





# **Economic Liberalization, Monetary Policy and Money Demand in Rwanda: 1980–2005**

By

Musoni J. Rutayisire  
*National Bank of Rwanda*

AERC Research Paper 193  
African Economic Research Consortium, Nairobi  
January 2010



**THIS RESEARCH STUDY** was supported by a grant from the African Economic Research Consortium. The findings, opinions and recommendations are those of the author, however, and do not necessarily reflect the views of the Consortium, its individual members or the AERC Secretariat.

Published by: The African Economic Research Consortium  
P.O. Box 62882 - City Square  
Nairobi 00200, Kenya

Printed by: Modern Lithographic (K) Ltd  
P.O. Box 52810 - City Square  
Nairobi 00200, Kenya

ISBN 9966-778-50-0

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## Abstract

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The objective of this study was to estimate a long and short run money demand function in the Rwandan economy. Using the Johansen approach, this paper established that there was a stable long-run equilibrium relationship between the demand for real money balances, real income, the rate of return on foreign financial assets (Libor-London inter-bank offered rate) and the expected depreciation of the Rwandan franc (RWF). The short-run dynamic model confirmed the stability of this relationship. These results suggest that the monetary aggregate used in this study, M2, is the appropriate monetary target in the Rwandan economy for monetary policy purposes and economic stabilization.

The significance of the return on foreign financial assets and of the expected depreciation of the domestic currency demonstrated the importance of the external determinants of money demand in Rwanda and confirmed the hypothesis of currency substitution in the Rwandan economy.

Attempts to include various interest rates in the money demand function revealed that these rates were not significant. This was not surprising because interest rates were controlled for most of the sample period. Moreover, the excess liquidity in the banking system in recent years made the interest rate ineffective as an instrument of monetary policy.

Finally, another significant finding of this research is the speed of adjustment of the demand for money, following deviation from its long-run equilibrium. As the short-run dynamic model showed, this adjustment period amounts to about three years, which is an indication of the persistence of monetary disequilibrium in the Rwandan economy.

*JEL classification: E41, E52.*

*Key words: Economic liberalization, monetary policy, money demand*

## Acknowledgements

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I would like to express my sincere gratitude to the African Economic Research Consortium (AERC) for the technical and financial support that enabled me to undertake and complete this research. I would also like to thank the resource persons and my colleague researchers for their valuable comments on previous versions of this paper during various biannual workshops organized by the AERC. I am also grateful to anonymous commentators. The views expressed in this study are entirely mine and do not necessarily represent those of the National Bank of Rwanda.

# 1. Introduction

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A good understanding of the determinants of the demand for real money balances in the economy by investigating the behaviour of the money demand function is crucial for the formulation and implementation of an effective monetary policy. Moreover, the identification of a stable relationship between the demand for money and its determining variables provides empirical evidence that the monetary targeting is an appropriate framework for economic stabilization policy.

I have noticed that in the past – and even today – the monetary authorities responsible for designing and implementing the monetary policy in Rwanda have never referred to the findings of such a function. And yet the National Bank of Rwanda-NBR (i.e., the Central Bank) has always applied a monetary targeting regime in the sense that in order to achieve the ultimate objective of macroeconomic policy, that is, the stability of domestic currency and prices, income and balance of payments, the Bank has relied on the control of an intermediate monetary target, namely the broad money aggregate, M2.

During the period 1980–1989, the control of the money supply was ensured by a direct control of credit and interest rates, while from 1990 to 2005, a period marked by the implementation of economic stabilization programmes with the support of the Bretton Woods Institutions, the regulation of the quantity of money in the economy was progressively achieved by means of indirect control instruments such as , the required reserve ratio , the National Bank’s re-financing rate and the open market operations.

In these programmes, the monetary policy is an essential element of the financial programming because monetary aggregates and credit play a key role in the determination of income, inflation and balance of payments .To be effective, however, the monetary policy implicitly assumes the existence of a stable relationship between money and macroeconomic variables through the money demand function.

The period covered by this study was marked by important economic reforms in Rwanda, among which was the liberalization of the financial sector carried out since the early 1990s. Since such reforms could be a potential source of money demand instability, one of the objectives of this research was to check whether these reforms had significantly affected the stability of the money demand function in Rwanda.

In this research, I used the cointegration econometric technique developed by Johansen (1988) and Johansen and Juselius (1990) to establish a stable long-run relationship between money demand and its determining variables; a vector error-correction model (Engle and Granger, 1987) was also estimated to analyse the short-run dynamics of money demand in Rwanda.

To the best of my knowledge, three studies using the same technical approach were recently carried out on money demand in Rwanda: Kigabo (2001), Nachega (2000) and

Hauner and Di Bella (2005). Kigabo's study, which covered the period 1975–1998, used annual data of three variables – income (GDP), prices and the official exchange rate – to estimate the demand for nominal balances with the aggregates M1 and M2. The results showed that interest rate and exchange rate were not significant variables in determining money demand in Rwanda. The coefficient for the income elasticity was less than one, while the values for the adjustment coefficient in the short-run models were -0.24 and -0.17 for the monetary aggregates M1 and M2, respectively.

Nachege's study covered the period 1980–1998 and used quarterly data. The author established a cointegrating relationship between nominal money balances of the aggregate M2, income, the variation of the official exchange rate of the Rwandan franc - RWF (proxy for the expected currency depreciation) and the deposit interest rate. Income and deposit interest rate were found to have a positive impact on money demand, while the effect of currency depreciation was negative. Finally, the study showed that the income elasticity was not significantly different from one.

In the research by Hauner and Di Bella that covered the period 1980–2003, the authors were concerned about the usefulness of econometric modelling in low-income countries in which the availability and the quality of data are questionable, and where governments exert a large control on the economy. For the case of Rwanda, the authors first examined the behaviour of the monetary multiplier and then, using cointegration technique, established a long-run relationship between the monetary aggregate M1, income and the exchange rate; a short-run model was also estimated. The results showed that in the money demand function, income had a positive impact on the demand for real money balances, while the variations of the RWF exchange rate had a negative effect. This research showed in particular that in spite of political instability and economic reforms that occurred in Rwanda during the sample period, the results obtained were consistent with the economic theory and contained useful information for monetary policy decision makers.

The objective of the present research is to empirically estimate a long and short run demand for money function in Rwanda and test its stability over the period 1980–2005. In comparison with Kigabo's and Nachege's studies, this study covers a longer period and thus uses more information; moreover, it uses real money balances while the other studies used nominal values. As for Hauner and Di Bella's study, it was concerned with the monetary aggregate M1, while my research is concerned with the monetary aggregate M2, which is used by the National Bank of Rwanda as an intermediate target in the conduct of monetary policy. Finally, compared with all the other studies on money demand in Rwanda, this research is the first one to have incorporated into the function a new variable that turned out to be significant – the rate of return on foreign financial assets. Furthermore, the present study established and tested the stability of the short-run model.

This study is structured as follows: Section 2 describes the institutional framework and the macroeconomic developments that occurred over the period 1980–2005 and Section 3 explores the theoretical considerations of this research. The methodology used in the study is presented in Section 4, while Section 5 discusses the results of the empirical estimations. Section 6 summarises the major findings of the research and their policy implications.



## 2. Institutional environment and macroeconomic developments

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### Institutional environment

Rwanda's transition from a strongly managed economy (1980–1989) to a free market determined economy (1990–2005) characterized the period chosen for this study. Until the end of the 1980s, not only did the Rwandan government manage an important economic portfolio, it also fixed the prices for goods and services and the monetary and financial market was strongly regulated. At the monetary and financial level, a complex mechanism of quantitative and qualitative control governed the distribution of credit. The NBR determined the total volume of credit, as well as how it would be shared out by bank and by sector, while other types of funding sources were subject to a prior agreement.

