# An Econometric Analysis of the Real Demand for Money in South Africa: 1990 to 2007


**by**

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# Dedication

*This thesis is dedicated to my late father, all Rwandans who died during genocide of 1994 and all its victims.*

# Declaration

The work described in this thesis was carried out by the author in the School of Economics and Finance, University of KwaZulu-Natal, Pietermaritzburg, from July 2007 to October 2009, under the supervision of Dr. Richard Simson.

The research reported in this thesis, except where otherwise indicated, my original research. It has not been submitted for any degree or examination at any other University. This has also been submitted to TURNITIN™ and the matches to existing research are fully acknowledged. Any errors of syntax and semantics remain the responsibility of the student.

Signed:………………………………….
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Dr. Richard Simson (Supervisor)

# Abstract

A stable money demand function plays a vital role in the analysis of macroeconomics, especially in the planning and implementation of monetary policy. With the use of cointegration and error correction model estimates, this study examines the existence of a stable long-run relationship between real money demand (RM2) and its explanatory variables, in South Africa, for the period 1990-2007. The explanatory variables this study uses are selected on the basis of different monetary theories, including the Keynesian, Classical and Friedman's modern quantity theory of money. Based on these theories, the explanatory variables this thesis uses are real income, an interest rate, the inflation rate and the exchange rate. All variables have the correct signs, as expected from economic theory, except the inflation rate. Thus real income and inflation have positive coefficients, while the interest rate and exchange rate coefficients are negative.

The results from unit root tests suggest that real income, interest rate and the inflation rate are found to be stationary, while RM2 and the exchange rate are non-stationary. Results from the Engle-Granger test suggest that RM2 and its all explanatory variables are cointegrated. Hence, we find a long-run equilibrium relationship between the real quantity of money demanded and four broadly defined macroeconomic components: real income, an interest rate, the inflation rate and the exchange rate in South Africa.

Overall, the study finds that the coefficient of the equilibrium error term is negative, as expected, and significantly different from zero, implying that 0.20 of the discrepancy between money demand and its explanatory variables is eliminated in the following quarter. This evidence suggests that the speed of adjustment for money demand implies the money market in South Africa needs about four quarters to re-adjust to equilibrium. This observation agrees with the public statements of the South African Reserve Bank. Whether this will hold after November 2009 is the obvious subject of future research.

# Acknowledgments

I wish to record my sincere thanks and appreciation to my supervisor, Dr. Richard Simson, for his unreserved hospitality and abiding patience. The value of his dedication, kind and untiring guidance and warmhearted advice throughout the execution of this thesis is not only difficult to estimate but also very hard to express adequately by the usual terms of acknowledgement. Without this assistance, the production of this thesis would not have been possible.

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# Abbreviations

**AEG:** Augmented Engle-Granger

**ACF:** Autocorrelation Function

**ADF:** Augmented Dickey-Fuller

**BA:** Bankers Acceptances

**CPI**: Consumer Price Index

**CRDW**: Cointegration Regression Durbin-Watson

**DF:** Dickey-Fuller

**DR**: Commercial bank retail Deposit Rate

**DW**: Durbin-Watson

**ECM:** Error Correction Mechanism

**EG:** Engle-Granger

**ER:** Exchange Rate

**GDE**: Gross Domestic Expenditure

**GDP:** Gross Domestic Product

**GNP:** Gross National Product

**OLS:** Ordinary Least Square

**RM2:** Real demand for money

**SA:** South Africa

**SPSS**: statistical Package for the Social Science

**TB:** Treasury-Bill

**USA:** United States of America

# CHAPTER ONE

# INTRODUCTION

## 1.1 BACKGROUND

Many economists acknowledge the importance of behaviour in a money demand relationship when formulating an efficient monetary policy. A stable demand for money plays a vital role in any macroeconomic model. However, there are many factors that may cause money demand functions to become structurally unstable over time in any country. For South Africa, Wasso (2002) named some of these factors as being the use of the financial rand and exchange controls, various monetary policy programs, financial liberalization and technological change.

The demand for money has often been studied, largely because the implications and predictions that follow from alternative hypotheses of money demand have been recognised to generate widely contrasting prescriptions of economic policy (Havrilesky, 1978). The money demand function is topical in applied economics in Western countries, especially in assisting the monetary authorities when establishing clear understandings of the reactions of different macroeconomic aggregates to changes in money supply. Currently, according to Harb (2003: 3), this area of research has become an interesting subject in developing countries in attempts to implement appropriate monetary policies.

As in other countries, the demand for money is also a topical issue in the context of the South African economy, with many efforts being made to estimate the money demand function. For example, Stadler (1981), Contogiannis and Shahi (1982), Courakis (1984), Whittaker (1985), McKenzie (1992), Naude (1992), Reinhardt (1998), Moll (2000), Jonsson (2001), Nell (2003) and Tlelima and Turner (2004) estimate the money demand function in South Africa, using many different specifications. Most of these studies show that there is a long-run relationship between the dependent and independent variables in the models. However, some of these studies indicate otherwise. For example, Tlelima and Turner (2004: 35) discovered that “recursive estimates of the steady-state elasticities with respect to income and the interest and inflation rate indicate that these important parameters are not stable throughout the period. It has been observed that the income elasticity of money demand has increased significantly through the period as has the sensitivity of money demand to the opportunity cost of holding money balances.” Others were found with signs of misspecification. The present thesis studies the long-run relationship between money demand and its explanatory variables in the South African economy, using quarterly data for the years 1990 to 2007.

The above-mentioned time period is said to have been characterized by many economic changes. In the late 1980s and early 1990s, the South African Reserve Bank was using target ranges for growth in broad money. This range was changed over time, with the intention of lowering inflation. Before the 1994 general elections, when the new government intensified liberalization efforts, broad money growth and inflation fell substantially, although the Reserve Bank often missed the explicit money growth target. Indeed, in 1995, the financial rand mechanism ended and the exchange rate unified, capital controls on residents were gradually liberalized and virtually all controls on non-residents were removed. There was also the notable change of low-income households gaining access to formal banking services. Between 1994 and 1999, the target range of broad money growth was exceeded but inflation was contained. The money growth target was regarded by the South African Reserve Bank as an informal guideline (see Farrell, 2001; Smal and Jager, 2001; Wasso, 2002).

In February 2000 the South African Reserve Bank adopted a new monetary policy called ***Inflation Targeting***. This is described by Aron and Muellbauer (2005) as a credible, transparent and predictable regime. Van der Merwe (2004) confirms that the inflation targeting system has seen several improvements, with evolving institutional design since its launch. According to Nell (2003), even under inflation targeting, as long as there is a stable money demand function, money plays an important role in the formulation of an efficient monetary policy strategy. As a result, it is crucial to analyze the long-run relationship between money demand and its determinants. If a long-run relationship does exist, the implication is that it is a stable money demand function. In other words, an efficient monetary policy depends either directly or indirectly on this relationship. Recently the South African Reserve Bank has been missing its target which points to the value of this research.

After clarifying concepts, Chapter Two provides a framework showing the incorporation of money in the utility function. Our work draws from Handa (2000) and Choi and Oh (2003). Chapter Two continues with a discussion of different but conventional theories of money demand, suggesting that the real money demand function, over a period of time, depends upon real income and variables such as the interest rate (R) or the inflation rate ($\pi$) and exchange rate (ER), the latter three representing the opportunity cost of holding money (Choudhry, 1995).

In order to find out if there is a long-run relationship between the real demand for money (RM2) and its explanatory variables in South Africa, cointegration and error correction methods are used. It is known that most macroeconomic data are non-stationary; therefore the first test is to check for stationarity, starting with a graphical analysis of each variable and proceeding then to examine each sample correlogram, which involves plotting the autocorrelation coefficient over time (Cameron, 2005) for each vaiable. A unit root test is used in this thesis as a more formal method for detecting non-stationarity. For this, Dickey-Fuller and Augmented Dickey-Fuller tests are used where the disturbance term in the model is not autocorrelated.

To test for cointegration, this thesis uses two tests. Firstly, Engle-Granger and Augmented Engle-Granger tests, that is the use of Dickey-Fuller and Augmented Dickey-Fuller tests, on the residuals and, secondly, the cointegration regression Durbin-Watson (CRDW), using Durbin-Watson values from the OLS estimate of the model but requiring a new set of critical values for testing the null hypothesis that it is zero.

The long-run relationship between two or more variables is given by these variables being cointegrated. However, a cointegrating relationship does not shed light on short-run dynamics. It is possible that there are some short-term forces required to keep the relationship between dependent and independent variables intact. Therefore, it is crucial to construct an error correction model that combines both short-run and long-run dynamics.

## 1.2 PROBLEM STATEMENT

Some questions that have arisen about the demand for money as a result of the literature review are:

- What is money, in general, and in South Africa in particular?
- Why do people demand money?
- Which money demand theory is appropriate?
- What can be included as independent variables in the money demand function?
- Should wealth or income, or both, be included in the demand for money model's specifications?

## 1.3 RESEARCH OBJECTIVES

The objectives of this research are to investigate the significance of the long-run relationship between money demand and its determinants in the context of the South African economy by:

- Analyzing different theories of money demand;
- Identifying the relevant exogenous factors in the money demand function;
- Estimating how money demand responds to changes in those determinants;
- Demonstrating how long it takes for monetary policy decisions to take effect in South Africa.

## 1.4 ORGANISATION OF THE THESIS

In pursuit of the objectives above, this thesis is organized as follows. Chapter Two delves into the theory of the demand for money in general. Major working concepts, such as money, its function, and the difference between real and nominal money balances, are clarified. At a theoretical level, a general equilibrium analysis of the money in the economy is discussed. The chapter continues with the three main debates surrounding the demand for money balances by focusing on the issues relating to this study. It also focuses on the alternative explanatory variables implied in the model specification.

Chapter Three is about the research methodology. It discusses the formulation and specification of real money demand models, estimated with the cointegration and error correction mechanism procedures this study uses.

Chapter Four presents empirical evidence on the subject of the demand for money in South Africa. It reports the different methods used to estimate the money demand function and the results of various studies using South African data.

In Chapter Five the results and findings are discussed. The chapter discusses the econometric procedures followed and provides the reasons for accepting or rejecting the various null hypotheses and also makes an economic interpretation of the results.

Chapter Six concludes the thesis by summarizing the major arguments and findings, while also providing some recommendations regarding monetary policy decisions in South Africa. In particular we suggest that monetary policy responses to the current reduction in output growth are unlikely to have an immediate impact as the economy takes about a year to respond to monetary shocks. This may be altered by changes to the Reserve Bank's leadership in November 2009 but this is clearly an item for future research.

# CHAPTER TWO

# MONEY DEMAND THEORIES AND LITERATURE REVIEW

## 2.1 INTRODUCTION

Money demand is one of the key factors in economic theory and plays an important role in macroeconomic policy. An understanding of the determinants of money demand and their long-run relationship is "crucial in the conduct of monetary policy, and for the choice of the instruments and intermediate targets of monetary policy", writes Qayyum (2005: 234). When investigating the theory of money demand, there are some important issues that need to be considered, such as the choice of the appropriate measure of money, the scale variable (income or wealth) and the opportunity cost variable (short- or long-term interest rates), as is explained by Haug and Lucas (1996). This chapter deals with theories surrounding the demand for money. Apart from attempting to critically analyze some major concepts and theories about the demand for money, it is also the intention of this chapter to arrive at a plausible set of determinants of the demand for money. These explanatory variables will not only shed light on the causes of demanding money, but also provide a basis on which to help make an econometric model.

The chapter is organized as follows: the next section presents a number of conceptual and formal definitions of money. The same section analyses the functions of money and gives clarity concerning the difference between real and nominal money balances and why we use one rather than the other. Following Handa's (2000) general equilibrium analysis, where money in an individual's utility function is discussed, deriving the demand for money function will be covered in section 2.3. Sections 2.4.1 to 2.4.4 examine the theories surrounding the demand for money, where we begin with classical economists' views; liquidity preference theory, Tobin's formulisation of the speculative motive and Friedman's modern quantity theory of money. Post-Keynesian and Neoclassical approaches to demand for money are not neglected. Issues of money demand stability are addressed in section 2.5. The chapter ends with a conclusion.

## 2.2 CONCEPTUAL CLARIFICATION AND WHAT DOES MONEY DO?

### *2.2.1 The Definition of Money*

One should not proceed to the theories or debates surrounding the demand for money without defining money and clarifying related concepts. Falkena, Meirjer and Merwe (1991) indicate that money has different meanings to different people. Vane and Thompson (1979: 49) and Cobham (1987: 46) emphasize that there is no commonly accepted definition among economists as to what constitutes money. Laidler (1977: 101) states that “there is no sharp distinction in the real world between money and other assets, but rather a spectrum of assets, some more like one’s rough idea of money than others.”

Money is defined by Bade and Parkin (2002) and Newlyn and Bootle (1978) as any commodity or token that is generally accepted as a means of payment. According to Mankiw (2003: 76), “money is the stock of assets that can be readily used to make transactions.” Similarly, Milton Friedman, as quoted in Handa (2000: 4), gave a broad definition of money as “the sum of currency in the hands of the public plus all of the public’s deposits in commercial banks.” Therefore, money is everything which allows making any transaction or conducting business.

In addition to the above definitions, there is also the narrow and broad definition of money. In the South African economy, according to Haydam (1997: 226), “narrow money or M1a combines all the coins and banknotes in circulation outside the banking sector.” Falkena *et al.* (1991: 44) defines other measures of money supply as:

*“…M1 = M1 (A)*

*plus other demand deposits with banking institutions.*

*M2 = M1*

*plus other short-term deposits and all medium-term deposits (including savings deposits) with banking institutions;*

*plus other short deposits and all medium-term deposits (including savings deposits and certain "share' investments) with building societies;*

*plus savings deposits with bank certificates of the Post Office Savings Bank.*

*M3 = M2*

*plus all long-term deposits with banking institutions;*

*plus all long-term deposits and other "share" investments with building societies*

*plus investments in national savings certificates issued by the Post Office Savings Bank."*

It should be noted that the definition of narrow and broad money varies from country to country. Henderson and Poole (1991: 346) state that money is defined by the functions it serves. To understand its meaning, certain attributes or characteristics are attached to any commodity acting as money or means of exchange. In other words, money is defined by what it does.

*2. 2. 2 Functions of Money*

One cannot doubt the role played by money in an economy. According to Naho (1985: 1), "the superiority of an economy of exchange to a barter economy is seen in the rapidity of accumulation of wealth and economic advancement realized under the former relative to the stagnant and primitive way of living characterising the latter."

Money has as four major functions. Firstly, money is a medium of exchange or means of payment because it is generally accepted in return for goods and services. This is different from barter, which requires a double coincidence of wants. Secondly, money is a unit of account or standard of value: it measures the value of all other goods and services because they are exchanged for it. According to Beecham (1988: 5), "price is value of a good in terms of money; by comparing the prices of various goods their values can be compared." Handa (2000) confirms that being a medium of exchange is the most essential function of money.

The third function of money is that money is a store of value. According to Klein (1982), people demand money not only for the goods and services they buy today, but for the goods and services that they will want to buy in the future. So the goods which need not be stored in inventories are maintained as savings. Money solves the problem of bridging the gap between production and consumption. Money is a store of value through which an economic unit can save for the purpose of consuming at a later date so its pattern of consumption and production need to be synchronized (Slovin and Sushka, 1977).

Fourth, money serves as a standard of deferred payment: people demand money to make contracts for future payments which are stated in terms of the current unit of account. This function is an outgrowth of the use of money as a means of paying debt and as a unit of account. For example, bonds, leases and mortgages contain promises to pay a certain number of Rand at intervals in the future. For Klein (1982) and Maisel (1982) money is both the standard by which deferred payments of bond interest are reckoned and the means by which these payments are made, because it is agreed that interest on bonds and the principal, when due, are to be paid in the form of money. From these functions of money, the demand for money is described.

The demand for money is defined by Henderson and Poole (1991: 388) as "the function showing the amount of money people want to hold as an asset, as determined by a specified list of economic variables such as their income and the cost of holding money." Kaplan (1960) adds that the demand for money is not the result of frictions or institutional considerations alone, but of a decision-making process; and this is the essence of the utility approach. There is a broad debate over which of these economic variables can be included in the money demand function. The choice between real and nominal money demand needs to be discussed in order to be able to estimate the appropriate money demand function.

*2.2.3 Real and Nominal Money Balances*

For Barro (1993), 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. In other words, the nominal quantity of money is the amount of currency and deposits people are holding without any adjustment for the price level, while real money balances refer to the number of rands and deposits people are holding deflated by a measure of the price level in order to reflect the purchasing power of the money holdings. A unit of measurement used shows the difference between real and nominal money balances. Like much of the literature, we use real money balances and call this variable RM2. See, for instance, Carlson and Parrot (1991), Duca (1995) Whitesell (1997), Dotsey, Lantz and Santucci (2000) and Carlson Hoffman, Keen and Rasche (2000) and many others.

Hafer and Kutan (1994) use nominal money demand to estimate the effect of economic reforms and long-run money demand in China. In their model specification they use real variables (income, price and interest rates) as the determinants, rather than using nominal variables. If the demand for money (M/P) which is usually used, is the real demand for money and one should not have the price level as one of the explanatory variables.

Traditionally, economists have asserted that the demand for money is a demand for real money balances. The amount of money demanded is determined mainly by people's real income, by the price level, by interest rates and by expectations about inflation and other anticipated events such as the 2010 world soccer competition, which it is hoped will have a positive impact on the exchange rate. In the case of such events, the Rand will be in high demand (appreciate). However, the factors determining the nominal quantity of money available to be held depend critically on the monetary system.

The aim of this study is to find the relevant factors determining the real demand for money in the context of South Africa and their long-run relationship. To carry out this experiment, this study uses the cointegration approach to determine if a long-run relationship between real money demand (RM2) and its explanatory variables exists for South Africa. As described by Civcir and Parikh (1998), "the cointegration technique is superior to the simple regression technique as it captures the underlying time-series properties of the data fully, providing estimates of all the cointegrating vectors that may exist whilst also offering test statistics for the number of cointegrating vectors which have an exact limiting distribution." Therefore, it may be viewed as superior to the simple regression-based approach in its ability to reject a false null hypothesis. Moreover, if a long-run relationship between both sides of an equation does not exist, an error correction mechanism model, proposed by Gujarati (2003) is formulated with stationary variables. This is discussed in more detail in Chapters Three and Five. We now turn to a determination of the factors influencing money demand.

## 2.3 GENERAL EQUILIBRIUM ANALYSIS OF MONEY IN THE ECONOMY

### *2.3.1 Money in the Utility Function*

The issue of whether real money balances should be included in an individual's utility function has been one of substantial debate among economists. On the one hand, the approach has been criticized by Clower (1967), Kareken and Wallace (1980), and Tobin (1980: 86), who have said that "the practice of putting money stocks in the utility function is reprehensible." On the other hand, the model has been utilized by Samuelson (1947), Patinkin (1965), Friedman (1969) and many others.

Following Handa (2000: 57), this subsection presents "the axiomatic basic for including money in the utility function." Individuals' tastes or preferences are different toward goods and their income or wealth. Economists make three critical assumptions about the properties of consumers' preferences: consistent (and completeness), transitivity and real cash balances as goods.

1) **Consistent**: If the individual prefers one bundle *(A)* to another *(B)* then this individual will always choose *A* over *B*. To this we can add the axiom of **completeness,** which is when "the consumer prefers the first bundle to the second, prefers the second to the first, or is indifferent between them" (Perloff, 2007: 76). This brings the possibility that the consumer cannot decide which bundle is preferable.

2) **Transitivity**: also known as rationality, is when the individual prefers bundle *A* to *B* and bundle *B* to *C*. Therefore, they also prefer bundle *A* to bundle *C*.

To these properties of preferences in the theory of the demand for commodities and monetary theory one usually adds the following:

3) **Real balances as a good**: "in the case of financial goods which are not used directly in consumption or production but are held for exchange for other goods in the present or the future, the individual is concerned with the former's exchange value into commodities, that is, their real purchasing power over commodities and not with their nominal quantity" (Handa, 2000: 57).

The first three properties of preferences ensure that the individual's preferences among goods can be ordered monotonically and represented by a utility or preference function. The fourth property ensures that financial assets, when considered as goods in such a utility function, should be measured in terms of their purchasing power and not their nominal quantity. The individual's utility function is represented as:

$$U(.) = (x_1,...,x_k,n,m^h). \qquad [2.1]$$

Where:

$x_k$ is the quantity of the kth commodity, k = 1,… , k;

*n* is the labour supplied in hours;

$m^h$ is the average amount of real balances held by the individual/household for their liquidity. U(.) is an ordinal utility function.

The assumption from equation 2.1 is that the first-order partial derivatives are $U_k = \partial U/\partial x_k > 0$ for all k, $U_n = \partial U/\partial n < 0$, and $U_m = \partial U/\partial m^h > 0$. All second-order partial derivatives of U(.) are assumed to be negative. In other words, each of the commodities and real balances yield positive marginal utility and hours worked has negative marginal utility (Handa, 2000: 57).

*2.3.2. Money in the Indirect Utility Function*

Handa (2000: 58) emphasises that money does not directly yield consumption services to the consumer, but that its usage saves on the time spent in making transactions. Only the first two properties (section 2.2.3) of preferences are implied. Only commodity and leisure, and not real balances, are considered. The utility function becomes:

$$U(.) = U(c, \Theta). \qquad [2.2]$$

Where *c* represents the consumption and $\Theta$ is leisure. It is assumed that the first-order partial derivatives are positive: ($\partial U/\partial c > 0$, $\partial U/\partial \Theta > 0$). Leisure is the time remaining from the total time available after deducting the time spent working and time spent in other activities such as shopping. Hence,

$$\Theta = h_o - n - n^{\sigma} . \qquad [2.3]$$

Where $h_o$ is the maximum available time for leisure, working and other activities such as shopping, n is time spent working and $n^{\sigma}$ is time spent on other activities such as shopping, cooking and fixing things around the house. People choose between working to earn money to buy goods and services and to consume. Leisure is all time spent not working. Therefore, time spent on other activities, here shopping, can be represented with the following function:

$$n^{\sigma} = f(m^h, c) , \qquad [2.4]$$

where, $\partial n^{\sigma} / \partial c$ is expected to be positive and $\partial n^{\sigma} / \partial m^h$ to be negative.

If one of these other activities increases, for example shopping time, this decreases leisure and therefore decreases utility. An increase in the amount of real money held and utilized decreases shopping time. Thus,

$$\partial U / \partial n^{\sigma} = (\partial U / \partial \Theta) (\partial \Theta / \partial n^{\sigma}) < 0; \qquad [2.5]$$

$$\partial U / \partial m^h = (\partial U / \partial n^{\sigma}) (\partial n^{\sigma} / \partial m^h) > 0. \qquad [2.6]$$

A proportional form of the shopping time function is:

$$n^{\sigma} / c = ø (m^h / c), \qquad [2.7]$$

where $-\infty < ø' \leq 0$, with *ø'* is the first-order derivative of *ø* with respect to $m^h$ / *c*. By incorporating this shopping time function into the utility function, we have the following function:

$$U(.) = U(c, h_o - n - cø\ (m/c)). \qquad [2.8]$$

It can be rewritten as an indirect utility function as we optimize a c, n and m:

$$V(.) = V(c, n, m^h). \qquad [2.9]$$

Now as 2.8 implies $\partial V / \partial \Theta$ is positive, but $\partial V / \partial m^h$ is negative, c ø and $ø' \leq 0$, then $\partial V / \partial m^h \geq 0$ and

$$\partial V / \partial m^h = \partial U / \partial \Theta\ [-c\ (\partial ø / \partial m^h)]. \qquad [2.10]$$

Comparing the usage of money in the indirect and direct utility functions, there are some similarities, but these are not identical. Both have the real balances as a variable. Therefore both functions are acceptable. Following Handa (2000: 59), due to the relative simplicity of using the direct utility function, this is preferred to the indirect utility one.

*2.3.3 Deriving the individual's demand for money function*

Every individual always wants to maximize their utility. However, the satisfaction of this need depends on income (Sayinzoga, 2005). Mathematically, deriving the individual's demand for real balances, we use maximization of the utility function specified in equation (2.1) in section 2.3.1:

$$U(.) = U\ (x, \ldots, x_K, n, m^h), \qquad [2.11]$$

subject to the budget constraint below:

$$\sum_k p_k\, x_k + (r - r_m)Pm^h = A_O + Wn \quad k = 1,\ldots,K, \qquad [2.12]$$

where $p_k$ stands for price of the $k^{th}$ commodity, *P* the price level, W the nominal wage rate and $A_0$ represents the nominal value of initial endowments of commodities and financial assets. And $x_k$ stands for the quantity of the $k^{th}$ commodity, n for labour supplied per hour and $m^h$ for average amount of real balances held by the individual for their liquidity needs; *r* represents the market interest rate on the illiquid asset and $r_m$ stands for interest rate paid on nominal balances; in other words, $(r - r_m)$ is the interest rate forgone from holding a unit of nominal balances. If we use the Langrangian method, which is a combination of an individual's utility function and its constraint, we get:

$$L = U(.) = U(x \ldots x_K, n, m^h) + \lambda [\textstyle\sum_k p_k x_k + (r - r_m) Pm^h - A_O - Wn]. \quad [2.13]$$

The first-order maximising conditions are:

$$\partial L / \partial x_k = U_k - \lambda p_k = 0 \quad k = 1, \ldots, K \qquad [2.14]$$
$$\partial L / \partial n_k = U_n + \lambda W = 0 \qquad [2.15]$$
$$\partial L / \partial m^h = U_m - \lambda(r - r_m)P = 0 \qquad [2.16]$$
$$\partial L / \partial \lambda = \textstyle\sum_k p_k x_k + (r - r_m)Pm^h - A_O - Wn \qquad [2.17]$$

Now, from equations 2.14 to 2.16 a unique solution to the following:

$$x_k^{dh} = x_k^{dh}(p_1,\ldots, p_k, W, (r - r_m)P, A_O) \quad k = 1, \ldots, K; \qquad [2.18]$$
$$n^s = n^s(p_1, \ldots, p_k, W, (r - r_m)P, A_O); \qquad [2.19]$$
$$m^{dh} = m^{dh}(p_1, \ldots, p_k, W, (r - r_m)P, A_O), \qquad [2.20]$$

might exist, where d and s symbolize demand and supply respectively, and *h* symbolizes households. There is a possibility of determining "the effect of the individual's demand and supply functions of increasing the nominal variables $p_1$, ..., $p_k$, W and $A_o$ by an identical proportion; such that these values are replaced respectively by $\alpha p_1$, ..., $\alpha p_k$, $\alpha W$ and $\alpha A_o$" (Handa, 2000: 61). For Sayinzoga (2005), "this does not change the quantities of real balances and commodities demanded." In other words, there is homogeneity of degree zero in p1... $p_k$, W and $A_o$ in the demand and supply functions. Therefore, equations 2.18 to 2.20 from maximizing 2.11 subject to 2.12 become:

$x_k^{dh} = x_k^{dh}(\alpha p_1,...,\alpha p_k,\alpha W,(r-r_m)\alpha P,\alpha A_O)$ k = 1… K; [2.21]

$n^s = n^s(\alpha p_{1,\ldots,}\alpha p_k, \alpha W, (r - r_m)\alpha P, \alpha A_O)$; [2.22]

$m^{dh} = m^{dh}(\alpha p_{1,\ldots,}\alpha p_k, \alpha W, (r - r_m)\alpha P, \alpha A_O)$. [2.23]

We cannot finish this subsection without incorporating relative effects, as asserted by Handa (2000: 62), that "the demand for commodities and real balances and the supply of labour depend only upon relative prices - but not on absolute prices – and the real value of initial endowment." The real value of initial endowment" therefore, if we let *α = 1/p*, equations 2.18 to 2.20 become:

$x_k^{dh} = x_k^{dh}(p_k/P,...,p_k/P,W/P,(r-r_m)A_O/P)$ k = 1,…, K; [2.24]

$n^s = n^s(p_1/P_{,\ldots,}p_k/P, W/P, (r - r_m)A_O/P)$; [2.25]

$m^{dh} = m^{dh}(p_1/P_{,\ldots,}p_k/P, W/P, (r - r_m)A_O/P)$. [2.26]

Where $x_k$ stands for quantity related to relative price of the $k^{th}$ commodity, W/P stands for the real wage rate and $A_o/P$ the real value of initial endowments. As demonstrated in 2.21 to 2.23, real demand and supply are unchanged. Even though the exogenous variables change to reflect relative price, this is justified by the above assertion. So, equation 2.26 is the household's demand for real balances, which is determined by the opportunity cost of holding money, the real wage rate, the real value of initial endowments and the relative prices of commodities (Sayinzoga, 2005: 28).

