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Inflationary Expectations,
Exchange Rate and Demand for
Money in Sudan
From 1970-2003

A research submitted in partial fulfillment for the
requirements of M.Sc. in Economics

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Dedication

To my parents, my mother, who taught me persistence and perseverance, and my father, who taught me that there is always a better solution.
Acknowledgements

In conducting this study, I have received help from a number of people and organizations. In particular, I would like to express thanks to Dr. Kabbashi, who supervised the study at various stages. I shall always keep his advice to make reading my habit.

Thanks are also due to the staff of the Department of Economics for their great help, and to my colleagues and friends for useful comments and suggestions. Special thanks are due to Emoo who shared difficult times with me and made me feel that tomorrow will be better.
Contents

-Abs tract 4

1- Chapter One
- Introduction 6

2- Chapter Two
   (2-1) The theory of money demand in different schools 8
   (2-2) previous studies on Sudan money demand 27

3- Chapter Three:
   (3-1) Methodology 32
   (3-2-1) The Properties of the Data 37

4- Chapter Four Discussion of the Empirical Model
   (4-1) Background about Sudan Economy 41
   (4-2) The Empirical Model of Sudan Money Demand and the Results 48

5- Chapter Five
   (1-5) Conclusion 59

- References 61

List of tables
Table (1) Real growth of money supply, GDP and Budget Deficit (1975-1995) 44
Table (2) Unit Root Test 48
Table (3) Cointegration Analysis of Broad Money Demand 50
Table (4) Estimation Result of the ECM1 55
Table (5) Diagnostic Test of ECM1 55

List of Figures
Figure (1) the log real Broad of money 1970-2003 45
Figure (2) Expected rate of inflation 45
Figure (3) the log real narrow of Money 45
Figure (4) the log of price level 46
Figure (5) Real log of M2 and real log of GDP 46
Figure (6) log of real M1 and M2 56
Figure (7) Growth rate of log real M2 and M1 57
Figure (8) Growth rate of real M2 and GDP 57
Figure (9) the ECM1 58
Figure (10) Residual one step 58
بسم الله الرحمن الرحيم

ملخص الدراسة

الهدف من الدراسة هو تقديم دالة الطلب على النقود في السودان باستخدام بيانات السلاسل الزمنية من الفترة 1970م – 2003م مستخدمة منهجية التكامل المشترك وتصحيح الأخطاء. وجدت الدراسة التكامل الخطي لمفردات الطلب على النقود "التعريف الواسع" الدخل، سعر الصرف، المستوى العام للأسعار والتضخم المتوقع في الأجل الطويل.

جدير بالذكر أن الطلب على النقود في الأجل الطويل تعديله وتصديره بواسطة منهجية جميل من مستوي وجولس ومن ثم استخراجت الطرق في نموذج تصحيح الأخطاء.

المتغيرات التفسيرية التي تؤثر في الطلب على النقود في الفترة القصيرة تشمل الدخل، التضخم المتوقع، سعر الصرف المتغير الصدري ومتغير تصحيح الأخطاء.

أكدت الدراسة ثبات دالة الطلب على النقود عليه يمكن استخدامها في التنبؤ وتطبيقات السياسة النقدية.
ABSTRACT

The purpose of this study is to estimate the demand for money in Sudan with annual data over the period 1970-2003, using cointegration and error correction methodology.

The analysis shows that broad money, income, exchange rate, prices and expected inflation are cointegrated, thus a dynamic model for money demand is specified and estimated using Johansen and Juseluis maximum likelihood cointegration method. The calculated errors from the long-run money demand were then used in the error correction model.

The results of the cointegration analysis confirm the existence of a stable money demand.

The results of the dynamic model of money demand suggest that money demand is influenced in the short run by income, the expected inflation and the exchange rate a dummy variable was included to allow the short run model to pass diagnosis tests. The policy implications of the study and also pointed out.
Chapter One

Introduction

Finding a stable money demand function is generally considered essential for formulation and conduct of efficient monetary policy. Hence, considerable effort has been made in the empirical literature – for both industrialized and developing countries – to determine the factors that affect the long-run demand for money and assess the stability of the relationship between these factors and various monetary aggregates.

The major research problem to be addressed in this study is to empirically assess the main determinates of demand for money in Sudan paying particular attention to the impact of inflation and exchange rate movements on the estimated function, and then points to the implications of the results for decision-making.

There is limited literature on demand for money in Sudan (El Ghoul, 1977), (Dowaitz and EL Badawi, 1987) and (Abdel-Rahman, 1997) have studied the demand for money in Sudan. This study follows this literature to estimate the demand for money for Sudan. In particular we use systems cointegration analysis and error-correction modeling to examine the behavior of broad money for the period 1970-2003. The statistical properties of the study variables showed that they could be included in the cointegration analysis. The results of such analysis indicated that, the demand for broad money in Sudan is stable despite the many structural changes, for instance the move from intervention to liberalization, which happened, in the early 1992s. The analysis also suggests that, in the long run, Sudan money demand is influenced by real income, price level, exchange rate and expected inflation. In the short run money the first lag of money growth, income growth, the exchange rate movements and expected inflation influenced demand.

The rest of the study is organized as follows; chapter two contains the literature review. Chapter three explains the research methodology to be used and the empirical model. Chapter four presents the properties of the data, and the discussion of the estimation results of the money demand for Sudan. Chapter five provides the conclusion and policy implications.
Chapter Two

Theories of Money Demand in Different Schools

In this chapter we survey the early theoretical literature on the demand for money. We begin with the classical version of the quantity theory of money, which remains considerably relevant even today. Then we move on to the Keynesian liquidity preference theory and we end with Milton Friedman’s modern quantity theory.

The critical question in this literature, is how we view the effect of money on aggregate economic activity, and to what extent the demand for the money is affected by changes in the interest rate and whether the velocity of money is constant or not and monetary aggregate is the primary determinant of aggregate spending.

Then we move to transactions theories of the demand for money that take many different forms; depending on how the process of obtaining money and making transactions is modeled. To see how these theories explain the demand for money there are three developed models of this type. The Baumal – Tobin Model) the shopping – time
model and cash – in- advance model. At the end we discuss the portfolio theories of the demand for money developed by Tobin (1958) and Sergeant and Wallace (1982)

The Equation of Exchange
(2-1-1) The Classical View for Money Demand

We begin with transactions version of the equation of exchange introduced by Irving Fisher (1911), which takes the form;

\[ M^v = Pt \]

Where \( M^v \) is actual stock of money, \( v \) its transactions velocity of circulation or more simply the average number of time per period that the stock of money changes hands to finance transactions.

The equation of exchange states that the quantity of money multiplied by the average number of times that it changes hands per period in making transactions must equal the number of transactions conducted over period multiplied by the average price of which they take place “which equal value of scale”.

In the literature we find a second formalation of the equation of exchange, known as the income version of the equation of exchange

\[ M^v = PY \] (2-1)

Where, instead of the volume of transaction \( T \), real output \( Y \) appears in his equation and the income velocity (the rate of circulation of money relative to the rate of production of real income) replaces the transactions velocity so this substitution is the assumption that real income and the volume of transactions are proportionately related.

The Quantity Theory of Money

Although equation (2-1) is nothing more than an identity, it can be used to develop theory by postulating certain things about the determinants of the equation of exchange variable. In particular, assuming (as Fisher did) that real activity and money are exogenously determined, that velocity has a constant equilibrium long-run value and that within the monetary sector, the price level is the only endogenous variable, then, the
equation of exchange (2-1) can be transformed into a version of the quantity theory of money which can be written as:

\[
\bar{m}\bar{v} = \bar{p}\bar{y}
\]  

(2-2)

With bars over \( M \), \( v \), and \( y \) indicates that they are determined independently of the other variable. Equation (2-2) is the quantity theory of money, which states the conditions under which nominal income is determined by movements in the quantity of money.

Alternatively equation (2-2) can be viewed as a theory of price level determination suggesting that the equilibrium price level is strictly proportional to the quantity of money.