Interest rates were fixed by the NBR; they remained unchanged for quite a long time. From the country's independence in 1962 to the end of the 1980s, the level of interest rates was only reviewed three times: in 1967, 1979 and 1987. Afterwards they remained fixed for certain sectors while for others they were negotiable between each bank and its customers.

With regard to exchange rates, the system in force in the 1980s was also of a controlled economy type, characterized by the NBR's control over all foreign exchange operations. Any import operation was subject to a licence that allowed the importer to obtain foreign currency. Similarly, all exports were subject to a prior declaration by exporters that implied for the exporters the obligation to repatriate their foreign currency proceeds and surrender them to the NBR. The same controls were exerted on capital movements for which the NBR had to ensure that they did not violate the provisions of the foreign exchange regulations. The value of the RWF was fixed by the President of the Republic and a law promulgated in February 1981 instituted a fixed exchange rate regime.

The period 1990–2005 was first marked by a war that lasted four years (1990–1994), then by the genocide and the collapse of the Rwandan economy. But it was also a period characterized by important economic reforms that enabled the country to make a progressive transition from a regulated to a free market economy. Those reforms were carried out within a framework of successive economic stabilization programmes – the Structural Adjustment Programme -SAP (1990) and the ESAF-PRGF (1998) – that the country implemented with the support of the international community.

The Government of Rwanda opted to turn the Rwandan economy into a liberalized management. This economic liberalization was materialized through various measures. Price controls were abolished in 1991 and the privatization process of state-owned firms started in 1996; most of these firms had been sold by the end of 2005. In connection

with the monetary and exchange rate policy, measures of direct control were progressively replaced by mechanisms that relied more on market forces to regulate the economy.

Regarding the monetary area, the direct control of credit was removed in 1992 and the interest rates were fully liberalized in 1996. The NBR adopted indirect control instruments to conduct monetary policy such as, the required reserve ratio, the re-financing rate and the open market operations; further more, the NBR's policy rate was introduced in 2005.

The reform of the exchange rate system began with the launch of the SAP in 1990. Residents were authorized to hold accounts in foreign currencies in commercial banks since 1990, while in 1995, the flexible exchange rate system was introduced and new exchange control regulations were put in place. The main features of these new regulations were: liberalization of current account operations, determination of the exchange rate by the market, introduction of foreign exchange bureaux, authorization of foreign direct investment in Rwanda and the transfer abroad of the return on this investment.

Other measures were taken later to supplement these exchange control regulations: right granted to exporters to own and use their foreign currency export proceeds and authorization given to residents to withdraw money from their foreign currency accounts without providing any justification. For certain operations, however, prior approval from the BNR was maintained ; this concerned invisible operations (medical care, tourist trips, etc.) for which the purchase of foreign currency was subject to ceilings and capital transfers abroad that were not related to current operations.

## Macroeconomic developments

Unfavourable external shocks were a major influence on the macroeconomic developments of the period selected for this study, notably the increase in the price of petroleum products (the oil crisis of 1979) and the fall in the prices of Rwanda's main export products. At the end of the 1980s, the current balance strongly deteriorated following a fall in world prices for coffee and tea and a fall in net transfers to Rwanda. This imbalance remained until 1993, especially because of the increase in imports in order to meet reconstruction needs. During the 1994–1996 period, the current balance saw large surpluses that came from considerable inflows of humanitarian aid, while from 1997–2002 it deteriorated again despite a strengthening of transfer inflows. The period from 2003 to 2005 saw a surge in foreign aid to Rwanda, but the current balance remained in deficit because of the increase in imports of intermediate goods and equipment meant to support economic growth, on the one hand, and, on the other hand, of consumer goods to fill the deficit in food products.

At the domestic level, production was particularly affected by natural factors such as recurrent droughts in certain parts of the country and the disruption of seasons by the El Nino phenomenon in the 1990s. These factors particularly affected the output of agriculture, whose contribution to the gross domestic product fluctuates around 40%. The war during the first half of the 1990s caused the destruction of infrastructure and the displacement of populations, and thereby considerably disrupted the whole production system.

The average rate of real GDP growth in the 1980s was around 3%, a rate that was insufficient to ensure an increase in the per capita income of a population whose average annual growth rate was 3.5%. In the 1990s, remarkable performance was achieved in

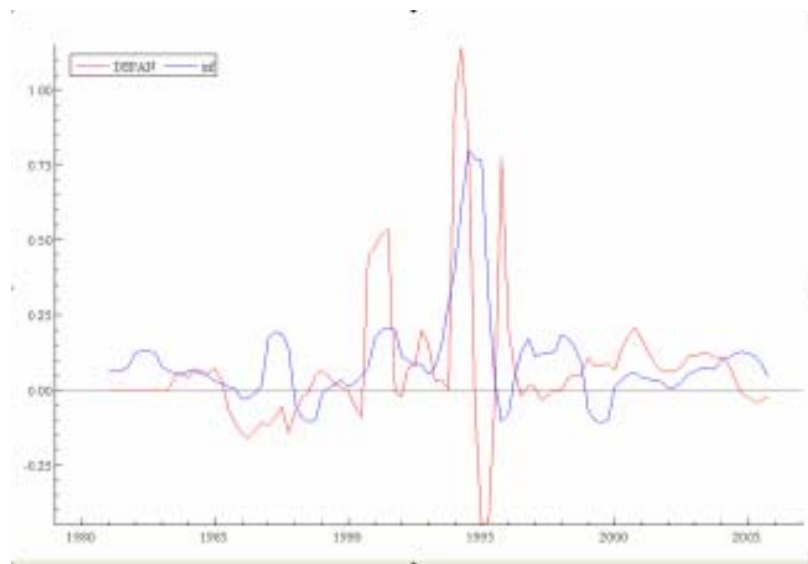
spite of a very unfavourable context. If one excludes the year 1994 during which the real GDP tumbled by about 50%, the average growth rate of the real GDP was 7% during the period; the growth rate has remained at an average of more than 5% since 2000.

At the monetary level, the evolution of the monetary aggregate, M2, saw a growth rate of an average of 7.9% in the 1980s, 15.3% in the 1990s and 23% in the 2000s. A notable fact in the period studied has been the improvement of the level of monetization of the Rwandan economy. This level, measured by the ratio M2/GDP, rose from 13.1% to 18.8% between 1980 and 2005. This progress is a result of the growth of income, the strengthening of the financial system by the creation of new financial institutions (banks and microfinance institutions) and the improvement of financial conditions (positive real interest rates), which contributed to attracting a bigger portion of the national savings into circulation.

Thanks to the direct control of credit and prices, inflation was kept at a low level during the 1980s, an average rate of 4.7%. In the context of the 1990–1994 war, inflation was bound to increase and it indeed reached 64% in 1994. During the 1996–2000 period, the progressive restoration of institutions and security in the entire country, the control of public expenditure and monetary policy allowed the country to contain inflation at an average level of 5.4%. During the 2001–2005 period, inflation was kept at an average rate of 6.7%.

The evolution of the exchange rate shown in Figure 1 indicates a certain stability as a result of the fixed exchange rate regime and a big amount of relatively stable foreign resources in the 1980s. But the figure also suggests an over-valuation of the RWF in 1980–1983 and 1985–1987 in the sense that the price fluctuations during the two periods were not entirely reflected in the fluctuations of the nominal exchange rate.