### *2.3.4 The Firm's Demand for Money and Other Goods*

Let $n$ be the number of workers, $\kappa$ a variable denoting the physical capital stock, $m^f$ real balances held by the firm and $x_k$ the quantity of the $k^{th}$ good, $k = 1, \ldots, k$ produced by the $k^{th}$ firm. Therefore, the production function of the firm which produces the commodity $x_k$ is:

$x_k = F(n, \kappa, m^f)$. [2.27]

And in the above $\partial F / \partial n > 0$, $\partial F / \partial \kappa > 0$ and $\partial F / \partial m^f > 0$ and all the second-order partial derivatives are assumed to be negative.

One may argue that money does not have a direct effect on a firm's productive capacity and it should not be incorporated in the production function. However, it may not appear directly but can be in the production function indirectly (Farmer, 1997) and (Handa, 2000). Therefore, in a modern economy money is very important to the firm because if the firm does not hold any balances, it has to persuade workers and other input suppliers to accept the commodity it produces as payment. Also the owners might have to accept the commodity as their dividend instead of money.

In monetary economy, where a firm operates in a perfect competitive market with the aim of maximizing profits, the profits model is:

$\Pi = p_k F(n, \kappa, m^f) - Wn - \rho_k \kappa - \rho_m m^f - F_{O,}$ [2.28]

where Π is the profits, ρ symbolizes the nominal user cost of variable physical capital, $F_o$ is the fixed cost of production and $\rho_m$ is the nominal cost of real balances and is to be adjusted using $(r - r_m)P_.$ The nominal user cost of physical capital is $\rho_k = (r + (\delta_k - \pi_k))p_{k,}$ where $\delta_k$ is the rate of depreciation of the capital good, $\pi_k$ is the rate of increase in the price of the capital good and $p_k$ is the price of the capital good. Assume $\delta_k = 0$, makes, $\rho_k = (r - \pi_\kappa)p_{\kappa.}$ The nominal user cost of variable physical capital depends on the real interest rate, which is also adjusted for an increase of price of the capital good (Sayinzoga, 2005). Consequently, equation 2.28 can be transformed to:

$\Pi = p_k F(n, \kappa, m^f) - Wn - (r - \pi_k)p_k \kappa - (r - \pi_k)Pm - F_{O.}$ [2.29]

According to Petersen and Lewis (1999), in order to find the maximum or minimum of a multivariate function, we firstly need to find the first-order partial derivative of the function with respect to each independent variable (*n, κ* and *m*) and set all partial derivatives equal to zero. Hence:

$\partial\Pi / \partial n = p_k F_n - W = 0;$ [2.30]

$\partial\Pi / \partial \kappa = p_k F_\kappa - (r - \pi_\kappa) p_\kappa = 0;$ [2.31]

$\partial\Pi / \partial m = p_k F_m - (r - \pi_m) P.$ [2.32]

As was done previously, we divide each term by the price level to get:

$(p_k / P) F_n = W / P;$ [2.33]

$(p_k / P) F_\kappa = (r - \pi_\kappa)(p_\kappa / P);$ [2.34]

$(p_k / P) F_m = (r - \pi_m) m^f.$ [2.35]

Returning to the firm's demand function for money and other goods, equations 2.33 to 2.35, are solved, to get:

$n^d = n^d\,(p_k / P, w, (r - \pi_\kappa)(p_\kappa / P), (r - r_m));$ [2.36]

$\kappa^d = K^d\,(p_k / P, w, (r - \pi_\kappa)(p_\kappa / P), (r - r_m));$ [2.37]

$m^{df} = m^{df}\,(p_k / P, w, (r - \pi_\kappa)(p_\kappa / P), (r - r_m)),$ [2.38]

where $n^d$, $k^d$ and $m^d$ are the firm's labour demand, demand for capital goods and demand for real balances, respectively. It should also be noted that w is the real wage, replacing W/P. The supply function of the commodity can be obtained by substituting equations 2.36 to 2.38 in 2.27 – the production function. Thus:

$x^s = x^s\,(p_1 / P, \dots, p_k / P, w, (r - \pi_\kappa)(p_\kappa / P), (r - r_m))$ [2.39]

What should be learned here is that the firm's demand, for labour, for capital and for real balances does not depend on absolute, but on relative prices. This is the same with the firm's supply for commodities. In other words, through both substitution and income effects, a change in the relative prices of the individual commodities would change the demand for real balances and also the absolute price level. The major determinant of the demand for real balances for the individual, as for all commodities collectively, is the scale variable (income or wealth) (Handa, 2000). We cannot terminate this subsection without considering the aggregate demand for money.

### *2.3.5 The Aggregate Demand for Money*

As described in the above subsection, equation 2.38 is the firm's demand for real balances and if we again use the symbols above, we obtain the supply functions for commodities and the demand functions for labour and the real balances of the firms, as follows:

$$x^s = x^s (p_1 / P, \dots ,p_K / P, W / P, (r - \pi_\kappa) (p_\kappa / P), (r - r_m)); \qquad [2.40]$$
$$x^s = x_\kappa (p_1 / P, \dots ,p_K / P, W / P, (r - \pi_\kappa) (p_\kappa / P), (r - r_m)); \qquad [2.41]$$
$$x^d = x^d (p_1 / P, \dots ,p_K / P, W / P, (r - \pi_\kappa) (p_\kappa / P), (r - r_m)); \qquad [2.42]$$
$$n^d = n^d (p_1 / P, \dots ,p_K / P, W / P, (r - \pi_\kappa) (p_\kappa / P), (r - r_m)); \qquad [2.43]$$
$$m^{df} = m^{df} (p_1 / P, \dots ,p_K / P, W / P, (r - \pi_\kappa) (p_\kappa / P), (r - r_m)). \qquad [2.44]$$

Equation 2.40 is the supply function for commodities and 2.43 the demand for labour. Equations 2.41 and 2.42 represent the supply and demand for physical capital stocks, respectively. Equation 2.44 stands for the firm's aggregate demand for real balances. The households and firm's demand for real balances are combined together to obtain the economy's aggregate demand for money. Thus:

$$m^d = m^d (p_1 / P, \dots ,p_K / P, W / P, (r - \pi_\kappa) (p_\kappa / P), (r - r_m), A_o/P). \qquad [2.45]$$

To have a complete model of the economy, an equation of the supply of real balances is needed, but this is not to be considered at this stage.

## 2.4 ECONOMIC THEORIES OF DEMAND FOR MONEY

A number of theories of the demand for money are found in the literature. This section discusses the forms of the most important theories, such as the classical quantity theory of money, the Keynesian theory of the demand for money and the modern quantity theory of the demand for money. In addition, we discuss Tobin's formalization of the speculative motive. This study does not ignore other theories of the demand for money such as post-Keynesian and Neoclassical. The emphasis is on the variables which these theories identify as the determinants of the demand (an quantity demeanded) for money and on the extent to which they predict the stability of the demand for money and justify the variables we use in our empirical work in equation 5.1 in Chapter Five.

### *2.4.1 The Classical Theory of Money*

According to Cobham (1987: 46), the classical quantity theory of money "is not strictly a theory of the demand for money, but it can reasonably be interpreted as being derived from a demand function, a supply function which has the money supply fixed exogenously by the government and an equilibrium condition which requires the supply of money to equal the demand for it." The classical quantity theory of money has two formulations: Fisher's equation of exchange and the Cambridge approach, as examined by Johnson (1971) and Ho (2003).

#### *2.4.1.1 Fisher's equation of exchange*

This is also known as the transactions approach to the quantity theory of money. People hold money because they want to make transactions, such as buying and selling goods and services. The greater the number of transactions the more money they hold. According to Mankiw (2003), the quantity of money in the economy is related to the number of Rands exchanged in transactions. Fisher's version of the quantity theory of money is expressed in terms of an equation which relates the money supply M, times the velocity of circulation of money V, to the price level P, times an index T of the transactions carried on in the economy (Cobham, 1987).

In Fisher's equation of exchange, the velocity of circulation is the key (Johnson, 1971). The velocity of circulation is "mainly determined by the institutions in an economy that affect the way individuals conduct transactions" (Ho, 2003: 93). Thus the quantity theory of money is written as follows:

$$MV \equiv PT . \qquad [2.46]$$

Where *M* is total quantity of money, *V* is the velocity of circulation, *P* is the price level and *T* is the number of transactions. Equation 2.46 is the demand and supply equation for money. *PT* is the demand for money and *MV* is the supply. Lloyd (1970) argues that *MV*, the number of Rands times the average number of times each Rand is spent is the value of all money spent: the supply of money in the quantity theory; and not the quantity of money, *M*. *MV* is, then, by definition, the value of everything bought with money.

The analysis of all the four variables in the equation is crucial. Three variables *(M, P* and *T)* are easily defined, but what about the fourth one *(V)* which is assumed to be fixed (Fisher, 1911)? V is defined as the number of times money turns over, or the transaction velocity of its circulation. Fisher assumes that "the quantity of money is determined independently of any of the three other variables and at any time can be taken as given. Moreover, *T*, the volume of transactions can also be taken as given" (Laidler, 1977). This assumption is justified as T is closely related to the level of output and the latter is assumed to be fixed at the level corresponding to the full employment of available resources (Cobham, 1987). Therefore the identity above becomes:

$$M\bar{V} = P\bar{T}. \qquad [2.47]$$

The assumption of *V* and *T* being fixed means that the money supply is controlled by monetary authorities or the government and is exogenous, and the price level becomes determined endogenously by *M*. In other words, an increase in the money supply *(M)* causes an increase in price level *(P)*. Returning to equation 2.47, we can rewrite it as:

$$M = P\bar{T}/\bar{V}. \qquad [2.48]$$

Thus the demand for money (*M*) varies directly and proportionally (although this can change) with the price level (*P*), when *T* and *V* are unchanged. It varies directly and proportionally with the level of real income and expenditure *T*, when *P* and *V* are fixed and it varies inversely and proportionally with desired velocity *V*, when *P* and *T* are unchanged (Wrightsman, 1971). In Fisher's exchange equation, the most important thing about money, as is demonstrated in the next section, is that it is transferred while the in the income version money is held to balance utilities (Friedman in Gordon, 1974).

*2.4.1.2 The Cash Balances (Cambridge) Approach*

This formulation is known also as the quantity theory of A.C. Pigou and it is developed from one of Marshall's theories. According to Wrightsman (1971), this approach differs from Fisher's theory in two important respects. First, Pigou links the demand for money to people's asset holdings, whereas Fisher links it to expenditures. In other words, the cash-balance approach focuses on the question of the fraction of one's assets not wanted to be kept in the form of money, while Fisher raises the question of how much money one needs to finance a given volume of transactions. Here is where Pigou replaces *T* by total output of the economy *Y.* This is because transactions and output are related. The more the economy produces, the more goods and services are bought and sold. However, Mankiw (2003) argues that transactions and output are not always the same.

Following the work of Pigou (1917) and Morgan (1978), Mankiw (2003) gives two alternatives of expressing the quantity theory of money:

$$M\bar{V} = P\bar{Y}; \quad [2.49]$$

$$M = kPY, \quad [2.50]$$

where *Y* stands for the quantity of goods and services produced and k = 1/V (where V = Velocity). If PY determines the quantity demanded for money, then equation (2.49) suggests that the demand for money is purely a function of income. Equation (2.50) shows that M is nominal and in our analysis if we divide by P we have real money demand. Therefore the equation becomes:

$$M_d = kY \quad and\ M_d = M/P. \quad [2.51]$$

The second difference is that Pigou does not assume that k and $Y$ are independent from the money supply, as Fisher assumes of $V$ and $T$. According to Pigou, cited by Wrightsman (1971: 106-107):

> *the proportion k of money to total assets is determined by marginal utility theory, that is, k is determined by equating the utility of last dollar held in money form to the utility of last dollar's worth of nonmoney assets, for only if the marginal utilities are equal will people be allocating their assets optimally. With k being determined by marginal utility theory, and with marginal utility of money affected by the quantity of money in supply, k is thus a function of the supply of money. Consider, if you will, an increase in the money supply. If money is subject to diminishing marginal utility, the increase in the money supply will cause the marginal utility of holding money to fall relative to the marginal utility of holding nonmoney assets. Thus it will pay for people to hold a larger proportion of their assets in nonmoney form and a smaller proportion in money. An increase in money supply thus causes k to fall. Conversely, a decrease in money supply raises k. Therefore, k is dependent on the size of the money supply.*

Returning to Pigou's analysis captured by equation 2.50, $kY$, which determines the quantity demand for money, the equation suggests that the demand for money is purely a function of income. Hence the function for the demand for money is:

$$M_d = f(Y), \qquad [2.52]$$

where $M_d$ is the real money demand and $Y$ is income.

Looking at both equations 2.46 and 2.50, $k$ appears on the right-hand side of the equation 2.50 and $V$ is on the left-hand side of 2.46. Since 2.50 has $Y$ rather than $T$, $k$ is the reciprocal of the income velocity of the circulation, while $V$ is the transactions velocity of the circulation. $Y$ and $T$ are strongly related and thus two formulations of the quantity theory of money are very closely related. However, it is argued that "the constant-velocity assumption refers to the short run, while the constant-velocity assumption in the Cambridge version refers more to some sort of long-run equilibrium" (Cobham, 1987: 48).

*2.4.1.3 Other Neoclassical Monetary Thoughts*

In the classical tradition, money is regarded as any object generally accepted and primarily used as a medium of exchange. No matter how things change, either technologically or institutionally, this definition will not be modified. Neoclassical monetary theory is a combination of the classical quantity theory of money and the neoclassical concept of equilibrium. In his work, is expanded later by Pigou, Marshall (1920), a Cambridge economist, modified Fisher's equation of exchange (see Section 2.4.1.2) to explain the demand for money as a proportion of nominal aggregate output. Thus the quantity of money demanded depends on national income and the proportion of nominal income that households and firms desire to hold as money (Payne and Ewing, 1997).

Although his statement is rejected by Patinkin (1965), Lavington (1921:30) believes that "the quantity of resources which (an individual) holds in the form of money will be such that the unit of money which is just (and only just) worthwhile holding in this form yields him a return of convenience and security equal to the yield of satisfaction derived from the marginal unit spent on consumables, and equals also to the net rate of interest." This is confirmed by Hicks (1935), when introducing the effect of interest rates on the quantity of money demanded. Therefore there is a negative relationship between the quantity of money demanded and interest rates (Payne and Ewing, 1997) (see also Section 2.4.2.3). Cannan (1921) explains that anticipated inflation which is expected to be negatively related to the quantity of money demanded must be also taken into consideration.

In summary, neoclassical monetary theorists believe that the money market would reach the equilibrium at the interest rate for which the quantity of money demanded equals the money supply. In the following section, the insertion of interest rates in the money demand function, under Keynes' liquidity preference theory is discussed.

### *2.4.2 The Keynesian theory of the demand for money*

Keynes analyses the demand for money under the title "Liquidity preference theory" (Struthers and Speight, 1986 and Johnson, 1971). Keynes believes that the demand for real money balances depends on the level of real income (Y) and interest rates (R). The demand for money is divided into two major components: "the demand for active balances and the demand for the passive (idle) balances" (Dornbusch and Fischer, 1998: 146). The demand for active balances is divided into two motives: transactions and precautionary motives, while the demand for idle balances is based on the speculative motive for holding real money balances.

#### *2.4.2.1 Transactions Motive*

The transaction motive arises from the function of money as a medium of exchange. One of the reasons why people hold part of their wealth in the form of money is that it allows them to make transactions without first undergoing the costs and inconvenience of converting some other asset into money (Perlman, 1981). Given institutional lags between the receipt of factor incomes and expenditure outlays, a certain amount of money is required to permit normal day-to-day transactions within the economy. The real value of this transaction demand is closely related to the real income (Greenway and Shaw, 1983). Consequently, the transactional motive of demand for money is essentially akin to the quantity theory of money.

According to Keynes, from Struthers and Speight (1986: 172), there are two motives for this type of demand for money:

*(i)* ***The income-motive:*** *This mainly depends on the amount of income and the normal length of the interval between its receipt and its disbursement.*

*(ii)* ***The business-motive****: To bridge the interval between expenditure and receipts, and this is mainly dependent on the value of current output and the number of hands through which the output passes.*

The cost of holding money can be represented by the interest rate, which is the opportunity cost of what could be earned if wealth is held in the form of interest-bearing assets rather than in the form of money. There are some post-Keynesian economists, such as Baumol, who expand this motive.

*2.4.2.1.a The Interest Rate Responsiveness of the Transaction Demand for Money: the Baumol-Tobin Approach*

Baumol (1952: 545) says that "a stock of cash is its holder's inventory of the medium of exchange, and like an inventory of a commodity, cash is held because it can be given up at the appropriate moment, serving then as its possessor's part of the bargain in an exchange." The assumptions of the Baumol-Tobin transactions inventory model, according to Cuthbertson (1985: 21), are: " a) the individual receives a known lump sum cash payment of T per period (say *per annum*) and spends it all evenly over the period; b) the individual invests in "bonds", paying a known interest rate *i* per period, or holds the cash (money) paying zero interest; c) the individual sells bonds to obtain cash in equal amounts, K, and incurs a (fixed) brokerage fee (*b*) per transaction." All relevant information is assumed to be known with certainty as well. Therefore, the model yields a square root relationship between the demand for money and the level of income, the brokerage fee and the bond interest rate (Cuthbertson, 1985):

$$M=\sqrt{2bT/i}\;/2. \qquad [2.53]$$

where *T* is income and *i* is the interest forgone by holding money. If the brokerage cost for each conversion of the asset to currency is represented by ($a + bE$), where a is the fixed cost, *b* the proportional cost, and *E* the value of cash withdrawn in equal amount, then the total cost (*C*) is given by:

$$C = T / E\ (a + bE) + iE / 2 = aT / E + bT + iE /2\ . \qquad [2.54]$$

The number of withdrawals is conceivably equal to income divided by E. But we need to determine the optimal E. By assuming that money holdings are run down evenly to zero after each encashment and *E/2* is the average money holding, in order to determine *E* we need to set the result equal to zero:

$$- aT / E^2 + i / 2 = 0 . \quad [2.55]$$

Thus,

$$E = \sqrt{2aT/i} = 2M . \quad [2.56]$$

Since the average money holding is *E/2*, the transactions money demand is an inverse function of the rate of interest and an increasing function of income. Hence the average transactions demand for money ($M^d$) often taking the 2 under the square-root sign, is

$$M^d = E / 2 = \sqrt{aT/2i} \quad . \quad [2.57]$$

According to Pierce and Tysome (1985: 55), the square root result has two important implications. Firstly, the way income is distributed plays an important role in determining the demand for money. If, for example, there is a redistribution of income away from high income earners towards low income earners, the aggregate demand for money would, according to this theory, rise. The second important implication is that the effects of an increase in the money supply under less that a full employment conditions will differ from those that would result if the demand for cash balances is proportional to the level of the transactions. In the latter case, an increase in the money supply would result in an equivalent proportional increase in the volume of transactions. But if the demand for money increases less than in proportion to the volume of transactions, then an increase in the money supply would result in a more than proportional increase in the volume of transactions at less than full employment. The Baumol-Tobin model suggests that monetary policy has a greater influence on economic activity than saying that the demand for money depends on income only.

*2.4.2.2 Precautionary Motive*

The desire to hold money, or near-money substitutes in asset portfolios in order to reduce risk, is known as the precautionary motive. It is the part of the income that is held because of the uncertainty of future income and consumption needs. Therefore it would be zero if the future value of these variables were fully known (Handa, 2000). Keynes (1936: 196) believes that:

> *To provide for contingencies requiring sudden expenditure and for unforeseen opportunities of advantageous purchases, and also to hold an asset of which the value is fixed in terms of money, to meet a subsequent liability fixed in terms of money, are further motives for holding cash.*

The precautionary demand for money is regarded as varying primarily with income and is usually aggregated together with the transaction's demand. According to Levacic (1978), the precautionary motive explains liquidity preference, which is the willingness of people to hold assets which are more liquid at a lower rate of return, than that obtainable on less liquid assets. Saving and precautionary money balances are two different concepts. For Handa (2000: 129) the difference is explained as "saving being the means of carrying purchasing power from one period to the next and precautionary money balances being the means of paying for unexpected expenditures during the period."

*2.4.2.3 The Speculative Motive*

The speculative motive for holding money is the most original of Keynes' theories about the demand for money. This motive is regarded as a pioneering attempt to consider the holding of monetary assets as part of an expanded portfolio. Unlike Fisher's (1911) formulation of the quantity theory, it emphasizes the role of money as a reliable store of purchasing power rather than as a medium of exchange. It helps explain the variability of the velocity of the money, often seen in the data (Spencer, 1992).

The speculative demand for money is related to expectations about future levels of market interest rates. Keynes emphasizes that money is a store of value which can serve as an alternative to interest rate bearing bonds. Therefore, according to Slovin and Sushka (1977: 37), "changes in interest rates and bond prices are inversely related, so that a change in interest rates alters the marketable value of bonds." For this reason, people hold money when they believe that interest rates are too low and are set to rise, causing capital losses upon holdings of fixed interest securities which are large enough to offset the interest coupon and so give them a negative overall return (Spencer, 1992).

Bain (1976: 84) writes that "since future interest rates are uncertain, asset-holders' expectations of how they will move are very likely to differ: some might expect interest rates to rise sharply, others might expect little change, and still others might expect a fall." Therefore, all of the first group of investors would certainly choose to hold cash. Some of the second group, and the remainder, who expected only a small capital loss on bonds, insufficient to offset the interest they would receive, plus all of the third group, would hold bonds. In other words, if the majority of investors expect interest rates to fall, the demand for bonds will be large and for money smaller and *vice versa* if interest rates are generally expected to rise (Laidler, 1977). Slovin and Sushka (1977: 38) believe that Keynes' speculative demand for money is not derived from investor uncertainty about future interest rates. Instead, each investor is assumed to hold with certainty his own unique idea about the normal rate. In addition to this assumption, we may argue that with speculative motives, what matters is not the absolute level of the current interest rate, but the degree of divergence from what is considered a fairly safe level of future interest rates. Hence, the speculative demand for money function is:

$$M_L = f(R). \quad [2.58]$$

Where $M_L$ is liquidity preference and $R$ is the real interest rate.

According to Laidler (1977) and Evans and Makepeace (1979), the total Keynesian real demand for money function makes transactions and precautionary balances a function of the level of income and speculative balances a function of current interest rates. More precisely, the transaction and precautionary motives link an uncertain future to a satisfactory present (Chick, 1983) and therefore are positively related to the level of transactions or income (Ho, 2003). This makes these motives consistent with the classical tradition. The speculative motive deals with the opportunity costs of holding money which is the interest rate that could have been earned if invested in some other asset, or stock. Therefore, the quantity demanded of money depends negatively on the interest rate (R) (Carrera, 2007). The money demand function with the introduction of the interest rate is shown below:

$$M_d = f(\overset{+}{Y}, \overset{-}{R}). \qquad [2.59]$$

Where $M_d$ is real money demand, $Y$ is income and R stands for the interest rate, and making i = R.

*2.4.3 Tobin's Formalisation of Speculative Demand for Money*

John Maynard Keynes and James Tobin rationalise in different ways the speculative demand for money. However, Tobin (1956: 242) agrees with Keynes that there are only two assets in which the individual can diversify an investment. These two assets are money and bonds. These assets differ in two respects; one is that a bond is not a medium of payment but it bears an interest rate (Handa, 2000).

To reply to the question of why any investment balances should be held in cash, in preference to other monetary assets, two possible sources of liquidity preferences, which are not mutually exclusive, can be distinguished. As stated by Tobin (1958: 175), "the first is inelastic of expectations of the future in interest rates. The second distinction is the uncertainty about the future of interest rates." In other words, Keynes bases his explanation on inelastic bond price expectations, while Tobin bases his explanation on uncertainty about the future course of bond prices, as Crouch (1971: 368) points out.

According to Handa (2000: 38), in a perfect competitive capital market, the market price of a bond will equal its present discounted value. Thus, $p_b$ being the price of a bond which has an instalment payment C per period, and discounted at a market rate of interest r on loan, the price of this bond will be:

$$p_b = C/_{1+r} + C/_{(1+r)^2} + \cdots ; \quad [2.60]$$

$$= C\left(\sum_{t=1}^{\infty} \frac{1}{(1+r)^t}\right); \quad [2.61]$$

$$= C\ (1 / r) = C / r, \quad [2.62]$$

and using (1+1/(1+ r…)) = (1+ r) / r. If it is assumed that $C = r$; $p_b = 1$, the bond which has been assumed to yield a coupon payment r in perpetuity, its *PV* at the rate of interest *r* would be *1* (Handa, 2000). "At the end of the year, the investor expects the rate on consols to be $r_e$. This expectation is assumed, for the present, to be held with certainty and to be independent of the current rate *r*" (Tobin, 1958: 175). Thus, the value of the Rand invested in consols today, with certainty, is expected to earn more. Therefore, the capital gain or loss *g* is *according* to Tobin:

$$g = (r / r_e) - 1 \quad [2.63]$$

If rearranged, equation 2.63, in order to get the sum of the coupon r and the capital gain g, we have:

$$r + g = r + (r / r_e) - 1 \quad [2.64]$$

Under the condition of the current rate being r + g and being greater than zero, people will only buy consols. Contrarily, if *r + g* is less than zero, they would hold money because money would be the asset with the higher yield compared to consols in this case (Handa, 2000) and Tobin (1958). Hence the equation above can be written as:

$$r_c = r_e / (1 + r_e) \quad [2.65]$$

Where $r_c$ is the critical level of the current rate. Therefore, if the current rate is above $r_c$, only consols will be bought and if the critical level of the current rate $r_c$ is above the current rate, only money will be held.

Diagrammatically, Handa (2000) describes how the individual's demand for money is the discontinuous step function *(AB, CW):* the rational individual's whole portfolio W is held in consols and the demand for money along *AB* is zero, below $r_{c,}$ all of *W* is held in money balances and the demand function is *CW in* Figure 2.1.a. if all individuals do not have the same critical rate, the speculative demand for money is negatively related to interest rate. In other words, aggregate demand for cash will rise as interest falls. This is shown by the continuous downward sloping curve $M^{sp}$ in Figure 2.1.b (see also Tobin, 1958: 176).

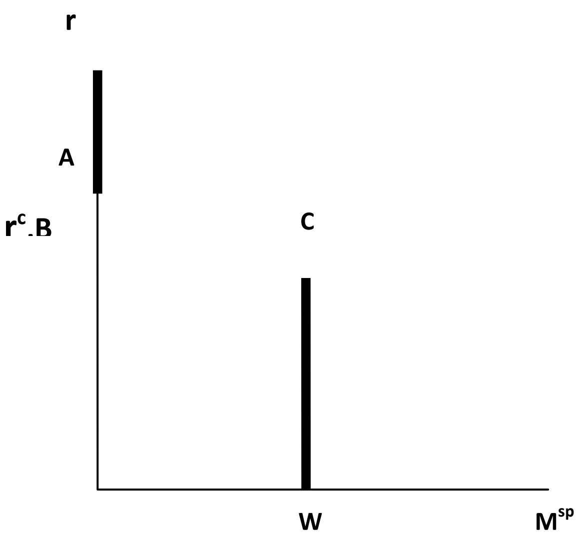



**Figure 2.1.a**

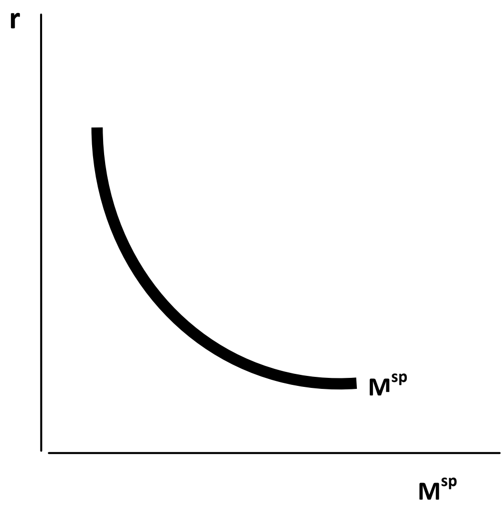



**Figure 2.2**

Figure 2.1 Tobin's formalsation of speculative demand for money

*Source: Handa (2000: 39)*

*2.4.4 The Friedman's Modern Quantity Theory of Money*

This is also known as the monetarist's demand for money. The first argument of Friedman (1956: 146) is that "the quantity theory is in the first instance a theory of the demand for money. It is not a theory of output or of money income, or of the price level." The main issue in this argument is "does money matter", by which is meant that changes in the money supply could cause changes in nominal variables and sometimes even in real ones, such as output and employment in the economy (Handa, 2000: 42).