The quantity theory demand for money

The quantity theory of money becomes a theory of the demand for money once one assumes that money market is in equilibrium that is \( M^s = M^d = M \). in this case equation (2-2) becomes (when solved

\[
M^d = kpy \quad \text{or} \quad \frac{m^d}{p} = ky
\]

(2-3)

Where; \( k = \frac{1}{\bar{v}} \). Equation (2-3) is the long run demand for money function, interpreted from the viewpoint of the quantity theory of money. It says that the demand for nominal (real) money is proportional to nominal (real) income.

(2-1-2) The Cambridge Cash Balance Equation

The neoclassical economists in Cambridge University took a somewhat different approach within the quantity theory tradition. In contrast to the classical macroeconomic approach, the Cambridge economists took a microeconomic approach, by asking the amount of money an economic agent would wish to hold. The emphasis was therefore on choice-making behavior at the microeconomic level.

The Cambridge economists treated money as a durable yields good yielding a flow of services such as (convenience and security) and interest rates. They argued that total wealth puts an upper bound on money, holdings and that money competes with other financial assets many of which offer advantages relative to money. In this regard they
argued that the division of total wealth into money and other assets by individuals could hold it optimal only if the marginal utility of money equals the marginal utility of investment in an alternative asset.

The Cambridge school, however, significantly simplified their formal demand for money relationship; it assumes that in the short run at least an economic agent would not alter the relationship between his level of wealth, the volume of transactions, and the level of income they then argued that money demand will be a constant fraction $k$, of income as follows:

\[ M^d = kpy \quad \text{Or} \quad \frac{M^d}{p} = ky \]  

Equation (2-4) is known as the Cambridge cash balance equation. It looks similar to equation (2-3) but rests on fundamentally different notions of the role of money in the economy as we discussed.

The Cambridge economist assumed in common with Fisher that the level of real income is exogenous; suggesting that demand for money is roughly proportional to the general level of prices. Notice that under the additional assumptions that the supply of money is exogenous and that money is willingly held (so that $M^s = M^d$) the Cambridge cash balance equation also implies the quantity theory predication that nominal income is determined by the quantity of money.

However, unlike the quantity theory (who assumed that the velocity can change with changes in institutional factors, but not with changes in other variable in the economic system) the Cambridge school allowed for the possibility of interest rate effects on the demand for money in the short run. It argued that $k$ could fluctuate in the short run with fluctuations in the yields and expected returns on other assets individuals could hold.

(2-1-3) The Keynesian Approach

Although the Cambridge school pointed to the importance of variables such as interest rates and wealth, it did not explicitly include these variables in money demand function. Keynes developed this analysis in his famous 1936 book, the General Theory of Employment, Interest and Money.
Keynes studied both transaction and asset theories of money demand. He called his overall theory of the demand for money: the liquidity preference theory and distinguished three motives for holding money. We briefly review below these ideas.

**First: Transactions Motive:**
Keynes followed closely Fisher and the Cambridge school and listed the transactions motive as an important (but not the only) motive underlying the demand of money. These transactions are carried out both by private persons and businesses so Keynes divided his transactions motive into the transactions or (business) demand for money, which is a stable function of the level of income.

**Second: Precautionary Motive:**
Keynes suggested that the demand for precautionary money balances depends on the level of income and slightly on the interest rate but for most part on the level of uncertainty about future.

**Third: Speculative Motive:**
Most of the innovation in Keynes’s arose from his analysis of the demand for money is speculative demand for money as an asset along with other interest yielding assets. The primary result of the Keynesian speculative theory is that the demand for money depends negatively on the interest rate.

We illustrate the Keynesian speculative theory of money demand by dividing the assets into two broad categories money and bonds assuming that the expected return on money is zero as Keynes did (in his time, unlike today, this was a reasonable assumption, since money was mostly of the outside type). The expected rate of return on bonds is the sum of the current yield and expected rate of capital gain (or loss).

If people expect interest to increase in the future (and therefore bond prices to decline), the expected rate of return on bonds would be less than the current yield, because the expected rate of capital gain is negative. In fact, if people expect future interest rates to increase substantially, the expected rate of capital loss might out weight the current yield, so that the expected rate of return on bonds would be negative. On the other hand, if people expect a substantial decline in interest rates (and therefore a
significant increase in bond prices), the expected rate of capital gain is positive. In this case, people will hold bonds and no money for speculative purposes.

The implication of this is that the demand for speculative money balances depends on both the observable market (nominal) interest rate and people’s expectations concerning the future. The decision with respect to holding bonds or money is described in Keynes in terms of some normal value that interest rates tend to. If interest rates are above this normal value, people will expect them to fall, and bond prices tends to rise, and capital gains tends to be realized. As a result, people will be more likely to hold their liquid wealth as bonds rather than money and the demand for money will be low.

If interest rates are below the normal value, people will expect them to rise, bond prices tend to fall, and capital losses tends to be realized. They will be more likely to hold money than bonds and the demand for money will be high. In fact at some very low interest rate, everyone will expect it to rise and the demand for money in aggregate will be perfectly elastic with respect to the interest rate – this is known as the liquidity trap.

We have discussed three separate demands for money – the transaction demand, the precautionary demand and the speculative (or asset) demand for money. Combining these three demands, we get the Keynesian liquidity preference functions, describing the total demand for money as,

\[
\frac{M^d}{P} = f(R, Y)
\]  

(2-5)

With \( fR \) and \( fY \), that is the demand for real money balances is negatively related to the nominal interest rate (R), and positively related to real income (y).

One implication of the Keynesian liquidity preference theory of the demand for money, which contrasts sharply with the classical quantity theory approach, is that the velocity is not constant but instead positively related to nominal interest rates we can see this by writing down the velocity that is implied by the liquidity preference function

\[
v = \frac{y}{\frac{m}{p}} = \frac{Y}{f((r, Y))}
\]  

(2-6)

We know when the interest rate increases the demand for money declines and therefore velocity rises. Hence, in contrast to the quantity theories view of a constant
velocity the Keynesian liquidity preference theory implies that velocity is procyclical and hence procyclical interest rate movements induce procyclical velocity movements.

(2-1-4) The Monetarist Approach

The Monetarists looks at the demand for money from the point of view of money as an asset. Friedman distinguishes two types of money demander firstly: ultimate wealth holders, who demand money as one way in which to hold their wealth.

Secondly: business enterprises that demand money as a productive resource, just like plant and machinery or any other asset that contributes towards production.

In particular Friedman did not specify, as Keynes did, any particular motives for holding money, he viewed money as a durable good (an asset) yielding a flow of a number of observable services (proportional to the stock). It enters as arguments in aggregate function (i.e. utility and production functions). He also assumed that money competes with other assets (such as for example, bonds, stocks, and physical goods) for a place in individuals and business firms portfolios and that the marginal utility of monetary services declines as the quantity of money hold increases.

Friedman’s theory of the demand for money can be expressed in terms of the following demand function for money for individual wealth holder.

\[ M^d = f \left( P, ib, ie \cdot \frac{1}{P} \frac{dp}{dt}, h, y, u \right) \]  

Where:

- \( P \) = general Price level
- \( ib \) = expected nominal rate of return on bonds.
- \( ie \cdot \frac{1}{P} \frac{dp}{dt} \) = expected nominal rate of return on equities
- \( h \) = the ratio of human to non-human wealth
- \( y \) = real permanent income
- \( u \) = tastes and preferences

The function is assumed to be homogenous of degree one in prices and money income. The demand equations must be considered independent in any essential way of the nominal units used to measure money variables. Thus if prices and money income change by x percent, all other independent variables remaining unchanged then the
demand for nominal money balances will change by x percent thus equation (2-7) may be written as,

\[
\frac{M^d}{p} = f\left(ip, ie, \frac{1}{p} \frac{dp}{dt}, h, \frac{y}{p}, u\right) \quad (2-8)
\]

Or

\[
\frac{M^d}{y} = f\left(ip, ie, \frac{1}{p} \frac{dp}{dt}, h, \frac{p}{y}, u\right) \quad (2-9)
\]

Equation (2-9) can now be used to derive a velocity function. The desired income velocity of circulation of money (denoted by Vd) may be identified as the ratio of income to stock of money that people wish to hold:

\[
vd = \frac{y}{md}
\]

Therefore:

\[
\frac{1}{vd} = \frac{md}{y} = f\left(ip, ie, \frac{1}{p} \frac{dp}{dt}, h, \frac{p}{y}, u\right) \quad (2-10)
\]

Or

\[
v^d = f\left(ib, ie, \frac{1}{p} \frac{dp}{dt}, h, \frac{y}{p}, u\right) \quad (2-11)
\]

The velocity of circulation is therefore, a function of the same variables as the demand for money as can be seen from equation (2-11).

