UNIVERSITY OF KWAZULU-NATAL

EFFECTIVENESS OF MONETARY POLICY AND MONEY DEMAND STABILITY IN RWANDA: A COINTEGRATION ANALYSIS

By

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Abstract

In 2007, the government of Rwanda launched a medium-term programme of four years, as stated in its Economic Development and Poverty Reduction Strategy (EDPRS). A part of this programme is a prudent monetary policy which is one of the responsibilities of the National Bank of Rwanda (NBR), especially *via* its role of controlling liquidity in the national economy for ensuring macroeconomic stability. The National Bank of Rwanda adjusts base money to ensure that the level of the monetary aggregate M2 is consistent with price stability. To effectively implement this monetary policy, two conditions are necessarily required: (i) a stable demand function for money; (ii) a stable long-run relationship between the money stock and the price level. Using a cointegration analysis we investigated the effectiveness of this policy through examining whether these two conditions are fulfilled for the years 1996:Q1 to 2008:Q3. This study confirmed the stability of the money demand function and found that the money stock in the Rwandan economy and prices trend together in the long-run. Thus, targeting the monetary aggregate M2 is a good indicator of the price level. Moreover, we found that at a *five point six per cent* (5.6%) significance level, the Rwandan money market needs 3.5 quarters to eliminate a half disequilibrium discrepancy in the money demand model. At a *six point five per cent* (6.5%) significance level, the Rwandan money market needs 4.5 quarters to eliminate a half disequilibrium discrepancy in the money supply model. Monetary policy implemented by the National Bank of Rwanda remains effective as it is still possible to achieve the overall objective of price stability through targeting the monetary aggregate M2.

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Abbreviations

AFDB	African Development Bank
CGD	Centre for Global Development
CPI	Consumer Price Index
CINTEREST	Credit interest rate (interest rate on time deposit)
DINTEREST	Debit interest rate (interest rate on loans distributed)
GDP	Gross Domestic Product
EDPRS	Economic Development and Poverty Reduction Strategy
EXCHAR	Exchange rate of the Rwandan franc against the US dollar
HIPC	Highly Indebted Poor Countries
IMF	International Monetary Fund
MDRI	Multilateral Debt Relief Initiatives
MINECOFIN	Ministry of Finance and Economic Planning
M2	Monetary Aggregates
NBR	National Bank of Rwanda
Rwf	Rwandan franc
UK	United Kingdom
US	United States
US $	United States dollar

CHAPTER ONE

INTRODUCTION

1.1 Purpose of the study

Under the Poverty Reduction and Growth Facility programme that has the aim of stimulating higher economic growth in Rwanda, the government of Rwanda, under pressure from the IMF to focus on price stability, made low and stable inflation as the final objective of monetary policy. This study seeks to analyse whether price stability adopted in Rwanda from 1998 (CGD, 2007) is still effective as a monetary policy framework for the country's economic stability. It achieves this by scrutinizing the predictability of the relationships between the price level, monetary aggregates (Handa, 2000: 296), the nominal exchange rate (Oskooee *et al*., 1990, Corden, 1984, Mundell, 1963), assessing the state of equilibrium between money supply and demand, and analysing whether, in the relationship between the variation in money supply and prices, causation runs from money supply to prices as assumed in the quantity theory of money (Colander and Gamber, 2002: 185). Achieving a low rate of inflation is the main objective of policy under examination by this study, and it is hoped that if such a policy leads to a stable price level, this reduces uncertainty in the economy, and promotes the formation of optimal saving and investment, which in turn increases output and employment (Handa, 2000: 296). In contrast, with the classical theoretical analysis which separates money from real variables, Friedman restates the quantity theory of money to limit its main role to that of a theory of the demand for money (Handa, 2000: 42), adding to the relationship between money supply and prices the demand for money. Moreover, Hansen and Kim (1995: 296) argue that a stable money demand function is crucial for the effectiveness of monetary stock targeting; otherwise, the monetary authorities cannot target inflation. The stability of the demand function for money means a reasonable volatility for the velocity of money (Wallace, 1978: 365), and this requires predictability between the demand for money and inflation be feasible to estimate and reliably assess. Keynesians and monetarists (Wallace, 1978: 368) agree that stability in money demand is primarily a matter of the stability in the velocity of circulation. This study uses the cointegration approach (a recent statistical approach to modelling economic time series) (Abadir, 2004, Granger, 2004) to analyse the stability of money demand in Rwanda, and the state of equilibria in money demand and supply models. We also examine the relationship between the money supply and prices for the time period of our study.

The outcome of this study will help improve monetary policy implementation and thus strengthen macroeconomic stability in Rwanda.

1.2 Statement of the problem, background and motivation for the study

An important question for the formulation and conduct of monetary policy by a central bank concerns the appropriate variables on which it can focus as indicators of the need for such a policy (Handa, 2000: 285). Investigating monetary policy in Rwanda, Sayinzoga and Simson (2006) and Rusuhuzwa *et al.*, (2006) confirm a stable money demand function. This study examines whether the excess quantity of money supply causes inflation in Rwanda and confirms this. Therefore, the assumption of causation running from money supply to prices can be accepted, while the former study proposes the inverse. The former study covers the first quarter of 1980 until the fourth quarter of 2000 and the latter considers the first quarter of 1995 up to the fourth quarter of 2006. Rwanda has recently experienced economic and financial events which motivate us to investigate their effects on current monetary policy in Rwanda. These events are: (i) in 2006, Rwanda (AFDB, 2007), became eligible for benefiting from the initiatives of HIPC (Highly Indebted Poor Countries) and MDRI (Multilateral Debt Relief Initiatives). These initiatives led to a reduction of debt firstly by 76.6 million US dollars and later a reduction of more than a billion dollars; (ii) in January 2008, the National Bank of Rwanda (Kanimba, 2008(a): 3) recommended, in conformity with the law, that the commercial banks increase their registered capital of shareholders from 1.5 billion Rwandan francs (2.7 million US dollars) up to a minimum of 5 billion Rwandan francs (9 million US dollars); (iii) in January 2007, foreign direct investment in Rwanda as well as the acquisition of Rwandan transferable assets by non-resident foreigners was fully liberalised. Non-residents are allowed to invest in government securities and financial resident savings institutions can invest in securities abroad (NBR, 2007); (iv) the exchange rate of the Rwandan franc against major international currencies maintained the same trend that had started at the beginning of the year 2004, with a slight but continuous appreciation of the Rwandan franc against the US dollar (Kanimba, 2008(a): 4). The appropriateness of any variable as an indicator of the need for monetary policy depends upon the structure of the economy (Handa, 200: 285). Therefore, these financial and economic events experienced in Rwanda could affect the existing structure of the Rwandan economy and result in the existing monetary policy being more or less effective for economic stabilisation. Others claim one cannot comment about the effectiveness of policy before analysing the current situation **(**Issing, 2004).

Using data collected at the National Bank of Rwanda from the first quarter of 1996 to the third quarter of 2008, we reinvestigate the stability of the money demand function and price stability effectiveness. Given some insights into inflation in Rwanda, it would not be wise to establish the causes of inflation before updating research in this area, as some, such as Levacic (1978: 250), see inflation being the outcome of the reactions in one sector of the economy to events occurring in other sectors. Moreover, it is worth noting that the period of this study is characterised by important inflows of foreign reserves to Rwanda and when this is the case Obstfeld (2002) proposes that the optimal monetary policy is inflation targeting of domestic prices and allowing the exchange rate to adjust residually. Chang and Velasco (2000) and Eichengreen *et al.*, (1999) share the same view.

Considering the United States as an example, we rate that over the past ten years there has been almost no connection between money growth and inflation, and predictions of inflation based on money growth have been wrong (Colander and Gamber, 2002). This phenomenon has also been seen in other countries with highly developed financial markets like the UK, Canada, and New Zealand which are currently using interest rates as an intermediate variable to target inflation; but developing countries with undeveloped financial markets have shown a stable relationship and some of them are still using monetary aggregates as a guide for targeting inflation. However, in developing countries sometimes economic structures are sensitive to unexpected changes in the velocity of money, political crises and other shocks (Wallace, 1978) which could make for an unstable relationship between money growth and inflation. Therefore, the prediction of inflation based on money growth may not always be correct. In addition, much research confirms that inflation targeting effectiveness is required for any economic stabilisation programme to work. An example is Kohn (2004) and Amato *et al*., (2002), who show that the essential elements of inflation targeting are the announcement of a numerical inflation objective with a clear desire on the part of the central bank and the government to achieve this objective. *Via* such a process, the central bank actively adjusts its instruments whenever it comes to believe that future inflation might deviate from the target assigned.

In contrast, Neumann and Hagen (2002) argue that despite a lot of effort, empirical studies have consistently failed to show convincingly that inflation targeting has been an important factor in achieving lower inflation rates, lowering the cost of disinflation, or raising the credibility of the central bank's commitment to lower inflation. With reference to the Lucas supply function (Handa, 2000), it is worth recalling that when expected inflation is greater than actual inflation, the output supplied in the economy is affected negatively. The inflation targeting framework has been used exclusively in industrial countries like the United Kingdom, Canada, New Zealand, and Sweden. Since the late 1990s, developing countries like Chile, Israel, the Czech Republic, Korea, Poland, Brazil, Colombia, and South Africa adopted this policy (IMF, 2006). According to Nassar (2005), developing countries with undeveloped financial markets generally rely on the existence of a stable money demand function for the formulation and conduct of efficient monetary policy. In fact, Lee *et al*., (2008) and Hacker and Hatemj, (2005) deem that monetary policy only has a role to play in macroeconomic stabilisation if the money demand function is stable. Indeed, the following paragraphs of this chapter emphasize the stability of the demand function for money as highlighted by others (Mehra, 1993). In African countries, the finding confirming the stability of demand function for money is observed often. For example, in Madagascar, Nassar (2005) estimates the relationship between prices, money, and the exchange rate and finds a stable long-run relationship among a monetary aggregate, domestic prices, real income, and foreign interest rates. His error correction model shows that changes in the monetary aggregates, the exchange rate, and foreign interest rates exert a significant impact on inflation. In Nigeria, Kabir *et al*., (1995) conclude that any depreciation in black market exchange rates exerts a significant negative impact on the domestic demand for money. Before concluding, we must recall from history that the point of view among economists about inflation and economic stabilisation depends upon that period's dominant ideas. Considering, for example, the stabilisation of real variables, Keynesians agree with the idea of a trade-off between inflation and unemployment, while modern classical and monetarists argue that only an apparent trade-off exists in the short-run when there is a divergence between actual inflation and expected inflation (Delorme and Ekelund, 1983). On theoretical and empirical grounds, both classical and the Keynesian's ideas, and Nassar's, (2005) IMF working paper on money demand and inflation in Madagascar, inspire this study.

1.3 Key questions and research hypotheses

From 1998, Rwanda adopted price stability as the goal for economic stabilisation (IMF, 1998: 7). The National Bank of Rwanda utilizes the M2 monetary aggregate (NBR, 2003: 30-31) as a guide variable for price stability and the monetary base (currency plus reserves) is considered the operating target (NBR, 2003: 33). From 2004 to 2008, net external reserves had increased (Kanimba, 2008(a): 4). Therefore, the exchange rate of the Rwandan franc against major international currencies maintained a trend of a slight but continuous appreciation of the Rwandan franc against the US dollar. In 2006, Rwanda benefited from a reduction of debt due to activities of the IMF, the World Bank and the African Development Bank (AFDB, 2007). In January 2008, the National Bank of Rwanda recommended that the commercial banks increase their registered capital (Kanimba, 2008(a): 3). These changes in Rwandan economic structures lead us to formulate the following research questions:

(i) Is the stability of money demand in Rwanda, as confirmed by previous researchers, still valid given the recent structural changes in the Rwandan economy?

(ii) Do equilibria exist in money demand and supply models and does the money stock indicate the price level?

(iii) Is money demand sensitive to exchange rate changes?

Based on these questions, our research will seek to confirm the following hypotheses:

(i) The demand function for money in Rwanda is still stable given the recent changes in the Rwandan economic structure. We confirm this in section (6.5.2) and thus we answer the research question (i) in the affirmative.

(ii) Equilibria exist in money demand and supply models and the money stock indicates the price level. We show such equilibria in section (6.6.1) and answer "yes" to research question (ii). We confirm in section (6.5.4) a long-run relationship between money stock and the price level.

(iii) Money demand is sensitive to exchange rate changes. We cannot confirm this on the basis of our sample.

1.4 Objectives and chapters' outlines

In Rwanda, the NBR sets base money as an operating target with the intention of achieving the intermediate target for monetary aggregate M2, consistent with price stability which is the final objective of monetary policy. To attain the final objective of price stability, two requirements are necessary: (i) a stable demand function for money and (ii) a stable long-run relationship between the money stock and the price level (Hansen and Kim, 1995: 286). The overall objective of this study is to investigate whether these two necessary conditions still hold after recent structural changes in the Rwandan economy, highlighted in sections (1.2) and (1.3) above, since the appropriateness of a variable as an indicator of the need for monetary policy depends upon the structure of the economy (Handa, 200: 285).

In order to achieve this objective the thesis adopts the following structure. Chapter two provides the specification of the money demand function emphasizing the role of real income, an interest rate, and the exchange rate (Handa, 2000: 40). Chapter three provides an overview of the theory of monetary policy and inflation. Chapter four reviews the Rwandan monetary policy framework based on a medium-term economic programme as stated in the Economic Development and Poverty Reduction Strategy (MINECOFIN, 2007). Chapter five summarizes the statistical estimation methodology and model specification we use. Chapter six proceeds to estimate the models plus present and discuss the statistical results. We conclude in chapter seven by summarizing the main empirical results as well as their policy implications.

1.5 A brief presentation of the main empirical results

Five years ago, Sayinzoga (2005) showed that the Rwandan money market needs over five quarters to eliminate half of the disequilibrium discrepancy as the error correction coefficient was -12 % per quarter. Currently, this situation has improved positively as the empirical results presented in chapter six (section 6.6.1) proved the error correction coefficients equal to -21.5 % per quarter for money demand model and equal to -12 % per quarter for money supply model. At a *five per cent* (5%) significance level these coefficients are not statistically significant. From a macroeconomic perspective, this is good because we see that in these circumstances, the impact of a monetary policy change in the Rwandan money market to be immediate. This means that indirect monetary instruments (open-market operations, discount window facilities, and reserve ratio requirements) covered in detail in chapter four (section 4.3), properly serve the National Bank of Rwanda to match the national liquidity with economic activities. In addition to the empirical results obtained at a *five per cent* (5%) significance level, it is important to verify how the change of the probability of the sample error (p-value) can affect them. We found that at a *five point six per cent* (5.6%) significance level, the Rwandan money market needs 3.5 quarters to eliminate a half disequilibrium discrepancy in the money demand model. At a *six point five per cent* (6.5%) significance level, the Rwandan money market needs 4.5 quarters to eliminate a half disequilibrium discrepancy in the money supply model. We see that the error correction coefficient of the money demand model has increased (in absolute value) about 10 % compared to its status five years ago (see table 1.1 below) and this means an improvement in the ability of monetary policy to affect the Rwandan money markets when correcting disequilibria.

Table 1. 1 Comparison of the error correction coefficients of money demand models in Rwanda

	Study done in 2005	study done in 2010
Error correction coefficient	-12% per quarter	-21.5% per quarter
Hypothesis (t- test)	H_O : error correction coefficient=0	H_O : error correction coefficient=0
t-test.statistic (calculated)	-2.41	-1.64084
t-critical.value at 5%		-1.68
t-critical.value at 5.6 %		-1.633

1.6 Rwanda's macroeconomic context: a brief review

Rwanda is located in East Africa. Its neighbouring countries are Tanzania to the east, Burundi to the south, Democratic Republic of Congo to the west, and Uganda to the north. Rwanda has put considerable effort into its rehabilitation and promoted reconciliation amongst its citizens after experiencing a very sad history of genocide that occurred in 1994. The economy of Rwanda has been mostly characterised by internal (budget deficit) and external (balance of payments) macroeconomic disequilibria. In addition, Rwanda's exports are composed mainly of tea and coffee, whose prices are subject to fluctuations on the international market and have not been able to cover import needs (MINECOFIN, 2007).

In 2007, the government of Rwanda launched a medium-term programme (four years), as stated in the Economic Development and Poverty Reduction Strategy (EDPRS), with the aim of enhancing public investment that can serve as an engine for private investment (MINECOFIN, 2007). This economic programme is supported by the IMF under a Poverty Reduction and Growth Facility programme. The IMF's mission in Rwanda is to assess how well the Rwandan government implements this programme (IMF, 2009). Rwanda has sustained strong economic growth over the last decade, but the country is still very poor**.** Sound macroeconomic and structural policies backed by substantial donor assistance have resulted in macroeconomic stability, good growth, low inflation, higher reserves, and lower debt.

CHAPTER TWO

REVIEW OF DEMAND FOR MONEY THEORY

2.1 Introduction

"It is perhaps an overstatement to suggest that no single issue has been the concern of more economists than examining both the theoretical and empirical analysis underpinning the demand for money" (Schmidt, 2008). Some economists like Mankiw (2007) and Wallace (1978) define the demand for money as the relationship between the quantity of money that people wish to hold and the variables which determine that quantity. Delorme and Ekelund (1983) and Sánchez-Fung (2008) consider the demand for money as the key element which policy-makers emphasise for formulating and conducting a sound monetary policy. Indeed, money fulfils many functions in the economy, serving as a medium of exchange, acting as a store of wealth, being the unit of account and the standard of differed payment (Wallace, 1978). The definitions of money based on these functions are reasonable, given that no unique definition of money has been agreed upon since the gold standard system (Evans *et al*., 2008). Even *fiat* money has problems of definition as payments technology changes. Like Keynes, Friedman reiterates that money balances cannot be separated from the role they perform, and it may be each Rand held performs many functions (Handa, 2000: 44). Economic theories analysing the determinants of the demand function for money vary from the classical economists' views, through to Keynes and then monetarists, to the modern treatment of the demand for money analysis carried out by post-Keynesians (Tobin and Baumol) and new-classical economists.

Section (2.2) covers the evolution of economic theories about the demand for money starting with the traditional classical economist's ideas such as Fisher (1911) who sums up the role of money *via* the concept of the quantity theory of money ultimately underpinning a theory of the price level (Wallace (1978) and Handa (2000)). Section (2.2.1) continues with the ideas of Marshall (1923) and Pigou (1917) emphasising the desire of people to hold a definite quantity of cash balances known as the Cambridge approach to the quantity theory of money, from which we derive a preliminary demand function for money. Further, section (2.2.2) briefly explains Keynes' (1936) theories evocating the desire for individuals to hold cash balances summarised in the three ways which are known as the transaction's, precautionary and speculative motive. Keynes' ideas brought a new concept in the demand for money analysis, concerning the speculative motive for holding money balances, given that the transactions and precautionary motives are virtually addressed in the Cambridge approach of Pigou (1917) and Fisher (1911), when they examine the role of money as a medium of exchange. Keynes summarises speculative motives as a liquidity preference concept and considers money as an asset competing with other financial assets (especially bonds in Keynes' analysis) in the economic agent's portfolio. Moreover, section (2.2.2) provides theoretical refinements of the demand for money analysis which are closer in spirit to microeconomics initiated by Tobin (1956) and Baumol (1952).

Furthermore, section (2.2.3) introduces the monetarists and especially Friedman's conceptual demand for money, and concerns the factors that determine how much money people wish to hold in their portfolios under various economic states (Delorme and Ekelund, 1983, Wallace, 1978). Apart from Friedman treating the demand for money as a demand like any other durable good, he introduces the tastes and preferences of the wealth holder (Delorme and Ekelund, 1983). The orthodox analysis addressed by classical economists and Keynes is essentially macroeconomic in character and must be considered in the context of the overall economy (Wallace, 1978). Handa's (2000) Warlasian analysis is covered in section (2.2.4).

Taking into account the rationality of economic agents when analysing the demand function for real money balances, enhances the quality of its specification and improves, therefore, the precision in the predictability, for decision makers, of money balances that individuals would like to hold in the overall economy. Hence, the monetary authorities obtain a reasonable picture of the quantity of money to inject into the economy as production grows and aids them in maintaining economic stability. Nevertheless, new-classical economists such as Lucas (1972) and Sargent *et al*., (1975: 9) argue that systematic monetary policy cannot affect real income. Their view is that monetary policy cannot change real income and the unemployment level because producers systematically increase prices by the expected level of inflation prior to the introduction of the policy changes. Contemporary macroeconomic theorists reiterate the critical role of money demand and money supply for predicting and analysing the trend of real variables and price changes in the overall economy (Delorme and Ekelund, 1983). In this way, Dreger *et al*., (2009) confirm that the vulnerability of the link between money balances and the macroeconomy causes an inability to predict monetary aggregates by the central bank. Section (2.3) briefly reviews the economic theories underlying the specification of the empirical econometric model we use in this thesis and the last section summarises the main points discussed in chapter two.

2.2 Evolution of money demand economic theories:

2.2.1 Classical economists' quantity theory of money and cash balance approach

Friedman (1991: 2) considers the concept of the quantity theory of money as the relation between the quantity of money in the economy and prices. According to Friedman, the quantity theory is one of the oldest in economics. Examining how the preliminary simple form of the demand function for money is derived from the concept of the quantitative theory of money, Handa (2000) evocates the traditional classical economist's idea about expenditures carried out by economic agents in the overall economy. He elucidates in a mathematical identity that $PY \equiv MV$ (2.1) as being the total value of expenditure, (PY) which is identical to the amount of money used (M), multiplied by the number of times it has been used over and over (V). The average rate of turnover (V) is known as the velocity of money income and is a function of the density of the population, their payment habits and technical conditions available to banks and individuals. However, neither the quantity of money in the overall economy nor the price level can affect that rate of turnover, and therefore V is often assumed to be constant.

Further, Pigou (1917) and Marshall (1923) progress from the exchange equation (2.1) attributable to Fisher (1911) to the version known as the Cambridge approach for explaining cash balances. It is worth recalling that it is the Cambridge approach that provides the preliminary function of the demand for money as $M=kPY$ (2.2) (where M: money stock in the overall economy, Y: real income, P: the price level; k: the proportion of the nominal income held as cash balances), which is improved by economists like Keynesians, monetarists, Tobin, Baumol and many others. In addition to Fisher's exchange equation, Pigou and Marshall, adherents of the Cambridge School, emphasise the fraction of total expenditure that people wish to hold in the form of money. From their perspective, equation (2.2), known as the quantity theory of money, embodies the behaviour of economic agents through the parameter k which captures an economic agent's decision to hold cash balances. As such, equation (2.2) represents a demand function for money (Ritter *et al*., 2004).

After establishing the relationship between the quantity of money that people would like to hold as a fraction of their expenditures and its determinants, economists strive to identify a reasonable justification for their formulation and provide comment about it. In this way, Pigou (1917) points out that unforeseen future circumstances (security, increase of prices and other factors) motivates people into keeping "k." Handa (2000: 31) captures this idea in mathematical form by $M^d/Y=k(r)$ (2.3) with $k'(r) <0$, and $k'(r)$ is the first derivative of the function k with respect to r, and r stands as the internal rate of return on investment and an approximate measure for satisfaction from forgone consumption. (M^d) and (Y) represent, respectively, the ratio of money balances demanded and total expenditures. For Marshall (1926: 75) this relationship is possibly stable over the long-run, but it might fluctuate in the short-run as the result of adjustments depending on the behaviour of the economic agents.

In fact, Wallace (1978: 320) suggests these adjustments originate from psychological reasons. Indeed, Mankiw (2007:86) says that the tendency for "k" being large will influence money income to change infrequently between economic agents. This clearly means the velocity of money income need not be constant as assumed by traditional classical economists.

According to Handa (2000), the orthodox classical economists' thinking could be broadly analysed with two components in models of monetary economics. One strand embodies the quantity theory of money for the determination of prices and the other emphasises the determination of an interest rate from the loanable funds theory. For the second component, Wicksell (1898) advises the monetary authority to create additional money for keeping actual rates steady in the face of a real shock that raises the natural rate above the market rate as viewed by economic agents (lenders and borrowers) on the basis of their expectations. In this thesis, we use the former model; the quantity theory provides a theory of price determination (because it forms the basis of the ideas we analyse in this thesis) as initiated by the classical economists and improved upon by Keynesians, monetarists and modern economists in their analysis of the demand for money.

One of the common perceptions of the classical economists' theory of money relies on economic activities being consistent with the full employment equilibrium level (a situation where the labour market clears). Recalling that at this level, real income Y is assumed fixed (because all resources are used optimally) and from the assumption of a constant velocity examined in the preceding paragraphs, and also based on the quantity theory relation, one can support the proportionality idea as summarised by Ritter *et al*., (2004). This is the notion that a change in the money supply produces a proportionate change in the price level. Hence, the quantity theory of money concept is considered a theory of price determination. Many others economists and researchers agree with this idea, for example Colander and Gamber (2002), Handa (2000), Mankiw (2007) and many others.

In summary, it is worth recalling the main outcomes from the classical analysis surrounding money demand theories: these are: (i) $M=kPY$ (2.4): This equation, known as the Cambridge version of the quantity theory of money, embodies the behaviour of economic agents and it can be interpreted as *a* *money demand function*; (ii) The velocity of money is assumed constant and real income is fixed at its full employment level; therefore a change in the money supply leads to a proportionate change in price level; hence the neutrality of money (all changes in the money supply do not affect the real value of all variables in the economy) and this separation of prices from values is the essence of the so-called classical dichotomy where the real values of the endogenous variables in the economy are independent of the nominal money supply and the price level.

2.2.2 Review of Keynesian and Post-Keynesian demand for money theories

Demand for money theories have evolved parallel to economic thought on other matters. Indeed Keynes (1936) questions, from the quantity theory (in its Cambridge school version), which is based on the assumption of an unchanged level of output and argues that changes in money supply can cause changes in output and employment. The Keynesian doctrine agrees with the passive movement of velocity as highlighted by Friedman (1991: 10), explaining that the rise in money implies a decline in velocity and *vice versa*. Therefore, Delorme and Ekelund, (1983: 136) conclude that the relationship between the money supply and the price level is rather indirect than direct as classical economists stipulate. In Keynesian thinking, it is practically impossible for an economy to be in full employment equilibrium. Keynes deems that even if this happens, this state could only exist for a very short time and any deviation from full employment can take longer (or never return) to that equilibrium level consistent with full employment. Handa (2000: 18) justifies Keynesian thinking using the concept of involuntary unemployment and price stickiness (hesitation on the part of businesses to raise prices because of the high cost incurred in communicating new prices to customers) both of which are encountered frequently in any economic agent's life.

In the controversy over the analysis of the classical economist's dichotomy, Keynes (1936) endeavours to integrate the money supply transmission mechanisms with the chain of causation running from the money supply to real output with a value theory explained by changes in real output and prices. Further, Maxwell (1995) highlights the importance of considering explicitly the existence of the opportunity cost of holding money balances advocated in the main by Keynes under the concept of liquidity preference. In fact, as Handa (2000) defines the demand for money balances as the desire of economic agents to hold a certain level of the stock of money and that individuals incur the inherent cost of holding money; it seems reasonable to consider the yields on assets that substitute for money when analysing the determinants of that desire.

In this way, when trying to motivate a demand function for money, Keynes (1936) identifies three basic reasons for pushing economic agents towards holding money balances. They hold transaction balances in order to bridge the gap between planned receipts and expenditures; they keep precautionary balances to meet unforeseen contingencies. Finally, they may hold speculative balances if they expect the market value of alternative assets to fall.

2.2.2.1 The transactions demand for money

When analysing the factors that motivate people to hold cash balances, Keynes (1936) views the transaction motive as the need for holding cash balances to pay for current transactions of personal and business exchanges. In this way, Handa (2000: 36) reiterates Keynes' ideas; Wallace (1978: 324) relates this motive for holding money balances to day-to-day economic dealings; and Delorme and Ekelund (1983: 103) reaffirm these ideas.

Considering economic agents as an example of households and businesses, Handa (2000) separates their transaction motives into an income-motive category and receipts from sales category, permitting them to maintain compulsory payments until the receipt of further income. Keynes (1936) encloses transaction and precautionary motives in one mathematical relation $M^{tr}=M^{tr}(Y)$ (2.5); (where M^{tr}: represents the amount of money held for transaction motives; Y: total value of the transaction) and Keynes (*op.cit*) supposes that the amount is not very sensitive to changes in the rate of interest and these balances increase in the same direction as the volume of transactions. In the same way, Ritter *et al.,* (2004: 473) bypass this idea, and argue that an increase in GDP leads to an increase in the amount of money demanded because people hold more cash to carry out the higher *level* of transactions.

Further, Wallace (1978: 324) shows the relationship between the frequency in receiving income and money balances that people and business firms wish to hold to satisfy transaction motives. According to him, the more frequent the pay period, the smaller could be the proportion of an individual's annual income that must be held to carry on day-to-day transactions. Delorme and Ekelund (1983: 103) support this idea.

2.2.2.1(a) Inventory analysis of the transactions demand for money

Handa (2000: 86) highlights the overriding input of Baumol (1952) and Tobin (1956) as enhancing Keynes' analysis of the transaction demand for money balances. With reference to Baumol (1952) and Tobin's (1956) analysis, Delorme and Ekelund (1983: 117) agree the lack of a relationship between transactions demand and an interest rate is problematic.

Clarifying this lack of dependence, Baumol (1952) bases his analysis on several assumptions and we emphasise some of them in the following discussion. Baumol, assumes for example, that money balances held do not pay interest and bonds or saving accounts do and the individual intends to convert his bonds into cash in lots of W spaced evenly through the period (see figure 2.1 and 2.2 below). From the fact that each maximum amount withdrawn (W) is spaced equally (Patinkin, 1965), it seems reasonable to assume that $1/2W=M_{tr}$ (2.6). Baumol also suggests that economic agents incur costs when converting bonds into cash balances. Further, there is no uncertainty in the timing or amount of the individual's receipts and expenditures. For the following analysis let W stand for the amount converted into cash balances as Baumol (1952) does. The fixed cost is (B_0) and variable costs (B_1). Therefore, the overall cost per withdrawal of W is (B_0+B_1W).

In fact, in financing the total expenditure Y, economic agents incur opportunity costs given that they could use that amount either as a capital investment or place it in, say, a savings account. Handa (2000) presents these opportunity costs mathematically as being $C=rW/2+B_0Y/W+B_1Y$ (2.7) where: $W/2=M$ is the average money balances based on the withdrawal, Y is the amount of the total expenditures, B_0: is a fixed brokerage cost per withdrawal, B_1: variable brokerage cost per withdrawal, and r is the rate of interest paid from the saving account. Now we need to find the optimal W rather than the maximum W.

Considering the economic agent as acting rationally and hence minimising the cost of holding transaction balances, we set the derivative of total cost with respect to W equal to zero:

$$dC/dW = d(rW/2 + B_0 Y/W + B_1 Y)/dW = d(rW/2)/dW + d(B_0 Y/W)/dW + d(B_1 Y)/dW$$

$$= r/2 - B_0 Y/w^2 + 0 = 0 \qquad (2.8)$$

and solving the equation (2.8) for (W) we get $W = (2B_0 Y / r)^{1/2}$ (2.9)

Replacing (W) by ($2M_{tr}$) in equation (2.9), as is assumed in equation (2.6), where $W/2= M_{tr}$ and solving equation (2.9) for M_{tr}, the transaction's demand function for money with an interest rate and income becomes: $M_{tr}=1/2\ W= (1/2B_0)^{1/2}\ Y^{1/2}\ r^{-1/2}$ (2.10)

Figure 2.1

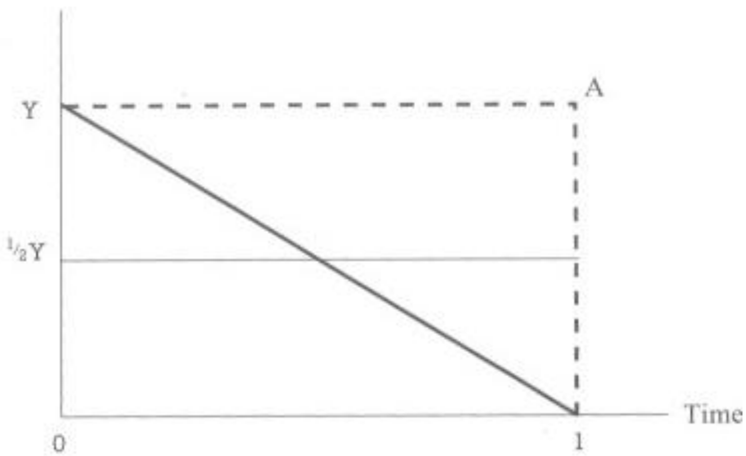


Figure 2.1: Conversion of financial assets (bond or savings) into cash balances (Source: Handa (2000: 88).

In figure 2.1, we show the problem with the interval between conversions arbitrarily set at unity. The cost minimising problem is to find the optimal time interval between conversions. Equations (2.10) is the money demand consistent with the vertical distance not set at Y but at the optimal Y, say Y*.

Figure 2.2

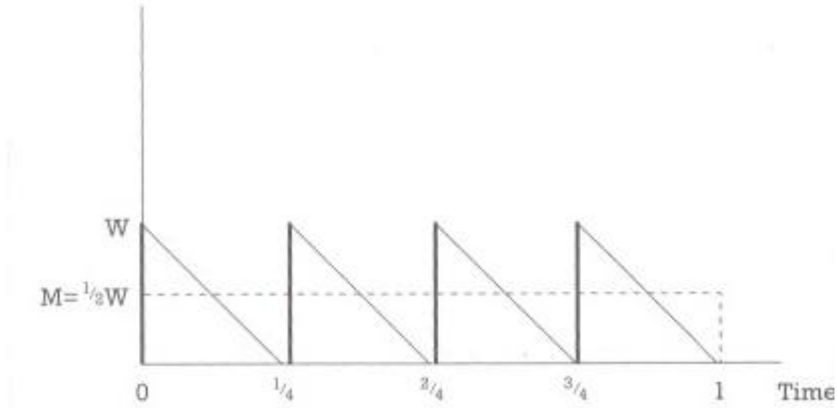


Figure 2.2: Conversion of financial assets (bond or savings) into cash balances (optimal interval=0.25). Source: Handa (2000: 88).

Figure 2.2 illustrates the amounts withdrawn (W) where for arguments sake the optimal interval (a fraction) is 0.25 giving the 'saw-tooth' diagram permitting the economic agent to finance the total expenditure Y during the given period.

In line with this model of Baumol (1952), Delorme and Ekelund (1983: 117) advocate a negative relationship between the transaction's demand for money and the interest rate and a positive one with respect to income. According to them, the awareness of this relationship is important for policy makers involved in controlling the money supply given that any effect on the interest rate may affect the transactions demand for money.

2.2.2.2 The precautionary demand for money

In the life of an economic agent, unforeseen contingencies can happen frequently. Ritter *et al*., (2004) supports this view, explaining the precautionary motive as being the desire for security, leading people to hold money balances equivalent to a certain proportion of their total resources.