**Figure 1: Fluctuations in inflation and the exchange rate**



The behaviour of the RWF exchange rate in the 1990s was more volatile. With the exchange rate control becoming less rigorous, the evolution of the rate was determined by market forces. Moreover, the huge macroeconomic imbalances that appeared at the end of the 1980s (the deterioration of foreign accounts, an increase in the budget deficit and the reduction in exchange reserves) – and which worsened during the war years – put such a pressure on the national currency that the monetary authorities had to adjust the RWF exchange rate through successive devaluations of the currency by 40% in 1990 and 15% in 1992. The RWF was over-valued again between 1992 and 1994, but after the liberalization of the exchange rate system and the change of currency marks in 1995, the RWF experienced a de facto depreciation of 45.6%. The fluctuations recorded in subsequent years were a reflection of an evolution characterized by the interplay of market forces and the BNR's interventions to stabilize the RWF.

### 3. Theoretical framework of the study

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The theoretical foundations of the demand function are well established in the economic literature and it is generally accepted that the demand for money is a demand for real cash in hand. Economic agents hold money for at least three reasons mentioned by Keynes: for the purposes of transactions, precaution and speculation. Subsequent studies stressed either transaction purposes (Baumol, 1952; Tobin, 1956) or portfolio ones (Friedman, 1956; Tobin, 1958).

#### Money demand specification

Consensus has since emerged around a long-term specification positing that the demand for money is a function of a measure of real transactions – a measure called scale variable – and of a variable that represents the cost of the opportunity to hold money.

This specification, which has been adopted in empirical research, is expressed as follows:

$$M^d / P = f(Y, R) \quad (1)$$

where  $M^d$  represents the quantity of the desired nominal cash in hand in the long term,  $Y$  the scale variable,  $R$  the vector of variables representing the cost of the opportunity to hold money, and  $P$  the consumer price index. The function  $f$  increases in comparison with  $Y$  and decreases in comparison with  $R$ . The formulation in terms of desired real cash in hand in Equation 1 implicitly assumes the homogeneity of the nominal cash in hand in relation to prices. This excludes monetary illusion, but this assumption can be empirically tested.

#### Choice of variables

The problems that are usually encountered in constructing the money demand function have to do specifically with the choice of variables to use in the function. The question thus arises as to whether they are endogenous variables or explanatory ones.

With regard to the endogenous variable representing the stock of money, several aggregates have been used in empirical research. Some researchers adopted the monetary aggregate M1 (composed of the paper money in the hands of the public and the deposits

in current accounts in banks), others used the aggregate M2 (which, in its definition, includes M1 plus fixed deposits), and still others preferred to use a larger aggregate, M3, which includes deposit certificates and other securities that indicate national savings (Laidler, 1993). Some authors have suggested that the appropriate aggregate would be the one over which monetary authorities have most control and which would have predictable effects on macroeconomic variables (Sriram, 1999). However, experience has shown that smaller aggregates, as easy to control as they may be, were less useful for running a monetary policy because their relationship with the nominal income was very volatile. On the other hand, larger aggregates seemed to be more stable relative to the nominal income but were less controllable (Ericsson and Sharma, 1996). Recent research argued that a monetary aggregate in the wider sense was more appropriate for capturing the financial innovations that took place in the financial sector and their impact on monetary policy (Hafer and Jansen, 1991). For these last reasons, I have chosen to use the enlarged aggregate, M2, in this study. This choice was further motivated by the fact that it is this very aggregate that has always been an intermediate target for the BNR for running its monetary policy.

With regard to exogenous variables, the issue is to determine the scale variable and the variable that represents the cost of the opportunity to hold money. According to some authors, the scale variable has been represented by current income, permanent income, wealth, industrial production or consumption expenses (Sriram, 1999). Most of the research on developing countries has adopted the current income, which is represented by GDP. This choice was justified by the availability of data and the overarching idea of transaction purposes for these countries' economies (Adenkule, 1968; Laumas and Laumas, 1976). In this study I opted to use the current income as measured by the GDP as the scale variable.

Regarding the cost of the opportunity to hold money, a distinction was made between the return rates of the elements included in the aggregate M2 (intrinsic money return) and the return rates of the financial assets used as an alternative to money. The rate of the intrinsic money return is an important variable if one wants to take into account financial innovations in the economy (Ericsson, 1998). The choice of the return of financial assets taken as an alternative to money depends on researchers' views. Those who put forward transaction purposes as the justification will use the short-term interest rate, while those who put emphasis on the portfolio justification will prefer using the long-term interest rate (Sriram, 1999). Certain studies also brought to light the fact that real assets could be close substitutes for money and gave a predominant role to the inflation anticipated in the demand for money (Friedman, 1956, 1969). For developing countries, the studies by Adenkule (1968), Crockett and Evans (1980), among others, showed that the interest rate was not a significant variable in the money demand function for the following reasons: one, financial markets were little developed or nonexistent; two, interest rates were not determined by the free game of market forces. On the other hand, other studies confirmed the importance of the rate of the anticipated inflation in the demand for money (Aghevli and Khan, 1978; Aghevli et al., 1979; Khan, 1980). These results reinforced the opinion that in the face of the scarcity of financial assets, people could only invest their savings in physical assets (land, buildings, animal husbandry, etc.), which, in addition to the resources they generated, could also be a substitute for

money for motives of speculation and precaution purposes (Randa, 1999). However, some recent studies have shown that the economic reforms leading to the liberalization of the financial sector in developing countries could result in interest rate as a significant variable in the money demand function (Rother, 1999; Nachega, 2001b). In Rwanda, interest rates remained unchanged for a long time, but they were completely liberalized in 1996. That is why it was interesting to check the extent to which the demand for money was sensitive to this variable: the present study therefore used interest rate as one of the potential explanatory variables of the demand for money.

Furthermore, empirical research also brought to light the fact that after developing countries experienced high inflation rates and important parallel foreign exchange markets, they experienced a phenomenon where economic agents replaced the national currency by the foreign in their portfolio (Adam, 1992; Bahmani-Oskooee and Pourheydari, 1990). This research thus established that currency depreciation leads to a reduction in the demand for cash in hand in local currency in favour of holding foreign currency or foreign financial assets. But it was also revealed that the depreciation of the national currency increases the value of assets held in foreign currency by residents. If the increase is perceived by these residents as an increase in their wealth, their demand for money will increase as a result of this real-cash-in-hand effect (Arango and Nadiri, 1981). Two other types of the cost of the opportunity to hold money thus emerge: the rate of the anticipated depreciation of the local currency vis-à-vis the foreign currency and the return rate of the foreign financial assets. Domovitz and Elbadawi (1987) established that where this phenomenon of substituting the foreign currency for the national currency existed, removing the variable measuring the depreciation of the national currency from the money demand function would bias the results of the estimations of the demand-for-money models by over-rating the influence of the inflation.

In Rwanda, the exchange rate, like interest rates, also remained fixed during the 1980s, but was progressively liberalized in the 1990s. This liberalization was followed by an increase in foreign currency deposits in Rwandan banks as the exchange rate control loosened, which was a sign of monetary substitution. Moreover, the progressive liberalization of the capital account gave Rwandan residents the opportunity to invest their assets abroad.

