Heller and Maxwell made use of the 12 months fixed deposit rate at commercial banks as a measure of the rate of interest, which they regressed on broadly defined money (Heller :currency, demand, savings and fixed deposits, Maxwell: currency demand, and savings deposits). Courakis used the rate on three month bankers acceptances and the rate on company stock debentures to measure the rate of interest, which were the same interest rates used by Stadler (1981) in his money demand function, except that Stadler used the logarithm of these rates, obtaining an insignificant result, whilst Courakis used the level form and found that the interest rate significantly explained the demand for narrowly defined (currency and demand deposits) money. Travlas however made use of the long-term government bond rate, as the opportunity cost of holding money, and the deposit rate, as money's own rate, and found the demand for money, broadly defined as M_3, to be interest elastic. Moreover, the buffer stock model estimated (with GDP as the income variable) by Travlas was stable.

As mentioned above, Stadler found the demand for money to be interest inelastic when regressing interest rates on both narrowly defined (currency and demand deposits) and broadly defined money. Contogiannis and Shahi (1982) replaced the interest rate in Stadler's function with adaptive price expectations as an alternative proxy for the opportunity cost of holding money and found this variable to be significant. Whether it is a good proxy for the opportunity cost of holding money however is debatable. Whittaker (1985) also found the demand for money to be interest inelastic and he used the Banker's Acceptance rate to measure the rate of interest, in order to have continuity with Courakis's results.

All the studies mentioned above have two similarities in that they all make use of the log-linear or double log functional form to express the money demand equation and they all employ an income variable as one of the determinants. The exact definition of this variable, current or measured income as opposed to permanent income or wealth, differs however from study to study. Heller, Maxwell, Stadler and Contogiannis and Shai, who all analyse the demand for broadly and for narrowly defined money (with the exception of Heller who uses only broadly defined money), all make use of current income (GDP, GNP, GDP, GNP respectively). Courakis, in analysing the demand for narrowly defined money (M_1), makes use of permanent income, but fails to explain which variable or process he used to measure it other than 'real income'. Whittaker however correctly notes that when analysing narrowly defined demand for money, the preferred measure for current income should be GDE (Gross Domestic Expenditure), as narrowly defined money is used more for expenditure. Travlas, in analysing only the demand for broadly defined money, M_3, used GDP to measure income, although Whittaker did previously raise the following caveat on GDP, that it has the well known tendency to be understated as a result of failing to measure the informal sectors income, a point which makes GDE more reliable as a proxy for current income.

Both Heller[25] and Maxwell include some measurement of wealth in their analyses, with Maxwell using the consolidated value of private and governmental holdings of (a.) buildings and construction, (b.) machinery, plant and equipment and (c.) inventories. Since these early studies, wealth has not been included amongst the determinants of the demand for money function , one of the reasons being the difficulty of measurement of this variable.

The use of real as opposed to nominal money demand has been quite prevalent in these analyses, eg. Maxwell, Stadler, Contogianiss and Shai. Courakis however made use of nominal money balances as he felt that by using real money balances, the 'negative effect' of inflation on the demand for real money would be overstated as for example when changes in the income variable occur there is a positive effect on real money demanded, but as changes in the inflation rate are assumed to be zero, that is the effects of inflation on the demand for real money are assumed to be zero, no change occurs in the demand for money, instead of causing a decline in money demand, hence overstating the effect. Courakis therefore believed that when using real money balances, the results will be biased. Whittaker

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[25] The actual figures which Heller used to measure wealth are not obtainable however as the reference he cited in which the definitions of the wealth variable are given (see Heller, 1966, p.336) is unavailable.

and Travlas, the money demand studies following directly on from Courakis, accordingly-used nominal money in their specifications.

3.6. Cointegration and Error Correction Modelling

Hurn and Muscetelli(1992) felt that while studies like Travlas's buffer stock approach have managed to specify money-demand functions which are stable over time, they have still not arrived at the correct specification of the long-run demand for money as a result of neglecting to examine the nature of the short-run adjustment towards the long-run level. Using the method of cointegration outlined in section three, Hurn and Muscetelli sought to estimate the long-run money demand function for M3 and then to examine nature of the long-run elasticities of the model.

In choosing the variables to include in the cointegrating equation, Hurn and Muscatelli wanted to satisfy two main objectives, (a) to choose variables which would ensure that a certain degree of compatibility was maintained with the previous studies, and (b) they wished to examine M3's dependence on its own and other interest rates. The reason for their choice of M3 as the dependent variable was that it is this broad definition of money balances which South African monetary policy targets, and consequently the policy makers need to know if it is stable for their policies to be effective. The explanatory variables Hurn and Muscatelli chose to regress M3 on were real income, measured by GDP at constant factor prices; interest rates, both the average commercial bank retail rate (as a proxy for M3's interest rate) and the interest rate on three year government stock as the alternative interest rate and a price variable measured by the GDP deflator. All the variables are expressed as logs, except for the interest rates. The next step in the analysis is to check the order of integration of all the time series to see if they are the same, as is required in order for the variables to be cointegrated. Hurn and Muscateli found them all to integrated of order I(1) (explained in section (4.4.2.)), giving rise to the following cointegrating regression

$$M3_t = \alpha_0 + \alpha_1(Y - p)_t + \alpha_2 P_t + \alpha_3 DR_t - \alpha_4 R_t \tag{3.17.}$$

where (Y - p) is real income, P_t is prices, DR_t is M3's own interest rate and R_t is the alternative interest rate. Estimating this regression with the maximum likelihood procedure, Hurn and Muscateli found that the demand for money was positively related to real income, prices and its own interest rate, and negatively related to the alternative rate of interest. These results are all consistent with theoretical expectations, and moreover as the variables are cointegrated there is a unique long-run relationship between M3 and its determinants.

Hurn and Muscateli then tested certain restrictions on the model in order to determine how robust it was. The first hypothesis tested was that the cointegrating parameter equaled zero, ie that $\alpha_1 = 0$, $\alpha_2 = 0$, $\alpha_3 = 0$, $\alpha_4 = 0$. However all the long run elasticities were significantly different to zero, including the interest rate semi-elasticities, ie both interest rates were found to significantly explain the money demand regression. The next hypothesis tested was that the price and income elasticities equaled one, but this hypothesis was rejected as well. The fact that a unit income elasticity could not be imposed on income elasticity, suggests that the use of GDP (a proxy for real income) as a scale variable is not such a good idea. Hurn and Muscatelli therefore suggested the inclusion of a wealth variable in order to improve the results.

The last hypothesis tested was that the interest rate elasticities have the same magnitudes, but different signs, and this hypothesis was accepted, indicating that it would be more appropriate to use interest rate differentials as opposed to levels. The fact that interest rates proved significant is very important as the earlier studies found that interest rates were not significant in determining the demand for money.

Hurn and Muscateli concluded on the basis of these significant results that there appeared to be a fairly robust long-run demand function for money, with all the elasticities in the constant elasticity model proving significant, with the correct signs. They acknowledged however that the problem of obtaining a stable function which included the short-run movements of the demand for money function still remained, indicating a need for further research.

Naudé (1992, p.51-61) managed to estimate such a short-run function by making use of an error correction mechanism which links the short-term behaviour of the dependent variable to its long-run behaviour. He used the error correction model in order to solve the problem of serial correlation that has plagued the partial adjustment models estimated in the past (see Contogiannis and Shahi, and Courakis). In order to compare the error correction model with the partial adjustment models used in the earlier literature, Naudé proposed, in keeping with the partial adjustment models, that the desired level of money balances is determined by permanent income, prices interest rates and inflation, as follows

$$m^* = k + \Phi_0 p + \Phi_1 y + \Phi_2 r + \Phi_3 \Delta p \qquad (3.18.)$$

where p is the price level, y is real income, r is the opportunity cost of holding money and Δp is the inflation rate. The price level was measured by the consumer price index (CPI), the three month treasury bill rate is used as a proxy for interest rates (r), and the inflation rate was measured by the growth rate in the CPI.

Naudè obtained the following error correction model by manipulating the above equation (3.18.) to obtain

$$m_t = \beta_1 + (\beta_1 - \beta_7)\Delta p_t + (\beta_2 + \beta_6)\Delta y_t + (\beta_3 + \beta_7)\Delta r_t$$

$$+ (\beta_4 - \beta_9)\Delta^2 p_t + (\beta_5 - 1)[m_{t-1} - p_{t-1} - y_{t-1}]$$

$$+ \beta_3 r_{t-1} + \beta_4 \Delta p_t \qquad (3.19.)$$

Estimating the error correction model, he found a high short-run elasticity of income which he explained by reference to South Africa's political and social instability, and thus a possibly high precautionary demand for money. He also found he found a high short-run elasticity of inflation. As Naudè used narrowly defined money to estimate the money demand function he attributes this as a possible further explanation for the high elasticities observed. The problem of serial correlation was solved by the error correction model, which also made use of unit income and price elasticities which were rejected by the partial adjustment model, however the model was not a good predictor of the period 1981 to 1989, possibly as a result of the use of narrow money, and thus Naudè notes that further research is needed using a broad definition of money such as M3.

3.7. Conclusion

These empirical studies show that real income is the most important determinant of the demand for money, although consensus on the magnitude of the income elasticity is not as easily reached. The literature seems on the whole to point to the need for the inclusion of a variable reflecting the opportunity cost of holding money, due to the existence of risk and return causing a substitution between money and other assets. Both long and short interest rates have been used, depending on whether a broad or narrow definition of money is adhered to. Studies show that narrowly defined money is sensitive to both long- and short rates. Broadly defined money, whilst also being responsive to both long and short rates, exhibited a theoretically inconsistent positive interest elasticity for short-term interest rates. The most commonly used figures to measure income was GDP, with GDE being used by only one study. A number of interest rates were used with the interest rate on twelve month fixed deposits being the most common. Both real and nominal specifications of money were used, but the recent trend in the demand for broad money involves modelling a real specification. Hurn and

Muscatelli (1992, p.164) suggest the inclusion of some measure of wealth into the specification for real broadly defined money in order to emphasise the asset demand for money. This present study attempts to fill the gap in the theory of regressing some measure of wealth on the demand for real money and so follows Hurn and Muscatelli's suggestion.

CHAPTER FOUR

The Model

4.1. Introduction

The theoretical and literature reviews in chapters two and three have emphasised the need for the inclusion of certain features when specifying a function for the demand for money. While the opinions expressed in the theory are often not in agreement, a general consensus exists on the use of the money stock as the dependent variable with some measure of income and the opportunity cost of holding money as explanatory variables.

The studies done in South African on the demand for money have most often used the interest rate to measure the opportunity cost of holding money, but not always with theoretically consistent results in regards to the sign of the coefficient (see Stadler (1981, p.147), Whittaker (1985, p.191) and Travlas (1989, p.7)). More specifically, theory points to a negative relationship between the demand for money and the opportunity cost of holding money so the attainment of a positive value for the estimated interest rate coefficient violates these expectations. Consequently one of the main aims of the specification of a money demand function for South Africa should be to obtain a function which yields a negative relationship between the demand for money and the opportunity cost of holding money, along with the positive relationship between the demand for money and income expected by theory. A general or standard model for the demand for money specifying these expected relationships between the variables is outlined below in section (4.4.5.)

In a more recent analysis of South African money demand Hurn and Muscatelli (1992, p.168) have suggested that the incorporation of a wealth variable into the function when current income is used as the scale variable would lead to improved results. In order to comply with this suggestion a proxy for wealth, defined below in section (4.3.), has been included in the estimation of the money demand function with a view towards ascertaining whether in fact the results improve with the inclusion of a wealth variable, as opposed to the results obtained when the wealth variable is excluded from the money demand function. Section (4.2.) therefore also presents a general specification of the demand for money function which includes a wealth variable amongst the regressors in the fashion most commonly indicated by economic theory and past studies.

The method of cointegration has been used to estimate the long-run money demand function, and an error correction model has then been applied which accounts for the short-run dynamics of the model and also provides a term which corrects for the short-run deviations from the long-run level of money demand. These estimation methods are in line with those used in recent money demand studies done in South Africa as well as in the rest of the world (see Hurn, 1991; Hurn and Muscatelli, 1992; Naudè, 1992; Hendry and Ericson, 1991; Hafer and Jansen, 1991; Dickey, Jansen and Thornton, 1991; Miller, 1991; Arestis and Demetriades, 1991; Psaradakis, 1993; Simmons, 1992; Huang, 1994; Choudry, 1995, Haug and Lucas, 1996).

A detailed explanation of the concept of cointegration and of the error correction model is therefore given in section (4.4.), along with definitions of all the relevant terms. First however it is necessary to provide a specification of the demand for money function which is widely accepted in the literature (reviewed in chapter two) in order to provide a base for all future explanations of the analysis.

4.2. Specification of The Model

The following model for the long-run demand for money can be estimated from the theory where the common consensus is that the demand for money ii a function of some measure of income or wealth and of the opportunity cost of holding money which is usually measured by the interest rate. A standard specification of the demand for real balances can therefore be given as

$$(m_t - p_t) = \alpha_0 + \alpha_1(y_t - p_t) - \alpha_3 i_t + u_t \qquad (4.2.1)$$

where $(m_t - p_t)$ is real money balances, α_0 is the intercept term, $(y_t - p_t)$is real income and i_t is nominal interest rates and u_t is the error term of the regression. Section (2.3.) above explains the theoretical reason for the inclusion of a nominal interest rate variable. Common consensus is reached in the theory reviewed in sections (2.4.1.) and (2.4.2.) on a relationship between the demand for money and income, and a negative relationship between the demand for money and interest rates.

The inclusion of a wealth variable in the estimation of the demand for money in South Africa has, as mentioned above, been suggested by Hurn and Muscatelli (1992,) in order to improve the results and as is stated in the introduction in chapter one forms the main feature of the present analysis. However due to the paucity of recent South African studies estimating money demand functions containing wealth variables it was not possible to follow a method laid out by a previous study and consequently the method employed by the Deutsch Bundesbank is followed instead. This involved first estimating equation (4.2.1.) above and then estimating the function for the demand for money which specified as

$$(m_t - p_t) = \alpha_0 + \alpha_1(y_t - p_t) - \alpha_3 i_t + \alpha_5(w_t - p_t) + u_t \qquad (4.2.2.)$$

where $(w_t - p_t)$ is a measure of wealth expressed in real terms, which is positively related to the demand for money. This equation is identical to equation (4.2.1.) above except for the inclusion of the wealth term. The reason for this is to enable comparison of the results. The lower case letters in both equations denote natural logarithms and from here onwards all variables denoted by lower case letters are in natural logarithms.

4.3. The Variables

4.3.1. Introduction

The empirical study is based on quarterly figures, from the second quarter of 1965 to the fourth quarter of 1996, yielding 127 observations in total. The data employed in the analysis is therefore time series data. All the variables are expressed in natural logarithms as is common in money demand analysis due to the need to express the nonlinear money demand function expected from economic theory in a linear form. Expressing the money demand function in natural logarithms also has the added benefit of providing the elasticities of the variables straight from their estimated parameters.

4.3.2. The Variables and Data Sources

1. The Monetary Aggregates.

In the empirical literature on money demand, both in South Africa and in the rest of the world, there is no one monetary aggregate (or definition of money) which is commonly used. Rather a broad spectrum of definitions have been used -from money defined in the most narrow sense to be just notes and coins - to more all-encompassing definitions including long-term deposits at monetary institutions and post office savings certificates. Most of the recent studies done on the South African demand for money have used broadly defined money, M3, in their analysis (see Travlas, 1989; Hurn, 1991; Hurn and Muscatelli, 1992). However Naudé (1992) has made use of a very narrow definition of just currency while Whittaker (1985) chiefly uses currency plus demand deposits.

The economic theories on the demand for money also do not reach a common consensus. The transaction and precautionary models of Baumol-Tobin, Whalen and Miller and Orr in chapter 2, section (2.4.1), employ a narrow definition of money, whereas the asset demand and consumer demand theories chiefly contributed by Allias and Friedman favour the use of a much broader definition of money (see section (2.4.2.)).

Consequently three alternative definitions of money have been employed in the analysis, defined by the South African Reserve Bank as M1, M2 and M3. M1 is the narrowest definition of money and consists only of banknotes and coins, M2 is broader adding cheque, transmission and other demand deposits of the private sector plus all other short-term deposits, less than one year, and medium-term deposits, usually less than three years that are currently being held by the South African domestic private sector (SARB, March 1997, p. S-23). M3 includes the definitions of M1 and M2 and adds long-term deposits of the private sector with all types of monetary institutions and post-office savings certificates to its definition of money. A consistent set of quarterly figures for M1, M2 and M3 were obtained from those published by the South African Reserve Bank on its website at *Http://www.resbank.co.za* and are identical to the figures given for M1, M2 and M3 in the Quarterly Bulletin, but have the added advantage of being readily available to download directly into your computer. (The file name the relevant data can be found in is kpb1.dat).