In the same way, Sriram (1999: 12) highlights the uncertainty of future income and consumption needs, as justifying the precautionary motive given that all purchases have to be paid in money. As such, economic agents strive to formulate subjective expectations as to probable dates of the receipt of income and likely payments to be made.

Further, it is worth recalling that the optimality issue must always guide the rational economic agent's expectations about receiving income and payments to be made in the near future. Shedding light on this issue, Wallace (1978) suggests a negative relationship between the yields from investments and the precautionary demand for money balances. In addition, Delorme and Ekelund (1983: 105) and Laidler (1977) deem the precautionary demand for money to vary positively with the income of the economic agent when they argue that, as the income of the economic agent increases, they are able to hold more money to meet their precautionary needs.

2.2.2.2 (a) Precautionary demand for money and uncertainty

The uncertainty underlying the precautionary demand for money balances is a particular concern of economists. Based on this concern, Handa (2000) draws attention to the costs incurred by economic agents when responding to future needs through precautionary savings influenced in part by the financial and economic circumstances and personal tastes for risk. Further, assume the yield on portfolio assets is known, and capturing uncertainty of income *via* a mean and variance in the same period and drawing each realization of income from a normal distribution, the precautionary demand function for money would be $m^{prd}=m^{prd}(b\ ,r\ ,\mu_y, \sigma_y)$ (2.11), where m^{prd}: precautionary demand for money, b: real brokerage cost, r: an interest rate, μ_y: the expected value of income and σ_y is the standard deviation of income.

Under uncertainty, the economic environment and personal attitude towards risk plays a significant role in the determination of precautionary demand. As such, the precautionary demand function for money becomes: $m^{prd}=m(b, r, \mu_y, \sigma_y, \rho, \Omega)$ (2.12) where ρ measures risk aversion, Ω indicates substitutes for precautionary money balances like credit cards, overdrafts from banks and trade credit from suppliers.

2.2.2.2 (b) The precautionary demand function as an extension of the transactions demand model

The extension of the transactions demand from Baumol's (1952) analysis to the precautionary demand for money balances is based on Whallen (1966), where a penalty cost is included as an additional cost to consider over and above brokerage and interest costs. This penalty is incurred when economic agents postpone payment to another date or order the bank to convert bonds into cash balances at short notice. As such, the total cost function incurred by an economic agent is $C=rM+B_0Y/W+\beta p\ (N>M)$ (2.13) , where C: the nominal cost of holding precautionary (including transactions) balances, M: money balances held, B_0: the nominal brokerage cost per withdrawal, Y: total (uncertain) nominal income/expenditures, W: amount converted each time from interest bearing bonds, N: net payments (expenditure less receipts), $p\ (N>M)$: probability of N>M, β: nominal penalty cost of a shortfall in money balances (Handa, 2000: 131).

As we saw in our previous discussion (section 2.2.2.2) of the precautionary demand for money, we are now dealing with an economic agent who strives to minimise his total opportunity costs function from holding cash balances, allowing him to postpone payments or ordering his bank to convert bonds into cash balances for meeting unforeseen contingencies at very short notice but with penalty. In this context, the additional costs of a shortfall in money balances emphasises these penalty costs and they increase the existing brokerage and interest costs.

To continue the analysis, we rely on Handa (2000) who assumes that the economic agent holds precautionary money balances $M=k\sigma_N$ (2.13'), where σ_N is the standard deviation (this is because these payments in the future are not certain) of net payments N, and by Chebyscheff's inequality stipulating that p (for $-k\sigma_N > N > k\sigma_N$) $\leq 1/k^2$ with k>1. Further, when an economic agent is estimating desired M, Handa (2000: 131) supposes this economic agent to be sufficiently risk-averse and consequently the decision is determined by the maximum value for the probability that payments can exceed precautionary money balances. Therefore, from Chebyscheff's inequality p (for $-k\sigma_N > N > k\sigma_N$) $\leq 1/k^2$ we have an equality $p\ (N > k\sigma_N) = 1/k^2$ and then by replacing k with M/σ_N as assumed in equation (2.13'), we obtain $p(N > M) = 1/\ (M/\sigma_N)^{\ 2}$ (2.14). The aim here is to get a measurable quantity to replace the probability expression in the total cost formula and then proceed to the minimisation process. After minimizing, one obtains the optimum level of precautionary cash balances to hold and provides the determinants of precautionary balances.

Further, after replacing *p* (N >M) by $1/(M/\sigma_N)^2$ in equation (2.13) we get $C=rM+B_0Y/W+\beta\sigma_N{}^2/M^2$ (2.15) and as in Baumol's (1952) analysis, taking into account the assumption that M=1/2W results in the cost equation becoming $C=rM+1/2\ B_0Y/M+\beta\sigma_N{}^2/M^2$ (2.16).

An economic agent minimises the total costs they incur in holding precautionary balances, Handa (2000: 131) applies the usual method of taking the partial derivative of equation (2.16) with respect to M. It is worth recalling that we are dealing with uncertainty as regards income and payments and this justifies why the total cost function C (2.16) has the variables Y and M rather than just Y as in Baumol's (1952) analysis. By setting the partial derivatives of the equation (2.16) with respect to M equal to zero, we obtain:

$$\partial C/\partial M = \partial(\mathrm{rM} + 1/2\mathrm{B}_0\mathrm{Y/M} + \beta\sigma_N{}^2/\mathrm{M}^2)/\partial M$$

$$= \partial(\mathrm{rM})/\partial M + \partial(1/2\mathrm{B}_0\mathrm{Y/M})/\partial M + \partial(\beta\sigma_N{}^2/\mathrm{M}^2)/\partial M$$

$$= \mathrm{r} - 1/2\mathrm{B}_0\mathrm{Y/M}^2 - 2\beta\sigma_N{}^2/\mathrm{M}^3 = 0 \quad (2.17)$$

Multiplying equation (2.17) by M^3 and assuming that the brokerage cost B_0 is zero (for simplicity) and solving for M gives us the precautionary demand for money as $M^{pr} = (2\beta)^{1/3} r^{-1/3} (\sigma_N{}^2)^{1/3}$ (2.18). From equation (2.18), we can see that the precautionary demand for money depends upon the variance, $\sigma_N{}^2$, of income and payments, and not necessarily on the level of income itself. To get the familiar function embodying the level of income as one of the determinants of money demand, Handa (2000: 132), assumes a normal distribution of net payments, and argues that the variance of receipts and payments could increase proportionately with Y^2. One possible function is $\sigma_N{}^2=\alpha Y^2$, where α stands as a constant depending on the time frequency of receipts and payments. Replacing $\sigma_N{}^2$ by αY^2 in equation (2.18) we get our familiar (but now embodying the level of income and payments) formula of the precautionary demand function for money: $M^{pr} = (2\alpha\beta)^{1/3} r^{-1/3} Y^{2/3}$ (2.19). Notice the income elasticity is now closer to the usual level of unity.

2.2.2.2 (c) Precautionary demand for money with overdraft

As we mentioned in section (2.2.2.2 (a)), the financial and economic environment significantly influences the precautionary demand for money balances. For this reason, economists scrutinising the determinants of the precautionary demand for money take into consideration aspects of the financial and economic environment in the analysis. This includes the evolution of technology leading to the use of credit cards and quality increases in services provided by banks to customers such as getting an overdraft easily and quickly. In this way, Handa (2000) formulates from Sprenkle and Miller's (1980) analysis, the total cost incurred by rational economic agents receiving an overdraft from their bank as being:

$$C = r\int_{-\infty}^{A}(\mathrm{A - Z})\,\mathrm{f(Z)}\,\mathrm{dz} + (\rho - \mathrm{r})\int_{A}^{\infty}(\mathrm{Z - A})\,\mathrm{f(Z)}\,\mathrm{dz}, \quad (2.20)$$

where A are precautionary balances held at the beginning of the period, Z stands for payments less receipts, f(Z) is the probability distribution of Z that Miller and Orr (1966) assume is known to economic agents, with $f(\infty)=0$; r is the interest rate on bonds; ρ is the interest rate charged on an overdraft, (ρ-r) is a net loss when using an overdraft assuming ρ>r; Z is a forecast error with E(Z)=0 so that the payments and receipts over the period are equal and this clarifies why we have $f(Z=\infty)=0$. Handa (2000: 134) uses equation (2.20) to get total cost incurred by economic agents when holding precautionary money balances or obtaining an overdraft from a bank or when economic agents use a combination of the two options. Dornbusch and Fisher (1990) support this idea as they stipulate that economic agents optimise this sum of cash balances by carefully weighing the interest costs against the advantages of not being caught illiquid. Familiar from sections 2.2.2.1(a) and 2.2.2.2(b) is the procedure for optimising the total cost incurred by an economic agent so as to obtain the determinants of the demand for money. Handa (2000: 134) endeavours to do the same using equation (2.20) where the first integral $r\int_{-\infty}^{A}(A-Z)\,f(z)\,dz$ shows the probable case of covering total payments using only precautionary balances with an initial amount being equal to A and the second integral $(\rho - r)\int_{A}^{\infty}(Z-A)\,f(z)\,dz$ illustrates that payments can exceed the precautionary balances and the economic agent must consequently take an overdraft from the bank to make these extra payments. The following paragraph highlights the steps undertaken for determining the optimum precautionary money balances to hold given the alternative possibility of obtaining an overdraft.

By setting up the derivative of the total cost C (equation 2.20) with respect to the initial amount A (to hold), we have:

$$dC/dA = dC/dA \left\{ r(\int_{-\infty}^{A} [(A - Z)\, f(Z)\, dz]) + (\rho - r)\, (\int_{A}^{\infty} [(Z - A)\, f(Z)\, dz]) \right\} (2.20')$$

$$= r\, dC/dA (\int_{-\infty}^{A} Af(z)dz - \int_{-\infty}^{A} zf(z)dz) + (\rho - r)\, dC/dA (\int_{A}^{\infty} Zf(Z)\, dz - \int_{A}^{\infty} Af(z)dz)\, (2.20'')$$

It is worth noting that we get zero when taking the derivative in equation $(2.20'')$ with respect to A for the second term and the third term because they are considered as constants as they do not contain *A*. For the first term and the last term in equation $(2.20'')$, the variable *A* disappears after taking the derivative as the derivative of *A* with respect to *A* is equal to one. Hence, we obtain equation $(2.20''')$ below:

$$= r\, (\int_{-\infty}^{A} f(z)\, dz - 0\ ) + (\rho - r)\ (0 - \int_{A}^{\infty} f(z)dz)\ (2.20''').$$

After integrating equation $(2.20''')$ we obtain the following expression: $r\, |F(A) - F(z)|_{\lim Z \to -\infty} + (-\rho + r)|F(\infty) - F(A)|$ $(2.20''')$. Assuming $F(\infty) = 1$ and $F(z)|_{\lim Z \to -\infty} = F(-\infty) = 0$ as A is the cash balances held at the beginning of the period and in the context of need for an overdraft, the minimum value taken by Z (net payments) is zero, hence the cumulative probability from Z=0 to Z=$-\infty$ is zero. Also, as it is familiar to us from statistics, when we sum all values taken by the probability distribution f (Z) for all possible values assigned to Z (all probable events) we get the value one, hence Handa (2000) assumes the same and we get $F(\infty) = 1$. Therefore, from equation $(2.20''')$ and after rearranging it we obtain:

$$dC/dA = rF(A) - 0 - \rho + \rho F(A) + r - rF(A) \qquad (2.21)$$

So that, setting the expression (2.21) equal to zero and solving it for F(A) we get F(A) = $\rho - r/\rho$ (2.22). Assuming the optimum amount of cash balances held at the beginning of the period is A*, we replace A in the equation (2.22) by A* and obtain F (A*) = $\rho - r/\rho$ (2.23).

The equation (2.23) can be interpreted as the cumulative probability that the optimal cash to hold is at least equal to the need for cash. Intuitively, it is understandable that at the optimum situation (cash held is at least equal to the need for cash), precautionary balances will be zero when actual overdrafts are positive. Therefore, to obtain the demand function for precautionary money balances from an optimum amount of precautionary money balances to hold at the beginning of the period, we integrate $M^{pr} = \int_{-\infty}^{A*} (A^* - Z)\, f(Z)\, dZ$ (2.24). Assuming a normal distribution for Z with zero mean and standard deviation σ, we get from Handa (2000:134) the precautionary demand for money equal to M^{pr}=A*F (A*) + σf (A*) (2.25). Replacing the expression for F (A*) from equation (2.23) into equation (2.25) we get $M^{pr} = A^*(\rho - r/\rho) + \sigma\, f(A^*)$. Our aim in this chapter two is to gain as much information about the determinants of demand for money. For the case examined in this section (2.2.2.2(c)) we have an economic agent behaving rationally but also having the possibility of obtaining an overdraft from the bank which shows us that as the interest rate on the overdraft (ρ) increases, the economic agent holds more precautionary money balances. The inverse is true when the rate of return on investment (r) increases.

2.2.2.3 Speculative demand for money

It is said that the future does not belong to anyone. So, economic agents strive to secure their present and future profit by competing with each other in predicting what changes the market holds in store for them. Wallace (1978: 325) has this in mind and according to him, the speculative motive is securing profit from knowing better than others in the market what future prices are going to be. Under the speculative motive, money is required as an asset rather than as a medium of exchange and as such the asset is drawn upon as needed at some future date. As such, the speculative motive is connected more to the store of value function for money. Economists like Ritter *et al.*, (2004) and Delorme and Ekelund (1983) claim the speculative demand is a Keynesian innovation and Keynes (1936) himself in the General Theory of Employment, Interest and Money reveals an overriding concern for holding money balances as an asset under the liquidity preference theory.

In order to secure their profits, economic agents regularly "guess" what will happen in the future and their speculation entails future variations in interest rates and prices because of changes in the economy's political and business climate and the expected response of the central bank to those changes (Delorme and Ekelund, 1983). Further, Keynes (1936) posits a simple form of the expectation function relating individual anticipations with a decision period which implies an expected price with no variance. Therefore, at the beginning of a decision period, economic agents expect a particular rate of interest to exist and accordingly they decide to transfer their financial assets into bonds or money. Handa (2000) asserts that, if the expected bond prices plus the accumulated interest is higher than current prices, they will place all their funds in bonds rather than in money and *vice versa*. With Keynes (1936), a particular economic agent will hold either bonds or money but not both. As a result, in Keynes' analysis, the speculative demand for money depends inversely upon the rate of interest and the speculative demand function for money can be written as $M^{sp} = L(r)$ (2.26) where M^{sp} stands for speculative demand for money, r is the market rate of interest and L represents the liquidity.

2.2.2.3(a) Speculative demand for money and the liquidity trap

When economic agents form expectations about future bonds prices and interest rates, Keynes (1936) argues that the speculative demand for money becomes infinitely elastic at the rate of interest at which the bond market participants prefer holding cash to bonds. Wallace (1978: 339) reiterates that uncertainty with respect to the future is the reason justifying why economic agents prefer to hold money rather than an income earning asset. Keynes (1936) emphasises that the liquidity trap occurs at the rate of interest at which a generally unanimous opinion comes into being that the rate of interest will not fall further but may rise. Therefore, the expectations with respect to the future value for an income-earning asset become pessimistic as bonds prices are expected to fall. As a result, monetary authorities lose effective control over the rate of interest and Maxwell (1995) points out that any attempt by the monetary authority to lower interest rates by increasing the money supply fails.

2.2.2.3(b) Speculative demand for money and Portfolio selection

In the controversy with Keynes' analysis of speculative demand for money over either its bonds or money approach, Tobin (1958) shows that a rational economic agent may desire to hold a portfolio of both bonds and money (see figure 2.3 below). While Keynes (1936) focuses on the speculator's expectations about future bond prices and concludes that economic agents hold either bonds or money, Tobin (1958) emphasises utility maximisation given the income generated from allocating wealth between bonds and cash balances in a portfolio decision.

Further, Tobin (1958) sheds light on portfolio selection optimisation using expected utility. He argues that as economic and financial environment changes, an economic agent's degree of risk aversion leads him to demand a less risky asset and this affects the optimal combination of the less risky assets in the portfolio. Handa (2000) advocates this eclectic approach by emphasising the capital loss from any holdings of the risky assets whose prices are declining.

Furthermore, Tobin (1958) views money as a riskless asset with a zero rate of return and a terminal value of unity and with zero standard deviation. But, he considers bonds as a risky asset with a positive return and a positive standard deviation. By terminal value Tobin (1958) means the total value at the end of the given period for the bond and is the total of the initial investment plus the income generated during the contract period.

In a slight controversy with Tobin (1958), Fisher (1975) deems that the risk aversion behaviour of economic agents alone could not be a sufficient reason to justify holding money, because money balances are sometime subject to the risk of price level changes, and thus for Fisher the safe asset must be a bond indexed to changes in the price level.

Figure 2.3 below illustrates the combination of choices between investing in money or bonds with a slight difference in the basic theory because we assume money to have a positive rate of return just for the sake of the analysis, but this return is less than that obtained by investing in the bond.

Figure 2.3

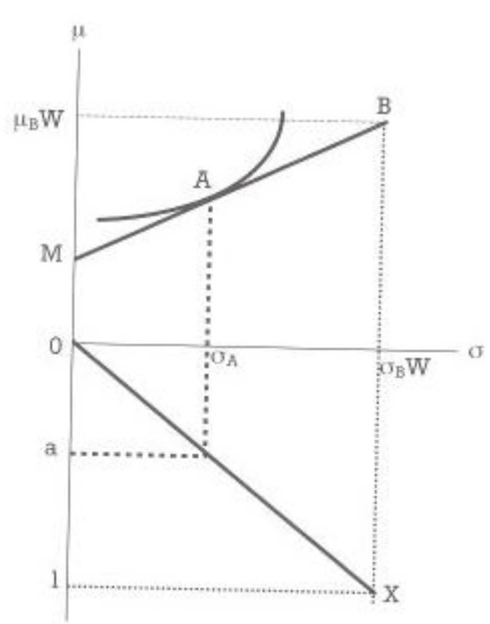


Figure 2.3: Combinations of investing in the money balances or bonds (source: Handa (2000: 112)).

Figure 2.3 presents the expected value μ of terminal wealth on the vertical axis and the standard deviation σ of wealth on the horizontal one. It shows that for an economic agent investing all his wealth in money, he is at point M and will be only in bonds at point B. Any other choice of a combination of both bonds and money is on the segment MB. In the bottom portion of this graph, choose a point on the vertical axis as 1. The distance from 0 to any point on the segment 1, is the proportion of wealth invested in bonds. The line from the origin down to the point given by (1, σ_BW) is OX. If for example the individual chooses point A, he invests the proportion *a* of his wealth in bonds and the proportion *1-a* in money. As we know money has a standard deviation of zero, therefore from the point *a* to the point *1* means no more movement on the horizontal axis. Tobin (1958) thus shows us the possibility of investing simultaneously in bonds with a standard deviation σ_A and in money with no variance.

2.2.3 Monetarist's review of demand for money theories

Monetarists, originally labelled the Chicago School, have produced ideas with significant implications for the role of money in the economy (Ritter *et al*., 2004). They adhere to all the beliefs of classical economists with slight changes. They illustrate the quantity theory as the relationship between money balances and overall economic activity rather than just the relation between money balances and prices. Further, they recognise that real output may deviate temporarily from full employment but have the invisible hand push the economy towards full employment. Furthermore, Friedman's revival of the quantity theory replaced the idea of a stable velocity with at least a predictable velocity where money demand may not be a fixed fraction of total spending but that rather there is a close and predictable relationship.

2.2.3.1 Monetarists and Challenges brought to Keynesian approach

Unlike Keynes, Delorme and Ekelund (1983) confirm that Friedman makes no distinction between the motives for holding money; rather he takes it for granted that individuals want to hold money. Economists like Handa (2000) and Wallace (1978) highlight the criticism by monetarists of the Keynesian's orthodoxy, where Keynesians stress the concept of cheap money by which rapid expansion of the money supply pushes interest rates down and expands investment. In this controversy, monetarists criticise this approach, emphasising cheap money's consequences, such as the rise and persistence of inflation which worsens the economic climate.

In addition Wallace (1978) deals with the fundamental transmission mechanism, distinguishing Keynesians' and monetarists' models. For him, the Keynesian model explains aggregate demand by a variety of factors including autonomous shifts in the consumption function of economic agents, increases or decreases in investment as a result of varying interest rates, and tax and public expenditure directed by public policy measures. In contrast, monetarists deem that what really matters are changes in the quantity of money and changes in money supply and these explain changes observed in money income, real output (in the short-run), and the price level. In the same way, the empirical study conducted by Friedman and Schwartz (1963) confirms the existence of a direct and causal link between changes in the quantity of money and changes in money income.

2.2.3.2 Friedman's demand for money analysis and the opportunity cost of holding money

In Friedman's demand for money analysis, the concern is the factors that determine how much money households and businesses want to hold in their portfolios and it is worth recalling that the allocation of wealth over different types of assets inherently involves opportunity costs. Based on this, Delorme and Ekelund, (1983) stress the rate of interest (i) and the expected rate of change in the price level $(\Delta P/P)^e$ as being important opportunity costs in Friedman's analysis. As such, a rise in the market interest rate implies an increase in the interest income on bonds and an economic agent having wealth in cash balances forgoes that income. Thus, the demand for money varies inversely with the market interest rate. Further, if the market value of physical or financial assets rises, the real value of money balances is likely to fall. Therefore, the cost of holding money balances increases with a rise in expectations of inflation.

2.2.3.3 Permanent income as the scale determinant of money demand

Apart from the determination of the opportunity cost incurred by economic agents in holding money balances, Sriram (1999) argues that an awareness of the scale determinant remains important as well, in order to get a sound and complete demand function for money from which we can approximate how changes in the money supply affect velocity and hence nominal income. Here Handa (2000: 44) helps shed light on the link between the supply and demand for money by emphasising Friedman and Keynes' views stipulating that money balances must not be separated from the function they perform in the economy, given that each unit of money balances held performs a variety of functions.

As such, economists like Levacic (1978: 169), Handa (2000), Delorme and Ekelund (1983) stress the scale variable in Friedman's analysis of demand function for money as being the wealth of economic agents and for theoretical reasons, permanent income can proxy wealth. Wealth is defined, in Friedman's analysis, according to Delorme and Ekelund (1983: 123) as being any asset generating income or services and it could be a nonhuman asset including for example bonds, equities, producer and consumer durable goods and human assets embracing for instance education, knowledge and skills and the ability to earn future income, which in turn could be used to purchase more nonhuman assets.

2.2.3.4 Friedman's demand function for money

In line with Friedman's analysis, Handa (2000) and Delorme and Ekelund (1983) lay emphasis on three most important features that determine how much real money economic agents would like to hold at any given time. Such factors could be: (i) the total wealth in all forms held by the economic agent, (ii) the opportunity cost of holding money, and (iii) the tastes and preferences of the wealth-holding unit. Therefore, the equation for the nominal demand for money is: $M^d=M^d(Y_p,w,i,\Delta P/P^e,P,u)$ (2.27) where: M^d is the nominal demand for money, Y_p is the permanent income, w is the ratio of nonhuman wealth to human wealth, i is the rate of interest, $\Delta P/P^e$ is the expected rate of change in prices, P is the price level, and u is an index representing taste and preferences. Handa (2000) strives to justify the relationship between wealth and permanent income as being specified by: $y^p=rw$ (2.28), where r is the expected average long-term interest rate. He emphasises that permanent income y^p could be seen as the expected average income over a future long period. Concerning the ratio of nonhuman wealth to human wealth, Delorme and Ekelund (1983) draw attention to Friedman's view stressing that as the ratio of nonhuman wealth to human wealth decreases, there is a larger demand for money to compensate for limited marketability of human wealth. Moving to tastes and preferences, Friedman (1969) places more emphasises on the disequilibrium between cash balances held by economic agents and the amount that they desire to hold. He points out that such a disequilibrium causes portfolio imbalance and the marginal utility of holding a unit in cash balances falls below the marginal utility of allocating it to other uses such as buying commodities or other financial assets. And the only way to restore equilibrium is to change the marginal utility of money by holding more or less of it.

In concluding this part, we would like to recall that the purpose of reviewing the monetarist's approach is to emphasise the components of a money demand function and consider their input to our empirical analysis. Being aware of the variables is relevant to us given that as we proceed with the review of the literature we are able to isolate the determinants of money demand function which is the overall objective of this chapter. From monetarists we end up with the following demand function for money: $M^d=M^d(Y_p,w,i,\Delta P/P^e,P,u)$*(the same equation as equation (2.27) above)*.

2.2.4 The demand function for money derived from utility and production functions

Theories underlying the demand function for money have clearly attracted economists, independent researchers and other academic fields presumably because of their important role in formulating and conducting sound monetary policy. Handa (2000) considers the demand for money in the overall context of the demand and supply for all goods in the economy, inspired by the Walrasian general equilibrium model, which assumes that all markets for commodities, labour, financial instruments and money will clear. Therefore, he treats real money balances as goods like any other goods in that market, thereby integrating money balances into the utility and production functions of economic agents drawing on Friedman. This analysis by Handa (2000) seems to add a little more to Friedman's demand for money concept..

2.2.4.1 Money in the direct utility function

Handa (2000) stresses that the link between money balances and the state of the economy is made stronger with a utility function expresses preferences. In this light, let the individual's one period utility function be designated as U (.)=U(x_1, ……, x_k, n, m^h) (2.29). This equation for utility has k+2 goods, consisting of k commodities, labour and real money balances and U (.) is an ordinal utility function. Where: x_k is the quantity of k^{th} commodity, k=1,…, k; n: is the labour supplied in hours; m^h: is the average amount of real money balances held by the individual/household for their liquidity services, the superscript h stands for designating the household. $U_k = \partial U / \partial x_k > 0$ (2.30) for all k, $U_n = \partial U / \partial n < 0$ (2.31), $U_m = \partial U / \partial m^h > 0$ (2.32) are the partial derivatives of the utility function with respect to each commodity (U_k), number of hours worked (U_n) and real money balances (U_m). The negative or positive signs observed in these partial derivative expressions, mean that an additional unit of each commodity ($\partial U / \partial x_k$) acquired and real money balances ($\partial U / \partial m^h$) yields positive marginal utility and an additional hour worked ($\partial U / \partial n$) generates negative marginal utility.

2.2.4.2 Money in the indirect utility function

The focus is now the overriding role of money in saving time spent for economic agents when making transactions. Clearly, this concern seems important in analysing the demand for money function; anyone can appreciate how the development of technology today allows a considerable number of transactions in quick succession. For example, by using electronic transfers to pay suppliers, employees or to purchase goods locally and abroad.

Using this idea, Handa (2000) reveals how money can be integrated into indirect utility functions which we summarise as follows: the one period utility function is: U (.)=U(c, Θ) (2.33) where c stand as consumption of commodities and Θ as leisure and U_c, U_Θ>0 are the partial derivatives of utility function with respect to the consumption of commodities and leisure and the signs show that an additional unit of goods and an extra hour for leisure provides positive utility to economic agents.

Assuming that consumption requires the purchase of goods which in turn requires shopping time and that leisure could be the time outstanding in the day after deducting the time spent working and in shopping, then leisure can be defined mathematically by the following equation $\Theta=h_o-n-n^{\sigma}$ (2.34) where: h_o is the maximum available time for leisure, work time and shopping time; n is the time spent working, n^{σ} is the time spent in shopping. Further, Handa (2000) defined the shopping time function equation as $n^{\sigma} = n^{\sigma}(m^h,c)$ (2.35), where $\partial n^{\sigma}/\partial c > 0$ and $\partial n^{\sigma}/\partial m^h \leq 0$ are the partial derivatives function of shopping time with respect to the number of purchased units of commodity and real money balances. The sign of these partial derivatives functions seem justified; intuitively it makes sense that when more money is involved in transaction activities, less will be time spent in making transactions and as economic agents spend more time purchasing goods, it will take more time to achieve that activity.

Furthermore, how important money usage is in transactions of economic agents is based on saving time in achieving them. This phenomenon is more understandable when comparing two economies: one with rigidities, for example, where it is hard to access an overdraft as lenders ask for more collateral or in another economy where the automatic means of payment are less developed and so on, compared to an economy in which all of these facilities are much more developed. The greater availability of facilities and modern means of payment in that second economy unambiguously diminishes the time spent in making a transaction. In this light, based on equations (2.33) and (2.34), $\partial U/\partial n^{\sigma} = (\partial U/\partial \theta)(\partial \theta/\partial n^{\sigma}) < 0$ (2.35) meaning that an increase in shopping time decreases leisure and in turn decreases utility. On the other hand, as illustrated by the following partial derivative of utility with respect to real money balances $\partial U/\partial m^h = \partial U/\partial n^{\sigma} \quad \partial n^{\sigma}/\partial m^h > 0$ (2.36), utility increases *ceteris paribus* with an increase in the amount of real money balances held which in turn decreases shopping time.

2.2.4.3 Money in the production function

After discussing the inclusion of money balances in the utility function of households, section (2.2.4.3) emphasises the incorporation of money balances into the production activity of firms. Handa (2000) proposes a production function specified as $x_k=F(n, k, m^f)$ (2.37), where x_k stands as the quantity of the k^{th} goods produced by the k^{th} firm, k=1,……………, K; n is the number of workers; k stand as the variable physical stock; m^f represents real money balances held by the firm and F stands as the production function symbol, and the superscript f stands for a designated firm involved in production. Real money balances integrated into the production function are considered as being of the same importance as any other input. Therefore, an insufficiency of currency in the firm's production activities could lead to difficulties in paying employees and suppliers and thus constraining the firm to reduce the number of employees and (or) the amount of capital allocated to the production, thereby reducing the firm's output. It seems reasonable to assume that higher real money balances used in production activities of firms lead to higher output levels.

2.2.4.4 The demand function for money derived from utility and profit function maximisation

The integration of money into the utility and production functions of economic agents has been examined in the above paragraphs, (*2.2.4.1; 2.2.4.2; 2.2.4.3)* and the following steps in this section concern maximising those functions and deriving the demand function for money balances, as illustrated by Handa (2000), as follows:

Maximise $U(X_1,........,X_k,n,m^h)$ (2.38)

Subject to: $\sum p_k X_k + (r - r_m)Pm^h) = A_0 + W$ (2.39) k=1,……………,K

$\therefore$

Set the Lagrangian function as:

$$U(.) = U(X_1,........,X_k,n,m^h) + \lambda((A_0 + W_n - \sum p_k X_k - (r - r_m)Pm^h)) \quad (2.40)$$

Where:

x_k quantity of the k[th] good;

P_k price of k[th] commodity;

P price level;

r market interest rate on the illiquid asset;

r_m interest rate paid on nominal balances;

$r\text{-}r_m$ net interest forgone from holding a unit of nominal balances;

P m nominal value of the m real balances;

W nominal wage rate;

A_0 nominal value of initial endowments of commodities and financial assets;

λ Lagrangian multiplier;

n the labour supplied in hours;

m^h real balances held by individuals.

Maximising utility subject to the budget constraint gives the first order maximising conditions represented by the following equations:

$$U_{X_k} = \partial U(.) / \partial x_k = \partial\left(U(X_1,\ldots\ldots, X_k, n, m^h) + \lambda((A_0 + W_n - \sum p_k X_k - (r - r_m)Pm^h))\right) / \partial x_k$$
$$= U_{X_k} - \lambda p_k = 0 \quad (2.41)$$

$$U_n = \partial U(.) / \partial n = \partial\left(U(X_1,\ldots\ldots, X_k, n, m^h) + \lambda((A_0 + W_n - \sum p_k X_k - (r - r_m)Pm^h))\right) / \partial n$$
$$= U_n + \lambda W = 0 \quad (2.42)$$

$$U_m = \partial U(.) / \partial m = \partial\left(U(X_1,\ldots\ldots, X_k, n, m^h) + \lambda((A_0 + W_n - \sum p_k X_k - (r - r_m)Pm^h))\right) / \partial m$$
$$= U_m - \lambda(r - r_m)P = 0 \quad (2.43)$$

$$U_\lambda = \partial U(.) / \partial \lambda = \partial\left(U(X_1,\ldots\ldots, X_k, n, m^h) + \lambda((A_0 + W_n - \sum p_k X_k - (r - r_m)Pm^h))\right) / \partial \lambda =$$
$$\sum p_k X_k + (r - r_m)Pm^h) - A_0 - W_n = 0 \quad (2.44) \quad k = 1,\ldots\ldots\ldots, k.$$

Solving this system of K+3 equations for the K+3 endogenous variables $x_1,\ldots\ldots,x_k$, n, m^h and λ where $p_1,\ldots\ldots.,p_k$, W, $r\text{-}r_m$, and P are the exogenous variables and assuming that a unique solution exists for each endogenous variable and the maximising conditions are satisfied, the solutions for K+3 endogenous variables have the general form as follows:

$$X_k^{dh} = X_k^{dh}(p_1,\ldots\ldots\ldots, p_k, W, (r - rm)P, A_0) \quad (2.45) \quad k=1,\ldots\ldots..,K;$$

$$n_S = n_S(p_1,........, p_k, W, (r - r_m)P, A_0) \qquad (2.46)$$

$$m^{dh} = m^{dh}(p_1,..............., p_k, W, (r - r_m)P, A_0) \qquad (2.47)$$

The superscript d; s; h stand for designating the demand for commodities (d), the supply of labour (s), and households (h).

It is worth recalling that when reviewing Handa's discussion about integrating money balances into the utility function of a household, our concern is to derive the demand function for money, $m^{dh}=m^{dh}(p_1,\ldots\ldots\ldots\ldots,p_k,W, (r-r_m)P, A_0)$ (2.48) carried out by maximising the utility function of economic agents and gaining progressively more information on the determinants of the demand function for money as is also our earlier purpose when reviewing monetarist, Keynesian, post Keynesians and classical economists views on the demand for money.

The maximisation procedure as applied to the utility function of a household so as to derive the demand function for real money balances is now applied for similar purposes by Handa (2000: 65) to the profit function of the firm. This firm is assumed to be operating in a competition environment. Profit is defined as being $\Pi=p_k F(n, k, m^f)-W_n- \rho_k K- \rho_m m^f -F_0$ (2.49), where: Π is the profit function symbol, ρ_k is the nominal user cost of physical capital, $\rho_m =(r-r_m)P$ (2.50) is the nominal user cost per unit of real money, F_0 is a fixed cost, n is the number of workers, p_k is the price of the physical capital goods, W_n is the nominal wage for n workers, k is the physical stock of capital, m^f represent the average real money balances held by the firm, and the superscript f stands for the designated firm involved in production. Handa (2000: 65) defines the nominal user cost of physical capital in a perfect market as being $\rho_k=(r+\delta_k-\pi_k) p_k$ (2.51), where δ_k is the rate of depreciation; π_k is the rate of increase in the price of the capital good; p_k is the price of capital, and r is the market interest rate on illiquid assets.