The question has often been asked as to which, between the official exchange rate and the parallel exchange rate, should be adopted in estimating the money demand function in developing countries. In the literature on the topic, both rates have been used. For example, Randa (1999) and Adam (1999) used the parallel exchange rate in their studies on Tanzania and Uganda, while Jenkins (1999) experimented with both rates – which turned out to be significant in the case of Zambia. In a more recent study covering a sample of 25 developing countries (among which were eight African countries), Bahmani-Oskooee and Tanku (2006) concluded that for some countries it was the parallel exchange rate that was the significant variable in the formulation of the money demand function, while for others it was the official exchange rate. For the present research, with the series of available data on the parallel exchange rate being incomplete, I used the official exchange rate, as did the authors of the studies mentioned above on money demand in Rwanda.<sup>1</sup>



## 4. The methodological approach

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This section first presents the model chosen for the research and the statistical characteristics of the data used. It then explains the reasons behind the use of cointegration techniques and the error correction mechanism for the estimation of the money demand function in Rwanda.

### Demand for money in Rwanda

Rwanda's financial system is still little developed: six commercial banks, a development bank, and savings and credit cooperatives are the key players in the Rwandan financial sector. Only three commercial banks were in operation before 1995. Private enterprises have no other source of funding than bank loans. The financial assets available on the market include interest-bearing fixed term deposits in commercial banks, development bills and Treasury bills. Until 2005, the volume of the last two types of assets was limited and their acquisition was essentially reserved for commercial banks, non-banking financial institutions and some state-owned companies.

It thus appears that except for physical assets and possibly foreign currency, substitutes for money are limited in the Rwandan economy. The lower the Rwandan population's income, moreover, the more limited are the changes in the composition of their portfolio.

In view of these peculiarities of the Rwandan economy, in order to estimate the money demand function in Rwanda, I adopted a specification commonly used in empirical studies on developing countries' economies:

$$LM2R = b_0 + b_1 Lyr + b_2 REF + b_3 Lib + b_4 DEPAN + u_t \quad (2)$$

where

$LM2R$  = the logarithm of the desired long-term real cash in hand for the aggregate M2

$Lyr$  = the logarithm of real income (GDP)

$REF$  = the Central Bank's re-financing rate

$Lib$  = the London interbank offered rate or Libor

$DEPAN$  = the anticipated fluctuation of the RWF exchange rate representing money depreciation

$u_t$  = the random error term, normally distributed, with a mean of zero and constant variance

$b_0, b_1, b_2, b_3,$  and  $b_4$  are the parameters to be estimated



Equation 2 is specified in logarithm except for the re-financing rate, Libor and the exchange rate fluctuation. The parameters of these variables will thus be interpreted as measures of elasticity for income and of (semi) elasticity for the other three variables.

The signs expected from the model's parameters are:

- $b_1 > 0$ , income has a positive impact on the demand for cash in hand.
- $b_2 < 0$ , the sign for this coefficient is negative because the increase in the BNR re-financing rate raises the cost of resources for commercial banks and has a negative effect on the amount of loans and monetary supply in general.
- $b_3 < 0$ , the sign for this coefficient is negative because Libor represents the return rate for foreign financial assets; its increase leads to an increase in the demand for foreign securities at the expense of the local currency.
- $b_4$ , the sign of this coefficient is unspecified because the response of the demand for positive effect of the real cash in hand (Arango and Nadiri, 1981) and the negative effect of substitution (Adam, 1992; Bahmani-Oskooee and Pourheydarin, 1990). The sign of the coefficient will eventually be determined by the predominant effect.

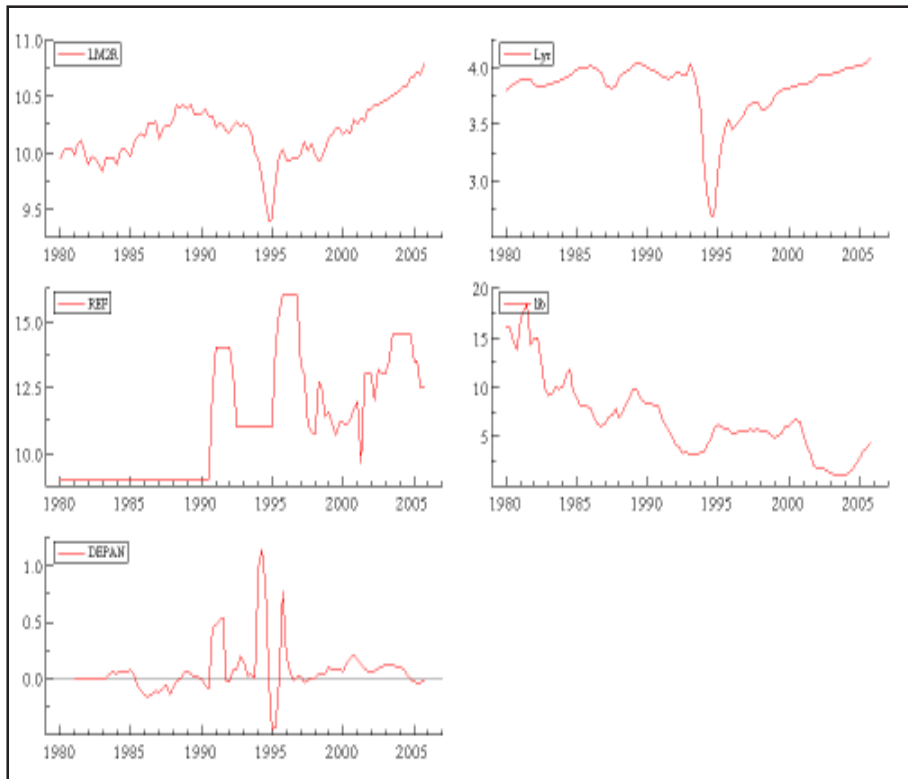
In addition to the determinant variables defined above, two qualitative variables (dummies) were incorporated into the model. The first, *Dummy 1*, plays the role of taking into account the permanent effect of the economic reforms that took place in Rwanda, notably in the financial sector (liberalization of loans and interest rates, institution of flexible exchange rates, etc.) from the 1990s.<sup>2</sup> The variable *Dummy 1* takes the value 0 for the 1980s (I)–1992 (II) and the value 1 for the rest of the period studied. The second qualitative variable, *Dummy 2*, was added to the model in order to capture the effects of the war, particularly in 1994; it takes the value 1 for the period (1994, I, II and III) and the value 0 for the other periods. Seasonal qualitative variables were also incorporated into the model.

## The data used

The series used were quarterly and drawn from various documents published by the NBR (Statistical Reports, Reports on the Economic and Financial Evolution of Rwanda, etc.) and by the International Monetary Fund - IMF (the *International Financial Statistics* and *World Economic Outlook*). The monetary aggregate used is M2, which includes money held by the public, deposits on current accounts, fixed-term deposits and foreign currency deposits in commercial banks. REF is the cost of resources acquired by commercial banks from the NBR or the re-financing rate.

The level of prices,  $P_t$ , the reference year for which is 1990, is represented by the consumer price index. The anticipated fluctuation of the RWF/US\$ exchange rate, *DEPAN*, which represents the RWF depreciation, was calculated from the series on the official exchange rate  $E_t$  and was estimated on an annual basis,  $DEPAN = (E_t - E_{t-4})/E_{t-4}$ . The Libor data were drawn from IMF publications.

**Figure 2: The model's variables: *LM2R*, *Lyr*, *REF*, *Lib* and *DEPAN***



It should be pointed out that since the data on the GDP were only available on an annual basis, the interpolation method proposed by Gandolfo (1981)<sup>3</sup> was used to generate quarterly series. Moreover, the nominal values of the monetary aggregates and the GDP were deflated by the consumer price index in order to find real values.

### Statistical characteristics of the variables

Before estimating the money demand function such as specified in Equation 2, it is advisable to first study the statistical characteristics of this function's variables in order to verify whether they are stationary or not. This verification is crucial because, as Granger (1986) and Hendry (1986) have shown, the results of econometric estimations on non-stationary variables are not statistically valid because the conventional tests, Student's and F, are biased. Such results actually lead to spurious regressions and not to a real correlation between a dependent variable and explanatory variables.