Friedman stresses that money should be treated as a durable good rather than a consumption service, as it had always been before his work. The important relative prices are in terms of inter-temporal rates of return, while the budget constraint must be cast in terms of wealth rather than income. The distinction can be made between the demand for money by ultimate wealth-holders, to whom money is one form in which to hold wealth, and firms to which money is a capital asset (Lewis and Mizen, 2000). This emphasizes the major issues raised in considering five different forms in which wealth can be held, as listed by Friedman (1956: 148):

> *"i) money (M), interpreted as claims or commodity units that are generally accepted in payment of debts at a fixed nominal value; ii) bonds (B) interpreted as claims to time streams of payments that are fixed in nominal units; iii) equities (E), interpreted as claims to stated pro-rate shares of the returns of enterprises; iv) physical non-human goods; and v) human capital (H)."*

In other words, the main explanatory variables of Friedman's individuals' demand for real balances are real yields on other assets which are bonds, equities and physical assets. He also includes the rate of inflation, real wealth and the ratio of human to non-human wealth (Handa, 2000: 43). The measurement of the ratio of wealth and non-human wealth is still a big issue in the analysis of demand for money and we do not enter in this debate here. Hence the demand function is:

$$M_d / p = f(r_1, r_2 \ldots r_n, \pi, y, w, \omega) \quad [2.66]$$

Friedman considers total wealth as permanent income *y*. Theoretically, $y^p = rw$, where *r* is the expected average interest over the future and w is wealth in real terms, and permanent income $y^p$ can be regarded as the average expected income over the future (Handa, 2000). Friedman (1956: 150) believes that "the tastes and preferences of wealth owning units for the service streams arising from different forms of wealth must in general simply be taken for granted as determining the form of the demand function." Friedman does not forget inflation as one of the determinants of demand for money. The real yield in money holdings depends upon movements in the price level (*p*). A sustained increase of the price level causes a fall of the real value of nominal balances, causing holders of the money to experience a capital loss in real terms and *vice versa* (Vane and Thompson, 1979). Therefore, the demand for money function is sometimes formulated as follows:

$$m^d = M^d/p = m^d(r_1, \ldots r_n, \pi, y^p, w, u), \quad [2.67]$$

where u stands for the tastes and preferences and π is the inflation rate.
If $r_e$ and $r_b$ are the returns on equity and bonds, respectively, the yield variables are:

For Bonds: $r_b - ((1 / r_b)(dr_b / dt)));$ [2.68]
For Equity: $r_e - ((1 / r_e)(dr_e / dt) + (1 / p.\ dp / dt));$ [2.69]

where the expected rate of changes are

$$((1 / r_b)(dr_b / dt)),$$
$$(1 / r_e)(dr_e / dt) \text{ and}$$
$$(1 / p.\ dp / dt).$$

The rate of return on equities can be shown in three different forms: "a nominal amount per year *($r_e$)*, an addition or subtraction to the nominal amount to adjust for changes in prices (1/p)(dp/dt*)*, and any change in the nominal price of the equity over time ((1/ $r_e$)($dr_e$/dt)" (Vane and Thompson,1979: 39). In other words, equities are not fixed in money value and if inflation is expected, the yield will be higher than if stable prices are anticipated (Johnson, 1971: 95). The major problems that arise in practice when applying equation 2.67 are the precise definitions of income and wealth, the estimation of expected rates of return, as contrasted with actual rates of return, and the quantitative specification of the variables designated by u.

The theory of money demand is regarded as a developmental process from classical theory to that of the monetarists. The above views are considered when building the econometric model in Chapter Three, by including income, an interest rate, inflation and the exchange rate as explanatory variables. We now consider the stability of this demand function.

## 2.5 THE ISSUE OF MONEY DEMAND STABILITY

In order to understand the transmission mechanism, the issue of demand for money stability should be taken into consideration. For this reason, it is advisable and crucial to specify the appropriate form of the money demand function and to investigate its stability (Laumas and Mehra, 1976). Friedman (1956: 156) states that "the quantity theorist not only regards the demand function for money as stable, he also regards it as of great importance for the analysis of the economy as a whole, such as the level of money income or of price." A stable money demand is crucial. In macroeconomics, the analysis of the demand for money has become a topical and challenging issue. Recently, economists realize that a stable demand for money forms a cornerstone in formulating and conducting an effective monetary policy (Kaweesa, 2004) and (Roley, 1985).

While the impact of monetary policy on other sectors of the economy is obvious, in the past, economists and policy-makers considered the money supply as the only one element from the monetary sector which is a policy tool required for the formulation of a suitable monetary policy aimed at the real variables of the economy. The money supply may be exclusively relied upon, simply because of the assumption the elasticity of the demand for money is thought to be unity. However, this is very rarely the case in the real world (Naho, 1985: 3). In addition, while a change in the demand for a given good has repercussions limited to a sector or few sectors of the economy, the impact of a change in the demand for money affects every sector of the economy. Thus the demand for money needs to be stable in order to have a stable economy.

Many recent studies have reinvestigated the traditional money demand specification which relates real money stock to real income and a bond rate of interest (Dutkowsky and Foote, 1988). According to Kaweesa (2004), when modeling the demand for money function, in order to ascertain if it is stable or not, requires the estimation and quantification of the demand for money function, using data and econometric methodology. McCallum and Goodfriend (1987: 780) state that "typical econometric estimates of money-demand functions combine long-run specifications such as partial adjustment processes that relate actual money-holdings to the implied long-run values." This approach uses a regression equation that includes a lagged value of the money stock as one of the explanatory variables. However, this approach has been shown to be weak (McCallum and Goodfriend, 1987). Before beginning the section on the demand for money specification, which will be used in the empirical chapter, it is vital to mention that an econometric relationship is stable if the parameters in such a relationship are not subject to permanent changes, over time (Sayinzoga, 2005 and Hoffman, Rasche and Tieslu, 1995) and then we can say that a long-run relationship exists between the real demand for money and its explanatory variables.

According to Friedman (1956), the money demand function assumes that there are stationary long-run equilibrium relationships between real money balances, real income and the opportunity costs of holding real balances. Whether a long-run relationship exists between money and income or wealth or between money and interest rate, inflation and the exchange rate crucially determines the role of money in the design and implementation of monetary policy.

These three economic variables of the previous paragraph gained importance in the literature from the 1980s (Olivo and Miller, 2000). Monetary authorities use empirical money demand estimations as a major tool in designing policies to influence the real economy *via* monetary balances. One may ask two questions: is the demand for money in South Africa stable and what are the independent variables of money demand function? The first question is answered in the empirical chapter, while we attempt to answer the second question in the next section.

*2.5.1 Choice of Variables*

There are many theoretical criticisms and econometric objections to how traditionally structured econometric models estimate the demand for money (Bischoff and Belay, 2001). According to Ericsson and Sharma (1996: 5), money is held because of at least two reasons: firstly as an inventory to smooth differences between income and expenditure streams and secondly as one of several assets in a portfolio. See also Baumol (1952), Friedman (1956) and Tobin (1956). With the quantity theory and transactions motive, nominal money depends on the price level and the volume of real transactions. Also, "holdings of money as an asset are determined by the returns on money as well as returns on alternative assets and by total assets (often proxies by income)" (Ericsson and Sharma, 1996: 5). Thus real money demand depends on real income and the interest rate shown by equation 2.59 in section 2.4.2.3:

$$M_d = f(\overset{+}{Y}, \overset{-}{R}) \qquad [2.70]$$

where $M_d$ is real money demand, Y is the real income and R r stands for the interest rate.

According to Bischoff and Belay (2001: 208), some possibly obvious variables are not included in the above traditional function of money demand. Some omitted candidates are the exchange rate and the inflation rate. Laidler (1977) points out that the variable excluded from the demand for money function is the level of the reserves made available by the Reserve Bank to the commercial banking system. This view is supported by Handa (2000). Our empirical study is based on Ericsson and Sharma (1996), following their long-run money demand model specification:

$$RM2 = \beta_1 + \beta_2 Y_t + \beta_3 R_t + \beta_4 \pi_t + \beta_5 ER_t + \mu_{t..} \qquad [2.71]$$

Where *RM2* stands for real money demand, $\beta_1$ is the intercept term, $\beta_2$, $\beta_3$, $\beta_4$ and $\beta_5$ are the slope coefficients of the explanatory variables; *Y* (which is real income), R (which is the Treasury Bill rate), $\pi$ (which stands for the inflation rate) and *ER* (which stands for the exchange rate), while $\mu$ is an error term and *t* is time. The regression coefficient on economic activity is expected to be positive. In other words, as economic activities grow the demand for money increases. Therefore $\beta 2$ is expected to be positive. The regression coefficient for the interest rate, inflation and exchange rates ($\beta_3$, $\beta_4$ and $\beta_5$) are expected to be negative. Thus, as these variables rise, the quantity demanded for money weakens (declines).

Theoretically and empirically, various aspects of the demand for money are examined, focusing on two important issues: the selection of the right variable to measure the opportunity cost of holding money and the appropriateness of income, compared with wealth as a scale variable. Therefore there are two categories of researchers: those who follow the classical theory and tend to use short-term *interest rates* to measure the cost of holding money and those who view holding money as part of a general portfolio decision process and so use rates of return on long-run financial assets (Bischoff and Belay, 2001).

There is a question whether or not to use the inflation rate or an interest rate and, indeed, both variables have been included simultaneously in many studies, especially in developing countries with high inflation rates. Some authors use the inflation rate alone, such as Eken, Cashin, Nuri and Martelkino (1995) and others use the inflation rate and interest rates alternatively such as Yashiv (1994). In this study both are used. The inflation rate can be translated into an effective cost of holding money (Barro, 1971). As we saw in section 2.2.2, money, like any asset, is a store of value. Therefore inflation, if anticipated, reduces the real balances people are willing to hold. Inflation whether it is anticipated or not can increase the cost of holding money. Hence, past inflation influences the expectations about future quantities of money demand (Kessel and Alchian, 1962). Inflation is therefore one of the determinants of demand for money used in this study and is expected to have a negative effect on money demand. In other words, higher inflation causes a shift from money to other assets and reduces economic efficiency (Fisher, 1974: 525).

Concerning the influence of the exchange rate on the demand for money, in every open economy the inclusion of foreign assets is one of the ways of extending the demand for money. Hence the expected rate of depreciation of a country's currency may be an opportunity cost of holding money (Brissimis and Leventakis, 1985). If the local currency is expected to depreciate, agents may prefer to substitute their local currency by foreign and stable currencies and *vice versa*. In the present study, the model includes the exchange rate.

The next sub-section addresses the cointegration and error correction mechanism methods. This methodology has only recently become widely accessible to applied economists, but because this model features extensively in the literature on cointegration, these methods can be used for the analysis of the demand for money function.

### *2.5.2 Cointegration and Error-Correction Mechanism*

According to Engle and Granger (1987), in macro-econometric's modelling it is possible to test the joint time series properties among a set of variables, in addition to the individual time series properties. Ewing and Payne (1999: 179) state that "the identification of stable money demand functions can be accomplished by examining the cointegrating relationships among a monetary aggregate and its determinants." Cointegration techniques have been used in a number of studies to examine money demand, for example, Johansen (1988) and (1990), MacKinnon (1991), Miller (1991), Hafer and Jensen (1991), Hendry and Ericsson (1991), McNown and Wellace (1992), Friedman and Kuttner (1992), Lee and Chung (1995) and Bahmani-Oskooee and Shabsigh (1996). Some of these are similar to the present study. This literature shows that cointegration has become an essential tool for applied economists wanting to estimate time series models. Without some form of testing for cointegration, non-stationary variables can lead to spurious regression.

The correlation between a series and its lagged values is assumed to depend only on the length of the lag and not on when the series started. A series meeting this condition is called a stationary time series, also referred to as a series that is integrated of order zero, or denoted as I(0) (Ramanathan, 1995: 569). A stationary time series tends to return to its mean value and fluctuate around it within a more-or-less constant range, while a non-stationary time series has a different mean at different points in time and its variance increases with the sample size (Harris, 1995: 15).

Most macroeconomic data time series are non-stationary because "they usually have a linear or exponential time trend" (Ramanathan, 1995: 569). However, it is possible to turn them into a stationary series by simply differencing the series but this means information is lost. But one may ask "what the problem with non-stationary data is?" The answer is that "when time series are used in a regression model the results may spuriously indicate a significant relationship when there is none" (Hill et al, 2001: 340). If the stationarity property does not hold, it still may be that two variables are cointegrated. A finding of cointegration indicates a stable money demand function and provides evidence that the monetary aggregate may be useful as a policy instrument (Ewing and Payne, 1999). Considering the conventional money demand function, and given South Africa is an open economy, what we seek to identify is a stable, long-run relationship between real money balances and real income, the interest rate, the inflation rate and the exchange rate. Consequently, the presence of cointegration can be interpreted as indicating one of a long-run equilibrium relationship even when individually the variables are non-stationary.

Even if there is cointegration between variables, there is also a possibility that the equilibrium does not exist in the model in the short run. Granger's theorem stated in Verbeek (2000: 285) is: "if a set of variables are cointegrated, then there exists a valid error-correction representation of the data." The dependent and independent variables are both non-stationary, but have a long-run relationship, indicating that there must be some force which pushes or pulls the equilibrium error back towards zero. To ensure that this disequilibrium is corrected, an error correction mechanism pushes back the model towards the long-run equilibrium (Engle and Granger, 1987: 251). According to Kennedy (1996: 267), economic theory plays two roles in the development of this testing model:

> *"first, it suggests explanatory variables for inclusion in this equation; and second, it identifies long-run equilibrium relationships among economic variables which, if not exactly satisfied, will set in motion economic forces effecting the variable being explained"*

We hope to conduct our empirical work in a later chapter along these lines. What can be said at this stage is that some of our variables are non-stationary and therefore we need to look first at the long run relationship and then its short-run error correction effects. We cannot conclude without stating that, as has been demonstrated in the empirical chapter, in order to get an appropriate result, cointegration and error correction mechanism methods have different tests to check for stationarity. We do this in chapter Five.

## 2.6 SUMMARY AND CONCLUSION

This chapter discusses various economists' views concerning the demand for money. Before a general equilibrium analysis of money in the economy, we consider the case where money, like any other good, is introduced into the utility function, from an individual and a firm's demand for money function, as well as an aggregate demand for money. Some concepts and functions of money are clarified as we discuss each approach. The usual approach to demand theory is to postulate that the satisfaction received by an individual when consuming goods provides the market demand for goods and services (Laidler, 1977). Therefore, as money can be considered as being the same as any other goods, it should be included in the utility function. However, many economists argue that money should be incorporated in the utility function indirectly rather than directly, because it does not yield consumption services, but rather helps consumers save time and therefore increases their leisure time (See section 2.4.2).

What is learnt in this chapter is that the demand for real balances depends on relative rather than absolute prices of other inputs into the production function. The individual's demand and supply functions for real goods, including money, are homogeneous of degree zero in prices and the nominal value of initial endowments. A change in all prices with the real value of wealth held constant does not change the individual's demand and supply function (Handa, 2000), but a change in a relative price would change an individual's real wealth. This is because part of the wealth is held in money and other financial assets. Therefore higher relative prices bring about a wealth effect *via* changes in the demand for goods by the individual and in the economy the relative prices of goods may change.

The demand for money theory is a developmental process, from the classical to the monetarists' theories. For classical economists, closely related to the demand for money, is an economic relationship known as the income velocity of money. The demand for money depends on income. The transactions and precautionary motives satisfy the immediate needs of either certain or uncertain motives (Chick, 1983) and are positively related to the level of transactions or income (Ho, 2003). This makes these motives consistent with the classical tradition. The speculative motive for holding money deals with opportunity cost, which is the interest rate that could have been earned if wealth had been invested in some other asset or stock other than money. The quantity of money demanded depends negatively on the interest rate (r) (Carrera, 2007). For Friedman, money is a durable good, not a consumption service. Monetarists see the distinction between income and wealth as a crucial one, and two additional determinants of the demand for money are tastes and preferences.

An analysis of long-run relationships between real money demand and its determinants is a vital one in order to implement and understand monetary policy. In this chapter, real income, an interest rate, the inflation and exchange rates are chosen as the explanatory variables in the model and RM2 (real money demand) is the dependant variable. As is known, most macroeconomic variables are non-stationary and, by using cointegration and the error correction mechanism, the identification of stability in the money demand function can be accomplished.

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.1 INTRODUCTION

The purpose of this chapter is to present the research methodology used in this thesis. Econometricians can analyse time series data erroneously by formulating a traditional regression model to represent the behaviour of data but not pay too much attention to the specification of the dynamic structure of the time series. One also needs to worry about simultaneity bias and autocorrelated errors. Time series data are assumed by econometricians to be non-stationary (Kennedy, 1996). In other words, time series data do not have a fixed stationary mean. Therefore, running a regression on non-stationary data may give misleading values of $R^2$, DW and t statistics; and this leads to the incorrect conclusion that a meaningful relationship exists among the regression variables, when it does not (Kennedy, 1996: 263). To solve this problem of spurious results, one uses the method of cointegration. Indeed, in this thesis (Sections 5.4 and 5.5), the method of cointegration is used to estimate the long-run money demand function, while the error correction mechanism (ECM) is applied to estimate the short-run dynamics of the model of this study.

Chapter Three is organised as follows. Section 3.2 addresses the data collection procedures and methodology. Section 3.3 concerns the specification of the econometric model of the demand for money to support our choice of equation 2.71 in section 2.5.1. Section 3.4 analyses hypothesis testing. Checking for stationarity is in section 3.5, in which the graphical analysis, sample correlogram or autocorrelation function and the unit root test are reviewed. Section 3.6 concerns testing for cointegration and related recommended procedures. Finally, the error correction mechanism is discussed in Section 3.7.

## 3. 2 DATA COLLECTION AND METHODOLOGY

The data this thesis uses consists of quarterly observations for RM2 as defined in Chapter One, income and the interest rate. According to Muscateli and Spinelli (2000), the inflation rate is the more important determinant of transaction balances. Therefore, following Ewing and Payne (1999), Qayyum (2005) and Ericsson and Sharma (1996), we include both the inflation rate ($\pi$) and the exchange rate (SA cents per USA dollar or middle rates (R1 = 100 cents) in the model as the determinants of money demand in South Africa from 1990 to 2007, making a sample size of 69 observations. This time period follows many different monetary and exchange rate policies, such as the conversion towards a system of indirect control of the money supply and the adjustment of short-term interest rates between 1980-1985, rather than using changes in cash and liquid asset requirements combined with credit ceilings and interest rate controls to affect liquidity conditions. One cannot ignore the adoption of the inflation targeting framework for monetary policy in 2000 (Jonsson, 2001: 44). Moreover, the political disturbances during the 1990s are one of the main characteristics of this period (Tlelima & Turner 2004: 35). The data are collected from the South African Reserve Bank. The conversion of these data to quarterly data did pose some difficulties which were solved in an appropriate manner.

The following methodology establishes whether or not there is a long-run relationship between real money demand (RM2) and its determinants in South Africa. In this study, RM2 is the dependent variable, and real income (Y), the Treasury-Bill rate (R), the inflation rate (π) and the exchange rate (ER) are the independent (explanatory) variables. In order to obtain RM2 we multiply the monetary aggregate (M2) by gross domestic expenditure (constant 2000 prices) and divide this result by the gross domestic expenditure (in current 2000 prices). The interest rate and the inflation rate are collected by month and we use the average in order to convert them to quarterly data. The same is done with the exchange rate. Because this is time series data, following Gujarati (2003), the first test is for stationarity and continues with a typical co-integration test. All these tests are done using SPSS (Statistical Package for the Social Sciences). The thesis uses other materials such as books, journals, articles, magazines, newspapers and the World Wide Web for information.

## 3.3 MODEL SPECIFICATION OF THE DEMAND FOR MONEY

### *3.3.1 Mathematical Model*

The following is the mathematical model:

$$RM2 = f(\overset{+}{Y}, \overset{-}{R}, \overset{-}{\pi}\ \overset{-}{ER}). \qquad [3.1]$$

And RM2 is a function of Y, R, π and ER. This means that RM2 is determined by real income, the interest rate, the inflation rate and the exchange rate. In other words, an increase in real income leads to an increase in real money demand, while an increase of the interest rate, inflation rate and the exchange rate causes a decrease in RM2 *ceteris paribus.*

*3.3.2 Econometric Model*

With all variables in logarithmic terms, except R, this thesis implements the following real money demand model:

$$\ln RM2_t = \beta + \beta \ln Y_t + \beta R_t + \beta \ln \pi + \beta \ln \mathrm{E}_t + \iota_t . \qquad [3.2]$$

Where RM2 stands for real money demand, $\beta_1$ is the intercept term, $\beta_2$, $\beta_3$, $\beta_4$ and $\beta_5$ are the slope coefficients of the explanatory variables: Y (which is real income), R (the Treasury-Bill rate), π (which stands for the inflation rate) and ER (which stands for the exchange rate) while μ (is an error term) and t (is time). The regression coefficient for economic activity (real income) is expected to be positive. As economic activities grow, the real demand for money increases and therefore $\beta_2$ is expected to be positive. The regression coefficient of the interest rate is expected to be negative. Thus, as the Treasury-Bill rate rises, the quantity demanded for money weakens (declines). Similarly the inflation and exchange rate coefficients are expected to be negative.

## 3.4 HYPOTHESIS TESTING

According to Hawkins and Weber (1980: 45), "a time series is a sequence of observations taken on some process that varies over time." This type of data poses many challenges to researchers, especially econometricians. We may ask why? The key problem is between data being stationary and non-stationary. Most empirical work based on time series data assumes that the underlying time series data is stationary, or its mean and variance do not fluctuate systematically over time (Gujarati, 2003: 26). However, it is known that many macroeconomic time series data are non-stationary (Hill, Griffiths and Judge, 2001).

Most economic time series are generally integrated of order one I(1) and become stationary only after taking first differences. One may ask what is the problem with non-stationary data? The answer is that "when time series are used in a regression model the results may spuriously indicate a significant relationship when there is none" (Hill *et al.,* 2001:340). There are different tests that are used to check for stationarity. These are dealt with in the section that follows.

## 3.5. CHECKING FOR STATIONARITY

### *3.5.1. Graphical Analysis*

It is advisable, as a first step, to plot the data under study before the researcher pursues formal tests to check variables for stationarity. This gives an initial idea about the likely nature of the time series (Gujarati 2003: 807). Section 5.3.1 uses graphs to provide a visual analysis of the data. It is preferable to use natural logarithms when plotting regression variables in order to show their growth. However, it should be noted that looking at time series plots alone is not enough to tell whether a series is stationary or non-stationary.

### *3.5.2 Sample correlogram or autocorrelation function*

The autocorrelation function at lag k, denoted by $\rho_k$, is defined as the covariance at lag k divided by the variance. A Plot of $\rho_k$ versus k is known as the sample or population correlogram (Gujarati, 2003: 808). One denotes k as the lag length when computing the sample autocorrelation function. According to Shumway and Stoffer (2000: 26), "the autocorrelation function has a sampling distribution, under complete independence, which allows us to assess whether the data comes from a completely random or white series or whether correlations are statistically significant at some lags." Hence, if a time series is stationary, the autocorrelation coefficient at various lags will remain around zero and decline quickly, while in a non-stationary time series the autocorrelation coefficient starts at a high value and declines very slowly towards zero as the lag lengthens (Gujarati, 2003: 810-811).

The population correlogram is defined as follows:

$$\rho_k = \gamma_k / \gamma_0 \qquad [3.3]$$

= covariance at lag k / sample variance.

If k = 0, $\rho_0$ will be equal to 1. However, only an estimation of the sample autocorrelation function $\hat{\rho}$ can be worked out. According to Gujarati (2003), this requires one first to compute the sample covariance at lag k, $\hat{y}_k$; and the sample variance, $\hat{y}_0$, and are represented by the following equations:

$$\hat{y}_k = \sum (y_t - \bar{y})(y_{t+k} - \bar{y}) / n \qquad [3.4]$$

$$\hat{y}_0 = \sum (y_t - \bar{y})^2 / n \, . \qquad [3.5]$$

Where n represents sample size and $\bar{y}$ stands for the sample mean. Therefore, the sample autocorrelation function at lag k is:

$$\hat{\rho}_k = \hat{y}_k / \hat{y}_0 \, . \qquad [3.6]$$

The above statement is applied in Chapter Five (Section 5.3.2), where the correlogram of some of the variables may reveal themselves to be non-stationary, while others show a subjective probability that the data series may be stationary.

### *3.5.3 Unit Root Test*

When discussing stationary and non-stationary time series, an alternative test, which has recently become popular, is known as the unit root test. This test is important as it helps to avoid the problem of spurious regression. In defense of this point, Harris (1995: 27) writes that "if a variable contains a unit root then it is non-stationary and unless it combines with other non-stationary series to form a stationary cointegration relationship, then regression involving the series can falsely imply the existence of a meaningful economic relationship." Testing for the presence of unit roots is not straightforward, but the easiest way to introduce this idea is to consider the following equation:

$$y_t = y_{t-1} + u_t. \quad [3.7]$$

And $u_t$ in the equation is the stochastic error term or white noise error term. There are several ways of testing for the presence of unit root. This study uses the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests for testing the null hypothesis that a series does contain a unit root or is non-stationary. Both the DF and ADF approaches are developed from equation 3.7. We now consider these tests in more detail, by developing 3.7.

**Dickey-Fuller Test (DF)**

If a series is differenced d times, for example, before it becomes stationary, then it is said to be integrated of order d, and is denoted I(d). If a series $Y_t$ is I(d) and $Y_t$ is non-stationary but $\Delta Y_t$ is stationary where $\Delta Y_t = y_t - y_{t-1}$ (Cuthbertson, *et al.,* 1995: 130), an appropriate test for stationarity has been suggested by Dickey and Fuller (Hill, *et al.*, 2001: 344). According to Gujarati (2003: 814), the following equations can be used for such a test:

$$y_t - y_{t-1} = \rho y_{t-1} - y_{t-1} + u_t$$

$$\Delta y_t = (\rho - 1) y_{t-1} + u_t$$

$$= \delta y_{t-1} + u_t. \quad [3.8]$$

Where $-1 \leq \rho \leq 1$, $\delta = \rho - 1$ and $\Delta$ represents the first-difference operator. In this scenario we are testing the null hypothesis $\delta = 0$ if $\rho = 1$, that is, we have a unit root. In other words, the time series under consideration is non-stationary if the null hypothesis is true. Moreover, if we ignore the unit root and estimate the above equation (3.8) then it can be shown that the distribution of the ordinary least square's (OLS) estimate of $\rho$ is not centred at 1 and the corresponding "t" statistic does not have a student's *t* distribution and therefore the usual *t* test for $\rho = 1$ does not apply (Ramanathan, 1995: 553). Instead of a *t* test, we use three forms of the $\tau$ (tau) test (Gujarati, 2003: 815).

Practically, the Dickey-Fuller test is applied to regressions using equations 3.9 to 3.11 as follows:

$$\Delta \;_{t} = \delta \;_{t-1} + u_t \;; \qquad [3.9]$$

$$\Delta \;_{t} = \beta_{1} + \delta \;_{t-1} + u_t ; \qquad [3.10]$$

$$\Delta \;_{t} = \beta_{1} + \beta_{2} t + \delta \;_{t-1} + u_t . \qquad [3.11]$$

Where t is the time or trend variable. The difference between 3.9 and the other two equations lies in the inclusion of the intercept ($\beta_1$) and a trend term. Equation 3.9 is the formula for a random walk, 3.10 the random walk with drift, while 3.11 represents the random walk with drift around a stochastic trend.

If the computed values of the τ statistic in absolute value exceed the critical DF value, the time series in the equation is stationary, but if the calculated τ statistic is less than the DF critical value the null hypothesis is not rejected. Thus the time series is non-stationary. Gujarati (1995: 719) stresses that if the regression is run in the form of 3.8, the estimated τ statistic usually has a negative sign. A large negative τ value relative to the critical value is generally an indication of stationarity. Thus one does not fail to reject the null hypothesis of non-stationary in this instance.