Considering that the rate of depreciation of the capital does not play any particular role in our further analysis, it is reasonable to let $\delta k=0$. Therefore, the nominal user cost of capital would be: $\rho_k=(r -\pi_k) p_k$ (2.52) and the profit equation becomes: $\Pi=p_k F(n, k, m^f)-W_n- (r -\pi_k) p_k k- (r-r_m)Pm m^f -F_0$ (2.53) . Taking the partial derivatives of the profit function with respect to: n, k and m^f, the first order conditions for maximising profits are represented by the following equations:

$$\Pi_n = \partial\Pi \big/ \partial n = \partial\left(p_k F(n,k,mf) - W_n - (r-\pi_k)p_k k - (r-r_m)Pm\right) \big/ \partial n = p_k F_n - W = 0 \quad (2.54)$$

$$\Pi_k = \partial\Pi \big/ \partial k = \partial\left(p_k F(n,k,mf) - W_n - (r-\pi_k)p_k k - (r-r_m)Pm\right) \big/ \partial k = p_k F_k - (r-\pi_k)p_k = 0 \quad (2.55)$$

$$\Pi_m = \partial\Pi \big/ \partial m = \partial\left(p_k F(n,k,mf) - W_n - (r-\pi_k)p_k k - (r-r_m)Pm\right) \big/ \partial m = p_k F_m - (r-r_m)P = 0 \quad (2.56)$$

In order to get the solutions in real terms after solving the equations (2.54), (2.55), (2.56), we proceed by dividing each term in the first-order conditions by the price level P and we get the following equations:

$$\left(p_k \big/ P\right) F_n = W \big/ P \qquad (2.57)$$

$$\left(p_k \big/ P\right) F_k = (r-\pi_k)\left(p_k \big/ P\right) \qquad (2.58)$$

$$\left(p_k \big/ P\right) F_m = (r-r_m)\, m^f \qquad (2.59)$$

Solving for endogenous variable n^d , k^d , m^{df} the equations (2.57), (2.58), (2.59) give us the following solutions:

$$n^d = n^d(p_k \big/ P, W, (r-\pi_k)(p_k \big/ P), (r-r_m)) \qquad (2.60)$$

$$k^d = k^d(p_k \big/ P, W, (r-\pi_k)(p_k \big/ P), (r-r_m)) \qquad (2.61)$$

$$m^{df} = m^{df}(p_k \big/ P, W, (r-\pi_k)(p_k \big/ P), (r-r_m)) \qquad (2.62)$$

The superscript (d) stands for the demand of labour and the variable physical stock. The superscript (f) stands for a designated firm.

The purpose of reviewing Handa's discussion about integrating money balances in the production function of firms was to highlight the derivation of the demand function for money $m^{df} = m^{df}(p_k/P, w, (r-\pi_k)(p_k/P),(r- r_m))$ (2.63) from profit maximisation function by firms and enhance again our awareness of the determinants of the demand for money function and this will help us later to adapt these determinants to a specific case under discussion in our empirical analysis.

After aggregating all consumers and firms in the economy, Handa (2000) presents us with one equation embodying aggregate demand for real money balances, inspired by the Walrasian general equilibrium model and is defined as follows: $m^d = m^d(p_{1/}P, \ldots\ldots\ldots\ldots, p_{k/}P, W/P, (r-\pi_k)(p_k/P), (r-r_m), A_{0/}P)$ (2.64).

2.3 Economic theories underlying the specification of our empirical econometric model

As chapter one mentioned, our empirical research is inspired mostly by the study of Nassar (2005). The economic model presented by Nassar (2005: 7) encloses two economic sectors such as monetary sector and commodity sector as shown by equation (2.65) and equation (2.66) below:

$$P_t = \lambda p_t^N + (1-\lambda) p_t^T \qquad (2.65)$$

Equation (2.65) represents the overall price level as a weighted average of the prices of tradable goods and other prices.

$$M^d / p_t = m_t^d = \alpha_1 y_t - \alpha_2 i_t + \alpha_3 \Delta e_t \qquad (2.66)$$

The equation (2.66) represents the economic model of demand for money where: M^d is money demand, p_t is the price level, y_t is the real income, i_t is the interest rate, Δe_t is the expected depreciation of the exchange rate. In equation (2.66), the demand for real money balances m_t^d is determined by real income y_t, an interest rate i_t and the expected depreciation of the exchange rate Δe_t. Nassar (2005) uses the expected depreciation of the exchange rate, real income and an interest rate as the determinants of real money demand. Classical, Keynesian, post Keynesian and monetarist economists emphasise real income and an interest rate have to be the determinants of money demand. With the support of these economic theories and inspired by the study of Nassar (2005), we include real income, an interest rate and the exchange rate variables in our econometric models for empirical analysis.

Also the economists such as Oskooee *et al*., (1990), Corden (1984) and Mundell (1963) justify the inclusion of the exchange rate as one of the determinants of real money demand. Thus, to enhance our analysis we add the effect of exchange rate in our empirical analysis.

Conclusions

The review of the economic theories on the demand for money is approached by examining the evolution of monetary theory from classical economists, Keynesians, post Keynesians, and monetarists plus more recent contributions connected with two techniques of optimization.

Mostly, the keys points from the classical economists cover the concept of neutrality of money and its real economic variables and also the constancy of velocity. The classical concept of the quantity theory of money is challenged by Keynes who advocates an income and expenditure approach by which he emphasises that expansionary monetary policy leads to a lower interest rate thereby reducing the cost of money (cheap money concept) and thus increases investments and output.

With the concept of liquidity preference, Keynes is the first to mention explicitly the relationship between the interest rate and the demand for money arising from the speculative motive for holding money balances which Keynes adds to the transaction and precautionary motives. He denies the concept of a constant velocity, arguing that economic agent behaviour is characterised by always guessing what the future holds for them. This argument does not give a stable demand function for money. Post Keynesians, especially William Baumol and James Tobin, show that the transactions demand for money depends on the interest rate and any economic agent acting rationally invests simultaneously in financial assets and cash balances.

Monetarists, even if they agree that money matters as do Keynesians, support most of the tenets of classical economists, principally that velocity need not be constant but rather must at least be predictable and they agree with the notion that the invisible hand pushes the economy towards the full employment equilibrium and for them any intervention by government in economic activities could worsen fluctuations in output.

Friedman has been the one to consider the demand for money as a demand like other goods in the economy. His conceptual framework has been advocated recently by Handa (2000) supporting the idea that the demand function for money is obtained from a maximisation of utility and profit and considers the demand for money as a demand like any other good under the assumption that all markets clear, as inspired by the Walrasian general equilibrium model.

CHAPTER THREE

A REVIEW OF MONETARY POLICY AND INFLATION

3.1 Introduction

"Most economists and policymakers agree that the overall aim of monetary policy is to advance the economic well-being of the country's citizens" (Hubbard, 2005: 476). By economic well-being, Hubbard (2005) emphasises an economy that performs and creates an economic environment providing maximum benefits to all citizens. To accomplish this, any monetary authority must *formulate and conduct an adequate monetary policy*. Mishikin (2007) and Handa (2000) highlight price stability as being the overriding objective of monetary policy so as to provide a sustained and favourable macroeconomic environment for economic agents. However, the question arises as to how monetary policy should be carried out to achieve the price stability goal? The main ideas embodied in this chapter endeavour to answer this question by examining the causes of inflation and the monetary policy needed for achieving low inflation. Indeed, Thornton (2007) emphasises that reducing market uncertainty in the economy could render long-run inflationary expectations more stable and therefore induce price stability in the economy. Further, Rasche and Williams (2007) show that the monetary policy of any central bank must target a macroeconomic variable such as the money stock, or an interest rate or the nominal exchange rate when trying to achieve the ultimate goal of price stability.

In many countries, economic agents (businesses and households) intend to accrue real wealth. Accordingly, the firms strive to predict trends in their economic activities and households seek ways to add to the real value of their future income (Hubbard, 2005). To attain these goals, economic agents need reliable nominal anchors to help establish subjective expectations of inflation, and this nominal anchor could either be market interest rates, or an inflation rate target or an exchange rate target or even other financial or monetary variables depending on the monetary policy in place (Mishikin, 2007).

To achieve price stability as an ultimate monetary policy objective, the monetary authority can define an intermediate target variable serving as the link between the direct actions of the central bank and the objective they wish to attain (Handa, 2000). According to Rasche and Williams (2007), the effectiveness of this intermediate target for price stability is controversial according to monetary economist's theories. Rasche and Williams (2007) assert that monetarists recommend targeting the aggregate money stock for providing a better nominal anchor to the economic system and this policy is supported by Friedman and Schwartz (1963), and Andersen and Jordan (1968). Monetarists treat sustained inflation as a monetary phenomenon and central banks must be held accountable for maintaining price stability. Hence, it is better to target the money aggregate's stock in order to attain the ultimate goal of price stability.

An opposite view takes root in Keynesian ideas and associates inflation with excess demand (spending) relative to the available supply of goods and services at the full employment equilibrium (Wallace, 1978). From the Keynesian's income-expenditure approach, emphasis is placed on targeting an interest rate and manipulating it to motivate investment. Apart from this controversy between Keynesians and monetarists on the most appropriate economic policy to implement, Handa (2000) highlights that the shift of monetary authorities from implementing one monetary policy to another policy is justified, mostly by the specific nature of economy for a country and also by the development of financial and stock markets. For some countries, because of a lack of development in financial markets, the relationship between money supply aggregates and the price level is not stable. Mishikin (2007) says that for the US and Germany, the empirical relationship between monetary aggregates, nominal income and inflation are no longer strong and stable enough to let monetary aggregates adequately inform monetary policy (used then as an intermediate target). Sargent and Wallace (1975) suggest that, in a model with rational expectations, the price level can be undefined if central banks target nominal interest rates, because the economy can lack a nominal anchor. In contrast, McCallum (1981) argues that an appropriately defined interest rate policy must include a nominal anchor and provide an adequate reference for forecasting future prices. Taylor (1993) also proposes the need for a nominal anchor to inform policy.

So summarising, it is worth noting that this chapter reviews theoretical and empirical outcomes and endeavours to respond to how the objective of price stability can be achieved by implementing different monetary policy regimes. Section (3.2) briefly discusses the theory and empirical outcomes underlying inflation, section (3.3) reviews different monetary policy regimes such as an inflation targeting framework and monetary policy with an implicit nominal anchor. A final section summarises the main points discussed here.

3.2 Review of theories and empirical outcomes underlying inflation

Many economic agents are concerned about inflation and frequently try to be present in front of their TV (television) screens watching the news, reading newspapers, so as to be informed as much as possible about stock market prices, overnight loan rates, exchange rate trends and struggle to forecast future inflation tendencies in their countries and overseas. Justifying this concern, Jordan (2006) emphasizes that money's effectiveness depends on its value being stable. Hubbard (2005) notes that steadily rising prices reduces the value of money. According to Jordan (2006) and Hubbard (2005), when the purchasing power of money is not stable, it becomes costly for economic agents to gather information about how much better or worse off they will be in the future and this uncertainty concerning the future is a handicap for investment. Maintaining stable prices by avoiding sustained inflation and the negative effects on the economy can reasonably be justified by many policy makers across the world as inflation has its greatest negative impact on the poor. Lower inflation helps economic growth and the stability of other macroeconomic variables (Handa, 2000). Some economists like Friedman (1991), Wallace (1978) and others (El-Sakka and Ghali (2005) and Lim and Papi (1997)) analyse the typical causes of inflation.

3.2.1 The causes of inflation

When analyzing the causes of inflation, El-Sakka and Ghali (2005) suggest the following three approaches, the monetary, the public finance and the structural approach.

The monetary approach

Quoting from Baetjer (2008: 11), we have "from Friedman's writings that inflation is always and everywhere a monetary phenomenon." Baetjer argues that inflation takes place once the quantity of money rises significantly faster than output. According to Friedman (1991), the money supply affects the general level of prices over any long period. In the short-run, the changes in the general level of prices can come from many sources. In the analysis of the monetary approach, Friedman (*op.cit*) suggests focusing on the rate of money growth relative to the rate of growth of output instead of mechanically associating the rate of inflation with the exact rate of monetary growth. In this way, Thornton (2008) investigating the relationship between money growth and inflation for 36 African countries, confirms the significance of this relationship. Thornton (*op.cit*) sees a weak effect in the case of money growth and inflation rates below 10 *per cent*, but a strong one when money growth and inflation go over that number. Siegel (2009) confirms that inflation is caused by too much money chasing too few goods in the economy. Subrata and Derek (1989) agree with this idea. Baetjer (2008) deems that one of the prominent reasons underlying inflation over a short-run horizon is people's expectations for the trend of prices today over the very short term. According to Baetjer (*op.cit*), these expectations influence how promptly the money supply responds to the growth rate of output. El-Sakka and Ghali (2005) agree that a sudden increase in prices as the aggregate supply of goods and services changes does not readily occur even in the short run.

Public finance approach

Friedman (1991) says that the intrusion of government into the economy and the reluctance to impose explicit taxes can exacerbate the increase in the quantity of money in the economy and this consequently provokes inflation. El-Sakka and Ghali (2005) highlight many governments' dependence on seigniorage to finance their budget deficits.

In the seigniorage process, central banks take over overdrafts of the public treasurer that finance government expenditures (Hubbard, 2005). Usually debt of the treasurer is covered as the revenue from tax collection increases. But the government expenditures financed through the seigniorage process can pump up aggregate demand over and above the short-run supply in the economy causing inflation.

To this end, Catao and Terrones (2001) analysed inflation in 23 emerging market economies and conclude that the long-run inflation rate falls from 1 to 6 *per cent* when the budget deficit to GDP ratio falls by 1 *per cent*. These findings confirm the relationship between the government's seigniorage process and inflation. One can then inquire why government should opt for seigniorage if it causes inflation? Many reasons could be given and the prominent motivation, supported by Keynes (1936) and Friedman (1991), gives emphasis to the commitment by governments to the policy of full employment. According to Friedman (1991), this commitment may induce governments to over-react to a temporary recession and consequently provoke a significant disequilibrium between aggregate demand and supply in the economy and possibly initiate short-run inflation.

The structural approach

In the structural approach, El-Sakka and Ghali (2005) regard the increase of prices as driven mostly by significant movements in wages, exchange rates and other factors that impact variability especially the openness of an economy. According to El-Sakka and Ghali, wage growth affects the cost of production and consequently producers increase prices of goods and services to cover higher wage costs. The results of empirical studies undertaken for developing countries show a correlation between the depreciation of the nominal exchange rate and inflation (El-Sakka and Ghali, 2005). When analysing the effect of openness on inflation, Romer (1993) examined a sample of countries and found that openness in severely indebted countries is responsible for over 22 *per cent* of the variation in inflation. It is worth recalling that between the three approaches, this thesis places more emphasis on the monetary approach as we review a monetary policy regime when applying our research question (identified in chapter one) to Rwanda.

3.2.2 Expectations of inflation and the Phillip's Curve

In section (3.1.1) above, Baetjer (2008) indicates that changes in expectations of inflation can drive up prices in the short run. According to Baetjer, these changes in expectations of inflation can occur when economic agents are concerned about inflation. If producers bid up prices consumers are quick to realise that their money is losing value because of inflation. Hence, everyone finds that prices in general are increasing and come to expect further increases. It is probably very difficult to reverse this situation after it has started (Baetjer, 2008). We examine this phenomenon in more detail in the next paragraph.

Phillip's Curve and inflation

The Phillip's Curve (see figure 3.1 below) shows that unemployment rates are assumed to fall as aggregate demand increases, and this rise in aggregate demand is accompanied (along PC_1 on figure 3.1) by a higher rate of inflation (Wallace, 1978: 498). Thus Sakka and Ghali (2005) reiterate such a trade-off between inflation and unemployment familiar to us from the Keynesians' economic theories. Adding to this idea, Wallace (1978) and Delorme and Ekulend (1978) assert that prices rising faster than nominal money wages causes real wages to fall and they presume this situation cannot hold permanently. Delorme and Ekulend (1978) maintain that people bargain for new salaries so as to catch up with the price level. Consequently, real wages get back to their former level and the employers will not be motivated to change employment levels and unemployment returns progressively (as nominal wages adjust) to the natural rate.

In addition, Wallace (1978), inspired by the expectations theory, assumes that new wage earners readily abandon money illusion and they, expecting further increases in the price level, bargain for increased money wages. If this happens, the short-run Phillip's curve in figure 3.1 below will shift upward from PC_1 to PC_2 in response to the expectation that inflation will continue from the base of expectation of say 4 *per cent*. If policy makers once again endeavour to stimulate aggregate demand the process will replicate itself, and the inflation rate will rise along the curve PC_2 to 6 *per cent* and this rate serves as a new base for expectations of further inflation occasioning a shift of the short-run Phillip's curve from PC_2 to PC_3. These shifts make Wallace (1978), Friedman (1991) and many others believe that rational expectation theory is not consistent with a trade-off between inflation and unemployment, as exploiting this trade-off only results in higher inflation. As part of this controversy, Cogley *et al*., (2008), drawing on a new Keynesian theory which claims that expansionary investment expenditure alleviates unemployment in the economy, assert from the findings of their study that inflation persistence is mostly generated by the changes in monetary policy. Hence, Section (3.3) reviews different monetary policy regimes and their ability to create a favourable economic environment.

Figure 3.1

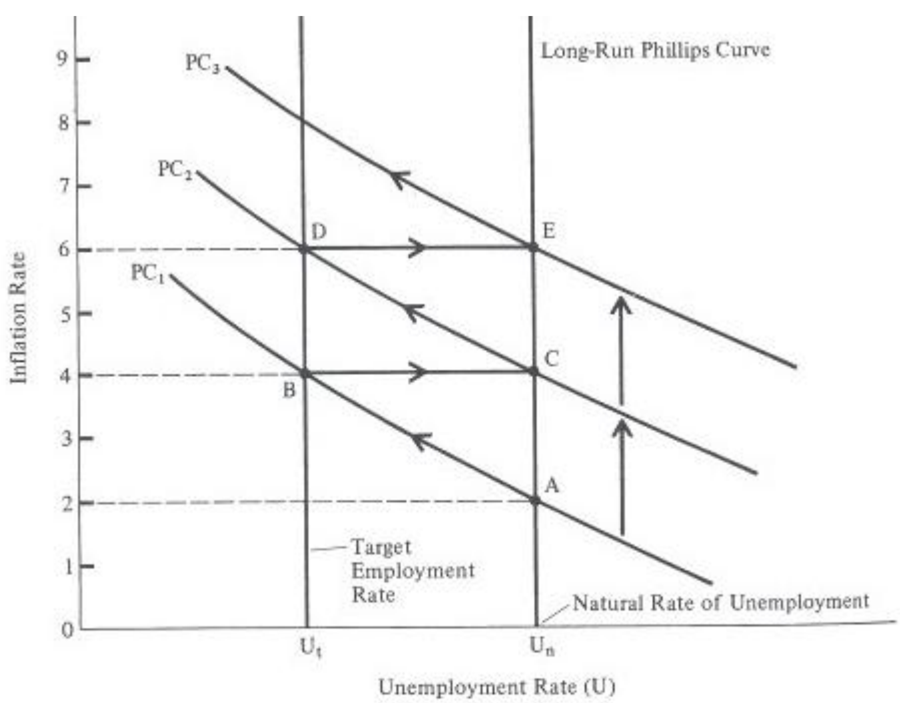


Figure 3.1. Phillip's Curve (source: Wallace (1978: 498))

Figure 3.1 shows the trade-off between unemployment and inflation familiar from Keynesian theory. According to this theory, an increase in aggregate demand will push the natural rate of unemployment U_n to the low target rate U_t. Nevertheless, monetarists and believers of the importance of the expectations theory do not support such a trade-off as any monetary policy change provokes persistent inflation without leading to a consistently lower unemployment rate (a shift of PC_1 to PC_2 and then to PC_3 and then usually moves from B to C and D to E).

3.2.3 Review of structure and dynamic models of inflation

Thornton (2008) endeavours to identify models of inflation using the equation of the quantity theory of money familiar to us from Handa (2000) and labelled as $MV \equiv PY$ (3.1), where M is the money supply, V is the velocity of money income, Y is real output, and P is the price level. With the intention of dealing with the growth rates of variables rather than their quantities, one can take the natural logarithm (ln) using identity (3.1) and obtain therefore ln ($MV \equiv PY$) giving $m+v \equiv y+p$ (3.2), where lower case letters denote growth rates or a change in the logarithm. Thus the value of p (grow rate) is equivalent to, $p \equiv m+v-y$ (3.3). Identity (3.3) embodies mainly two ideas: *(i)* the proportionality proposition, which shows that in the long run, a permanent increase in money growth leads to an equal increase in the rate of inflation; and *(ii)* the neutrality of money which states that a permanent increase in the growth rate of money leaves output and velocity unaffected in the long-run (Thornton, 2008). Identity (3.3) represents a structural model of inflation as it can link policy (m) to inflation (p). Apart from this model, Laidler (1977), drawing from the works of Cagan (1956) and Dutton (1971), builds a dynamic model of inflation and bases changes in the price level on expectations of inflation by economic agents. For the equation of inflationary expectations, Laidler follows an *error-learning process* (Gujarati, 2003) which assumes that economic agents update expectations of inflation using the current information on prices and the mistakes made in previous forecasts. This equation is $\Delta P^e_t = h\ \Delta P_t + (1-h)\ \Delta P^e_{t-1}$ (3.4) where ΔP^e_{t-1} is the expected rate of inflation at the end of the period t-1, ΔP_t is the proportion change in the price level between period t-1 and period t, and ΔP^e_t is the expected rate of inflation at the end of the period t.

Further, Laidler (1977) adds expected inflation as one of the determinants of the demand for money by using the equation $m_t-p_t=w+ky-a\Delta p^e_{t-1}$ (3.5), where: m_t-p_t is the natural logarithm of real money balances at time t, w is the constant term, y is the natural logarithm of real income at full employment level and

Δp^{e}_{t-1} is from equation (3.4). Equation (3.5) is the familiar one discussed in chapter two (section 2.2.3.4) which identifies some components of the demand for money (Delorme and Ekelund, 1983).

3.3 Review of different monetary policy regimes

To achieve the objective of price stability, monetary authorities attempt to define and implement monetary policy which they presume to be appropriate for the state of the economy (Mishikan, 2007). Some countries prefer to use the aggregate money supply as an intermediate target and others choose an interest rate. The policies under review in this section cover inflation targeting and monetary policy with an implicit nominal anchor.

The emphases here are the macroeconomic effects resulting from implementing each monetary policy regime with regard to providing price stability in the economy. For now, we postpone the review of policy tools and operating targets that link policy decision and economic agent's behaviour. These are covered in chapter four of this thesis as they apply to Rwanda's situation.

3.3.1 Inflation targeting regime

Across the world, monetary authorities strive to create a reliable economic environment facilitating any economic agent's ability to anchor inflation expectations (Bernanke and Woodford, 2005). Fountas *et al*., (2006) maintain that inflation uncertainty causes imbalances in the allocation of resources among different investment opportunities. Striving to alleviate these imbalances, some monetary authorities across countries opted for inflation targeting policies. Mishikin (2007: 207) considers a inflation targeting regimes as a monetary policy characterised by the official announcement that low and stable inflation is the overriding goal of monetary policy and thereby setting an inflation rate to achieve in a given period. Stimulated by a particular reason, commonly the collapse of a previous monetary policy, some countries implement new policies to restart a reliable nominal anchor for economic agents. In fact, many countries shifted to inflation targeting regimes as the overriding goal of their monetary policy, one of them being South Africa, where the empirical study carried out by Mitchell *et al*., (2007) confirms the effectiveness of this policy from the year 2000. Hence, Mitchell *et al*., (2007) deem that South Africa did manage to control inflation under an inflation targeting regime.

Clarifying the reasons that motivate some countries to opt for an inflation targeting regime, Mishikin (2007) argues that the exchange rate peg regime failed to reassure the public that monetary policy would remain disciplined in the UK and Sweden. To overcome this shortcoming, these countries shifted to inflation targeting. In Canada, the adoption of this policy was implemented after unsuccessfully trying to use a monetary aggregate targeting approach. Furthermore, research from many countries shows inflation targeting to be an effective policy. This includes the study undertaken by Levin *et al*., (2004) confirming that in the past decade inflation targeting has played a role in anchoring inflation expectations and in reducing inflation persistence for some industrial countries. Another study, carried out by Lin and Ye (2007) and another by Dueker and Fischer (2006), confirm the effectiveness of inflation targeting. For Huang and Liu (2005) the interest in inflation targeting seems justified as this policy focuses on stabilizing the variability in inflation and the output gap.

3.3.1.1 Advantages of inflation targeting monetary policy regime

According to Mishikin (2007), inflation targeting has several important advantages: (i) in contrast to exchange rate targeting, but like monetary aggregate targeting, inflation targeting enables a focus on domestic considerations and responds to shocks from the domestic economy; (ii) velocity shocks are largely irrelevant because the inflation targeting policy is no longer reliant on a stable money to inflation relationship; and (iii) an inflation targeting policy can reduce the likelihood that the central bank will fall into the time-inconsistency trap in which under political pressure, the monetary authorities are pushed to engage in expansionary monetary policy for misguided purposes. One other advantage, according to Bernanke and Woodford (2005), is that inflation targeting lets the monetary authority make use of all existing information to consider for setting up of an adequate monetary policy and thus it can be readily understood by the public and can be highly transparent.

3.3.1.2 Challenges to an inflation targeting monetary policy regime

Bernanke and Woodford (2005) emphasise that in transition economies, central banks can face a trade-off between transparency and a need to control inflation. This is because inflation is a sustained movement in the consumer price index and these movements could unfortunately reflect other factors than monetary policy measures. Consequently, central banks face a serious challenge in overcoming the accountability and transparency required in a regime of inflation targeting. According to Mishikin (2007), low inflation that results from an inflation targeting policy, might have substantial negative effects on real economic activity. Economic agents can presume that disinflation will occur in the near future and then deflation does follow in the economy. With regard to a range that the target must cover and the time necessary to affect the economy, Bernanke and Woodford (2005: 387) deem that too large a band could reduce the ability of an inflation targeting policy to anchor inflation over expectations and the effects of such a policy might only come after a long lag. Further, Bernanke and Woodford suppose one year to be the approximate time horizon as in most countries there are a number of drawbacks: (i) the frequent missing of the inflation target as has been the case in South Africa; (ii) instrument instability, (iii) and insufficient control of output fluctuations by the central banks have been the consequences of target inflation rate for a period of less than one year. It is thus of some interest that we find the adjustment period in Rwanda to be about one year.

To conclude this section (3.3.4) which reviews the theory of inflation targeting regimes, it is worth noting that despite the benefits of an inflation targeting monetary policy, Mishikin (2007) shows us that many countries have achieved excellent low and stable inflation records without using an explicit nominal target to anchor inflationary expectations. Mishikin (2007) argues that a monetary strategy can posit an implicit, but not an explicit nominal anchor as an overriding emphasis in policy to control inflation in the long-run. However, the lack of an explicit nominal anchor can be a potential problem for the “just do it” strategy. In this case, the central bank can be exposed to the risk of inflation rising.

Conclusions

Chapter three emphasises the overall aim of monetary authorities as being the promotion of a reliable and consistent economic environment permitting economic agents to anchor their expectations of inflation and then be able to make rational choices for investment or consumption. The activities of monetary authorities arise from monetary policies whose focus has as a final goal, economic stabilization, including controlling output fluctuations and emphasising price stability. The price stability goal has been the particular concern of this chapter as it embodies one of the objectives of the study undertaken in this thesis. Potential causes of inflation are examined under the three approaches. These are the monetary approach, the public finance view and a structural approach to price level changes. The monetary approach takes root in monetarists’ views which stipulate that sustained long-run inflation is a monetary phenomenon. The public finance approach points out that expansionary government expenditure can cause seigniorage problems. The structural approaches focuses on significant changes that can occur in aggregate demand, movements in exchange rates and other factors especially those related to the openness of the economy. Achieving a price stability goal through maintaining low and stable inflation, the monetary authorities endeavour to formulate and implement monetary policy such as inflation targeting and monetary policy with an implicit nominal anchor.

With an inflation targeting monetary policy, it is assumed that economic agents anchor expectations of inflation as they focus explicitly on a “known” rate of inflation or a range for inflation over a given time horizon. Many advantages have been associated with an inflation targeting policy such as focusing more on domestic considerations in responding to monetary policy shocks; the irrelevance of velocity shocks for disturbing monetary policy; reducing the time-inconsistency problem in monetary policy and many other benefits. Apart from these advantages, drawbacks such as the frequent missing of the inflation target and insufficient control of output fluctuations by the central banks are highlighted. Finally, we offer some examples of countries who have successfully achieved low inflation like South Africa through implementing an inflation targeting monetary policy. Others countries have managed to achieve price stability without using an explicit nominal target to anchor inflationary expectations like the US.

CHAPTER FOUR

A REVIEW OF THE MONETARY POLICY FRAMEWORK IN RWANDA

4.1 Introduction

In line with its “vision 2020”, the Government of Rwanda has put in place, with technical and financial support from its development partners, a medium-term programme as stated in the Economic Development and Poverty Reduction Strategy (EDPRS) (Kanimba, 2008(a): 1). Monetary policy one of the responsibilities of the National Bank of Rwanda (NBR) is part of this programme, especially the role of creating a favourable environment that fosters production and investment by ensuring macroeconomic stability by controlling liquidity within the national economy and monitoring the financial system (Kanimba, 2008(a): 1).

This chapter provides an overview of the monetary policy framework in Rwanda by examining the National Bank of Rwanda’s control of broad money (M2) in the national economy (intermediate objective) with the intention of achieving the final objective of price stability (NBR, 2003: 30-31). To achieve the final objective the National Bank of Rwanda uses an indirect monetary instrument. This instrument allows the NBR to adjust the monetary base (currency plus reserves) which is considered an operating target (NBR, 2003: 33). Chapter four outlines this framework in three sections:

Section (4.2) outlines the process of control of the monetary base by the National Bank of Rwanda with the intention of attaining a level of the money stock, M2, consistent with price stability. Section (4.3) discusses the tools used by the National Bank of Rwanda to implement sound monetary policy. Sub-section (4.3.1) outlines the open market operations through which the NBR accepts surplus liquidity from banks and in return transfers eligible securities to them as collateral. Sub-section (4.3.2) covers the discount window facility in case a bank fails to get the desired liquidity from the Repurchase Agreement Operations (REPO) auction or from the inter-bank market. A penultimate section points the reserves requirement changes used by the National Bank of Rwanda to affect free reserves of the banks and ultimately the supply of broad money. Section (4.4) gives some of the obstacles which the monetary authorities face in attempting to forecast national liquidity. Finally, a conclusion summarises the main ideas outlined in this chapter.

4.2 Controlling the money stock M2 by the National Bank of Rwanda

In 1998 the National Bank of Rwanda came under pressure from the IMF to maintain a low and stable inflation rate (IMF, 1998: 7). Implementing this recommendation and staying in line with the Rwandan Government's economic programme as stated in the Economic Development and Poverty Reduction Strategy (EDPRS), the NBR forecasts the level of monetary aggregate M2 each year as consistent with economic activities in Rwanda and also consistent with price stability. Taking as an example the year 2008, one observes that, in accordance with government's programme of achieving a growth rate in real GDP ranging between 5.5 *per cent* and 6 *per cent*, the NBR set its inflation target to 7 *per cent* (Kanimba, 2008(a): 8) and the monetary aggregate M2 at 444, 4 billion Rwandan francs (Kanimba, 2008: 23).

In attempting to achieve the targeted level of M2, the NBR makes projections of bank liquidity on a weekly basis. Basically, the annual forecast consists of envisaging the sources of excess liquidity from: (i) net foreign assets, (ii) net claims on government, and (iii) the total credit provided by the banking system to the economy (Kanimba, 2008: 23). This forecast of the excess liquidity on the annual monetary stock is converted into monthly forecasts and updated from time to time. Weekly forecasts of banking liquidity are based on the following factors, such as: (i) currency in the hands of the public, (ii) the net foreign exchange position at the NBR, and (iii) the government deficit (NBR, 2003: 34). Practically, in a particular week, actual base money is compared with the forecast level and the gap indicates the direction of monetary policy. In the case of actual weekly or monthly liquidity levels being inconsistent with forecasts and thus ultimately annual monetary plans, open market operations can inject or mop up excessive liquidity from the economy (Kanimba, 2008: 23-24) and (NBR, 2003: 37). Thus, the NBR adjusts liquidity levels according to the needs of the economy so that the monetary base stays in line with annual forecasts. Before concluding this section, it is worth noting that the achievement of price stability as the final objective depends on the NBR being capable of accurately forecasting M2. The NBR tries to maintain equilibrium between the supply and the demand for money, with the intention of keeping the economy's liquidity at levels consistent with stable price levels. However, the evolution of the monetary stock can only be scrutinized indirectly by adjusting an operational objective, which is the monetary base in the case of Rwanda (NBR, 2003: 33). The monetary base is chosen since the central bank can control currency and bank reserves on a daily basis and assuming a stable relationship, say for instance $M=K.BM$, between the monetary base (BM) and the money supply (M), where $K = \frac{c+1}{c+r}$ is the monetary base multiplier and is a function of currency in circulation ratio (c), and the commercial bank reserve ratio (r) (Munyankindi *et al.*, 2008: 60). Economic theory stipulates that the more stable the monetary base multiplier, then the central bank is better able to control M2 through changes in the monetary base (Handa, 2000; Hubbard, 2005). In the case of Rwanda, the NBR deems that the required condition of stability in the money multiplier is not always guaranteed (Munyankindi *et al.*, 2008: 63-66). The difficulty the NBR faces is that it needs daily information on M2 whereas this is only available on a monthly basis. Thus, the NBR has to forecast M2 and to do this uses the monetary base, which is available on a daily basis, and thus can be used to provide a daily forecast of M2 (Sayinzoga, 2005: 74). As we have mentioned, in the case of a divergence between actual liquidity in the economy and the forecast (NBR, 2003: 37), the NBR attempts to regulate the monetary base using the usual instruments of monetary policy which we discuss below.

4.3 Instruments of monetary policy in Rwanda

As a part of its responsibility to regulate the banking system's liquidity, the National Bank of Rwanda conducts daily monitoring of liquidity and regulates the money market (NBR, 2009: 59). In line with its current indirect monetary policy, the NBR uses monetary policy instruments to control the commercial banks' free reserves and makes sure that the supply of base money remains in the range consistent with price stability. In this way, the indirect monetary instruments utilised by the NBR are (NBR, 2003: 38-46):

(i) Open-market operations;
(ii) Discount window facilities;
(iii) Reserve ratio requirements.

Each of these instruments is discussed below.