The characteristics of the variables of Equation 2 will be analysed using non-stationarity tests – the augmented version of the Dickey–Fuller (ADF) test (1981) and the Phillips–Perron (PP) test (1988) in order to detect the presence of the unit root in the series and to determine the order of the integration of the variables.

## The cointegration of variables

The cointegration technique makes it possible to test the existence of a relationship of a long-term equilibrium among non-stationary economic variables. Engle and Granger (1987) have shown that even if individual variables are non-stationary, there can be a linear combination among them so that they form a new series, which in the course of time will converge to equilibrium; in that case, they will be cointegrated. The multivariate system cointegration test developed by Johansen (1988) and applied by Johansen and Juselius (1990) was used in the present study. This technique relies on the maximum likelihood method to determine the coefficients, the number and the significance of the cointegration vectors in the series. This approach also makes it possible to test the restrictions suggested by the economic theory on the estimated parameters.

The Johansen and Juselius (1990) method is based on a general vector autoregressive model:

$$X_t = \Pi_1 X_{t-1} + \dots + \Pi_k X_{t-k} + \mu + \psi D_t + \varepsilon_t \quad (t = 1, \dots, T) \quad (3)$$

in which  $X_t$  is a vector ( $n \times 1$ ) of endogenous variables (the variables used in the model),  $\Pi_i$  is the matrix ( $n \times n$ ) of the model's parameters,  $\mu$  is the constant,  $D_t$  is a vector of deterministic variables including seasonal variables,  $\psi$  is the matrix of the parameters associated with these last variables, and  $\varepsilon_t$  is the random error term.

This model is then reformulated as an error correction vector model of the form:

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{k-1} \Delta X_{t-k+1} - \Pi X_{t-k} + \mu + \psi D_t + \varepsilon_t \quad (4)$$

where  $\Gamma_i = -(I - \Pi_1 - \Pi_2 \dots - \Pi_i)$  ( $i = 1, \dots, k-1$ ) and  $\Pi = -(I - \Pi_1 - \dots - \Pi_k)$

So specified, the model contains information relating to the short- and long-term adjustments that occurred as a result of the variations of the variables in  $X_t$ , through the parameters of matrices  $\Gamma$  and  $\Pi$  respectively. The question that arises is that of determining the rank  $r$  of the matrix  $\Pi$ .

A matrix  $\Pi$  of limited rank, that is  $r(0 \leq r \leq n)$ , indicates that there are  $r$  cointegration vectors, which suggests that, where  $\alpha$  and  $\beta$  are matrixes  $n \times r$ . The  $\beta$ 's are interpreted as parameters of  $r$  cointegration vectors while the  $\alpha$  are short-term adjustment coefficients. The number of cointegration vectors and the corresponding parameters are determined by two likelihood-ratio tests, the trace test ( $\lambda_{trace}$ ) and the maximal eigenvalue test ( $\lambda_{max}$ ) statistics.

## The dynamic model

According to Granger's representation theorem (Engle and Granger, 1987), if it is established that variables are cointegrated, it follows that there are forces that tend to restore the equilibrium relationship between variables each time it is broken. This also

means that this return to equilibrium goes through a process of a dynamic short-term adjustment, which can be represented through an error-correction mechanism. The error-correction model is specified with primary difference values of variables,  $DX_t$ , and the error correction term  $ECM_{t-1}$ . From Equation 2, the general error correction model can be formulated as follows (Randa, 1999):

$$A(L)\Delta LM2R_t = \alpha_o + B(L)\Delta Lyr_t + C(L)\Delta REF_t + D(L)\Delta Lib_t + E(L)\Delta DEPAN_t - \gamma ECM_{t-1} + CS_t + \varepsilon_t \quad (5)$$

where  $D$  is the primary difference operator, while  $A(L) \dots E(L)$  are polynomials of the form  $A(L) = \sum \alpha_i L^i$  in which  $L$  is a delay operator such that  $L^i x_t = x_{t-i}$ ,  $ECM_{t-1}$  is the error-correction term and  $S_t$  represents qualitative variables ( dummies) among which are seasonal variables.

In Equation 5, the error correction term,  $ECM_{t-1}$ , is calculated from the long-run Equation 2 as the difference between the actual and the estimated values of LM2R at period  $t-1$ ; the coefficient of the error-correction term,  $\gamma$ , which measures the speed of adjustment of the real money balances to their long-run equilibrium level, must have a negative sign and be significantly different from zero.

## 5. Estimation and interpretation of the results

Application of the ADF and the PP root test to the variables in Equation 2 produced the results summarized in Table 1. The two tests are complementary as the PP test is less restrictive than the ADF test and its results are valid even when the requirements of absence of autocorrelation and heteroscedasticity of errors are not met. The results of the two tests shows that all the variables used, except the *DEPAN* variable, which is stationary, display characteristics of level non-stationarity, but they become stationary in primary difference; it thus follows that they are integrated to the order of 1, I(1).

**Table 1: Unit root tests**

Variables in level	ADF test		PP test	
	With constant	With constant and trend	With constant	With constant and trend
LM2R	-1.104494	-1.618780	-1.216753	-1.705480
Lyr	-1.806273	-1.728648	-2.386103	-2.351717
Lib	-3.430300	-3.922097	-2.333597	-2.441396
REF	-2.255242	-4.009060	-2.215450	-3.187350
DEPAN	-6.546963	-6.699957	-4.588417	-4.595297
Critical value at the 1% significance threshold	-3.4972	-4.0530	-3.4946	-4.0494
<b>In primary difference</b>				
LM2R	-5.207705	-5.332705	-9.471423	-9.489048
Lyr	-4.946644	-4.957583	-5.864348	-5.839418
Lib	-3.933241	-4.234663	-7.901926	-7.986801
REF	-4.731035	-4.702315	-9.369428	-9.327275
DEPAN	-9.942984	-9.894565	-8.853162	-8.786092
Critical value at the 1% significance threshold	-3.4979	-4.0540	-3.4952	-4.0503

### Cointegration tests

This section analyses the cointegration of the model's variables – the monetary supply M2, income, Libor and exchange rate fluctuation. The refinancing rate was not included because it was not significant in all the specifications. I would have liked to include the differential between the interest rate on deposits and the rate on Treasury bills in the model, as Ericsson (1998) and Nachea (2001b) ) did, but in the case of

Rwanda, with Treasury bills having been introduced only in 1998, this differential could not have been calculated for the entire period covered by the study. I also tried to incorporate the inflation rate into the estimations in order to capture the effect of the substitution of real assets for money, but each time I did this variable carried a positive sign or was not significant and I abandoned it.<sup>4</sup> This does not mean that inflation is not important in economic agents' expectations, however, or that it does not have an effect on the real cash in hand held by the public. Inflation is indeed present in the RWF depreciation rate, the developments of which are closely linked to inflationary anticipations. This was confirmed by the strong correlation between the inflation rate and the RWF depreciation. The lack of influence of inflation on the demand for money could also be explained by the fact that the effect of substituting real assets for money was dominated by the effect of substituting foreign currency for the local.

The procedure proposed by Hafer and Jansen (1991) was adopted to determine the number of lags used in the model; the appropriate number was set to five, thanks to the likelihood ratio statistic; the number of lags was confirmed by the Akaike information criterion (AIC) test.

The results obtained from the application of the Johansen (1988) and Johansen and Juselius (1990) procedure are presented in Table 2.