(2-2) The Developed Transactions Theories of Money Demand

(2-2-1) Interest – elasticity of the transactions demand

Baumal 1952 and Tobin 1956 have provided reasons why the transactions demand for money might be significantly interest elastic.

Money is held in transaction balances because it is convenient to do so. But holding transactions balances also involves cost. In terms of
income that is forgone. It is argued for example, that the benefit of holding money is the convenience and its cost is the interest rate income foregone.

To see how maximizing economic agent trade off these benefits, consider an individual agent who plans to spend $y$, in real terms, gradually over the course of a year, the agent has a choice of holding his wealth in the form of (non-interest-yielding) money or in the form of interest-yielding bonds. Bond yield an interest rate $R$ per period, which is assumed to be constant over the period and reflects the opportunity cost of holding money. It is also assumed that each exchange of interest-bearing bonds for money involves a lump-sum transactions cost $b$ in real term – $b$ is what Baumal calls the brokerage fees. In the setting described assuming that $k$ is the real value of bonds turned into money each time such a transfer take place, the total cost of making transactions is the sum of the brokerage cost, $b(y/k)$ where $(y/k)$ is the number of withdrawals, and the foregone interest if money is held instead of bonds which is $R(k/2)$ where $k/2$ is the average amount of real money holdings = $M/p$ thus the total cost can be written as

$$\frac{\partial \text{Total Cost}}{\partial k} = b \frac{y}{k} + R \frac{k}{2} \cdots 0$$

by taking the partial derivative of equation (2-12) with respect to $k$ setting it equal to zero and solving for $k$ we find the optimal value of $k$ – the value of minimizes total cost, as,

$$\frac{\partial \text{Total Cost}}{\partial k} = \frac{by}{k^2} + \frac{R}{2} \cdots 0$$

$$k = \sqrt{\frac{2by}{R}}$$

Which yields the square root relationship between $k$ and $y$, $b$ and $R$.

At this value of $k$ average, money holding in real terms is,

$$\frac{M}{p} = \frac{k}{2} = \frac{1}{2} \sqrt{\frac{2by}{R}}$$
It is suggested that the demand for real money balances is proportional to the square root of $y$ and inversely proportional to the square root of $R$.

(2-2-2) The Shopping Time Model

McCallum and Goodfriend (1987) and Kevin Dowd (1990) suggest the analysis of demand for money by taking explicitly into account the transactions facilitating services provided by money.

They argued that trade with money, unlike trade by barter which is inefficient and time consuming, produces large savings of what is called shopping time, such saving are desirable, because shopping time reduces leisure which in turn reduces utility. Consider an economy composed of a large number of similar, infinite lived individuals. The representative person, who can be viewed as the head of the representative extended family, has preference given by:

$$u = \sum_{t=0}^{\infty} B^t u(c_t, \ell_t)$$  \hspace{1cm} (2-13)

Where $c_t$ and $\ell_t$ are the individual’s consumption of goods and leisure respectively, during period $t$. $B$ is discount factor and within period utility function $u(u_t, l_t)$ is assumed to satisfy the conditions $u_t(c_t, l_t) > 0$ and $u_{tt}(c_t, l_t) < 0$

To bearing in the role of money, it is assumed that the representative agent holds money (even though higher – yielding assets are available) because it helps to facilitate transactions. In particular, the agent spends time (and energy) devoted to shopping is positively related to consumption, but for a given level of consumption, negatively related to real money holdings.

Of course, the greater the time (and energy) spent in shopping, the smaller the amount left over for leisure, which in turn suggests that leisure will be negatively related to consumption and positively related to real money holdings. We can summarize these ideas in the form of a function, $f$ for leisure demanded.

$$l_t = f(c_t, m_t) \hspace{1cm} f_t(0, f) > 0$$
Where \( M_t = \frac{M_t}{p} \) with \( M_t \) being nominal money balances held during period \( t \) and \( p_t \) is the price level.

\( \text{(2-2-3) Cash-in-advance models} \)

Another popular device for introducing money into macroeconomic equilibrium is the cash-in-advance constraint, proposed by Robert Clower (1967) this approach captures the role of money as a medium of exchange by requiring that a transaction can take place only if the money needed for the transaction is held in advance. Moreover, it provides an explanation as to why rational economic agent holds money an asset that is intrinsically useless.

The simplest cash-in-advance model parallels the Sidrauski shopping time models and was introduced by Stockman (1981) following Stockman (1981) we consider an economy with a representative individual with perfect foresight solving the following problem.

\[
\text{Max}_{\{c_t, k_{t+1}, M_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} B_t u(c_t)
\]  

\( (2-14) \)

Subject to a series of one period budget constraints (for all \( t \)).

\[
f k_t + v_t = c_t + k_{t+1} - (1 - \delta)k_t + \frac{M_t + 1}{p_t} - M_t
\]  

\( (2-15) \)

And \( \frac{M_t}{p_t} + v_t \geq c_t \)  

\( (2-16) \)

The first constraint is the dynamic budget constraint corresponding to asset accumulation equation of the Sidrauski model. \( M_t \) is the amount of nominal money balances carried over from the previous period \((t-1)\) and \( M_t + 1 \) is the amount of nominal balances held at the end period \( t \) and is carried forward to the next.

The second constraint, cash-in-advance constraint, according to which real money balances, carried into a given period plus the government transfer received at the start of the period cannot be less than real consumption spent during this period.

However, although the Buamol model pays attention to money’s role as a means of exchange in markets for goods and services, it does not focus explicitly on that role. It
does for example explain the holding of money in terms of the transaction facilitating services provided by money, but in terms of transactions cost, which influences money demand and consumption decisions. It is only the shopping time and Cash-in-advance models that focus explicitly on transactions services and money’s role as medium of exchange.

(2-3) Portfolio Theories of Money Demand

(2-3-1) Tobin theory of Liquidity preference

Tobin in his article “liquidity preference as behavior towards risk” reformulated Keynes’s speculative theory of money demand. He does not agree with Keynes that rational individuals decisions would be to hold either all bonds or all cash. But people hold combinations of both bonds and money and where they have diversified portfolio. And he diversified the risk to the risk lover, risk averter and risk neutral. Tobin (1958) derived his same demand for money relationship for an individual from the assumption of uncertain expectations and risk avoidance. The latter being the basis for his Nobel price in economics.

The theory of risk avoiding behavior appears to have several advantages over the Keynesian analysis of the interest elasticity of demand for money that does rest upon speculators being certain in their own minds about what is going to happen to the rate of interest. It can also explain why some people might have a positive relationship between their demand for money and the rate of interest at least over some ranges of the interest rate. The theory also provides an explanation of why portfolio are usually diversified, containing both bonds and cash as the same time the theory can account for non-diversified portfolio.

(2-3-2) Money and overlapping generations

Sargent and Wallace (1982) developed demand for money theory based on the overlapping generations model, this model has nothing to do with the means of exchange function of money.
Assume that time is discrete (induced the subscript \( t = 1, \ldots, \infty \)) that people live for two periods, and the population grows at the rate \( v \), so that by appropriate normalization \( L_t = (1 + v)^t \). people born at time \( T \) are young at \( T \) and old at \( T+1 \) in this first period of life each individual is endowed with one unit of the storable consumption goods, but receives no endowment when old. To keep things simple, assume that all agents born at time \( t \) have identical preferences and that the representative agents utility functions is given by

\[
u = u(c, t) + Bu(c_{2t} + 1)\]

Where \( c_t \) devotes the amount of the good consumed in the first period of life by an individual born in period \( t \) and \( c_{2t} + 1 \) denotes the amount that the same individual consumes in the second period of life. In other words, the first subscript gives the age of consumer and the second one gives the date (because the economy itself goes on forever).