4.3.1 Open-market operations, the inter-bank money market and other operations

Instead of operating a direct lending and borrowing link to commercial banks, the NBR introduced a money market as part of its programme of achieving better control over the money supply (NBR, 2003: 38). The NBR can now modify base money through banks lending and borrowing in the short-term liquidity market. In addition, monetary policy analysis is improved by the creation of a monetary policy committee that meets weekly, to assess whether the state of liquidity and conditions prevailing in the foreign exchange market are consistent with the forecasts; if not they suggest corrective measures (NBR, 2003: 47-51). Indeed, this committee (NBR, 2003: 47-51) has to:

(i) Undertake a retrospective analysis of the current monetary situation and determine how monetary policy accommodates any variation occurring in the liquidity of the banking system;

(ii) Forecast base money for subsequent periods and determine the necessary interventions of the NBR in the money market in order to achieve its macroeconomic goals;

(iii) Propose any other actions the NBR might undertake to maintain control over the money supply and provide backing for continued bank supervision.

We now scrutinize a number of the mechanisms that the NBR has available to carry out open market operations.

a. Repurchase Agreement Operations (REPO)

In order to conduct an efficient monetary policy, from August 8th 2008, the NBR decided to opt for the "Repurchase Agreement Operations" (REPO) instead of overnight or weekly open market operations. The REPO operations took place every working day with a duration of up to two weeks at competitive bids (NBR, 2009: 58). The NBR reviews from time to time the duration of REPOs depending on the success of the instrument (Kanimba, 2008: 42). In carrying out these operations, the NBR accepts surplus liquidity from banks and in return it transfers eligible securities to banks as collateral. The two parties

(NBR and banks) agree to reverse the transactions at a future point in time, when the NBR as a borrower repays the loan plus interest and the creditor bank returns the collateral to the NBR. The replacement of the overnight operations and other open market operations by the use of the REPO aims to force commercial banks to forecast their liquidity adequately. Thus, the NBR is better able to conduct an efficient monetary policy. Based on the situation prevailing in 2008 in the money market in Rwanda and forecasts of future conditions, the NBR set the money market reference rate at 8 *per cent* (key repo rate) *per annum* (Kanimba, 2008: 42).

b. Treasury bills

Treasury bills have a double role in the Rwandan economy. Not only can the NBR buy and sell these instruments but they are principally issued by the government to finance its expenditure' plans (NBR, 2003: 42). By buying (or selling) these bills, the NBR modifies liquidity levels in the national economy and thus induces base money to remain in line with their forecasts of liquidity consistent with price stability. Non-financial companies and individuals can bid to buy (or sell) treasury bills through commercial banks (NBR, 2003: 39).

c. Deposit facility

To enhance liquidity management in the national economy, the Rwandan monetary authorities introduced (in December 2008), an investment facility called the "deposit facility". With this facility banks are allowed to deposit their excess liquidity at the NBR, on a daily basis, for a maximum of 28 days at a fixed rate of 7 *per cent* with a discount option halfway to maturity (NBR, 2009: 58).

d. The inter-bank market

In 2000, an inter-bank market was initiated to motivate the exchange of liquidity between banks (Sayinzoga, 2005: 80). The gain this brings is that banks do not look for accommodation at the NBR (NBR, 2003: 38-39). This borrowing and lending is relatively unrestricted but collateral is provided. In carrying out these operations, the interest rate is lower than other markets as the NBR sets the inter-bank interest rate close to the key REPO rate of 8 *per cent*. As an example, from August 2008, the inter-bank interest rate range was fixed to fall between 6.75 *per cent* and 9.25 *per cent*. This encourages inter-bank market activities, and the NBR helps by lending money to banks on a competitive basis and absorbs excess funds at some lower rate (NBR, 2009: 58).

e. Selling of foreign reserves as a supplementary monetary instrument

Since 2004 the Rwandan banking system experienced continuous excess liquidity mainly generated by financial inflows from external donors to support the national budget (Kanimba, 2008(a): 6). In order to adjust the liquidity in line with monetary indicators, the National Bank of Rwanda mops up excess liquidity through sales of foreign exchange, sells in overnight markets, and makes general sales of treasury bills (Kanimba, 2008: 23-24). Sales of foreign exchange to commercial banks are regarded as a supplementary monetary instrument utilised mainly to smooth out unexpected liquidity fluctuations in the money markets. The excess liquidity (in Rwandan francs) generated in the national economy by the government's expenditures are indirectly collected from the national economy through commercial banks by bidding in the foreign exchange market coordinated by the NBR. In return, the NBR credits the demand deposit accounts held abroad by commercial banks, an equivalent amount in foreign currency (mostly in US dollars). These available reserves (held abroad) in dollars are used by commercial banks for financing imports. Thus foreign exchange sales to banks by the NBR serve as a supplementary monetary instrument which can regulate liquidity within the Rwandan economy (Kanimba, 2008: 41).

4.3.2 The discount window

Central banks usually limit commercial banks to add liquidity by using a penalty rate on borrowing. In Rwanda the NBR's last resort facility remains available just in case a commercial bank fails to get the desired liquidity from the Repo auction or the inter-bank market. The interest rate, if one uses this facility, is set at the daily clearing Repo auction rate plus a penalty of 2 *per cent* (Kanimba, 2008: 43).

4.3.3 Reserve requirements

Cash reserves can affect banks' free reserves in the short-run and the supply of broad money in the long-run. Principally, reserve requirements are considered as a prudential instrument used by the central bank to make sure that the commercial banks keep enough funds on hand to meet any unpredicted withdrawals by customers. Cash reserve requirements are also an instrument that the NBR can use for controlling base money (Sayinzoga, 2005: 82). Indeed, the occurrence of a surge in lending money to customers by commercial banks can oblige the NBR to adjust the reserve requirements ratio (NBR, 2003: 44). An increase in these ratios leads to a tightening of the banking system's liquidity and, consequently, reduces the commercial banks' capacity to create money through lending to customers, while a reduction allows the reverse (NBR, 2003: 44). However, the option to use of this instrument should not be frequent and it is better to use it when banking liquidity expands enormously (Sayinzoga, 2005: 82).

4.4 Obstacles to implementing a satisfactory monetary policy in Rwanda

Monetary policy management in Rwanda faces a number of obstacles especially at this time which is marked by the financial crisis. Currently, the world is experiencing one of the worst economic shocks in the last 60 years (Kanimba, 2008: 8). But Rwanda experienced high inflationary pressures during the first half of 2008 (Kanimba, 2008: 16; 23) and the persistent excess liquidity in the Rwandan banking system continued even late into 2008. To keep the monetary policy programme on track, it is important to reinforce the economy's capacity to absorb growing inflows from a scaling up of external assistance (Kanimba, 2008(a): 6). The low absorptive capacity of the Rwandan economy and higher aid flows result in the NBR facing extra costs when mopping up this excess liquidity.

Furthermore, unpredictable behaviour on the part of commercial banks can cause problems for the NBR. In normal circumstances, the Rwandan financial sector is characterised by a low degree of monetization. There is general agreement that the conduct of monetary policy is enhanced by the existence of well-functioning markets, and that indirect monetary policy instruments serve to deepen financial markets (Sayinzoga, 2005: 84). In this way, developed markets can serve as channels facilitating the implementation of monetary policy. In the case of Rwanda, the money market has been operational since

September 1997 (NBR, 2003: 38), and from 2008 a capital market has been launched (NBR, 2009: 59). Markets in Rwanda are still developing. As these markets develop monetary policy can only improve.

In addition, it is difficult to forecast future real GDP growth and accordingly predict national liquidity needs. In 2007 there was a significant difference between the increase in money supply, M2, (31.25 *per cent*) and that of the nominal GDP (13 *per cent*) (Kanimba, 2008(a): 5). For the same time period the general price level increases from 8.9 *per cent* to 9.1 *per cent* .

This situation is attributable to the Rwandan economy being in the main informal, and to the lack of technical skills in some sectors making an estimate of real GDP subject to wide variation.

Conclusions

In line with the Rwandan Government's programme of Economic Development and its Poverty Reduction Strategy (EDPRS), the National Bank of Rwanda (NBR) has the role of creating a favourable environment for production and investment through controlling liquidity within the national economy.

In attempting to achieve the targeted level of M2, the NBR makes projections of bank liquidity which require daily information on M2, whereas this is only available on a monthly basis. Thus, the NBR forecasts M2 using the monetary base, which is available on a daily basis. Practically, in a particular week, the actual base money is compared with the forecast level and the discrepancy indicates the direction of monetary policy. The NBR tries to alleviate the gap between the forecast and actual situation in national liquidity by adjusting the monetary base using: (i) open-market operations; (ii) discount window facilities and (iii) reserve ratio requirements.

Some problems in implementing monetary policy are: (a) the coordination between monetary policy and fiscal policy in order to absorb foreign aid; (b) a lack of a developed money market; (c) difficulties in forecasting real GDP growth and predicting the national liquidity needs.

CHAPTER FIVE

STATISTICAL ESTIMATION, METHODOLOGY AND MODEL SPECIFICATION

5.1 Introduction

This chapter discusses all the relevant statistical estimation concepts and techniques as well as the specification of the models to estimate in chapter 6. Before attempting any regression analysis using time series, the first step one undertakes is to check the existence of stationarity or otherwise in the data (Gujarati, 2003: 792) and (Brooks, 2002: 367). Indeed, the motivation for investigating stationarity, among other reasons, is to avoid getting biased results from a spurious regression. These results come from regressing non-stationary time series data on each other (Maddala and Kim, 1998: 28).

If one uses non-stationary data, a spurious regression can show insignificant estimates for coefficients and a high R^2 which results from a regression between two unrelated time series variables but trending together over time (Enders, 2004: 171; Brooks, 2002: 367-368; Noriega and Ventosa, 2007: 439-444). Furthermore, the OLS estimators from a spurious regression do not converge asymptotically to the true values of population parameters. Thus, it is worthless to use the usual inferencial statistics by which researchers extrapolate sample results to the population under examination (Maddala and Kim, 1998: 25-26).

The problems caused by non-stationary time series data constrain researchers to be cautious and they must always start their analysis by determining whether their time series data is stationary or otherwise before attempting any regression analysis (Hill *et al*., 2001: 340). In this way, a stationary time series can usually be included in the econometric model, while a non-stationary time series may first have to be differenced or detrended before adding it to any econometric model. In addition, when considering long-run relationships between time series, a cointegration analysis should be done. Researchers have to include in their econometric models the cointegrating but non-stationary time series. This chapter is divided into five sections:

Section (5.2) discusses the concept of stationarity in time series, and includes definitions and examines other properties of time series. Furthermore, it discusses the Dickey-Fuller (DF), Augmented Dickey Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity tests. Section (5.3) examines the concept of cointegration, plus the Engle Granger (EG) and the Augmented Engle Granger (AEG) tests of cointegration based on a residuals approach. In section (5.4) we outline the Johansen approach used when one has more than one relationship to investigate in the long-run cointegrating relationships among time series. Section (5.5) identifies the regression with the time lags of the variables and it justifies the choice of variables that are included in both models we estimate based on the economic theory we reviewed in chapter two and three and we base the analysis on previous empirical research. Both these models are known as Vector autoregression and we call them VAR1 and VAR2.

5.2 Stationary and non-stationary time series data

In outlining stationarity within a time series, it is necessary to highlight the behaviour of a time series when a shock occurs in the data generating process. Brooks (2002: 240) deems that the stationarity or otherwise of a time series influences its behaviour. According to Patterson (2000: 601) and Gujarati (2003: 811), when a shock affects a stationary time series, it decays progressively and disappears over time. Hill *et al*., (2001: 341) reiterates the progressive decline of the effect of a shock on a stationary time series. Moreover, Gujarati (2003: 797) stipulates that shocks can generally indicate some change (such as a change of economic policy for instance) during a particular time period in the data generating process, and for *non-stationary time series* this shock persists over time, while for a stationary time series it decays progressively and it disappears over time. One must also be careful, in the case of a stationary time series, that differences exists between a weakly and strictly stationary process. It is to this issue we now turn.

5.2.1 Strictly and weakly stationary process

Gujarati (2003: 797-798) and Brooks (2002: 230) emphasise that a strictly stationary process is one having the same probability of generating a time series say, y_t as time progresses. Furthermore, Gujarati (2003: 797) and Maddala and Kim (1998: 11) deem that the process generating time series data rarely behaves in this way, especially for macroeconomic time series. Additionally, Brooks (2002: 230-231) and Gujarati (2003: 797) turned the concept of a strictly stationary process into a weak stationary process by requiring stationarity within a time series. According to Brooks (2002: 231) and Enders (2004: 53), a stationary time series has three properties:

(i) a stationary time series has a constant mean (E (y_t) = μ): The mean of a stationary time series does not change within time. Graphically, this time series crosses the mean line frequently as time progresses and it does not have any time trend.

(ii) a stationary time series has a constant variance (E (y_t - μ) (y_t - μ) = $\sigma^2 \prec \infty$): As the time progresses the dispersion of a stationary time series above and below its mean values is almost the same.

(iii) a stationary time series has a constant covariance (E (y_{t_1} - μ) (y_{t_2} - μ) = $\gamma_{t_2 - t_1}$) : The correlation between a time series and its own lags remain unchanged for all values separated by the same interval of time. For instance, E (y_{t_1} - μ) (y_{t_2} - μ) is equal to E ($y_{t_{10}}$ - μ) ($y_{t_{11}}$ - μ) and so on.

Empirically a weak stationary process shows some of these three properties, mostly the property of constant variance (a progressive decay of a shock in time series) and we scrutinise our variables by using formal tests which we review in section (5.2.3) below.

5.2.2 Autocorrelation and partial autocorrelation functions within an AR ($_p$) model

The significance of autocorrelation and partial autocorrelation coefficients indicate how a time series is correlated with its own lags as time progresses and can generally tell one a great deal about the presence of stationarity within a time series (Box and Pierce, 1970). According to Brooks (2002: 239) and Maddala and Kim (1998: 13-15), an autoregressive process is one where the current value of a variable, y_t depends upon only the values that the variable took in the previous periods plus an error term. Therefore, a process of order p denoted AR (p), can be written as:

$y_t = \mu + \theta_1 y_{t-1} + \theta_2 y_{t-2} + \theta_3 y_{t-3} + \cdots\cdots\cdots + \theta_p y_{t-p} + U_t$, where U_t is the disturbance or error term.

5.2.3 Empirical tests for stationarity

The condition of stationarity is achieved through testing for the presence of a unit root in a time series. In this way, Brooks (2002: 377) stipulates that one can test for a unit root through checking the significance of autocorrelation function coefficients, or examining the correlogram plots to determine if the correlogram is decaying (stationarity) or not. However, Enders (2004: 175) and Brooks (2002: 377) reiterate that when one is analysing the decay of a correlogram, one can sometimes reach the wrong conclusion about the existence of stationarity within a time series. Thus, hereafter formal stationarity hypothesis testing is discussed.

We suggest that in order to test stationarity, popular tests such as the Dickey-Fuller (DF) test, the Augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) tests, and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test (Patterson, 2000: 257-260) and (Maddala and Kim, 1998: 126-128) be used.

5.2.3.1 Dickey-Fuller stationarity test

Fuller (1976) and Dickey and Fuller (1979) investigate the null hypothesis that $\phi = 1$ in the model $y_t = \phi y_{t-1} + u_t$ (5.1) against one side alternative hypothesis that $\phi \prec 1$. In addition to model (5.1), Fuller (1976) and Dickey and Fuller (1979) examine two other models, (5.2) and (5.3) below, having respectively, a constant, and a deterministic trend and a constant. It is worth noting that when empirical testing fails to reject the null hypothesis that $\phi = 1$, one posits that there exists a unit root in the data generating process of time series y_t. This emphasises the non-decaying effect of any shock occurring in this series as time progresses. To carry out this test one can estimate the following models:

$$H_0 : y_t = y_{t-1} + u_t \qquad (5.1)$$

$$H_1 : y_t = \phi\, y_{t-1} + u_t, \phi \prec 1$$

$$H_0 : y_t = y_{t-1} + u_t \qquad (5.2)$$

$$H_1 : y_t = \phi\, y_{t-1} + \mu \; + u_t, \phi \prec 1$$

$$H_0 : y_t = y_{t-1} + u_t \qquad (5.3)$$

$$H_1 : y_t = \phi\, y_{t-1} + \mu \; + \lambda t + u_t, \phi \prec 1$$

According to Gujarati (2003: 815), the null hypothesis of a unit root can be empirically investigated through estimating the model $\Delta y_t = \psi\, y_{t-1} + \mu + \lambda t + u_t$, with $\Delta\, y_t = y_t - y_{t-1}$ and $\psi = \phi - 1$. The test statistic is defined as $\frac{\hat{\psi}}{S\hat{E}(\hat{\psi})}$, where $S\hat{E}(\hat{\psi})$ is the standard deviation of an estimate of the coefficient on y_{t-1}. The critical values for DF tests are given in Fuller (1976: 373), Brooks (2002: 675), Patterson (2000: 237) and Maddala and Kim (1998: 64) and can be obtained by simulation. As is familiar to us from the econometrics literature, for a given significance level, we do not fail to reject the null hypothesis of a unit root in favour of stationarity when the test statistic $\frac{\hat{\psi}}{S\hat{E}(\hat{\psi})}$ is greater (less negative) than the critical value for the DF tests. In the same way, one can fail to reject the null hypothesis of a unit root if the test statistic $\frac{\hat{\psi}}{S\hat{E}(\hat{\psi})}$ is, for a given significance level smaller than the critical value for the DF tests. Before concluding on these DF tests, it is worth noting that the estimates of the intercept and that of the coefficient on the time trend variable, included in the models (5.2) and (5.3) are not examined by a unit root test (Dickey and Fuller, 1981: 1062). The asymptotic distribution of the DF tests supposes that the errors u_t are identically and independently distributed (Maddala and Kim, 1998: 74).

5.2.3.2 Augmented Dickey-Fuller unit root test (ADF-tests)

The distribution of errors can be identically and independently distributed (iid $\sim (0, \sigma^2)$) or maybe not, the latter especially if there is autocorrelation in the dependent variable of the regression (Δy_t)(Brooks, 2002: 379). According to Patterson (2000: 239-241), to correct for the effect of serial correlation in the errors, Dickey and Fuller augment the initial regression (seen above under DF test) by the lagged dependent variables (Δy_{t-1}) to improve the test statistic. In this way, Brooks (2002: 379-380) emphasises that the dependent lagged (Δy_{t-1}) variables be in the regression model (see equations (5.4 to 5.6) below) for the purpose of correcting any autocorrelation in the dependent variable (Δy_t) to make sure that the autocorrelation in u_t is removed. Otherwise, the usual test statistic will be incorrect and leads one to make the incorrect decision as to the null hypothesis of a unit root (Brooks, 2002: 380). It is worth noting that $\Delta y_t = y_t - y_{t-1}$, where for any given period "T" of study, y_t is the value of a time series "Y" observed at *t* and y_{t-1} is the value seen in the previous time period, *t-1*.

$$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-1} + u_t \qquad (5.4)$$

$$\Delta y_t = \mu + \psi y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-1} + u_t \qquad (5.5)$$

$$\Delta y_t = \mu + \psi y_{t-1} + \lambda t + \sum_{i=1}^{p} \alpha_i \Delta y_{t-1} + u_t \qquad (5.6)$$

Enders (2004: 182) maintains that the same critical values for the Dickey-Fuller (DF) test can be used with the *augmented Dickey-Fuller (ADF) test* and is still conducted on the ψ coefficient of y_{t-1}. We do not fail to reject the null hypothesis of a unit root in favour of stationarity or we fail to reject the null hypothesis of a unit root if the test statistic is greater or less than the DF critical values at a given significance level respectively. In determining the optimal number of lags of the dependent variable (Δy_t), one can use Akaike's (1974) information criterion[1] (AIC), or Schwartz's (1978) Bayesian information criterion[2] (SBIC).

5.2.3.3 Phillips-Perron (PP) tests

The augmented Dickey-Fuller unit root tests assumes that the autocorrelation of errors is caused by the autocorrelation in the dependent variable (Δy_t) (Patterson (2000: 239-241). To remove the bias caused by autocorrelation in the error tem, the lagged dependent variables should be included in the regression model as regressors. In addition, Maddala and Kim (1998: 79) advocate the point that autocorrelation may have many sources. Taking into consideration this idea, Phillips (1987) and Perron (1988) devised a new test statistic[3] by applying a correction factor to the usual ADF test statistic. These corrections are $s_e^2 = T^{-1}\sum_{t=1}^{T} e_t^2$ and $s_{Tl}^2 = T^{-1}\sum_{t=1}^{T} e_t + 2T^{-1}\sum_{\tau=1}^{l}\sum_{t=\tau+1}^{T} e_t e_{t-\tau}$ for respectively correcting for the variance of errors (σ_e^2) and the variance of the sum of squared errors (σ^2); where T is the total number of sample observations, e_t are regression errors, l is the number of lags (Maddala and Kim, 1998: 78-81). It is worth noting that the econometric software package, Eviews 6.0, calculates the PP tests statistic and provides

1 $AIC = \ln(\hat{\sigma}^2) + \frac{2k}{T}$

2 $SBIC = \ln(\hat{\sigma}^2) + \frac{k}{T}\ln T$,), where $\hat{\sigma}^2$ is the variance of residuals (also equivalent to the residual sum of squares divided by the number of degrees of freedom $T-k$; k is the number of parameters estimated and T is the sample size) (see Maddala and Kim, 1998: 77).

3 AR (1) without drift: $Z_t = \frac{s_e}{s} t_{\hat{p}} - \frac{1}{2}\frac{(s^2 - s_e^2)}{s\left(T^{-2}\sum_1^T y_{t-1}^2\right)^{1/2}}$, for simplification let designate s_{Tl}^2 by s^2.

AR (1) with a drift: $Z_t = \frac{s_e}{s} t_{\hat{p}} - \frac{1}{2}\frac{(s^2 - s_e^2)}{s\left[T^{-2}\sum_1^T (y_{t-1} - \bar{y}_{-1})^2\right]^{1/2}}$

AR (1) with a drift and a linear trend: $Z_t = \frac{s_e}{s} t_{\hat{p}} - \frac{T^3(s^2 - s_e^2)}{4\sqrt{3} D_x^{1/2} S}$, where $D_x = \det(X'X)$ and the regressors are $X = (1, t, y_{t-1})$. (Maddala and Kim (1998: 78-81).

the critical values at different significance levels. Concerning the power of these tests in detecting the existence of a unit root within a time series, Brooks (2002: 380-381) shows that the PP and ADF tests have the limitation of failing to reject the null hypothesis of a unit root in the case of stationary process for an insufficient number of times. Despite this limitation, we use these tests as they are popular in the literature.

5.2.3.4 Testing stationarity as a null hypothesis: KPSS tests

Maddala and Kim (1998: 126-128) stipulate that one way of getting around the problem of failing to reject the null hypothesis of unit root when false is to perform a test which has the stationarity under the null hypothesis. Kwiatkowski-Phillips-Schmidt-Shin (KPSS) developed such a test for a series appearing stationary by default in those cases where there is little information within the sample of data (Kwaitkowski *et al*., 1992). In empirical tests, it is recommended that one compare the results of the KPSS tests with the results obtained from the ADF/PP procedure to see if the same conclusions are reached. One must note that the null and alternative hypotheses under each test are not the same and are as follows:

ADF/PP	**KPSS**
$H_0 : y_t \sim I(1)$	$H_0 : y_t \sim I(0)$
$H_1 : y_t \sim I(0)$	$H_1 : y_t \sim I(1)$.

The econometric package Eviews 6.0 calculates the KPSS test statistic and provides critical values for this. In comparing the results from ADF/PP and KPSS tests, the four following outcomes can take place:

(i) Reject H_0 in ADF/PP test and do not reject H_0 in KPSS test

(ii) Do not reject H_0 in ADF/PP test and reject H_0 in KPSS test

(iii) Reject H_0 in ADF/PP test and reject H_0 in KPSS test

(iv) Do not reject H_0 in ADF/PP test and do not reject H_0 in KPSS test

If the results from testing stationarity in the empirical research fall under the outcome (i) and (ii), we can unambiguously conclude for stationarity. Conflicts arise if outcomes (iii) or (iv) occur. In this case, it will be difficult to make a decision and the only way to avoid this difficulty is to obtain more information.

5.3 Cointegration methods and linear combinations of non-stationary time series

The inclusion of a time series in regression analysis requires that the time series be stationary. A non-stationary time series can be made stationary by differencing or detrending and these procedures can be guided by the results from the unit root tests (Gujarati, 2003: 802-804). The elimination of any trend (stochastic or deterministic) may result in the loss of relevant information about the long-run relationships among macroeconomic time series (Patterson, 2000: 602). However, there might be equilibrium between variables and research must include cointegrating non-stationary time series in their analysis (Patterson, 2000: 602).

According to Enders (2004: 325), time series trending together can appear to have a long-run equilibrium since they cannot progress "independently" from each other. Furthermore, the fact that these series trend together could induce some linear combination of the two to become stationary and are said in this case to be *cointegrating*, and this stationary linear combination must be included in the econometric model if there is a sound economic reason for doing so (Brooks, 2002: 392) and (Enders, 2004: 322).

The next section discusses cointegrating (stationary linear combinations) non-stationary time series. Brooks (2002: 388) stipulates that the vector $x_t = (x_{1t}, x_{2t}, \ldots, x_{nt})'$, is cointegrated of order d, b, denoted $x_t \sim CI(d,b)$ if two necessary conditions are verified:

(i) all components of x_t are integrated of order d;

(ii) if there exists a vector $\beta = (\beta_1, \beta_2, \beta_3, \ldots, \beta_n)$ called the *cointegrating vector* such that a linear combination $\beta_1 x_{1t} + \beta_2 x_{2t} + \cdots\cdots + \beta_n x_{nt} = \beta x_t$ is integrated of order $(d-b)$ where $b \succ 0$. The order d of integration of a time series indicates how many times one has to difference it in order to get the series stationary (Ender, 2004: 164).

In defining the long-run equilibrium resulting from a linear combination of non-stationary series trending together over time, it can happen that one of these series deviates from the equilibrium trend and causes disequilibrium among the cointegrating series. However, the subsequent period can be characterised as a short-run dynamic movement of that series such that there is a return to the long-run equilibrium (correcting the previous disequilibrium) and therefore the system (these series) returns to the long-run equilibrium (Maddala and Kim, 1998: 36) and (Patterson, 2000: 608). The following sub-section (5.3.1) summarises this phenomenon using the concept of error correction models.

5.3.1 Cointegration, error correction models, weak exogenous and Granger causality

The proportion of the deviation from the equilibrium relationship of cointegrating time series corrected in each period is estimated using an econometric model called the *error correction technique* (Enders, 2004: 328-329). Furthermore, to illustrate the error correction model, let us say that y_t and x_t are cointegrating time series. Indeed, the proportion of adjustment to the long-run equilibrium can be estimated using equations (5.7) and (5.8) below:

$$\Delta x_t = \alpha_x \left(y_{t-1} - \beta x_{t-1}\right) + \varepsilon_{xt}, \quad \alpha_x \succ 0 \qquad (5.7)$$

$$\Delta y_t = -\alpha_y \left(y_{t-1} - \beta x_{t-1}\right) + \varepsilon_{yt}, \quad \alpha_y \succ 0 \qquad (5.8)$$

Where ε_{yt} and ε_{xt} are white noise disturbance terms, α_y, α_x are named speeds of adjustment to equilibrium, β is the long-run equilibrium parameter and $\left(y_{t-1} - \beta x_{t-1}\right)$ is the deviation in a previous period from the long-run equilibrium between y_t and x_t (Patterson, 2000: 608-609) and (Enders, 2004: 328-329).

The estimation of an error correction model can give biased results if there is autocorrelation in the error terms. To alleviate this problem, as is done for the Augmented Dickey-Fuller test, one includes lagged values of the dependent variables in the error correction model as an explanatory variable (Brooks, 2002: 391). In this way, it is appropriate to estimate equations (5.9) and (5.10) seen below:

$$\Delta x_t = a_{10} + \alpha_x \left(y_{t-1} - \beta x_{t-1}\right) + \sum a_{11}(i)\,\Delta x_{t-i} + \sum a_{12}(i)\,\Delta y_{t-i} + \varepsilon_{xt} \qquad (5.9)$$

$$\Delta y_t = a_{20} - \alpha_y\left(y_{t-1} - \beta x_{t-1}\right) + \sum_{a_{21}} (i)\Delta x_{t-i} + \sum_{a_{22}} (i)\Delta y_{t-i} + \varepsilon_{yt} \qquad (5.10)$$

After estimating equations (5.9) and (5.10), one can apply the standard statistical tests (t-test, F-test) for the significance of the coefficients and the model, since all variables included in these models are stationary. Furthermore, if it happens that $\hat{\alpha}_x$ is not significant, one should note that $\{x_t\}$ does not respond to the deviation $\left(y_{t-1} - \beta x_{t-1}\right)$ from equilibrium and $\{x_t\}$ is therefore said to be *weakly exogenous* (Enders, 2004: 334). In addition, if the estimates of the coefficients of the lagged variables Δy_{t-i} are not significantly different from zero in equation (5.9), we can conclude that $\{y_t\}$ does not Granger cause $\{x_t\}$. This interpretation can be applied to $\{y_t\}$ in the case of $\hat{\alpha}_y = 0$ in (5.10).

5.3.2 The Engle-Granger methodology: Testing for Cointegration

For testing cointegration of non-stationary time series, Engle and Granger (1987) suggest examining whether the residuals from the regression of a non-stationary time series have a unit root or not (Xiao *et al*., 2002). Indeed here we undertake two regression models: (i) the first model is $y_t = \beta_0 + \beta_1 x_t + e_t$ (5.11) corresponding to the regression of non-stationary time series and (ii) the second model $\Delta\hat{e}_t = a_1\hat{e}_{t-1} + \varepsilon_t$ (5.12) has enclosing residuals from an estimation of equation (5.11) (Brooks, 2002: 391) and (Shin, 1994).

Furthermore, a Dickey-Fuller or augmented Dickey-Fuller unit root test is carried out on these residuals to ensure that they are stationary given that these residuals represent the deviations $(y_t - \beta_0 - \beta_1 x = e_t)$ from their long-run equilibrium (Brooks, 2000: 393-394). Their stationarity entails that any shock to the cointegrating non-stationary time series, which causes disequilibrium, will disappear over time and the series return to equilibrium (Banerjee *et al*., 1996).

Additionally, if we reject the null hypothesis that $a_1 = 0$ from equation (5.12), we can conclude that the $\{y_t\}$ and $\{x_t\}$ sequences are cointegrated (Xiao *et al*., 2002). Moreover, it is worth noting that when we estimate the error correction model, the residuals $\{\hat{e}_{t-1}\}$ can substitute for the deviations from long-run equilibrium (Engle and Granger, 1987) and (Engle and Yoo, 1987).

5.4 Multivariate models and the Johansen methodology for testing cointegration

When we have one stationary linear combination of macroeconomic variables, the Engle-Granger methodology suffices. However, when we intend to have more than one cointegrating relationship among non-stationary time series, Enders (2004: 347) suggests we make use of Johansen's methodology. Furthermore, for investigating cointegration within the Engle-Granger framework, the usual test of the unit root hypothesis is a two step process where the second step uses an autoregressive model of the residuals obtained from the regression carried out in the first step (see section 5.3.2). This second regression can give biased results since any error introduced in the first regression can affect the second (Patterson, 2000: 341-343).

To avoid these problems, Johansen (1988) and Stock and Watson (1988) using full information maximum likelihood methods estimate a differenced vector autoregressive model $\Delta x \ = (A_1 - I)x_{t-1} + e_t$, where $x_t = (x_{1t}, x_{2t}, \ldots\ldots\ldots, x_{nt})'$ is a vector enclosing n non-stationary time series (variables), A_1 is a matrix of regression coefficients, I is an identity matrix. In this way, Johansen (*op.cit*) and Stock and Watson (*op.cit*) determine the coefficients and eigenvalues of the matrix $\pi = (A_1 - I)$ and they show that the test for cointegration is done through investigating the statistical significance of the nonzero eigenvalues from this matrix π and is thus a multivariate unit root test (Xiao *et al*., 2002) and (Enders, 2004: 348).

The statistical software package, Eviews 6.0, helps in estimating the eigenvalues of the matrix π (Brooks, 2002: 426). These values help to calculate two tests' statistics, $\lambda_{trace}(r) = -T\sum_{i=r+1}^{n}\ln(1-\hat{\lambda}_i)$ and $\lambda_{\max}(r, r+1) = -T\ln(1-\hat{\lambda}_{r+1})$, where: $r =$ the number of independent cointegrating vectors, $\hat{\lambda}_i$ = the estimated value for the i^{th} ordered eigenvalue from 1 to n (n is the number of non-stationary time series components of the vector x_t).The main objective of the λ_{trace} and $\lambda_{\max}$ tests statistics is to investigate among the number of eigenvalues of the matrix π, how many of them are insignificantly different from one but keeping track of the number of co-integrating relationships (Enders, 2004: 352). In performing the test, Brooks (2002: 404-405) and Enders (2004: 352-353) point out that the test statistic λ_{trace} under the null hypothesis is the number of independent cointegrating vectors *less than or equal* to r against a general alternative hypothesis. According to Brooks and Enders, (*op.cit*), the test statistic, $\lambda_{\max}$, is under the null hypothesis the number of independent cointegrating vectors equal to r against an alternative hypothesis of $r+1$ vectors. Johansen and Juselius (1990) provide the asymptotic critical values for the two statistics. In this way, comparing the calculated test statistic and the critical values at conventional significance levels, we can form a subjective opinion as to the number of the cointegrating vectors between two variables. Eviews 6.0 provides the calculated test statistic, λ_{trace} and λ_{max}, and their critical values at different significance levels. After comparing the values of the test statistic with the critical values, we obtain some idea as to the number of cointegrating vectors among variables in our data.

5.5 Model specification

To our knowledge only a few studies analyse the stability of the demand for money function and show whether the monetary aggregate M2 serves as an adequate intermediate target to achieve the primary objective of price stability in Rwanda and not using the more recent data we have obtained.

In line with this prior research, we find it valuable to undertake this research in order to ensure that policies still remain valid after changes (cited in the introduction) occurred in the Rwandan macroeconomic structure. The support for this research comes from Handa (2000: 285) stipulating that the appropriateness of a macroeconomic variable (either monetary aggregate, or interest rate or exchange rate) as an indicator of the need for monetary policy depends upon the structure of the economy.

According to Handa (*op.cit*), one is not sure that existing policies remain effective after changes in economic structures even if they appear to be minor. The best action to take in these circumstance is to keep updating research to ensure policy makers know whether their policies are still on track and this study is indeed useful for this purpose.

All the economic theories reviewed in chapters two, three, and what we expect to find from the estimation of the econometric models in chapter 6, are centred on figure 5.1 that is a summary of the monetary policy framework in Rwanda.