**Table 2: Cointegration analysis: The Johansen procedure**

Period of analysis: 1982.2 – 2005.4

Number of lags: 5

<b>Cointegration vectors</b>				
<b>Rank</b>	<b>Trace test (Prob)</b>	<b>Max test (Prob)</b>	<b>Trace test (T-nm)</b>	<b>Max test (T-nm)</b>
0	110.89 (0.000)**	79.33 (0.000)**	87.54 (0.000)**	62.63 (0.000)**
1	31.55 (0.030)*	19.61 (0.081)	24.91 (0.170)	15.48 (0.268)
2	11.95 (0.161)	11.86 (0.116)	9.43 (0.333)	9.36 (0.263)
3	0.09 (0.765)	0.09 (0.765)	0.07 (0.790)	0.07 (0.790)
<b>Standardized <math>\beta</math> coefficients</b>				
	<b>LM2R</b>	<b>Lyr</b>	<b>Lib</b>	<b>DEPAN</b>
	1.000	-1.5878	0.097804	1.9216
<b>Standardized <math>\alpha</math> coefficients</b>				
	<b>LM2R</b>	<b>Lyr</b>	<b>Lib</b>	<b>DEPAN</b>
	-0.045560	0.077732	-0.41826	-0.18800
<b>Significance test for variables</b>				
	<b>LM2R</b>	<b>Lyr</b>	<b>Lib</b>	<b>DEPAN</b>
Chi <sup>2</sup> (1) =	10.495	22.578	16.363	26.339
p-value	(0.0012)**	(0.0000)**	(0.0001)**	(0.0000)**
<b>Weak exogeneity test for variables</b>				
	<b>LM2R</b>	<b>Lyr</b>	<b>Lib</b>	<b>DEPAN</b>
Chi <sup>2</sup> (1) =	7.6727	25.228	3.7333	17.037
p-value	(0.0056)**	(0.0000)**	(0.0533)	(0.0000)**
<b>Diagnostic tests</b>				
Vector Portmanteau (11)	=	175.032		
Vector AR 1-5 test	=	F (80.183)	=	1.3500 (0,0512)
Vector Normality test	=	Chi <sup>2</sup> (8)	=	91.877 (0.0000)**
Vector hetero test	=	F (400.213)	=	0.59247 (1,0000)

Note: \* Indicates the rejection of the null hypothesis at the 5% significance level, while \*\* indicates the rejection of the null hypothesis at the 1% significance level.

From the results shown in Table 2, it appears that on the basis of the trace test ( $I_{trace}$ ) and maximal eigenvalue test ( $I_{max}$ ) statistics, the hypothesis of no cointegration was rejected. However, while the trace test indicates that there are two cointegrating vectors, the maximal eigenvalue test suggests that there is only one cointegrating vector. Given that the trace test is more powerful than the maximal eigenvalue test (Serletis and King, 1997), I went along with the conclusion of the trace test, which points to two cointegrating vectors. This is also in agreement with Johansen and Juselius's (1990) recommendation for the case when the two tests yield different results.

The presence of two cointegration vectors in our results calls for some clarifications, though. The cointegration test was applied to an autoregressive vector containing the variables  $I(1)$ ,  $LM2R$ ,  $Lyr$  and  $Lib$ , and one variable  $I(0)$ ,  $DEPAN$ . According to Harris (1995), although the same integration order is generally required for all the variables in a cointegration test,  $I(0)$  variables can be associated with  $I(1)$  variables in the Johansen procedure in order to establish a long-term relationship if the economic theory justifies the significance of including the  $I(0)$  variables. The practical consequence of including these in a cointegration test lies in the appearance of an additional cointegration vector corresponding to every stationary variable integrated into the model.<sup>5</sup> In their study, Cheng and Lai (1997) had the choice of using the Johansen procedure with only the  $I(1)$  variables, but in the end they opted to include the  $I(0)$  variable, as it enables one to improve the effectiveness of the estimators. I followed the same approach in this study.

It thus follows that in my results, one of the cointegration vectors is associated with the stationary variable,  $DEPAN$ . In order to know if the second vector identified does indeed correspond to a relationship that can be interpreted as a money demand function, standardization was done on the variable of interest,  $LM2R$ ; the matrix - containing the parameters of cointegration vectors was examined to check if these parameters have the characteristics predicted by the economic theory. On the basis of the signs and values of the - parameters, it transpires that the second cointegration vector can be interpreted as a long-term money demand function for the aggregate  $LM2R$ . All the variables of the cointegration relationship are significant at the 1% threshold.

Various diagnostic tests on the properties of the residuals were applied to examine the validity of the model. The conventional tests of serial correlation, heteroscedasticity and functional form misspecification revealed no particular problem. However, the hypothesis of normality was rejected; but, as was demonstrated by Gonzalo (1994), the results from the Johansen procedure are robust under non-normality of error distribution. The weak exogeneity test was also performed and the results showed that this hypothesis was rejected for the variables  $LM2R$ ,  $Lyr$  and  $DEPAN$ , but was accepted for the variable  $Lib$ . The first three variables are thus endogenous while, as one would expect,  $Lib$  is exogenous. These results suggest that the process of the economy returning to monetary equilibrium is realized through adjustments of money supply, exchange rate and income, which also means that money supply fluctuations not only influence the exchange rate, but also have a real effect on income.

The results of the estimations with the variables used are presented in Equation 6 in which the coefficient of income is interpreted as elasticity while the coefficients of the other two variables ( $Lib$  and  $DEPAN$ ) are semi-elasticities:<sup>6</sup>



$$LM2R_t = 1.5878 Lyr_t - 0.0978 Lib_t - 1.922 DEPAN_t \quad (6)$$

and in (7) where all the coefficients are elasticities:<sup>7</sup>

$$LM2R_t = 1.5878 Lyr_t - 0.665 Lib_t - 0.138 DEPAN_t \quad (7)$$

All the variables have predicted signs by theory: income has a positive effect on the demand for real cash in hand, while the elasticity of this cash in hand in relation to income is higher than 1, with a value of 1.5878. The hypothesis of the unit elasticity of income was rejected, as shown by the result of the restriction test, the  $\chi^2(1) = 8.4600$  [0.0036]. The studies of Aghevli et al., (1979), Tseng and Corker (1991) on Asian countries, and of Simmons (1992) and Arize et al. (1999) on African countries, also found that income elasticity had a coefficient that was higher than 1. Moreover, as in the case of Rwanda, the hypothesis of the unitary income elasticity was rejected in the studies of Aghevli et al., (1979), and Arize et al. (1999). The presence of a coefficient for the income elasticity that is higher than 1 suggests that an increase in income leads to a higher increase in the demand for real money balances and in a reduction of the velocity of money. This result has been attributed to the rapid monetization of developing countries' economies in which the gradual absorption of the non-monetary sector by the monetary sector is accompanied by an increase of cash in hand that is faster than that of income. It was also noticed that this could be due to the lack of alternative assets to money, to preference for liquidity and to the absence of scale economies in developing countries. In the case of Rwanda, the strengthening of monetization is demonstrated by the progress of the M2/GDP ratio, the value of which rose from 13.1% to 18.8% between 1980 and 2005. Moreover, the acquisition of alternative assets to money is still limited; thus the preference for liquidity seems obvious in the Rwandan economy in relation to the importance of the fiduciary money in the money supply (22.1% at the end of 2005). It thus seems reasonable that the income elasticity is higher than 1 in the demand for money in Rwanda.

The variables for openness, which are outside determinants of the demand for money, are the fluctuation of the official nominal exchange rate of the RWF (approximation of the anticipated depreciation of the RWF) and Libor. The coefficients for these two variables carry negative signs as expected.