As presented in chapter two, Friedman (1956, p.5) uses a broad definition of money, defining it "*as claims or commodity units that are generally accepted in payment of debts at a fixed nominal value*". One would therefore anticipate that when the expectation of the most appropriate monetary aggregate to use is based on these asset demand theories (see section 2.4.2.), the broadly defined M3 would then not be the closest out of the above three alternatives to Friedman's definition of money as it includes assets that are not generally accepted in payment such as short-, medium- and long-term deposits. However due to the significance held by M3 in South Africa through its adoption in 1986 as the monetary target, and the fact that it has been the variable most commonly used in recent South African studies, M3 is expected to be the monetary aggregate most appropriate as the dependent variable for the estimation of a demand for money function over period 1965:02 to 1996:04. The theory on the demand for money tends to support this belief as the use of a broad definition of money is advocated when a wealth variable is included amongst the regressors (see Friedman, 1969, p.74). This last point is of considerable interest to the present analysis due to the paucity of recent South African money demand studies including a wealth variable as a regressor, and in chapter five once the estimation procedure has been carried out the validity of using M3 as a dependant will be examined.

2. The Scale Variables.

The theory reviewed in chapter two, section (2.4.2.), has shown that early analyses (see Chow, 1966, p.113; Meltzer, 1963, p.222) found that using a measure of real wealth or real permanent income as the scale variable for broadly defined money gave better results than a current measure of income. The earlier South African empirical literature on the demand for money also advocates the use of wealth and permanent income as the relevant scale variables to include in the analysis (see Maxwell (1971)). However as there is a lack of official figures for wealth in South Africa it is difficult to obtain meaningful figures for wealth, and for estimation reasons permanent income figures have usually not been used. As a result the majority of studies on the South African demand for money have made use of a current measure of income such as GDP(Gross National Product), GNI(Gross National Income) and GDE (Gross Domestic Expenditure). GDP has been used most commonly in the South African literature and has consequently been included as one of the measures of current income in the analysis.

Judd and Scadding (1982, p.993) however argue that the explanatory variables used in specification of the demand for money function should be highly representative of spending and economic activity in the real sector in order to ensure the functions stability. Further Whittaker (1985, 191) surmises that GDE tends to be a more reliable measure of current income in South Africa than GDP because of the tendency of GDP to underestimate the true gross domestic product of the country as it does not take the product of informal (and illegal) sector activities into consideration and also suffers in the estimation of goods and services produced for self-consumption. Figures for GDE are included in the analysis and have been obtained, together with the GDP figures from same source as the monetary aggregates above.

The construction of permanent income is possible with the use of a geometrically declining lag structure of all past and future incomes (see section (2.4.2.)) but the use of such an econometric technique exceeds the boundaries of the present analysis. Instead a wealth variable has been employed following Hurn and Muscatelli's (1992, p.164) suggestion that *"when modelling the demand for broad money some measure of wealth might profitably be included, a development which would emphasise the asset demand for money"*. The incorporation of a wealth variable into the function when current income is used as the scale variable is then consistent with this suggestion of Hurn and Muscatelli who use GDP to measure of income. In order to comply with this suggestion a proxy for wealth has been included in the estimation of the money demand function with a view towards ascertaining whether in fact the results do improve.

The wealth variable used is the financial assets of domestic households and enterprises, as measured by figures obtained from the reserve bank on consumer credit in South Africa, where consumer credit consists of personal loans, instalment sale and lease agreements and open accounts. Domestic Credit has also been used as an alternative to consumer credit and is defined as the total broad monetary credit extended to the domestic private sector. Domestic credit is further defined by the reserve bank to include mortgage advances, instalment sales, leasing finance, investments[26], and other loans and advances (South African Reserve Bank Quarterly Bulletin (SARB), 1997, p.21) thereby giving a broader definition than consumer credit. (Total credit on the other hand is defined as total domestic credit extended by the broad monetary sector and includes domestic credit plus net credit extended to the government sector and was also included as a variable in the analysis).The data series for all three forms of credit were obtained for both via personal communications and facsimile transmissions with the Reserve Bank.

The motivation for using consumer credit and domestic credit extensions to the domestic private sector as a measure of wealth is presented below, but the main reason as mentioned before is due to

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[26] Investments here refers to credit extended to the public sector through public sector interest bearing securities such as yield bearing securities issued by local governments, public companies and enterprises, and subsidiary companies of the public sector (as defined by Mev. van der Winter in the National Accounts Department of the South African Reserve Bank; South African Reserve Bank's DI900 sheet).

no official figures on wealth being available causing an alternative proxy to be sought. Credit therefore was employed as it can be argued that it provides a measure of wealth for the following reasons. The surplus capital of agents in the economy provides a main source of the funds that are extended as credit with the result that the level of credit can then provide some measure of wealth or capital (Falkena *et al*, 1991, p.27). Money that is borrowed on credit is usually by its very nature done so in order to enable the debtor to purchase some asset whether it is the fees for a university degree, payments on a house or to use in wealth creation opportunities. These assets are also forms of wealth even to the extent of human capital as defined by Friedman (section (2.4.2.), p.30). Further in Friedman's (1957, p. 9-10) theory of the consumption function (see section (4.4.2.), p.30) wealth is defined as the total of the agents expected receipts of money (whether borrowed as credit or received as earnings) over a period. In the present analysis it can be argued that in the South African case credit extended such as mortgage advances, leasing finance, instalment sales (hire purchase), other loans and advances and lease sales (South African Reserve Bank Quarterly Bulletin, 1997 p.21) to the private sector does provides some measure of the receipts of money borrowed by the individual in the period (which here is one quarter of the year[27]).

Total credit, being a still broader measure of credit is also included as an alternative proxy to see if it improves the results. While not conforming to the conventional measures of wealth, credit measured in real terms is used as proxy for wealth in the present analysis.

3. The Opportunity Cost of Holding Money

Interest rates have mainly been used in the theory (see section 2.4.) and the empirical literature to provide a measure of the opportunity cost of holding money (see Stadler (1981);Courakis(1984);

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[27] It is acknowledged that Friedman (1957, p.11) argues that this definition of wealth in consumption theory "*makes much more sense if...regarded as a generalization from this special case to a longer horizon*". To comply with this definition would then require the extension of the figures to obtain the present value of permanent income for each time period and provides indication for the possibility of further analysis using appropriate estimation techniques for permanent income given above. However due to the focus of this thesis being on the application of cointegration and error correction modelling to the South African demand for money it has been decided not to pursue this additional estimation. This is partly due to length, and partly to the use of error correction modelling which provides a function for the short-run demand for money so that the use of current income, which is more of a short-term measurement of income than permanent income, is then more appropriate.

Travlas (1989); Hurn and Muscatelli (1992) for South African applications) because of the measure of the return on alternative assets that they provide. As a result care should therefore be taken not to use returns of broadly defined money itself from fixed and other deposits as a measure of the opportunity cost of money. The interest rates which have been used in the analysis as measures of the opportunity cost of holding money are the yield on three year government bonds, the yield on fifteen year government bonds, and to be consistent with previous studies, the interest rate on twelve month fixed deposits at commercial banks has also been used[28]. Use of the own rate of return of broadly defined money (the interest rate on twelve month fixed deposits at commercial banks), will cause a positive, as opposed to a negative, relationship to occur between the demand for money and the interest rate, which has in fact often been the case in the South African literature (see section 3.).

The theory of the transaction and asset motives points to the use of longer term interest rates when a broad measure of money is employed and shorter term interest rates for narrow definitions of money, which means that the yields on three and fifteen year government bonds would then be expected to be more appropriate as the opportunity cost of holding M3. The inflation rate has also been used as an a measure of the opportunity cost of holding money by a number of studies, and in South Africa Stadler(1982) and Contogiannis and Shahi(1982) have made use of the expected price level. This is not an appropriate variable to include in the specification of the function for the real demand for money however as the nominal interest rate has been argued by Barro (1993) (see section (2.4.4.)) to include the expected rate of inflation. For these reasons the nominal interest rate has been used instead in the specification of the demand for real balances. Consistent series for these variables were obtained for the three interest rates from various issues of the South Africa Reserve Bank quarterly bulletins and via personal communications with the Bank. The CPI (consumer price index) rate was also obtained in the same fashion and has been used as the price variable to deflate the nominal values of the monetary aggregates and the income and wealth variables to express them in their real terms.

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[28] Use of a differential interest rate might in fact be a better measure of the opportunity cost of holding money, but would not have been consistent with the methods employed by the Deutsche Bundesbank (1995) and Wong and Kennedy (1992), and so for this reason has not been included.

4.4. The Method of Cointegration and Error Correction Modelling as an Estimation Procedure

4.4.1. Introduction

As the data being used in this analysis is time series data it becomes necessary to pay attention to the problems that can arise when regressions are run on time series data. Spurious or false regressions are often obtained where the variables appear to be meaningfully related, but on closer inspection the relationship actually turns out to be false (spurious) due to the existence of a common trend running through the data and not, as supposed, to the explanatory power of the regressors. The method of cointegration enables the pure relationship between the variables to be estimated without any trends in the data affecting the results. This is done by only using variables which are cointegrated with one another (integrated of the same order) so that the trends then cancel out. Section (4.4.3.) gives the tests that can be carried first out on the data to ascertain whether they are integrated of the same order, or not, and section (4.4.4.) reviews the method of cointegration. Before proceeding to these sections however it is necessary to first review the concepts of stationarity, differencing and unit roots as they form the basis of the tests used in finding the order of integration of the variables.

4.4.2. Stationarity, Differencing and Unit roots

A time series is generally thought of as being generated by a stochastic (or random) process, and when this process has a constant mean, variance and autocovariance[29] over time then the series is said

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[29] Where autocovariance refers to the covariance of the time series, X_t, with itself, ie the covariance between two time periods. When the autocovariance is constant over time this means that the value of the covariance between the two time periods does not depend on the actual time at which the covariance is computed, but rather on the distance between the two time periods, which is constant (Gujarati, 1995, p.713).

to be weakly[30] stationary (Harris, 1995, p.15; Gujarati, 1995, p.713). A stationary time series is therefore one in which the underlying stochastic process that generates the series is time invariant which means that plotting the data for a variable from two separate but equal length time periods would give two plots with similar, if not identical statistical properties (McDermott, 1990, p.2). This is because the data series keeps returning to its mean level, and so is stationary about its mean. Any sudden changes or innovations experienced in one period do not continue to affect the data series in future time periods because of this characteristic of constantly varying around and returning to the same mean value.

Granger (1986, p.214) and Engle and Granger (1987, p.252-253) formally define a stationary time series as one which:

(i.) has a zero mean and a finite variance
(ii) has a finite expected time length between the crossings of the mean
(iii) results in a change or innovation only having a temporary effect on the time series
(iv) has autocorrelation that is finite and decreases over time.

This definition of constant variance and a zero mean value of stationary data can be illustrated by way of examining a very simple data generating process for the time series X_t. The following first order autoregressive process, AR(1), is used where X_t is generated by the regression of X_t on itself lagged by one time period or,

$$X_t = \rho X_{t-1} + u_t \qquad (4.4.1.)$$

where ρ is the coefficient of autocovariance, X_{t-1} is X_t lagged by one period, and u_t is white noise - a random error term that is not correlated with itself in different time periods, and has a zero mean and a constant variance. The process continues as the term X_{t-1} is itself determined by the same data

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[30] A time series is stationary, as opposed to being weakly stationary, when it complies with the description given by Engle and Granger (1987, p.252-253).

generating process so that

$$X_{t-1} = \rho X_{t-2} + u_{t-1} \qquad (4.4.1.a.)$$

and similarly X_{t-2} is generated by

$$X_{t-2} = \rho X_{t-3} + u_{t-2} \qquad (4.4.1.b.)$$

and so on. In equations (4.4.1) it can therefore be seen that the value of the time series in one period depends on its value in the previous period and on a random error component, while the coefficient of autocovariance, ρ, determines by how much the current value of X_t depends on its previous value. When $|\rho| < 1$, then the current value of X_t is influenced by only a fraction of its previous values, which means that innovations in the past are able to gradually die out as time passes by and when $|\rho| = 0$ the innovations will vanish altogether by the next time period as $X_t = u_t$ so that each observation (X_t) is not influenced by any previous values of itself. The time series can then be seen to regularly return to its previous values, having a constant mean and a constant variance when it is stationary.

The error terms associated with the time series, X_t, are not perfectly correlated when the series is stationary ($|\rho| < 1$) because the current value of X_t is influenced is by only a fraction (or by none) of its past values so that the error term associated with the current value of X_t is then only influenced by a fraction of the value of error terms in previous periods. Also the most recent error term will be weighted more heavily than preceding errors (see footnote 28) in stationary time series so that autocorrelation (the correlation of the error term with itself over time) is finite and decreasing.

In comparison a non-stationary time series is defined (see also Granger, 1986, p.214, Engle and Granger, 1987 p.253) as having:

(i.) an infinite variance as time tends to infinity (ii.) changes which occur in one period permanently affecting the time series in all subsequent periods

(iii.) an infinite expected time length between the crossings of the mean

(iv) an autocorrelation coefficient close to one.

Returning to equations (4.4.1) above, the time series X_t can be seen to be non-stationary when $\rho = 1$ as the full influence of every past value of X_t will then come to bear on the generation of the present value of X_t. Consequently any innovations or changes that occur in one period never have a chance to die out, but are instead carried through into all the subsequent periods. This can be shown with the use of the following equation (4.4.2.), obtained from equations (4.4.1) with $\rho = 1$ and the method of repeated substitution, that the current value of X_t is determined by its initial value X_{t-n} plus the sum of all the error terms between t - (n - 1) and t, or

$$X_t = X_{t-n} + \sum_{t=1}^{t-(n-1)} u_t \qquad (4.4.2.)$$

from Harris, 1995, p.15. This means that the full impact of the random growth of every past value of the time series comes to bear on the generation of the current value so that the variance of X_t will become infinitely large as $t \to \infty$. Further the error term of the time series will be perfectly correlated with itself over time, indicating the presence of autocorrelation. The time series, X_t, will then have different means at different points in time (Harris, 1995, p.15) rather than one mean value in the conventional sense as the time lapse between the series returning to one of its original values is infinite.

As mentioned above, running regressions on non-stationary time series using conventional econometric techniques such as OLS often results in spurious, or nonsense, regressions where a statistically significant relationship appears to exist between the highly trended variables (variables whose mean changes over time), but on closer inspection this relationship is found to be false as it is due to a trend component in the non-stationary data, and not to the existence of a valid causal relationship between the variables. These regressions typically have high R^2 values and very low Durbin-Watson (DW) statistics (see Banerjee *et al,* 1986, p. 254; Granger and Newbold, 1986, p.205; Mills, 1990, p. 268) as a result of them appearing to show meaningful relationships between the variables hence the high R^2.

A non-stationary error structure is said to be associated with relationships estimated using highly trended variables (see Malley, 1989, p.52) because the variables are influenced by a trend component that, when not taken into account by including it in the regression as a variable, is then captured by the error term of the regression and the error term will then become non-stationary. The error terms then become correlated with one another in a regression run on non-stationary data with the result that the regression suffers from autocorrelation (hence the low DW values showing the presence of autocorrelation). The consequences of this are (see Granger and Newbold, 1974, p. 111) that:

(a.) the parameter estimates obtained in the regression are inefficient, ie the variances of the regression coefficients are large

(b.) forecasts made from these spurious regressions are inferior

(c.) the usual tests of significance (t and F) tests are no longer reliable (and neither is the DW (Durbin Watson) statistic)

Philips (1986, p. 313) noted that the t-tests distributions tend to diverge from the normal distribution, which then causes the use of conventional critical values of the standard t distribution to be invalid. Further as the sample size increases, the tendency to reject the null hypothesis that estimates of the regression coefficients equal zero increases, due to the tendency of non-stationary series to exhibit increasing variance as time goes by (as the sample size increases), which means that the probability of accepting the existence of a (false) relationship between unrelated non-stationary time series increases (Granger and Newbold, 1974, p.115; Harris, 1995, p.15). It can therefore be seen that regression coefficients of non-stationary time series do not tend to converge in probability to constant values as the sample size increases (as time goes by) so that the estimated regression is unstable and therefore not ideal for forecasting purposes. Stock and Watson (1988, p. 151) argue in particular that because of the random growth of random walks, forecasts of the levels of non-stationary data will increase in uncertainty as the time frame over which the forecasts are being made lengthens because this random growth in the stochastic trend of the variable in one period forms the base from which the next period's growth results.