Figure 5.1

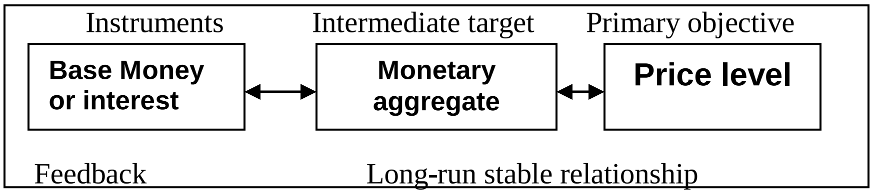


Figure 5.1: Monetary targeting. (Source: Munyankindi *et al.*, 2008: 55)

Based on this figure, the NBR sets base money as an operating target with the intention of changing the intermediate target of any monetary aggregate (money stock in the economy). Indeed monetary aggregate targeting is part of the strategy by which the National Bank of Rwanda chooses the money stock as the nominal anchor for achieving price stability as a final objective. To attain this final objective, the following two requirements are necessary: (i) a stable demand function for money; (ii) a long-run relationship between the money stock and the price level (Hansen and Kim, 1995: 286).

These two necessary conditions ((i) and (ii) above) are combined into two macroeconomic relationships, which are subjected to cointegration analysis. The cointegration analysis sets out to identify all the existing long-run cointegrating relationships, based primarily on the economic theory covered in chapters two, three, and on empirical work of Nassar (2005) for the case of Madagascar, and improve on studies undertaken for Rwanda by Sayinzoga and Simson (2006) and Rusuhuzwa *et al.*, (2006).

These previous studies on Rwanda cover in large part the period of this thesis and use the Johansen framework for detecting the cointegrating vectors and include the exchange rate in the long-run relationship of the money stock with other economic variables. In addition, since weekly auctions in which the NBR sells US dollar reserves to commercial banks began, the exchange rate became linked to market forces (IMF, 2009: 25).

Furthermore, the cointegration analysis we undertake in chapter six (sections 6.5.1.1 and 6.5.1.2) covers the cointegrating long-run relationships between the variables of the VAR1[4] (based principally on the demand function for money) and VAR2[5] models (mainly based on the long-run relationship between the money stock and the price level). The VAR1 model has four variables: real money balances (LNM2-LNCPI), real income (LNREALGD), a lending interest rate (DINTERES), and the nominal exchange rate

[4] VAR1: is the vector autoregressive model representing the conditions giving a stable demand function for money: VAR1= (LNM2-LNCPI, LNREALGD, DINTERES, LNEXCHAR);
[5] VAR2= (LNM2, LNREALGD, DINTERES, DLNEXCHA): is the vector autoregressive model representing the second condition representing principally the long-run relationship between the money stock and the price level.

(LNEXCHAR). The VAR2 model contains the money stock (LNM2), the price level (LNCPI), real income (LNREALGD), a lending interest rate (DINTERES), and the depreciation of the exchange rate (DLNEXCHA).

Additionally, the cointegrating relationship among the components of the VAR1 model is represented as: VAR1 = ((LNM2-LNCPI), α_1 DINTERES, α_2 LNREALGD, α_3 LNEXCHAR). In the VAR1 model α_2 is expected to be positive given that an increase in real income increases the demand for money for transactions purpose while α_1 and α_3 are expected to be negative as they both represent an opportunity cost of holding money. An increase in the opportunity cost of holding money discourages the economic agents to hold money balances and this behaviour consequently provokes an increase in the outstanding money stock, which can then causes an increase in the price level.

The second long-run cointegrating vectors can be represented as: VAR2= (LNM2, β_1 LNREALGD, β_2 LNCPI, β_3 DINTERES, β_4 DLNEXCHA) and inform about the effectiveness of monetary policy in controlling prices and regulating aggregate demand. Indeed, the significance of real income in the VAR2 shows the effectiveness of monetary policy in influencing real income and we expect the sign of β_1 to be positive. In addition, under the VAR2 model we expect to observe from the sample of data that an increase in the money stock provokes an increase in the price level and the causation is to run from the money stock to prices and thus the expected sign of β_2 is positive. In this case, targeting the monetary stock as the intermediary objective for attaining the final objective of price stability is considered an effective monetary policy.

Furthermore, the IS-LM theory emphasises that an increase of the money stock in the economy reduces the interest rate (Colander and Gamber, 2002) and (Hubbard, 2005: 482). We therefore expect to have from our sample of data a negative relationship between changes in the money stock and the changes in the lending interest rate.

Additionally, according to El-Sakka and Ghali (2005), most of the empirical studies undertaken in developing countries show a positive correlation between the depreciation of the nominal exchange rate and inflation. The positive correlation between the depreciation of the nominal exchange rate and inflation, can justify a positive sign between the depreciation of the exchange rate and the money stock. This can happen when economic agents are anticipating further inflation by observing the current deprecation of the local currency. In this way, they can avoid further inflation *via* a depreciation of the exchange rate and opt to buy more in the current time period than in the future. This situation is summarised as trying to get ahead of possibly increasing inflation by purchasing more now, including imports (Beatjer, 2008: 15).

Summary and conclusion

The statistical estimation methodology and model specification discussed in chapter five are firstly, based on the techniques of testing the integration order of a time series so as to identify the non-stationary time series $I(1)$ from the stationary time series $I(0)$. This endeavour is completed through the Dickey-Fuller (DF) unit root test, the Augmented Dickey-Fuller (ADF) unit root test, Phillips-Perron (PP) unit root test, and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity test.

Furthermore, the procedure of investigating cointegrating time series summarises the Engle-Granger residuals based approach and the Johansen methodology based on determination of the rank (identifying non-zero eigenvalues) of the matrix of the coefficients in a multivariate system.

Additionally, chapter five discusses the specification of the VAR model to be estimated in chapter six.

CHAPTER SIX

MODEL ESTIMATION, PRESENTATION AND DISCUSSION OF RESULTS

6.1 Introduction

This chapter provides an explanation of the empirical estimates and is done jointly with both a presentation and interpretation of the results. The focus of the empirical exploration is to develop two long-run cointegrating relationships. The first cointegrating relationship (VAR1) is between real money balances, real income, a lending interest rate, and the exchange rate. The second (VAR2) model is developed between the money stock, the price level, real income, a lending interest rate, and the depreciation of the exchange rate. Further, from the cointegrating relationships we can formulate the dynamic short-run models which embrace an error correction model providing a picture of the adjustment of the system (both demand and supply) to long-run equilibrium.

Section (6.2) of this chapter highlights the data sources and covers the choice of variables in reference to the theory discussed in chapters two, three, and four of this thesis. Furthermore, based on the discussion outlined in chapter five, this chapter divides the estimation procedure into five sections. Section (6.3) emphasises the transformation of the data. This stage includes the log transformation of all the variables except the interest rate. Further, the transformation of nominal income into real income and the determination for real money balances are carried out. In addition, the depreciation of the Rwandan franc against the US dollar is determined. In section (6.4), the estimation procedure undertakes tests of integration based on the Augmented Dickey-Fuller (ADF-tests), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit roots tests for stationarity in order to separate the non-stationary variables $I(1)$ from the stationary $I(0)$ variables. This section also presents the results concerning stationarity and motivates the subsequent approach of testing for cointegration. Section (6.5) undertakes the tests of cointegration using the Johansen approach. Under the Johansen framework, variables are arranged into a multivariate VAR model (Vector Autoregressive) and the order of lag ($_p$) is determined using standards methods. Further, the estimation of the VAR models is done by choosing a model with a constant in the cointegrating space, or a model having a linear trend in the data and a constant in the cointegrating space, or a model having a linear trend and a constant in the data as well as in the cointegrating space. Furthermore, section (6.5) presents and discusses the results of the estimated cointegrating vectors in both models, namely, VAR1 and VAR2. Section (6.6) exploits the long-run relationships, VAR1 and VAR2 in order to develop VECM1 and VECM2 models (Vector Error Correction Models). The VECM (s) are formed by the equations that capture the correction of the demand for money balances back to equilibrium and the correction of the disequilibrium in the outstanding money stock in the economy. Section (6.7) involves diagnostic tests of the error correcting models: VECM1 and VECM2. We also verify exogeneity tests to check whether there is a possibility of the existence of a single equation relationship to be estimated using OLS.

6.2 Data collection

The data is from the National Bank of Rwanda for the period 1996: Q1 to 2008: Q3. Information about the data is available in the various publications of the National Bank of Rwanda, including quarterly and annual reports.

***Monetary aggregate* M2 (*LNM2*)**: Broad money comprising narrow money M1 (currency in circulation and demand deposits), time and savings deposits, and foreign currency assets. The National Bank of Rwanda targets M2 with the aim of achieving a final goal of price stability.

Real income (LNREALGD): The quarterly Gross Domestic Product (GDP) data is collected from the NBR and according to the National Institute of Statistics can be categorized into three activities including the *agriculture sector* (food crops, export of crops, livestock, forestry and fisheries), *the industry sector* (mining and quarrying, manufactured goods; foodstuffs, beverages and tobacco, electricity, gas and water and construction), *and services* in the wholesale and retail trade, restaurants and hotels, transport, storage and communication, finance, insurance, real estate and business services, public administration, education, health and other services (NBR, 2009: 130).

Further, when researchers choose a scale variable to include in the money demand function, some prefer considering money as an asset competing with other financial assets and suggest using the wealth of economic agents as a scale variable. On the other hand, if the focus is the demand for money for transactions, the current income of economic agents can serve as a scale variable. Given that the economy of many African countries (including Rwanda) is based on agriculture and their financial markets are less developed, most of the empirical research examining the demand for money in these countries emphasize the transaction motive and most use real GDP as a scale variable (Rusuhuzwa *et al.*, 2006: 52). Indeed, we use real GDP here to represent a scale variable in the econometric models.

***Lending interest rate* (*DINTERES*)**: Basically, in the context of demand for money the opportunity cost is represented by the rate of return remunerating other financial assets that economic agents should choose as an alternative investment to holding money balances.

According to Laidler (1999), the interest rates in the money market usually trend together (as all of them are determined as a function of inflation) and anyone of them can be a proxy for each other in any empirical analysis. We make this assumption here.

In Rwanda, the developing financial market started in December 2007 and from that date until December 2008 only three bonds were issued. Furthermore, only some banks and other private or public institutions are directly involved in the money market engaged in the selling and buying of treasury bills, and not the rest (small businesses) of Rwandan economic agents. To this end, the demand for money emphasising the transactions' motive may fit well into the Rwandan macroeconomic context, over our sample period.

It is worth noting that we were not able to collect the data on interest rates for treasury bills transactions over the study period. For this reason, and considering Laidler's (1999) idea that the interest rates in money market trend together, we suggest use the lending interest rate as representing the cost of holding money in our econometric model.

***Exchange rate* (*LNEXCHAR*)**: According to (Oskooee *et al*., 1990, Corden, 1984, Mundell, 1963) the nominal exchange rate should be included in the list of the determinants of demand for money. In conformity with this suggestion, the exchange rate of the Rwandan franc against the US dollar is included in our econometric model to represent the opportunity cost of holding money balances in the local (Rwandan franc) currency (Rusuhuzwa *et al.,* 2006: 53).

Depreciation of the exchange rate (DLNEXCHA): According to Mishikin (2007), changes in the exchange rate can either be an appreciation (increase in the value of the domestic currency) or a depreciation (a decrease in the value of the domestic currency). Indeed, a depreciation of domestic currency can cause inflation.

In an empirical study of money demand and inflation conducted by Nassar (2005: 7) for Madagascar, the expected depreciation of the local currency is found to be a major factor in stoking inflationary expectations. In the same way as Nassar, we include this variable in the econometric models under study here for assessing its effect in the context of Rwanda.

Consumer price index (LNCPI): The ultimate objective of the NBR is to achieve price stability through targeting the monetary aggregate M2. For this reason, we investigate the existence of a stable long-run relationship between nominal money stocks and the price level as part of answering our research questions so as to evaluate the effectiveness of this policy. In the case of Rwanda, the Consumer Price Index comprises a wide range of goods and services, including: food, non-alcoholic and alcoholic beverages, clothing, housing, gas, water, electricity, furnishing, restaurants, and hotel services (NBR, 2009: 132).

Dummy variable: This variable captures the fact that in 2006: Q4**,** Rwanda (AFDB, 2007), became eligible for benefits from the initiatives of the HIPC (Highly Indebted Poor Countries) and the MDRI (Multilateral Debt Relief Initiatives). These initiatives lead to a reduction of debt by 76.6 million US dollars and later a further 1.150 billion US dollars.

Dummy2 variable: In January 2008, the National Bank of Rwanda (NBR; 2007: 3) recommended, in conformity with law and regulation, that commercial banks increase their capital of 1.5 billion Rwandan francs up to a minimum of 5 billion Rwandan francs (roughly 9 million US dollars). We add this dummy to capture the higher capital requirement.

6.3 Data transformation

This stage involves the natural log transformation of the variables except for the interest rate. And it also involves the determination of real income, real money balances and the depreciation of the exchange rate of the Rwandan franc against the US dollar.

Natural Log Transformation

It is standard practice to transform macroeconomic time series data into the natural log form since the non-transformed data usually trends upwards and unit root tests undertaken on these series may mistakenly conclude they are non-stationary (Maddala and Kim, 1998: 88). In addition, a natural logarithm transformation of time series data facilitates interpretation of results given that in the natural logarithm transformation any responses are thus stated in percentage change rather than in measured units. Furthermore, it is worth recalling that the interest rate variable is already in percentage terms; thus it needs no transformation.

Transformation of nominal income into real income

Normally, to deflate nominal GDP economic theory recommends the use of the GDP deflator (Colander and Gamber, 2000). In the absence of a GDP deflator variable use of the consumer price index has become popular with the intention of removing the effect of price increases (or decreases) in the value of aggregate income. In this way, the consumer price index is used here to remove the effects of price changes to obtain real income since we were not able to get the GDP deflator from the National Bank of Rwanda over the study period.

Transformation of nominal M2 into real M2 balances

Economic theories discussed in chapter three emphasise that a rational economic agent negotiates their income in terms of purchasing power. Further, the economic theories discussed in chapter two suggest analysing money demand in terms of real balances. Empirically, the transformation of nominal M2 into real M2 is carried out by taking the natural logarithm of M2 minus the natural logarithm of CPI (LNM2-LNCPI) (Nassar, 2005: 7).

Calculation of the depreciation of the exchange rate

Inspired by Nassar (2005: 7), the depreciation of the exchange rate between the Rwandan franc against the US dollar is calculated by taking the natural logarithm of the nominal exchange rate series at period t and then taking a one period lag of the natural logarithm of the exchange rate and subsequently determining the difference between the natural logarithm of the exchange rate series and its lagged value. It is worth noting that a positive value for the difference is an appreciation of the exchange rate. In African countries (including Rwanda) with less developed economies, usually the exchange rate depreciates rather than appreciates. Indeed, we make this assumption for the exchange rate of the Rwandan franc against the US dollar.

6.4 Estimation of order of integration, and the methodology for testing for cointegration

This section tests for the order of integration of the time series under study and reports the results of unit root tests. In addition, the correlation of a series with its own lags and interaction among series under study point to the right approach to use for identifying the cointegrating vectors among them. In this endeavour, the results of the test for stationarity of time series are crucial when estimating the econometric model, since only non-stationary time series are involved in the cointegrating relationships.

6.4.1 Estimation of order of integration

Before attempting the formal test of unit root hypothesis in each time series, one can first plot the data and the correlogram of each time series using Eviews 6.0 and SPSS 15.0. Through these plots one can identify whether a time series is a random walk from a decaying-correlation of each time series with its own lags exists. In appendix 1, the plots and the correlogram of each variable show the presence of a random walk and a slowly decaying-sample correlogram leading one to posit a unit root in these series. But not in the interest rate and the depreciation of the exchange rate series. With the intention of enhancing the analysis, the second step is to detect formally the presence of unit roots using the ADF, PP, and KPSS (detailed earlier in chapter five, sections 5.2.3.2; 5.2.3.3, and 5.2.3.4) unit root tests and we report the results in table 6.1 below.

Table 6.1 - ADF, PP, and KPSS Unit Root Tests Results

Method	Variables	Lags	Test stat. in levels	Critical stat.	Lags	1st differences Test stat.	Critical stat.
ADF	LNM2	5	0.692470	-3.568308 (at 1%)	1	-2.736707	-2.614029 (at 1%)
PP	LNM2		2.669686	-2.921175 (at 5%)		-5.462030	-2.613010 (at 1%)
KPSS	LNM2		0.945057	0.739000 (at 1%)		0.231649	0.739000 (at 1%)
ADF	LNREALGD	0	- 2.945529	-3.568308 (at 1%)	5	-1.981951	- 1.948313 (at 5%)
PP	LNREALGD		-2.539169	-2.921175 (at 5%)		-3.341006	-1.947665 (at 5%)
KPSS	LNREALGD		0.929907	0.463000 (at 5%)		0.361287	0.463000 (at 5%)
ADF	LNCPI	1	1.229258	-2.922449 (at 5%)	0	-1.990681	-1.947665 (at 5%)
PP	LNCPI		2.191048	-2.921175 (at 5%)		-2.277329	-1.947665 (at 5%)
KPSS	LNCPI		0.924418	0.739000 (at 1%)		0.388436	0.463000 (at 5%)
ADF	LNEXCHAR	6	-1.359759	-2.922449 (at 5%)	0	-1.990681	-1.947665 (at 5%)
PP	LNEXCHAR		-1.167608	-2.921175 (at 5%)		-2.061025	-1.947665 (at 5%)
KPSS	LNEXCHAR		0.858294	0.739000 (at 1%)		0.262838	0.463000 (at 5%)
ADF	DLNEXCHA	0	-2.356622	-2.922449 (at 5%)	0	-6.486051	-2.614029 (at 1%)
PP	DLNEXCHA		-2.471651	-2.922449 (at 5%)		-6.967225	-1.947816 (at 5%)
KPSS	DLNEXCHA		0.159793	0.216000 (at 1%)		0.097808	0.146000 (at 5%)
ADF	DINTERES	0	-0.557625	-1.947665 (at 5%)	10	-2.836376	-2.624057 (at 1%)
PP	DINTERES		-0.792918	-1.947665 (at 5%)		-12.38874	-2.614029 (at 1%)
KPSS	DINTERES		0.490598	0.739000 (at 1%)		0.143834	0.463000 (at 5%)

Table 6.1 shows the results from the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests. In performing the ADF test, the lags of each variable are determined through considering the minimum values of Schwarz-Bayesian information criterion (SBIC) statistics (not reported). In practice, the SBIC is most preferred because it penalises strongly each additional term added to the regressors in the econometric model estimated with the intention of investigating the presence of unit roots within the series (Brooks, 2002: 427).

With the intention of obtaining reliable results from unit root tests, the Phillips-Perron (PP) test can enhance the results obtained from the ADF test. Some econometric literature argues that in empirical analysis, the ADF and PP tests reach similar conclusions most of the time and suggests undertaking a confirmatory test (Brooks, 381-382). Thus, the KPSS stationarity test is used here for validating the conclusions from the ADF and the PP tests (Maddala and Kim, 1998: 126). To this end, the KPSS test does not fail to reject the null hypothesis of stationarity since the calculated tests statistics are greater than their critical values.

Finally, the results from the formal unit root tests conclude that there is a unit root in all variables under study and this view matches the view of non-stationarity based on the informal investigation examining the plots and their correlograms.

Additionally, it is worth noting that before summarising the conclusion from the results shown in table 6.1, that all variables have a unit root, we reject (not reported) a linear trend in the data generating process for all variables under study. To this end, the unit root tests undertaken on our series using the econometric model allowing the presence of a linear trend in the data generating process, failed to reject the unit root hypothesis and therefore do not show the presence of a significant linear trend in the data (Maddala and Kim, 1998: 87-88).

In addition, table 6.1 shows that all differenced time series are stationary. The theory says that in such a case one can include these stationary time series in the econometric models and run a regression analysis. But, that analysis can be incomplete as it misses the long-run relationships usually found in macroeconomic variables and examined through a cointegration test.

6.4.2 Methodology for testing cointegration

With the intention of obtaining a full and correct specification of the econometric models in the empirical research, the literature recommends investigating for the presence of cointegrating non-stationary time series with the aim of including them in the econometric models. Informally, one can get a good idea whether the series are cointegrating or not by plotting together the series as a system. To this end, figure 6.1 and figure 6.2 (seen below) show that the series under study are trending together over time and the probability of finding cointegrating relationships among them is high.

Figure 6.1

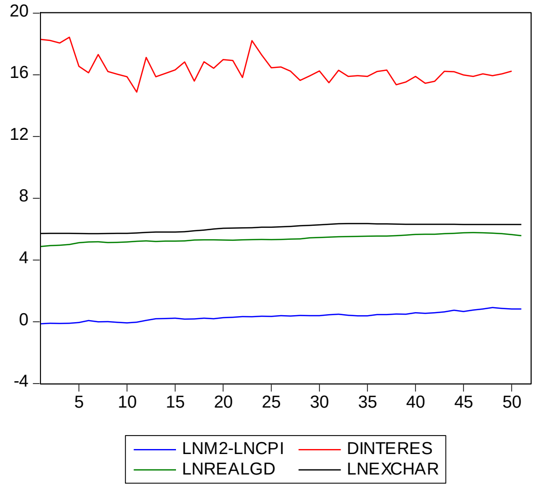


Figure 6.2

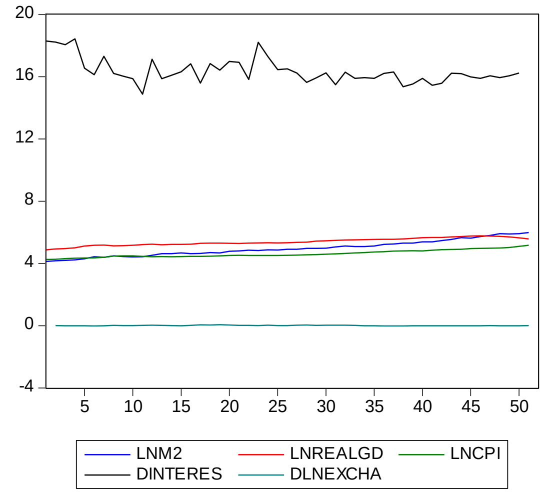


Figure 6.1: Time series trending together in the VAR1 model (source: reproduced from the data). Figure 6.2: Time series trending together in the VAR2 model (source: reproduced from the data).

Formally, to investigate the cointegrating relationship between time series, one can either use the Engle-Granger univariate single equation method or the Johansen multivariate approach. In this chapter, the choice between these two approaches is based on information from table x1 to table x5 (see page 103-page 105) in appendix 2, which show that the significance of correlation-coefficients of series and their own lags persist up to 16 lags. In addition, the tables x6 and x7 (see page 105-page 106) in appendix 2, highlight interactions between the series under study.

In the endeavour to identify cointegrating series and with the intention of capturing correlations between these series with their own lags and interactions among series, the Johansen methodology developed with the vector autoregressive model (VAR) is the most appropriate approach.

6.5 Vector Autoregressive model selection

This stage involves selecting the order (p) of a VAR model and then deciding whether to include an intercept in the cointegrating space, or to add a linear trend. In fact, when selecting the order (p) of a vector autoregressive model, Patterson (2000: 632), Enders (2004: 357) and Brooks (2002: 335-336) propose using the AIC and SBIC statistics and retaining the number of lags which correspond to the optimum value of the AIC and SBIC statistics. In the same way, Enders (2004: 358) suggests that researchers should set a maximum number of lags equal to $T^{\frac{1}{3}}$ (T is the number of the sample observations) and choose between one up to this number, as the order of the VAR corresponding to the optimum value of AIC and SBIC. Concerning the optimum value, some literature (Enders, 2004: 370; Brooks, 2002: 336) proposes keeping to a minimum the value of AIC and SBIC. In addition, Pesaran and Pesaran (1997: 354) suggest considering, in the case of a single equation, the order of the VAR corresponding to the minimum value of AIC and SBIC statistics and the maximum value of AIC and SBIC statistics in a multivariate regression context.

In determining the order of the VAR1 and VAR2 (specified in chapter five, section 5.5), the first step is to set the maximum order using the formula $T^{\frac{1}{3}} = (51)^{\frac{1}{3}} = 3.7084 \approx 4$, since we have 51 observations in the sample (Enders 2004: 358) and then select the order of the VAR1 and VAR2 equal or close to 4 which is convenient as quarterly data are analysed here (Brooks, 2002: 380). By applying Ender's formula and considering the suggestion of Brooks (2002: 380) and Pesaran and Pesaran (1997: 354), the optimum order of each VAR1 and VAR2 is equal to 4 and 3 respectively (see appendix 2, table x8 and table x9, page 106). Note that the econometric software package Eviews 6.0 helps in determining the value of AIC and SBIC at different lag levels of each VAR model.

Additionally, under the Johansen methodology, Eviews 6.0 proposes different specifications of the econometric models which can be estimated with the aim of identifying the cointegrating vectors among the series. These specifications are: (i) assuming a constant in the cointegrating space or (ii) having a constant in the cointegrating space and allowing for the existence of a linear trend in the data or, (iii) considering a linear trend and a constant in the data as well as in the cointegrating space (Brooks, 2002: 426).

In this research, the choice of the model is based on Patterson (2000: 630) stipulating that the variables which are stochastically cointegrated are mostly assumed to be deterministically cointegrated. In this way, the model allowing for a linear trend in the data and a constant in cointegrating space is the one most used in empirical research. Thus we estimate the VAR1 and VAR2 models by assuming the existence of a linear trend in the data and a constant in the cointegrating space.

6.5.1 Identification of the Cointegrating vectors

The cointegration analysis investigates the existence of cointegrating relationships between the variables of the VAR1 and VAR2 models. The VAR1 model has four variables: real money balances (LNM2-LNCPI), real income (LNREALGD), a lending interest rate (DINTERES), and the nominal exchange rate of the Rwandan franc against the US dollar (LNEXCHAR). The VAR2 model contains the money stock (LNM2), the price level (LNCPI), real income (LNREALGD), a lending interest rate (DINTERES), and the depreciation (mostly) of the Rwandan franc (DLNEXCHA).

6.5.1.1 Identification of the Cointegrating vectors in the VAR1 model

The results from the identification of the cointegrating vector in VAR1 = ((LNM2-LNCPI), α_1 DINTERES, α_2 LNREALGD, α_3 LNEXCHAR), are summarised in table 6.2 below. For details, one can see the table x10 in appendix 2, pages 107-108.

Table 6.2: Cointegration analysis results for variables in the VAR1 model

Eigenvalues (trace test)	0.575543	0.374261	0.229440	0.066208
Hypothesis (for trace test)	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$
λ trace (test.statistic)	74.47072	35.90823	14.81127	3.082586
λ trace (critical.value at 5%)	47.21	29.68	15.41	3.76
λ trace (critical.value at 1%)	54.46	35.65	20.04	6.65
Hypothesis (for max test)	$r = 0$	$r = 1$	$r = 2$	$r = 3$
λ max (test.statistic)	38.56249	21.09696	11.72869	3.082586
λ max (critical value at 5%)	27.07	20.97	14.07	3.76
λ max (critical value at 1%)	32.24	25.52	18.63	6.65

In table 6.2, the investigation of the cointegrating vectors is based on the 95 *per cent* and *99 per cent* critical values of the maximum eigenvalue test statistic and the trace test statistic. The λ trace test and λ max test fail to reject the null hypothesis at the 5 *per cent* significance level that there are two or fewer cointegrating relationships in the VAR1 model. However, at the 1 *per cent* significance level the λ max test suggests one cointegrating relationship in the VAR1 model while the λ trace test maintains two or fewer cointegrating relationships. Enders (2004: 354) recommends to retain the smallest number of cointegrating vectors in the case of conflicting results between the maximum eigenvalue test statistic and the trace test statistic.

Based on Enders' recommendation (2004: 354) and the economic theory underlying this research we retain here one cointegrating relationship in the VAR1 model as it provides a general picture of the demand for money. For details, one can see the table x10 in appendix 2, page 107.

Normalized cointegrating coefficients (std.err. in parentheses)

LNM2-LNCPI	LNREALGD	DINTERES	LNEXCHAR
1.000000	-1.310661	0.042936	0.002618
	(0.19846)	(0.03297)	(0.14314)

Adjustment coefficients (std.err. in parentheses)

D(LNM2-LNCPI)	-0.215440
	(0.13130)
D(LNREALGD)	-0.019999
	(0.05873)
D(DINTERES)	-5.31168
	(1.22353)
D(LNEXCHAR)	0.045956
	(0.02478)

Once we identify the equation of demand for real money balances, it is possible to rewrite this equation in the usual form and obtain:

LNM2-LNCPI = -0.042936 DINTERES + 1.310661 LNREAL GDP -0.002618 LNEXCHAR.

In this equation, all the estimates of the coefficients of the variables have the correct sign and are statistically significant except for the estimate of the coefficient of the exchange rate. The results for the test of significance of the coefficients in the VAR1 model are summarised in table 6.3 below. For details, one can see the table x12 in appendix 2, on the page 111 and page 112.

Table 6.3: Results of the test of significance of the coefficients of variables in theVAR1 model

Coefficients	χ^2	p-value for the test statistic
$\hat{\alpha}_1 = -0.042936$	13.18422	0.000282
$\hat{\alpha}_2 = 1.310661$	11.98906	0.000535
$\hat{\alpha}_3 = -0.00261\varepsilon$	2.155080	0.142099*

Ho: Null hypothesis: $\hat{\alpha}_i = 0$ (estimated coefficients of the variables in the VAR1 model)

*: fail to reject the null hypothesis

It is worth noting that when testing the significance of the estimates of the coefficients in a cointegrating relationship, Brooks (2002) recommends the χ^2-*test statistic* because the usual *t-test statistic* can result in incorrect conclusions since we use non-stationary time series.

6.5.1.2 Identification of the Cointegrating vectors in the VAR2 model

The overall aim of section (6.5.1) is the identification of the cointegrating vectors in the VAR1 and VAR2 models respectively. VAR1 embodies the demand function for real money balances and VAR2 traces out the effectiveness of monetary policy by analysing the relationships between the money stock and some relevant macroeconomic variables. The concern in this sub-section (6.5.1.2) is the identification of the cointegrating vectors in VAR2 = (LNM2, β_1 LNREALGD, β_2 LNCPI, β_3 DINTERES, β_4 DLNEXCHA). The results from the maximum eigenvalue test statistic and the trace test statistic are summarised in table 6.4 below. For details, one can see table x11 in appendix 2, pages 109-110.

Table 6.4: Results of Cointegration analysis for variables in the VAR2 model

Eigenvalues (for trace test)	0.636895	0.472999	0.342279	0.150399	0.042437
Hypothesis (for trace test)	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r \leq 4$
λ trace (test.statistic)	102.5524	56.96456	28.13972	9.285883	1.951386
λ trace (critical.value at 5%)	68.52	47.21	29.68	15.41	3.76
λ trace (critical.value at 1%)	76.07	54.46	35.65	20.04	6.65
Hypothesis (for max test)	$r = 0$	$r = 1$	$r = 2$	$r = 3$	$r = 4$
λ max (test statistic)	45.58787	28.82484	18.85384	7.334497	1.951386
λ max (critical value at 5%)	33.46	27.07	20.97	14.07	3.76
λ max (critical value at 1%)	38.77	32.24	25.52	25.52	6.65

In table 6.4, the investigation of the cointegrating vectors is based on the 95 *per cent* and *99 per cent* critical values of the maximum eigenvalue test statistic and the trace test statistic. The λ trace test and λ max test fail to reject the null hypothesis at the 5 *per cent* significance level that there are two or fewer cointegrating relationships in the VAR2 model. Conversely, at the 1 *per cent* significance level, the λ max test concludes there is one cointegrating relationship in the VAR1 model while the λ trace test maintains two cointegrating relationships. Based on Enders' view (*op.cit*) and the economic theory underlying the model specification (chapter 5 in section 5.5), we accept for this thesis one cointegrating relationship as it permits one to get a good idea of the relationship between the money stock and other relevant macroeconomic variables, especially the price level. For details, one can see table x11 in appendix 2, page 109.

Normalized cointegrating coefficients (std.err. in parentheses)

LNM2	LNCPI	DLNEXCHA	LNREALGD	DINTERES
1.000000	-1.535878	-7.338497	-1.001417	0.054221
	(0.61876)	(1.50581)	(0.53012)	(0.03847)

Adjustment coefficients (std.err. in parentheses)

D(LNM2)	-0.120026
	(0.07683)
D(LNCPI)	-0.001604
	(0.03200)
D(DLNEXCHA)	0.043896
	(0.01862)
D(LNREALGD)	-0.001249
	(0.03972)
D(DINTERES)	-4.116767
	(0.84731)

After identifying the relationship between the money stock and the price level, we can put this relation into the usual form of the equation as follows:

LNM2 = 1.001417 LNREALGD +1.535878 LNCPI - 0.054221 DNTERES + 7.338497 DLNEXCHA.

In this equation, based on results on the bottom of page 112 and page 113, all estimates have the right signs and are statistically different from zero except the estimate of the coefficient of the lending interest rate but with an observed level of significance not too far from the usual level. In table 6.5 we summarise the results from the test of significance of the coefficients of the variables in the VAR2 model.

Table 6.5: Results of the test of significance of the coefficients in the VAR2 model

Coefficients	χ^2	p-value for the test statistic
$\hat{\beta}_1 = 1.001417$	6.934144	0.008457
$\hat{\beta}_2 = 1.535878$	8.528249	0.003497
$\hat{\beta}_3 = -0.054221$	3.758494	0.052540
$\hat{\beta}_4 = 7.338497$	12.42097	0.000425

Ho: Null hypothesis: $\hat{\beta}_i = 0$ (estimated coefficients of the variables in the VAR 2 model)

6.5.2 Results from the test for stability in the demand function for money

One of the main aims of this research is to test the stability of the demand function for money. The stability of the demand function for money means a reasonable volatility in the velocity of money (Wallace, 1978: 365). In addition, classical economists highlight that the total value of expenditure (Y) equals the amount of money used (M); multiplied by the number of times it has been used over and over (V) (Handa, 2000: 25). In this way, classical economists consider money demand as a fixed fraction of total spending. Furthermore, monetarists enhance slightly the classical economists' ideas about the constancy of velocity. For monetarists, instead of considering velocity as fixed, it is better to maintain that it is at least predictable (Ritter *et al*., 2004: 440). Empirically, the velocity of money income is estimated through a unitary income elasticity restriction in the demand function for real money, (Rusuhuzwa *et al*., 2006: 75) and Nassar (2005: 9). In the context of Rwanda, the test for the null hypothesis of a unit income elasticity failed to reject this hypothesis as it has $\chi^2(1)$ =1.63 with a p-value= 0.201208. Moreover, the stability of the demand function for real balances is tested through examining whether the inverse-characteristics' roots of the characteristic's polynomial (see appendix 4, page 114, for more details) formulated using the variables in VAR1 lay inside (see figure 2 below) the unit circle (Enders (2004: 46-47), Patterson (2000: 601-604)). The econometric package, Eviews, allows one to plot the inverse roots of the characteristic polynomial of the endogenous variables in the VAR. From there, one can find out whether the inverse roots are positioned inside or outside the unit circle. Otherwise, any response to a shock in the system (from the endogenous variables in VAR) leads to an explosive process.