**Augmented Dickey-Fuller Test (ADF)**

This test suggests that the tau τ statistic must take larger negative values than usual in order for the null hypothesis ($\delta = 0$, a unit root or non-stationary process) to be rejected in favour of the alternative that is $\delta < 0$, which indicates a stationary process. To preclude the possibility that the error term in one of the above equations (under DF), are autocorrelated, some additional terms are included. These additional terms are usually the lagged values of the dependent variables (Hill *et al*., 2001: 344). An important assumption of the DF test, according to Gujarati (2003: 818), is that the error terms are independently and identically distributed, while the ADF test adjusts the DF test to take care of possible serial correlation in the error terms by adding the lagged and differenced terms of the regressand.

If the error term is found to be autocorrelated under the Dickey-Fuller test, the Augmented Dickey-Fuller test (ADF), which is a test that includes additional lagged terms, is used. In this case, the ADF equation is:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \alpha_i \sum_{i=1} \Delta y_{t-1} + \varepsilon_t . \quad [3.12]$$

Where $\Delta y_t = (y_{t-1} - y_{t-2})$, $\Delta y_t = (y_{t-2} - y_{t-3})$ and so on and ε is the white noise term, while m stands for the lag length (we use four lags).

The ADF test is comparable to the simple DF test, but the slight difference is that the first involves adding an unknown number of lagged first differences of the dependent variable to capture autocorrelation in omitted variables that would otherwise enter the error term. However, as emphasized by Harris (1995: 34), it is also very important to select the appropriate lag length; too few lags may result in over-rejecting the null hypothesis when it is “true” while too many lags may reduce the power of the test. However, one may not proceed to cointegration testing without looking at the limitations of the unit root test.

**Limitations of the Unit Root Test**

The unit root is influenced by the size and power of the test. The size of the test is given by the level of significance, while the power test is the probability of rejecting the null hypothesis when it is false. A Type II error is when the null hypothesis is false and we decide not to reject it. The Type I error is when the null hypothesis is true and we decide to reject it (Hill, *et al*., 2001). In taking the decision which model is true between 3.9; 3.10 and 3.11 at a given level of significance, say 5 *per cent*, the conclusion could be wrong because the chosen level of significance might be inappropriate.

The power of the Dickey-Fuller unit root test tends to be low and, as a result, the test tends to fail to reject the null hypothesis of a unit root as many times as it should. Gujarati (2003: 819) states that the test may find a unit root, even when none exists, for the following reasons:

1. The power depends on the time span of the data more than mere sample size;
2. If $\rho \approx 1$ but not exactly 1, the unit root test may declare such a time series non-stationary;
3. These types of test assume a single unit root;
4. If there are structural breaks in a time series, the unit root tests may not detect them.

To overcome the spurious regression problem that may arise from relating a non-stationary time series on one or more non-stationary series, some suggest transforming these time series so as to be stationary. This is not always a good idea, as critical information is lost.

We believe that 69 is a good sample size, with a high probability of obtaining accurate results. This concurs with Keller and Warrack (2003) and Mann (2004), who confirm that the results from a sample size equal to or greater than, 30 make more sense than the ones from a small sample size (< 30).

## 3.6 TESTING FOR COINTEGRATION

The theory of cointegration was developed in the 1980s and 90s by several researchers such as Engle and Granger (1987), Johansen (1988) and Engle and Yoo (1987) and others. Similarly, Robinson and Marinucci (2003: 334) reconfirm that cointegration analysis has been developed as a major theme of time series econometrics and generated much applied interest, prompting considerable methodological and theoretical developments during the 1990s. Therefore the cointegration method has become a useful econometric tool (Johansen and Juselius, 1990: 192).

According to Harris (1995: 22), "if a series must be differenced *d* times before it becomes stationary, then it contains *d* unit roots and is said to be integrated of order *d*, denoted *I(d)*." But the question to be asked is why are observed time series integrated? Granger and Newbold (1974: 115) reply: "...variables are integrated either because they are driven by other integrated variables, or because the dynamic processes generating them contain autoregressive roots of unity; in other words, unit roots may be found in either the marginal or conditional subsystems, or, of course, both." In the case where residuals are expressed, as a linear combination of the variables which are all I(1), this linear combination will itself be I(1), but it would be desirable to obtain residuals that are I(0). This can only be achieved if the variables are cointegrated (Brook, 2002).

Before attempting any form of cointegration test, it may be that the real RM2 and its explanatory variables are cointegrated, as demonstrated, by the Engle and Granger (1987: 251) study. In the present thesis, the analysis is conducted by using South African data so as to determine cointegration using the Engle and Granger method.

### *3.6.1 Engle-Granger and Augmented Engle-Granger Test*

The Engle-Granger test is one of the methods that are used when the data available are thought to be non-stationary and possibly cointegrated. As a rule, non-stationary time series should not be used in regression models, to avoid the problem of spurious regression (Hill *et al.*, 2001: 346). If time series data are I(1) or non-stationary, then we estimate the cointegrating regression using ordinary least squares. However, it is not possible to perform any inferences on the coefficient estimates from the usual regression. One can only estimate the parameter values after making sure that the residuals of the cointegrating regression are I(0), and if so then one can proceed to the next step, which is the error correction mechanism (ECM). If the residuals are I(1), one cannot use the estimated standard errors and the associated *t* values of the estimated coefficients (Gujarati, 1995: 727), but a model containing only first differences should be estimated (Brooks, 2002). The different orders of integration imply a hidden assumption of the error term being non-stationary.

An important point with this testing method is that if two individual I(1) variables are co-integrated, when a linear combination of both variables is I(0), then their entry into the estimating equation will not create spurious results (Kennedy, 1998: 228). To avoid the problem of a meaningless regression, the Engle-Granger test is used. From this model the residuals are estimated and a unit root test is utilized to find out whether variables co-integrate. This determines whether or not there is a long-run relationship between them. If this test does not give a satisfactory result, the Augmented Engle-Granger (AEG) test is used. However, the difference between Engle-Granger and AEG is to run a cointegration regression, by estimating the Augmented Dickey-Fuller regression, but with the AEG we use the lagged values of the residuals (Gujarati, 1995).

The lesson to be retained from using the Engle-Granger test is that one must be aware of the fact that it does not prove that there is really a long-run relationship. According to Charemza and Deadman (1993: 157), a strong belief in a long-run equilibrium relationship between the variables must be supported by relevant economic theory. We base the theoretical justification for the model this thesis uses on Section 2.5 in in Chapter Two.

*3.6.2 Cointegration Regression Durbin-Watson (CRDW)*

An alternative, easy and a quicker method of finding out whether dependent and independent variables are cointegrated is the Durbin-Watson test, whose critical values are first introduced by Sagan and Bhargava (1983). Charemza and Deadman (1993: 153) point out that the distribution of the cointegration regression Durbin-Watson test is not fully investigated and its critical values are not known. Based on 10 000 simulations formed from 100 observations each, Gujarati (1995: 728) notes that the 1, 5 and 10 *per cent* critical values of *d* (not DW) to test the null hypothesis that d = 0 are 0.511, 0.386 and 0.322, respectively. Therefore the alternative hypothesis of cointegration will be rejected if the computed *d* value is smaller than, say, 0.386 at the 5 *per cent* level and if it is greater than the critical value, the null hypothesis is accepted, which means that the variables are cointegrated.

It should be remembered that the power of a cointegration regression test depends positively on the goodness of fit of the ordinary least squares estimate of the long-run relationship of the specified model. From this, Banerjee *et al.* (1986) propose a simple 'rule of thumb' for a quicker evaluation of the cointegration hypothesis: that if computed *d* value for the residuals is smaller than the coefficient of determination ($R^2$) the apparent significance of a statistic relationship is likely to be false. This is an indication that the model has a problem of autocorrelation. If the Durbin-Watson value is above $R^2$, there is a higher probability that cointegration needs investigation.

## 3.7 ERROR CORRECTION OR EQUILIBRIUM CORRECTION MECHANISM (ECM)

The error correction model was initially used by Sargan (1984), Hendry and Anderson (1977) and Davidson *et al*. (1978) to make adjustments in a dependent variable which depends not on the level of some explanatory variable, but to the extent to which an explanatory variable deviates from an equilibrium relationship with the dependent variable. In other words, if there is cointegration between variables and there is a possibility that in the short-run there may be disequilibrium one uses this model. Therefore, to correct this disequilibrium, an error correction mechanism hopefully pushes the model back towards the long-run equilibrium (Engle and Granger, 1987: 251). The error correction model thus plays an important role, in that it is a force that pulls the error back toward zero as should be the case when moving back towards equilibrium.

The error correction model is simply a linear transformation of the autoregressive-distributed lag model. One may ask what its distinguishing feature is. The difference in the error correction modelling is that parameters describe the extent of short-run adjustment to equilibrium are immediately provided by the regression (Benerjee *et al.,* 1993: 51). Therefore, in practice, the error correction term, which is nothing more than the lagged residuals from the levels regression, $\hat{U}$ and is preferable to other regression methods. The error correction model can be estimated for more than two variables. The following is the ECM equation for this study:

$$\Delta M2_t = \chi_1 + \chi_2 \Delta \ln Y_t + \chi_3 \Delta \ _t + \chi_4 \Delta \ln \pi + \chi_5 \Delta \ln E \ _t + \chi_6 \hat{J}_{t-1} + \varepsilon \qquad , [3.13]$$

where ε is an error term. The coefficient $\alpha_6$ is expected to be negative, which means that $\Delta RM2_t$ is reduced after a shock (Gujarati 2003: 825).

Furthermore, the error correction model describes how the change in RM2 in period t responds to a change in Y, R, $\pi$ and ER in period t, plus a correction for discrepancy between RM2 and its equilibrium value in period t-1. During periods of disequilibrium, $\hat{U}_{t-}$ is non-zero and measures the distance real money demand is away from equilibrium during time t. Thus an estimate of $\alpha$ will provide information on the speed of adjustment back to equilibrium (Harris, 1995: 24). Its strict definition is that "it measures the proportion of last period's equilibrium error that is corrected for" (Brooks, 2002: 391). A large $\alpha$ close to negative one, implies a quick adjustment, while a small value close to zero suggests, that an adjustment to the long-run steady-state is slow. This makes the equilibrium correction model formulation attractive, because it immediately provides the parameter describing the rate of adjustment from disequilibrium in the short-run (Ericsson and Sharma, 1996: 26). The conclusion is made from the sign and value of $\alpha_6$.

## 3.8 CONCLUSION

Besides providing the model specification and data collection method, this chapter discusses problems encountered in time series data and how to overcome them. It shows that regression with non-stationary series is generally biased and inconsistent. In other words, regressing one non-stationary series on one another is likely to yield spurious results. However, a cointegration analysis allows us to conduct an econometric analysis using non-stationary variables. According to Harris (1995: 25), "failure to establish cointegration often leads to spurious regressions which do not reflect long-run economic relationships but, rather, reflect the 'common trends' contained in most non-stationary time series."

This chapter presents the steps which should be followed: checking for stationarity, testing for unit roots when testing for the order of integration of the residuals from the cointegration regression, using the Dickey-Fuller (DF) test and the augmented Dickey-Fuller (ADF) test. In terms of cointegration testing, this chapter focuses on Engle-Granger and Augmented Engle-Granger tests for the long-run relationship between real money demand and its explanatory variables. For the short-run relationship, the error correction mechanism is used. Therefore there is a useful and meaningful link between the long- and short-run approaches to econometric modelling. The next chapter, Chapter Four deals with the empirical analysis for South Africa.

# CHAPTER FOUR

# THE EMPRICAL ANALYSIS OF MONEY DEMAND IN SOUTH AFRICA

## 4.1 INTRODUCTION

Much theoretical and empirical research on the demand for money has been carried out in South Africa over the past four decades. These studies evaluate money demand using different approaches. This chapter looks at four different studies. The first approach deals with money demand in South Africa using the Cointegration and Error Correction Models. The second is the partial stock adjustment model, which is extremely popular method from the 1970s (Sriram, 2001). Generally, though, as shown by many studies, for example Cooley and LeRoy (1981), Goodfriend (1985), Hendry (1985), Hendry and Mizon (1978) and many others, this method of partial stock adjustment suffers from specification problems and highly restrictive dynamics. The third is the linear function approach. The fourth approach is the buffer-stock model, which is based on the theory of the precautionary demand for money, as described in Cuthbertson and Taylor (1987) and Milbourne (1988). We also focus on models of the error correction type, as they have become increasingly popular in the literature.

According to Shin (1994), "it is thought to be important, for both economic and statistical reasons, to be able to determine whether there is a stable long-run relationship between multiple economic series, even though each series is considered to be I(1) process." The concept of stable, long-run equilibrium is demonstrated by Granger (1986) as "the statistical equivalence of cointegration." Therefore, when cointegration holds, and if there is any shock that causes disequilibrium, there exists a short-term dynamic adjustment process such as the Error Correction Mechanism that pushes the system back towards the long-run equilibrium (Sriram, 2001). The existence of a dynamic error-correction form relating to the variables in question is implied by cointegration (Engle and Granger, 1987). This thesis focuses on these newer models and this chapter presents empirical evidence on the subject of the demand for money using South African data. We conclude that as regards stability the tests present a "mixed-bag" of results and we try to correct for this in our testing which is presented in Chapter Five.

## 4.2 COINTEGRATION AND ERROR CORRECTION MODELLING

Hurn and Muscatelli (1992) agree that some studies such as Courakis' (1984), who uses the autoregressive distributed lag approach, on the one hand, and Whittaker (1985) and Tavlas (1989), who used buffer stock approach, on the other hand, to estimate the money demand function in South Africa, discover that the function is stable over time (see section 4.3, 4.4 and 4.5). Hurn and Muscatelli point out that these studies do not manage to estimate the long-run relationship between money demand and its determinants. With the data period from 1965(I) to 1990(IV), they use the cointegration approach to examine this relationship and the nature of the long-run elasticities of the model.

Hurn and Muscatelli (1992: 158) give two main aims of their study, which are: "first, to outline how recent developments in the theory of cointegration enable the estimation of the long-run responses of a linear model within a maximum likelihood framework. Second, to investigate some of the long-run properties of the demand for the broad South African monetary aggregate M3." The choice of broad M3 is made because it is considered the highest broad money balance in South African monetary policy targets. Therefore, it is chosen to be the dependent variable. The explanatory variables chosen to regress with M3 are real income, which is measured as GDP at constant prices, the interest rate being the average of the commercial bank retail deposit rate (DR) and the interest rate on three year government stock (R). Before proceeding to the estimation of the long-run demand function for M3, Hurn and Muscatelli check if all time series are the same order of cointegration, as required by cointegration methodology theory. Hence, the following equation is estimated:

$$M3_t = \beta_0 + \beta_1 (Y - P)_t + \beta_2 P_t + \beta_3 DR_t - \beta_4 R_t + u_t \qquad [4.1]$$

Where (*Y-P*) is real income, *P* stands for prices, DR is the own interest rate and R is the alternative interest rate. All determinants are found positively related to real M3 except the alternative interest rate, which is negatively related. Those results meet the expectations of economic theory; therefore they suggest that there is a long-run relationship between M3 and its determinants.  In Chapter Five we find a relationship between M2 and its determinants.

Then Hurn and Muscatelli test for unit price and income elasticities of demand. In terms of income, unitary elasticity is rejected: it could not be imposed on the long-run demand function. Further study of South African literature, using GDP as the scale variable is suggested, which others have done and we attempt to replicate this in Chapter Five. The wealth variable would be a better choice in this case but this data is difficult to measure. Unity price elasticity is also rejected. The last step is to test the null hypothesis of equality of the two interest rate elasticities. The outcome shows that they have equal magnitude but opposite signs and the hypothesis is accepted, indicating that it would be appropriate to use interest rate differentials rather than the levels. The interest elasticities are statistically significant and an important point to be noted, because in previous studies interest rates are found to be insignificant.

Hurn and Muscatelli conclude that the long-run relationship between real M3, income, prices and interest rates in South Africa, using the cointegration analysis the function, appears to be well behaved. The coefficients are found to be statistically significant with the correct signs. Hence, a long-run relationship between real M3 and its explanatory variables does exist, according to them.

Moll (2000) analyses the demand for money using a cointegration approach, with real variables rather than nominal money and income. The following equation is estimated:

$$(m - p) = \beta_0 + \beta_1(y - p) + \beta_2 r_{M3} + \beta_3 r_{10} + \beta_4 \Delta p + \varepsilon \qquad [4.2]$$

Where *m* is M3, p is the price level, y is GDP, $r_{M3}$ and $r_{10}$ are interest rates and $\Delta p$ is the inflation rate. The β's are the coefficients and ε the error term. According to the quantity theory of money by Friedman (1956) (see also Section 4.3), the coefficient of income is expected to be equal to one or it is expected to be 0.5 with the transaction's demand theory of money (Baumol, 1952). The expectations of other coefficients are that $\beta_2 > 0$ and $\beta_3$, $\beta_4 < 0$.

In terms of real income, the results show that the elasticity is close to unity (their estimate is 1.11), which is a standard finding and similar to the one of Tavlas (1989) and others. Both interest semi-elasticities have the expected signs, while the inflation rate tends to reduce real money demand. The interest rate variables are not directly comparable with those estimated by Tavlas, because Moll's interest rate variables are in logarithmic terms, similar to ours.

Then Moll compares many different types of cointegrating vectors such as using the Johansen-Juselius trace, a Hendry/PcGive unit root and the popular two-step approach of Engle and Granger. The results show that all these tests give the same signs. The coefficients on lagged real income are very close with these methods. Hence these approaches corroborate each other. Moll realizes that the Engle-Granger test is not valid in the study and this led to the three unit root test's failure to reject the null hypothesis of non-cointegration.

Moll concludes that the money demand function of the period of study has stable parameters and could be predicted better using this model rather than other alternatives. Moll discovers that real M3 surges in the period 1993-1998, growing by a 39 *per cent,* when real income grew by 11 *per cent*. Therefore there is no structural change and this could be explained by the decline of inflation.

Nell (2003) analyses the stability of M3 money demand and monetary growth targets in South Africa, using the cointegration approach. The long-run money demand model is:

$$m3_t = \beta_0 + \beta_1 y_t + \beta_2 p_t^c + \beta_3 (RM - RO)_t + u_t \quad [4.3]$$

Where m3 stands for the demand for nominal M3 money balances, y is real income (GDP), $p^c$ is the price level (CPI), RM represents the ten-year government bond yield and RO the long-term own interest rate represented by the fixed deposit rate of twelve months. The above equation [4.3] looks like our model, except that we include the exchange rate as one of the explanatory variables.

The results of the Augmented Dickey-Fuller (ADP) unit root tests for Nell indicate that the interest rate differential (RM-RO) is I(0) and will therefore cointegrate with a unit coefficient, while all other variables (income, price level) appear to be I(1). Based on Engle-Granger's procedure, Nell estimated the long-run relationship, which is found to be I (1), with the following equation:

$$m3_t = \beta_0 + \beta_1 y_t + \beta_2 p_t^c + u_t \quad [4.4]$$

The results indicate that m3, y and $p^c$ are cointegrated at the five per cent significance level. Therefore, there is a long-run relationship between m3, income and the price level. If real money is I(1) and inflation rate I(0), the long-run relationship between real money and inflation may be spurious (Nell, 2003). The cointegration approach appears to be useful as a first indicator, because it helps to avoid some complicated problems which may occur with other methods when analyzing the demand for money. Some studies such as Inder (1993) show that the omission of dynamics may be adjusted for using error correction modeling.

Kennedy (1998) and Charemza and Deadman (1993) give a format of the error correction model estimation, which is as follows:

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_t + \beta_2 \Delta x_{t-1} + \beta_3 (y_{t-1} - x_{t-1}) + \varepsilon_t . \qquad [4.5]$$

Nell (2003) applies this format of the error correction model with the consideration of the lags of the dependent variable (Δm3):

$$\Delta m3 = -0.065 - 0.34\Delta m3_{t-1} + 0.27\Delta y + 0.76\Delta p - 0.006\Delta(RM - RO) - 0.01\Delta(RM - RO)_{t-1} + 0.06D_{70S} - 0.59ecm_{t-1} \qquad [4.6]$$

The Error Correction coefficient of -0.59 gives approximately one year for the money market in South Africa to readjust to back to the equilibrium. These results are in the line with our results of four quarters (see Section 5.5).

Likewise, with South African data, Naudè (1992) estimates an Error Correction Model to estimate the long-run equilibrium relationship between dependent and independent variables for desired money holdings with the following equation:

$$m^* = \alpha + \beta_0 p + \beta_1 y + \beta_2 r + \beta_3 \Delta p , \qquad [4.7]$$

where $m^*$ is the desired level of money holdings, p stands for price level (CPI), y is real disposable income, r for the three month Treasury Bill rate and Δp is the inflation rate, as measured by the growth rate in the consumer price index. All variables are in logarithmic terms. Three out of four of the determinants of our money demand model specification are similar to the ones of Naudè (see Section 3.3).

After manipulating the partial adjustment model and going through the analysis of a loss function serving as a rationale for estimating money demand within the Partial Adjustment model, Naudè obtains the following Error Correction Model:

$$\Delta m^{*} = \delta_{} + \phi_{} + \phi_{})\Delta p_t + \phi_{} + \phi_{})\Delta y_t + \phi_{} + \phi_{})\Delta r_t + \phi_{} + \phi_{})\Delta\, p_t + \phi_{} - )[m_{t-} - p_{t-} - y_{t-}]$$
$$+ \phi_{} r_{t-} + \phi_{}\Delta p_{t-}\,, \qquad [4.8]$$

where $(\phi_{} - )[m_{t-} - p_{t-} - y_{t-}]$ is the error correction term which indicates that the proportion of the disequilibrium between nominal income and money that is corrected from the one period to the next (Boswijk 1990: 101). Equation 4.8 justifies our Error Correction Model specification in Chapter Five.

Naudè's results show two important features when compared to previous studies. First, the short-run income elasticity is high and second, the short-run elasticity of inflation is large. These two features of the Error Correction Model in South Africa may be caused by the instability of the money demand function, as well as political and social instability during the period. Naudè compares the results obtained from the ECM and those found when using the partial adjustment model by Contogiannis and Shahi (1982) and Courakis (1984). With the ECM, the problem of serial correlation is solved, while it is rejected by partial adjustment methods. In addition, with the ECM the hypothesis of unitary long-run income and price elasticities are not rejected.

Similarly, Tlelima and Turner (2004: 25-36) estimate the demand for money in the South African economy over the period 1971: I to 2002: III using the Error Correction Model. GDP and consumption are used as the alternative scale variables. The following equations represent the money demand function with GDP and consumptions scale variables respectively:

$$\Delta \; _t = \;_1\Delta \; + \;_2(i_{t-1} - \;_{t-4}) + \;_3(\pi_{t-1} - \tau_{t-4}) - \;_4\Delta \; - \;_5(m_{t-1} - \;_{t-1} + \;_{t-1} + \tau_{t-1}) + \; ;$$

[4.9]

$$\Delta \; _t = \;_1(i_{t-1} - \;_{t-4}) + \;_2 \; (\pi_{t-1} - \tau_{t-4}) - \;_3\Delta \; - \;_4(m_{t-1} - \;_{t-1} + \;_{t-1} + \tau_{t-1}) + \; .$$

[4.10]

The coefficients of determination of both equations are very close: 0.31 for 4.9 and 0.29 for equation 4.10. Standard errors of these equations are the same (0.02) and Durbin- Watson values are also close: 2.04 and 2.06. Even though the results show that there is no indication of significant misspecification, equation 4.9 appears to be better due to its economic interpretation.

A direct estimation of equation 4.5 probably would not be the best way forward because of the fact that in 4.5 the variables have, by assumption, different orders of integration. Both $\Delta y_t$ and $\Delta x_t$ may be I(0), while $x_{t-1}$ and $y_{t-1}$ are I(1) (Charemza and Deadman, 1993). Our results from the cointegration test (see Section 5.4) show that three out of five of our variables are I(0). Therefore in this thesis we follow Kennedy (1998), Wooldridge (2000) and Gujarati (2003) to estimate the Error Correction Model, where the partial adjustment part is not included, but only the change of explanatory variables and the residual ($\hat{U}$) from the levels regression (see Sections 3.7 and 5.5). Our Error Correction regression differs from those with higher-order integration, for example I(2) or I(3).

## 4.3 THE PARTIAL STOCK ADJUSTMENT MODEL

According to Handa (2005: 161), lags often occur in the adjustment of a variable to its desired long-run value and one reason for such a lag can be the short-run cost of making changes to any variable. The following model of Maxwell's uses similar variables to other studies here and estimates,

$$\ln M_t = \chi + \chi \ln M_{t-} + \chi \ln r + \chi \ln A_t , \qquad [4.11]$$

and $M_t$ represents the observed real money stock at time *t, r* is the interest rate and A the appropriate wealth constraint. The results from this regression substantially improve earlier work. The *t*-ratios show that the coefficients are statistically significant. Durbin-Watson (DW) tests show that there is no autocorrelation and also shows that there is no misspecification at the 1 *per cent* significance level, unlike previous studies. Chow tests indicate the demand function is not stable. When running the regression in separate sub-periods the function performs differently (Maxwell, 1971: 18), but not convincingly enough to conclude that function 4.11 is stable.

Maxwell's work is surprisingly modern and uses the partial adjustment model (pre- and post-war periods) and he indicates the results are different. For the pre-war period, the results are good for narrow (M1) and broad (M2) money because the standard error of estimation was small; and even though the DW is high, the coefficients of the variables are significant and meet the conditions of money demand theory with expected signs. For the post-war period, the results show signs of autocorrelation and the M1 coefficients had unexpected signs and are insignificant. Due to these differences Maxwell concludes that the money demand function is not stable in the long-run.

Stadler (1981) also uses the Partial Adjustment Model and considers $M^*$ as money balances individuals would like to hold and its demand or quantity will change over time as income, interest rates and other determinants change. However, he finds it also reasonable to assume that the quantity of money demanded is not instantaneously adjusted in response to the said determinants. The difference between desired and actual money balance brings into existence a fraction (*g*) of desired change for a given time period. The following is the Partial Adjustment Model used by Stadler:

$$M_t - M_{t-} = g(M_t^* - M_{t-}) \text{.} \quad [4.12]$$

where 0<g<1. Thus $M$ is moved to its desired level when compared to the immediate past but only a fraction of this adjustment is achieved. If desired balances $M^*$ are determined by a decrease of expected income ($\gamma$) and price (p) we have:

$$M_t^* = b_0 + b_1\gamma_t + b_2 p_t + u_t \qquad [4.13]$$

Combining the adjustment with the determinants in (4.13) we obtain:

$$M_t = gb_0 + gb_1\gamma + gb_2 p_t + (1-g)M_{t-1} + g\mu_t \qquad [4.14]$$

The results Stadler obtains indicate that, in one quarter, the coefficient of adjustment gives forty-five and thirty percent as the adjustment for $M_1$ and $M_2$, respectively. Stadler considers expected income is directly observable and proposes the following hypothesis for income expectations:

$$\gamma^e_t - \gamma^e_{t-1} = k(\gamma_t - \gamma^e_{t-1}) \qquad [4.15]$$

where 0<k<1 and $\gamma^e$ represents expected income. With this adjustment, there is high multicollinearity between the variables.

As does Stadler, Contogiannis and Shahi (1982: 26-34) also include price levels in the estimated model instead of an interest rate. As an extension of Stadler's work, the examination of the demand for money uses firstly, price expectations alone, and secondly, price expectations and a partial demand adjustment factor and lastly both together. Adaptive expectations' mechanisms are constructed for other explanatory variables, such as income. The data covers the period 1965-1980. With an adaptive expectations process, the following equation is the adjustment capturing price expectations:

$$P_t^* - P_{t-1}^* = \delta(P_t - P_{t-1}^*), \qquad [4.16]$$

where δ is the coefficient of price expectations, standing for the fraction of the difference between actual and the previous (lag) price and $0 \leq \delta \leq 1$. It is assumed that individuals adjust their actual money balances to desired levels by a fixed proportion γ, which is the coefficient of adjustment. The following is for the price expectations plus a partial adjustment model:

$$M_t - M_{t-1} = \gamma(M_t^* - M_{t-1}), \quad [4.17]$$

where $0 \leq \gamma \leq 1$ and actual money balances adjust to desired levels. Using the function:

$$M_t^* = a + b y_t + c P_t^* + u_t \quad , \quad [4.18]$$

with $y_t$ being real income, Contogiannis and Shahi develop their 'Model B':

$$M_t = a\gamma\delta + b\gamma y_t - b\gamma(1-\delta) y_{t-1} + c\gamma\delta P_t + (2-\gamma-\delta)M_{t-1} - (1-\gamma)(1-\delta)M_{t-2} + u_t, \quad [4.19]$$

and this is estimated using a non-linear estimation method. This method is also used when combining adaptive expectations and Partial Adjustment Methods.