The above problems associated with running regressions on non-stationary time series can be solved however by making the relevant time series stationary. This can be done by running a regression of the form

$$X_t = \alpha + \beta t + u_t \qquad (4.4.3.)$$

and then simply removing the deterministic time trend, βt (where a trend is roughly described as being deterministic when it is perfectly predictable and not subject to erratic changes) and the intercept, α.

Nelson and Plosser (1982, p. 140) however observe that macroeconomic time series tend to display upwards trends and increasing variances so that it is more appropriate to describe them as being non-stationary with a (stochastic) drift trend rather stationary with a (deterministic) time trend - a stochastic trend being one which is highly variable and so is subject to random movements or shifts away from the path previously being followed by the variable (see also Box and Jenkins, 1970, p.7). Non-stationary time series that exhibit stochastic trends therefore follow random paths or walks because of the stochastic trends influencing them and so do not have a constant mean, variance or auto-covariance over time. A stationary time series in comparison is one that is governed by a deterministic trend because it continues to revert back to the mean over time and therefore has a finite variance and autocovariance.

This distinction between the type of trend influencing non-stationary series is of importance to this analysis as it has already been established in a review of the theory that the demand for money is stochastic and not deterministic in nature, as summed up by Milbourne (1983, p.685) who states that

> *"money is held not only because of the lack of syncronization between receipts and payments, but also because the timing and amounts of inflows and outflows cannot be perfectly anticipated. Consequently, the stochastic nature of inflows and outflows plays an important role in the demand for money, and optimal rules of money holdings under stochastic specifications are likely to be different from those of deterministic models."*

Nelson and Kahn (1981, p.748) argue that applying the above trend stationary process to remove non-stationarity in the data when the underlying data generating process is non-stationary with a stochastic drift trend causes valid dynamics to be lost which then results in a loss of information previously contained in the data. Instead they advocate the process of differencing the variables in order to render them stationary (as do Granger and Newbold, 1974, p. 118). This involves subtracting the value of the variable lagged by one period from its current value, and, if necessary, repeating the process by subtracting lagged values from the new values until X_t equals u_t. To explain the concept of differencing more fully, the first order autoregressive equation (4.4.1), repeated here as equation (4.4.4.), can be estimated,

$$X_t = \rho X_{t-1} + u_t \qquad (4.4.4.)$$

where u_t is the random error term defined above. If the coefficient of the lagged dependent variable is unitary in value, $\rho = 1$, the time series has a unit root and is then non-stationary. A time series with a unit root is called a random walk time series and is an example of a non-stationary time series (Granger and Newbold, 1974, p.113. When $p = 0$, the term ρX_{t-1} disappears from equation (4.4.4.), so that the variable X_t becomes equal to the error term, u_t, which is stationary, so the variable X_t is stationary, that is

$$X_t = u_t \tag{4.4.5.}$$

A time series with a unit root, $\rho = 1$, can be made stationary by differencing equation (4.4.4) to obtain,

$$\begin{aligned} X_t - X_{t-1} &= (\rho - 1)X_{t-1} + u_t \\ \Delta X_t &= (\rho - 1)X_{t-1} + u_t \end{aligned} \tag{4.4.6.}$$

where Δ is the first difference operator so that $\Delta X_t = (X_t - X_{t-1})$. When $\rho = 1$,

$$\begin{aligned} X_t - X_{t-1} &= u_t \\ \Delta X_t &= u_t \end{aligned} \tag{4.4.7.}$$

and the first difference of the non-stationary series has been rendered stationary through differencing. The previously non-stationary time series has therefore become stationary and so contains no unit roots, because the only deviations from the mean are caused by the white noise error term, u_t.

When it is only necessary to difference the time series once in order for it to become stationary the time series is said to be integrated of order 1, which is denoted I(1) such that $X_t \sim I(1)$. A time series that must be differentiated d times to make it stationary is said to be integrated of order d, I(d), such that $X_t \sim I(d)$. A time series that is integrated of order zero, I(0), is therefore stationary (as it needs to be differenced zero times to become stationary) and a time series that is integrated of order one, I(1), or higher is non-stationary (see Granger, 1981, p. 122). The number of times a variable needs to be differenced to render it stationary therefore depends on how many unit roots are contained in the series, for one is removed each time the variable is differenced. Integrated time series can therefore be seen to be non-stationarity because they contain unit roots that cause the presence of stochastic trends in the data (see Dolado, Jenkinson and Sosvilla-Rivero (1990, p.249).

To formally test the series for stationarity, the **Dickey-Fuller (DF)** and **Augmented Dickey-Fuller Tests** (ADF) (Dickey and Fuller, 1979) can be used where the null hypothesis is that a series contains a unit root, ie that the series is non-stationary[31].

4.4.3. Tests for Stationarity

The simplest form of the **DF** test (See Dickey and Fuller, 1981) entails first running the AR(1) regression (4.4.6.) reproduced here as (4.4.8.)

$$\Delta X_t = (\rho - 1)X_{t-1} + u_t \qquad (4.4.8.)$$

whereΔ is the first difference operator as above and the null hypothesis is $H_0{:}\rho = 1$ (from Harris, 1995, p.28).Once equation (4.4.8) has been estimated then ρ is statistically tested to see if it equals 1, ie to see if there is a unit root. The test of significance used is the **τ(tau)** test however and not the conventional t-test as the t-test is now invalid (as mentioned above in the consequences of running regressions on non-stationary) because the data no longer follows the standard t-distribution in the presence of non-stationarity. The distribution which is followed instead is known as the Dickey-Fuller

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[31] There are other tests with this null hypothesis such as the non-parametric tests of Philips and Perron (1988), which are based on the Philips (1987, p. 287-288) Z-test and involve calculating the DF statistic and then adjusting the test statistic so as to remove any autocorrelation in the model before comparing it with the tabulated DF critical values; and the Sargan-Bhargava (1983) Cointegrating Regression Durbin-Watson (CRDW) test that is based on the Durbin-Watson statistic and involves similar work on regression residuals and is explained in section (4.4.3).

distribution, and so the calculated statistic is called the **Dickey-Fuller (DF) or τ (tau) statistic**. The critical values used to test the tau statistic have been computed by Dickey and Fuller (1979, p.430) and are given in appendix B table (B.1.). More complicated versions involve the inclusion of a constant and a trend term (see Gujarati, 1995, p. 720).

The assumed data generating process in (4.4.8.) is believed to be one which has a zero mean and no deterministic trend. When one is not certain what the nature of the series is however, then it is safer to make allowances by including a constant in the regression when testing for unit roots, so that (4.4.8.) will then become

$$\Delta X_t = \alpha + (\rho - 1)X_{t-1} + u_t \qquad (4.4.9.)$$

where α is a constant (and is time invariant). The appropriate D-F critical values to use will be the set in the table where a constant is included, namely τ_2 (see table B.1 in appendix B) which is invariant with respect to the initial value of X_t, so that whatever the initial value of X_t is (and therefore whatever the mean of X_t is), the distribution of the test statistic is not influenced. When there is the likelihood of a deterministic trend being present, which is the most common case (Harris, 1995, p.30), then the regression should also include a time trend when testing for unit roots so that the regression will then be

$$\Delta X_t = \alpha + \lambda t + (\rho - 1)X_{t-1} + u_t \qquad (4.4.10.)$$

where t is a time trend variable. The critical values used in the table will now be τ_3 (see table B.1 in appendix B), the critical values for including a constant and a linear time trend, which is invariant with respect to the initial X_t value and to the intercept, α. The test statistic, τ_3, is therefore not influenced by the drift term or the initial value of X_t. When the underlying data generating process is unknown then it would then be most suitable to use regression (4.4.10.) to test the variable for the presence of unit roots, as the possibility of the data generation process having a non-zero mean, and a deterministic trend, is then accounted for.

To continue with the actual testing procedure, the Dickey-Fuller (tau) statistic is then calculated, by dividing the estimated ρ by its standard error, and then comparing it to the appropriate D-F critical value in the table. When the absolute value of the tau statistic exceeds its critical value, we can reject the null hypothesis that there is a unit root, ie $\delta = 0$, or $\rho = 1$, and conclude instead that the time series is stationary. To make a non-stationary variable stationary by differencing it is then necessary to check each successive difference equation for unit roots until the time series is stationary, that is the testing stops immediately when the null hypothesis of a unit root can be rejected. The DF tests enjoy widespread popularity and usage as a result of their clarity and ecumenical nature (Harris, 1995, p.28) and are regarded as the conventional test diagnostics to use.

When autocorrelation is present in the model then the **augmented Dickey-Fuller (ADF) test** is used where (4.3.12 is modified (augmented) as follows

$\Delta X_{t-i} = X_{t-1} - X_t$
$i=1$
$i=2 = X_{t-2} - X_{t-1}$
$i=3 = X_{t-3} - X_{t-2}$

$$\Delta X_t = \alpha + \lambda t + (\rho - 1)X_{t-1} + \gamma \sum_{I=1}^{m-1} \Delta X_{t-I} + u_t \qquad (4.4.11.)$$

Fatal error [illegible]!

where $\Delta X_{t-1} = (X_{t-1} - X_{t-2})$, $\Delta X_{t-2} = (X_{t-1} - X_{t-3})$ and continues to $\Delta X_{t-m} = (X_{t-m} - X_{t-(m-1)})$. The number of lagged difference terms to include will depend on the order of the autoregressive process which determines the data[32], basically the idea being to include enough lagged difference terms so that the

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[32] When an AR(1) process is modeled as the data generation process when in fact the series follows an autoregressive process of the mth order, ie

$$X_t = \gamma_1 Xt_{-1} + \gamma_2 Xt_{-2} + \ldots + \gamma_m Xt_{-2m} + u_t \qquad (4.3.11.a.)$$

error term is no longer autocorrelated. The null hypothesis is still $H_0:\rho = 1$ against $H_1:\rho < 1$ or H_0: $(\rho - 1) = \delta = 0$ against H_1: $\delta < 0$ as in the Dickey-Fuller test so that the presence of unit roots is still being tested for. The same critical values are be used to test the ADF statistic against as are used for the Dickey-Fuller statistic because the ADF statistic has the same asymptotic distribution as the DF statistic (Gujarati, 1995, p.720).

The ADF test does not take account of permanent shifts or structural breaks in the data, viewing them just as stochastic trends and so is described as having low power (Perron, 1989, p. 1372). When the breaks in the series are known then it is possible to take account of them by including dummy variables in the ADF test so that there are an equal number of deterministic regressors as there are deterministic components in the data generation process (Harris, 1995, p. 28). The critical values for the adjusted ADF unit root test are given by Perron (1990, p. 157-158). A test for when the time of the structural break is not known is given by Banerjee *et al* (1992) along with the relevant critical values. Unit root tests for seasonally unadjusted data are also available (see Harris, 1995, p.42) and Davidson and MacKinnon (1993) demonstrate that, where possible, seasonally unadjusted data is actually preferable to seasonally adjusted data because by adjusting a variable for seasonality, certain intrinsic characteristics of the data will be lost or altered.

It has thus far been shown that by differencing the data and applying relevant unit root tests it is possible to make non-stationary data stationary for the purpose of avoiding spurious regressions. But once the problem of non-stationarity is solved by differencing another problem arises as differencing often causes the loss of long-run information which is given by the levels but not by the differences of the variables (Hendry, 1986, p.204). Equally important is the fact that most economic theory is expressed as a long-term relationship between variables in their level forms and not in their difference forms so that running a regression on differenced data would be theoretically inconsistent. A way to avoid this loss of information from differencing the time series is the method of cointegration.

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then the residuals of the regression will exhibit autocorrelation because of functional misspecification.

developed by Granger and his colleagues in a succession of papers (see Granger and Weiss, 1983; Granger, 1986, Engle and Granger, 1987) and reviewed below in section (4.4.4.).

4.4.4. The Method of Cointegration

The method of cointegration is able to provide non spurious results when regressing the level of the variables on each other even when the variables are non-stationary, providing that these variables are integrated of the same order. This is because when variables are integrated of the same order they contain the same trend(s) and so regressing the variables on one will causes these trends to cancel out, leaving only the pure relationship between the variables behind.

When two (or more) non-stationary variables form an equilibrium relationship in the long-term the method of cointegration allows these time series to be regressed on each other in their level forms even though they may be non-stationary, providing that these variables are integrated of the same order, or, cointegrated. This is because the non-stationary components cancel out leaving a stationary relationship between the variables so that the equilibrium, stable or long-run relationship between the cointegrated variables is revealed. Engle and Granger (1987, p.251) define equilibrium as

> *"equilibrium is a stationary point characterized by forces which tend to push the economy back towards equilibrium whenever it moves away."*

This stationarity is displayed in the relationship of variables in the cointegrating regression. The following is an example of a cointegrating regression can be written as

$$z_t = Y_t - \beta_1 - \beta_2 X_t \qquad (4.4.12)$$

where β_2 is the cointegrating parameter, Y_t and X_t are integrated of the same order and z_t is a white noise and so is stationary, I(0).This error term, or equilibrium error, shows the amount by which the system deviates from equilibrium at time t and so is known as the equilibrium error (Engle and Granger, 1987, p.252). As the equilibrium error is stationary, the relationship between the cointegrated variables, Y_t and X_t on the right hand side of the equation is therefore stationary and is said to be integrated of order zero, I(0).

An important feature of cointegration is that when Y_t and X_t are cointegrated, then Y_{t-n} and X_{t-n} are also cointegrated (the time series Y_t is cointegrated with the time series X_t)for all n. This means that cointegrated variables can be thought of as random walks moving in unison over time, where both the variables are wandering on separate paths but are going in the same general direction. Granger (1981, p.129) explains this as

> *"the conditions for co-integration of two series state that the two series move in a similar way, ignoring lags, over the long swings of the economy..(so that)...(a)lthough the two series may be unequal in the short-term, they are tied together in the long run."*

A more formal definition of cointegration is given by Engle and Granger (1987, p.253) who state that two or more variables, represented by the vector x_t, are cointegrated of order d, b, and are denoted as $x_t \sim CI(d,b)$ when

(i) they are all integrated of the same order, I(d)

(ii) there exists a (non-zero) cointegrating vector, α, of the vector of the variables (x_t) such that $z_t = \alpha' x_t \sim I(d - b)$ and b is > 0.

The term b here comes from the explanation Engle and Granger (1987, p.253) give on the stationarity of a particular variable where they argue that when a time series $X_t \sim I(1)$, then $a + b\ X_t$ is also I(1) where a and b are constants and $b \neq 0$. Thus when the components of the vector x_t, the variables, are integrated of the order 1, the equilibrium error would be I(0), ie then $z_t = \alpha' x_t \sim I(d - b)$ will be $z_t = \alpha' x_t \sim I(1 - b)$ which is $z_t = \alpha' x_t \sim I(0)$ which means b = 1.

The definition therefore explains that it is possible for two or more non-stationary variables to be regressed on each other to create a meaningful relationship between them without any risk of spurious regressions occurring. The method of cointegration therefore enables us to then regress one variable on the other in order to check if there is a long-term relationship between the variables or if there is in fact no link, and they merely move together as a result of a common trend in the data (McDermott, 1990, p.11).

There are a number of tests available to check if a cointegrating relationship exists between variables. The following three tests were found by Engle and Granger (1987, p. 268) to be extremely powerful and, as they are the tests most commonly used in cointegration studies because they simple and easy to apply, they have subsequently been used in the estimation procedure in chapter 5.

The **Cointegrating Regression Durbin-Watson (CRWD) Test** involves the use of the Durbin-Watson d statistic from the cointegrating regression where the null hypothesis is $d = 0$ (that there is no cointegration).The test regression is the regression that is being tested for cointegration with a general specification being

$$y_t = c + \beta_1 x_t + u_t \qquad (4.4.13.)$$

The critical values for this test have been calculated by Sargan and Bhargava (1983) and are given in table (B.2) in appendix B. When the computed d (Durbin-Watson) statistic of the regression is smaller than the 1% critical value of 0.51 the hypothesis of no cointegration, that is $d = 0$, is accepted at the 1% level.

The **Engle-Granger (EG) Test** and the **Augmented Engle-Granger (AEG) Test** are relatively simple tests which are based on the DF and ADF tests reviewed above in section (4.4.3.) (p.86-89). The EG and AEG tests are carried out by running the regression and then testing the regression residuals for the presence of unit roots with the DF test. This is done by differencing the residuals and then regressing on their lagged (level) values without the inclusion of an intercept term. The null hypothesis is of no cointegration against the alternative hypothesis of cointegration. The test regression for the Engle-Granger test is

$$\Delta u_t = -\varphi u_{t-1} + \varepsilon_t \qquad (4.4.14.)$$

where u_t is the residual from the cointegrating regression, Δu_t is the first difference of this value and ε_t is white noise (Engle and Granger, 1987, p. 268). For the Augmented Engle-Granger test the test regression is specified as a fourth-order autoregressive distributed lag model in order to take account the possibility of autocorrelation in the error term, having of the following form

$$\Delta u_{t1} = -\varphi u_{t1-1} + \Delta\beta_1 u_{t-1} + \ldots + \Delta\beta_i u_{t-4} + \varepsilon_t \qquad (4.4.15.)$$

and the same null hypothesis as the EG test above. When a negative nonzero value is obtained for φ on the basis of the conventional t-statistic exceeding the critical value then the hypothesis of no cointegration is accepted for the test. Since this statistic is not distributed under the t distribution, special critical values are used for the EG and AEG cointegration tests which have been calculated by Engle and Granger (1987, p. 269) and are given in appendix B. in table (B.2).