Figure 6.3

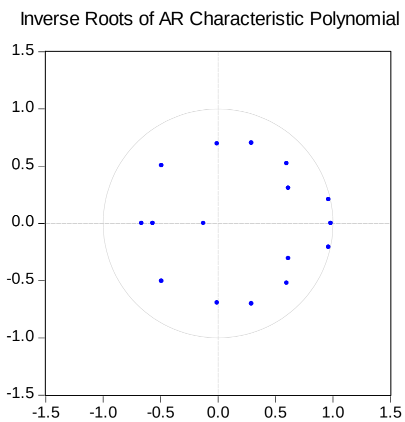


Figure 6.3: Inverse roots from the endogenous variables in the VAR1 model. (Source: reproduced from the data).

Figure 6.3 shows that the stability condition is satisfied in the VAR1 model since all inverse roots lie inside of the unit circle except for three unit roots (see figure 6.3 and table 14 in appendix 2, page 114) for which non-decaying effects to shocks are accounted for by the cointegrating relationships (stationary linear combination of the non-stationary series) in the VAR1 model. Thus, we confirm the stability of both the velocity of money income and the demand for real money balances. It is usual to find some inverse roots which lie on the unit circle (not inside the circle) in a cointegrating system when we investigate its stability since each series in the system is not stable (stationary) by definition.

After identifying the cointegrating vectors in models VAR1 and VAR2, the following sub-section (6.5.3) examines the economic meaning of the cointegrating vectors identified using our sample based on data collected at the National Bank of Rwanda from 1996:Q1 to 2008:Q3.

6.5.3 Discussion of Results obtained from the Cointegrating vector in the VAR1 model

The statistical significance of the estimate of the coefficient of real income in the long-run equation of money demand shows the extent of the effectiveness of monetary policy in regulating aggregate demand in Rwanda (Handa, 2000: 17). This responsiveness of the real money balances to real income growth is theoretically supported by Keynesian economic theories emphasising that an increase in real income increases the demand for money for transaction purposes. In the case of Rwanda, this responsiveness is justified by the remarkable effort of rebuilding the country in the aftermath of the war and the Genocide of 1994 leading the expansionary monetary policy. In this endeavour, Rwanda has been assisted financially and technically by the international community. Basing our opinion on the existence of a stable long-run relationship between real money balances and real income, one can affirm the existence of sound macroeconomic stability over the sample period. This performance is also pointed out by the IMF (2009: 7) reporting that from 1997 until 2006, real GDP of Rwanda increased at 7.4 *per cent*. In 2007, the increase was slightly above this average growth and greater than the increase of real GDP observed in East African Countries (IMF, 2009: 7).

Concerning the proxies for the opportunity cost of holding money, from our sample of data, we found that the lending interest rate contributes to an explanation of demand for money balances while the nominal exchange rate does not. The statistical insignificance of the nominal exchange rate over the sample period may be explained by the low volume of transactions done by economic agents in preferring to keep their wealth in US dollars. Most of the wealth in foreign currency belong to the central government or public establishments. These assets come from donors in terms of grants, government budget support or disbursements that flow from multilateral or bilateral loans, and from the exportation of goods and services especially tea, coffee, minerals reserves and tourism (Kanimba, 2008: 14-16; 25-26).

In addition, the National Bank of Rwanda sells some of these assets in foreign reserves to the commercial banks through a weekly auction. In turn, the commercial banks progressively sell their reserves in foreign currency to their customers in need of importing goods and services (Kanimba, 2008: 25-26). In our opinion, the primary motivation of commercial banks intervening in the weekly auction for buying reserves in foreign currency is for satisfying their customers in need of these reserves rather than speculating about changes in the nominal exchange rate. This explains the non-significance of the nominal exchange rate of the franc as an opportunity cost of holding money.

Additionally, the analysis of the sample of data shows that the lending interest rate, a proxy for the cost of money, is statistically significant (see table 6.3, page 85). In this way, the negative signs and the statistical significance of its coefficient in the equation of the demand for real money shows that as this rate increases, economic agents become discouraged from borrowing money from the banks. Some economists deem that commercial banks can speculate around the lending interest rate and this speculation should cause very high levels in the lending interest rate (Friedman, 1991: 26) compared to the interest rate of a time deposit and savings' deposit.

In the case of Rwanda, Kanimba (2007: 12) highlights the remarkable gap between the interest rate on time deposits and a lending interest rate as a result of the absence of competition in the Rwandan bank system. On the other hand, banks justify this gap as a necessary increment for covering intermediation costs and the inherent risk on loans (Rusuhuzwa and Barebereho, 2008: 67). In our opinion, both arguments from both the monetary authorities and commercial banks may have some merit. The banks collect a big part of their time deposits and savings' deposits mostly from public institutions (social security funds for instance or the Rwanda Tea Authority). The reserves collected serve to distribute loans to economic agents, perhaps with some risk since the banks know that the borrowers do not have other alternatives of getting funds for financing their businesses.

On the bank's side, most of time they argue that many businesses present their projects without doing proper feasibility studies and some projects' promoters are speculators in the sense that once they present their projects and get their money, they disappear without ever paying back the loan.

Maybe, with time, and as the private sector gets stronger and develops in Rwanda, then speculation in the banking system might became less rampart. The development of the private sector needs huge and profitable private sector investment projects to generate savings. These savings can in turn be used for distributing loans to new projects.

6.5.4 Discussion of Results obtained from the Cointegrating vectors in the VAR2 model

According to Friedman (1991: 15), the money supply affects the general level of prices over a long-run period. In this way, Friedman (*op. cit*) suggests focussing on the rate of money growth relative to the rate of growth of output instead of mechanically associating the rate of inflation to the exact rate of monetary growth.

In the case of Rwanda, the statistical significance and the correct sign of the estimate for the coefficient of the price level in the long-run relationship with the money stock confirms the monetarists' view that money stock growth affects the general level of prices over time. This result confirms and answers one of the main questions of this study, namely, targeting a monetary aggregate could still be considered as an effective intermediary objective in the process of achieving the primary objective of price stability in Rwanda. In addition, the classical economists' view that the price elasticity of unit in the long run is identified from our sample. The test for the null hypothesis of a unit price elasticity failed to reject this hypothesis as it has $\chi^2(1)$ =0.478593 with a p-value= 0.489060. This outcome reinforces the accuracy of the long-run relationship between the money stock and price level detected from the sample. For details, one can see the table x_4 in appendix 3, page 124.

Furthermore, the statistical significance of real income in the VAR2 model shows the effectiveness of monetary policy in influencing real income. In addition, the IS-LM theory emphasises that an increase of the money stock in the economy reduces the interest rate (Colander and Gamber, 2002) and (Hubbard, 2005: 482). The macroeconomic interpretation of the real income and lending interest rate in the VAR2 model is similar to that outlined in the VAR1 model for the case of Rwanda. To continue the discussion we now move onto an analysis of the results based on the depreciation of the nominal exchange rate of the Rwandan franc against the US dollar. The starting point in this endeavour relies on a study done by El-Sakka and Ghali (2005), highlighting that the results from many empirical studies undertaken on developing countries show a positive correlation between a depreciation of the nominal exchange rate and inflation.

In the case of Rwanda, over the study period, the positive sign and the statistical significance of the estimate of the coefficient of the depreciation of the nominal exchange rate in the relationship with the money stock confirms the empirical finding of El-Sakka and Ghali, (2005) and Nassar (2005: 7) that the depreciation of the nominal exchange rate can add to inflationary expectations.

This situation observed in Rwanda during the period 1996-2003, is marked by the depreciation (see figure 6.4 below) of the nominal exchange rate of the Rwandan franc against the US dollar. One possible explanation could be that economic agents are anticipating further inflation by observing the current depreciation of the local currency. In this way, they can avoid inflation based on this depreciation and thus prefer to buy more in the current period than in the future (Beatjer, 2008: 15).

Figure 6.4

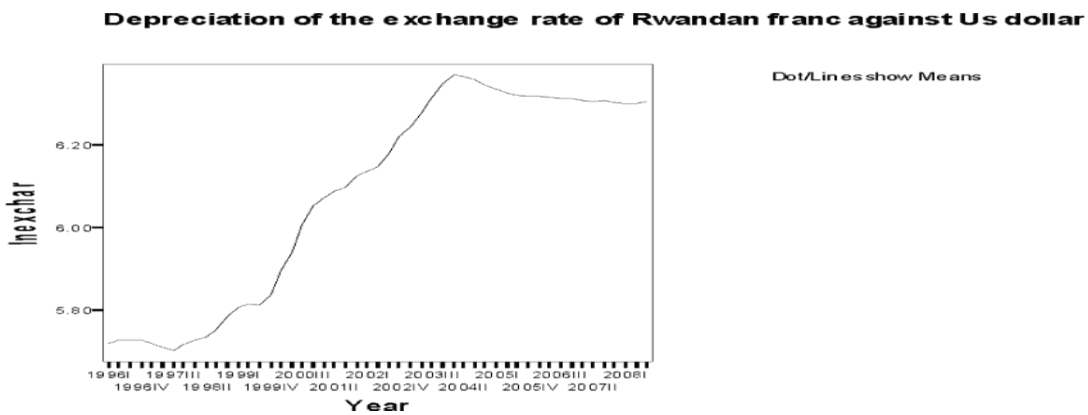


Figure 6.4 shows that from 1997 until 2003, the exchange rate of the Rwandan franc against the US dollar was rapidly depreciating and generally appreciated in subsequent periods (IMF, 2009: 25).

6.6 Discussion of Results obtained from the estimation of the Vector Error Correction Models (VECM)

The Johansen methodology shows that there is a stable (see appendix 2, table x 14, page 114) long-run equilibrium between real money balances, real income, a lending interest rate, and the nominal exchange rate and a stable (see appendix 2, table x 15, pages 114-115) long-run equilibrium exists between the money stock, the price level, real income, a lending interest rate, and the depreciation of the nominal exchange rate of the Rwandan franc against the US dollar. As chapter five mentions in section (5.3), the previous dynamic short-run movements in any one of the cointegrating variables can sometimes deviate from its equilibrium level. The error correction model demonstrates that this previous disequilibrium is progressively corrected in order to re-establish the long- run equilibrium situation among cointegrating variables. The results from estimation of the error correction models (VECM1) and (VECM2) are presented and discussed in sub-section (6.6.1) below.

6.6.1 Results obtained from the estimation of the VECM1 and the VECM2 models

The estimation of the VECM1 and VECM2 models (appendix 3, table x1 and table x3, pages 116-123) results in the estimates of the error correction term's coefficients equal to -21.5 *per cent* per quarter and to -12 *per cent* per quarter respectively. The *t-test* shows that both estimates are not statistically significant at a five *per cen*t (5%) significance level since the critical value of the *t-test* statistic of -1.684 (see page 138) is greater (in absolute value) than the calculated t-test statistic which is -1.64084 for the VECM1 model and equals to -1.56218 for the VECM2 model. The degrees of freedom are 33 (51-18) in the VECM1 model and equal to 34 (51-17) in the VECM2 model.

Macroeconomically it is unusual that a disequilibrium which occurs in a cointegrating relationship in a given period be completely eliminated by stakeholders (economic agents, policy makers) in the same period. However, Gujarati (2003: 825) shows that an error correction term which is statistically insignificant can be interpreted as a coefficient of a macroeconomic relationship which deviates from an equilibrium in a certain period and adjusts toward its long-run equilibrium over the same time period. Therefore, based on Gujarati's (2003: 825) interpretation and the estimation results of the VECM1 and VECM2 models we can say that, over the sample period, if the demand for money and the outstanding money stock in the Rwandan economy deviate from their equilibrium in any quarter, they will adjust to their equilibrium level in the same quarter. In this regard, one can say that the monetary instruments utilised by the National Bank of Rwanda (open-market operations, discount window facilities, reserve ratio requirements) to adjust base money for controlling the money stock M2 are effective as we point out in chapter one (section 1.5) as being a highlight of this thesis.

In addition to the empirical analysis at the five *per cen*t (5%) significance level, we checked how the change of the probability of the sample error (p-value) can modify our initial results. In this way, we found that at the *five point six per cent* (5.6%) significance level, the Rwandan money market needs 3.5 quarters to eliminate a half-life of the disequilibrium discrepancy in the money demand model. At the *six point five per cent* (6.5%) significance level the Rwandan money market needs 4.5 quarters to eliminate a half-life of the disequilibrium discrepancy in the money supply model. At the *five point six per cent* (5.6%) and *six point five per cent* (6.5%) significance levels, the critical values of the *t-test* statistic are equal to -1.633 and -1.552 respectively. Both error correction coefficients of -21.5 *per cent* per quarter and -12 *per cent* per quarter become statistically significant in the VECM1 and VECM2 models (see page 139 for details). This finding is a useful complement to the results at the five *per cen*t (5%) significance level as both results trace out an important improvement in monetary policy affecting the Rwandan money market compared to the results carried out five years ago as reviewed in chapter one (section 1.5).

Furthermore, the coefficient of the dummy variable capturing the eligibility of Rwanda to benefit from a reduction of the debt due to policies of the IMF, AFDB, and the World bank of more than 1.5 billion of US dollars, is not statistically significant (see the table x9 in appendix 3, pages 132-135). It may take more time for Rwandan economic agents to adjust their economic activities to new circumstances. Similar behaviour was also detected after the decision taken in January 2008 by the National Bank of Rwanda (NBR, 2007: 3) recommending that commercial banks increase their capital from 1.5 billion Rwandan francs (roughly 2.7 million US dollars) to a minimum of 5 billion Rwandan francs (roughly 9 million US dollars).

6.7 The diagnostic test of the models VECM1 and VECM2 and exogeneity tests

The results from the tests (see appendix 3, table x5 and table x6, pages 127-130) for the normality of residuals, the variable's autocorrelations, homoscedasticity of the residuals, and variable's serial correlation tests show that both the VECM1 and the VECM2 models are in general of good quality. In fact, we failed to reject the null hypotheses for our tests for the VECM1 model. An example is the non rejection of the null hypothesis for homoscedasticity (variance constant) of the residuals in the VECM1 and the VECM2 models since we have $\chi^2(180) = 194.8626$ with a p-value= 0.2125 for VECM1 and $\chi^2(480) = 489.6039$ with a p-value= 0.3709 (see pages 128 and 130) for VECM2. It is worth noting that in a linear regression model, homoscedasticity of the residuals is one of the requirements for getting unbiased results. However, we rejected the null hypotheses for the tests of normality of residuals and variable's autocorrelation in the VECM2 model (see appendix 3, table x6, pages 128-129), but according to Gonzalo (1994) this is not an issue here since we used the Johansen framework in this research.

Furthermore, the empirical analysis shows that in the VECM1 and the VECM2 models, real income does not respond to changes in real money balances and the price level does not respond to changes in the money stock in the short-run. So they are said in this circumstance to be *weak exogenous variables* (see appendix 3, table x7 and table x8, pages 130-132). These findings are consistent with economic theories stipulating that monetary policy affects the *real economy* over a long-run horizon. One of theories is Friedman's (1991) which says that the money supply affects the general level of prices over a long time period.

Before concluding this section, we emphasize the limitations of this research, in formulating a specific OLS model from the VECM1 and the VECM2 models. The underlying justification is that the interactions found among variables (endogeneity behaviour) justify the use of a general model (Enders, 2004: 373). Further studies must confront this issue and perform Granger causality tests and calculate impulse responses to innovations in money demand and the outstanding money stock in the economy. However, the test of stability and the diagnostic tests that we performed on the VAR1, VAR2, VECM1 and VECM2 models ensured the quality of the empirical results.

Conclusions

The cointegration analysis confirms the existence of a stable long-run relationship between real money balances (LNM2-LNCPI), real income (LNREALGD), a lending interest rate (DINTERES), and the nominal exchange rate of the Rwandan franc against the US dollar (LNEXCHAR).

Furthermore, the cointegration analysis was extended to the velocity of money income and the results confirmed its stability (from a classical view) or its predictability (from a monetarist's view). In addition, a stable long-run relationship is confirmed for the money stock (LNM2), the price level (LNCPI), real income (LNREALGD), a lending interest rate (DNTERES), and the depreciation of the exchange rate of the Rwandan franc against the US dollar (DLNEXCHA).

Additionally, the previous dynamic short-run movements in the cointegrating variables can sometimes cause a deviation from the long-run equilibrium. The correction of the disequilibrium is determined by estimating the VECM1 and the VECM2 models. The findings from the estimation of the VECM1 and the VECM2 models reveal that the demand for money and the outstanding money stock in the Rwandan economy deviate from their equilibrium in any quarter and adjust to equilibrium in the same quarter. We supplement this finding by examining the situation at the observed significance level. We found that the Rwandan money market needs 3.5 quarters and 4.5 quarters to eliminate a half-life of the disequilibrium discrepancy in the money demand and supply models respectively.

CHAPTER SEVEN

CONCLUSIONS AND POLICY IMPLICATIONS

7.1 Introduction

The emphasis in this thesis is a cointegration analysis of the effectiveness of monetary policy and money demand stability in Rwanda. In line with the "Rwanda Vision 2020" and with a goal of enhancing economic growth and stability, the government of Rwanda has put in place a medium-term programme of four years as stated in its Economic Development and Poverty Reduction Strategy (EDPRS). A part of this programme is a prudent monetary policy which is one of the responsibilities of the National Bank of Rwanda (NBR), especially *via* its role of controlling liquidity in the national economy so as to ensure macroeconomic stability. To this end, the NBR adjusts base money for making sure the level of the monetary aggregate M2 is consistent with price stability. Two necessary conditions required for effectively implementing this monetary policy are: (i) a stable demand function for money; (ii) a stable long-run relationship between the money stock and the price level. Chapter one introduced the motivation of this study, chapters two to four provide a theoretical support for the conditions required for successfully achieving price stability through targeting the monetary aggregate M2 in the national economy. Chapters five and six outline the methodology and empirical results respectively.

7.2 Research hypotheses

In line with the necessary requirements for achieving the final objective of price stability through targeting the monetary aggregate M2, chapter one asks three questions, capturing the research hypotheses of the thesis, to be answered after analysing the empirical results:

(i) Is the stability of the demand function for money in Rwanda as confirmed by previous researchers still valid given recent structural changes in the Rwandan economy?

(ii) Do equilibria exist in money demand and supply models and does the money stock indicate the price level?

(iii) Is real money demand sensitive to exchange rate changes?

Based on these questions, our research sought to confirm the following hypotheses:

(i) The demand function for money in Rwanda is still stable given the recent structural changes in the Rwandan economy.

(ii) Equilibria exist in money demand and supply models and the money stock determines the price level.

(iii) Real money demand is sensitive to exchange rate changes.

7.3 Conclusions and future research

After applying the methodology examined in chapter five, chapter six outlines the empirical results. In reference to these results, we confirm the existence of a stable money demand model over the sample period which addresses our first research question. Also a unitary elasticity of real income in the money demand model is a good indication that real money balances and real income move one to one over the period of study. Therefore, the velocity of money income can be predictable over the long-run horizon.

Moreover, the results show that over the sample period, a stable long-run relationship exists between the money stock and the price level which responds to the second research question. This result falls in the monetarist's view that in the long-run, inflation is always a monetary phenomenon. Thus, targeting the monetary aggregate M2 is a good indicator of the tendency of the price level over time. Lastly, over the sample period, the study found that the exchange rate of the Rwandan franc against the US dollar was not significant in the demand for real money balances model which indicates that the money demand is not sensitive to exchange rate changes.

Furthermore, at a *five per cen*t (5%) significance level, the analysis of short-run relationships in the money demand and supply models reveals that over the sample period, if the demand for money and the outstanding money stock in the Rwandan economy deviate from their equilibrium in any quarter, they will adjust back to equilibrium in the same quarter. In addition to the empirical analysis at a *five per cen*t (5%) significance level, we found that at a *five point six per cent* (5.6 %) and a *six point five per cent* (6.5%) significance level, the Rwandan money market needs 3.5 quarters and 4.5 quarters to eliminate a half-life of the disequilibrium discrepancy in the money demand and supply models respectively. The error correction coefficients are -21.5 *per cent* per quarter and -12 *per cent* per quarter in the VECM1 and

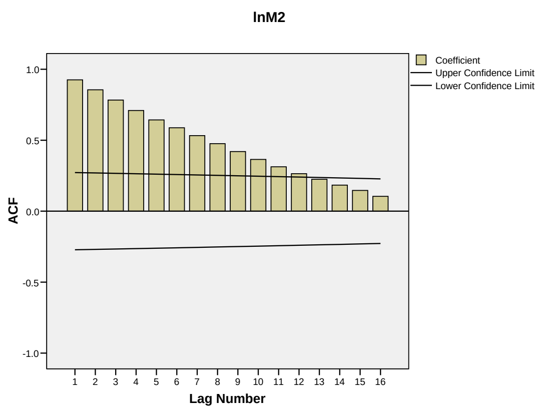
VECM2 models. Both results trace out the important progress of monetary policy to stabilise the Rwandan economy in comparison to the results carried out by a different study five years ago.

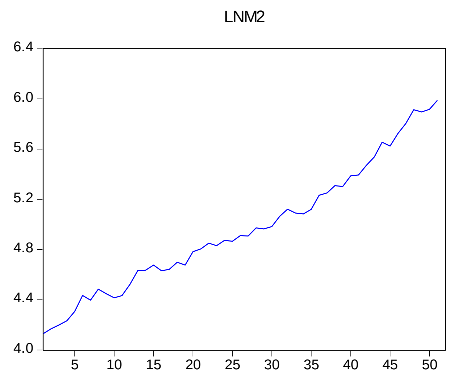
In conclusion, for the National Bank of Rwanda to be able to achieve the overall objective of price stability through targeting the monetary aggregate M2, the conditions of (i) a stable demand function for money and (ii) a stable long-run relationship between the money stock and price level are supported by the results of the current study. Therefore, despite recent changes that have occurred in Rwandan economic structures, monetary policy remains effective.

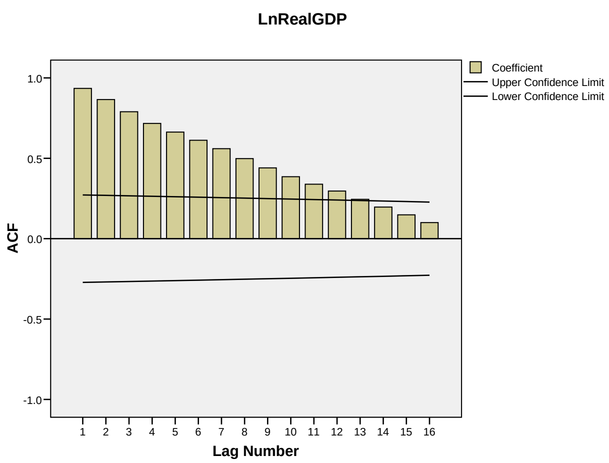
However, it is worth noting the limitations of our study: 1) the specification of the money demand function does not integrate with the interest rate for money market operations; 2) in this study the consumer price index proxies the GDP deflator. Therefore, there is no assurance that real GDP properly measures current income. 3) We assumed that changes in the depreciation of the exchange rate of the Rwandan franc against the US dollar captures real aspects of expecting further inflation, though many other factors can influence such an expectation. 4) The estimation of equations with small sample sizes could bias the results. Any future study could allow for these deficiencies.

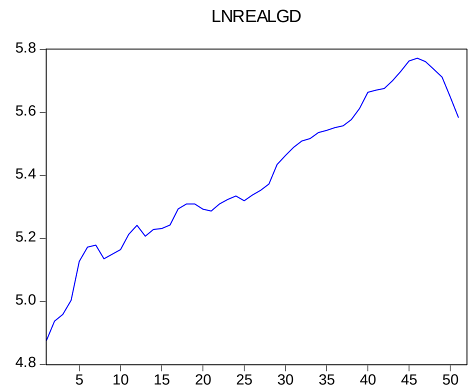
Appendices

Appendix 1: Correlogram and random walk graphs for variables in the VAR1 and VAR2 models

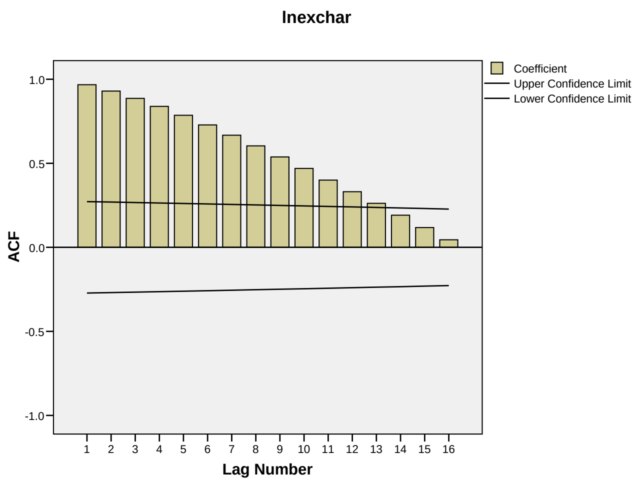


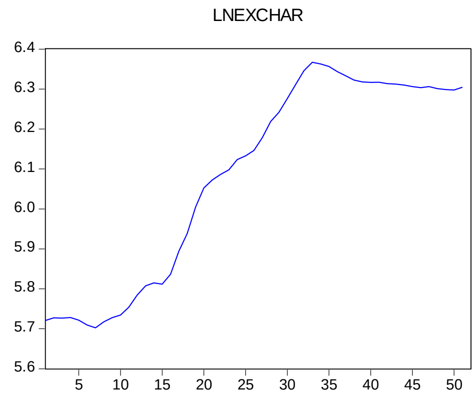


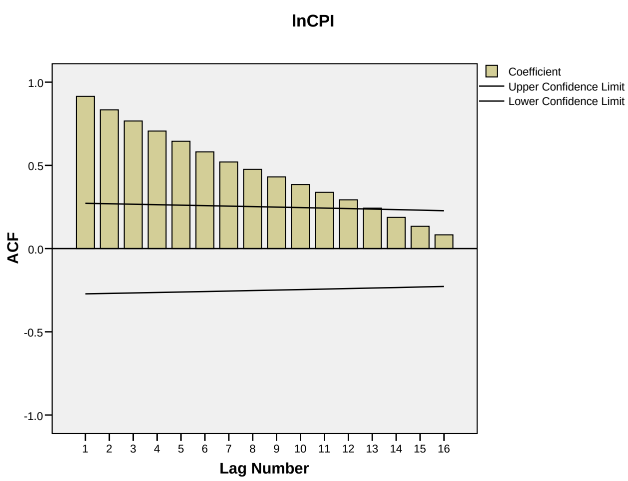


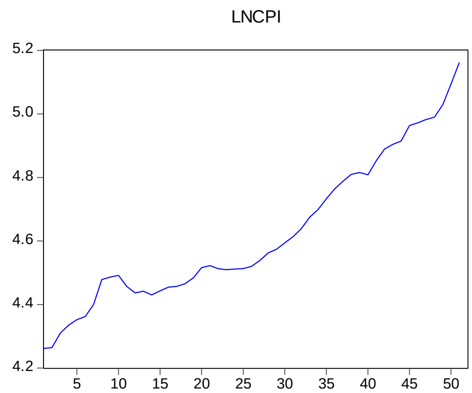


Appendix 1 (continued): Correlogram and random walk graphs for variables in the VAR1 and VAR2 models

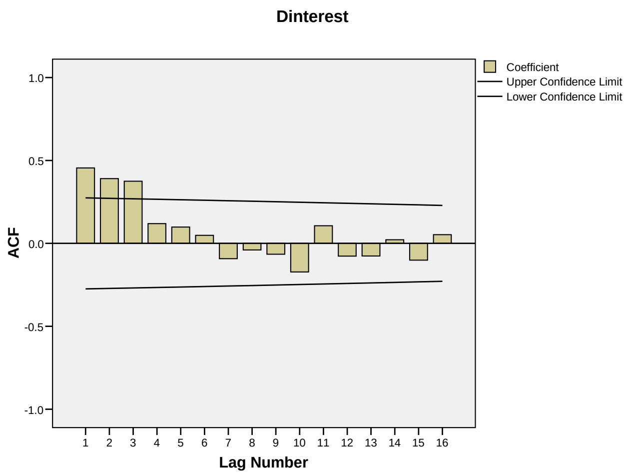


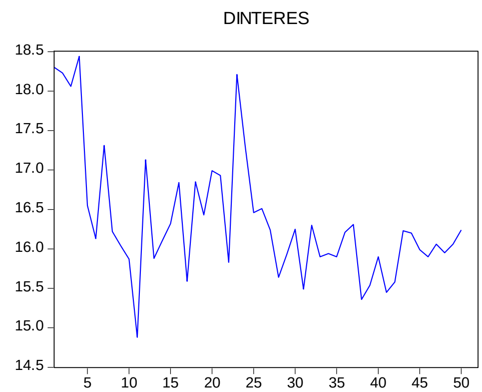


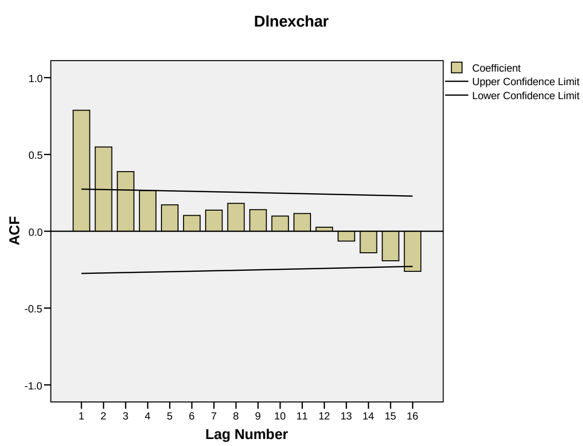


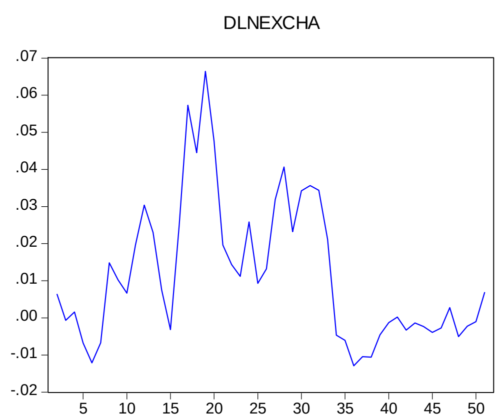


Appendix 1 (continued): Correlogram and random walk graphs for variables in the VAR1 and VAR2 models









Appendix 2: Tests for correlation and covariance, Determining the order of VAR1 and VAR2 using AIC and SBIC statistics, identification of cointegrating vectors, tests of significance of coefficients, stability in the VAR1 and VAR2 models

a) Tests for correlation

Table x1 : lnM2

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<tr><td>. |******|</td><td>. | . |</td><td>2</td><td>0.855</td><td>-0.006</td><td>86.630</td><td>0.000</td></tr>
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<tr><td>. |**** |</td><td>. | . |</td><td>7</td><td>0.532</td><td>-0.029</td><td>212.54</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>8</td><td>0.476</td><td>-0.054</td><td>226.75</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>9</td><td>0.420</td><td>-0.030</td><td>238.11</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>10</td><td>0.365</td><td>-0.032</td><td>246.88</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>11</td><td>0.312</td><td>-0.010</td><td>253.48</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>12</td><td>0.264</td><td>-0.015</td><td>258.31</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>13</td><td>0.225</td><td>0.023</td><td>261.89</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>14</td><td>0.183</td><td>-0.044</td><td>264.35</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>15</td><td>0.146</td><td>-0.011</td><td>265.96</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>16</td><td>0.105</td><td>-0.062</td><td>266.81</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>17</td><td>0.067</td><td>-0.001</td><td>267.17</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>18</td><td>0.036</td><td>0.008</td><td>267.27</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>.*| . |</td><td>19</td><td>-0.002</td><td>-0.075</td><td>267.27</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>20</td><td>-0.037</td><td>-0.028</td><td>267.39</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>21</td><td>-0.070</td><td>-0.024</td><td>267.84</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>22</td><td>-0.094</td><td>0.036</td><td>268.67</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>23</td><td>-0.121</td><td>-0.046</td><td>270.07</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>24</td><td>-0.148</td><td>-0.054</td><td>272.28</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>25</td><td>-0.175</td><td>-0.027</td><td>275.44</td><td>0.000</td></tr>
</table>

Table x2: lnReal GDP

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |*******</td><td>. |*******</td><td>1</td><td>0.935</td><td>0.935</td><td>47.244</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>.*| . |</td><td>2</td><td>0.865</td><td>-0.068</td><td>88.548</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>.*| . |</td><td>3</td><td>0.790</td><td>-0.085</td><td>123.66</td><td>0.000</td></tr>
</table>

<table>
<tr><td>. |***** |</td><td>. | . |</td><td>4</td><td>0.717</td><td>-0.018</td><td>153.20</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. |*. |</td><td>5</td><td>0.663</td><td>0.112</td><td>179.03</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>6</td><td>0.612</td><td>-0.019</td><td>201.55</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>7</td><td>0.560</td><td>-0.064</td><td>220.79</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>.*| . |</td><td>8</td><td>0.498</td><td>-0.106</td><td>236.37</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>9</td><td>0.440</td><td>0.022</td><td>248.84</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>10</td><td>0.386</td><td>-0.004</td><td>258.65</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>11</td><td>0.339</td><td>0.011</td><td>266.40</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>12</td><td>0.296</td><td>-0.031</td><td>272.48</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>.*| . |</td><td>13</td><td>0.245</td><td>-0.105</td><td>276.75</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>14</td><td>0.197</td><td>-0.002</td><td>279.57</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>15</td><td>0.148</td><td>-0.013</td><td>281.22</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>16</td><td>0.100</td><td>-0.042</td><td>282.00</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>17</td><td>0.061</td><td>0.006</td><td>282.30</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>18</td><td>0.023</td><td>-0.041</td><td>282.34</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>19</td><td>-0.015</td><td>-0.039</td><td>282.36</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>20</td><td>-0.056</td><td>-0.046</td><td>282.63</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>21</td><td>-0.095</td><td>-0.026</td><td>283.45</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>22</td><td>-0.128</td><td>0.012</td><td>284.98</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>23</td><td>-0.158</td><td>-0.025</td><td>287.38</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>24</td><td>-0.183</td><td>-0.030</td><td>290.74</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>.*| . |</td><td>25</td><td>-0.214</td><td>-0.076</td><td>295.48</td><td>0.000</td></tr>
</table>