As we include inflation in this study's specified model (see Chapter Three), Contogiannis and Shahi (1982: 29) give reasons for supporting the inclusion of the price level in the money demand function by stating that: "… in line with evidence found in other countries, people seem to treat money in the same way as luxury goods: as something of which they like to hold proportionately more when their real incomes are higher. The results also indicate that the expected change in price is a significant variable in the demand for money function." The expected price level is highly significant, with an elasticity of negative 0.5. Real income has the expected sign, with elasticity greater than one. According to other studies on South Africa (Heller, Maxwell; Stadler; Contogiannis and Shahi) one may conclude that, contrary to parts of traditional theory, money demand is determined by income and the price level, rather, as the interest rate effect is weak.

In his work, Courakis (1984: 1-41) acknowledges the importance of expectations in determining the demand for money and the possibility of how the desired money stock adjusts to changes in the actual money stock with a time lag, as shown by Stadler (1981) and Contogiannis and Shahi (1982). Courakis (1984) points out after deriving all relationship *ab initio* that there are conceptual problems with the theoretical equations of Stadler and Contogiannis and Shahi.

Courakis avoids these problems over the period of 1960-1980, using the following logarithmic money demand function found in the famous paper of Friedman (1959: 111-139):

$$M_t = \chi_{\_} + \chi_{\_} \bar{Y}_t + \chi_{\_} \bar{P}_t, \qquad [4.20]$$

where $M_t$ is nominal money balances, $\bar{Y}$ is permanent real income and $\bar{P}$ the permanent price level. Equation 4.20 is used to obtain:

$$M_t = \lambda\delta\alpha_{\_} + \lambda\delta\alpha_{\_} Y_t - \lambda\ 1-\delta\ \alpha_{\_} Y_{t-} + \delta\alpha_{\_} P_t - \lambda\ 1-\delta\ \alpha_{\_} P_{t-} + \ 2-\lambda - \delta\ M_{t-} - \ 1-\lambda\ (1-\delta\ M_{t-} \qquad [4.21]$$

.

Similar to our model (see Chapter Five, Section 5.2) the variables in 4.21 are in logarithmic terms. This is the equation Courakis considers most useful for his study. Using the Chi-squared test, he finds that the hypothesis of unitary income expectations and equal expectation coefficients for real income and the price level are statistically insignificant. The estimation of equation 4.21 shows a significant improvement, but it is not sufficient as it does not include an interest rate variable. This is the reason why Courakis decides to adjust 4.21; seeking a more general specification of the money demand function to include interest rates and expected inflation as additional determinants to obtain the following log-linear function as is done here in Chapter Five:

$$M_t = \alpha_{\_} + \alpha_{\_} \bar{Y}_t + \alpha_{\_} \bar{P}_t + \alpha_{\_} \bar{R}_t + \alpha_{\_} \bar{X}_t \quad . \qquad [4.22]$$

Where $\bar{X}_t = \bar{P}_t - \bar{P}_{t-1}$ and $\bar{R}$ is the permanent or expected interest rate, such that $\bar{R}_t = \mu R_t + (1-\mu) R^*_{t-1}$ .

Courakis's study gives unexpected the elasticities of demand with respect to the permanent price level. With respect to permanent income, elasticities of demand of M1 and M2 were more than one and this indicates misspecification. Therefore there is no homogeneity between income and price. This leads to a rejection of Friedman's (1957) theory, as he finds that the income elasticity is more than one. Courakis disagrees with the use of a price level by Contogiannis and Shahi (1982). Courakis (1985: 12) feels that "*the expected price level cannot by itself serve as a proxy for the expected rate of change in the price level.*" The inclusion of both the interest rate and the expected inflation rate in the money demand function gives new results. The interest rate does not add the analysis, but the price expectations variable is found to be statistically significant. These results are similar to ours (see Section 5.4).
Courakis proceeds to the adjustment mechanism of actual to desired money balances, using the following equation:

$$M_t = \gamma M_t^* + (1-\gamma) m_{t-1} + \phi [(M_t^* - M_{t-1}) - (M_{t-1}^* - M_{t-1})], \qquad [4.23]$$

where $M^*$ is the desired stock of money balances. This adjustment is nominal rather than real. When we estimate our model (in Chapter Five) we differ for Courakis, because our model's variables are in real terms.

Although the expected rate of inflation remains an important determinant of money demand with the expected sign (negative), Courakis (1984: 17) did not find any role attached to opportunity cost in terms of financial assets and this may lead to a misspecification in the model. It is confirmed that "irrespective of the nature of the expectation formation processes for $\bar{Y}$ , $\bar{P}$ and $\bar{R}$ and of serial correlation pattern, *the hypothesis that the demand for narrow money does not depend on opportunity costs in* *terms of financial assets does not, for any of the 27 variants of the envelope relationship, carry a probability of acceptance of even 1, 0 per cent* (Courakis, 1984: 31)."

Courakis does not consider the characteristics of the error terms. The estimation is based on an assumption of the white noise disturbance term being attached to the reduced form he derives. Courakis (1984:18) realizes that with the consideration of white noise disturbance terms, "the possibility that the true structural model implies a reduced form that exhibits autocorrelated disturbances cannot be precluded." The results show the interest rate to be statistically significant. Furthermore, it remains statistically significant even when lagged values of the dependent variable are of a higher order than two. For income, the elasticity of demand for narrow money is found to be less than, or equal to unity, which is different from what is predicted by theory (Friedman, 1956: 58). For the price level, the elasticity is also less than one. Moreover, as theory suggests, opportunity costs, in terms of a return on alternative financial assets, are the least significant determinant of the demand for narrow money. In the conclusion of his study, Courakis (1984: 37) confirms that "the overall best equations traces the movement of M1 very closely, and exhibit no structural breaks, notwithstanding the direct intervention policies of the authorities and the fluctuations in economic activity that characterize experience over the period under review." The long-run demand for money in South Africa is stable over the period 1965 to 1980 according to the above research.

In his comments about the demand for money in South Africa, Whittaker (1985: 184-196) considers many short-comings of the previous work of Stadler, Contogiannis and Shahi and Courakis. He argues that Courakis' study does not present a clear picture, or define the parameters of the South African money demand function. He notes that Courakis does not manage to convincingly verify or reject any of the theoretical relationships connected with the money demand function.

Whittaker is specific when he criticizes the usage of the Chi-squared test by Courakis and suggests that using the F test may lead to lower levels of confidence in the rejection of constrained forms of the estimated equations. For example, the critical value of the F-distribution shows that the hypothesis could not be rejected at 1 *per cent* significance level, but with the Chi-Squared test ($\chi^2$) it could be.

Whittaker proceeds by accepting that the Koyck terms are statistically insignificant and then introduces the following equation to test the model with different data series and time periods:

$$M_t = \imath_0 + \sum_{\omega=0}^{6} {}_{\omega}V_{T-} + \sum_{v=0}^{6} {}_{v}P_{t-} + \sum_{\sigma=0}^{6} {}_{\sigma}R_{t-} + \sum_{j=1}^{7} {}_{j}M_{t-} + \imath , \qquad [4.24]$$

where the variables are defined in the usual way.

Another reason for re-estimating the equation is to test the robustness of Courakis' money demand equation under different circumstances. The results show the parameter values are different for each data set and change markedly. Their standard deviations are large, unlike Courakis' results, and they appear to be unstable. By using the Chow test for stability, Whittaker discovers the estimated parameters are not appropriate for the entire set of observations. The hypothesis of parameter constancy is therefore rejected.

Whittaker believes that Gross Domestic Product is probably not too different from Gross Domestic Expenditure (GDE) and it is more appropriate when examining the demand for narrow money. GDP is measured in ways that makes it prone to error. Instead of measuring the opportunity cost of holding money, using the Treasury-Bill (TB) rate, Whittaker offers that the rate for three-month Bankers' Acceptances (BA) is better, because "most of the existing stock of TB's has been in the hands of the Reserve Bank or National Finance Corporation as a result of rediscounts and the participation by these institutions in the tender system" (Whittaker, 1985: 190-191). The BA rate is an appropriate measure of the market cost of short-term credit. However, when the BA rate is used instead of the TB rate, the results show that the coefficient is positive and close to unity while it is expected to be negative. It is also statistically insignificant. Whittaker realizes there is little point in discussing other parameter values, because they display large variances and instability. Based on the sensitivity of the estimated parameters to the model structure, Whittaker is of the opinion the time period of study, the data series and the results show the demand for narrow money, even over that period covered by Courakis, is unstable.

## 4.4 THE LINEAR FUNCTION APPROACH

Apart from the velocity of circulation, studied by Lachmann (1956) and De Kock (1956), the study of the demand for money in South Africa begins with Heller (1966). In his estimation of money demand, he considered money as coins, notes and most deposits. This combination is the dependent variable, while the explanatory variables are current income represented by GNP, an interest rate (which is measured by a fixed 12-month rate paid by commercial banks) and union Treasury-Bill rates. Another third determinant is the general price level explained by the wealth deflator. Heller considers wealth as one of the determinants of money demand. The following is the model in Heller's study:

$$M_t = \alpha_0 + \alpha_1 GNP_t - \alpha_2 W_t + \alpha_3 P_t - \alpha_4 R_t + \mu_t \qquad [4.25]$$

He adds $M$ as nominal money demand, GNP is current nominal income, W is wealth, and R is the interest rate variable (Treasury-Bill rate and 12-month fixed deposit rate). P is the price level and μ the error term. One may ask the following questions: How is wealth defined in this case? How does it differ from income and why are both included in one model? To partly answer these questions, Heller (1966: 336) estimates equation (4.25) three times, by excluding the wealth variable and GNP each time. From this, it is discovered that the $\alpha_1$ coefficient changes its value slightly while the (wealth) $\alpha_2$ coefficient is unstable. Therefore income is the relevant determinant of $M_t$ compared to wealth, in their opinion.

Heller (1966: 337) found that "the inclusion of the price level among the independent variables increases the explanatory power of the equation significantly." This is expected if a nominal measure of money is used. Among the two different interest rates used, the union Treasury-Bill rate is found to be insignificant and the interest rate on 12-month fixed deposits is the 'best' for the model. Thus, the model becomes:

$$M_t = \alpha_0 + \alpha_1 GNP_t + \alpha_3 P_t - \alpha_3 R_t + u_t \quad [4.26]$$

When examining the stability of the components of the demand for money model, given the definition of money in use, the signs of coefficients are not constant. For example, as the interest rate on fixed deposits increases, the quantity demanded of deposits decreases, while fixed and savings deposits increase in volume. Surprisingly, Heller (1966: 338) concludes that the components making up the total demand for money are stable.

To test the stability of the demand for money function over time, Heller divides the sample into three sub-periods, with different definitions of money in each period. The sub-periods are as follows: Period I: 1918 to 1932; Period II: 1933 to 1946, Period III: 1947 to 1955. It is found that only a money equation using a narrow definition of nominal balances is significant in the first period, regardless of the significant level. Heller concludes that the short run and long run stability may differ and states "the demand for money function was stable only in the long run." However, this conclusion is misleading because, using a *t*-test, out of 29 parameters less than half were significant. The simple regression model by Heller for the long-run shows the existence of instability in the parameters. For example, the money demand function over the period 1918 to 1955 is unstable, even though, according to Heller, this is the case for short-run only. Maxwell (1971) estimates a linear function using the same variables as Heller, in logarithmic form, for the period 1918 to 1960. Maxwell found that Heller did not estimate a stable long-run function for money because his model could not be fixed over both the pre- and post-war period.

Maxwell (1971) develops a regression model with narrow and broadly defined real money stocks as the dependent variable and three explanatory variables. The variables are, firstly, the interest rate (the rate of interest on 12-month fixed deposits) and GDP (current income). Secondly, the interest rate and permanent income and thirdly wealth and the interest rate for the whole period (1918-1960). "Over the whole period and both sub-periods it was revealed that an interest elastic Permanent Income Model gave the best results, followed by a current model and lastly the wealth model" (Maxwell, 1971: 21). Furthermore, the interest rate's coefficient is a negative one, as expected from theory.

Looking at Maxwell's other results, 16 out of 18 values of the coefficient of determination ($R^2$) are all greater than 0.7 and nearly equal to one which indicates a supposed good fit. However, there are many extremely low Durbin-Watson statistics and this indicates a possibility of misspecification in the analysis. In other words, the null hypothesis of no serial correlation (against the alternative) is rejected. However, Maxwell checks the possibility of misspecification by estimating the logarithm function of the demand for money by running two separate regressions (pre- and post-war periods) and the results are substantially different. Then he includes a price variable to see if it could improve the regression. The results are not significantly different from the previous ones, although the price variable is significant. From this, Maxwell did not consider the low value of the DW as being caused by misspecification, but rather, it is as a result of using the linear function.

The linear function approach is also used by Stadler (1981: 145-152) and in his paper all variables are in logarithmic form. When the log-linear model of the real money balances is analyzed, the determinants are real income and the interest rate. Also, both the broad and a narrow definition of money are used. For the interest rate, two types are used: a three months bankers' acceptance rate and the rate on company stock debentures. Stadler uses data for the period 1965: I to 1979: II. Stadler's estimated model shows that the coefficient of the interest rate is positive in all cases. He finds the incorrect sign, as theory suggests a negative relationship. Therefore, unlike Maxwell's result, where the interest rate is found to be inelastic and based on the t-ratio, the interest elasticity is not statistically significant in a number of cases. This may be caused by the difference in time periods under study or also the different sample sizes. Stadler confirms these results by running a regression of the narrow and broad money stock against a long-term interest rate. He shows a positive correlation between variables. This is in contrast to Contogiannis (1979), who discovers that the interest rate is significant when explaining movements in the velocity of narrow money. Although the coefficient of determination adjusted for degrees of freedom shows a good fit, like Maxwell's (1971) results, the Durbin-Watson statistics are very low, being close to zero, which leads to a rejection of the null hypothesis of no autocorrelation. Therefore there is an indication of a possible misspecification of the function. To elaborate on this, Stadler replaces the interest rate variable with the price level and the model specification becomes:

$$M_t = \beta_0 + \beta_1 Y_t + \beta_2 P_t + u_t \quad \text{[4.27]}$$

The results show a low price elasticity meaning that price is not supposed to be one of the money demand function's determinants. To explain these results, Heller (1966: 337) says that "this might be taken as an indicator of the presence of a certain type of money illusion on the part of the holders of money: as prices go up, they will not expand their money holdings because they believe that the nominal amount of money they do hold is able to perform its function, even with a higher price level. On the other hand, it might also reflect a conscious effort on behalf of the holders of money balances to economize on their use."

Theoretically, money demand depends on the level of income and the interest rate, but in all studies using the linear function approach with the South African data, there is a failure to show a stable estimated specification for the long-run demand for money. To correct these short-comings, Contogiannis and Shahi (1982: 26-34) suggest that a non-linear estimation technique should be used. They attempt this by using the partial lagged stock adjustment mechanism to model the long-run demand for money and we report these results in the previous section.

## 4.5 THE BUFFER STOCK OR DISEQUILIBRIUM MONEY MODEL

Milbourne (1987: 130) writes that "the buffer stock model has been a new growth industry in monetary economics, and its success has been acclaimed or simply taken for granted, with little testing or discussing that normally accompanies a new theory." In South Africa, the buffer stock hypothesis has been employed in a number of empirical studies to show evidence of significant buffer-stock effects. Tavlas (1989: 1-13) criticizes Whittaker regarding Courakis' study, that the usage of the buffer stock model is an appropriate one, in which money supply shocks are the appropriate determinants of real money balances. The disequilibrium money model is named from the assumption that the role of cash balances is to absorb unexpected inflows or outflows, acting as a buffer (Milbourne, 1987). It is believed that the buffer-stock model is supposed to be able to differentiate between shifts in money demand due to traditional factors, such as income and interest rates, and shifts due to expected changes in monetary policy.

Tavlas sets out the conventional specification of the demand for real money balances as follows:

$$m_t - p_t = \alpha_0 + \alpha_1 y_t + \alpha_2 r_t + \alpha_3 (m_{t-1} - p_{t-1}) + \mu_t \,, \qquad [4.28]$$

where $m_t$, $p_t$ and $y_t$ are the logarithm of a measure of the nominal money stock, price index and a scale variable such as income and wealth, respectively, while $r_t$ is the logarithm of an opportunity cost variable and $\mu_t$ is an error term. The lagged dependant variable of $(m_t - p_t)$ stands for adjustment costs. This model specification is used in previous studies and it is found that estimated coefficients using this form have been unstable. This is the reason why Tavlas proposes the following buffer stock model as an alternative to solve the problem:

$$m_t - p_t = \alpha_0 + \alpha_1 y_t + \alpha_2 r_t + \alpha_3 (m_{t-1} - p_{t-1}) + \alpha_4 (m_t - m_t^a) + \mu_t \,, \qquad [4.29]$$

where $m_t^a = g^1 z_t$ and $m_t = g^1 z_t + v_t$ and $z_t$ stands for the variables that have an important influence on the money supply, $m_t^a$ is the logarithm of the anticipated money supply, g represents a vector of coefficients to be estimated and $v_t$ is the white noise error term. To run these two models (4.28 and 4.29), South African data over the period 1977-1987 is used. The results from equation 4.28 show that real GDP as a measure of income is insignificant. The coefficient of the Treasury-Bill rate (used as the opportunity cost) is negative but insignificant, while the coefficient of the deposit rate was positive, as predicted by theory, but insignificant. The only significant variable is the lagged dependent variable. With the period split in half (1977: IV to 1983: III and 1983: IV to 1987: III), the Chow stability test is used to indicate that the equation 4.28 is very unstable. Next Tavlas ran the regression eight times, with alternative variations of the explanatory variables, in order to find a regression which gave a more stable function.

Inflationary expectations from equation 4.29 were tested and the results indicate that the coefficient has a negative sign and is statistically significant. Therefore inflationary expectations do not have a separate impact on the demand for money, apart from their effect on nominal interest rates. In the same way, Tavlas replaces the Treasury-Bill rate by the long-term bond yield and there is some improvement but the Chow test continues to indicate instability, however.

Tavlas estimates a buffer stock model with a monetary shock term and the results show that all parameters are statistically significant. The monetary shock variable is very significant and positive. The Chow statistic shows that the buffer stock model is stable. However, Tavlas discovers at least one problem with this type of model specification. The $m_t$ component of the unanticipated money supply variable may be correlated with the numerator of the dependent variable (real money balances). To address this problem, Tavlas uses two procedures, firstly, replacing the money supply by the monetary base in order to generate a series of the anticipated monetary base. The motivation behind this replacement was that a change in the base influences changes in M3, which lessens the correlation between real money balances and a monetary shock term. Secondly, Tavlas replaces the unanticipated money base series by the unanticipated M3 series. After finding that the procedure used to derive the shock variable is not satisfactory, an alternative procedure is one of utilizing instrumental variables to generate an estimated series on for $m_t$ and re-estimating equation 4.28. The empirical results are better, because the monetary shock variable became highly significant and the Chow statistic shows some stability.

Tavlas questions that if the money supply is completely endogenous to the interest rate, the buffer stock model would not be an appropriate one for the South African economy. This is because the disequilibrium money model relies on exogenous shocks to the money supply, influencing real money demand. Exogeneity is examined using Grangers' and Sims' tests. The results indicate that M3 Granger causes interest rates, but not the other way around. From all of the above, Tavlas concludes that there is a stable specification for M3 in South Africa. However, one may argue that ten years of quarterly data (a sample size of 40 observations) is not enough for a critical analysis of the demand for money, as with smaller sample sizes it is easier to fit a stable function.

## 4.6 CONCLUSION

This chapter and the review it presents shows there are not many studies using cointegration and Error Correction Model approaches on the demand for money using South African data. To be fair many studies are from a period before the econometric literature had developed these techniques. But the observation of Shin (1994: 91) "the limiting distribution of the test statistic for cointegration can be made free of nuisance parameters when the cointegration relation is efficiently estimated…it is also shown that this test is consistent" is instructive. To add to the literature on money demand estimates for South Africa we propose to use the above techniques, as the prior literature offers "mixed-bag" of results. Overall it appears the larger the time period studied, the less stable is the function. This seems rather obvious: there is more time for things to change.

The chapter also reports on the methods used to estimate the money demand function in South Africa and outcomes from other studies. Some studies on the subject of the demand for money use a linear function approach, but the partial stock adjustment model concludes that these methods do not provide a stable specification for the long-run demand for money. In addition, the demand for narrow money (M1) function is found to be unstable. One study we report uses the buffer-stock or disequilibrium money model, with results showing a stable specification for M3 in South Africa. However, with a sample size of 40 observations, one may reason that it is easy to reach such a conclusion. Chapter Five presents our results based on newer techniques, up-to-date data and with a fairly long time period. Finding stability in these circumstances is going to be a surprise.

# CHAPTER FIVE

# RESULTS, ANALYSIS AND DISCUSSION

## 5.1 INTRODUCTION

Theoretically and empirically, the equilibrium relationship between the demand for money and its explanatory variables plays an important role in macroeconomic models. The aim of this thesis based on Chapter One, as pointed out in section 1.4, page five, is to investigate the significance of the long-run relationship of real money demand (RM2) and its determinants, in the context of South Africa. As discussed in the literature chapter (Sections 2.5.1 and 2.5.2), the fundamental issues are: what are the determinants of money demand and how to determine whether this relationship does exist or not? According to Miyao (1996) the relationship between money demand and its explanatory variables must be assumed in the first place, when one estimates a money demand function or analyses its applications. This assumption is supported by Feldstein and Stock (1992) and Konishi, Ramey and Granger (1993), who demonstrate, and confirm, that real money demand (what we call RM2) plays a key role in the analysis of real activities.

The most recently used method for examining long-run equilibria of money demand is the cointegration technique, discussed in Chapter Three, Section 3.6. Many researchers including the giants in the field of money demand (for example, Hafer and Jansen, 1991, Miller, 1991 and Friedman and Kuttner, 1992) use this technique and find long run equilibrium between real money demand and its explanatory variables. Our South African counterpart is RM2.

In the empirical analysis, the following methodology is used. As discussed in Chapter Three, the Gujarati (2003, Chapter 21) procedure is carried out in order to reach an accurate conclusion for this chapter. Firstly, different tests (such as a graphical analysis, sample correlograms and unit root tests) are conducted to check for stationarity. Secondly, after knowing whether the series are stationary or not, the cointegration test is the next step, as discussed in Section 3.6. Before estimating an economic model one might first-difference the time series, due to the fact that most of macroeconomic series are non-stationary. But according to Hafer and Jansen (1991), this can remove much of the long-run characteristics of the data. However, Engle and Granger (1987) note that, even though most macroeconomic series are non-stationary, economic theory often provides a rationale why certain variables should obey certain equilibrium constraints. It is the meeting of these equilibrium constraints that serves as measure of stability: a critical aim of this thesis. We do find stability under this view.

Many studies, such as those of Friedman (1959), Meltzer (1963) and Laidler (1966), have generally satisfactory results, in the sense that results match the general theory of money demand. However, this literature is criticized by Courchene and Shapiro (1964), who identify certain dynamic problems with it, such as difficulties with autocorrelation and the once-lagged money stock possesses a significant role. According to Miller (1991), a distinction between the long-run and short-run demand for money should be made. Chow (1966) argues that short-run money demand adjusts slowly toward long-run equilibrium. For Miller (1991: 139), "this stock-adjustment specification has weathered significant storms and remains the centerpiece of many money demand studies."

If the expectation of the existence of the long-run equilibrium is met, the last step is to use the Error Correction Mechanism (ECM) test, as discussed in Section 3.7, to estimate the short-run dynamic adjustment equation which identifies how changes in the money stock responds to changes in the determinants of long-run money demand (Handa, 2000). The ECM defines the deviation of the model from its long-run value as an error and measures it by residuals.

The demand for money is a topical issue in the context of the South African economy, as it has been in other countries, and many efforts have been made to estimate the money demand function in South Africa, for example, Stadler (1981), Contogiannis and Shahi (1982), Courakis (1984), Whittacker (1985), McKenzie (1992), Naude (1992), Reinhardt (1998), Moll (2000), Jonsson (2001), Nell (2003), Tlelima and Turner (2004), Todani (2007) and Ziramba (2007) estimate the money demand function in South Africa using many different specifications. The methodologies used and their outcomes are discussed in Chapter Four.

This chapter is organized as follow. Section 5.2 concerns the data and specification of the model. Section 5.3 checks for stationarity, a graphical analysis (5.3.1) and sample correlograms (5.3.2) are examined. Subsection 5.3.3 is for the unit root test, in which the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) results are discussed and an analysis given. The chapter continues with testing for cointegration in section 5.4 and the ECM is in Section 5.5. Section 5.6 concludes the chapter showing the impact of monetary shocks last about one year.

## 5.2 THE DATA AND SPECIFICATION OF THE MODEL

According to Baumol (1952), Tobin (1956) and Friedman (1956), money is held because it is used as an inventory to smooth differences between income and expenditure streams, and as one among several assets in a portfolio. For Ericsson and Sharma (1996) the transaction motive implies that nominal money demand depends on the price level and some measure of the volume of the real transactions. Holdings of money as an asset are determined by the return to money, as well as returns on alternative assets, and by total assets (often proxied by income). The present thesis investigates empirically the impacts of determinants such as income and an interest rate on the demand for money (RM2). It is believed that the demand for money is likely to depend upon the exchange rate and inflation rate, in addition to the interest rate and the level of income (Handa, 2000). On the basis of the above assumptions, this thesis follows the Ericsson and Sharma (1996: 6) model. However, this thesis uses only one interest rate variable and it includes an exchange rate variable as a cost of holding money. Thus the Ericsson and Sharma (1996) model is explicitly written for this thesis as:

$$RM2_t = \beta_1 + \beta_2 Y_t + \beta_3 R_t + \beta_4 \pi_t + \beta_5 ER_t + u_t \qquad [5.1]$$

Where RM2 stands for real money demand, $\beta_1$ is the intercept term, $\beta_2$, $\beta_3$, $\beta_4$ and $\beta_5$ are the slope coefficients of the explanatory variables, *Y* is real income, *R* is the Treasury-Bill rate, $\pi$ is the inflation rate and *ER* stands for the exchange rate; while $u_t$ is the usual error term and *t* is time.

This thesis is an analysis of the long-run relationship between real money demand and its explanatory variables in South Africa. It employs quarterly data for the period 1990 to 2007 (69 observations). RM2 is used as a measure of real money stock. To obtain RM2 we multiply the monetary aggregate (M2) by gross domestic expenditure (in constant 2000 prices) and divide this result by the Gross Domestic Expenditure (in current 2000 prices). Gross Domestic Expenditure (in constant 2000 prices) is used as the real income (*Y*) variable and is also known as the scale variable.

For the opportunity cost variables of holding money, the Treasury-Bill rate for 91 days is used as the interest rate (R). In contrast with existing studies on the subject, the present thesis includes the inflation rate and the exchange rate in the estimated demand for money model. The change in the consumer price index (CPI) for metropolitan areas is used as a measure of the inflation rate. For the foreign exchange rate: US cents per SA rand and middle rates (1US$ = 100 cents) are used. The Treasury-Bill rate, the inflation rate and the exchange rate are collected monthly and converted to quarterly data. These are obtained from the South African Reserve Bank database, except for the inflation rate ($\pi$), which is from Statistics South Africa.