When the cointegration tests show that cointegration does exist then a cointegrating regression is obtained which then gives the long-run or equilibrium relationship between the variables. As mentioned earlier, when a linear combination of variables is cointegrated then an equilibrium, stable or long-run relationship is obtained between them.

The OLS parameter estimates in the presence of cointegration are superconsistent estimates of the true regression coefficients which means that the estimates of the cointegrating regression parameters approach their probability limits faster than the conventional OLS estimates do so that they are more stable (Stock, 1987, p. 1037). The stability of the cointegrating regression, a point which is of considerable interest to this paper as it seeks to find a stable function for the long-run demand for money in South Africa, is thus obtained through this superconsistency of the estimates the cointegrating regression.

This property of superconsistency has however been shown by Banerjee et al. (1986, p. 257) to only be a large sample property, and that when using a small sample of observations (such as twenty to thirty observations) superconsistency does not exist in the regression parameters. A further small sample property of cointegration is that the regression estimates also tend to biased of order 1/T, where T is the size of the sample of observations (Engle and Granger, 1987, p.262 and Stock, 1987, p.1041). These small sample problems are not attendant when an error correction representation of the cointegrating regression is estimated and Banerjee et al. (1986, p.255) therefore argues that the use of the Error Correction Mechanism (ECM), reviewed in the following section, section (4.4.5.), is preferable in the situations of small sample data.

4.4.5. The Error Correction Model

Cointegration allows inferences on the equilibrium or long-run nature of the demand for money to be made using short-run data (Taylor, 1991, p.4) as, when evidence of the existence of the long-run relationship is confirmed, a basis is then provided for the examination of the short-run movements of the demand for money. This is done by including an error correction mechanism which 'corrects' for the short-run deviations of the variables from their long-run equilibrium.

As mentioned earlier, when variables are cointegrated a long-run or equilibrium relationship exists between them, but as theory points to a relationship between variables both in the long and in the short-run, it becomes necessary to also incorporate the short-run movements of the variables in the specification of a money demand function. The cointegrating regression does not take the short-run movements of the variables into account and is for this reason inappropriate to use as the final specification of the model. An error correction representation of the cointegrating regression is therefore used instead as it incorporates a short-run dynamic element into the model. Also, as these short-term dynamics of money demand are rarely in equilibrium due to non-stationary variables tending to spend more time moving towards and away from equilibrium than they do in it (see section (4.4.2.) above), the error correction model provides for this by including an error correction term which corrects for any short-run movements away from the long-run (equilibrium) level of money demand.

The error correction mechanism (ECM) (see Salmon, 1982; Nickell, 1985; Granger, 1986; Engle and Granger, 1987) is therefore able to link the short-term behaviour of the dependent variable to its long-run behaviour and so correct for short-run disequilibrium. The way that the ECM does this can be demonstrated by the following example where equation (4.4.16) is a cointegrating regression of Y_t on X_t

$$Y_t = \alpha_0 + \alpha_1 X_t + u_t \qquad (4.4.16.)$$

and u_t is white noise. A very simple error correction representation of the above cointegrating regression (4.4.16.) can then be written as

$$\Delta Y_t = \beta_0 + \beta_1 \Delta X_t + \beta_2 u_{t-1} + \varepsilon_t \qquad (4.4.17.)$$

where u_{t-1} is the lagged value of the residual of the cointegrating regression (4.4.16.), ΔY_t is the first difference of Y_t, ΔX_t is the first difference of X_t and ε_t white noise. The error correction model of (4.4.17.) is then able to relate the change in Y_t to the change X_t as well as to the error in the preceding period. The short-run disturbances in Y_t are then captured by $Y_t - Y_{t-1}$, and the error correction term, u_{t-1}, captures the extent of the adjustment that needs to be made to correct for the deviation in the previous period from the long-run equilibrium. The error correction term should therefore have a negative sign and a significant t-value so as to be able to decrease the level of money in the present period should it rise to high in the previous period in relation to the regressors, and vice versa.

The error correction model is very flexible in terms of the number of lags that can be used. This means that a large number of differenced lagged variables can be specified and then excluded if insignificant through the use of significance tests, with the result that the data itself is then able to exert a strong influence on the final specification of the dynamic structure of the model. For this reason the error correction model is usually developed in two stages.

First a general autoregressive distributed lag model is estimated containing numerous lags (including the lag of order zero) of the variables suggested by economic theory, including the lagged value of the dependent variable. The model is specified as an error correction representation in order to account for short-run dynamics and to obtain the error correction term which accounts and corrects for the imbalances that occur when the long-run relationships between the variables, as specified by economic theory, are not exactly fulfilled. The second stage of the approach involves decreasing the number of explanatory variables by testing all the explanatory variables for significance through a sequence of testing-down procedures (Kennedy, 1992, p.251). This is done by imposing exclusion restrictions on certain variables to constrain them to take the value of zero, and so remove them from the model (Stewart, 1984, p.119). When these variables have been removed the estimates of the remaining variables change so that a restricted version of the error correction model is obtained. The tests are continued in this manner until a restricted version of the original model is estimated which includes all the variables that significantly explain the dependent variable.

The test of significance that is used in the testing down processes is the F statistic, with x and n-k degrees of freedom where x is the number of restrictions imposed and n-k is the number of degrees of freedom in the unrestricted model, n being the number of observations and k the number of regressors including the explanatory variable (Stewart, 1984, p.121). The final estimated restricted model from the testing-down process is then the one that is then considered as the specification for the demand for money function. This method is used in the analysis as it has the advantage of letting the data specify the function by starting with numerous lagged values of the regressors and then testing down until the insignificant values are eliminated.

4.5. Model Selection Tests

The following two tests are commonly used criteria for judging the qualities of a model.

a). The Akaike information criterion, *AIC*:

$$AIC = (-2ln\mathrm{L}(\mathrm{y},B_1)+2k)/n \qquad (4.4.18.)$$

Source: Judge and Griffiths, 1980, p.423

where:

$L(y,B_1)$ is the likelihood function, and $2k$ is the adjustment made for parsimony (k being the number of explanatory variables, including the intercept term, in the model).

The likelihood function is a function of the parameters for given observations, and, when maximised, allows for the choice of the estimated beta value(B_1 used here) which is most likely to generate the observed sample values to be made, ie the estimator which maximises the likelihood function associated to y will be chosen. What this means is that the estimator that generates the maximum likelihood of having a distribution which reflects the observed values (the one most likely to yield the observed values of y-the dependent variable) can be identified.

There thus is a trade off between parsimony (having as few explanatory variables as is reasonably possible) and precision (choosing the estimate which is most likely to generates the observed y values). The model with the smallest *AIC* value, which measures the loss of information, is selected.

The *AIC* criterion can be used in testing both nested as well as non-nested hypotheses (as opposed to the adjusted R^2 criterion used in dealing with the nested model selection problem). The *AIC* criterion, in testing hypotheses, breaks away from the conventional procedures which test for 'significance' in the parameters[33]. A criticism of the *AIC* criterion is that it cannot be used when n tends to infinity and the probability to one as it does not tend to choose the model with maximum information.

b). The Final Prediction Error criterion, *FPE*:

$$FPE = (n + k) / (n - k) * (s^2) \qquad (4.4.19.)$$

Source: Charemza and Deadman, 1992, p.294

The *FPE* criterion involves post-sample predictive testing, and uses actual values of explanatory variables for the period to be predicted with the parameter estimates for the whole sample, *including* the period being forecast. The model with the smallest post-sample prediction error is chosen. The *FPE* criterion makes use of parsimony through the inclusion of k, implying that a model should be reduced in size if this increases the predictive power of the model.

The most important test for the predictive power of a model (outside the sample period) is the basic post-sample predictive test involving a comparison of the sum of squares of the prediction errors with those of the fitted model.

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[33] Such as the t-test and the Chi squared test.

4.6. Conclusion

The chapter began by specifying a standard model for the demand for real money in South Africa from the theory and applied work reviewed in chapters two and three. A wealth variable has been included in one specification of this money demand function and then excluded in the second as follows the method used by the Deutsch Bundesbank Report where the purpose is to examine whether the inclusion of a wealth variable in the model improves the results. The variables to be used in this analysis are defined and explained in section (4.3.) and reasons for their inclusion based on economic theory and previous South African money demand studies have been forwarded. The data sources have also been given for all the series, and the data itself is quarterly time series data covering the entire period from the second quarter of 1965 to the fourth quarter of 1996..

Section (4.4.) forms the main body of this chapter as it describes the estimation procedure used in the analysis and all the theory surrounding it. The method of cointegration is combined with the error correction model to obtain a stable function for the demand for real money in South Africa. The procedure begins with examining the characteristics of the data. As it is time series data special care is needed to ensure that spurious regressions are not obtained by neglecting to check whether it is stationary or non-stationary. Tests are given for this purpose in section (4.4.3.) and are also used to determine the order of integration of the data. This is necessary for when the data is nonstationary valid results can still be obtained if the variables are all integrated of the same order (or cointegrated). If the variables are non-stationary but are found to be cointegrated then the cointegrating regression which is obtained from these variables has the property of superconsistency which means that it is a stable function. As the regression is expresses the variables in their level form no loss of information occurs. The cointegrating regression thus obtained expresses the long-run relationship of the demand for money.

In order to take the short-term nature of money holding into account, an error correction representation can be used which incorporates the short-run dynamics of the demand for money whilst also correcting for any deviations experienced in the short-run from the long-run equilibrium. This error correction model is explained in section (4.4.5.). Use has been made of general-to-specific modelling through first specifying the error correction model as an autoregressive distributed lag model which contains numerous lagged values for all of the regressors of the cointegrating regression. The variables in the error correction model are expressed in their differenced form (and not in their level form as in the cointegrating regression) because modelling the differences of the variables gives the short-run nature of the demand for money. Once the general model has been specified testing down procedure are applied to eliminate the variables which are not significant in explaining the demand for money. A restricted version of the general model is then obtained as a final estimate. This estimation procedure has been followed by Wong and Kennedy (1992) in an analysis on currency substitution but as an econometric estimation procedure it is argued that it just as justified to apply it to the analysis of the demand for money.

Chapter five implements this estimation procedure and presents the results and findings. The models are also compared above on the basis of the AIC (Akaike Information Criterion) and FPE (Final Prediction Error Criterion) given above.

CHAPTER FIVE

The Estimations and the Results

5.1. Introduction

The results obtained from estimating the cointegrating regressions and the error correction models for the demand for real money in South Africa over the period 1965 to 1996 are presented and discussed in this chapter. The demand for money functions are estimated using quarterly time series data from the second quarter of 1965 to the fourth quarter of 1996 for both narrow and broad definitions of money. All the variables are expressed in real terms except for the interest rate, and are estimated in natural logarithms using the cointegrating technique of ordinary least squares (OLS) and the error correction mechanism as explained in chapter four (section (4.4.)). The computer package used in estimating all the models and test procedures is SHAZAM version 7.0 (White, 1978; 1993).

The estimation procedure that is followed is based on those used by Wong and Kennedy (1992) and the Deutsche Bundesbank (1995), and has been summarised into the following steps for clarity and ease of reference:

(1). All the variables used in the analysis are tested with the Dickey-Fuller test for stationary, both in their level and in their first-difference forms, to ascertain the order of integration of each variable.

The monetary aggregates used to measure the money demand variable are the three definitions of money M1, M2 and M3. The scale or income variables employed are GDE and GDP, and the proxies for the wealth variables used are consumer credit, domestic credit and total credit for reasons given in section (4.3.). Both short- and long-term interest rates (in nominal form) are employed with the short-term interest rates being measured by the yield on the three year government bond and the interest rate of the 12 month fixed deposit at commercial banks and the long-term interest rate being given by the yield on the fifteen year government bond (reasons for the use of these interest rates are given in section (4.3.).

(2). The next step involves estimating the cointegrating regressions. The specification of the regressions is based on those used by the Deutsch Bundesbank Monthly Report (1995, p.31) (see section (4.2.)). Equation (5.1) is the long-run demand for real balances including an asset variable and equation (5.2) is the long-run demand for real balances excluding an asset variable, or

$$(m - p)_t = \alpha_0 + \alpha_1 y_t + \alpha_2 w_t - \alpha_3 r_t + z_t \tag{5.1}$$

$$(m - p)_t = \beta_0 + \beta_1 y_t - \beta_2 r_t + \upsilon_t \tag{5.2}$$

where $(m - p)_t$ is real money balances, y_t is real income at 1995 prices, w_t is the wealth or asset variable in real terms at 1995 prices, r_t the nominal interest rates and z_t and υ_t are the residuals or error terms of the respective regressions.

These two equations, equation (5.1.) and equation (5.2.) are identical except for equation (5.1.) employing a real wealth variable $(w - p)_t$ as one of the explanatory variables in the regression while equation (5.2.) does not do so. This method, of estimating the money demand function, once with an asset variable, and once without, is followed by the Deutsche Bundesbank Monthly Report (1995, p.30)with the purpose being, as explained in section (4.2.), to provide a means of assessing whether there has been any improvement in the results obtained with the inclusion of a wealth variable as opposed to the results obtained without the wealth variable.

Steps (1.) and (2.) which involve the testing of the order of integration of the variables to find cointegrating regressions of the demand for money, are of great importance to the analysis as they also test the stability of the long-run money demand function. This is because, as explained in chapter four, variables which form a cointegrating regression exhibit superconsistent regression parameters which means that the parameters give highly consistent estimates of the true value of the parameters of the long-run function of the demand for money over time (see section 4.4.). The function is then highly stable which is of vital importance for policy considerations (see section (2.5.)).

The short-run money demand for money on the other hand is are characterised by disequilibrium (see section (2.2.)). These dynamics are accounted for by the inclusion of an error correction term in the model through the estimation of an error correction model (ECM).

(3). To this purpose unrestricted seventh-order autoregressive models[34] of the variables in their first difference form[35] are estimated, including the lagged value of the residuals, z_t and υ_t, of the cointegrating regressions estimated in equations (5.1.) and (5.2.). The purpose of which is to provide an indication of which lags of the explanatory variables are significant using both t-tests and F-tests and general-to-specific modelling so that significant variables are then unlikely to be excluded. These models took the respective form of

$$\Delta(m-p)_t = \alpha_0 + \lambda_0(L)\Delta(m-p)_{t-1} + \lambda_1(L)\Delta y_{t-1} + \lambda_2(L)\Delta w_{t-1} - \lambda_3(L)\Delta r_{t-1} + \Delta\sum_{I=1}^{3} \gamma_i\, z^{i}_{t-1} \qquad (5.3.)$$

$$\Delta(m-p)_t = \beta_0 + \psi_0(L)\Delta(m-p)_{t-1} + \psi_1(L)\Delta\Delta y_{t-1} - \psi_2(L)\Delta r_{t-1} + \Delta\sum_{I=1}^{3} \phi_I\, \upsilon^{i}_{t-1} \qquad (5.4.)$$

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[34] Numerous lags are employed in the general model of the general to specific modelling approach and the use of seven lags for each of the differenced variables was chosen here to comply with this requirement for a large number.

[35] Which then implies a maximum of eight lags per variable when the variables are in their level form.

where the seven lags have been used so that the lag operators, $\lambda_i(L)$, gives I = 0, 1, 2,3,4,5,6,7 and $\psi_i(L)$, I = 0, 1,2,3,4,5,6,7 where I denotes the number of times the variable has been lagged. Following Wong and Kennedy (1992, p.4), in order for equations (5.3.) and (5.4.) to be regarded as money demand equations the income elasticity must be positive, $\lambda_1(1) \geq 0$, $\psi_1(1) \geq 0$, and the interest rate elasticity must be negative $\lambda_3(1) \leq 0$, $\psi_3(1) \leq 0$; while for stability to exist the coefficient of the lagged dependent variable must be greater than -1 but less than 1 or $-1 < \lambda_0(L) < 1$ and $-1 < \psi_0(L) < 1$. To ensure the existence of cointegration $\gamma_i < 0$, $\phi_I < 0$ (Hendry and Ericson, 1991, p.23). Further, in order for these error correction models, equations (5.3.) and (5.4.), to exist at least one of the γ's and at least one of the ϕ's must be significant (Wong and Kennedy, 1992, p.4).