The coefficients of the semi-elasticity and the elasticity of the exchange rate fluctuation are 1.92 and 0.138, respectively. The behaviour of the exchange rate as revealed by this study means that when the Rwandan franc depreciates, the public anticipates further depreciation and the demand for foreign currency increases at the expense of the demand for the local currency.

Thus, it seems that to avoid losses of their assets in capital, economic agents acquire not only real assets, but also foreign currency. This substitution of the foreign currency for the local currency in people's portfolios is attested by the growing amount of deposits in foreign currencies in banks, the corresponding share of which rose from 3.5% to 20% of the monetary supply (M2) between 1990 and 2005. The increase in foreign currency deposits has been particularly high since 1995 when the measures to liberalize the foreign



exchange market were adopted. Moreover, this increase has happened at the expense of fixed-term deposits in Rwandan francs, which suggests that the holders of these deposits regard foreign currency, even when there is no return on it, as a better value reserve than the other financial assets offered by the banking system. With the long-term elasticity of the exchange rate fluctuation being  $-0.138$ , this would mean that a 10% increase in the exchange rate fluctuation will lead to a 1.38% reduction in cash in hand in Rwandan francs in favour of the acquisition of foreign currency.

The variation of *Lib* also has a negative effect on the demand for real cash in hand in Rwanda, as indicated by the values of the coefficients of the semi-elasticity and elasticity of the Libor, which are  $-0.098$  and  $-0.665$ , respectively. The fact that these coefficients are negative suggests that the demand for money in Rwanda is sensitive to the return rate of the financial foreign assets, as represented by Libor. This would suggest that in the long run Rwandan economic do arbitrage between the local currency and foreign financial assets while making up their portfolio and that, as a result, part of their funds is deposited abroad. On the basis of the value of the long-term elasticity of the *Lib* variable,  $-0.665$ , it follows that a 10% increase in Libor would lead to a 6.65% fall in the demand for local currency in favour of the acquisition of foreign securities. To this effect, it would thus be conjectured that such flows of capital going out of the country in a lawful or fraudulent way could be the act of individuals who are anxious to protect their savings by depositing them in hard currency abroad. But it is also possible that foreign firms operating in Rwanda carry out such transactions by transferring part of their funds to foreign banks. This study is the first to establish empirically the significance of the return rate of foreign financial assets in the demand for money in Rwanda, as the other studies already mentioned used only the exchange rate to capture the influence of external determinants. For other African countries, Nachegea (2001b) has also shown that the demand for money in Uganda was sensitive to changes of Libor, while Owoye and Onafowora (2007) have established that the demand for money in Nigeria was significantly influenced by the interest rate on the United States' Treasury bills.

Finally, the negative signs for the coefficients of the openness variables, the exchange rate and Libor in the demand for money in Rwanda could also be a reflection of the intense activity of the parallel exchange market where important transactions are carried out. The parallel market meets the demand for foreign currency that is not satisfied by the banking system for lawful operations and supplies the Rwandan economic operators with the foreign currency they need to cover their transactions on the neighbouring countries' markets or those of elsewhere (e.g., Dubai). But it is also possible that people acquire foreign currency on the parallel market in order to engage in illicit import or capital flight operations.

## The dynamic model

The short-term model in Equation 8 provides information relating to the adjustments that occur between the different variables to restore the long-term equilibrium in response to the short-term disturbances of the demand for money. It is a vector error correction model, the elements of which are primary difference values of the long-term model's variables and the error correction term ( $EMC_{t-1}$ ) whose role is to ensure that the

short-term deviations in relation to the long-term relationship are corrected; it was constructed on the basis of the long-term model in Equation 6.

In the first instance, I estimated a general dynamic model consisting of the same number of delays as the long-term model. As the values of the variables are stationary, the model was estimated using the ordinary least squares method. From the results of the general dynamic model, I constructed a parsimonious model in which the non-significant elements of the general dynamic model were eliminated using the value of Student's t-statistic. This process of moving from the general to the specific brings about a simplification of the model that makes estimations more reliable and increases the power of the tests. It is this parsimonious version of the model, represented by Equation 8, that I opted for. Its results are analysed below:

$$\begin{aligned} \Delta LM2R = & 0.404 - 0.259\Delta LM2R_{t-1} + 0.538\Delta Lyr_t + 0.419\Delta Lyrt_{-1} \\ & + 0.014\Delta REFt_{-2} + 0.016\Delta Lib_{t-5} + 0.088DEPAN_{t-1} \\ & - 0.082ECM_{t-1} + 0.024Dummy2 \\ & - 0.045Cseasonal \end{aligned} \quad (8)$$

The quality of the model seems to be satisfactory, as indicated by the results of the different diagnostic tests presented in Table 3. The coefficients of all the variables of the model were individually significant and the F test clearly rejected the hypothesis that these coefficients jointly had a value equal to zero.

The coefficient of multiple determination ( $R^2$ ) had a value of 0.72, which is reasonable with first difference estimations (Randa, 1999). Finally, none of the other diagnostic tests presented any particular problem concerning the properties of residues, either. The hypothesis of normality, absence of autocorrelation and heteroskedasticity were accepted, while the hypothesis of functional form misspecification was rejected.

In this model, the coefficient for income carries a positive sign, which conforms to the economic theory; that is, even in the short term, the growth of real income affects positively the demand for real money balances. The re-financing rate is significant, but its sign is positive, which is the opposite of the expected sign. This confirms the results of the long-term model in which this interest rate was non-significant and did not carry the expected sign.

The coefficients of the openness variables – the exchange rate and Libor – have positive signs. This means that when they fluctuate in an upward trend this has a positive effect on the short-term demand for money, contrary to the results of the long-term model in which these coefficients had negative signs. Some explanatory comments are in order here: One would have indeed expected negative signs for these coefficients marking the substitution of foreign currency and foreign financial assets for the local currency when this depreciates and when the return on foreign financial assets improves. This type of result, which is at first sight surprising, was obtained by, among others, Henstridge (1999) for Uganda, Fielding (1994) for Kenya and Adam (1999) for Zambia. According to Adam (1999), this could be explained by the fact that in the short term anticipating monetary depreciation causes people to accumulate cash in hand in the local currency, with a view to going to the parallel market to look for foreign currency. And

this is done at the expense of the local assets, the return on which does not compensate for the devaluation effect. One could also think of the effect of real cash in hand pointed out by Arango and Nadiri (1981).

**Table 3: The short-term parsimonious model**

	Coefficient	Std. error	t-value	Part. R <sup>2</sup>	Statistic L <sub>c</sub>
$\hat{i}LM2R_{t-1}$	-0.258697	0.07618	3.40	0.1159	0.0537
Constant	0.404534	0.05188	7.80	0.4086	0.0700
$\hat{i}Lyr_t$	0.538756	0.08688	6.20	0.3041	0.0321
$\hat{i}Lyr_{t-1}$	0.419110	0.09192	4.56	0.1911	0.0156
$\hat{i}REF_{t-2}$	0.0138234	0.005441	2.54	0.0683	0.1045
$\hat{i}Lib_{t-5}$	0.0161761	0.005428	2.98	0.0917	0.1649
$\hat{i}DEPAN_{t-1}$	0.0876541	0.03060	2.86	0.0853	0.0195
$ECM_{t-1}$	-0.0825433	0.01063	-7.76	0.4064	0.0627
dummy2	0.240065	0.04072	5.90	0.2832	0.0088
CSeasonal	-0.0452773	0.01051	-4.31	0.1741	0.4651