According to Gujarati (1999), an appropriate elasticity can easily be estimated using a log-linear model. The slope coefficients of the linear model gives the absolute change in the quantity of money demanded for a unit change in the one of the determinants, but this is not an elasticity. For Ramanathan (1995) the logarithmic function is closely related to the concept of elasticity used in economics and econometrics. As elasticities are critical in applied economics, it is convenient to have a constant elasticity model and the logarithmic function gives such a model (Wooldridge, 2000). All variables this thesis uses are in their natural logarithmic forms, as is the case for most studies on the subject using South African and other countries' data. Hence, to emphasize this logarithmic issue, our model becomes:

$$\ln RM2_t = \beta + \beta \ln Y_t + \beta \ln R_t + \beta \ln \pi + \beta \ln \mathrm{E}_t + \iota_t \qquad [5.2]$$

The data sources are given in Appendix 1. Table 5.1 illustrates the summary statistics of the variables used in this thesis. This descriptive investigation shows that the data are not normally distributed. In other words, observed distributions are flat, relative to the normal. This is because the kurtosis of a normal distribution is 3, while the ones used here are all less than 3. In addition, the skewness measure shows that the distribution has a long right tail, where it is positive, and a negative value for the skewness variable implies that the distribution has a long left tail. Three of our series have such a tail. According to Brooks (2002) and Ziramba (2007), this non-normality is probably due to the presence of outliers over the sample period. Despite this possibility we do not use robust methods in this thesis but it is clearly an avenue for future research.

| | *lnRM2* | *lnY* | *R* | *lnπ* | *lnER* |
|---|---|---|---|---|---|
| **Mean** | 13 | 12.32 | 2.45 | 2.03 | 4.69 |
| **Standard Error** | 0.03 | 0.02 | 0.04 | 0.05 | 0.01 |
| **Median** | 12.99 | 12.3 | 2.46 | 2.05 | 4.71 |
| **Standard Deviation** | 0.27 | 0.16 | 0.3 | 0.44 | 0.12 |

| | | | | | |
|---|---|---|---|---|---|
| **Sample Variance** | 0.07 | 0.03 | 0.09 | 0.2 | 0.01 |
| **Kurtosis** | -0.69 | -0.38 | -0.9 | -0.77 | 0.58 |
| **Skewness** | 0.56 | 0.68 | -0.28 | -0.14 | -0.96 |
| **Minimum** | 12.62 | 12.1 | 1.89 | 1.15 | 4.34 |
| **Maximum** | 13.58 | 12.71 | 3.01 | 2.78 | 4.84 |

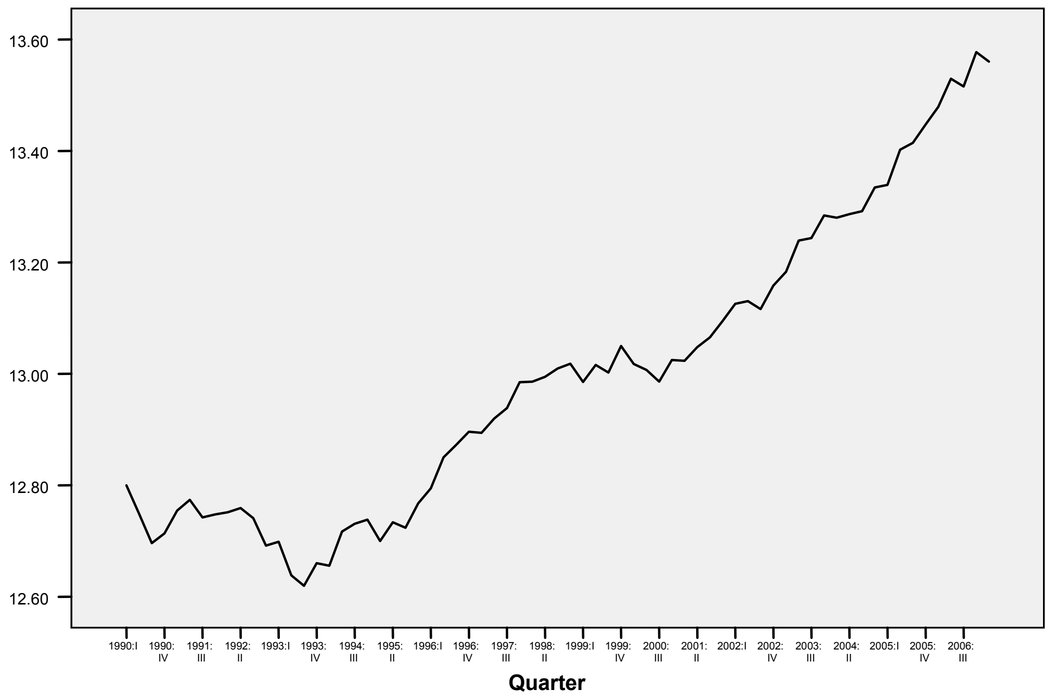
Table 5.1. Summary statistics for the series. *Source: estimated by the present author.*

The next section, provides the results of the various methods of testing for stationarity of the series used in this thesis.

## 5.3 CHECKING FOR STATIONARITY

### *5.3.1 Graphical Analysis*

The first step in this study, as in any other time series analysis, is to plot the observed values of the data series over time, in order to have an idea whether the given data is a stationary time series or not. Many, if not all, variables studied in macroeconomics are non-stationary time series and the use of such data can lead to the spurious regression problem (see Section 2.5.2). All variable are plotted using natural logarithms (even the interest rate for consistency) in order to show their growth over time and *RM2* and *Y* are in real terms. The following are the individual plots of the data this thesis uses. (*Source: computed by the present author).*



LnRM2

Figure 5.a. The Natural Logarithm of Real Money Demand (*RM2*)

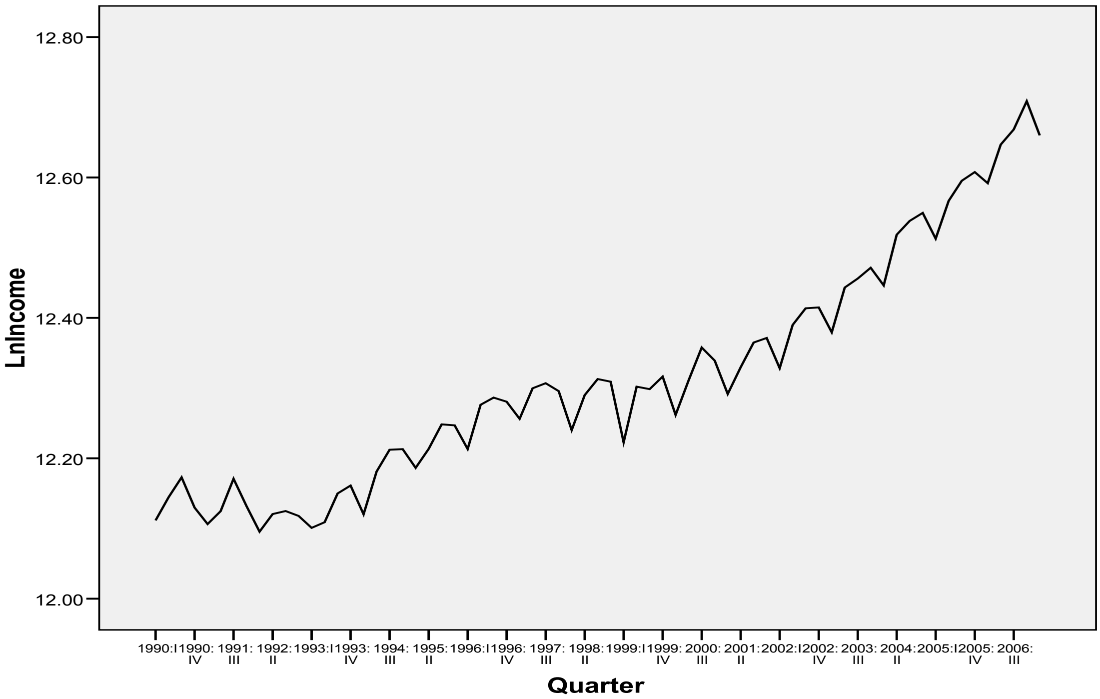



Figure 5.b. The Natural Logarithm of Real Income (*Y*)

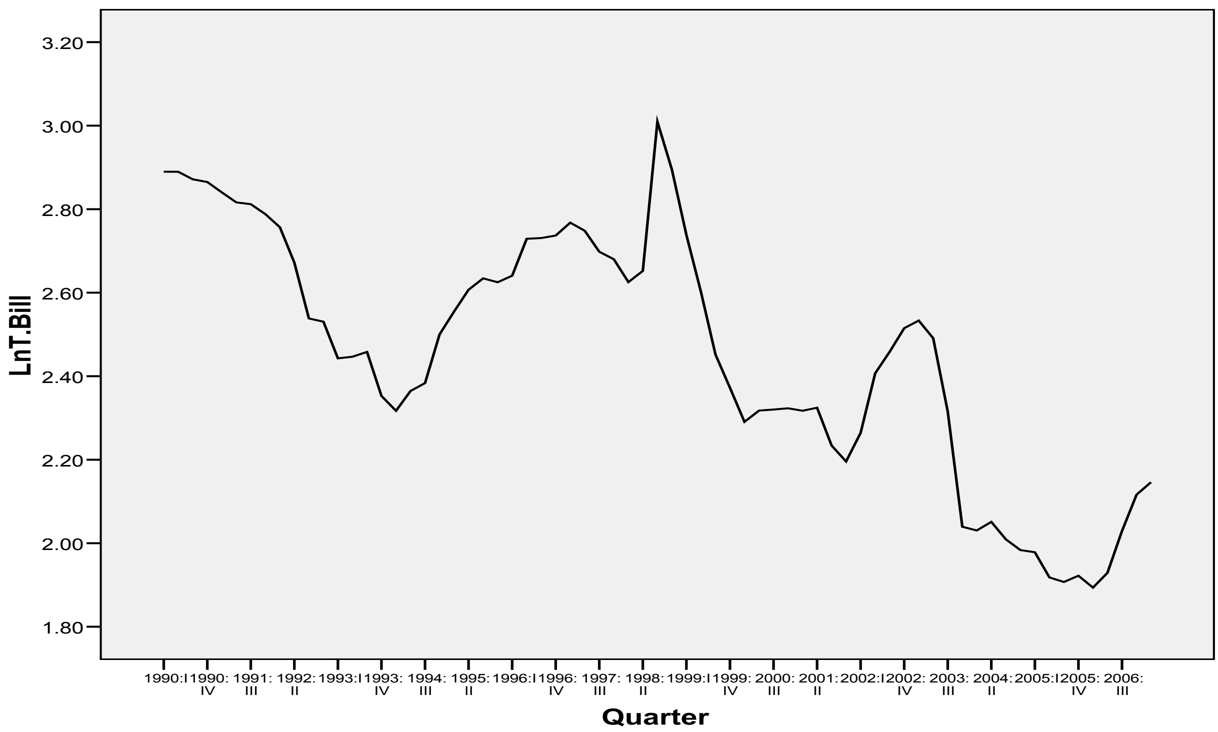



Figure 5.c. The Natural Logarithm of the Treasury-Bill rate (*R*)

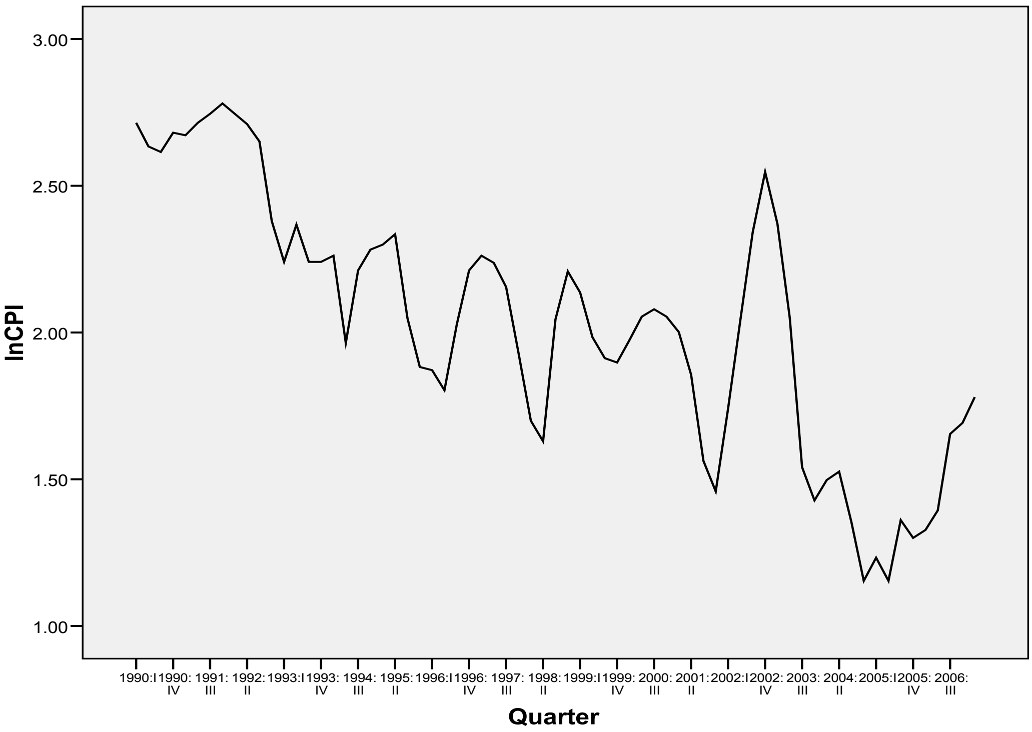



Figure 5.d The Natural Logarithm of the Inflation rate (π)

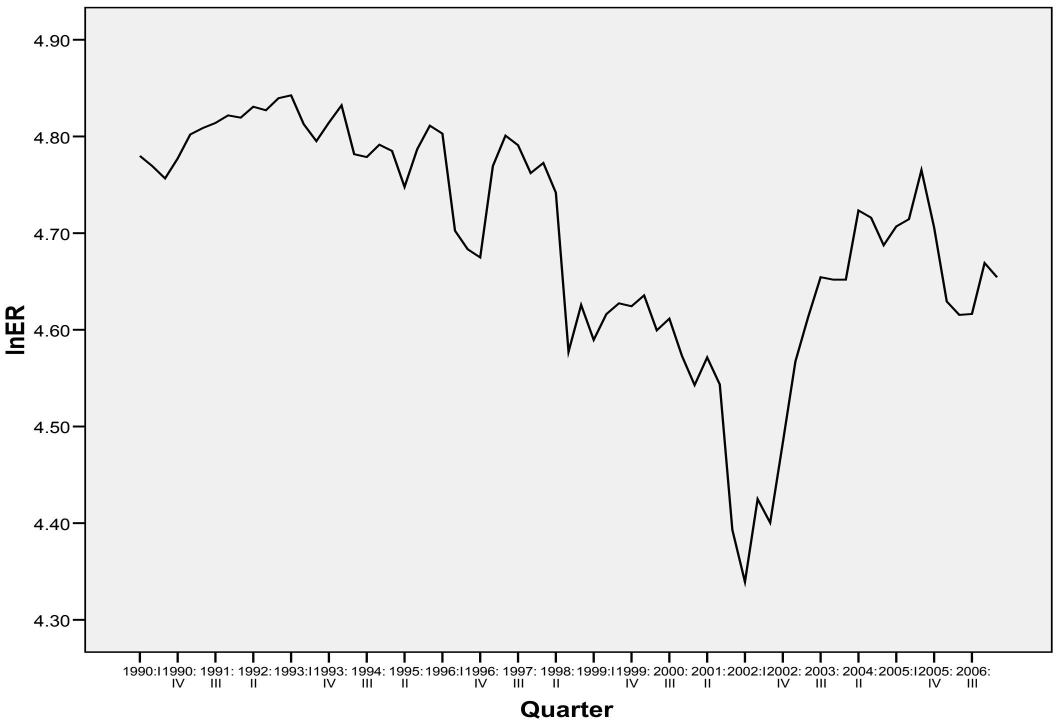



Figure 5.e The Natural Logarithm of the Exchange Rate ($/R)(*ER*)

Both RM2 and real income (Figures 5.a and 5.b) are trending upwards. This suggests that their means are changing. This may show that RM2 and real income are not stationary. Figures 5.c and 5.d (inflation and the interest rate) might represent a random walk series which shows a definite trend. The one series that could possibly "slowly turns one way or other" (Hill *et al*, 2000: 338) is the exchange rate series in Figure 5.e, with the possible exception of the 2001/2 year. Thus this series might be stationary. Gujarati (2003: 807) suggests that the above realizations are the starting point of any analysis. Figure 5.e validates the significant depreciation of exchange rates in early 2002, when the rand was 25 *per cent* weaker than its value in the same period of the previous year (MacDonald and Ricci, 2003). The most noticeable feature of figure 5.d is the peak around 2001 and 2002. This is in line with Mitchell-Innes, Aziakpono and Faure (2007: 687), who conclude that "this peak was primarily due to exchange rate developments that caused inflation to accelerate."

### *5.3.2 Sample Correlogram or Autocorrelation Function (ACF)*

Another very important diagnostic tool for checking for stationarity is the sample autocorrelation function (ACF), also known as the correlogram, whose interpretation can be somewhat subjective. In Figures 5.f to 5.j, the observations above the zero horizontal line present positive values and those below the line are negative values. The choice of lag is based on the rule of thumb that says "compute autocorrelation function up to one-third to one quarter the length of the time series" (Gujarati, 2003: 812). The sample size this thesis uses is 69 and the choice of lag ranges between 17 and 23. It is felt that a lag of 20 is reasonable. According to Bartlett (1946), the sample autocorrelation coefficient is normally distributed with zero mean and variance (1/N). Our sample size of 69 implies a variance of 1/69 or a standard error of $1/\sqrt{69}$ (= 0.1204). Therefore the 95 *per cent* confidence interval for any correlation $\rho_k$ is ±1.96 (0.1204) = 0.236 on either side of zero. If $\rho_k$ falls within this range then the series might be stationary. Hence, for any estimated $\rho_k$ which falls inside the interval (-0.236, 0.236) we do not reject the null hypothesis that the true $\rho_k$ is zero. For those which lie outside this confidence interval, we do not fail to reject the null hypothesis that the true $\rho_k$ is zero and thus the series is non-stationary.

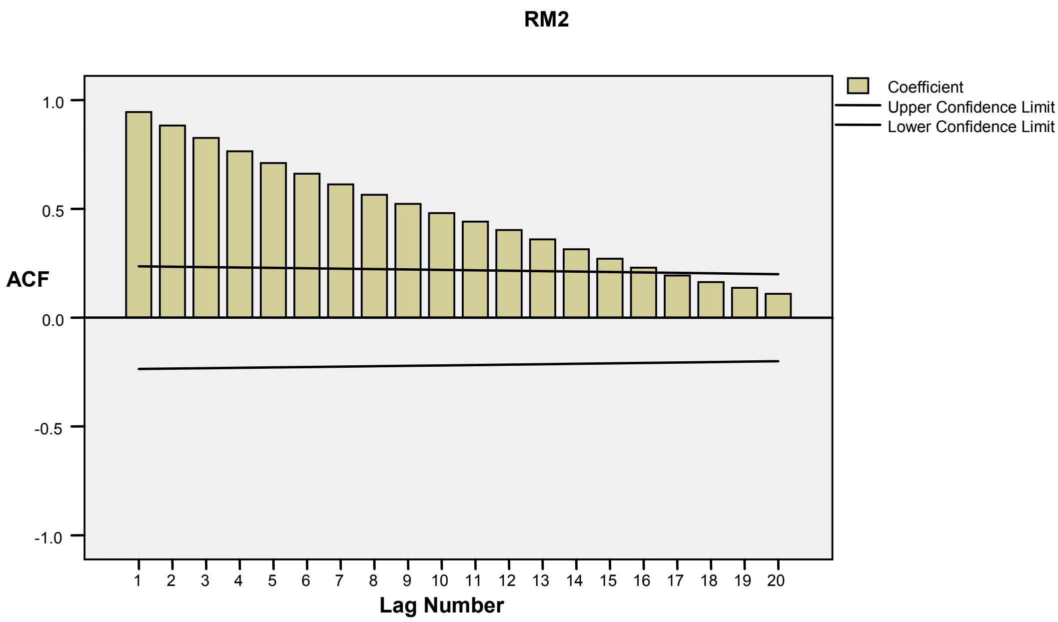



Figure 5.f Sample Correlogram of RM2 (logarithms)

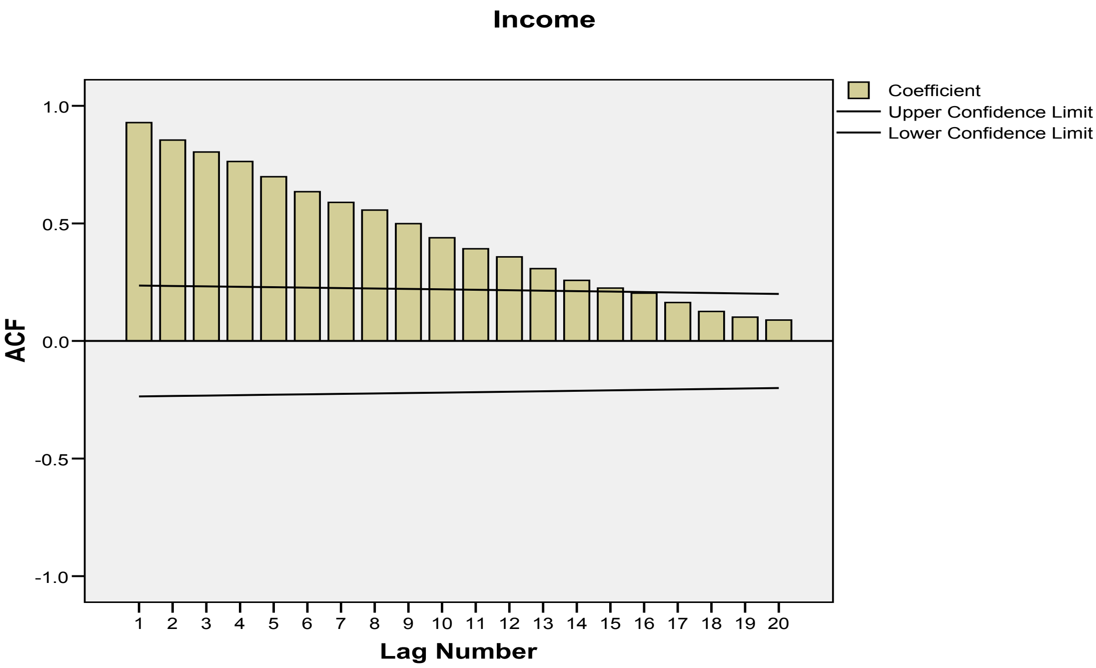



Figure 5.g Sample Correlogram of Real Income (Y) (logarithms)

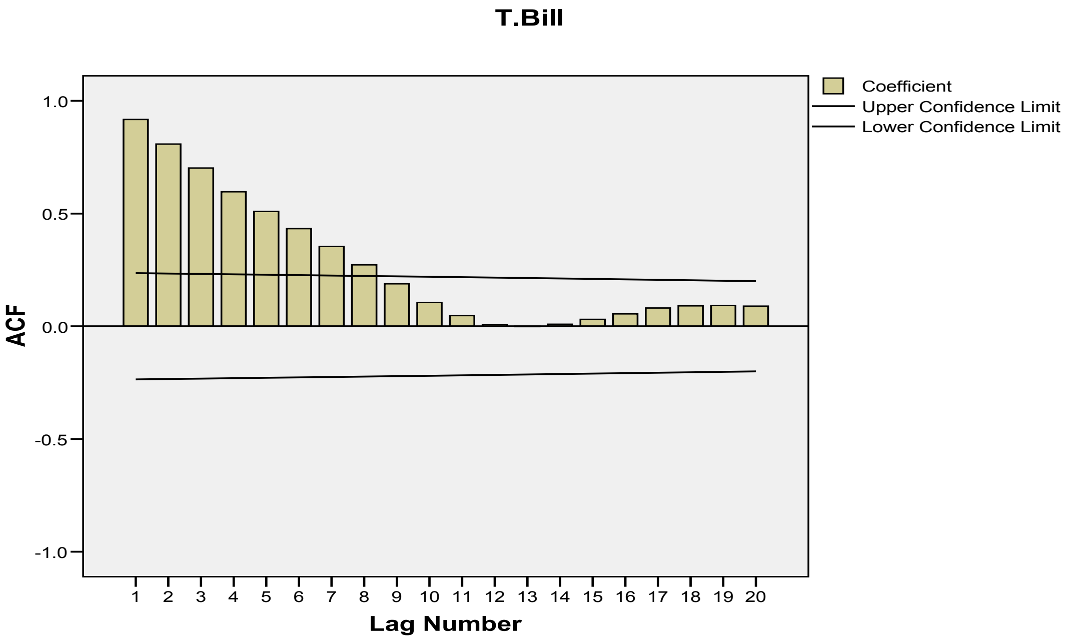



Figure 5.h Sample Correlogram of Treasury-Bill Rate (R) (logarithms)

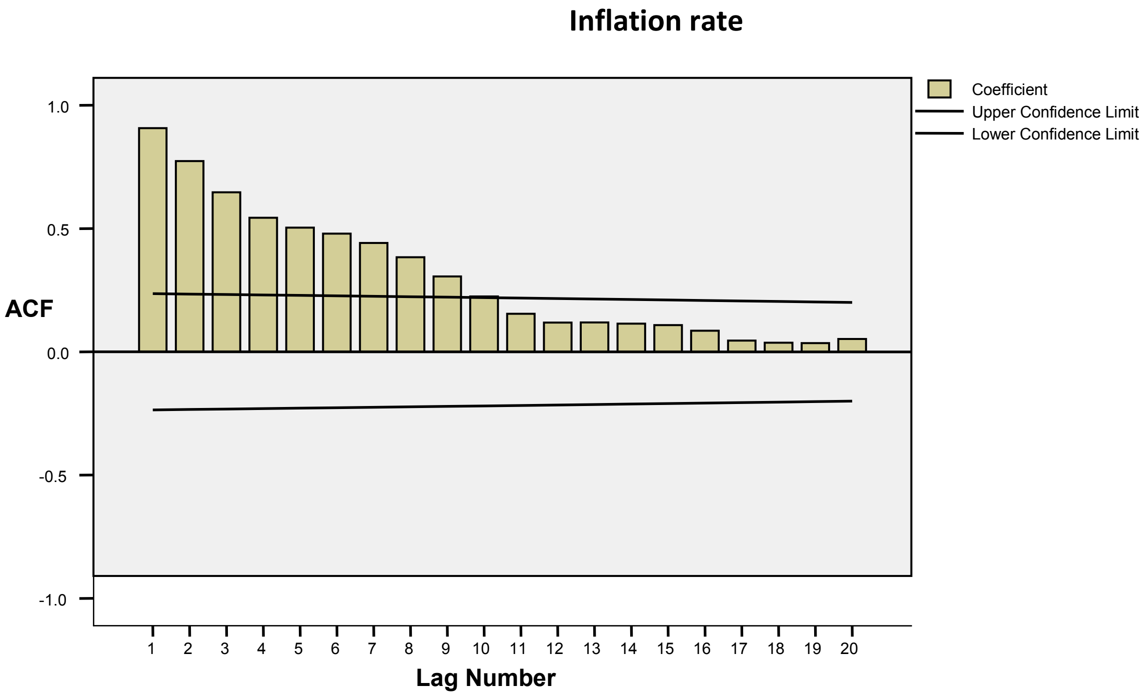



Figure 5.i Sample Correlogram of the inflation rate (logarithms)

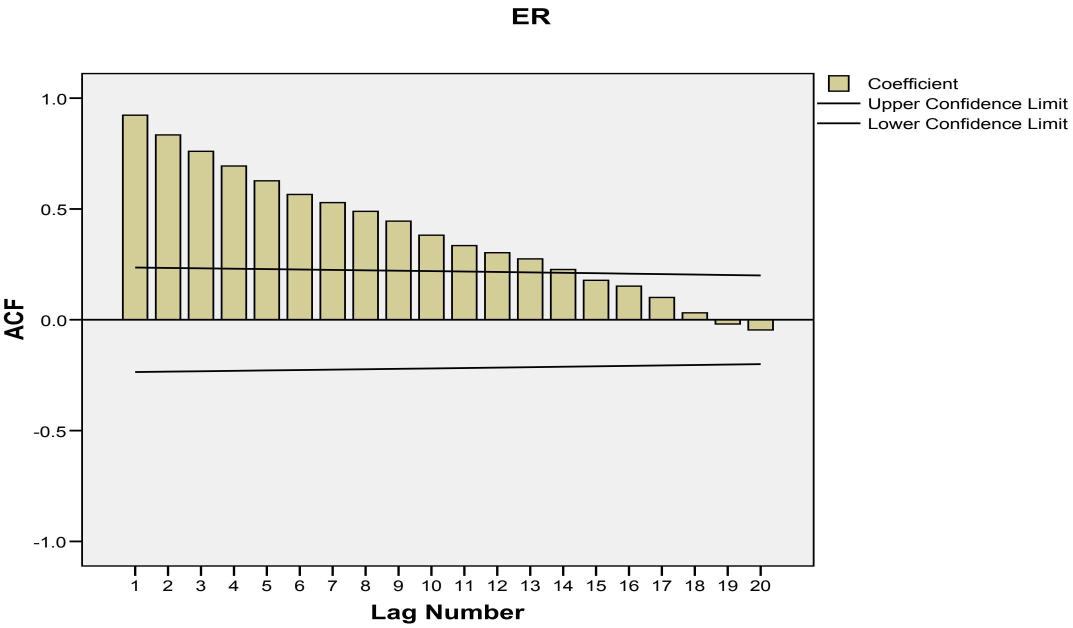



Figure 5.j Sample Correlogram of Exchange rates (logarithms)

*Source: all computed by the present author.*

In Figures 5.f and 5.g, the autocorrelation coefficient for real money demand and real income starts at very high at low lag values and declines very slowly. Both real money demand and the real income appear non-stationary. Both show the typical correlogram of a non-stationary time series, and our conclusion is that at least visually these do not appear to be the correlograms of a stationary time series (Gujarati, 2003).