The reason that nonlinear (as opposed to linear) error-correction terms, the z^i_{t-1} and υ^i_{t-1}, have been included in the specifications is in order to allow the speed of adjustment of the short-term dynamics towards the long-run equilibrium to vary in relation with the actual size of the disequilibrium (error) experienced (Hendry and Ericson, 1991, p.25). More simply what this means is that the error terms from the cointegrating regressions (equations (5.1.) and (5.2.) in step two above) have been raised to the powers of 1 through to 7, instead of being lagged and then differenced, as the other variables in the error correction models, (5.3.). and (5.4.) have been. This then allows for the speed of the adjustments back to equilibrium to be greater, the greater the size of the deviation from equilibrium.

(4.) Lastly, the estimated parameters obtained from running these seventh-order autoregressive models are analysed to find out (a). which of the lagged explanatory variables satisfy the criteria of consistency with the *a priori* theoretical expectations listed above in step (iv) and (b.). whether they are significant under the t- and F-tests. Those variables which are both theoretically consistent and significant are then used to estimate restricted versions of equations (5.4.) and (5.5) in order to obtain simplified versions of the error correction models.

An additional step can be incorporated into this estimation procedure after step two, following

Hendry and Ericson (1991, p. 24) who argue that when the short-term interest rates are cointegrated with the long term rate, and with each other, then the interest rates can be used interchangeably in the cointegrating regressions without the results being affected. The reasoning behind their assertion relies on the theory of cointegration where, as mentioned before, in order for variables to be cointegrated, they must necessarily be of the same order of integration (see chapter 4) so that when the interest rates are cointegrated with each other any of them can validly be included in the cointegrating regression as they are all integrated of the same order. This then provides a method of testing the twelve month fixed deposit to see if it can be included in the regression.

This additional step would then check whether (a). the interest rates are or are not cointegrated, and then (b.) whether the type of interest rates used in the cointegrating regressions does or does not yield different results.

The next section, section (5.2.), examines the estimation procedure in more detail when presenting the results.

5.2. The Stationarity Tests

The application of the theory of cointegration processes depends upon knowledge of the order of integration of the underlying time series. To find out if the data is stationary the augmented Dickey-Fuller tests, (see section (4.4.3.) in chapter four, p.76-77) are used. To reiterate, the augmented Dickey-Fuller test provides a means of verifying the difference stationarity of the underlying data generating processes, while also taking into account the possibility of autocorrelated disturbance terms. The null hypothesis in the augmented Dickey-Fuller test is that a unit root does exist which means that the data series is non-stationary. In order to be able to reject the null hypothesis of a unit root the estimated tau value (τ-test statistic) must be greater than the critical value.

The results for the variables tested for stationarity in both their level forms and their difference forms by the augmented Dickey-Fuller tests are given below in table (5.1.) where *m1* denotes M1 expressed in real terms, *m2* denotes M2 also in real terms, *m3* denotes money stock M3, *gde* denotes real gross domestic expenditure (GDE), *gdp* denotes real gross domestic product (GDP), *wc* denotes real consumer credit, *wd* denotes real domestic credit, *wt* denotes real total credit, *inm* denotes the nominal interest rate on 12 month fixed deposits at commercial banks, *int* denotes the nominal yield on three year government bonds, and *inf* denotes the nominal yield on fifteen year government bonds.

Augmented Dickey-Fuller Tests for Unit Root: 1965Q2 to 1996Q4

Variable	Test Specifications	Level	First Differences	Critical Values (1%)	Critical Values (5%)
m1	c	-0.0100	-3.8348	-2.88	-2.57
m2	c	-1.0650	-3.7131	-2.88	-2.57
m3	c	-2.5972	-4.2865	-2.88	-2.57
gde	c	-1.9436	-3.9932	-2.88	-2.57
gdp	c	-2.5834	-3.6234	-2.88	-2.57
wc	c	-1.6029	-4.3424	-2.88	-2.57
wd	c	-2.1905	-3.9300	-2.88	-2.57
wt	c	-1.4157	-4.2424	-2.88	-2.57
inm	c	-1.5420	-4.2074	-2.88	-2.57
int	c	-0.93921	-4.5362	-2.88	-2.57
inf	c	-1.5770	-4.2107	-2.88	-2.57

Table (5.1.)

The use of small letters to denote the variables in the table implies the logarithms of these respective variables. The letter c denotes the inclusion of a constant (see section (4.4.2.)). Further in the table the estimated tau test statistics are given under the columns labeled Level and First Differences for the variables in their level and first difference forms respectively and the 1% and 5% Dickey-Fuller critical values are also provided.

In the table above the estimated test statistic for all the variables in their level forms (excepting M3 and GDP) are smaller than the 5% critical value of 2.57 which means that they are non-stationary. The variables M3 and GDP on the other hand are stationary at the 5% level as the null-hypothesis that there is a unit root can be rejected at the 5% confidence interval because the estimated t-tests statistics for these two variables in their level forms are greater than the critical values. This means that we can be certain with 95% confidence that GDP and M3 should be excluded from the cointegrating regressions as they are stationary and so integrated of order zero, I(0), and therefore of a different order of integration to the rest of the (non-stationary) variables.

Under the use of the more stringent 1% critical value however all the variables in their level form (including M3 and EGDP) are non-stationary as the estimated test statistics of all these variables are smaller than the 1% critical value of 2.88. This means that all the data series in their level form are non-stationary at the 1% level of confidence or alternatively we can be 99% certain that all the variables in their level form are non-stationary.

The next step to follow is to test the difference stationarity of the data to ascertain the order of integration. Accordingly the first-differences of all the data series is obtained by subtracting each observation from its previous value. Then the augmented Dickey-Fuller tests are run on the first-differences of the data to check whether differencing has caused the non-stationary data to become stationary. Checking the estimated tau statistics of the variables in first difference form against the 1% and 5% critical values in table 5.2. above it can be seen that the estimated tau values all exceed the critical values. This means that the null hypothesis of a unit root can be rejected as the variables in their first differences are stationary. Simple differentiation has therefore ensured that all the previously non-stationary time series are now stationary and are therefore integrated of order one, I(1). Regressions are not run on these difference stationary variables however as differencing involves the loss of short-run information (see section (4.4.3.)) and so the method of cointegration is used instead.

As noted above in chapter four section (4.4.3.), all the variables must be integrated of the same order of integration in order for them to be cointegrated with one another which means that they must all be stationary at the same level of integration. As this has been found to be the case with all the variables being integrated of order one I(1) the cointegrating relationships can now be estimated.

5.3. The Estimation of the Long-Run Demand for Real Money: The Cointegrating Relationships

Once variables are found to be cointegrated, as noted above, then it is possible to estimate cointegrating regressions in order to obtain the long-run relationships between the real money stock and the explanatory variables.

The method that was followed involved first estimating the regressions containing the asset variables by separately regressing the three monetary aggregates, M1, M2 and M3 on the income, wealth and interest rate variables. The income variables, GDE and GDP were each included separately in a regression with the wealth, interest rate and monetary variables, with the same approach being used for the three proxies of wealth and for the three interest rate variables so that a total of one hundred and forty four regressions were run altogether. Every combination of the variables measuring real money stock, real income, nominal interest rates and real wealth have therefore been included in a regression to evaluate the performance of the variables and decide on the most appropriate regression(s) to use to model the long-run demand for money.

Next the three monetary aggregates were regressed separately on the income and interest rate variables to obtain the money demand estimates excluding the asset variables so that a total of sixtythree regressions were run altogether. The following table (5.2.), presents results of the estimations of the long-term relationships between the money stock and the explanatory variables for both of the approaches presented here (first the inclusion of, and then the exclusion of a wealth variable in the money demand equation) from the second quarter of 1965 up to and including the fourth quarter of 1996. The Durbin-Watson (DW) statistic and the adjusted R^2 value for each regression are also given in the table below. The DW statistic is used to denote whether the regression is significant with respect to the CRWD test at the 1% (***), 5%(**) or 10%(*) levels of confidence, with the critical values being 0.511; 0.386 and 0.322 respectively.

Estimates of the Long-Term Relationships for the money stock M3

	Money Demand M3			
Variable	Excluding Assets	Including Assets: wc	Excluding Assets	Including Assets: wt
c	0.851	1.015	1.263	0.606
gde	0.813	0.720	0.735	0.503
wc		0.120		
wt				0.384
int	0.056	-0.010		
iny			0.142	-0.021
Test Statistics				
R^2	0.976	0.978	0.978	0.991
DW	0.369*	0.336*	0.371*	0.331*

Table 5.2.

When the computed DW (or *d*) statistic is smaller than the chosen critical value then the hypothesis of cointegration is rejected, while an estimated *d* statistic that exceeds the value of the chosen critical value suggests that the variables are cointegrated.

Only the regressions which are theoretically consistent and are cointegrating regressions, that is those where the DW statistic of the regression exceeds the critical values of the CRWD test, have been reported here. In order to be theoretically consistent the income and wealth variables coefficients must be significant and positive whilst those of the interest rates must be significant and negative. After running the regressions, only two out of all the cointegrating regressions that included an asset variable were theoretically consistent. These regressions are presented in table 5.2. above.

Out of the three monetary aggregates, M3 is the only one that yielded theoretically consistent and statistically valid cointegrating regressions. The regressions for M1 and M2, both with and without the inclusion of a wealth variable, either did not form cointegrating regressions or did not give the *a priori* expected signs on the regression coefficients or both. The income variable GDP is not used in any of the preferred cointegrating equations leading to the conclusion that it appears to perform poorly in relation to GDE as a measure of income in the money demand function.

Further high R values and low Durbin-Watson statistics were obtained in all the regressions confirming the existence of non-stationarity in the data. This is a major finding as it implies that all previous demand for money functions estimated in South Africa using the monetary aggregates and income and interest rate variables used in this analysis are likely to be suspect unless they have made use of the method of cointegration. This is because running regressions on non-stationary data tends to result in spurious regressions where a meaningful relationship appears to exist between the variables when in actual fact they are not related (see section (4.4.1.)).

When the asset variable is excluded from the regressions, the regressions became theoretically inconsistent with the interest elasticity changing from negative to positive. All of the regressions estimated which excluded an asset variable displayed this characteristic (of theoretical inconsistency with the *a priori* expectations for the estimated coefficients) a problem which has resulted before in money demand estimations in South Africa. Stadler (1981, p.147) found this result where in every one of his estimations the interest elasticity of the demand for money has the incorrect sign[36]. Courakis (1984, p. 6) in re-estimating Courakis's money demand specification (and correcting for previous mistakes) also obtained theoretically inconsistent results which led him to suggest that the money demand estimation was incorrectly specified as a result of suffering from the omission of relevant variables that are positively correlated with permanent income (Courakis, 1984, p.10).

In contrast to these results, Maxwell (1971, p.29), who included a wealth variable in his analysis, obtained theoretically consistent results. This does not mean that no acceptable results have been achieved in South Africa without the inclusion of a wealth variable (see chapter 3) but rather that the inclusion of a wealth variable in the specification of a function for the South African demand for money, as suggested by Hurn and Muscatelli (1992, p.168) could perhaps lead to an improvement in the results obtained so far.

The positive signs obtained for the interest rate variables in the two regressions which excluded the wealth variable (presented in table 5.2. above) changed to the expected negative sign on the inclusion of an asset variable[37] thereby improving the results. These changes in the sign(s) of one or more of the regression coefficients when a variable is dropped from the regression is highly indicative of the omission of a relevant variable in the analysis, and Gujarati (1995, p.458) states that it is not advisable to omit a relevant variable (here the wealth variable) from a model that is formulated on the basis of

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[36] Whittaker (1985, p.191) also recorded obtaining positive values for the interest elasticity of the demand for money and Travlas (1989, p.7) obtained a positive sign on the interest rate coefficient in certain specifications when using the 3 month treasury bill rate as a measure of the interest rate, whilst Contogiannis and Shai (1982, p. 31) obtained statistically insignificant results from the inclusion of various interest rate variables but did not report on the sign of these coefficients (See chapter three, section (3.3.), for more detail).

[37] The theoretically incorrect sign of the interest elasticity of the demand for money obtained in the two regressions above that exclude the wealth variable was in fact experienced for all the cointegrating regressions estimated without an asset variable. With eighteen regressions being run altogether for the three monetary aggregates regressed separately on different measures of income and interest rates, the positive coefficient of the interest rate variable appeared to be the norm regardless of which measure of income, interest rates or money aggregates was used.

pertinent theory because of the detrimental consequences that arise. Some of the consequences he lists being that the remaining parameters will be biased and inconsistent and the tests on the statistical significance of the remaining estimated parameters are misleading, so that the estimated regression cannot then be considered as being a correct specification of the demand for money due to the existence of the specification error of the omission of a relevant variable (Gujarati, 1988, p.402). In contrast when the asset variables are taken into account the quality of the estimations are improved as they then pass the criteria of being consistent with theoretical expectations.

It is also interesting to note that different interest rates are significant in the two regressions, depending on which measurement of the wealth variable is used. That is the long-term interest rate is the only one out of the three choices of interest rates that does meet the selection criteria to be included in the demand for money regression with total credit, and likewise the yield on three year government bonds is the only interest rate that gives a statistically significant and theoretically consistent estimate when included in the money demand regression where wealth is measured by consumer credit. This would appear to show that the type of interest rate used in the regression does in fact appear to significantly affect the results and, following the argument of Hendry and Ericson (1991, p.24), it would then need to be determined if in fact no cointegrating relationship exists between the interest rates.

To see if this assumption is true the interest rates are examined next to see if they are cointegrated.

5.4. Tests for the Existence of Cointegration Relationships between the Long-Term and Short-Term Interest Rates

To test for a cointegrating relationship between the long-term and the short-term interest rates two regressions were subsequently run in accordance with the test procedure used by Engle and Granger (1987, p.273), where the long-term rate (the yield on fifteen year government bonds, denoted as iy_t,

Results of the Test for the Existence of a Cointegrating Relationship between the Interest Rates with the Long-Term Interest Rate (iy) as the Dependent Variable

	The CRWD test:							
	General Specification:	Critical Values			General Specification:	Critical Values		
Variable	$iy = c + \beta_1 inc + u_{t1}$	1%	5%	10%	$iy = c + \beta_2 int + u_{t2}$	1%	5%	10%
c	0.248				0.789			
inc	0.937							
int					0.733			
Test Statistics								
adjR^2	0.844				0.914			
DW	0.197	0.511	0.386	0.322	0.214	0.511	0.386	0.322

	The DF (or EG) test:					
	General Specification: $\Delta u_{t1} = -\varphi u_{t1-1} + \varepsilon_t$			General Specification: $\Delta u_{t2} = -\varphi u_{t2-1} + \varepsilon_t$		
	Test		EG Critical values	Test		EG Critical values
Variable	Specification	Level	1%	Specification	Level	1%
u_{t1-1}	-	-0.133 (-3.15)	-4.07			
u_{t2-1}				-	-0.100 (-4.079)	-4.07

	The Augmented DF (or Augmented EG) test:					
	General Specification: $\Delta u_{t1} = -\varphi u_{t1-1} + \Delta\beta_1 u_{t1} + \ldots + \Delta\beta_i u_{t1} + \varepsilon_t$			General Specification: $\Delta u_{t2} = -\varphi u_{t2-1} + \Delta\beta_1 u_{t2} + \ldots + \Delta\beta_i u_{t2} + \varepsilon_t$		
	Test		Critical values	Test		Critical values
Variable	Specification	Level	1%	Specification	Level	1%
u_{t1-1}	-	-0.148	-3.77			
u_{t2-1}				-	-0.132	-3.77

Table 5.3.

is first regressed on the interest rate at commercial banks on twelve month fixed deposits, and then on the yield on three year government bonds (int_t), or

$$iy_t = c_1 + \beta_1 inf_t + u_{t1} \tag{5.5.}$$

$$iy_t = c_2 + \beta_2 int_t + u_{t2} \tag{5.6.}$$

where u_{t1} and u_{t2} are the residuals from the respective regressions. These regressions were then tested to see if cointegrating relationships exist with the aid of the Cointegrating Regression Durbin Watson (CRDW) test, the null hypothesis of the this test being that there is no cointegration. The results are presented below in table (5.3.) in the first section. The DW statistic values for the first regression, (5.5.), is 0.197 and for the second regression, (5.6.), is 0.214. Both these values do not exceed the critical values of the CRDW test at either the 10% (0.322) , 5%(0.386), or 1% (0.511) levels, which therefore suggests that it is not possible to reject the null hypothesis of no cointegration for either of the regressions.