In order to open up an intergenerational trade opportunity, introduce money into the economy by assuming that the government gives \( H \) perfectly divisible units of fiat money that can be stored between periods and assume that fiat money is not value in the future. In particular we assume that the old and every subsequent generation believed that money could be exchanged for goods at prices \( P_t \) at time \( t \) we refer to \( P_t \) as the price level.

For fiat money to have value the economy must go on forever, the supply of fiat money must be limited, and it must be impossible (or very costly) to counterfeit. In other words in such a finite lived economy, money could not be introduced at all and the economy would remain at the barter equilibrium. Hence, the assumption that the economy goes on forever is a necessary but not a sufficient condition for money to be valued if, for example, individuals had the ability to print money costless, its supply would rapidly approach infinity, driving its value to zero. This is brief idea about what is so called over generation model.

(3-4) Models of Currency Substitutions

The term currency substitution first used by Calvo and Rodriquez (1977). The phrase refers to the demand for domestic money by foreign residents and the demand by
domestic residents for foreign currency. Currencies substituted for money for many reasons, for example the differences on the rates of returns or the services that one currency offers relative to another. Models of currency substitution explain the demand for each currency to the relative rewards that they offer. Currency means demand side currency substitution. This stands in distinction from the supply side substitution that occurs under fixed exchange rate regimes. Krueger (1983) categorized models of currency substitution into two types.

(3-4-1) Monetary Models:

This model interpreted currency balance surpluses (deficits) as an excess demand (supply) for foreign currency by domestic residents.

(3-4-2) Global currency substitution Model:

This model views the relevant money supply as the world money supply. There are two motives for holding currency substitution they are transactions – based and speculative.

Global currency substitutions can be subdivided by the way they represent domestic residents’ portfolios of assets. There are two-stage portfolio allocation model. In the first stage the portfolio is divided between money and bonds. In the second stage, these independent portfolios are divided up between domestic bonds and foreign bonds and between domestic money and foreign money. McKinnon (1984) called the division of liquid assets between domestic and foreign money direct currency substitution. A single-stage portfolio allocation model uses a portfolio balance model in which all assets are available to portfolio holders and a combination of assets is chosen to maximize the return of portfolio subject to a minimal level of risk in a single decision process.

Finally, the portfolio balance model allows simultaneous and unrestricted choice between domestic and foreign money and bonds. The allocation of wealth is determined by the rates of return to the available assets, and is subject to no constraint except the total asset stocks should equal to total wealth.
This review suggests that a scale variable such as income and a measure of the opportunity cost of holding money must be included and identified in any applied work on demand for money.

(2-5) Previous Studies on Sudan

In this part we review the empirical studies, which were written about money demand in Sudan.

El Ghoul (1977) estimated a demand for money model using annual data over the period 1958-1973. He employed a partial adjustments specification and argued that the demand function in Sudan is a special case of Friedman money demand function. Although El Ghoul included the interest rate as opportunity cost for holding money but he found that it was insignificant and argued that speculative demand for money should be extremely sensitive to the yield on real assets, as approximated by relative changes in prices. Generally his results confirmed the relevance of the partial adjustment specification for studying demand for money in Sudan.

Also Andrew and Evants (1980) specified a demand for money function, for a group of countries including Sudan, of the following form:
\[
\ln\left(\frac{M}{p}\right) = a_0 + a_1 \ln\frac{p}{p-1} + a_2 \ln\frac{y}{p}
\]

Where:

- \( m \) = money stock
- \( p \) = price level
- \( p - 1 \) = price level in previous period
- \( y \) = income

They used annual data over the period (1964-1977), for Sudan money demand function they used both narrow and broad definition of money, and used gross domestic product as scale variable. Their model looks like a quantity theory demand for money it say’s that “the demand for nominal (real) money is proportional to nominal (real) income” the estimation technique they applied partial adjustment modeling technique and estimated two models for narrow and the broad definition of money. Their results for Sudan indicate that there was no difference in adjusted \( R^2 \) in the case of narrow and broad money that means these two aggregates were similar in the case of Sudan.

Although this study involved a number of limitations; for example the data employed was of poor quality and generated over a short period, nevertheless the high degree of similarity between the experiences of different countries in the sample suggests that the income elasticity of demand for broad money probably falls in the range of 1.25 to 1.50.

Domowitz and El badawi (1987) employed an error-correction modeling strategy. They organized their work as follows first they provided a theoretical basis for demand for private balances, which distinguishes between the long-run equilibrium relations and short-term adjustments. Then estimated the model for Sudan, the model takes the following form:

\[
M^* = k + \beta_0p + \beta_1y + \beta_2e + \beta_3\Delta P, \text{ Where;}
\]

\( M^* \) = desired nominal balances
\[ p = \text{the price level} \]
\[ y = \text{income} \]
\[ e = \text{the exchange rate (Sudanese Pound relative to the US dollar)} \]
\[ \Delta p = \text{the rate of inflation} \]

They used annual data over the period 1956-1982, the model used inflation rate as opportunity cost for holding money following Gangn (1956). The exchange rate was added to pick up the direct opportunity cost effect of holding foreign exchange as alternative to domestic real balances.

The estimated results of the model showed that elasticity of income effects on cash balances was 0.18 at the level of variable. Thus the long-run homogeneity assumption can not be substantiated from their results. The short-run adjustment elasticity was 0.43. The effect of the disequilibrium error-correction term is not large it was estimated at (-0.18) which implies a relatively slow adjustment to equilibrium following a shock.

Abd El Rahman (1997) attempted to investigate the effects of high inflation on the adjustment and error correction mechanisms governing basic money demand function in Sudan. He used a model based on quantity theory of money and Gagan type mechanisms, which suggests that demand for real money balances is predominantly explained by inflation. Abd El Rahman substituted the interest rate by inflation for many reasons, first organized money capital markets simply do not exist, second interest rate were never taken seriously most of time they were pegged and third interest rates were abolished within an Islamization package in (1984). Abd El Rahman examined the stability of basic function and investigated the possibility of structural breaks. The basic model was specified as follows:

\[
(M - p) = f(y, P^e) + \Sigma
\]

Where:
\[
(M - p) = \text{the natural log of the desired stock of money}
\]
\[ y = \text{the natural log of real income} \]
\[ P^e = \text{expected inflation rate} \]
He used quarterly observation over the period (1970-1991). Quarterly observations were generated by use of larrngian interpolation procedure. To check for stability in the absence of prior information about the exact period of break, he employed a simple method which requires the estimation of the original equation in first difference and then uses the estimated residuals to identify possible points of breaks. Two periods of breaks were identified; the first being at 1979: 1 and the second being at 1987:1. Next he re-estimated the basic equation using dummy variables in means and slopes of the income variable to account for structural changes. The results confirmed the significance of structural shift dummies.

Then he extended the basic function as follows;

\[(M - p)' = f(y - P^*, prem, Msurp, Seign) + \Sigma\]

Where:

- \(Msurp\) = surprise money
- \(Seign\) = seigniorage
- \(prem\) = premium

The idea is to cater for the dynamics; he applied Hendry general-to-specific modeling strategy starting from a general dynamic Autoregressive distributed Lag ADL.

His results confirmed the significance of the all the variables included in the determination of the demand for money function for Sudan. More important, the error correction coefficient was estimated at (-0.014) which was small in magnitude and found insignificant. The estimated partial adjustments the EC term was 0.021 which was also small in magnitudes however was significant implying that the current change in real balances is related to its past level but with low speed of adjustment. Thus he concluded that inflation significantly affects the speed of adjustment to the equilibrium demand for money following a shock.
Chapter three

(3-1) The Methodology

This study used quantitative techniques consisting of both econometrics model and statistical methods.