Table x3 : dlnexcha

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |******|</td><td>. |******|</td><td>1</td><td>0.788</td><td>0.788</td><td>32.932</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>.*| . |</td><td>2</td><td>0.549</td><td>-0.190</td><td>49.235</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>3</td><td>0.388</td><td>0.064</td><td>57.569</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>4</td><td>0.264</td><td>-0.048</td><td>61.523</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>5</td><td>0.172</td><td>-0.002</td><td>63.230</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>6</td><td>0.103</td><td>-0.020</td><td>63.855</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. |** |</td><td>7</td><td>0.138</td><td>0.225</td><td>65.002</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>8</td><td>0.182</td><td>-0.006</td><td>67.044</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>.*| . |</td><td>9</td><td>0.141</td><td>-0.135</td><td>68.301</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>10</td><td>0.099</td><td>0.033</td><td>68.939</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. |*. |</td><td>11</td><td>0.116</td><td>0.123</td><td>69.831</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>**| . |</td><td>12</td><td>0.026</td><td>-0.329</td><td>69.879</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. |*. |</td><td>13</td><td>-0.064</td><td>0.087</td><td>70.164</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>14</td><td>-0.140</td><td>-0.107</td><td>71.574</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>.*| . |</td><td>15</td><td>-0.192</td><td>-0.095</td><td>74.320</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>.*| . |</td><td>16</td><td>-0.261</td><td>-0.192</td><td>79.533</td><td>0.000</td></tr>
<tr><td>***| . |</td><td>. | . |</td><td>17</td><td>-0.365</td><td>-0.064</td><td>90.057</td><td>0.000</td></tr>
<tr><td>***| . |</td><td>. | . |</td><td>18</td><td>-0.354</td><td>0.061</td><td>100.22</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>19</td><td>-0.275</td><td>0.019</td><td>106.58</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>.*| . |</td><td>20</td><td>-0.250</td><td>-0.091</td><td>112.00</td><td>0.000</td></tr>
</table>

<table>
<tr><td>**| . |</td><td>.*| . |</td><td>21</td><td>-0.281</td><td>-0.120</td><td>119.06</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>22</td><td>-0.285</td><td>-0.050</td><td>126.61</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>23</td><td>-0.273</td><td>0.038</td><td>133.81</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>24</td><td>-0.280</td><td>-0.061</td><td>141.67</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>25</td><td>-0.299</td><td>0.026</td><td>150.99</td><td>0.000</td></tr>
</table>

Table x4 : LnCpi

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |*******</td><td>. |*******</td><td>1</td><td>0.914</td><td>0.914</td><td>45.200</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>. | . |</td><td>2</td><td>0.834</td><td>-0.014</td><td>83.545</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>. | . |</td><td>3</td><td>0.766</td><td>0.039</td><td>116.63</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>4</td><td>0.706</td><td>0.009</td><td>145.31</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>5</td><td>0.645</td><td>-0.035</td><td>169.74</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>6</td><td>0.581</td><td>-0.044</td><td>190.03</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>7</td><td>0.520</td><td>-0.023</td><td>206.65</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>8</td><td>0.476</td><td>0.061</td><td>220.90</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>9</td><td>0.431</td><td>-0.032</td><td>232.84</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>10</td><td>0.385</td><td>-0.021</td><td>242.61</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>11</td><td>0.338</td><td>-0.036</td><td>250.31</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>12</td><td>0.293</td><td>-0.021</td><td>256.27</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>.*| . |</td><td>13</td><td>0.243</td><td>-0.072</td><td>260.46</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>.*| . |</td><td>14</td><td>0.187</td><td>-0.070</td><td>263.02</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>15</td><td>0.134</td><td>-0.030</td><td>264.37</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>16</td><td>0.083</td><td>-0.039</td><td>264.90</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>17</td><td>0.035</td><td>-0.029</td><td>264.99</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>18</td><td>-0.009</td><td>-0.019</td><td>265.00</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>19</td><td>-0.049</td><td>-0.014</td><td>265.21</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>20</td><td>-0.080</td><td>0.012</td><td>265.77</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>21</td><td>-0.107</td><td>-0.014</td><td>266.80</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>22</td><td>-0.134</td><td>-0.024</td><td>268.46</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>23</td><td>-0.159</td><td>-0.022</td><td>270.89</td><td>0.000</td></tr>
<tr><td>.*| . |</td><td>. | . |</td><td>24</td><td>-0.184</td><td>-0.034</td><td>274.29</td><td>0.000</td></tr>
<tr><td>**| . |</td><td>. | . |</td><td>25</td><td>-0.207</td><td>-0.017</td><td>278.73</td><td>0.000</td></tr>
</table>

Table x5 : Lnexchar

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>PAC</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |*******</td><td>. |*******</td><td>1</td><td>0.967</td><td>0.967</td><td>50.600</td><td>0.000</td></tr>
<tr><td>. |*******</td><td>.*| . |</td><td>2</td><td>0.930</td><td>-0.101</td><td>98.266</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>.*| . |</td><td>3</td><td>0.886</td><td>-0.099</td><td>142.49</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>.*| . |</td><td>4</td><td>0.838</td><td>-0.081</td><td>182.92</td><td>0.000</td></tr>
<tr><td>. |******|</td><td>.*| . |</td><td>5</td><td>0.786</td><td>-0.091</td><td>219.18</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>.*| . |</td><td>6</td><td>0.728</td><td>-0.086</td><td>251.04</td><td>0.000</td></tr>
</table>

. |***** |	.*| . |	7	0.667	-0.079	278.36	0.000
. |**** |	. | . |	8	0.604	-0.047	301.27	0.000
. |**** |	. | . |	9	0.538	-0.064	319.89	0.000
. |*** |	.*| . |	10	0.469	-0.071	334.42	0.000
. |*** |	. | . |	11	0.400	-0.049	345.23	0.000
. |** |	. | . |	12	0.331	-0.032	352.81	0.000
. |** |	. | . |	13	0.262	-0.045	357.69	0.000
. |*. |	.*| . |	14	0.191	-0.077	360.36	0.000
. |*. |	.*| . |	15	0.118	-0.103	361.39	0.000
. | . |	. | . |	16	0.045	-0.051	361.55	0.000
. | . |	. | . |	17	-0.023	0.010	361.59	0.000
.*| . |	. | . |	18	-0.087	0.000	362.21	0.000
.*| . |	. | . |	19	-0.143	0.044	363.94	0.000
.*| . |	. | . |	20	-0.193	0.030	367.19	0.000
**| . |	. | . |	21	-0.238	-0.015	372.30	0.000
**| . |	. | . |	22	-0.280	-0.024	379.60	0.000
**| . |	. | . |	23	-0.317	-0.030	389.31	0.000
***| . |	. | . |	24	-0.350	-0.012	401.56	0.000
***| . |	. | . |	25	-0.378	-0.024	416.43	0.000

b) Tests for covariance

Table x6: Covariance analysis within VAR2 model

Covariance Analysis: Ordinary
Date: 10/07/09 Time: 11:25
Sample (adjusted): 2 50
Included observations: 49 after adjustments
Balanced sample (listwise missing value deletion)

Covariance Correlation	LNM2	LNREALGD	LNCPI	DINTERES	DLNEXCHA
LNM2	0.227610 1.000000				
LNREALGD	0.104201 0.968902	0.050816 1.000000			
LNCPI	0.100286 0.977039	0.046388 0.956487	0.046288 1.000000		
DINTERES	-0.162406 -0.453170	-0.090920 -0.536929	-0.077256 -0.478026	0.564277 1.000000	
DLNEXCHA	-0.002739 -0.301228	-0.001166 -0.271450	-0.001585 -0.386588	0.000435 0.030388	0.000363 1.000000

Table x7: Covariance analysis within VAR1 model

Covariance Analysis: Ordinary
Date: 10/07/09 Time: 10:02
Sample (adjusted): 1 50
Included observations: 50 after adjustments
Balanced sample (listwise missing value deletion)

Covariance Correlation	LNM2-LNCPI	DINTERES	LNREALGD	LNEXCHAR
LNM2-LNCPI	0.076324 1.000000			
DINTERES	-0.101974 -0.465087	0.629863 1.000000		
LNREALGD	0.061580 0.948484	-0.109529 -0.587257	0.055227 1.000000	
LNEXCHAR	0.060578 0.880508	-0.090296 -0.456875	0.052468 0.896543	0.062015 1.000000

C) Determining the order of VAR1 model and VAR2 model using AIC and SBIC statistics

Table x8: VAR 1 (LNM2-LCPI, LNREALGD, LNEXCHAR, DINTERES): Money demand equation

LAG –AIC/SBIC	AKIC	SBIC
9	-19.22217	-13.03660
8	-15.00684	-9.545589
7	-13.96864	-9.217497
6	-13.22209	-9.167117
5	-11.54424	-8.171799
4	-10.99038	-8.287174
3	-11.12920	-9.082225
2	-11.38119	-9.977792
1	-10.4686	-9.69647

Table x9: VAR 2 (LnM2, LNREALGD, DLNEXCHAR, DINTERES, LNCPI): relationship money stock, real income, depreciation of exchange rate, interest rate, price level.

LAG -Information criteria	AKIC	SBIC
7	-28.18191	-20.73475
6	-20.59465	-20.59465
5	-18.02144	-12.74997
4	-17.18163	-12.96608
3	-16.49703	-13.31678
2	-16.74571	-14.58064
1	-16.46574	-15.29624

d) Identification of the cointegrating vectors in the VAR1 and VAR2 models

Table x10: Identification of the cointegrating vectors in the VAR1 model

Date: 05/19/10 Time: 13:50
Sample(adjusted): 6 50
Included observations: 45 after adjusting endpoints
Trend assumption: Linear deterministic trend
Series: LNM2-LNCPI LNREALGD DINTERES LNEXCHAR
Lags interval (in first differences): 1 to 4

Unrestricted Cointegration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.575543	74.47072	47.21	54.46
At most 1 **	0.374261	35.90823	29.68	35.65
At most 2	0.229440	14.81127	15.41	20.04
At most 3	0.066208	3.082586	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 2 cointegrating equation(s) at both 5% and 1% levels

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.575543	38.56249	27.07	32.24
At most 1 *	0.374261	21.09696	20.97	25.52
At most 2	0.229440	11.72869	14.07	18.63
At most 3	0.066208	3.082586	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates 2 cointegrating equation(s) at the 5% level
Max-eigenvalue test indicates 1 cointegrating equation(s) at the 1% level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LNM2-LNCPI	LNREALGD	DINTERES	LNEXCHAR
-15.74505	20.63642	-0.676024	-0.041219
15.91788	-1.775572	-0.784114	-15.31810
-25.07036	37.19759	4.450285	0.615230
15.70302	-14.75124	-0.900022	-0.079762

Unrestricted Adjustment Coefficients (alpha):

D(LNM2-LNCPI)	0.013683	0.005441	0.012125	-0.008216
D(LNREALGD)	0.001270	-0.008795	-0.003970	-0.002561
D(DINTERES)	0.337354	0.109269	-0.073969	0.039329
D(LNEXCHAR)	-0.002919	0.002034	-0.002840	-0.000976

1 Cointegrating Equation(s): Log likelihood 325.7909

Normalized cointegrating coefficients (std.err. in parentheses)

LNM2-LNCPI	LNREALGD	DINTERES	LNEXCHAR
1.000000	-1.310661	0.042936	0.002618
	(0.19846)	(0.03297)	(0.14314)

Adjustment coefficients (std.err. in parentheses)

D(LNM2-LNCPI)	-0.215440
	(0.13130)
D(LNREALGD)	-0.019999
	(0.05873)
D(DINTERES)	-5.311648
	(1.22353)
D(LNEXCHAR)	0.045956
	(0.02478)

2 Cointegrating Equation(s): Log likelihood 336.3394

Normalized cointegrating coefficients (std.err. in parentheses)

LNM2-LNCPI	LNREALGD	DINTERES	LNEXCHAR
1.000000	0.000000	-0.057836	-1.052083

		(0.04849)	(0.09386)
0.000000	1.000000	-0.076886	-0.804709
		(0.04449)	(0.08611)

Adjustment coefficients (std.err. in parentheses)

D(LNM2-LNCPI)	-0.128835	0.272708
	(0.18523)	(0.17136)
D(LNREALGD)	-0.159997	0.041828
	(0.07442)	(0.06885)
D(DINTERES)	-3.572317	6.767756
	(1.67493)	(1.54950)
D(LNEXCHAR)	0.078335	-0.063845
	(0.03414)	(0.03158)

3 Cointegrating Equation(s): Log likelihood 342.2038

Normalized cointegrating coefficients (std.err. in parentheses)

LNM2-LNCPI	LNREALGD	DINTERES	LNEXCHAR
1.000000	0.000000	0.000000	-1.010905
			(0.08098)
0.000000	1.000000	0.000000	-0.749968
			(0.06659)
0.000000	0.000000	1.000000	0.711971
			(0.37955)

Adjustment coefficients (std.err. in parentheses)

D(LNM2-LNCPI)	-0.432802	0.723714	0.040442
	(0.26679)	(0.33793)	(0.03627)
D(LNREALGD)	-0.060462	-0.105855	-0.011631
	(0.10874)	(0.13773)	(0.01478)
D(DINTERES)	-1.717878	4.016273	-0.642923
	(2.46859)	(3.12685)	(0.33557)
D(LNEXCHAR)	0.149541	-0.169495	-0.012262
	(0.04784)	(0.06060)	(0.00650)

Table x11: Identification of cointegrating vectors in the VAR2 model

Date: 05/19/10 Time: 13:37
Sample(adjusted): 6 50
Included observations: 45 after adjusting endpoints
Trend assumption: Linear deterministic trend
Series: LNM2 LNCPI DLNEXCHA LNREALGD DINTERES
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.636895	102.5524	68.52	76.07
At most 1 **	0.472999	56.96456	47.21	54.46
At most 2	0.342279	28.13972	29.68	35.65
At most 3	0.150399	9.285883	15.41	20.04
At most 4	0.042437	1.951386	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Trace test indicates 2 cointegrating equation(s) at both 5% and 1% levels

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.636895	45.58787	33.46	38.77
At most 1 *	0.472999	28.82484	27.07	32.24
At most 2	0.342279	18.85384	20.97	25.52
At most 3	0.150399	7.334497	14.07	18.63
At most 4	0.042437	1.951386	3.76	6.65

*(**) denotes rejection of the hypothesis at the 5%(1%) level
Max-eigenvalue test indicates 2 cointegrating equation(s) at the 5% level
Max-eigenvalue test indicates 1 cointegrating equation(s) at the 1% level

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LNM2	LNCPI	DLNEXCHA	LNREALGD	DINTERES
10.95256	-16.82180	-80.37532	-10.96807	0.593858
13.06140	-45.58880	-63.36621	7.912773	-2.567359
11.03669	-9.735172	-50.60395	-11.35232	-0.843458
-1.898999	-8.573662	35.60281	17.24943	2.241637
-24.21244	-10.40578	-35.24769	62.11797	2.355861

Unrestricted Adjustment Coefficients (alpha):

D(LNM2)	-0.010959	-0.020069	0.007438	-0.000228	0.003544
D(LNCPI)	-0.000146	0.003504	0.005226	0.003911	-0.001156
D(DLNEXCHA)	0.004008	0.000836	0.003144	-0.002432	-0.000295
D(LNREALGD)	-0.000114	0.006833	-0.002088	-0.003918	0.002563
D(DINTERES)	-0.375873	0.038306	0.021026	-0.040602	-0.055151

1 Cointegrating Equation(s): Log likelihood 463.1048

Normalized cointegrating coefficients (std.err. in parentheses)

LNM2	LNCPI	DLNEXCHA	LNREALGD	DINTERES
1.000000	-1.535878	-7.338497	-1.001417	0.054221
	(0.61876)	(1.50581)	(0.53012)	(0.03847)

Adjustment coefficients (std.err. in parentheses)

D(LNM2)	-0.120026
	(0.07683)
D(LNCPI)	-0.001604
	(0.03200)

D(DLNEXCHA)	0.043896				
	(0.01862)				
D(LNREALGD)	-0.001249				
	(0.03972)				
D(DINTERES)	-4.116767				
	(0.84731)				

2 Cointegrating Equation(s): Log likelihood 477.5172

Normalized cointegrating coefficients (std.err. in parentheses)

LNM2	LNCPI	DLNEXCHA	LNREALGD	DINTERES
1.000000	0.000000	-9.292925	-2.264426	0.251293
		(2.14006)	(0.20399)	(0.07705)
0.000000	1.000000	-1.272515	-0.822337	0.128312
		(0.83962)	(0.08003)	(0.03023)

Adjustment coefficients (std.err. in parentheses)

D(LNM2)	-0.382161	1.099289
	(0.10059)	(0.28677)
D(LNCPI)	0.044161	-0.157273
	(0.04850)	(0.13827)
D(DLNEXCHA)	0.054814	-0.105527
	(0.02885)	(0.08225)
D(LNREALGD)	0.087995	-0.309574
	(0.05777)	(0.16469)
D(DINTERES)	-3.616438	4.576532
	(1.31290)	(3.74276)

3 Cointegrating Equation(s): Log likelihood 486.9442

Normalized cointegrating coefficients (std.err. in parentheses)

LNM2	LNCPI	DLNEXCHA	LNREALGD	DINTERES
1.000000	0.000000	0.000000	-0.941363	-0.304755
			(0.49191)	(0.19200)
0.000000	1.000000	0.000000	-0.641165	0.052170
			(0.07803)	(0.03046)
0.000000	0.000000	1.000000	0.142373	-0.059836
			(0.06276)	(0.02450)

Adjustment coefficients (std.err. in parentheses)

D(LNM2)	-0.300069	1.026877	1.776135
	(0.11639)	(0.28405)	(0.65441)
D(LNCPI)	0.101840	-0.208150	-0.474717
	(0.05419)	(0.13225)	(0.30469)
D(DLNEXCHA)	0.089518	-0.136139	-0.534218
	(0.03218)	(0.07854)	(0.18094)
D(LNREALGD)	0.064955	-0.289252	-0.318154
	(0.06836)	(0.16682)	(0.38434)
D(DINTERES)	-3.384384	4.371844	26.71960
	(1.56199)	(3.81205)	(8.78239)

4 Cointegrating Equation(s): Log likelihood 490.6114

Normalized cointegrating coefficients (std.err. in parentheses)

LNM2	LNCPI	DLNEXCHA	LNREALGD	DINTERES
1.000000	0.000000	0.000000	0.000000	0.510615
				(0.23572)
0.000000	1.000000	0.000000	0.000000	0.607521
				(0.14798)
0.000000	0.000000	1.000000	0.000000	-0.183153
				(0.04168)
0.000000	0.000000	0.000000	1.000000	0.866159
				(0.22579)

Adjustment coefficients (std.err. in parentheses)

D(LNM2)	-0.299636	1.028829	1.768031	-0.126977
	(0.11689)	(0.28826)	(0.68547)	(0.14148)
D(LNCPI)	0.094412	-0.241684	-0.335464	0.037470
	(0.05230)	(0.12897)	(0.30667)	(0.06330)
D(DLNEXCHA)	0.094137	-0.115286	-0.620810	-0.114993

	(0.03093)	(0.07628)	(0.18139)	(0.03744)
D(LNREALGD)	0.072395	-0.255663	-0.457633	0.011438
	(0.06697)	(0.16516)	(0.39273)	(0.08106)
D(DINTERES)	-3.307280	4.719955	25.27404	3.486645
	(1.56098)	(3.84938)	(9.15357)	(1.88926)

e) Test of significance of coefficients

Table x12: Test of significance of coefficients in the VAR1 model

Vector Error Correction Estimates
Date: 10/19/09 Time: 13:37
Sample (adjusted): 4 50
Included observations: 47 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, B(1,2)=0 REAL INCOME
Convergence achieved after 28 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	11.98906
Probability	0.000535

Vector Error Correction Estimates
Date: 10/19/09 Time: 13:40
Sample (adjusted): 4 50
Included observations: 47 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, B(1,3)=0 Dinterest
Convergence achieved after 40 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	13.18422
Probability	0.000282

Vector Error Correction Estimates
Date: 10/19/09 Time: 13:42
Sample (adjusted): 5 50
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, B(1,4)=0 nominal exchange rate
Convergence achieved after 218 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	2.155080
Probability	0.142099

Date: 10/09/09 Time: 12:33
Sample (adjusted): 6 50
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, B(1,2)=-1
Convergence achieved after 42 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	1.633585
Probability	0.201208

Table x13: Test of significance of coefficients in the VAR2 model

Vector Error Correction Estimates
Date: 10/19/09 Time: 12:26
Sample (adjusted): 5 50
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, B(1,2)=0 cpi
Convergence achieved after 76 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	8.528249
Probability	0.003497

Vector Error Correction Estimates
Date: 10/19/09 Time: 12:31
Sample (adjusted): 5 50
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, B(1,3)=0 DLNEXCHA
Maximum iterations (500) reached.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	12.42097
Probability	0.000425

Vector Error Correction Estimates
Date: 10/19/09 Time: 12:34
Sample (adjusted): 5 50
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, B(1,4)=0 REAL INCOME
Convergence achieved after 46 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	6.934144
Probability	0.008457

Vector Error Correction Estimates
Date: 10/19/09 Time: 12:37
Sample (adjusted): 5 50
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, B(1,5)=0 Interest rates
Convergence achieved after 16 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	3.758494
Probability	0.052540

f) Tests of stability in VAR1 and VAR2 models

Table x14 : Results for stability of demand for money (VAR1 model)

Roots of Characteristic Polynomial
Endogenous variables: LNM2-LNCPI LNREALGD DINTERES LNEXCHAR
Exogenous variables: C
Lag specification: 1 4
Date: 11/02/09 Time: 12:17

Root	Modulus
0.962954 - 0.208418i	0.985251
0.962954 + 0.208418i	0.985251
0.982380	0.982380
0.598853 - 0.522395i	0.794683
0.598853 + 0.522395i	0.794683
0.292159 - 0.701819i	0.760202
0.292159 + 0.701819i	0.760202
-0.491160 - 0.504290i	0.703951
-0.491160 + 0.504290i	0.703951
-0.007014 - 0.694414i	0.694449
-0.007014 + 0.694414i	0.694449
0.614586 - 0.307047i	0.687018
0.614586 + 0.307047i	0.687018
-0.663330	0.663330
-0.566488	0.566488
-0.125070	0.125070

No root lies outside the unit circle.
VAR satisfies the stability condition.

Table x15: stability of VAR2 model

Roots of Characteristic Polynomial
Endogenous variables: LNM2 LNCPI DLNEXCHA LNREALGD DINTERES
Exogenous variables: C
Lag specification: 1 3
Date: 11/02/09 Time: 12:23

Root	Modulus
0.996215	0.996215
0.899828 - 0.146390i	0.911658
0.899828 + 0.146390i	0.911658
0.648329 - 0.539562i	0.843479
0.648329 + 0.539562i	0.843479
0.360295 - 0.563412i	0.668764
0.360295 + 0.563412i	0.668764
0.607145	0.607145
-0.554738 - 0.175569i	0.581858

-0.554738 + 0.175569i	0.581858
-0.138526 - 0.555615i	0.572623
-0.138526 + 0.555615i	0.572623
-0.283500 - 0.388362i	0.480830
-0.283500 + 0.388362i	0.480830
0.355729	0.355729

No root lies outside the unit circle.

VAR satisfies the stability condition.

Appendix 3: Estimation of error correction models, restrictions for a unity real income elasticity and a unity price elasticity, tests for quality of the models and test for exogeneity

Table x1: Results from the estimation of the Vector Error Correction Model1 (VECM1)

Vector Error Correction Estimates
Date: 10/08/09 Time: 10:45
Sample (adjusted): 6 50
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1
Convergence achieved after 1 iterations.
Restrictions identify all cointegrating vectors
Restrictions are not binding (LR test not available)

Cointegrating Eq:	CointEq1
LNM2(-1)-LNCPI(-1)	1.000000
LNREALGD(-1)	-1.310650
	(0.19846)
	[-6.60422]
DINTERES(-1)	0.042933
	(0.03297)
	[1.30202]
LNEXCHAR(-1)	0.002608
	(0.14314)
	[0.01822]
C	6.034506

Error Correction:	D(LNM2-LNCPI)	D(LNREALGD)	D(DINTERES)	D(LNEXCHAR)
CointEq1	-0.215441	-0.020001	-5.311698	0.045959
	(0.13130)	(0.05873)	(1.22355)	(0.02478)
	[-1.64084]	[-0.34055]	[-4.34121]	[1.85438]
D(LNM2(-1)-LNCPI(-1))	0.086034	-0.040553	7.656058	-0.048675
	(0.20782)	(0.09296)	(1.93660)	(0.03923)
	[0.41399]	[-0.43624]	[3.95334]	[-1.24086]
D(LNM2(-2)-LNCPI(-2))	0.111443	-0.092429	5.593277	-0.064521
	(0.22891)	(0.10240)	(2.13320)	(0.04321)
	[0.48684]	[-0.90266]	[2.62202]	[-1.49322]

D(LNM2(-3)-LNCPI(-3))	-0.294040	-0.011316	5.361384	0.006086
	(0.20810)	(0.09309)	(1.93924)	(0.03928)
	[-1.41297]	[-0.12157]	[2.76468]	[0.15492]
D(LNM2(-4)-LNCPI(-4))	0.156248	0.011876	3.439811	0.044100
	(0.20853)	(0.09328)	(1.94325)	(0.03936)
	[0.74928]	[0.12731]	[1.77013]	[1.12036]
D(LNREALGD(-1))	0.309809	0.256663	-7.551962	0.007344
	(0.40214)	(0.17988)	(3.74748)	(0.07591)
	[0.77040]	[1.42683]	[-2.01521]	[0.09676]
D(LNREALGD(-2))	-0.168410	0.017914	-4.024775	0.050958
	(0.41079)	(0.18375)	(3.82805)	(0.07754)
	[-0.40997]	[0.09749]	[-1.05139]	[0.65719]
D(LNREALGD(-3))	0.163862	-0.214806	-1.080901	0.008737
	(0.41104)	(0.18386)	(3.83037)	(0.07759)
	[0.39866]	[-1.16830]	[-0.28219]	[0.11261]
D(LNREALGD(-4))	0.021075	-0.114253	-5.738992	-0.164707
	(0.36991)	(0.16546)	(3.44709)	(0.06982)
	[0.05697]	[-0.69050]	[-1.66488]	[-2.35890]
D(DINTERES(-1))	0.004737	-0.007407	-0.922479	0.001538
	(0.01550)	(0.00693)	(0.14441)	(0.00293)
	[0.30565]	[-1.06855]	[-6.38776]	[0.52569]
D(DINTERES(-2))	0.013797	0.000304	-0.829454	-0.005852
	(0.01977)	(0.00885)	(0.18427)	(0.00373)
	[0.69769]	[0.03433]	[-4.50118]	[-1.56790]
D(DINTERES(-3))	0.014099	-0.000783	-0.263902	-0.004740
	(0.02108)	(0.00943)	(0.19641)	(0.00398)
	[0.66893]	[-0.08308]	[-1.34361]	[-1.19137]
D(DINTERES(-4))	0.010600	-0.003923	0.044133	-0.000233
	(0.01613)	(0.00722)	(0.15033)	(0.00304)
	[0.65711]	[-0.54373]	[0.29358]	[-0.07645]
D(LNEXCHAR(-1))	1.245797	-0.175869	19.46144	0.806627
	(0.90847)	(0.40637)	(8.46584)	(0.17148)
	[1.37131]	[-0.43278]	[2.29882]	[4.70386]
D(LNEXCHAR(-2))	-1.599927	0.209628	-3.828449	-0.097328
	(1.22011)	(0.54577)	(11.3699)	(0.23031)
	[-1.31130]	[0.38410]	[-0.33672]	[-0.42260]
D(LNEXCHAR(-3))	0.595635	0.089344	-6.156428	0.057297
	(1.22626)	(0.54852)	(11.4273)	(0.23147)

	[0.48573]	[0.16288]	[-0.53875]	[0.24754]
D(LNEXCHAR(-4))	0.411673	-0.106962	21.82273	-0.151702
	(0.87907)	(0.39322)	(8.19190)	(0.16593)
	[0.46830]	[-0.27202]	[2.66394]	[-0.91424]
C	0.006214	0.015650	-0.653911	0.008282
	(0.02212)	(0.00990)	(0.20616)	(0.00418)
	[0.28087]	[1.58144]	[-3.17182]	[1.98336]
R-squared	0.370326	0.374520	0.726316	0.824238
Adj. R-squared	-0.026135	-0.019301	0.553997	0.713573
Sum sq. resids	0.084489	0.016905	7.337007	0.003010
S.E. equation	0.055939	0.025022	0.521288	0.010559
F-statistic	0.934079	0.950991	4.214947	7.448052
Log likelihood	77.39827	113.6007	-23.04328	152.4260
Akaike AIC	-2.639923	-4.248918	1.824146	-5.974491
Schwarz SC	-1.917258	-3.526253	2.546811	-5.251826
Mean dependent	0.019318	0.011626	-0.006889	0.012807
S.D. dependent	0.055222	0.024784	0.780565	0.019730

Determinant resid covariance (dof adj.)	4.67E-11
Determinant resid covariance	6.05E-12
Log likelihood	325.7911
Akaike information criterion	-11.10183
Schwarz criterion	-8.050573

Table x2: Results from the estimation of the Vector Error Correction Model1 (VECM1): Velocity of money income (unit elasticity of real income)

Vector Error Correction Estimates
Date: 10/09/09 Time: 12:33
Sample (adjusted): 6 50
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, B(1,2)=-1
Convergence achieved after 42 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	1.633585
Probability	0.201208

Cointegrating Eq:	CointEq1
LNM2(-1)-LNCPI(-1)	1.000000
LNREALGD(-1)	-1.000000

DINTERES(-1)	0.059543
	(0.02982)
	[1.99680]
LNEXCHAR(-1)	-0.216518
	(0.05771)
	[-3.75156]
C	5.418086

Error Correction:	D(LNM2-LNCPI)	D(LNREALGD)	D(DINTERES)	D(LNEXCHAR)
CointEq1	-0.171813	-0.061112	-4.991817	0.048154
	(0.13788)	(0.05946)	(1.33142)	(0.02546)
	[-1.24613]	[-1.02784]	[-3.74925]	[1.89109]
D(LNM2(-1)-LNCPI(-1))	0.079069	-0.002565	8.130889	-0.057030
	(0.22287)	(0.09611)	(2.15212)	(0.04116)
	[0.35478]	[-0.02669]	[3.77807]	[-1.38556]
D(LNM2(-2)-LNCPI(-2))	0.083597	-0.045704	5.731916	-0.071140
	(0.24337)	(0.10495)	(2.35009)	(0.04495)
	[0.34350]	[-0.43550]	[2.43902]	[-1.58278]
D(LNM2(-3)-LNCPI(-3))	-0.307154	0.022773	5.628933	-0.000110
	(0.21967)	(0.09473)	(2.12129)	(0.04057)
	[-1.39822]	[0.24040]	[2.65354]	[-0.00270]
D(LNM2(-4)-LNCPI(-4))	0.155163	0.039578	3.878342	0.037250
	(0.21912)	(0.09449)	(2.11597)	(0.04047)
	[0.70811]	[0.41885]	[1.83289]	[0.92045]
D(LNREALGD(-1))	0.357402	0.221174	-7.046426	0.007356
	(0.40946)	(0.17657)	(3.95394)	(0.07562)
	[0.87286]	[1.25260]	[-1.78213]	[0.09728]
D(LNREALGD(-2))	-0.134504	0.001669	-3.513371	0.048665
	(0.41774)	(0.18014)	(4.03393)	(0.07715)
	[-0.32198]	[0.00927]	[-0.87096]	[0.63077]
D(LNREALGD(-3))	0.206663	-0.246028	-0.614651	0.008571
	(0.41855)	(0.18049)	(4.04169)	(0.07730)
	[0.49376]	[-1.36311]	[-0.15208]	[0.11088]
D(LNREALGD(-4))	0.016979	-0.114632	-5.839963	-0.163833
	(0.37721)	(0.16266)	(3.64252)	(0.06966)
	[0.04501]	[-0.70472]	[-1.60328]	[-2.35174]
D(DINTERES(-1))	0.009246	-0.007510	-0.820013	0.000708
	(0.01536)	(0.00662)	(0.14834)	(0.00284)

	[0.60190]	[-1.13359]	[-5.52778]	[0.24970]
D(DINTERES(-2))	0.018547	-0.000959	-0.740854	-0.006432
	(0.01962)	(0.00846)	(0.18947)	(0.00362)
	[0.94527]	[-0.11338]	[-3.91022]	[-1.77494]
D(DINTERES(-3))	0.017966	-0.001949	-0.194080	-0.005176
	(0.02116)	(0.00912)	(0.20429)	(0.00391)
	[0.84925]	[-0.21364]	[-0.95004]	[-1.32489]
D(DINTERES(-4))	0.011439	-0.003650	0.068097	-0.000462
	(0.01646)	(0.00710)	(0.15896)	(0.00304)
	[0.69492]	[-0.51414]	[0.42840]	[-0.15186]
D(LNEXCHAR(-1))	1.177630	-0.090473	19.31580	0.797806
	(0.93245)	(0.40210)	(9.00425)	(0.17221)
	[1.26294]	[-0.22500]	[2.14519]	[4.63275]
D(LNEXCHAR(-2))	-1.742163	0.219265	-6.953018	-0.072803
	(1.23801)	(0.53387)	(11.9548)	(0.22864)
	[-1.40723]	[0.41071]	[-0.58161]	[-0.31842]
D(LNEXCHAR(-3))	0.690243	0.036845	-4.849433	0.052724
	(1.24790)	(0.53813)	(12.0504)	(0.23047)
	[0.55312]	[0.06847]	[-0.40243]	[0.22877]
D(LNEXCHAR(-4))	0.178438	-0.054876	17.30635	-0.120728
	(0.86737)	(0.37404)	(8.37581)	(0.16019)
	[0.20572]	[-0.14671]	[2.06623]	[-0.75365]
C	0.010429	0.012626	-0.607157	0.008253
	(0.02243)	(0.00967)	(0.21664)	(0.00414)
	[0.46483]	[1.30503]	[-2.80257]	[1.99192]
R-squared	0.345196	0.395487	0.694392	0.825028
Adj. R-squared	-0.067088	0.014867	0.501972	0.714861
Sum sq. resids	0.087861	0.016339	8.192855	0.002997
S.E. equation	0.057045	0.024599	0.550853	0.010535
F-statistic	0.837278	1.039060	3.608731	7.488867
Log likelihood	76.51776	114.3678	-25.52573	152.5274
Akaike AIC	-2.600789	-4.283014	1.934477	-5.978997
Schwarz SC	-1.878124	-3.560349	2.657142	-5.256332
Mean dependent	0.019318	0.011626	-0.006889	0.012807
S.D. dependent	0.055222	0.024784	0.780565	0.019730
Determinant resid covariance (dof adj.)		4.84E-11		
Determinant resid covariance		6.27E-12		
Log likelihood		324.9743		
Akaike information criterion		-11.06552		
Schwarz criterion		-8.014271		

Table x3: Results from the estimation of the Vector Error Correction Model1 (VECM2)