Using the Dickey-Fuller (DF) test for cointegration (or the Engle-Granger, EG, test), the test regressions are respectively

$$\Delta u_{t1} = -\varphi u_{t1-1} + \varepsilon_t \tag{5.7.}$$

$$\Delta u_{t2} = -\varphi u_{t2-1} + \varepsilon_t \tag{5.8.}$$

where Δu_{t1} and Δu_{t2} are the respective error terms from the regressions (5.7.) and (5.8.) above. The Engle-Granger test for cointegration proceeds in the same fashion as the Dickey-Fuller test for stationarity excepting that the residuals of the regression are being tested for stationarity instead of the variables themselves. If the interest rate variables are cointegrated then the residuals of the resulting cointegrating regressions will be stationary because the residuals will then be purely white noise[38]. The null hypothesis of the EG test is that the residual is non-stationary.

The results of the EG test, see the second section in table (5.3.) below, also show that the short and the long-run interest rates are not cointegrated. The tau-statistics of -0.133 for the long-term rate regressed on the 12 month fixed deposit rate and -0.100 for the long-term rate regressed on the yield on three year government bonds do not exceed the Engle-Granger (EG) critical value of 4.07 at the 1% level, nor the Engle-Granger (EG) critical value at the 10%(3.03) or 5%(3.37) levels.

The Augmented Engle Granger test (Engle-Granger, 1987, p.268-269) to test for cointegration is similar to the ADF test for stationarity with a null hypothesis of non-stationarity. The test assumes a fourth-order autoregressive process but is similar to the DF (or EG) test in every other way and is therefore as robust, excepting for the case where the system is in first order (Engle and Granger, 1987, p. 267) where it has less power. The test regressions are

$$\Delta u_{t1} = -\varphi u_{t1-1} + \Delta\beta_1 u_{t1} + \ldots + \Delta\beta_i u_{t1} + \varepsilon_t \qquad (5.9.)$$

$$\Delta u_{t2} = -\varphi\, u_{t2-1} + \Delta\beta_1 u_{t2} + \ldots + \Delta\beta_i u_{t2} + \varepsilon_t \qquad (5.10.)$$

for equations (5.5.) and (5.6.). The results are given in the last section of table (5.3.) where the coefficients of the level autoregressive term, -0.148 and -0.132, are both insignificant as their

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[38] Random with a zero mean, constant variance and autocovariance as explained in section (4.4.2.).

corresponding t-statistics fall below the 1% (3.77), 5%(3.17) and 10%(2.84) AEG critical values. However as noted by Engle and Granger (1987, p.268) when the system is in first order as is the case here (all the variables were found to be of order one in the pre-testing section of (5.2.) including the interest rates) the augmented DF test has slightly lower power and so is less reliable than the CRDW test and the DF test for cointegration.

The values in round brackets, (-3.15) and (-4.079), that are reported in the DF test section of table (5.3.) are the values calculated by SHAZAM's Dickey-Fuller test on the residuals of cointegrating regressions (see White, 1993, p.163). These values differ from the results obtained by running test regressions (5.8.) and (5.9.) above, but as the test equations used in the SHAZAM Programme are unfortunately not given no comparisons can be made and so it is not possible to give a reason for these differences but it is indicated below which test will be relied on. The Dickey-Fuller value (calculated by SHAZAM) for the regression of the long-term rate on the fixed deposit rate is still below the EG critical value however so that the null hypothesis of no cointegration is not rejected either by SHAZAM's Dickey-Fuller test on the residuals.

The discrepancy arises when the DF value for the long rate regressed on the yield on three year government bonds is calculated by SHAZAM as a DF value is obtained which is greater than the EG critical value, which means that the null hypothesis of no cointegration is rejected. This is at odds with the results obtained on all three other test in table (5.3.) which all show that no cointegrating relationship exists between the long-term interest rate and the yield on three year government bonds causing this conflicting result to be in the minority. Engle and Granger (1987, p.270) however report the CRDW to be the most powerful test for cointegration when the system is in first order, outperforming the Dickey-Fuller test every time and for this reason recommend it as the preferred test to rely on when choosing between the result given by the two.

On the whole therefore it may be concluded on the evidence of the CRDW, DF and ADF tests that the long-term interest rate, the yield on fifteen year government bonds, is not cointegrated with either of the short-term interest rates. This suggests that when the interest rates cannot be used interchangeably in the cointegrating money demand regression they tend not to be cointegrated with one another, which is consistent with the argument of Hendry and Ericson(1991) given above in section (4.1.). This result is of interest, pointing to the fact that long and short-term interest rates do not appear to be linked as in the long-run as no cointegrating relationship has been found to exist.

Returning now to estimation procedure of the money demand function, the next step in section (5.1.) after estimating the cointegrating regressions involves the formulation of the error correction representations which is presented below in section (5.5.).

5.5. The Error Correction Representations

As reported in chapter four, Granger (1981, p. 129) and Engle and Granger (1987, p. 255) argue that when an equilibrium relationship exists between a set of integrated variables, the cointegrating regression which results from a regression run on these variables can be represented in the form of an error-correction model (ECM). This error correction term (ECT) should have a negative (significant) coefficient in order to guarantee that the divergences which occur in one period are then corrected for in the next period (Engle and Granger, 1987, p.254). The implications of this negative error correction term for the demand for money is that when the level of the money stock is in disequilibrium, for example it is too high in relation to the explanatory variables, the negative value of the error term would cause a downwards adjustment in the level of money stock to occur in the subsequent periods in order to correct for the disequilibrating error.

When modelling the ECM the differenced values, lagged up to seven quarters, of the variables in the four cointegrating regressions above were modeled in four unrestricted seventh-order error correction representations[39]. The results of these regressions are presented below in tables (5.4.), (5.5.), (5.6.)

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[39] For an approach of this kind see Hendry and Ericson (1991), Hendry (1979), Hendry and Richard(1982), Hendry and Richard (1983), Wong and Kennedy (1992).

and (5.7.). In essence this step is just a working step to ascertain the appropriate lag structure of the final error correction models by first estimating general unrestricted models to avoid inflicting erroneous *a priori* restrictions on the error correction models by excluding any significant variables from the model.

Due to the likely existence of multicolinearity amongst the regressors of the seventh-order autoregressive distributed lag models, and the resulting consequences of insignificant t-statistics due to large variances of the estimators and wider confidence intervals (see Gujarati, 1995, p.327-330), the use of t-tests could become a problem when deciding on the statistical significance of the variables for inclusion in the error correction models. This is because variables that do actually have some explanatory power could then be excluded as a result of their lower t-statistic values. The solution here would then be to use the F-test of joint significance instead of the t-tests because the F-test still provides a reliable method of testing the statistical significance of the regressors in the presence of multicolinearity[40].

Further, the null hypothesis that is used here in the F-tests forms an integral part of the estimation procedure because it involves the imposition of exclusion restrictions on certain parameter estimates in the model through constraining (or restricting) these estimates to equal the value zero, which then effectively excludes the corresponding variables from the model (Stewart, 1984, p.119).The number of remaining explanatory variables is then reduced, causing new parameter values to be obtained for these variables. In this manner restricted versions of the error correction models are then obtained which are essentially simplified versions of the original unrestricted error correction models.

Proceeding in this way the estimations of the four unrestricted autoregressive distributed lag models were obtained. They are presented below in tables (5.4.) to (5.7.). In these tables the corresponding t-statistic for each estimated coefficient is given below the estimate in the round brackets. The lag index gives the order of lag of each first differenced variable where 0 corresponds to no lag and 1 corresponds to the variable lagged once. The same notation as before has used to denote the variables

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[40] See Kennedy (1992, p.58-61);Griffiths, Hill and Judge (1993, p.335-336); Gujarati (1995, p.334).

with the addition of ECT which stands for the error correction term, and the use of the small triangle (Δ) means that the variable are in their differenced form as explained in section (4.4.2.).

In regards to the error term itself the values have not in fact been lagged and differenced, but have, instead, as noted in section (5.1.), been raised to the powers of 1 through seven so that in the context of the error correction term the lag index is not denoting the number of lags but rather is giving the size of the of the exponent where 2 corresponds to the square of the error correction term, 3 corresponds to the cube of the error term and so on.

Estimation of these four unrestricted models completes step (3) of the estimation procedure. Step (4) can now be commenced with which involves the application of F-tests to the unrestricted models in the testing down procedure. Following Wong and Kennedy (1992, p.4) a sequence of nested[41] F-tests are used to simplify the unrestricted models in this procedure. For the unrestricted models in tables (5.4) to (5.7.) below the corresponding critical F-statistic is 1.94 at the 10% level, 1.59 at the 5% level and 1.43 at the 1% level with 30 and 80 degrees of freedom. Using the F-test to test down the corresponding F-statistics will be given as F(x, y) where x is the number of variables being excluded in each test and y is the corresponding degrees of freedom (see section (4.4.4.)).

Equation (5.11.) is the result of three reduction processes carried out on the unrestricted error correction model in table (5.4.) The corresponding F-statistics for the testing down procedure are F(14, 80)=3.8117, F(8, 94)=1.3184 and F(10, 102)= 1.2242 [with T=119]. The final F-statistic obtained does not exceed the critical values at the 10%, 5% or 1% level meaning that the final list of explanatory variables (in the restricted equation (5.4.)) are jointly significant at the 1% level.

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[41] Each F-test is nested in the previous F-test which means that each subsequent F-test is a special case of the previous F-test, ie it is nested in the previous test. This is due to the testing down procedure carried out through the imposition of a sequence of exclusion restrictions whereby more and more variables are excluded from the model with the imposition of each F-test.

An Unrestricted Error-Correction Representation For Real M3, Conditional on Interest Rates, Income and Wealth: 1965Q2 to 1996Q4.

	lag i (or index)							
Variable	0	1	2	3	4	5	6	7
Δm_{t-i}	-1	0.261 (2.265)	0.010 (0.079)	0.127 (0.996)	0.124 (0.995)	-0.045 (-0.385)	0.092 (0.823)	-0.052 (-0.683)
Δgde_{t-i}	0.180 (2.261)	-0.117 (-1.265)	0.005 (0.056)	-0.193 (-2.215)	-0.014 (-0.177)	0.052 (0.660)	0.008 (0.108)	0.073 (1.055)
Δwc_{t-i}	0.055 (1.126)	0.070 (1.337)	-0.006 (-1.114)	0.061 (1.262)	0.045 (0.872)	-0.021 (-0.452)	-0.090 (-1.819)	-0.031 (-0.633)
Δint_{t-i}	-0.050 (-2.184)	-0.006 (-0.252)	-0.004 (-0.160)	-0.004 (-0.191)	-0.028 (-1.197)	0.013 (0.530)	-0.040 (-1.632)	-0.007 (-0.264)
ECT	-	-0.317 (-1.525)	-10.470 (-1.607)	149.18 (1.025)	4142.9 (1.753)	-39074 (-1.164)	-352190 (-1.642)	2952500 (1.214)
Constant	0.008 (2.006)	-	-	-	-	-	-	-

Note: t - values in parentheses; T = 119, R^2 = 0.4489, adjusted R^2 = 0.1903, $\hat{\sigma}$ =0.0003. Table5.4.

The restricted version of the error correction model in table (5.4.) is

$$\Delta m3 = 0.0039 + 0.2022\Delta m3_{t-1} + 0.2021\Delta gde_t + 0.0663\Delta wc_t + 0.0597\Delta wc_{t-1} - 0.0372\Delta int_{t-} - 0.0113\Delta int_{t-4} - 0.1299\Delta ECT_{t-2} \quad (5.11.)$$

An Unrestricted Error-Correction Representation For Real M3, Conditional on Interest Rates, Income and Wealth: 1965Q2 to 1996Q4.

	lag l (or index)							
Variable	0	1	2	3	4	5	6	7
Δm_{t-l}	-1	0.331	0.051	0.142	0.141	-0.041	0.060	-0.073
		(3.031)	(0.413)	(1.165)	(1.198)	(-0.372)	(0.567)	(-0.966)
Δgde_{t-l}	0.195	-0.095	0.020	-0.119	0.019	0.043	-0.001	0.070
	(2.513)	(-0.977)	(0.221)	(-1.448)	(0.249)	(0.571)	(-0.018)	(1.000)
Δint_{t-l}	-0.052	-0.027	-0.013	-0.005	-0.035	0.008	-0.036	-0.010
	(-2.256)	(-1.141)	(-0.569)	(-0.223)	(-1.408)	(0.307)	(-1.429)	(-0.405)
ECT	-	-0.245	-0.561	67.28	-23.61	-12585	7292.4	558100
		(-1.254)	(-0.116)	(0.462)	(-0.018)	(-0.427)	(0.079)	(0.332)
Constant	0.005	-	-	-	-	-	-	-
	(1.195)							

Note: t - values in parentheses; T = 119, R^2 = 0.3761, adjusted R^2 = 0.1657, $\hat{\sigma}$ =0.0003. Table5.5.

The corresponding F-statistics for the testing down procedure are F(9, 88)=26.3350, F(3, 97)=0.6009 and F(4, 100)= 0.4866 [with T=119].The restricted version of the error correction model in table (5.5.) is

$$\Delta m3 = 0.0034 + 0.2361\Delta m3_{t-1} + 0.1074\Delta m3_{t-2} + 0.1127\Delta m3_{t-4} + 0.2181\Delta gde_t - 0.0366\Delta int_t - 0.0315\Delta int_{t-1} - 0.0074\Delta int_{t-2} - 0.0217\Delta int_{t-4\ 1} - 0.1798\Delta ECT_{t-}1 \quad (5.12.)$$

An Unrestricted Error-Correction Representation For Real M3, Conditional on Interest Rates, Income and Wealth: 1965Q2 to 1996Q4.

	lag I (or index)							
Variable	0	1	2	3	4	5	6	7
Δm_{t-I}	-1	0.339	0.110	0.223	0.122	0.034	0.050	0.005
		(3.141)	(1.002)	(2.039)	(1.112)	(0.301)	(0.456)	(0.049)
Δgde_{t-I}	0.095	-0.028	0.029	-0.037	0.066	0.043	-0.004	0.021
	(1.598)	(-0.449)	(0.472)	(-0.645)	(1.153)	(0.715)	(-0.070)	(0.405)
Δwt_{t-I}	0.475	-0.248	-0.143	-0.211	-0.051	0.048	0.060	-0.021
	(5.886)	(-2.459)	(-1.432)	(-2.008)	(-0.474)	(0.465)	(0.569)	(-0.198)
Δinf_{t-I}	-0.0312	-0.069	-0.016	0.012	-0.059	-0.010	0.126	-0.030
	(-0.830)	(-1.886)	(-0.436)	(0.318)	(-1.669)	(-0.282)	(0.330)	(-0.795)
ECT	-	-0.283	-4.265	215.66	1994.6	-69329	-244660	5121200
		(-1.869)	(-0.643)	(1.177)	(0.603)	(-1.130)	(-0.603)	(0.850)
Constant	0.004	-	-	-	-	-	-	-
	(1.263)							

Note: t - values in parentheses; T = 119, R^2 = 0.6752, adjusted R^2 = 0.5228, $\hat{\sigma}$ =0.0002. Table5.6.

The F-statistics for the testing down procedure are F(16, 80)=5.6553, F(6, 96)=2.5689 and F(10, 102)= 1.8676 [with T=119] giving the following restricted version of the model in table (5.6.) is

$$\Delta m3 = 0.0021 + 0.1352\Delta m3_{t-1} + 0.0544\Delta gde_t + 0.5397\Delta wt_t - 0.0747\Delta inf_{t-1} - 0.0380\Delta inf_{t-4} - 0.1144\Delta ECT_{t-2} \qquad (5.13.)$$

An Unrestricted Error-Correction Representation For Real M3, Conditional on Interest Rates, Income and Wealth: 1965Q2 to 1996Q4.

	lag I (or index)							
Variable	0	1	2	3	4	5	6	7
Δm_{t-I}	-1	0.304	0.049	0.180	0.130	-0.002	0.065	-0.043
		(2.998)	(0.452)	(1.557)	(1.144)	(-0.022)	(0.614)	(-0.601)
Δgde_{t-I}	0.215	-0.128	0.003	-0.112	0.006	0.058	0.031	0.056
	(3.088)	(-1.672)	(0.041)	(-1.519)	(0.086)	(0.804)	(0.445)	(0.820)
Δinf_{t-I}	-0.062	-0.011	-0.037	-0.019	-0.073	-0.036	-0.337	-0.063
	(-1.363)	(-2.348)	(-0.802)	(-0.419)	(-1.602)	(-0.766)	(-0.727)	(-1.408)
ECT	-	-0.382	-1.904	282.33	619.4	-75281	-54090	4951500
		(-1.801)	(-0.356)	(1.599)	(0.357)	(-1.823)	(-0.381)	(1.819)
Constant	0.007	-	-	-	-	-	-	-
	(1.776)							

Note: t - values in parentheses; T = 119, R^2 = 0.4122, adjusted R^2 = 0.2141, $\hat{\sigma}$ =0.0003. Table5.7.