The study followed the approach of Error Correction Mechanism focusing on the short-run dynamics while making them consistent with long-run equilibrium. Cointegration is a new statistical concept that is introduced into the economics literature by Engle and Granger (1987). And have been used widely in studies concerning financial time series. The individual time series should be non-stationary for inclusion in the cointegration analysis. Below we show the technique for testing for stationarity.

(3-1-1) The Stationarity:

Every empirical work based on time series data should first test for stationary before running any estimation to avoid the problem of spurious regression [when running two time series together and obtains a very high $R^2$ although there is no meaningful relationship between the two variables]. Unit root test is performed to test for the stationary of variables. Dickey and Fuller (1979) (AD) propose a testing method that we use in the study. The simple form of the DF test could be expressed as:

$$\Delta y_t = \delta y_{t-1} + U_t$$  \hspace{1cm} (3-1)

DF test equation with a constant:

$$\Delta y_t = \alpha + \delta y_{t-1} + U_t$$  \hspace{1cm} (3-2)

DF test equation with a constant and trend:

$$\Delta y_t = \alpha + \beta \text{trend} + \delta y_{t-1} + U_t$$  \hspace{1cm} (3-3)

ADF test equation:

$$\Delta Y = \alpha + \beta \text{trend} + \delta y_{t-1} + \sum_{i=1}^{k} \lambda_i \Delta y_{t-i} + \epsilon_i$$  \hspace{1cm} (3-4)

Where;

$Y_T$ = the variable under study
$U_t$ = random variable  $U_t = \text{IID (0.62)}$

The null hypothesis is that $\delta = 0$ and alternative hypothesis $\delta < 1$. 

The Augmented Dickey and Fuller (ADF) allows for lags of length \( k \) in estimation of the coefficient \( \delta \). The series is stationary if \( \delta \) is significantly different from zero i.e. \( \delta \neq 0 \).

Simply we can calculate the D.F. statistic and compare it with Mackinnon critical value using Microfit defaults. Then we test the null hypothesis and alternative hypothesis. If the critical value less than the calculated value of D.F statistic we reject the null hypothesis \( \delta = 0 \) and this means that the variable under study is stationary Johnston (1997) and if the critical value is more than the calculated value of D.F. statistic we support the null hypothesis \( \delta \neq 0 \) and this means the variable under study is not stationary.

(3-1-2) Cointegration:
Cointegration is relatively new statistical concept introduced into economics literature by Engle and Granger (1987). It is designed to deal explicitly with the analysis of the relationship between integrated series in particular, it allows individual time series to be integrated but requires a linear combination of the series to be stationary.

The basic idea behind cointegration to search for a linear combination of individually integrated time series that itself is stationary.

Cointegration in multivariate system
The Johansen ML Approach:
Engle and Granger suggested a two equations method for cointegration analysis; however we use Johansen and Juselius procedure, which is a multivariate generalization of the ADF test. Johansen and Juselius (1992) consider the following \( p \)-dimensional vector autoregressive (VAR) model of order \( k \)

\[
X_t = \sum_{i=1}^{k} A_i X_{t-i} + \varepsilon_t
\]  

(3-5)

Where \( X_t \) is \( p \times 1 \) vector and \( \varepsilon_t \) is an independently distributed \( p \)-dimensional vector of innovations with zero mean and variance matrix \( \Sigma_u \).

The maximum likelihood estimation and likelihood ratio test of this model has been investigated by Johansen (1988) and can be described as follows. First letting \( \Delta = 1-L \), where \( L \) is log operator, equation (3-5) can be expressed as;
\[ \Delta X_t = \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \pi X_{t-1} + U_t \] (3-6)

Where
\[ \Gamma_i = -(I - \sum_{j=1}^{i} A_j) \] and \[ \pi = -(I - \sum_{i=1}^{k} A_i) \] (3-7)

With the PXP ‘total impact’ matrix \( \pi \) containing information about the long-run relationship between the variables in \( X_t \).

In the context of (3-6), the number of distinct cointegrating vectors that exist between the \( P \) elements of \( X_t \) will be given by the rank of \( \pi \), devoted as \( r \). The rank of a (square) matrix is the number of linearly independent rows (Columns) in the matrix and is given by the number of its ‘eigenvalues’ that significantly different from zero.

In the context of (3-6), if \( \pi \) consists of all zeros, its characteristic equation has solution \( \lambda_1 = \lambda_2 = \cdots = \lambda_p = 0 \) and rank \( \pi = 0 \) where \( \lambda \) means an eigenvalue (or characteristic root). In this case, (3-5) is the usual VAR model in the first differences and there are \( p \) unit roots and no cointegration.

Johansen proposes two tests for the number of distinct cointegrating vectors – the trace and maximum eigenvalue tests. In the trace test, the null hypothesis that there are at most \( r \) cointegrating vectors is tested (against a general alternative) by calculating the test statistic;
\[ \lambda_{\text{trace}(r)} = -T \sum_{t=r+1}^{\hat{\lambda}_i} \log(1 - \hat{\lambda}_i) \]

Where \( \hat{\lambda}_i \) \((i = 1, \cdots, p)\) are the estimated eigenvalues obtained from the estimated \( \pi \) that has solutions \( \lambda_1 = \lambda_2 = \cdots = \lambda_p = 0 \). In this case each lag \( (1 - \hat{\lambda}_i) \) will equal zero (since \( \log 1 = 0 \)) and \( \lambda_{\text{trace}} \) equal zero, the more negative is each of expressions lag \( (1 - \hat{\lambda}_i) \), and the larger the \( \lambda_{\text{trace}} \) statistic.
In the maximum eigenvalue test, the null hypothesis of \( r \) cointegrating vectors is tested against the alternative of \( r+1 \) cointegrating vectors by calculating the test statistic
\[
\lambda_{\text{max}}(r;r+1) = -T \log \left( 1 - \hat{\lambda}_{r+1} \right)
\]

Again if the estimated eigenvalue, \( \hat{\lambda}_{r+1} \), is close to zero, \( \lambda_{\text{max}} \) will be small and the null hypothesis that the number of cointegrating vectors is \( r \) will not be rejected.

(3-1-3 Error Correction Models:

If cointegration relationship is identified \( \hat{\Sigma}_t \) is integrated of order zero, then according to the Engle and Granger representation theorem there must exist an error correction representation relating current and lagged first difference at \( y_t \) and \( x_t \) at least one lagged value of \( \hat{\Sigma}_t \). The error correction model can be-written as:
\[
\Delta y_t = \beta_1 + \beta_y \hat{\Sigma}_{t-1} + \sum_{j=1}^{s} \beta_{1j} \Delta y_{t-j} + \sum_{j=1}^{s} B_{1j} \Delta x_{t-j} + v_t, \quad (3-8)
\]
\[
\Delta x_t = \beta_2 + \beta_x \hat{\Sigma}_{t-1} + \sum_{j=1}^{r} \beta_{2j} \Delta y_{t-j} + \sum_{j=1}^{s} B_{2j} \Delta x_{t-j} + v_t, \quad (3-9)
\]

Where \( \beta_1, \beta_2, \beta_y, \beta_x, \beta_{1j}, \) and \( \beta_{2j} \), are all parameters \( \sum y_t \) and \( \sum x_t \) are white noise disturbances and \( \hat{\Sigma}_{t-1} \) estimates the deviation from long – run equilibrium in period \( t - 1 \).

The purpose of error correction model is to focus on the short-run dynamics while making them consistent with the long-run equilibrium. In particular, the error correction model show how \( y_t \) and \( x_t \) change in response to stochastic shocks, represented by \( \sum y_t \), and \( \sum x_t \) and to the previous periods deviation from long-run equilibrium represented by \( \hat{\Sigma}_{t-1} \).

Notice that \( \beta_y \) and \( \beta_x \) can be interpreted as speed of adjustment parameters. For example, the larger is \( \beta_y \) the greater the response of \( y_t \) to the previous periods deviation from long-run equilibrium.
On other hand, very small values of $\beta_y$ imply that $y_t$ is relatively unresponsive to the last period’s equilibrium error. In fact for $y_t$ to be unaffected by $x_t$, $\beta_y$ and all the $\beta_{12}(j)$ coefficient in (eq. (3-8)) must be equal to zero.