Figures 5.h and 5.i look different from Figures 5.f and 5.g, as the Treasury-Bill rate and the inflation rate start at a high level (close to one) and when they reach the ninth and eighth lag, respectively they fall below the upper confidence limit line but do not become negative. Given that the lag is too long these series appear on the basis of this visual test to be non-stationary. However, these visual tests can be subjective and misleading. RM2, real income, the interest rate and the inflation rate may be non-stationary in their means and variances, or both. In the case of Figure 5.j, the series (the exchange rate) does start at a high level, like previous variables (RM2, real Y, R and $\pi$), and when it reaches the ninetieth lag it becomes negative, but it does not go beyond the lower confidence limit line. Yet only the first thirteen lags are statistically significant, due to the fact that they are above the upper confidence level. The rest are statistically insignificant. It is concluded that the exchange rate time series is also non-stationary. Thus we now move to more formal tests.

*5.3.3 Unit root test*

The implications of finding a unit root in macroeconomic data are serious. If a structural variable, such as RM2, is truly I(1), then shocks to this I(1) series have permanent effects. If this is shown to be the case, then this observation mandates serious reconsideration of the analysis of macroeconomic policy. This is a reason why, in many cases, it is very important to have a formal test for a unit root. The following section is the route for testing for a unit root which is suggested by Gujarati (2003).

*5.2.3.1 Dickey-Fuller (DF) Test*

Unit root tests are designed to check the order of integration of variables (Darnell, 1994). The stationarity of a time series is tested directly with the unit root test. The starting point of the unit root test is given by equation 3.9, which we reproduce here:

$$y_t = \rho y_{t-1} + u_t \quad \text{where} \quad -1 \leq \rho \geq 1 \qquad [5.3]$$

The hypothesis test uses the tau, **τ** (tau), statistic value to test whether there is a unit root or not and at a significance level of 5 *per cent* is set (for $\rho = 1 - \delta$) as follows:

***$H_0$** (Null Hypothesis):* **$\delta = 0$ $\rho = 1$** (non-stationary)
***$H_1$** (Alternative Hypothesis):* **$\delta \neq 0$ and positive $\rho < 1$** (not non-stationary)

The underlying idea behind the unit root test is to test for stationarity, with the null hypothesis that a series does contain a unit root and is non-stationary. According to Gujarati (2006), the null hypothesis *($H_0$)* is rejected in favour of the alternative *($H_1$)* if the calculated absolute value of **τ** (tau) is less than the absolute value of the critical value. If this is the case, there is enough evidence to conclude that there is a unit root;

the time series in question are not stationary. In other words, if ρ = 1, the unit root equation 5.3 (3.9 in Chapter Three) becomes a random walk model without drift and is a non-stationary stochastic process (Gujarati, 2003). The critical values at 1, 5 and 10 *per cent* for a sample size of 69 for **τ** (tau) values are shown in Table 5.2:

| **Significance level** | **0.01** | **0.05** | **0.10** |
|---|---|---|---|
| **No constant** | -2.62 | -1.95 | -1.61 |
| **Constant included** | -3.58 | -2.93 | -2.60 |
| **Constant and linear trend** | -4.15 | -3.50 | -3.18 |
| **Constant, linear trend and lagged difference terms of the dependent variables included** | -4.15 | -3.50 | -3.18 |

Table 5.2. DF tau τ Values.
***Source:*** Adapted from DA Dickey and WA Fuller (1979). "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." *Journal of the American Statistical Association, 74: 427-431.*

As explained in Section 3.5.3, the three equations 3.9, 3.10 and 3.11 are estimated separately and we discuss the results in subsections a), b) and c).

*a) Random Walk*

The simplest version of the DF test to be analyzed is the random walk using equation 3.9:

$$\Delta y_t = \delta y_{t-1} + u_t \qquad [5.4]$$

With a null hypothesis of δ = 0, the series is non-stationary and is a random walk and the expected value and population variance of $y_t$ are not defined. The results of a random walk test are reported in Table 5.3:

| Variable | Coefficients* | $R^2$ | Adj. $R^2$ | SE of the estimate | F |
|---|---|---|---|---|---|
| **ΔlnRM2** | 0.001 (3.159) | 0.130 | 0.117 | 0.0295 | 9.979 |
| **ΔlnY** | 0.001 (1.821) | 0.047 | 0.033 | 0.03650 | 1.517 |
| **ΔR** | -0.005 (-1.232) | 0.022 | 0.008 | 0.0084 | 1.517 |
| **Δlnπ** | -0.010 (-1.064) | 0.017 | 0.002 | 0.168 | 1.132 |
| **ΔlnER** | -0.000 (-0.372) | 0.002 | -0.013 | 0.046 | 0.139 |

** tau values are in parentheses (critical value at 5 per cent is – 1.95)*

Table 5.3. Random walk: results.
*Source: estimated by the present author.*

From the results in Table 5.3, the estimated coefficients of RM2 and real Y are positive. This implies that $\rho > 1$ but $\delta$ is supposed to be equal to $(\rho - 1)$. The RM2 and real income time series are thus explosive. Thus these series cannot be random walks. The estimated coefficients for the interest rate, the inflation and the exchange rate are negative and their absolute values of the computed tau values are |(-1.232|, |-1.064| and |-0.372|, respectively, which are all less than critical values at 1, 5 and 10 *per cent* level when the equation has no constant. Therefore we fail to reject the null hypothesis and conclude that there is a unit root in each series. Thus the interest rate, inflation rate and the exchange rate time series are not stationary.

*b) Random Walk with drift*

With the inclusion of a constant variable term, in a general version of the autoregressive process (equation 5.2), we have a random walk with drift. Testing with this specification gives the results in Table 5.4.

| Variable | Coefficients* | $R^2$ | Adj. $R^2$ | SE of the estimate | F |
|---|---|---|---|---|---|
| **ΔlnRM2** | -0.318 (-1.776) | 0.049 | 0.034 | 0.029 | 3.381 |
| **ΔlnY** | 0.046 (0.132) | 0.000 | -0.015 | 0.037 | 0.012 |
| **ΔR** | 0.107 (0.085) | 0.029 | 0.014 | 0.084 | 1.96 |
| **Δlnπ** | 0.164 (1.736) | 0.053 | 0.039 | 0.165 | 3.709 |
| **ΔlnER** | 0.363 (1.660) | 0.041 | 0.026 | 0.045 | 2.79 |

** tau values are in parentheses (critical value at 5 per cent is – 2.93)*

Table 5.4. Random walk with drift: results.
*Source: estimated by the present author.*

The results in Table 5.4 are slightly different from the ones for the random walk in Table 5.3. The estimated coefficients for RM2 and real Y are still positive. Hence the series are explosive, while the computed absolute tau (τ) values of the interest rate, the inflation rate and the exchange rate variables are less than the critical value. We thus fail to reject the null hypothesis and conclude that none of the explanatory variables is stationary at this stage.

Normally, for a series that has obvious time trends, there is a need to modify the unit root test. A trend-stationary process, which has a linear trend in its mean but is I(0) about its trend, can be mistaken for a unit root process if we do not control for a time trend in the Dickey-Fuller regression. If the usual DF or Augmented DF test is carried out on a trending but I(0) series, the test has low power for rejecting the hypothesis of a unit root. Consequently we add a trend in the following section (Section, c)), because de-trending a unit root process tends to make it look more like an I(0) series.

*c) Random walk with drift around a stochastic trend*

According to Dougherty (2002: 368), random walks are not the only type of non-stationary process. There is another common example of a nonstationary time series which possess a time trend. Its expected value at time t depends on the trend and its population variance is not defined. The results from this type of test are presented in Table 5.5.

| **Variable** | **Constant*** | **Trend*** | **Coefficient (Variables)*** | **$R^2$** | **Adj. $R^2$** | **SE of the estimate** | **F** |
|---|---|---|---|---|---|---|---|
| **ΔlnRM2** | 1.203 (2.384) | 0.002 (3.194) | -0.096 (-2.396) | 0.178 | 0.152 | 0.027 | 7.027 |
| **ΔlnY** | 2.901 (2.921) | 0.002 (3.044) | -0.241 (-2.919) | 0.125 | 0.098 | 0.035 | 4.64 |
| **ΔR** | 0.269 (1.706) | -0.001 (-1.217) | -0.099 (-1.830) | 0.050 | 0.021 | 0.083 | 1.728 |
| **Δlnπ** | 0.525 (2.429) | -0.003 (1.850) | -0.208 (-2.634) | 0.101 | 0.073 | 0.16 | 3.634 |
| **ΔlnER** | -0.571 (-1.964) | 0.000 (-1.083) | -0.119 (-1.979) | 0.058 | 0.029 | 0.045 | 1.984 |

* *tau values are in parentheses* *(critical value at 5 per cent is – 3.50)*

Table 5.5. Random walk with drift around a stochastic trend: results
*Source: computed by the present author.*

In the case of random walk with drift around a stochastic trend, that all the estimated coefficients are negative. The absolute value of tau for the logarithms of $RM_{t-1}$, $Y_{t-1}$, $R_{t-1}$, $\pi_{t-1}$ and $ER_{t-1}$ are | -2.396|, |-2.919|; |-1.830| and |-1.979| respectively. They are less than absolute critical values at the 1, 5 and 10 *per cent* significance levels. Consequently we do not reject the null hypothesis and conclude that these time series are non-stationary. On the basis of the graphical analysis (Figures 5.a and 5.e), the Autocorrelation Function (ACF) and the DF tests, the conclusion is that for quarterly data from 1990 to 2007, real M2, real Y, R, the exchange rate variable and π are not stationary. This makes the usual regression method with this data inadequate as an inferential tool.

*5.3.3.2 Augmented Dickey-Fuller (ADF) Unit Root Test*

In those cases where the DF test fails to help distinguish a time series that is integrated of order one I(1) from order zero, I(0), Dickey and Fuller (1981) advocates the Augmented Dickey-Fuller (ADF) test. This test uses the lagged values of the dependent variable as an additional explanatory variable to approximate autocorrelation that may exist in the data. The ADF test is thus aimed at correcting for a possibly autocorrelated error term. The ADF test is regarded as the most efficient test from among the simple tests for integration and is at present the one most widely used. We apply it to test the order of integration of the variables in our model. The deviation from unity of the estimated largest root should be zero if the series has a unit root (Ericsson and Sharma, 1996). Using equation 3.12 (see Section 3.5.3), Table 5.6 shows the outcome from the ADF test:

| **Variables** | **ADF test (τ)*** | **Δ Variable** | **ADF test (τ)** | $R^2$ | **Adj.** $R^2$ | **DW** |
|---|---|---|---|---|---|---|
| **lnRM2** | -2.343 | **ΔlnRM2** | 4.106 | 0.295 | 0.261 | 2.421 |
| **lnY** | -3.957 | **ΔlnY** | 2.859 | 0.248 | 0.211 | 2.140 |
| **R** | -4.382 | **ΔR** | 6.929 | 0.469 | 0.443 | 1.480 |
| **lnπ** | -7.194 | **Δ lnπ** | 8.035 | 0.563 | 0.542 | 1.105 |
| **lnER** | -1.267 | **ΔlnER** | 10.290 | 0.660 | 0.644 | 1.923 |

** To be compared to the critical values*

Table 5.6. ADF Unit Root Test Results
*Source: estimated by the present author.*

The results in Table 5.6 are obtained when testing $H_0$, whether $\delta = 0$ (that is, $\rho = 1$) and the ADF test follows the same asymptotic distribution as the DF statistic (see Section 5.2.3.1). A conclusion as to stationarity and interpretation is made by comparing the critical value of τ (tau) from Table 5.2 with the estimated τ (tau) values. Real M2, Y, R; π and the exchange rate time series are measured using lagged differences. All computed τ (tau) values (second column of Table 5.6) are negative, as expected. Except for the τ values associated with $RM2_t$ and the exchange rate variable, all others are greater in absolute value than the critical at the 5 *per cent* significance level. Therefore we do not fail to reject the null hypothesis and conclude that real income, the interest rate and the inflation time series are stationary, while the τ (tau) values of $RM2_t$ and the exchange rate are less than the critical value of |-3.50| at the 5 *per cent* significance level. The null hypothesis is accepted that RM2 and the exchange rate variable are not stationary at the 5 *per cent* significance level. There is a unit root for these two variables and they are non-stationary in natural logarithmic form.

The fourth column in Table 5.6 shows that all variables are stationary when looking at their first differences. This is shown by a plot of the first difference of the variables used in the model here.

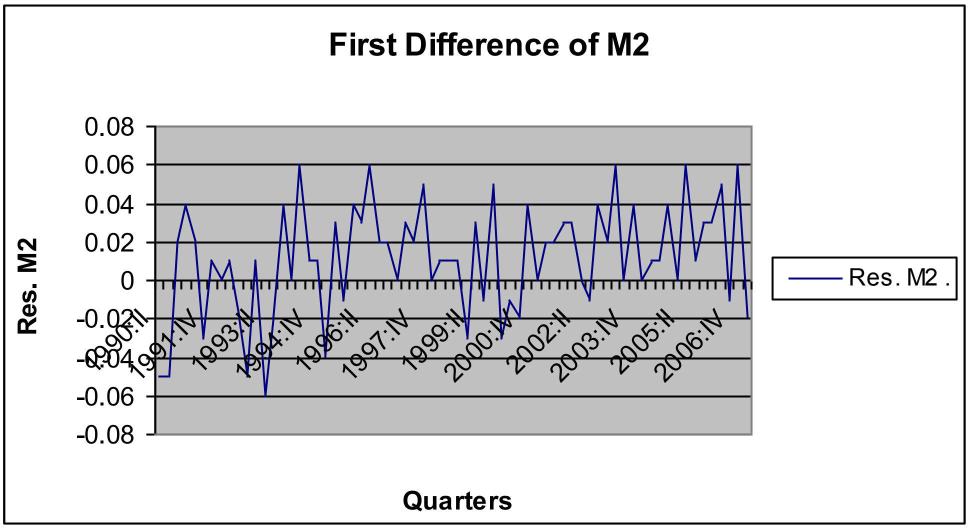



Figure 5.k: First Difference of Real M2. *Source: computed by the present author.*

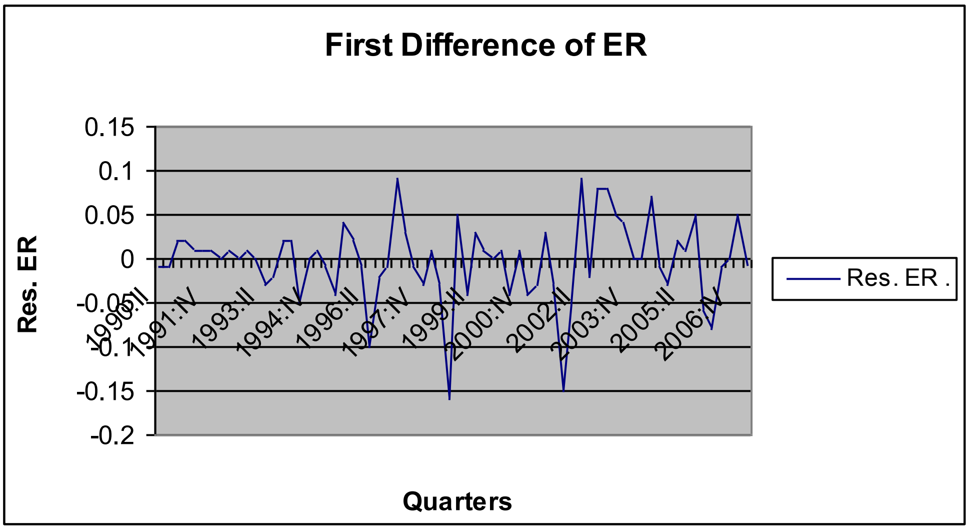



Figure 5.l. First Difference of ER

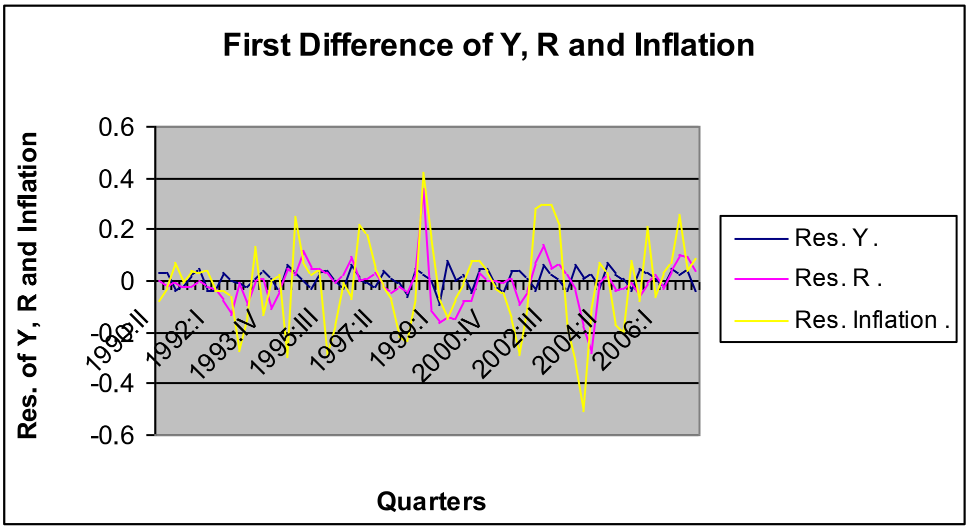



Figure 5.m. First Difference of Y, R and inflation. *Source: computed by the present author.*

Since some of the variables are not stationary, but become stationary in their first differences, these that become stationary, are integrated of order one I(1). Three of the five variables appear to be integrated of order zero at the 5 *per cent* significance level, except RM2 and the exchange rate variable, both of which are integrated of order one.

The statistical evidence concludes that real income (Y), the interest rate (R) and the inflation rate (π) appear to be I(0) or stationary, while real money demand (RM2) and the exchange rates are I(1) or non-stationary. Brooks (2002) indicates that a combination of I(1) variables will itself be I(1), but it is better to obtain residuals that are I(0).

## 5.4 TESTING FOR COINTEGRATION

As a general rule, non-stationary time variables must not be used in a regression model, in order to avoid the problem of spurious regression (Hill *et al.,* 2001). In a case where two or more variables share similar stochastic trends, they are said to be cointegrated if a linear combination of them is stationary. A cointegrating relationship may be seen as a long-term or equilibrium phenomenon, since it is possible that cointegrating variables may deviate from their relationship in the short run, but their association would return to equilibrium ones in the long run (Brooks, 2002).

Before attempting any form of cointegration test, it is known that, in general, real income and RM2 may be cointegrated from Engle and Granger (1987: 215). However, the results from a study in one country may not apply in another country. This thesis tests the hypothesis, using South African data, whether RM2 is cointegrated not only with real income, but also with the other explanatory variables (an interest rate, the inflation rate and the exchange rate). There are a number of tests for cointegration, but this thesis uses the two methods discussed in Section 3.6. First is the DF and ADF test on the residuals ($\hat{U}_t$), estimated from the cointegrating regression which is also known as the Engle-Granger (EG) and Augmented Engle-Granger (AEG) test. A second method is the Cointegrating Regression Durbin-Watson (CRWD) test. To illustrate these tests we first obtain the regression from estimating equation 3.2 (see Section 3.3.2), and regressing RM2 on Y, R, π and ER in natural logarithmic form, obtaining the following results:

$$\ln RM2_t = -\ .953 + \ .5289Y_t - 0.002R_t + 0.003\ln\pi_t - 0.193\ln ER_t \qquad [5.5]$$

**SE** (1.267) (0.086) (0.004) (0.03) (0.075)

Tau = (-3.908) (17.79) (- 0.394) (0.096) (-2.564)

$R^2$ = 0.945 Adj. $R^2$ = 0.941 DW= 0.814 F = 272.405

Standard error of estimate = 0.064

From the results in equation 5.5, we note that the F- statistic is very high, which means that the model as a whole is statistically significant. Except for *ln π*, other estimated coefficients have the expected signs. The computed τ (tau) statistic for Y (17.79) is highly statistically significant and the computed τ for the exchange rate value (-2.564) is also statistically significant. But the computed τ for the interest rate and the inflation rate variables, as defined, are not statistically significant. This confirms analysis by Todani (2007), that "the long-run link between money and inflation is rather weak." This means that both the interest rate and the inflation rate do not have a statistical influence on money demand in South Africa. It agrees with Contogiannis and Shahi (1982) who show that the interest rate included in their model is found to be not statistically significant. This might support neoclassical theory concerning the neutrality of money, where the impact of high growth in the money stock results in a similar increase in the inflation rate. Empirical evidence reviewed by Handa (2000) suggests that money can be neutral in some cases and non-neutral in others. Although the present results show that money might be neutral in the long-run equilibrium for South African data, Handa (2000: 493) points out that this long-run neutrality operates only in a simple exchange economy with commodities and money but not in a more complex economy where consumers base consumption decisions on the permanent income hypothesis. But these are spurious results as we explain below.

The $R^2$ from equation 5.5 is high, which shows a good fit for the variation in the dependent variable (RM2). In other words, there is some link between money demand and the determinants, but Miller (1991) stresses that a high $R^2$ may only indicate correlated trends and not true economic relationships. The computed Durbin-Watson (DW) value for equation 5.5 is very low, indicating that the model has a problem of autocorrelation. This might be because some of the time series are non-stationary. One may strongly suspect that the estimated regression is spurious due to RM2 and exchange rate variable, which are individually non-stationary at the 5 *per cent* level, while the explanatory variables are stationary at this significance level. A good rule of thumb for one having a spurious regression is when the $R^2 > DW$, which is indeed the case here.

The results show that intercept is statistically significant. The inflation rate has a positive sign while the other variables do meet the traditional expectations. The insignificance of the interest rate elasticity coefficient, while surprising, is not different from other studies focusing on the demand for money in South Africa, which show similar results (see, for example, Stadler, 1981; Contogiannis & Shahi, 1982 and Whittaker, 1985). This is also confirmed by Fair (1987) who found four out of 27 equations have the wrong sign for the interest rate, namely those for Sweden, South Africa, India and the Philippines.

Compared to Todani's (2007) study, the income elasticity obtained here (1.517), shown in Table 5.8, is not much higher than unity, as expected from theory (see Friedman, 1959; and Friedman and Schwartz, 1982). These results agree with Feige (1967), who found an estimated income elasticity of 1.3. Our income elasticity result says that, in the long-run, a one *per cent* increase in income leads to an increase of 1.517 *per cent* in the real quantity of money demanded. These results also agree with Handa (2000), who believes that the income elasticity of RM2 can be theoretically justified to be unity or greater. However, this differs from Goldfeld (1973), who found that the long-run income elasticity of M2 is a huge 2.3, but the interest rate elasticity does not fall in the usual range of - 0.15 to – 0.50, posited by Handa (2000) (see Friedman, 1959; and Friedman and Schwartz, 1982). Table 5.7 shows all the long-run elasticities.

| Variable | Elasticities |
|---|---|
| **lnY** | **1.4488** |
| **R** | **-0.0013** |
| **lnπ** | **0.0005** |
| **lnER** | **-0.0695** |

Table 5.7. Long-run Elasticities for Equation 5.5
*Source: estimated by the present author.*

According to Engle and Granger (1987), cointegration analysis confronts the problem of a spurious regression by identifying conditions in an equation for which a relationship might have some economic meaning. To find whether or not the regression (5.5) is not spurious, we perform the Engle-Granger and Augmented Engle-Granger test by investigating whether or not the data contains a unit root using residuals from equation (5.5), in the next sections.

*5.4.1 Engle-Granger Test*

The asymptotic critical values used for this test are from Engle and Yoo (1987):

| **Number of Explanatory Variables** | **Sample Size** | **Significance Level** | | |
|---|---|---|---|---|
| | | **0.01** | **0.05** | **0.10** |
| **4 (Y, R, π and ER)** | 50** | -4.94 | -4.35 | -4.02 |
| | 100 | -4.75 | -4.22 | -3.89 |
| | 200 | -4.70 | -4.70 | -3.89 |

** To be considered

Table 5.8 Asymptotic Critical Values for the Engle-Granger Cointegration test

Our results are:

$$\Delta\hat{U}_t = -\ .410\hat{U}_{t-} \qquad [5.6]$$

Tau = (-4.164)

$R^2$ = 0.206 Adj. $R^2$ = 0.194 DW = 1.805 F = 17.335

$$\Delta\hat{U}_t = 0.001 - 0.410\hat{U}_{t-1} \qquad [5.7]$$

Tau = (0.154) (-4.132)

$R^2$ = 0.205 Adj. $R^2$ = 0.193 DW = 1.806 F = 17.070

$$\Delta\hat{U} = -\ .003 + )t - ).414\hat{U}_{t-} \qquad [5.8]$$

Tau = (-0.270) (0.392) (-4.124)

$R^2$ = 0.207 Adj. $R^2$ = 0.183 DW = 1.803 F = 8.503

The results obtained, based on the residuals from the regression of RM2 and its explanatory variables, with four lags, show *tau* statistics for $\hat{U}_{t-}$ of |-4.164|, |-4.132| and |-4.124| for change in $\hat{U}_t$. These calculated values are less than the 5 *per cent* absolute critical value of |-4.35|. We conclude that there is evidence of no cointegration between real M2 and its determinants. Our next step (Section 5.4.2) is to proceed to the application of the augmented Engle-Granger (AEG) test with four lags, to see if these results are robust.

*5.4.2 Augmented Engle-Granger Test*

A cointegration regression is run by estimating the augmented DF regression. The lagged error term and a change in that variable are included. The following are the results from the AEG estimation:

$$\Delta\hat{U}_t = -0.008 + 0t - 0.486\hat{U}_{t-1} + 0.389\Delta\hat{U}_{t-1} \qquad [5.9]$$

Tau = (-0.700) (0787) **(-5.238)** (3.889)

$R^2$ = 0.359 Adj. $R^2$ = 0.329 DW = 1.792 F = 11.943

The absolute value of the computed *tau* value of $\hat{U}_{t-}$ (|-5.238|) is greater than absolute critical value at 5 *per cent* of significance level (-4.35). We do not fail to reject the null hypothesis that cointegration exists between RM2 and its explanatory variables. These results reveal that all variables in one model, despite two initially being individually non-stationary, are cointegrated. This leads to the conclusion that the estimated econometric model (equation 5.5) represents the long-run money demand and is a candidate for examination of stability. This concurs with other studies using the cointegration test in South Africa, such as those of Hurn and

Muscatelli (1992), Moll (2000) and Nell (2003). These results are similar to those of Wasso (2002) and Ziramba (2007), who confirm, based on the results of bounds testing, the presence of a long-run equilibrium relationship between the demand for real money (RM2) and its determinants. This stability of money demand in South Africa is confirmed by Tavlas (1989), who uses the buffer stock or disequilibrium money market model.

#### *5.4.3 Cointegrating Regression Durbin-Watson test (CRDW)*

There are a number of alternative tests for cointegration. The simplest and quickest method, when one wants to find out if dependent and independent variables are cointegrated, is the cointegration regression Durbin-Watson (CRDW) test proposed by Sargan and Bhargava (1983). According to Harris (1995), it is known to be the uniformly most powerful and invariant test of the null hypothesis of no cointegration. The null hypothesis is that there is a unit root in the potentially cointegrating regression residuals, while with the alternative, the residuals are stationary (Brook, 2007). This is based on the standard DW statistic obtained from equation 5.5. A comparison shows, the computed Durbin-Watson of 0.814 (from equation 5.5) is greater than the given critical values of 0.511; 0.386 and 0.322 at the 1, 5 and 10 *per cent* significance levels, respectively (see Section 3.6.2). In this case, we do not fail to reject the null hypothesis of no cointegration, as for the previous method (Section 5.4.2) and we conclude that RM2 and its explanatory variables are cointegrated. Hence it shows a meaningful relationship between the variables (Banerjee, Dolado, Hendry and Smith, 1986). This conclusion remains the same even if one compares the computed DW with the one suggested by Sargan and Bhargava (1983) for a money-demand model, whose critical value for rejecting the null hypothesis of no cointegration is 0.48.