The corresponding F-statistics for the testing down procedure are F(10, 88)=2.8336, F(1, 98)=1.5751 and F(10, 99)= 1.5023 [with T=119].The restricted version of the error correction model in table (5.7.) is

$$\Delta m3 = 0.0038 + 0.2245\Delta m3_{t-1} + 0.0922\Delta m3_{t-2} + 0.1316\Delta m3_{t-4} + 0.2279\Delta gde_t - 0.0349\Delta inf_t - 0.0830\Delta inf_{t-1} - 0.0260\Delta inf_{t-2} - 0.0409\Delta inf_{t-4} - 0.1731\Delta ECT_{t-1} \qquad (5.14.)$$

The estimated coefficients for all four of the final estimations of the error correction models (reproduced below in table 5.8. for ease of comparison and reference) satisfy the necessary sign constraints (given above in equations (5.3.) and (5.4.)) for the estimated regressions to be construed as demand for money equations. The estimated coefficients of the lagged error correction terms all have significant t-values at the 1% level[42], as well as the necessary negative signs expected for cointegration and to ensure that any short-run imbalances are reduced over time.

The small values obtained for the error correction coefficients imply that the short-run movements away from the long-run level of the demand for money are quite small as the size of the necessary correction to bring the short-run movements away from equilibrium in line with the long-run level (given by the coefficients of the error correction terms) is low. The adjustments all occur with a lag of one quarter, suggesting that the adjustment towards the desired (or equilibrium) level of money holdings after the occurrence of an imbalance is quite rapid. This could possibly be due to the high degree of liquidity of even assets included in the definition of M3 through every increasingly competitive financial innovations.

The low coefficients of the lagged monetary aggregates, and the low significance of the lags of more than one period of these aggregates, suggests that past changes in the level of money holdings do not have a very strong impact on the present level of money holdings implying that agents are forward as opposed to backwards looking. In other words agents are not to base their decisions heavily on past levels of money, thereby tending to be more rational[43] in their money holding decisions. The size of the income coefficients were surprising for a South African study as they tended to be much closer to the income elasticity of 0.3 postulateded in the Miller-Orr model than to the previous expectations

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[42] In order to test for the existence of cointegration through examining the significance of the error correction terms, use of the usual Dickey-Fuller tests is no longer possible as these tests have a low degree of power as a result of the imposition of differencing on the residuals (Kremers, Ericson and Dolado, 1992, p. 325). For this reason the DF tests were not used here to test for cointegration and the t-value of each error correction term in the dynamic models was tested against the critical t value with the usual students t-test (Kremers *et al*, 1992, p. 325).

[43] By rational the usual definition applies where the agents form their expectations or decisions on present experiences, as well as past, so that they do not neglect any "*current available and relevant information in forming their expectations*" (Shaw, 1984, p.47).

of an income elasticity of one.

As mentioned earlier a problem which could influence the results is multicolinearity. This is because it causes the standard errors of the estimated coefficients to be high (biased upwards) thereby resulting in insignificant t-statistics being obtained. As a result certain variables which ought to be included in the models could thereby be excluded when reliance is placed on the t-tests. The inclusion of certain variables insignificant estimates in the final estimates can be justified on these grounds. Further excluding these variables results in the joint significance of the regression decreasing as a whole. This means that while these variables are possibly not significant themselves, they do considerably increase the significance of the regression as a whole and for this reason have not been excluded from the final estimations (presented in table (5.8.)).

In selecting between the four regressions estimated above a number of model selection tests can be used. Also the attributes of the models themselves can be examined to determine whether the models are good models.

5.6. The Models' Attributes and Model Selection Tests

An examination of table (5.8.) shows that the inclusion of the wealth variables in the regressions seems to reduce the number of explanatory variables in the regression as a whole (increases parsimony[44]). Another attribute commonly given of a good model is identifiability where a model is said to have the characteristic of identifiability if there is only one set of parameter values for the data, ie there is only one estimated value for a parameter (Gujarati, 1988, p.400). This attribute is also consistent with the final estimates, not surprisingly as it tends to follow that the greater the

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[44] Parsimony means keeping a model as simple as possible, which is necessary as a model is essentially an abstraction of reality, and not a mirror of reality itself. A good model therefore will seek to simplify reality as much as possible whilst still capturing the essence. To this purpose as few explanatory variables as adequately explain the model should be used, and all other random or minor influences on the model should be relegated to the error term.

Estimates of the error correction models for the money stock M3

	Money Demand			
Variable	Excluding assets: wc	Including Assets: wc	Excluding Assets: wt	Including Assets: wt
c	0.0034 (1.8054)	0.0039 (2.1700)	0.0038 (2.0061)	0.0021 (1.3858)
$\Delta m3_{t-1}$	0.2361 (2.7639)	0.2022 (2.2505)	0.2245 (2.6526)	0.1352 (1.8935)
$\Delta m3_{t-2}$	0.1074 (1.2049)		0.0922 (1.0499)	
$\Delta m3_{t-4}$	0.1127 (1.3009)		0.1316 (1.5226)	
Δgde_t	0.2181 (3.5388)	0.2021 (3.2850)	0.2279 (3.9512)	0.0544 (1.0023)
Δwc_t		0.0663 (1.5935)		
Δwc_{t-1}		0.0596 (1.4673)		
Δwt_t				0.5397 (7.3859)
Δint_t	-0.0367 (-1.9835)	-0.03719 (-2.1122)		
Δint_{t-1}	-0.0315 (-1.6287)			
Δint_{t-2}	-0.0074 (-0.3913)			
Δint_{t-4}	-0.2170 (-1.1407)	-0.0112 (-0.6088)		
Δinf_t			-0.0349 (0.9408)	
Δinf_{t-1}			-0.82950 (-2.1229)	-0.0747 (-2.5221)
Δinf_{t-2}			-0.0260 (-0.6730)	
Δinf_{t-4}			-0.0409 (-1.1267)	-0.0380 (-1.2568)
ECT	-0.1799(-4.1473)	-0.1298(-3.2349)	-0.1731(-2.314)	-0.1144 (-2.6524)
Test Statistics				
$AdjR^2$	0.2474	0.2377	0.2417	0.4600
Std	0.0173	0.0174	0.0174	0.0147
FPE	0.00032587	0.00032500	0.00032832	0.00022842
AIC	0.00032575	0.00032494	0.00032820	0.00022838
B-P	6.360 (7.815)	7.629(9.210)	10.416 (11.345)	6.669 (6.635)
h test		0.959 (1.645)		1.919 (1.645)

Table 5.8.

parsimony of a model the less likely it is to have problems of identifiability because of the reduced number of variables in it.

The goodness of fit of the model is traditionally measured by the $R^{2,}$ or more preferentially adjusted R^2, to take into account the degree of freedom associated with the residuals. Although a high adjusted R^2 value is always agreeable as it is reflecting the degree of variation in the dependent variable that is explained by the explanatory variables, it should be used with caution as a criterion for selecting models as the true model's adjusted R^2 value only exceeds that of an incorrectly specified model on average, not one hundred percent of the time (Johnston, 1984, p.505). The test is also not useful in rejecting all of the models if none of them are actually the best one. Furthermore the statistic is acknowledged not to be useful in model selection by Charemza and Deadman (1992, p.17-18) whilst Judge and Griffiths (1980, p.418) highlight the failure of this statistic in not considering the purpose for which the model is to be used as one of its major downfalls. Nevertheless the value of R^2 for the regression containing total credit exceeds the criterion for the regression excluding total wealth whilst the adjusted R^2 values for the regression containing consumer credit does exceed the value obtained for the regression excluding consumer credit. On the whole the adjusted R^2 values for the final estimates of the error correction models are not very high at all.

Further including the wealth variables in these short-run models (Error Correction Models) reduces the number of explanatory variables in the regression as a whole (increases parsimony) whilst the AIC information Criterion and FPE are both lower for the models including a wealth variable than when one is excluded.

Based on the improved results obtained when the models do contain a wealth variable, as opposed to when they exclude it, the conclusion can be made that the results tend to improve with the inclusion of a wealth variable as suggested by Hurn and Muscatelli (1992).

5.7. Summary and Conclusion

The results obtained overall indicate that the inclusion of a wealth variable in the specification of the demand for money constantly improves the results. In the cointegrating regression the interest elasticities change from negative to positive when the wealth variables are included in the regression (as opposed to them being excluded).This represents a major finding as theoretically inconsistent positive interest elasticities have been obtained in the past.

The high R^2 values and low Durbin-Watson statistics obtained in all the cointegrating regressions, shows that the data series used in the estimations are nonstationary. This is significant in that it means that money demand regressions which do not use cointegration in their estimation procedure run the danger of obtaining false or spurious regressions. (Where the results appear meaningful but when examined more closely the relationship between the dependent variable and the explanatory variables is false).

The general error correction models estimated in tables (5.4.) to (5.7.) show that there is a decreasing structure of the error correction term over time. This means that the short-run deviations in the level of money holdings are being adjusted towards the long-run level of money holdings as smaller and smaller adjustments need to be made over time. The error correction term is therefore exhibiting a dampening effect on the short-run movements in the demand for money to ensure that they stay in line with the long-run equilibrium level.

The use of the variables in the results are consistent with the expectations. The significance of GDE compared with the complete failure of GDP to be significant in any one of the regressions is consistent with Judd and Scadding's (1982, p.993) criteria for a stable function where they argue that the explanatory variables should be highly representative of spending. Further the inclusion of the wealth variable decreases the number of explanatory variables in the regression as a whole, leading to increased parsimony. The FPE criterion further indicates that the regressions including wealth variables have better post-sample prediction ability than those without and so have better predictability in regards to forecasting accuracy. The lower AIC criterion also indicates that the regressions including wealth variables are better than those excluding wealth.

CHAPTER SIX

CONCLUSION

In the South African context the real demand for money has not been recently modeled on wealth. Heller (1965) and Maxwell (1971) made use of the wealth variable in their estimations, with both of them concluding that it was not the appropriate scale variable to use. The results from this study have indicated that when wealth is included in the function of the demand for real money with GDE and either the yield on three or fifteen year government bonds, then the results of regressions show a significant improvement to the situation where the wealth variable is excluded from this function. This is true for both the cointegrating equations and the error correction models.

Stable long-run functions for the real demand for money have been obtained for the demand for real money in South Africa with the method of cointegration. The equations are of the form

$$m3_t = \phi_0 + \phi_1 gde_t + \phi_2 wc_t - \phi_3 int_t$$

$$m3_t = \beta_0 + \beta_1 gde_t + \beta_2 wt_t - \beta_3 inf_t$$

with the yield on the three year government bond and the yield on the fifteen year government bond both having the expected negative interest elasticities consistent with economic theory. No cointegrating relationship has been identified between these interest rates implying that they cannot be used interchangeably in the cointegrating regressions, but depend on the proxy that is used for wealth. The error correction representations of these regressions have significant error correction terms implying a stable *function* for the demand for real money as specified by the error correction models below

$$\Delta m3 = \alpha_0 + \alpha_1 \Delta m3_{t-1} + \alpha_2 \Delta gde_t + \alpha_3 \Delta wt_t - \alpha_4 \Delta inf_{t-1} - \alpha_5 \Delta inf_{t-4} - \alpha_6 \Delta ECT_{t-2}$$

$$\Delta m3 = \varkappa_0 + \varkappa_1 \Delta m3_{t-1} + \varkappa_2 \Delta gde_t + \varkappa_3 \Delta wt_t - \varkappa_4 \Delta inf_{t-1} - \varkappa_5 \Delta inf_{t-4} - \varkappa_6 \Delta ECT_{t-2}$$

where a significant coefficient has been obtained by each of the error correction terms. The coefficient of both of the error correction terms are negative which is a further indication of the existence of a cointegrating relationship between the variables. By including a wealth variable into the function for real money demand in South Africa it has enabled the estimation of a stable long-run function and theoretically consistent stable representations of the short-run dynamics.

The actual nature of the short-run monetary aggregates on the other hand was found to be non-stationary and followed a random walk. The variables in the long-run equations were all found to be integrated of order one and so are cointegrated, meaning that they move together over time in the long-run. This finding gives additional support to the transaction demand theory of Miller and Orr(1966) who argue that the short-run demand for money holdings follows a random walk within the bands or levels of money demand which are determined by the long-run.

The surprising results came from the income elasticities obtained in the short-run money demand functions as these were closer to the value of 0.3 predicted by Miller and Orr (1969) than to 1 as expected for South Africa. The interest rate elasticities where on the other hand closer to zero, as expected for South Africa, than to -0.3 predicted by Miller and Orr.

The income elasticities for the long-run demand for real money without wealth variables were close to one, however the interest elasticities were positive. Inclusion the wealth variables resulted in the interest elasticities changing from positive to negative thereby indicating previous misspecification of the function due to an omission of a relevant variable. The results regarding the income elasticity did not improve however for while still positive they decreased in value. The inclusion of an wealth variable into the analysis did not therefore improve the results as far as emphasising the asset demand for money. (That is achieving a unitary elasticity for income as postulated by the asset theories). The interest elasticities have also moved closer to zero when the wealth variables were included in the regressions.

It can be argued that while not improving the results in terms of emphasising the asset demand for money as suggested by Hurn and Muscatelli (1992, p.164), the inclusion of wealth variables in the analysis did significantly improve the results obtained overall. The demand for broadly defined real money therefore appears to depend on GDE, wealth, and the medium and long-term interest rates.

APPENDIX A

THE MONETARY AGGREGATES AND THE CONSUMER PRICE INDEX

		M1	M2	M3	CPI
1965	01				
	02	1 518.6	2959.3	4 846.0	4.6
	03	1 505.0	3041.3	4 840.3	4.7
	04	1 546.6	3200.7	4 902.0	4.7
1966	01	1 553.0	3192	4 960.3	4.8
	02	1 637.3	3259	5 118.0	4.8
	03	1 680.3	3377.7	5 295.3	4.8
	04	1 705.6	3426.3	5 368.6	4.9
1967	01	1 683.3	3401	5 451.0	4.9
	02	1 704.0	3451.3	5 536.0	5
	03	1 705.3	3507	5 608.3	5
	04	1 785.0	3640.3	5 718.6	5
1968	01	1 800.6	3663.3	5 876.3	5
	02	1 862.0	3761.7	6 062.3	5.1
	03	1 899.0	3909.7	6 275.0	5.1
	04	2 130.6	4240.3	6 521.3	5.1
1969	01	2 142.0	4268.7	6 688.3	5.2
	02	2 181.3	4297	6 811.6	5.2
	03	2 181.3	4403	6 891.3	5.3
	04	2 258.6	4599	7 210.0	5.3
1970	01	2 255.0	4675.7	7 281.0	5.4
	02	2 339.3	4995.7	7 487.6	5.4
	03	2 370.6	5045.3	7 642.3	5.5
	04	2 415.3	5139.7	7 803.6	5.5
1971	01	2 307.0	5075.7	8 001.0	5.6
	02	2 373.0	5207.3	8 183.0	5.7
	03	2 417.0	5290	8 300.0	5.8
	04	2 505.6	5453	8 473.3	5.9
1972	01	2 492.6	5424.7	8 692.3	6
	02	2 601.3	5575	8 916.3	6.1
	03	2 755.0	5841.3	9 388.0	6.2
	04	2 846.6	6113	9 802.3	6.3
1973	01	2 786.0	6269.7	10 199.3	6.5
	02	3 021.3	6798.3	10 916.6	6.7