The cointegration and error-correction framework have proved to be successful tools in the identification and estimation of aggregate money demand functions. This type of approach to the demand for money captures the long-run equilibrium relationship between money and its determinants the short-term dynamics. It is in this sense that this approach represents a significant improvement over the partial adjustment specification, which severely restricts the lag structure by relying solely on ad hoc economic theory without examining the actual data.

(3-2) The Properties of The Data

The empirical studies on the demand for many starts by postulating a demand for money function. In the standard literature money is demanded because of the role it plays as a medium of exchange and as store of value. In most of empirical models demand for money is a positive function of level of economic activities and the price level “because agents demand real balances” money is also a negative function of the cost of holding it.

This study proposes five variables to be included in the empirical study corresponding to the theoretical concepts (Gross Domestic Product (GDP), broad and narrow definition of money, expected rate of inflation, parallel exchange rate and general price level.

(3-2-1) The dependent variable:

First: Money Stock:

Either theoretical considerations or empirical evidence is conclusive in demonstrating aboard definition of the money stock [all the deposit liabilities of the banking system] or narrow definition (covering only currency and demand deposits). However we use the broad definition of money.
(3-2-2) The Independent Variables:

First: The Scale Variable:

The most commonly used in studying the demand for money function is the gross domestic product GDP either in developed countries or under developed ones. In the case of Sudan the real GDP is the best variable for economic scale, but according to demand for money theories many variables can be use such as permanent income, wealth and current income.

Second: The opportunity Cost Variables:

There are many variables that can be used to measure the opportunity cost variable for holding money such as interest rate, the interest on other assets and the rate of inflation Cangn (1956).

In this study we used the expected inflation rate to measure the opportunity cost for several reasons: first, financial markets outside the banking system are not well developed, so that the possibilities of substitution between money and other financial assets are limited. Second, the interest rates are often centrally determined and remain unchanged for a long period for example in Sudan. The central bank changed the interest rate only six times. In December 1966 July 1973, August 1973 February 1984 November 1981 and January 1983. Third, interest rates were altogether abolished within an Islamization package in 1984. The study used expected inflation, as in Cangn (1956) and Vito Tanzi (1980), as explanatory variable in determining the opportunity cost for holding money.

These results agreeable with Modigliani’s rule of thumb and supported by Dornbusch and Fischer in their macroeconomic textbook1.

The rule of thumb states that “if the nominal interest rate exceeds the expected rate of inflation, the nominal interest rate should be thought of as the cost of holding money if the expected inflation rate exceeds the nominal interest rate, think of the expected inflation rate as cost of holding money.

---

Exchange rates:
Due to the increasing dollarization of the Sudanese economy we used the parallel rate of exchange in Sudanese pounds per dollar. This variable intended to pick up the direct opportunity cost effect of holding foreign exchange vis-à-vis domestic real balances.

The general price level:
The study used the consumer price index CPI as the price level.

The Data Sources:
The data collected from different sources, the broad definition of money M₂ and the parallel exchange rate collected form the Central Bank. The rate of inflation “consumer price index” and Gross Domestic Product (GDP) from the Central Bureau of Statistic (CBS) and Ministry of Finance.

Chapter Four
(4-1) Background about Sudan Economy
Sudan is not unlike many developed countries in the sense that, it’s economy appeared to be quite stable in the fifties and the sixties. The annual average inflation rate was modest 6.5% over the period (1958-1977) with a corresponding average annual rate of growth in real output of 3.8%.
During the 1970s the economy experienced a degree of stagnation and some inflationary tendencies. But exchange rate was fixed. It was only in 1978 that it started to fluctuate.

The idea behind liberalization of foreign exchange was to check the deficits in the balance of payments. In mid 1978 a first major devaluation was undertaken, but the devaluation of Sudanese pound occurred in 1972, 1973, 1978, 1979 and 1981, in the year of first major devolution the rate of growth in GDP decreased to -3.7% which was considered the least over the period (1978-1989). In the period of 1978 to 1982 the inflation rate grew to 23%.

Notwithstanding, the inflation developments in Sudan can be roughly divided into three periods: first there was a period of moderate to high inflation from 1970 to 1988 with annual inflation rate hovering around 20-30 percent except in 1973 and 1987 where it grew by 44 and 67 respectively. Second, there was a process of very high inflation crossing the classical threshold of hyperinflation over the 1989-1996. Third, inflation receded to 17% average rate over 1997-2002 (Kabbashi, 2005).

In the early 1980’s the economy started on descent. GDP growth averaged 0.5% against a population growth rate of 3.1%.

In the early to mid 1990’s inflation started to run loose in the economy and in 1996 it grew by 130% the highest rate of inflation in Sudan (three digit) and the exchange rate became uncontrollable (see figure 2).

If we compare the growth rate of GDP and growth rate of money supply “see table 1” we find that through the period 1975 to 1995 the growth rate of money supply was always more than the GDP growth rate which indicates excessive liquidity in the economy. The trend of the growth of money supply during the period 1975-1995 was fluctuating (see figure 1). The high growth rate of money supply caused high inflationary pressure “the highest rate was in year 1992 with a rate of inflation growing at 119%.

From 1996 to 1998 there was a severe deterioration in economy and there were many factors contributing to this deterioration, for example the inconsistency between monetary and fiscal policy, the decline in public revenue and the increasing budgets deficits and the external balance of payments deficit.
In late 1990s and early 2000s the inflation rate decreased sharply until it grew to single digit in 2000 up to 2003. This was due to the growth in real export including oil, as well as the inflow of foreign capital. The GDP growth showed a strong response to these developments it grew by 6.8 on average over the period (1999-2002) (see figure 5).

The plots of figures (6) and (7) suggest that there was no significant difference between M1 and M2 and figure (8) indicate that M2 follows GDP closely. Accordingly we use M2 in the subsequent analysis.
Table (1) Real Growth of GDP and Money Supply and Government Budget Deficit in Millions LS.

<table>
<thead>
<tr>
<th>Year</th>
<th>Real growth in GDP (1)</th>
<th>Growth in Money Supply (2)</th>
<th>Government Budget deficit (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>-0.2</td>
<td>17</td>
<td>-130.3</td>
</tr>
<tr>
<td>1976</td>
<td>24.3</td>
<td>24.90</td>
<td>-169.5</td>
</tr>
<tr>
<td>1977</td>
<td>5.2</td>
<td>42.86</td>
<td>-139.3</td>
</tr>
<tr>
<td>1978</td>
<td>1.5</td>
<td>27.49</td>
<td>-179.3</td>
</tr>
<tr>
<td>1979</td>
<td>-12.2</td>
<td>30.18</td>
<td>-154.4</td>
</tr>
<tr>
<td>1980</td>
<td>-6.6</td>
<td>29.37</td>
<td>-280.0</td>
</tr>
<tr>
<td>1981</td>
<td>19.1</td>
<td>41.99</td>
<td>-640.0</td>
</tr>
<tr>
<td>1982</td>
<td>2.8</td>
<td>41.18</td>
<td>-499.0</td>
</tr>
<tr>
<td>1983</td>
<td>-5.9</td>
<td>116.60</td>
<td>-754.0</td>
</tr>
<tr>
<td>1984</td>
<td>-14.8</td>
<td>17.63</td>
<td>-1153.0</td>
</tr>
<tr>
<td>1985</td>
<td>17.4</td>
<td>64.63</td>
<td>-2025.0</td>
</tr>
<tr>
<td>1986</td>
<td>10.1</td>
<td>27.91</td>
<td>-2767.0</td>
</tr>
<tr>
<td>1987</td>
<td>10.4</td>
<td>33.19</td>
<td>-3916.0</td>
</tr>
<tr>
<td>1988</td>
<td>3.4</td>
<td>36.12</td>
<td>-6857.0</td>
</tr>
<tr>
<td>1989</td>
<td>-26.4</td>
<td>53.32</td>
<td>-9132.0</td>
</tr>
<tr>
<td>1990</td>
<td>36.3</td>
<td>48.75</td>
<td>-2124.0</td>
</tr>
<tr>
<td>1991</td>
<td>10.1</td>
<td>67.55</td>
<td>-337.49</td>
</tr>
<tr>
<td>1992</td>
<td>11.1</td>
<td>161.62</td>
<td>-30044</td>
</tr>
<tr>
<td>1993</td>
<td>6.5</td>
<td>89.68</td>
<td>-13706.0</td>
</tr>
<tr>
<td>1994</td>
<td>7.5</td>
<td>50.92</td>
<td>-63000.0</td>
</tr>
<tr>
<td>1995</td>
<td>8.5</td>
<td>74.14</td>
<td>-9000.0</td>
</tr>
</tbody>
</table>