### 5.5 ERROR CORRECTION MECHANISM

The estimation of money demand has a rich tradition, as it has been calculated in many countries. Initial studies by Friedman (1959), Meltzer (1963) and Laidler (1966) found satisfactory results, in the sense that the observed results matched theoretical *priors*. Courchene and Shapiro (1964) identify certain issues such as autocorrelation and lagged money stock effects which could play an important role. According to

Miller (1991), a distinction between the long-run and short-run demand for money should be made. Chow (1966:115) states "that short-run money demand adjusted slowly toward long-run equilibrium; this stock-adjustment specification has weathered significant storms and remains the centerpiece of many money demand studies." We adopt a modern measure of this effect.

In the model (equation 5.9, Section 5.4.2), it is shown that the dependent (real M2, shown as RM2) and independent variables (Y, R, π and ER) are cointegrated, meaning there is a long-term equilibrium between them. Finding that there is cointegration between variables does not mean that equilibrium exists in the model. It is possible that when economic theory posits a long run equilibrium function for a variable, in the short-run we may have disequilibrium. The cointegration technique captures the long-run relationship between the dependent and explanatory variables, but does not capture the dynamic response of the former to changes in the latter. To correct for these disequilibrium issues, the Error Correction Mechanism (ECM) is introduced to estimate how the observed model moves towards the long-run equilibrium whenever it has been pushed away (Engle and Granger, 1987: 251). The results of the ECM (based on Wooldridge (2000, page 592) are shown below:

$$\Delta \ln RM2_t = 0.008 + 0.317\Delta \ln Y_t - 0.012\Delta R_t - 0.021\Delta \ln \pi_t - 0.061\Delta \ln ER_t - 0.20\hat{U}_{t-} \quad [5.10]$$

**t-values** (3.296) (3.073) (-0.33) (-0.89) (-0.79) (-3.43)

$R^2 = 0.222$  Adj. $R^2 = 0.1599$  DW = 1.939  F = 4.459

According to Engle and Granger (1987: 254), the error correction coefficient should be negative and statistically significant in order to guarantee that the divergences, which occur in one period, are corrected in the next period. The results show the coefficient of the equilibrium error term ($\hat{U}_{t-}$) to be negative, as expected, and statistically significantly different from zero, implying that 0.20 of the discrepancy between money demand and its explanatory variables, for this thesis, in the previous quarter is eliminated in the following quarter. This value of 0.20 shows that there is the possibility for the monetary policy committee to anticipate changes when making policy recommendations. These results of the error correction method are not too far from the Reinhardt (1998), Moll (2000) and Tlelima and Turner (2004) studies. When using Ayto's (1989) half-life formula ( $\frac{\ln 0.5}{0.20} =$ 3.47), half the adjustment will be reached after four quarters (3.47). This speed of adjustment for money demand suggests that the money market in South Africa needs about four quarters to re-adjust to equilibrium. This is also checked by Monte Carlo simulation of equation 5.10 with 200 repeated random samples. Simulations with father tailed distributions suggests the estimate of approximately four quarters is on upper limit.

Estimation 5.10 shows that the money demand relationship can be out of equilibrium in the short-term, as the coefficient on $\hat{U}_{t-}$ is negative (-0.176). This means that in about four quarters, roughly half of the excess demand in the money demand market corrects itself. The implication of this negative error correction term for the demand for real money is observed when the real level of the money stock is in disequilibrium. For example, if real money demand 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 the money stock to occur in subsequent periods in order to correct for the disequilibrating error. The "speed of adjustment" calculation shows, and is a core result of this thesis, the adjustment to equilibrium is found to be four quarters. The equilibrium error is corrected by appropriate adjustments that tie the short-run behaviour of RM2 to its long-run value. These results agree with those of Ericsson and Sharma (1996), Moll (2000) and Sayinzoga (2005), who found error correction coefficients of -0.127, -0.14 and -0.12, respectively although for different time period and countries.

When we use our estimated standard error (0.028) to calculate the variance, the results obtained with usage of the half-life formula (Ayto, 1989) are a range of a lower and upper tail of approximately two and eight quarters, respectively, in which four quarters falls in the middle of this range, as shown in the figure below:

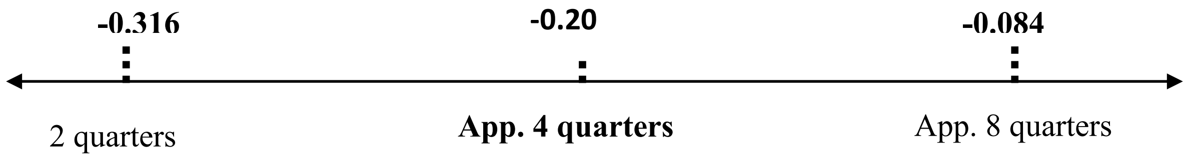



Figure 5.n: Variance of the half life of the error adjustment. *Source: Estimated From the Data.*

These results agree with Mboweni's (2009: 1-2) Statement of the Monetary Policy Committee, in which he said that:

> "*the most recent central forecast of the bank shows a near-term deterioration in the inflation outlook but a more favourable trend is forecast for the medium term, which is the relevant time frame for monetary policy. Consumer price inflation is expected to average 8, 1 percent in the first quarter of 2009 and then to decline to below six percent in the third quarter of the year. As a result of technical base effects, inflation is then expected to marginally exceed the upper end of the inflation target range, before returning back to within the range in the second quarter of 2010 and to remain there until the end of the forecast period in the fourth quarter of 2010, when it is expected to average 5,3 percent.* "

This means that the speed of adjustment for money demand in South Africa, which is equal to 0.20, is low. However, our results differ from those of Jean-Claude (2001) and George (2002), who found an error correction coefficient of -0.3 for Cameroon and 2.5 for Uganda, respectively.

The Durbin-Watson and F-statistic we obtain show that the explanatory variables are statistically significant at the 5 *per cent* level. The value of the Durbin-Watson test (1.939) for the cointegration regression demonstrates that a spurious regression is unlikely. This is because the null hypothesis of a unit root in the errors, or CRDW ≈ 0, is rejected, due to the calculated value of 1.939 being larger than the relevant critical value of 0.5 (Brooks, 2002).

The short-run income coefficient obtained (0.3) is closer to the value predicted by Miller and Orr (1968) than to the one expected by general theory (see Section 5.4). A pleasing result is that the observed signs for the interest rate and inflation rate variable are as expected. It is surprising that the absolute value of the effect is 0.012 for both variables. We note that, as the exchange rate depreciates, the demand for domestic currency falls; the effect for the exchange variable is -0.06. Note that these values are not elasticites.

## 5.6 CONCLUSION

The main aim of this thesis is to investigate the stability of the long-run relationship between money demand and its determinants in South Africa. After giving different theories concerning the demand for money in Chapter Two, we estimate the long-run South African money demand function in a cointegration and error correction model framework in this chapter, In order to be able to support our estimated model; we demonstrate our methodology in Chapter Three. For this chapter, following an introductory section in which is the data and specification of the model and we proceed with the hypotheses analysis, where we checked for stationarity using a graphical analysis, autocorrelation functions and unit root tests in Sections 5.3.2 and 5.3.3. After estimating that three out of four of the explanatory variables are stationary individually at the five *per cent* significance level and the dependent variable (RM2) is non-stationary; we proceed in the same section to use the co-integration test. Three tests are implemented: Engel-Granger, a Co-integration Regression Durbin-Watson test and the Error Correction Mechanism test.

The Cointegration, Co-integration Regression Durbin-Watson and ECM tests support the presence of a long-run relationship between RM2, real income, the interest rate, the rate of inflation and the exchange rate in South Africa and are consistent with research conducted in other countries. The results confirm our *a priori* expectations of a positive relationship between real income; the inflation rate and a negative relationship between RM2 and the remaining explanatory variable (see Sections 2.4 and 2.5.1). The estimated elasticities for income and inflation rate agree with the literature (see Handa, 2000). The error correction coefficient for $\hat{U}_{t-}$ (at -0.20) from the error correction model indicates that disequilibrium in the money market can last for up to four quarters and agrees with how the Reserve Bank views their own policy impact, and Monte Carlo simulations of this specification with data drawn from distribution other than the normal but changes in leadership (November 2009) may alter this time frame. In general, this thesis (Section 5.5) presents evidence indicating that policy changes by monetary authority have an impact on the economy, and last for one year.

# CHAPTER SIX

# SUMMARY AND CONCLUSION

## 6.1 SUMMARY

A stable money demand function is a key factor in macroeconomics analysis, especially in selecting appropriate monetary policy (Ziramba, 2007). Many researchers such as Meltzer (1963), Laidler (1966), Lucas (1988) and others have followed the objectives of Friedman (1956) to find a stable function for money demand that depends upon a limited number of variables. Since the early 1980s, a major focus in research is on economic variables such as the interest rate, income, exchange rates and inflation rates and these variables have gained importance in the literature concerning the demand for money.

This thesis estimates a stable long-run equilibrium relationship between money demand and its explanatory variables in South Africa over the period 1990 to 2007, using cointegration and error correction methods. Different economic theories concerning the demand for money are reviewed in Chapter Two. Monetary theory is a specific area of general macroeconomic theory. Two competing theories of macroeconomics, classical and liquidity preference (Keynesian) theory emphasize the use of money as a medium for transactions and a set of opportunity cost variables, in general. Similar to Ewing and Payne (1999), Qayyum (2005) and Ericsson and Sharma (1996), the opportunity costs used in this thesis include the interest rate, an inflation rate (opportunity cost of holding money relative to real goods) and the exchange rate (the opportunity cost of holding money relative to assets denominated in foreign currency).

It is known that many macroeconomic variables such as real income and real money demand tend to have a trend term and are non-stationary. Using such variables in statistical analysis can lead to the problem of "spurious regression." To solve this problem, Handa (2000: 169) believes that:

> "*Detrending the data prior to its use in the regression analysis can introduce its own statistical problems, so that cointegration analysis, which does not involve prior detrending, is preferable.*"

According to Hamori and Tokihisa (2001: 305), the presence of cointegration between real money balances and its appropriate determinants implies that the money demand function is stable or otherwise unstable. The methodology chapter (Chapter Three) shows the steps (which we follow here) of the cointegration method in Gujarati (2003), such as testing for stationarity, using a graphical analysis, sample correlograms and unit root tests in which the Dickey-Fuller and Augmented Dickey-Fuller tests are utilized. For cointegration, Durbin-Watson, Engle-Granger and Augmented Engle-Granger tests are applied. This thesis does not end with the use of cointegration tests only, but then proceeds to error correction methods. All variables are in logarithmic terms.

The South African empirical literature review is discussed in Chapter Four. It is found that many methods are used to analyze the demand for money in South Africa, for example the linear function approach, the partial stock adjustment model and the buffer stock disequilibrium money model. Few studies are done using cointegration and error correction methods and not all of these studies show that the money demand function in South Africa is stable: unlike the stability we find here.

In this thesis, the theoretical foundation of testing and reporting results follow Dickey and Fuller (1979: 427) and Engle and Granger (1987: 270). Except for the exchange rate, all explanatory variables are found stationary at the 5 *per cent* level of significance after first differencing. Real money demand (RM2) also has a unit root in the level form.

The existence of the long-run relationship between money demand (RM2) and its determinants in South Africa with the cointegration method is confirmed using the following equation:

$$\ln RM2_t = \beta + \beta \ln Y_t + \beta R_t + \beta \ln \pi + \beta \ln \mathrm{E}_t + \iota_t . \qquad [6.1]$$

This equation when applied to South African data gives an unexpected inflation rate sign (positive): the other coefficients are as expected. The error correction method results are obtained from the following equation:

$$\Delta \ln RM2_t = \chi_0 + \chi_1 \Delta \ln Y_t + \chi_2 \Delta r_t + \chi_3 \Delta \ln \pi_t + \chi_4 \Delta \ln E_t + \chi_5 \hat{\mathfrak{I}}_{t-1} + \varepsilon_t \qquad [6.2]$$

The above equation expects the sign for the error correction term to be negative which is indeed the case, with the time needed for the money market in South Africa to re-adjust back to equilibrium being four quarters (about one year).

The supposed long-run income elasticity for real money demand is approximately 1.4488, while for the short-run it is approximately 0.3. The interest rate elasticity is equal to approximately 0.0013 for the long-run and 0.012 for the short-run. The inflation rate coefficient is approximately 0.0005 in the long-run and in the short-run approximately 0.021.

## 6.2 CONCLUDING REMARKS

The main objective (Section 1.3, page 4) of this study is to investigate the policy significance of the long-run relationship between real money demand (RM2) and its determinants in South Africa. It uses cointegration and error correction methods. In contrast with other studies on the subject, besides real income and the interest rate, the present study includes the inflation and exchange rates as determinants of real money demand RM2. The results confirm that there is a long-run equilibrium relationship between RM2 and its determinants in South Africa. This result is also examined from the point of view of the variances of our estimates. We note with some concern the non-normality of the data. Robust estimates are clearly an item for future research.

The crucial results indicate that monetary policy is effective but, in spite of its efficiency, it does not have a quick effect, needing at least four quarters (one year) from its inception to make a real difference. In other words, there might difficulties in implementing monetary policy in an emergency situation. Monetary authorities in South Africa should remember that policy decisions need at least four quarters to achieve their aims and need to plan ahead of time. The setting of interest rates needs to be based on at least what inflation might be over the next four quarters. A topic for future research is to investigate how the new monetary policy authorities (who take over in an environment of missed inflation targets) can work with other new policy makers on fiscal matters in order to devise solutions to emergent situations in world markets that impact upon South Africa.

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# APPENDICES

**APPENDIX1: Data**

| Quarter | Real M2 | Real Y | T-Bill (91 days) | Inflation | Exchange rate |
|---|---|---|---|---|---|
| 1990:I | 362122.7771 | 181959.88 | 17.99 | 15.1 | 119.09 |
| 1990:II | 344112.1228 | 188053.5 | 17.985 | 13.93 | 117.83 |
| 1990:III | 326467.1267 | 193448.56 | 17.66517 | 13.67 | 116.35 |
| 1990:IV | 332199.57 | 185299.69 | 17.54833 | 14.6 | 118.78 |
| 1991:I | 346107.3937 | 181004.42 | 17.12133 | 14.47 | 121.76 |
| 1991:II | 352826.6707 | 184355.77 | 16.71317 | 15.1 | 122.58 |
| 1991:III | 341895.9649 | 193067.53 | 16.64117 | 15.57 | 123.22 |
| 1991:IV | 343716.6743 | 185677.83 | 16.24917 | 16.13 | 124.19 |
| 1992:I | 345071.4889 | 179053.08 | 15.74733 | 15.57 | 123.9 |
| 1992:II | 347667.482 | 183602.36 | 14.46733 | 15.03 | 125.31 |
| 1992:III | 341402.0588 | 184399.06 | 12.65783 | 14.17 | 124.85 |
| 1992:IV | 325020.9496 | 183108.75 | 12.5617 | 10.8 | 126.42 |
| 1993:I | 327249.6491 | 180031.13 | 11.506 | 9.4 | 126.79 |
| 1993:II | 308127.7576 | 181479.31 | 11.5485 | 10.67 | 123.07 |
| 1993:III | 302389.4688 | 189075.56 | 11.68267 | 9.4 | 120.92 |
| 1993:IV | 314923.7911 | 191225.36 | 10.51467 | 9.4 | 123.26 |
| 1994:I | 313487.5015 | 183543.66 | 10.14667 | 9.6 | 125.48 |
| 1994:II | 333320.211 | 195046.72 | 10.63967 | 7.13 | 119.3 |
| 1994:III | 337985.2511 | 201221.75 | 10.842 | 9.13 | 118.95 |
| 1994:IV | 340492.0143 | 201395.66 | 12.183 | 9.8 | 120.48 |
| 1995:I | 327702.6077 | 196097.63 | 12.87183 | 9.97 | 119.7 |
| 1995:II | 338910.0383 | 201458.63 | 13.55817 | 10.33 | 115.33 |
| 1995:III | 335591.2673 | 208635.09 | 13.93383 | 7.76 | 119.92 |
| 1995:IV | 350593.3113 | 208336.77 | 13.8055 | 6.57 | 122.87 |
| 1996:I | 360188.5566 | 201439.13 | 14.02267 | 6.5 | 121.87 |
| 1996:II | 380804.3518 | 214523.8 | 15.31967 | 6.07 | 110.22 |
| 1996:III | 389381.3274 | 216741.06 | 15.34717 | 7.6 | 108.13 |
| 1996:IV | 398703.6411 | 215460.78 | 15.43783 | 9.13 | 107.21 |
| 1997:I | 397933.2845 | 210278.17 | 15.92117 | 9.6 | 117.85 |
| 1997:II | 408264.8136 | 219631.44 | 15.6135 | 9.37 | 121.61 |
| 1997:III | 415957.6754 | 221228.05 | 14.85067 | 8.63 | 120.41 |
| 1997:IV | 435763.9932 | 218745.44 | 14.58433 | 6.9 | 116.99 |
| 1998:I | 436166.7792 | 206932 | 13.81033 | 5.47 | 118.22 |
| 1998:II | 439986.3531 | 217489 | 14.18383 | 5.1 | 114.64 |
| 1998:III | 446611.5313 | 222535 | 20.2815 | 7.73 | 97.25 |
| 1998:IV | 450470.1512 | 221700 | 18.07567 | 9.1 | 102.07 |
| 1999:I | 435921.8006 | 203372 | 15.45767 | 8.47 | 98.45 |
| 1999:II | 449455.2957 | 220135 | 13.4885 | 7.27 | 101.11 |
| 1999:III | 443376.8286 | 219362 | 11.61 | 6.77 | 102.25 |
| 1999:IV | 465012.2364 | 223327 | 10.72167 | 6.67 | 101.94 |
| 2000:I | 450239.0718 | 211475 | 9.881833 | 7.2 | 103.09 |
| 2000:II | 445445.3654 | 222212 | 10.15083 | 7.8 | 99.43 |
| 2000:III | 436184.2975 | 232746 | 10.178 | 8 | 100.64 |
| 2000:IV | 453454.622 | 228461 | 10.20667 | 7.8 | 96.83 |

| | | | | | |
|---|---|---|---|---|---|
| 2001:I | 452835.2225 | 217861 | 10.14767 | 7.4 | 93.96 |
| 2001:II | 464012.1111 | 226290 | 10.21933 | 6.4 | 96.68 |
| 2001:III | 472254.1794 | 234430 | 9.337667 | 4.77 | 94.02 |
| 2001:IV | 486259.1512 | 235962 | 8.987 | 4.3 | 80.89 |
| 2002:I | 501597.6777 | 226016 | 9.622167 | 5.7 | 76.65 |
| 2002:II | 503976.2562 | 240391 | 11.09983 | 7.73 | 83.51 |
| 2002:III | 496837.794 | 246144 | 11.68417 | 10.4 | 81.49 |
| 2002:IV | 518259.1127 | 246445 | 12.36633 | 12.77 | 88.53 |
| 2003:I | 531179.3387 | 237855 | 12.59433 | 10.7 | 96.29 |
| 2003:II | 561872.9044 | 253532 | 12.073 | 7.77 | 100.75 |
| 2003:III | 564359.0869 | 256782 | 10.12917 | 4.67 | 105.05 |
| 2003:IV | 587742.8649 | 260792 | 7.685333 | 4.17 | 104.78 |
| 2004:I | 585397.2118 | 254298 | 7.617833 | 4.47 | 104.78 |
| 2004:II | 589150.1928 | 273335 | 7.7763667 | 4.6 | 112.56 |
| 2004:III | 592253.5158 | 278784 | 7.457667 | 3.87 | 111.72 |
| 2004:IV | 618015.6386 | 281950 | 7.2695 | 3.17 | 108.58 |
| 2005:I | 620815.0998 | 271802 | 7.230833 | 3.43 | 110.71 |
| 2005:II | 661373.8119 | 286850 | 6.808 | 3.17 | 111.54 |
| 2005:III | 669524.6431 | 295179 | 6.733167 | 3.9 | 117.35 |
| 2005:IV | 691837.6298 | 298848 | 6.8355 | 3.67 | 110.59 |
| 2006:I | 714052.452 | 294164 | 6.643667 | 3.77 | 102.44 |
| 2006:II | 751180.6583 | 310781 | 6.883167 | 4.03 | 101.03 |
| 2006:III | 740732.5675 | 317568 | 7.607667 | 5.23 | 101.13 |
| 2006:IV | 787945.6892 | 330625 | 8.300667 | 5.43 | 106.6 |
| 2007:I | 774596.0181 | 314910 | 8.549667 | 5.93 | 105.03 |

**APPENDIX2: Data (logarthms)**

| Quarter | lnRM2 | lnY | lnR | lnπ | lnER |
|---|---|---|---|---|---|
| 1990:I | 12.7997386 | 12.1115415 | 2.889816048 | 2.714694744 | 4.77987951 |
| 1990:II | 12.74872282 | 12.14448178 | 2.889538077 | 2.634044788 | 4.769242908 |
| 1990:III | 12.69608454 | 12.17276692 | 2.871594904 | 2.615203651 | 4.75660289 |
| 1990:IV | 12.71349118 | 12.12972974 | 2.864958789 | 2.681021529 | 4.777273043 |
| 1991:I | 12.75450439 | 12.10627673 | 2.840325055 | 2.672077541 | 4.802051894 |
| 1991:II | 12.7737322 | 12.1246227 | 2.816197031 | 2.714694744 | 4.808763878 |
| 1991:III | 12.74226177 | 12.1707953 | 2.811879745 | 2.745345986 | 4.813971376 |
| 1991:IV | 12.74757298 | 12.13176835 | 2.788041831 | 2.780680892 | 4.821812651 |
| 1992:I | 12.75150689 | 12.09543758 | 2.756670827 | 2.745345986 | 4.819474789 |
| 1992:II | 12.75900179 | 12.12052761 | 2.671893004 | 2.710048204 | 4.830790667 |
| 1992:III | 12.74081612 | 12.12485749 | 2.538275996 | 2.651127054 | 4.827113017 |
| 1992:IV | 12.69164492 | 12.11783552 | 2.530652502 | 2.379546134 | 4.839609697 |
| 1993:I | 12.69847861 | 12.10088506 | 2.442868638 | 2.240709689 | 4.842532175 |
| 1993:II | 12.63826977 | 12.10889693 | 2.446555558 | 2.367436065 | 4.812753299 |
| 1993:III | 12.6194711 | 12.149902 | 2.458106547 | 2.240709689 | 4.79512917 |
| 1993:IV | 12.66008596 | 12.16120791 | 2.352771425 | 2.240709689 | 4.814295946 |
| 1994:I | 12.65551477 | 12.12020785 | 2.317145573 | 2.261763098 | 4.832146383 |
| 1994:II | 12.7168589 | 12.1809944 | 2.364589468 | 1.964311234 | 4.781641329 |
| 1994:III | 12.73075754 | 12.21216281 | 2.383427481 | 2.211565695 | 4.778703237 |
| 1994:IV | 12.73814695 | 12.21302671 | 2.500041537 | 2.282382386 | 4.791483764 |
| 1995:I | 12.69986179 | 12.18636793 | 2.555041203 | 2.299580584 | 4.784988613 |
| 1995:II | 12.73348998 | 12.21333933 | 2.606989318 | 2.335052283 | 4.747797584 |
| 1995:III | 12.72364923 | 12.24834202 | 2.634319696 | 2.048982334 | 4.786824854 |
| 1995:IV | 12.76738217 | 12.24691114 | 2.625067063 | 1.882513832 | 4.811126886 |
| 1996:I | 12.79438294 | 12.21324253 | 2.640675306 | 1.871802177 | 4.802954903 |
| 1996:II | 12.85004101 | 12.27617597 | 2.729137624 | 1.803358605 | 4.702478368 |
| 1996:III | 12.87231442 | 12.28645865 | 2.730931092 | 2.028148247 | 4.683334207 |
| 1996:IV | 12.89597367 | 12.28053418 | 2.736820991 | 2.211565695 | 4.674789528 |
| 1997:I | 12.89403964 | 12.25618655 | 2.76764967 | 2.261763098 | 4.769412629 |
| 1997:II | 12.9196713 | 12.29970615 | 2.748135925 | 2.237513096 | 4.800819203 |
| 1997:III | 12.93833879 | 12.30694935 | 2.698044982 | 2.155244505 | 4.790902586 |
| 1997:IV | 12.98485608 | 12.29566396 | 2.679947665 | 1.931521412 | 4.762088461 |
| 1998:I | 12.98577997 | 12.24014552 | 2.625416863 | 1.699278616 | 4.772547295 |
| 1998:II | 12.99449899 | 12.28990355 | 2.652102583 | 1.62924054 | 4.741796784 |
| 1998:III | 13.00944444 | 12.31283967 | 3.00970914 | 2.045108863 | 4.577284982 |
| 1998:IV | 13.0180471 | 12.3090804 | 2.894566835 | 2.208274414 | 4.625658852 |
| 1999:I | 12.98521815 | 12.22279209 | 2.73810532 | 2.136530509 | 4.589548805 |
| 1999:II | 13.01579167 | 12.30199627 | 2.601837471 | 1.983756292 | 4.616209033 |
| 1999:III | 13.00217532 | 12.29847861 | 2.451866796 | 1.912501087 | 4.627420795 |
| 1999:IV | 13.049819 | 12.31639234 | 2.372266927 | 1.89761986 | 4.624384405 |
| 2000:I | 13.01753399 | 12.26186207 | 2.290698021 | 1.974081026 | 4.635602393 |
| 2000:II | 13.00682988 | 12.31138716 | 2.317555476 | 2.054123734 | 4.599453879 |
| 2000:III | 12.98582013 | 12.35770301 | 2.320228528 | 2.079441542 | 4.611549793 |
| 2000:IV | 13.02465048 | 12.3391208 | 2.323041428 | 2.054123734 | 4.572956864 |

| | | | | | |
|---|---|---|---|---|---|
| 2001:I | 13.02328359 | 12.29161252 | 2.317244122 | 2.00148 | 4.54286916 |
| 2001:II | 13.04766593 | 12.32957264 | 2.324281025 | 1.85629799 | 4.571406556 |
| 2001:III | 13.06527264 | 12.36491231 | 2.234056435 | 1.562346305 | 4.543507526 |
| 2001:IV | 13.09449699 | 12.37142605 | 2.195779089 | 1.458615023 | 4.393090207 |
| 2002:I | 13.12555364 | 12.32836107 | 2.264069499 | 1.740466175 | 4.339249605 |
| 2002:II | 13.13028444 | 12.39002204 | 2.406929793 | 2.045108863 | 4.424966385 |
| 2002:III | 13.11601888 | 12.41367201 | 2.458234934 | 2.341805806 | 4.400480313 |
| 2002:IV | 13.15823061 | 12.41489412 | 2.514977457 | 2.54709867 | 4.483341478 |
| 2003:I | 13.18285498 | 12.37941652 | 2.533246713 | 2.370243741 | 4.567364471 |
| 2003:II | 13.23903095 | 12.44324533 | 2.490971554 | 2.050270164 | 4.612642201 |
| 2003:III | 13.24344601 | 12.45598275 | 2.31541938 | 1.541159072 | 4.654436427 |
| 2003:IV | 13.28404483 | 12.47147843 | 2.039313707 | 1.427916036 | 4.651862914 |
| 2004:I | 13.28004589 | 12.44626209 | 2.030491946 | 1.497388409 | 4.651862914 |
| 2004:II | 13.28643643 | 12.51845343 | 2.051089224 | 1.526056303 | 4.723486413 |
| 2004:III | 13.29169006 | 12.53819257 | 2.009242631 | 1.353254507 | 4.715995741 |
| 2004:IV | 13.33426904 | 12.54948503 | 1.983687513 | 1.153731588 | 4.687487228 |
| 2005:I | 13.33878857 | 12.51282914 | 1.978354244 | 1.232560261 | 4.70691417 |
| 2005:II | 13.40207448 | 12.56671471 | 1.918098391 | 1.153731588 | 4.714383271 |
| 2005:III | 13.41432325 | 12.59533723 | 1.907045612 | 1.360976553 | 4.765160922 |
| 2005:IV | 13.44710657 | 12.60769036 | 1.92212962 | 1.300191662 | 4.705829669 |
| 2006:I | 13.4787117 | 12.59189271 | 1.89366407 | 1.327075001 | 4.629277261 |
| 2006:II | 13.52940146 | 12.64684376 | 1.929078866 | 1.393766376 | 4.615417502 |
| 2006:III | 13.51539493 | 12.66844725 | 2.029156555 | 1.654411278 | 4.616406818 |
| 2006:IV | 13.57718444 | 12.70874008 | 2.116335873 | 1.691939134 | 4.669083512 |
| 2007:I | 13.56009691 | 12.66004216 | 2.145892335 | 1.780024213 | 4.654246024 |