Vector Error Correction Estimates
Date: 10/08/09 Time: 14:54
Sample (adjusted): 6 50
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1
Convergence achieved after 1 iterations.
Restrictions identify all cointegrating vectors
Restrictions are not binding (LR test not available)

Cointegrating Eq:	CointEq1
LNM2(-1)	1.000000
LNCPI(-1)	-1.535907
	(0.61876)
	[-2.48223]
DLNEXCHA(-1)	-7.338500
	(1.50580)
	[-4.87350]
LNREALGD(-1)	-1.001393
	(0.53011)
	[-1.88902]
DINTERES(-1)	0.054218
	(0.03847)
	[1.40940]
C	6.764274

Error Correction:	D(LNM2)	D(LNCPI)	D(DLNEXCHA)	D(LNREALGD)	D(DINTERES)
CointEq1	-0.120029	-0.001603	0.043896	-0.001249	-4.116802
	(0.07683)	(0.03200)	(0.01862)	(0.03972)	(0.84732)
	[-1.56218]	[-0.05011]	[2.35769]	[-0.03145]	[-4.85864]
D(LNM2(-1))	-0.030000	0.052836	-0.074004	-0.048569	4.117285
	(0.17431)	(0.07260)	(0.04224)	(0.09012)	(1.92232)
	[-0.17210]	[0.72781]	[-1.75200]	[-0.53892]	[2.14183]
D(LNM2(-2))	0.060897	0.119777	-0.042560	-0.055920	3.683241
	(0.19427)	(0.08090)	(0.04707)	(0.10044)	(2.14233)
	[0.31348]	[1.48047]	[-0.90412]	[-0.55677]	[1.71927]

D(LNM2(-3))	-0.290949	0.055643	-0.010753	-0.042857	2.815874
	(0.17684)	(0.07365)	(0.04285)	(0.09143)	(1.95021)
	[-1.64523]	[0.75551]	[-0.25094]	[-0.46874]	[1.44388]
D(LNCPI(-1))	0.195878	0.393587	-0.017965	0.043489	-10.69311
	(0.52835)	(0.22004)	(0.12803)	(0.27316)	(5.82657)
	[0.37074]	[1.78872]	[-0.14032]	[0.15921]	[-1.83523]
D(LNCPI(-2))	-0.685913	-0.087173	0.105172	0.406806	-4.044338
	(0.56218)	(0.23413)	(0.13623)	(0.29065)	(6.19961)
	[-1.22010]	[-0.37233]	[0.77204]	[1.39964]	[-0.65235]
D(LNCPI(-3))	0.505232	-0.044234	-0.072366	-0.195227	-11.36792
	(0.52559)	(0.21889)	(0.12736)	(0.27173)	(5.79610)
	[0.96127]	[-0.20208]	[-0.56820]	[-0.71845]	[-1.96130]
D(DLNEXCHA(-1))	0.108867	0.047495	0.213878	-0.041739	-14.57898
	(0.74210)	(0.30906)	(0.17982)	(0.38367)	(8.18382)
	[0.14670]	[0.15368]	[1.18937]	[-0.10879]	[-1.78144]
D(DLNEXCHA(-2))	-1.280549	-0.081846	0.027509	-0.000896	-17.54201
	(0.66878)	(0.27852)	(0.16206)	(0.34576)	(7.37518)
	[-1.91476]	[-0.29386]	[0.16975]	[-0.00259]	[-2.37852]
D(DLNEXCHA(-3))	-0.567871	-0.090816	0.037617	0.031743	-24.94339
	(0.71524)	(0.29787)	(0.17332)	(0.36979)	(7.88758)
	[-0.79396]	[-0.30488]	[0.21704]	[0.08584]	[-3.16236]
D(LNREALGD(-1))	0.526587	0.116837	-0.014109	0.279952	-4.917005
	(0.36502)	(0.15202)	(0.08845)	(0.18872)	(4.02543)
	[1.44261]	[0.76857]	[-0.15951]	[1.48342]	[-1.22149]
D(LNREALGD(-2))	-0.316561	-0.022417	0.079219	0.158260	-0.992516
	(0.40344)	(0.16802)	(0.09776)	(0.20858)	(4.44905)
	[-0.78466]	[-0.13342]	[0.81034]	[0.75875]	[-0.22309]
D(LNREALGD(-3))	0.668605	0.203765	-0.071724	-0.343622	-1.680915
	(0.37842)	(0.15760)	(0.09170)	(0.19564)	(4.17312)
	[1.76685]	[1.29295]	[-0.78218]	[-1.75636]	[-0.40280]
D(DINTERES(-1))	0.005582	0.003623	0.001222	-0.006419	-0.912341
	(0.01299)	(0.00541)	(0.00315)	(0.00672)	(0.14328)
	[0.42964]	[0.66953]	[0.38818]	[-0.95558]	[-6.36754]
D(DINTERES(-2))	0.003486	-0.004905	-0.006062	0.002430	-0.834002
	(0.01641)	(0.00684)	(0.00398)	(0.00849)	(0.18102)
	[0.21237]	[-0.71755]	[-1.52408]	[0.28628]	[-4.60726]
D(DINTERES(-3))	0.005671	-0.003461	-0.004780	0.001022	-0.300532

	(0.01490)	(0.00620)	(0.00361)	(0.00770)	(0.16428)
	[0.38072]	[-0.55784]	[-1.32418]	[0.13274]	[-1.82942]
C	0.029952	-0.001501	0.004459	0.012381	0.024151
	(0.01632)	(0.00680)	(0.00395)	(0.00844)	(0.17996)
	[1.83543]	[-0.22092]	[1.12768]	[1.46741]	[0.13420]
R-squared	0.440843	0.433816	0.503153	0.386765	0.718711
Adj. R-squared	0.121325	0.110282	0.219241	0.036345	0.557975
Sum sq. resids	0.062007	0.010755	0.003641	0.016574	7.540889
S.E. equation	0.047059	0.019598	0.011403	0.024330	0.518958
F-statistic	1.379713	1.340868	1.772212	1.103719	4.471367
Log likelihood	84.35912	123.7771	148.1469	114.0455	-23.65998
Akaike AIC	-2.993739	-4.745647	-5.828750	-4.313134	1.807110
Schwarz SC	-2.311222	-4.063130	-5.146233	-3.630617	2.489627
Mean dependent	0.035805	0.016487	0.000128	0.011626	-0.006889
S.D. dependent	0.050203	0.020777	0.012905	0.024784	0.780565

Determinant resid covariance (dof adj.)	8.49E-15
Determinant resid covariance	7.92E-16
Log likelihood	463.1045
Akaike information criterion	-16.58242
Schwarz criterion	-12.96910

Table x4: Results from the estimation of the Vector Error Correction Model1 (VECM2) : Unit price elasticity

Vector Error Correction Estimates
Date: 10/14/09 Time: 09:54
Sample (adjusted): 6 50
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, B(1,2)=-1
Convergence achieved after 78 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	0.478593
Probability	0.489060

Cointegrating Eq:	CointEq1
LNM2(-1)	1.000000
LNCPI(-1)	-1.000000
DLNEXCHA(-1)	-6.970710
	(1.16327)
	[-5.99236]
LNREALGD(-1)	-1.443783
	(0.11088)
	[-13.0210]
DINTERES(-1)	0.079418
	(0.04188)
	[1.89617]
C	6.270247

Error Correction:	D(LNM2)	D(LNCPI)	D(DLNEXCHA)	D(LNREALGD)	D(DINTERES)
CointEq1	-0.083908	-0.006113	0.039578	-0.010821	-3.787120
	(0.07224)	(0.02952)	(0.01727)	(0.03662)	(0.78462)
	[-1.16148]	[-0.20706]	[2.29203]	[-0.29552]	[-4.82667]
D(LNM2(-1))	-0.041973	0.055203	-0.074127	-0.043657	4.166957
	(0.17774)	(0.07263)	(0.04249)	(0.09009)	(1.93048)
	[-0.23614]	[0.76004]	[-1.74477]	[-0.48457]	[2.15851]
D(LNM2(-2))	0.030983	0.125943	-0.043316	-0.043147	3.853137
	(0.19952)	(0.08153)	(0.04769)	(0.10113)	(2.16698)
	[0.15529]	[1.54473]	[-0.90828]	[-0.42664]	[1.77812]
D(LNM2(-3))	-0.306514	0.058941	-0.011306	-0.036032	2.920610

	(0.18070)	(0.07384)	(0.04319)	(0.09159)	(1.96258)
	[-1.69626]	[0.79821]	[-0.26177]	[-0.39340]	[1.48815]
D(LNCPI(-1))	0.237542	0.390568	-0.026833	0.036798	-9.915324
	(0.53648)	(0.21923)	(0.12823)	(0.27193)	(5.82670)
	[0.44278]	[1.78159]	[-0.20926]	[0.13532]	[-1.70170]
D(LNCPI(-2))	-0.649378	-0.089823	0.097402	0.400931	-3.362954
	(0.57138)	(0.23348)	(0.13657)	(0.28962)	(6.20570)
	[-1.13652]	[-0.38471]	[0.71319]	[1.38436]	[-0.54191]
D(LNCPI(-3))	0.601539	-0.049584	-0.095765	-0.207449	-9.273513
	(0.52667)	(0.21521)	(0.12589)	(0.26695)	(5.72011)
	[1.14216]	[-0.23039]	[-0.76073]	[-0.77710]	[-1.62121]
D(DLNEXCHA(-1))	0.298105	0.031044	0.178478	-0.077591	-11.54522
	(0.73270)	(0.29941)	(0.17513)	(0.37139)	(7.95785)
	[0.40686]	[0.10369]	[1.01910]	[-0.20892]	[-1.45080]
D(DLNEXCHA(-2))	-1.175818	-0.089434	0.005215	-0.017715	-15.58674
	(0.67306)	(0.27503)	(0.16088)	(0.34115)	(7.31004)
	[-1.74699]	[-0.32517]	[0.03242]	[-0.05193]	[-2.13224]
D(DLNEXCHA(-3))	-0.396751	-0.112655	0.018010	-0.014553	-23.46844
	(0.71496)	(0.29216)	(0.17089)	(0.36240)	(7.76522)
	[-0.55492]	[-0.38559]	[0.10539]	[-0.04016]	[-3.02225]
D(LNREALGD(-1))	0.513677	0.111753	-0.000638	0.270029	-6.254469
	(0.37575)	(0.15355)	(0.08981)	(0.19046)	(4.08102)
	[1.36707]	[0.72782]	[-0.00711]	[1.41779]	[-1.53257]
D(LNREALGD(-2))	-0.335371	-0.024572	0.089489	0.154270	-1.984417
	(0.41170)	(0.16824)	(0.09841)	(0.20868)	(4.47150)
	[-0.81459]	[-0.14605]	[0.90938]	[0.73926]	[-0.44379]
D(LNREALGD(-3))	0.681511	0.198973	-0.067600	-0.353382	-2.142530
	(0.38696)	(0.15813)	(0.09249)	(0.19614)	(4.20280)
	[1.76118]	[1.25831]	[-0.73087]	[-1.80167]	[-0.50979]
D(DINTERES(-1))	0.008264	0.003454	0.000606	-0.006799	-0.857633
	(0.01296)	(0.00530)	(0.00310)	(0.00657)	(0.14074)
	[0.63776]	[0.65225]	[0.19560]	[-1.03511]	[-6.09361]
D(DINTERES(-2))	0.007107	-0.005283	-0.006627	0.001617	-0.787502
	(0.01637)	(0.00669)	(0.00391)	(0.00830)	(0.17783)
	[0.43406]	[-0.78967]	[-1.69322]	[0.19486]	[-4.42843]
D(DINTERES(-3))	0.008258	-0.003784	-0.005089	0.000336	-0.276985
	(0.01502)	(0.00614)	(0.00359)	(0.00761)	(0.16311)
	[0.54990]	[-0.61663]	[-1.41757]	[0.04416]	[-1.69817]

C	0.030138	-0.001613	0.004594	0.012156	0.009777
	(0.01665)	(0.00680)	(0.00398)	(0.00844)	(0.18078)
	[1.81065]	[-0.23712]	[1.15475]	[1.44076]	[0.05408]
R-squared	0.420050	0.434631	0.498592	0.388650	0.717014
Adj. R-squared	0.088650	0.111563	0.212073	0.039308	0.555307
Sum sq. resids	0.064313	0.010739	0.003674	0.016523	7.586401
S.E. equation	0.047926	0.019584	0.011455	0.024292	0.520522
F-statistic	1.267502	1.345323	1.740170	1.112519	4.434044
Log likelihood	83.53760	123.8095	147.9413	114.1148	-23.79537
Akaike AIC	-2.957227	-4.747087	-5.819611	-4.316213	1.813127
Schwarz SC	-2.274710	-4.064570	-5.137094	-3.633696	2.495644
Mean dependent	0.035805	0.016487	0.000128	0.011626	-0.006889
S.D. dependent	0.050203	0.020777	0.012905	0.024784	0.780565

Determinant resid covariance (dof adj.)	8.58E-15
Determinant resid covariance	8.01E-16
Log likelihood	462.8652
Akaike information criterion	-16.57179
Schwarz criterion	-12.95846

Table x5: Results from the test of quality of the Model 1 (VECM1)

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 10/08/09 Time: 10:19
Sample: 1 52
Included observations: 47

Component	Jarque-Bera	df	Prob.
1	4.063349	2	0.1311
2	2.991615	2	0.2241
3	2.954633	2	0.2282
4	1.005677	2	0.6048
Joint	11.01527	8	0.2008

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 10/08/09 Time: 10:14
Sample: 1 52
Included observations: 47

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	Df
1	1.884778	NA*	1.925751	NA*	NA*
2	4.764155	NA*	4.933101	NA*	NA*
3	15.63280	0.4789	16.54279	0.4158	16
4	33.34298	0.4018	35.90042	0.2906	32
5	50.12079	0.3893	54.67560	0.2359	48
6	59.37781	0.6404	65.28730	0.4318	64
7	75.03260	0.6361	83.68168	0.3672	80
8	87.15925	0.7291	98.29585	0.4159	96
9	95.49791	0.8680	108.6095	0.5731	112
10	101.1258	0.9618	115.7584	0.7730	128
11	114.4285	0.9670	133.1258	0.7317	144
12	132.4759	0.9451	157.3609	0.5442	160

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 10/08/09 Time: 09:27
Sample: 1 52
Included observations: 47

Joint test:

Chi-sq	df	Prob.
194.8626	180	0.2125

VEC Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 10/08/09 Time: 10:16
Sample: 1 52
Included observations: 47

Lags	LM-Stat	Prob
1	9.942308	0.8696
2	12.44352	0.7129
3	17.41976	0.3590
4	17.72263	0.3404
5	18.64503	0.2875
6	10.92278	0.8142
7	17.16506	0.3750
8	15.03200	0.5223
9	9.037599	0.9119
10	7.401637	0.9647
11	14.51433	0.5605
12	20.05442	0.2178

Probs from chi-square with 16 df.

Table x6: Results from the test of the quality of the Model 2 (VECM 2)

VEC Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
Null Hypothesis: residuals are multivariate normal
Date: 10/08/09 Time: 14:13
Sample: 1 52
Included observations: 45

Component	Jarque-Bera	df	Prob.
1	6.443336	2	0.0399
2	6.985476	2	0.0304

3	7.375110	2	0.0250
4	5.558557	2	0.0621
5	7.076518	2	0.0291
Joint	33.43900	10	0.0002

VEC Residual Portmanteau Tests for Autocorrelations
Null Hypothesis: no residual autocorrelations up to lag h
Date: 10/08/09 Time: 14:08
Sample: 1 52
Included observations: 45

Lags	Q-Stat	Prob.	Adj Q-Stat	Prob.	Df
1	11.19504	NA*	11.44947	NA*	NA*
2	21.52265	NA*	22.25744	NA*	NA*
3	38.62527	NA*	40.58167	NA*	NA*
4	69.46285	0.0000	74.42780	0.0000	25
5	85.48400	0.0013	92.45159	0.0002	50
6	106.5246	0.0098	116.7292	0.0015	75
7	134.1209	0.0129	149.4090	0.0010	100
8	153.0797	0.0446	172.4670	0.0032	125
9	172.4998	0.1008	196.7422	0.0062	150
10	183.9625	0.3062	211.4799	0.0312	175
11	207.9381	0.3354	243.2124	0.0199	200
12	238.3272	0.2586	284.6520	0.0043	225

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution

VEC Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 10/08/09 Time: 14:12
Sample: 1 52
Included observations: 45

Lags	LM-Stat	Prob
1	20.97977	0.6937
2	18.26505	0.8309
3	24.81840	0.4726
4	33.18227	0.1266
5	19.46411	0.7743
6	19.15758	0.7895
7	32.54894	0.1427
8	23.49544	0.5487
9	24.91983	0.4669
10	15.61688	0.9258
11	36.48540	0.0646

12	48.57216	0.0032

Probs from chi-square with 25 df.

VEC Residual Heteroskedasticity Tests: No Cross Terms (only levels and squares)
Date: 10/08/09 Time: 14:17
Sample: 1 52
Included observations: 45

Joint test:

Chi-sq	df	Prob.
489.6039	480	0.3709

Table x7: Test of exogeneity in the VAR1 model

Vector Error Correction Estimates
Date: 10/19/09 Time: 10:16
Sample (adjusted): 6 50
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(2,1)=0 real Income
Convergence achieved after 34 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	0.128297
Probability	0.720204

Vector Error Correction Estimates
Date: 10/19/09 Time: 10:19
Sample (adjusted): 6 50
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(3,1)=0 Dinteres
Convergence achieved after 27 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	13.71933
Probability	0.000212

Vector Error Correction Estimates

Date: 10/19/09 Time: 10:21
Sample (adjusted): 6 50
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(4,1)=0 exchange rate
Convergence achieved after 104 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	3.990247
Probability	0.045764

Table x8: Test of exogeneity in the VECM2 model

Vector Error Correction Estimates
Date: 10/19/09 Time: 11:51
Sample (adjusted): 5 50
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(1,1)=0 Money stock
Convergence achieved after 112 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	9.629317
Probability	0.001915

Vector Error Correction Estimates
Date: 10/19/09 Time: 12:09
Sample (adjusted): 5 50
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(2,1)=0 LNCPI
Convergence achieved after 22 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	1.204870
Probability	0.272350

Vector Error Correction Estimates
Date: 10/19/09 Time: 12:10
Sample (adjusted): 5 50
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(3,1)=0 DLNEXCHA
Convergence achieved after 235 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	11.27639
Probability	0.000785

Vector Error Correction Estimates
Date: 10/19/09 Time: 12:14
Sample (adjusted): 5 50
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(4,1)=0 real GDP
Convergence achieved after 24 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	1.194268
Probability	0.274470

Vector Error Correction Estimates
Date: 10/19/09 Time: 12:16
Sample (adjusted): 5 50
Included observations: 46 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1, A(5,1)=0 Interest rate
Convergence achieved after 10 iterations.
Restrictions identify all cointegrating vectors
LR test for binding restrictions (rank = 1):

Chi-square(1)	1.152792
Probability	0.282965

Table x9: Vector Error Correction Model considering dummy and dummy2 variables

Vector Error Correction Estimates
Date: 11/02/09 Time: 10:34
Sample (adjusted): 6 50
Included observations: 45 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegration Restrictions:
B(1,1)=1

Convergence achieved after 1 iterations.
Restrictions identify all cointegrating vectors
Restrictions are not binding (LR test not available)

Cointegrating Eq:	CointEq1
LNM2(-1)-LNCPI(-1)	1.000000
LNREALGD(-1)	-2.487805
	(0.61502)
	[-4.04507]
DINTERES(-1)	0.055751
	(0.07080)
	[0.78741]
LNEXCHAR(-1)	0.753576
	(0.36594)
	[2.05931]
C	7.628134

Error Correction:	D(LNM2-LNCPI)	D(LNREALGD)	D(DINTERES)	D(LNEXCHAR)
CointEq1	-0.124890	0.001549	-3.464838	0.018999
	(0.07878)	(0.02901)	(0.67200)	(0.01543)
	[-1.58537]	[0.05339]	[-5.15599]	[1.23158]
D(LNM2(-1)-LNCPI(-1))	-0.026988	-0.014964	5.369959	-0.019133
	(0.19818)	(0.07299)	(1.69061)	(0.03881)
	[-0.13618]	[-0.20503]	[3.17634]	[-0.49299]
D(LNM2(-2)-LNCPI(-2))	0.055119	-0.022750	3.606564	-0.034814
	(0.22137)	(0.08152)	(1.88839)	(0.04335)
	[0.24899]	[-0.27905]	[1.90986]	[-0.80309]
D(LNM2(-3)-LNCPI(-3))	-0.352196	0.048428	3.411532	0.030361
	(0.20535)	(0.07562)	(1.75171)	(0.04021)
	[-1.71513]	[0.64039]	[1.94754]	[0.75501]
D(LNM2(-4)-LNCPI(-4))	0.061956	-0.000744	2.168373	0.064097
	(0.20818)	(0.07667)	(1.77586)	(0.04077)
	[0.29761]	[-0.00970]	[1.22103]	[1.57230]
D(LNREALGD(-1))	0.314928	0.162572	-6.388625	-0.015803
	(0.41374)	(0.15237)	(3.52944)	(0.08102)
	[0.76117]	[1.06696]	[-1.81010]	[-0.19504]
D(LNREALGD(-2))	-0.210657	-0.083192	-2.481350	0.039839
	(0.43084)	(0.15867)	(3.67530)	(0.08437)

	[-0.48894]	[-0.52432]	[-0.67514]	[0.47219]
D(LNREALGD(-3))	0.132322	-0.321581	0.236018	-0.009033
	(0.42837)	(0.15776)	(3.65424)	(0.08389)
	[0.30890]	[-2.03846]	[0.06459]	[-0.10769]
D(LNREALGD(-4))	0.058255	-0.159542	-5.250456	-0.173232
	(0.38176)	(0.14059)	(3.25659)	(0.07476)
	[0.15260]	[-1.13480]	[-1.61226]	[-2.31723]
D(DINTERES(-1))	0.001116	-0.007793	-0.969500	0.001554
	(0.01628)	(0.00599)	(0.13885)	(0.00319)
	[0.06858]	[-1.30015]	[-6.98255]	[0.48749]
D(DINTERES(-2))	0.009774	-0.001129	-0.799177	-0.006257
	(0.02080)	(0.00766)	(0.17741)	(0.00407)
	[0.46995]	[-0.14745]	[-4.50462]	[-1.53636]
D(DINTERES(-3))	0.009240	-0.002529	-0.223666	-0.004953
	(0.02241)	(0.00825)	(0.19116)	(0.00439)
	[0.41233]	[-0.30645]	[-1.17008]	[-1.12874]
D(DINTERES(-4))	0.006807	-0.006332	0.065524	5.85E-05
	(0.01703)	(0.00627)	(0.14531)	(0.00334)
	[0.39960]	[-1.00940]	[0.45091]	[0.01754]
D(LNEXCHAR(-1))	1.059416	-0.269045	17.03134	0.855463
	(0.90955)	(0.33496)	(7.75895)	(0.17811)
	[1.16477]	[-0.80321]	[2.19506]	[4.80289]
D(LNEXCHAR(-2))	-1.368514	0.200930	-0.885878	-0.114239
	(1.26478)	(0.46578)	(10.7892)	(0.24768)
	[-1.08201]	[0.43138]	[-0.08211]	[-0.46124]
D(LNEXCHAR(-3))	0.544973	0.098256	-6.945675	0.041781
	(1.25532)	(0.46230)	(10.7085)	(0.24582)
	[0.43413]	[0.21254]	[-0.64861]	[0.16996]
D(LNEXCHAR(-4))	0.593161	-0.324646	27.77492	-0.160123
	(0.94465)	(0.34789)	(8.05839)	(0.18499)
	[0.62791]	[-0.93319]	[3.44671]	[-0.86559]
C	-0.028874	-0.042177	-0.747030	0.007205
	(0.05386)	(0.01983)	(0.45943)	(0.01055)
	[-0.53612]	[-2.12651]	[-1.62599]	[0.68315]
DUMMY	0.003213	0.014066	0.808127	0.000136
	(0.03978)	(0.01465)	(0.33932)	(0.00779)
	[0.08078]	[0.96019]	[2.38162]	[0.01744]

DUMMY2	0.038152	0.054731	-0.625879	-0.000318
	(0.05905)	(0.02174)	(0.50369)	(0.01156)
	[0.64615]	[2.51699]	[-1.24259]	[-0.02747]
R-squared	0.390487	0.589612	0.778004	0.816888
Adj. R-squared	-0.072744	0.277717	0.609287	0.677722
Sum sq. resids	0.081784	0.011092	5.951355	0.003136
S.E. equation	0.057196	0.021064	0.487908	0.011200
F-statistic	0.842965	1.890418	4.611291	5.869906
Log likelihood	78.13044	123.0825	-18.33375	151.5042
Akaike AIC	-2.583575	-4.581446	1.703722	-5.844632
Schwarz SC	-1.780614	-3.778484	2.506684	-5.041671
Mean dependent	0.019318	0.011626	-0.006889	0.012807
S.D. dependent	0.055222	0.024784	0.780565	0.019730
Determinant resid covariance (dof adj.)		3.64E-11		
Determinant resid covariance		3.46E-12		
Log likelihood		338.3312		
Akaike information criterion		-11.30361		
Schwarz criterion		-7.931173		

Appendix 4: Summary for some econometrics concepts and Student's_t-distribution

a) Stability in the VAR

According to Patterson (2000:601-604), "stability is concerned with the following question: the impact of a shock to the innovation in one of the equations of a VAR, does the response to this shock (eventually die out as we get further away in time from the date of the shock? If the answer is yes the model is stable; if not the model is unstable. A stable VAR is stationary". Considering one equation for illustration, Enders (2004:46-47) demonstrates that stationarity is a desirable property of an estimated AR model: $y_t = \mu + \theta_1 y_{t-1} + \theta_2 y_{t-2} + \theta_3 y_{t-3} + \cdots\cdots\cdots + \theta p y_{t-p} + U_t$ (1), for several reasons: One important reason is that a model whose coefficients are non-stationary will exhibit the unfortunate property that *previous values of the error term will have a non-declining effect on the current value of* y_t as time progresses. Setting μ to zero, for a zero mean AR (p) process y_t, equation (1) can be expressed as $\theta(L)y_t = U_t$ (2). The process AR (p) is stationary if it is possible to write from equation (2) the process $y_t = \theta(L)^{-1}U_t$ (3) with $\theta(L)^{-1}$ converging to zero. This means that the autocorrelation among y_t and its previous values will decline as the lag length is increased. When the expansion $\theta(L)^{-1}$ is calculated, it will contain an infinite number of terms, and can be written as an $MA(\infty) = a_1U_{t-1} + a_2U_{t-2} + a_3U_{t-3} + \cdots\cdots\cdots + U_t$ (4). If the process described through equation (1) is stationary, the coefficient in the $MA(\infty)$ representation will decline with lag length, so that $a_1 \succ a_2 \succ a_3 \succ \cdots\cdots$.On the other hand, if the process is non-stationary the coefficient in the $MA(\infty)$ representation would not converge to zero as the lag length increases.

The condition for testing for stationarity of a general AR (p) model is that *the roots of the characteristics equation* $1 - \theta_1 z - \theta_2 z^2 - \theta_3 z^3 - \cdots\cdots\cdots - \theta_p z^p = 0$ (5) *all lay outside the unit circle*. The notion of a characteristic equation is so-called because its roots determine the characteristics of the process y_t.

b) Error correction models, weak exogenous in a multivariate model

In the custom of econometric analysis, the long-run equilibrium among time series (cointegrating vectors) implies that current changes in these series are trying to remove the deviation from the long-run equilibrium among these series if stable. In this way, after identifying the cointegrating vectors under the multivariate analysis, it is possible to formulate an error correction model as was the case for a single equation (see section 5.3.2). In the case of the multivariate estimation, the new error correction model is the so-called Vector Error Correction Model (VECM).

Furthermore, it is worth noting that all the features of the error correction model and weak exogeneity are still applicable in the VECM except that the VECM has a multivariate context (more than one equation). For that reason, we assume that it suffices to give an illustration of the general equation of the VECM, which we estimate using Eviews 6.0 in chapter 6. Useful literature can be found in Enders (2004: 352), Patterson (2000: 608-610) and Brooks (2000: 403).

The VECM has a general form: $\Delta x_t = \Pi x_{t-k} + \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \cdots\cdots + \Gamma_{k-1} \Delta x_{t-(k-1)} + u_t$, where Π is the matrix of the error correction coefficients, x_{t-k} is the long–run relationships (error correction term) and Γ_i represents the matrix of the dynamic adjustments responses of the dependent variables Δx_t to changes in the differenced and lagged Δx_{t-p} determinants of the vector x_t (Enders, 2004: 352) and (Brooks, 2000: 403).

Before concluding on the use of VECM's, it is worth noting that when estimating then we learn about the current responses of variables to the deviations in previous period of the system from the long-run equilibrium (cointegrating vectors). This can sometimes lead to a focus on current responses of the system to innovation (new economic policies for instance, or economic crises or other factors).

c) Student's_t-distribution

One Sided	75%	80%	85%	90%	95%	97.5%	99%	99.5%	99.75%	99.9%	99.95%
Two Sided	**50%**	**60%**	**70%**	**80%**	**90%**	**95%**	**98%**	**99%**	**99.5%**	**99.8%**	**99.9%**
1	1.000	1.376	1.963	3.078	6.314	12.71	31.82	63.66	127.3	318.3	636.6
2	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	14.09	22.33	31.60
3	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	7.453	10.21	12.92
4	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	4.029	4.785	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767
24	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
40	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.551
50	0.679	0.849	1.047	1.299	1.676	2.009	2.403	2.678	2.937	3.261	3.496
60	0.679	0.848	1.045	1.296	1.671	2.000	2.390	2.660	2.915	3.232	3.460
80	0.678	0.846	1.043	1.292	1.664	1.990	2.374	2.639	2.887	3.195	3.416

100	0.677	0.845	1.042	1.290	1.660	1.984	2.364	2.626	2.871	3.174	3.390
120	0.677	0.845	1.041	1.289	1.658	1.980	2.358	2.617	2.860	3.160	3.373
∞	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291

Source: http://en.wikipedia.org/wiki/Student's_t-distribution: Accessed 20.05.2010

Calculation of the critical values of the t-student distribution at different p-values

Degrees of freedom =33	p-value=5.5%	critical value of t-test =-1.642	t-test statistic (calculated) = -1.64084
Degrees of freedom =33	p-value=5.6%	critical value of t-test =-1.632	t-test statistic (calculated) = -1.64084
Degrees of freedom =34	p-value=6%	critical value of t-test =-1.595	t-test statistic (calculated) = -1.56218
Degrees of freedom =34	p-value=6.4%	critical value of t-test =-1.560	t-test statistic (calculated) = -1.56218
Degrees of freedom =34	p-value=6.5%	critical value of t-test =-1.552	t-test statistic (calculated) = -1.56218

Source: http: //www.stattrek.com/Tables/T.aspx. Accessed 10.10.2010

Appendix 5: Data

Year	GDP	M2	EXCHAR	CPI	DINTEREST
1996I	92.88	62.13	305.16	70.90	18.30
1996II	99.10	64.58	307.14	71.10	18.23
1996III	105.98	66.60	306.94	74.40	18.06
1996IV	113.70	68.87	307.42	76.33	18.44
1997I	130.81	74.14	305.35	77.63	16.55
1997II	138.27	84.29	301.67	78.40	16.13
1997III	144.51	81.11	299.65	81.43	17.31
1997IV	149.70	88.60	304.13	88.10	16.22
1998I	153.06	85.45	307.25	88.77	16.04
1998II	156.19	82.66	309.30	89.27	15.87
1998III	158.31	84.18	315.44	86.20	14.88
1998IV	159.65	91.99	325.17	84.47	17.13
1999I	154.97	102.79	332.73	84.90	15.88
1999II	156.51	103.04	335.24	83.93	16.10
1999III	158.99	107.38	334.18	85.00	16.32
1999IV	162.69	102.51	342.67	86.00	16.84
2000I	171.73	103.80	362.87	86.23	15.59
2000II	175.85	109.72	379.39	86.93	16.85
2000III	179.17	107.36	405.45	88.57	16.43
2000IV	181.97	119.39	425.22	91.47	16.99
2001I	182.04	122.17	433.65	92.03	16.93
2001II	184.28	127.75	439.91	91.13	15.83
2001III	186.47	125.32	444.86	90.90	18.21
2001IV	188.92	130.69	456.52	91.07	17.29
2002I	186.32	129.70	460.78	91.20	16.46
2002II	190.99	135.60	466.90	91.80	16.51

Year	GDP	M2	EXCHAR	CPI	DINTEREST
2002III	197.57	135.30	482.01	93.53	16.24
2002IV	206.41	144.31	502.01	95.80	15.64
2003I	222.07	143.25	513.80	96.87	15.93
2003II	233.14	145.89	531.69	98.87	16.25
2003III	244.19	158.31	550.98	100.83	15.49
2003IV	255.56	167.53	570.24	103.43	16.30
2004I	266.99	162.41	582.43	107.24	15.90
2004II	278.61	161.28	579.73	109.82	15.94
2004III	290.11	167.25	576.23	113.56	15.90
2004IV	301.95	187.23	568.84	117.18	16.21
2005I	311.30	190.84	562.92	120.06	16.31
2005II	324.30	202.11	556.99	122.70	15.36
2005III	338.07	200.90	554.44	123.39	15.54
2005IV	353.15	218.37	553.73	122.49	15.90
2006I	371.60	220.07	553.86	128.01	15.45
2006II	387.73	237.64	552.04	132.81	15.58
2006III	403.56	254.15	551.29	134.84	16.23
2006IV	419.72	285.65	550.01	136.24	16.20
2007I	455.62	277.12	547.87	143.08	15.99
2007II	463.69	306.41	546.37	144.33	15.90
2007III	463.53	331.43	547.89	145.81	16.06
2007IV	455.71	370.07	545.12	146.86	15.95
2008I	462.24	363.58	543.89	152.77	16.06
2008II	463.52	371.37	543.35	163.02	16.24
2008III	464.42	398.98	547.14	174.58	

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22 JULY 2009

MR. A NSABIMANA (207508046)
ECONOMICS & FINANCE

Dear Mr. Nsabimana

ETHICAL CLEARANCE APPROVAL NUMBER: HSS/0224/09M

I wish to confirm that ethical clearance has been granted for the following project:

"Effectiveness of monetary policy and money demand stability in Rwanda: A cointegration analysis"

PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years

Yours faithfully

....

MS. PHUMELELE XIMBA
ADMINISTRATOR
HUMANITIES & SOCIAL SCIENCES ETHICS COMMITTEE

cc. Supervisor (Dr. R Simson)
cc. Mrs. G Ponsford

DECLARATION

I ....NSABIMANA Adelit..................................declare that

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