	04	23 795.0	47269	64 020.3	25.9
1985	01	24 891.3	48575.7	65 712.6	27.1
	02	24 950.3	49896	67 787.3	28.3
	03	24 871.0	51526.3	69 803.0	29.3
	04	22 114.0	53451.7	71 454.0	30.5
1986	01	21 961.0	53905.7	73 308.3	32.2
	02	22 840.3	54454.3	75 175.3	33.3
	03	23 898.6	54845.3	76 710.3	34.8
	04	24 754.0	56370.7	78 499.6	36.2
1987	01	25 972.0	56347	79 522.6	37.5
	02	27 874.6	58790.3	82 691.3	38.9
	03	29 377.3	60823.3	86 063.0	40.4
	04	32 357.6	67239.7	91 239.0	41.7
1988	01	35 197.0	72508.7	96 350.0	42.7
	02	37 162.6	77089	101 818.0	44
	03	38 169.0	82484.3	108 608.3	45.4
	04	40 969.6	90244.7	115 400.3	46.6
1989	01	41 479.0	96586	122 186.6	48.5
	02	42 498.3	100381	128 068.0	50.5
	03	43 100.3	106617.3	135 615.6	52.3
	04	47 101.6	116138.3	142 423.0	53.9
1990	01	50 328.0	121605.7	148 703.0	53.8
	02	49 608.3	123021	152 742.0	57.6
	03	47 035.3	123207.7	154 397.3	59.4
	04	50 462.0	129985.7	159 054.6	61.8
1991	01	54 627.3	139822.7	168 130.6	63.9
	02	56 742.0	145991.3	175 638.6	66.2
	03	58 460.3	149938.7	177 270.6	68.6
	04	60 617.0	154973	180 889.0	71.8
1992	01	61 311.3	157943.7	186 168.0	74.6
	02	61 921.0	164326.7	189 189.6	76.3
	03	67 876.6	169153.7	193 545.0	78.3
	04	71 359.3	172166.3	196 726.3	79.6
1993	01	69 221.3	168484.3	195 824.3	81.1
	02	70 852.3	168203.7	196 256.6	84.3
	03	69 769.3	170743.3	200 414.0	85.6
	04	73 503.6	177433.3	208 728.0	87.1
1994	01	81 872.0	186271.7	216 625.6	88.8
	02	89 486.6	195971	224 799.0	90.4
	03	89 577.3	142035.3	231 325.6	93.5
	04	92 071.6	212876.3	239 580.6	95.7
1995	01	91 763.0	212920.7	243 206.6	97.6
	02	96 775.6	226678.7	260 706.3	100.1
	03	98 255.3	227129.7	267 996.6	100.6
	04	105 232.0	237230.7	273 399.0	101.9

1996	01	112 318.3	246790	281 481.0	104
	02	122 467.6	262994.3	297 736.0	106
	03	128 683.6	269593.7	307 719.6	108.3
	04	140 873.6	279380	314 189.0	111.3

THE INCOME VARIABLE AND WEALTH VARIABLES

		GDE	GDP	Consumer Credit	Domestic Credit	Total Credit
1965	01					
	02	7953	7665	828	4293.0	4802.6
	03	7872	7667	845	4330.6	4858.6
	04	7529	7783	863	4294.0	4939.6
1966	01	7775	8044	881	4225.3	4866.0
	02	7900	8269	901	4235.0	4943.6
	03	8243	8466	921	4334.6	5048.6
	04	8686	8677	941	4429.3	5207.3
1967	01	9100	8946	963	4583.6	5334.0
	02	9269	9132	981	4709.3	5506.0
	03	9655	9752	985	4832.6	5609.0
	04	9188	9590	1012	4902.6	5753.3
1968	01	9443	9886	1040	4987.3	5636.3
	02	9548	9913	1069	5039.0	5636.3
	03	9906	10203	1096	5173.0	5734.6
	04	10291	10498	1121	5390.0	5953.6
1969	01	10372	10925	1145	5534.0	5989.3
	02	11184	11203	1176	5687.6	6278.0
	03	11847	11710	1164	5890.6	6476.0
	04	11881	11742	1204	6101.0	6858.3
1970	01	12140	12012	1282	6316.0	7016.3
	02	12823	12475	1320	6456.3	7253.0
	03	12964	12357	1366	6699.0	7484.3
	04	13733	13048	1363	6890.6	7795.3
1971	01	14040	13134	1368	7110.6	8169.6
	02	14017	13483	1393	7253.3	8393.6
	03	14633	14024	1421	7482.6	8680.6
	04	14678	14427	1464	7593.6	8873.3
1972	01	14842	14930	1495	7767.3	8862.6
	02	14629	14966	1520	7852.3	8931.3
	03	15090	15683	1584	8131.3	9399.0
	04	15903	16561	1651	8497.6	9880.3
1973	01	16630	17579	1744	8953.0	10385.3
	02	17672	18357	1897	9425.3	10958.0
	03	19428	19909	2009	10152.6	11593.3
	04	20954	21027	2137	10688.3	12240.3

1974 01	21592	22263	2212	11350.3	12801.3
02	23313	23296	2305	11817.6	13400.3
03	24655	23974	2341	12332.6	13791.6
04	25688	25227	2406	12682.6	14525.6
1975 01	26545	25932	2514	13239.3	15218.0
02	26574	25960	2572	13498.0	15596.6
03	28052	27236	2718	14131.0	16863.0
04	28005	27456	2887	14656.0	17728.0
1976 01	29570	28649	2984	15336.6	18641.0
02	30489	29818	3057	15579.6	19135.3
03	30157	30540	3129	15922.6	19728.3
04	31028	31073	3180	16396.3	20460.3
1977 01	30217	31464	3235	16862.6	20928.3
02	29898	32039	3118	17194.3	21568.3
03	32332	34071	3219	17758.3	22111.0
04	33213	35478	3120	17 895.6	22390.3
1978 01	33510	35988	3444	18334.3	22097.6
02	34749	36981	3680	18936.6	22975.6
03	36402	39518	3793	19758.0	23698.0
04	37327	40501	3880	20113.6	23980.0
1979 01	38088	43219	4054	20749.6	24079.3
02	40122	43332	4194	21350.0	25100.6
03	42174	45900	4406	22393.3	26230.6
04	44700	50637	4718	23200.0	27332.0
1980 01	48841	57631	4987	24385.3	27994.6
02	56132	58120	5335	25504.6	29776.3
03	58533	62393	5879	27115.0	30721.0
04	61778	63168	6397	29026.6	32797.3
1981 01	66802	67649	6930	31669.3	34949.3
02	72293	69861	7445	34298.3	37972.0
03	75051	72339	7896	36399.6	39882.6
04	74946	74471	8650	37932.0	41822.0
1982 01	79331	75839	9045	40173.6	43630.6
02	81443	78562	10434	41412.3	44870.3
03	80261	82453	10947	42997.3	46223.3
04	81449	85270	11465	44628.0	47626.0
1983 01	80949	86678	12271	46666.3	49541.0
02	86044	90145	12948	48376.0	52014.3
03	89003	92977	13439	51271.0	55228.6
04	96268	96028	14943	53610.0	57688.3

1984 01	101231	101794	15953	56502.3	60015.3
02	105096	105419	17146	59845.0	63836.3
03	107810	109464	18645	62879.0	66407.0
04	106411	112207	18617	65926.3	69064.6
1985 01	108805	116868	19403	68311.6	70629.6
02	110370	120631	19349	70630.0	73040.0
03	112678	123966	19746	72563.3	74915.0
04	116043	131039	19743	75399.3	78383.6
1986 01	122476	132437	19742	78596.0	80757.3
02	126343	140197	19602	79288.0	82607.3
03	132946	146764	19059	80149.0	83261.3
04	138179	153622	19804	81725.0	84777.3
1987 01	139714	157962	17596	83036.3	85801.3
02	150891	162704	19164	84501.6	88634.6
03	158340	169485	20255	87349.6	90363.3
04	165687	178241	21347	92482.6	95932.0
1988 01	175761	186870	22337	98210.6	101767.3
02	188544	196012	23906	102537.0	107248.3
03	194053	206109	25159	110069.0	114104.3
04	199982	212801	27031	118467.3	121979.6
1989 01	213932	224130	29641	125212.6	127650.3
02	229240	240513	30537	127877.3	132315.7
03	232055	246923	31429	134508.0	136846.0
04	237041	250990	34253	142835.0	143366.6
1990 01	243653	262523	36850	148570.0	147672.6
02	262443	276278	39687	153028.6	154468.0
03	267282	280340	43344	158330.6	158829.3
04	264190	285099	47441	163836.6	166974.6
1991 01	283310	294263	49725	173 528.0	176634.6
02	292278	305982	47634	179018.0	182411.6
03	299219	316148	50675	184728.3	187034.6
04	303513	323903	50158	191722.3	195108.6
1992 01	317215	335494	51956	194 471.3	195593.0
02	321482	336049	52479	194731.0	199385.0
03	333535	345054	50277	201710.0	203722.6
04	336340	347255	51631	206855.6	212913.0
1993 01	351466	361230	53501	211293.3	216360.3
02	357548	377041	54882	209685.3	213286.6
03	375444	392492	56036	218439.6	221094.0
04	390010	404017	56895	226473.6	233746.6
1994 01	395825	408531	57612	233091.3	246052.3

02	415494	427102	58610	237703.3	261669.0
03	434912	440038	59404	250403.6	270639.0
04	449321	451173	60328	264181.3	281930.0
1995 01	470309	468566	61166	274797.6	285908.0
02	481596	479289	62034	283715.0	301210.6
03	489844	493408	63210	296648.6	309075.0
04	500339	501745	64368	309613.6	315234.0
1996 01	514368	519099	65455	324132.0	324677.0
02	537185	536361	66512	335386.0	345763.6
03	550921	555086	67559	350644.6	360537.0
04	553442	561510	68626	363288.6	372054.6

THE INTEREST RATES

	Twelve month fixed deposit rate	Yield on three year government stock	Yield on fifteen year government stock
1965 01			
02	5.50	4.500	5.5
03	5.50	4.833	5.83
04	5.50	5.000	6
1966 01	5.50	5.000	6
02	5.50	5.000	6
03	6.50	5.000	6.5
04	6.50	5.000	6.5
1967 01	6.50	5.083	6.5
02	6.50	5.379	6.5
03	7.00	5.379	6.5
04	7.00	5.379	6.5
1968 01	6.83	5.500	6.5
02	6.50	5.416	6.5
03	6.50	5.166	6.5
04	6.50	5.000	6.5
1969 01	6.50	5.000	6.5
02	6.50	5.000	6.5
03	6.50	5.000	6.5
04	6.66	5.000	6.5
1970 01	7.00	5.250	6.5
02	7.00	5.250	6.83
03	7.16	5.250	7.5
04	7.50	5.250	7.75
1971 01	7.50	5.833	8
02	7.50	6.500	8.5
03	7.50	6.500	8.5
04	7.50	6.500	8.5
1972 01	7.50	6.500	8.5
02	7.33	6.250	8.5
03	7.00	5.960	8.29
04	7.00	5.629	8.12
1973 01	7.00	5.333	8
02	7.00	4.583	7.75

03	7.00	4.250	7.75
04	7.00	4.416	7.83
1974 01	7.33	5.500	8.25
02	8.50	5.833	8.33
03	9.50	6.833	9.58
04	9.50	7.000	9.67
1975 01	9.50	6.700	9.5
02	9.50	6.516	9.5
03	9.50	6.786	9.83
04	9.50	7.529	10
1976 01	9.50	7.889	10
02	9.50	8.026	10
03	9.50	8.716	10.5
04	9.50	8.813	11
1977 01	9.50	8.763	11
02	9.50	8.799	11
03	9.50	8.809	11
04	9.50	8.799	10.83
1978 01	9.50	8.836	10.75
02	9.50	8.659	10.67
03	9.16	8.389	10.54
04	8.50	7.946	10
1979 01	8.16	7.256	10
02	7.50	6.216	10
03	7.33	6.116	9.38
04	7.00	5.196	9.38
1980 01	7.16	4.779	9.38
02	7.50	5.396	9.25
03	7.50	5.843	9.8
04	7.66	8.099	10.37
1981 01	8.16	9.309	11.5
02	10.00	10.083	12.51
03	10.50	12.286	13.02
04	10.83	13.079	13.22
1982 01	12.16	14.856	14.14
02	16.00	15.063	14.29
03	16.00	15.069	13.84
04	15.25	10.843	11.77
1983 01	12.50	8.423	11.41
02	11.00	10.046	12.45
03	13.33	12.953	13.28

04	14.83	14.319	13.52
1984 01	16.00	14.836	13.9
02	16.33	16.439	14.68
03	17.50	17.413	16.01
04	18.33	17.599	16.31
1985 01	19.16	18.356	17.2
02	18.00	16.846	16.1
03	14.33	15.373	16.08
04	14.33	15.733	17.79
1986 01	14.00	14.849	17.36
02	13.00	14.026	17.28
03	11.16	10.976	15.26
04	10.16	11.316	15.55
1987 01	9.83	11.216	15.16
02	10.00	10.789	15.44
03	10.50	10.979	15.25
04	10.50	11.019	15.34
1988 01	10.66	12.983	16.43
02	11.66	14.033	16.34
03	12.66	13.693	16.07
04	14.00	14.879	16.65
1989 01	15.00	12.259	16.73
02	16.33	16.136	17.28
03	16.50	16.0136	17.02
04	17.00	15.8903	16.57
1990 01	17.00	15.5963	15.59
02	17.83	15.6309	16.33
03	17.16	15.7106	16.37
04	16.50	16.0856	16.32
1991 01	16.50	15.6926	15.74
02	16.00	15.6309	16.05
03	16.00	16.1489	16.69
04	15.50	16.2166	16.9
1992 01	15.50	15.823	16.64
02	14.33	14.893	16.07
03	13.16	12.319	14.62
04	12.33	12.146	14.43
1993 01	11.33	12.639	14.58
02	11.66	13.126	14.96
03	12.00	12.623	13.98
04	11.33	11.423	12.76

1994 01	10.16	11.159	12.67
02	10.50	11.856	13.82
03	10.83	13.863	15.96
04	12.33	15.886	16.88
1995 01	13.16	15.843	16.85
02	13.83	15.803	16.85
03	14.50	15.413	16.02
04	14.16	14.196	14.7
1996 01	13.66	13.676	14.3
02	14.33	15.116	16.03
03	14.50	15.343	15.54
04	14.66	15.986	16.06

Appendix B

Table (B.1.) Critical values for the Dickey-Fuller test

Sample Size T	*Significance Level*							
	0.01	0.025	0.05	0.01	0.90	0.95	0.975	0.99
No Constant Included, τ_1								
25	-2.66	-2.26	-1.95	-1.60	0.92	1.33	1.70	2.16
50	-2.62	-2.25	-1.95	-1.61	0.91	1.31	1.66	2.08
100	-2.60	-2.24	-1.95	-1.61	0.90	1.29	1.64	2.03
250	-2.58	-2.23	-1.95	-1.62	0.89	1.29	1.63	2.01
300	-2.58	-2.23	-1.95	-1.62	0.89	1.28	1.62	2.00
∞	-2.58	-2.23	-1.95	-1.62	0.89	1.28	1.62	2.00
Constant Included, τ_2								
25	-3.75	-3.33	-3.00	-2.62	-0.37	0.00	0.34	0.72
50	-3.58	-3.22	-2.93	-2.60	-0.40	-0.03	0.29	0.66
100	-3.51	-3.17	-2.89	-2.58	-0.42	-0.05	0.26	0.63
250	-3.46	-3.14	-2.88	-2.57	-0.42	-0.06	0.24	0.62
300	-3.44	-3.13	-2.87	-2.57	-0.43	-0.07	0.24	0.61
∞	-3.43	-3.12	-2.86	-2.57	-0.44	-0.07	0.23	0.60
Constant and Linear Trend Included, τ_3								
25	-4.38	-3.95	-3.60	-3.24	-1.14	-0.80	-0.50	-0.15
50	-4.15	-3.80	-3.50	-3.18	-1.19	-0.87	-0.58	-0.24
100	-4.04	-3.73	-3.45	-3.15	-1.22	-0.90	-0.62	-0.28
250	-3.99	-3.69	-3.43	-3.13	-1.23	-0.92	-0.64	-0.31
300	-3.98	-3.68	-3.42	-3.13	-1.24	-0.93	-0.65	-0.32
∞	-3.96	-3.66	-3.41	-3.12	-1.25	-0.94	-0.66	-0.33

From Fuller (1976).

Table (B.2.) Critical Engle-Granger and CRWD values

Number of Var's N	Sample Size T	EG Critical Values		
		Significance Level		
		1%	5%	10%
1^a	50	2.62	1.95	1.61
	100	2.60	1.95	1.61
	250	2.58	1.95	1.62
	500	2.58	1.95	1.62
	∞	2.58	1.95	1.62
1^b	50	3.58	2.93	2.60
	100	3.51	2.89	2.58
	250	3.46	2.88	2.57
	500	3.44	2.87	2.57
	∞	3.43	2.86	2.57
2	50	4.32	3.67	3.28
	100	4.07	3.37	3.03
	200	4.00	3.37	3.02
3	50	4.84	4.11	3.73
	100	4.45	3.93	3.59
	200	4.35	3.78	3.47
4	50	4.94	4.35	4.02
	100	4.75	4.22	3.89
	200	4.70	4.18	3.89
5	50	5.41	4.76	4.42
	100	5.18	4.58	4.26
	200	5.02	4.48	4.18

From Engle and Yoo (1987, p. 157)

Model I: $\Delta y, \Delta x$ independent standard normal, 100 observations, 10,000 replications, p =4.

Statistic	Critical Values			
	Name	1%	5%	10%
1	CRWD	0.51	0.39	0.32

From Engle and Yoo (1987, p. 15).

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