Source 3: Bank of Sudan. Annual Reports.
Figure (1) Log narrow money 1970-2003

Figure (2) expected rate of inflation, 1971-2003

Figure (3) Log of broad money
Figure (4) log of price level

Figure (5) Log of real broad money and real GDP

Figure (6) log of real M1 and M2, 1970-2003
Figure (7) Growth rate of real M1 and M2, 1970-2003

Figure (8) Growth rate of log real broad of money and GDP 1970-2002
In this study, we build a demand for money function of the demand for money; therefore, the desired demand for money could be specified as follows:

\[ m^d_t = \beta_0 + \beta_1 p_t + B_2 y_t + B_3 e_t + B_4 in + v_t \]  \hspace{1cm} (4-1)

Where all lower-case letters lettering, henceforth, denotes logarithms of the variables and;

- \( m^d_t \): is log desired nominal money
- \( p_t \): log of general level of price CPI
- \( y_t \): log of real GDP
- \( e_t \): log of parallel exchange rate
- \( in \): the rate of expected inflation
- \( v_t \): error term

The expected signs and the magnitudes of the coefficients are:

\[ \beta_1 < 0, \beta_2 > 0, B_3 < 0, B_4 < 0. \]

The model is based on quantity theory assuming long run demand for money at equilibrium, that is;

\[ M^d_t = M^s_t. \]

The exchange rate is added to account for the openness of the economy and to pick up the direct opportunity cost effect of holding foreign exchange as alternative to domestic real balances (currency substitutions) (see Dowaitz and El Badawi, 1987). Expected inflation is included as a measure of the opportunity cost for holding money as in Cangn argues 1956 (see Abdel-Rahman, 1997).

### (4-3) Stationarity Result

Before modeling error correction the univartate unit roots were tested to check for stationarity, the unit root tests are given for the log level and first difference (changes) of the data and the result in table (2).

**Table (2) Unit Root Tests**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Level ADF-statistics</th>
<th>Lag</th>
<th>First difference ADF-statistics</th>
<th>Lag</th>
</tr>
</thead>
<tbody>
<tr>
<td>( m_2 )</td>
<td>-2.432</td>
<td>(4)</td>
<td>-4.226 **</td>
<td>(0)</td>
</tr>
<tr>
<td>( p )</td>
<td>-3.442</td>
<td>(3)</td>
<td>-2.07</td>
<td>(3)</td>
</tr>
</tbody>
</table>
**Notes:**

ADF is augmented Dickey Fuller Test. The null is that the series tested contain until root. Each variable was expressed in log and has been included with four lags; the test includes a constant and time trend for all variables in level and constant for the variables in first differences. Asterisks * and ** denote rejection of the null hypothesis at 5% and 1% level respectively.

The results of the test statistic ADF showed that the test failed to reject the unit root hypothesis when the variables tested in levels. The ADF confirm the null hypothesis for general level of price in level and difference, while the null hypothesis is rejected for the first difference for the other variable.

**Cointegration Results**

As the results of unit root showed in table (2) we can apply the cointegration technique to estimate the long-run money demand. We used Johansen and Juselius (1990) because this method, is based on maximum likelihood optimization, and provides more robust results, especially when more than two variables involved, (see Irfan Civeir (1999). In order to test the number of cointegration relationship amongst the variables Johansen and Juselius (1990) provides two different tests to determine the number of cointegration vectors, namely trace and maximum eigenvalue tests. In this study, we include VAR in order two depending on the sequential LR test, include the time trend to capture the changes in monetary policy and devaluation. Table (3) shows the results of estimation.

<table>
<thead>
<tr>
<th>y</th>
<th>-2.3438</th>
<th>(3)</th>
<th>-3.597 *</th>
<th>(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>e</td>
<td>-2.084</td>
<td>(4)</td>
<td>-4.654 **</td>
<td>(0)</td>
</tr>
<tr>
<td>in</td>
<td>-1.674</td>
<td>(3)</td>
<td>-3.982 *</td>
<td>(1)</td>
</tr>
</tbody>
</table>
### Table (3)

**Cointegration Testing and Analysis of the Money Demand**

<table>
<thead>
<tr>
<th>Eigenvectors</th>
<th>0.70870</th>
<th>0.55059</th>
<th>0.43609</th>
<th>0.3806</th>
<th>0.16170</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null Hypothesis</td>
<td>r = 0</td>
<td>r ≤ 1</td>
<td>r ≤ 2</td>
<td>r ≤ 3</td>
<td>r ≤ 4</td>
</tr>
<tr>
<td>Rank π = r</td>
<td>38.235*</td>
<td>24.79</td>
<td>17.75</td>
<td>14.85</td>
<td>5.46</td>
</tr>
<tr>
<td>95% critical values</td>
<td>37.68</td>
<td>31.79</td>
<td>25.42</td>
<td>19.22</td>
<td>12.39</td>
</tr>
<tr>
<td>Trace-statistics</td>
<td>101.11*</td>
<td>62.87</td>
<td>38.08</td>
<td>20.32</td>
<td>5.4</td>
</tr>
<tr>
<td>95% critical values</td>
<td>87.17</td>
<td>63.00</td>
<td>42.34</td>
<td>25.77</td>
<td>12.39</td>
</tr>
</tbody>
</table>

**Normalized cointegration vectors**

<table>
<thead>
<tr>
<th>m2</th>
<th>p</th>
<th>y</th>
<th>e</th>
<th>in</th>
<th>trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.714</td>
<td>-0.561</td>
<td>0.070</td>
<td>0.0045</td>
<td>-0.117</td>
</tr>
<tr>
<td>(0.000)</td>
<td>(0.0839)</td>
<td>(0.2618)</td>
<td>(0.0696)</td>
<td>(0.080)</td>
<td>0.0172</td>
</tr>
</tbody>
</table>

**Restricted cointegration vectors**

<table>
<thead>
<tr>
<th>X² (1): 1.7327 (0.188)</th>
<th>1</th>
<th>-0.766</th>
<th>-1.000</th>
<th>0.086</th>
<th>-0.04</th>
<th>-0.095</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.000)</td>
<td>(0.1100)</td>
<td>(0.000)</td>
<td>(0.0933)</td>
<td>(-88)</td>
<td>(-0.018)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>X² (2): -4.285 (0.117)</th>
<th>1</th>
<th>-1.000</th>
<th>-1.000</th>
<th>0.253</th>
<th>0.015</th>
<th>-0.065</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.058)</td>
<td>(0.016)</td>
<td>(0.018)</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

The estimation period is (1970-2003), the VAR under 2 using the analysis included trend to capture the changes in monetary policy and devaluation Asterisk* denotes significance at 5% level number in parentheses are symptomatic standard error and numbers in brackets are p-value of the X² statistics.

As can be seen from table (3) the results of testing using á-max eigenvvalue statistics and trace statistics suggest that the hypothesis of unique cointegrating vector is not rejected.

The normalized cointegrating vector corresponding to the long-run demand for money is shown in table (3) in row number 8. As seen, the estimated coefficient for price is below unity equal -0.714 while that of income is equal -0.561. The estimated long-run coefficient for price level, rate of expected inflation, exchange rate and trend were
statistically significant and the income was not. According we proceed to impose restrictions on the estimated coefficients that are most likely to accept.

The imposition of unitary restriction on the income coefficient is accepted $X^2 = 1.7327$ (0.183) \(^2\) finally we impose unitary restrictions on the price coefficient and is accepted $X^2 = -4.285$ (0.117) the restricted long-run money demand relationship is written as \(^3\):

\[
m_2 - p = y - 0.2538E - 0.01560\text{in} + 0.0659 \text{trend} \quad (4-2)
\]

\[
(0.058) (0.016) (0.018)
\]

The restricted demand relationship of equation (4-2) reveals that the income elasticity of nominal $M_2$ is unity in consistence with the quantity theory hypothesis. The semi-elasticities of nominal money with respect to the exchange rate as well as inflation were statistically significant implying the relevance of the currency substitution hypothesis and the work of Cangn type of mechanism for Sudan. The positive trend implies that the innovation in the monetary institutions, throughout the study period, positively contributes to strengthening of the demand for money.

\[(4-5) \text{The Result of Error Correction Model:}\]

Based on cointegration analysis, the next step is to model the short-run demand for real broad money in a single equation context using error correction model (ECM). The short-run model reveals how the adjustment mechanism works to revert the system to the equilibrium condition when it is disturbed by exogenous shocks and thus deviations from the long-run level. In the case of money demand, the error correction terms (ECM) represents the disequilibrium from the long-run solution, with money adjusting in the subsequent period. The error term coefficient should have a negative sign be not large than one. The error correction model could be specified as follows:

\[
\Delta m_2 = \gamma_0 + \sum_{i=1}^{k_1} \gamma_i \Delta m_{t-i} + \sum_{i=0}^{k_1} \gamma_{2i} \Delta y_{t-i} + \sum_{i=0}^{k_1} \gamma_{3i} \Delta e_{t-i} + \sum_{i=0}^{k_1} \gamma_{4i} \Delta \text{in}_{t-i} + \lambda (ECM)_{t-1} \delta D_t + v_t \quad (4-3)
\]

\(^2\) The calculated Chi-square is followed by symptomatic P. value in parentheses.

\(^3\) Numbers in parentheses are asymptotic standard errors.
Where all the variables in the first difference and we include the real balance of broad money and we added dummy to account for the changes in fiscal policy and to capture the high inflation in Sudan during the period 1992 to 1997.

We can specify the model above and divide it into four parts. The first represents the quantity theory of money because it is exogenously determined; the price level is only endogenous variable. So the demand for real money is proportional to real income, the second part is exchange rate, which represents the currency substitution motive, which assumes that agents maximize the return on their wealth subject to given level of risk. Agents can hold different assets and switch between them simultaneously; these assets are domestic money, domestic bonds, foreign money, and foreign bonds (see Irfan Civeir, 1999). In this model the agent substituted the domestic currency with the dollar this phenomena is called dollarization (see Abdel-Rahman, 1997) and (Dowaitz and El Badawi, 1987). The third part refers to the expected inflation and this is based on Cangn hyperinflation type of mechanisms the last part is the error correction term, which accounts for the deviations from the long-run relationship. In this representation short-run dynamics is modeled by estimating in first difference.

The model is fitted to annual data over the period (1970-2003) and ordinary least square estimation was used to obtain the error correction model and the result were shown in table (4).

The $R^2$ suggests that 63 percent of variation in the dependent variable were explained by the explanatory variables. F test was high and significant implying this model is well specified. D.W test suggests that there is no auto correlation problem.

The diagnostic statistics shown in (table 5) do not indicate any misspecification in the model, except the test for non-normality of the residuals, which fail. However, since the normal distribution is only of limited importance for out inference we do not consider these results as problematic.

The estimated coefficients of the ECM were significant and consistent with the economic theory except the exchange rate that economically consistent but statistically insignificant. The coefficient on $M_2$ (-1) has negative sign and this result is similar to one
obtained by (Akinct, 2004) who argued that this sign is expected according to the evidences shown in the extensive literature on empirical money demand.

The coefficient of the ECM was negative and significant and it implies that 35 percent of disequilibrium is corrected each year.

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Coefficient</th>
<th>F-Ratio</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.4045</td>
<td>4.1285</td>
<td>(000)</td>
</tr>
<tr>
<td>Δ rm2 (-1)</td>
<td>-0.1691</td>
<td>-1.218</td>
<td>(0.234)</td>
</tr>
<tr>
<td>Δ ry</td>
<td>0.4634</td>
<td>2.4817</td>
<td>(0.020)</td>
</tr>
<tr>
<td>Δ e</td>
<td>-0.00187</td>
<td>-0.1121</td>
<td>(0.912)</td>
</tr>
<tr>
<td>Δ in</td>
<td>-0.00188</td>
<td>-1.746</td>
<td>(0.093)</td>
</tr>
<tr>
<td>ecm1(-1)</td>
<td>-0.3503</td>
<td>-3.633</td>
<td>(0.001)</td>
</tr>
<tr>
<td>D</td>
<td>-0.1533</td>
<td>-1.986</td>
<td>(0.058)</td>
</tr>
</tbody>
</table>

R² = 0.630   Adjusted R² = 0.5419   F = 7.112(0.000)
DW = 2.132

Table (5) Diagnostic Test

<table>
<thead>
<tr>
<th>Test statistics</th>
<th>LM version</th>
<th>F version</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Serial Correlation</td>
<td>1.684 (0.194)</td>
</tr>
<tr>
<td>B</td>
<td>Functional Form</td>
<td>1.0790 (0.299)</td>
</tr>
<tr>
<td>C</td>
<td>Normality</td>
<td>76.1896 (0.000)</td>
</tr>
<tr>
<td>D</td>
<td>Hetero Scedasticity</td>
<td>0.36087 [0.548]</td>
</tr>
</tbody>
</table>

Notes:
A: Language multiplier test of residual correlation
B: Ramsegs RESET test using the square of fitted values
C: Based on a test of skewness and kurtosis of residual
D: Based on the regression of squared residuals on squared fitted values
This means that agents will come back to their equilibrium line slowly following a shock to demand for money. This coefficient is greater than that obtained by (Abdel-Rahman, 1997) and (Dowaitz and El Badawi, 1987).

The one step forecast test shows the probability values where the hypothesis of parameter constancy would not be rejected as it is seen in figure (10). Overall, the parameter constancy test reveals that short term Sudan demand for real M$_2$ is stable and can be used for forecasting.

In Sudan, the interest rate, as opportunity cost, is not an important determinant of money demand (see El Ghoul 1977), (Dowitz and El Badawi 1987) and (Abdel-Rahman 1997). So the expected inflation and the exchange rate are the instruments, which affect money demand. Our analysis confirms this observation, and suggests that, either the exchange rate or the stock of money could be used in the management of the economy. An important policy implication of our analysis is that; the broad money aggregate could be used in the process of monetary targeting for inflation control in Sudan. Exchange rate stability can be effective in controlling inflation in short-run.
Figure (9) The ECM term 1970-2003

Figure (10) RES 1-step
Chapter Five

Conclusion and Policy Implication

This study used cointegration and error correction to estimate the money demand in Sudan over the period 1970-2003. The study utilized Johansen and Juselius maximum likelihood cointegration procedure to estimate the long-run money demand. Then used the OLS to estimate the short-run dynamic ECM for money demand. Overall, cointegration was confirmed among the key variables considered in the demand function and the study also indicates that the error correction mechanism is a good representation of money demand in Sudan over the period 1970-2003 period.

The factors that determined the demand for money in the short-run was income, expected inflation, the parallel exchange rate, dummies and the error correction from the long demand for money.

The study excluded the rate of interest following the arguments porposed by AlGoul (1977) Abd El Raham (1997) and Dowitz and Elbadwi (1987),

The results of the analysis provide evidence in support of the presence of currency substitution and Cangn type of mechanism in the money demand in Sudan. Thus the monetary authority should take into account the impact of the exchange rate and expected inflation in the formulation and conduction of monetary policy in the country. An important policy implication of our analysis is that; the broad money aggregate could be used in the process of monetary targeting for inflation control in Sudan. Exchange rate stability can be effective in controlling inflation in short-run.
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