Diagnostic tests

R <sup>2</sup>	=	0.723272
F(9.88)	=	25.56 [0.000]**
DW	=	2.18
No. of observations	=	98
No. of parameters	=	10
AR 1-5	: F (5.83)	= 2.2776 [0.0542]
ARCH 1-4	: F (4.80)	= 0.62189 [0.6482]
Normality	: Chi <sup>2</sup> (2)	= 0.23878 [0.8875]
Hetero	: F(16.71)	= 0.47790 [0.9501]
hetero-X	: F(46.41)	= 0.56744 [0.9684]
RESET	: F (1.87)	= 0.64091 [0.4256]

The error correction term,  $ECM_{t-1}$ , was significant, and as required by the stability condition of the dynamic model, its sign was negative. This de facto confirms the existence of a cointegration relationship among the variables of the model. The value -0.082 of the coefficient of the error correction term means that 8.2% of the surplus of cash in hand observed at period  $t-1$  was eliminated at period  $t$ . Since this model was formulated on the basis of quarterly data, that would mean that the surplus, or the imbalance recorded during one quarter, will be corrected at the rate of 8.2% in the following quarter. The surplus of cash in hand will be eliminated by a restrictive monetary policy, by a reconstitution of economic agents' portfolios or by the price increase mechanism. This result indicates that the rate at which the cash in hand adjusts itself to its long-term level in the Rwandan economy following shocks is relatively slow. This is a reflection of the under-development of the financial market and the presence of high transaction costs in the economy. It thus transpires that in the current structure of the Rwandan economy, the equilibrium of the cash in hand is restored after a period of 12 quarters, that is an average period of three years, which is indicative of the persistence of the monetary disequilibrium in the economy. The coefficient of the cash-in-hand adjustment obtained here is comparable to that found

in the studies already mentioned that focused on other African countries. For example, Arize's (1999) study on four African countries (Ghana, Morocco, South Africa and Tunisia) found a coefficient situated between -0.29 and -0.59; Simmons' (1992) research on five other African countries (Congo, Côte d'Ivoire, Morocco, Mauritius and Tunisia) found a coefficient varying between -0.22 and -0.56. Since the two authors used annual data, the coefficients they have reported suggest that the adjustment of real money balances in the countries they studied was achieved in an average period of two to three years in the case of Arize's study, and of two to four years in the case of Simmons' study.

## Stability tests

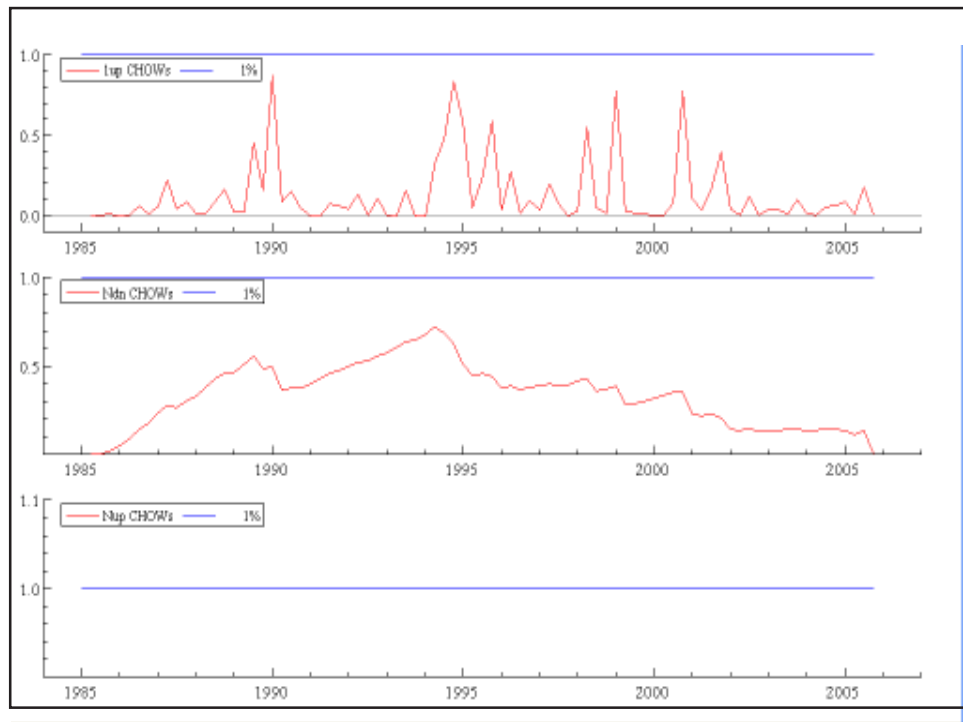
The implementation of a monetary policy aimed at stabilizing prices and income through the control of a monetary aggregate rests in a crucial way on the assumption of stability of the relationship between the demand for money and its determining variables or the constancy of the parameters of the established model. The impact of money supply on real variables is indeed predictable only if the demand for money is stable, thus allowing the monetary authorities to intervene in an efficient way. But if this function is not stable because of various innovations due, for example, to institutional or technological changes, the effect of any intervention may be limited or even lead to unexpected consequences.

Considering the economic reforms carried out in Rwanda from the 1990s, in particular in the liberalization of the financial sector, it was necessary to check whether the structural stability of the money demand function in Rwanda could have been affected by those changes. To assess the stability of the short-run model, recursive estimation of Chow's (1960) structural break test was performed; the results of the estimates are represented by the graphs in Figure 3 and are based on the assumption of the constancy of the model's parameters.

It emerges from these results that no point from the Chow tests exceeds the 1% level of significance, thus indicating that the assumption of the constancy of the short-run model's parameters cannot be rejected for the period covered by this study.

Hansen's test (1992) was also used to test the stability of the short-run model. Unlike Chow's test, Hansen's test does not require prior knowledge of the structural break period. However, this test can only be applied to stationary variables, which is a condition satisfied by the model in Equation 8. Hansen's stability test produces two types of statistic: an individual test that assesses the stability of individual parameter of the model and a test that assesses the stability of the overall model. The null hypothesis of the stability of estimations will be rejected if the values of the individual tests and the overall test are higher than the critical values calculated by Hansen (1992, Table 1, p. 524) for the  $L_c$  statistic. Applying Hansen's test to the dynamic model in Equation 8 revealed that the values of the variance ( $\sigma^2 = 0.0910$ ) and of the individual stability tests of the parameters were all lower than the critical value, with  $L_c = 0.47$  at the 5% significance level, as indicated by the test results in the last column of Table 3. The same applies to the overall test whose value is 1.4960 compared with the critical value,  $L_c = 2.75$ . So, this test, after Chow's test, confirms the stability of the short run money demand model in Rwanda.

**Figure 3: Stability of the short-run model: Chow tests**



## 6. Conclusion

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The aim of this study was to estimate the function of the demand for money in the short and long term in the Rwandan economy during the 1980–2005 period. Using the maximum likelihood method developed by Johansen (1988) and Johansen and Juselius (1990), the study established that there exists a stable function of demand for money in the long term in Rwanda. The dynamic model also established that there exist short-term stable relationships among the demand for money, income, the re-financing rate, Libor and the exchange rate fluctuation.

Several implications for monetary policy follow from the results of the study. The first of these is that the economic reforms carried out in Rwanda to liberalize the economy, particularly the financial sector, have not had a significant impact on the stability of the relationship between the demand for money and its determining variables. It follows from this that monetary targeting is an appropriate system in the Rwandan economy for the running of the monetary policy and economic stabilization.

The study also brought to light the sensitivity of the demand for money to openness variables, namely, the exchange rate and Libor. It has thus confirmed the existence of the phenomenon of substituting foreign currency for local, as well as the sensitivity of the demand for money to the return rate of foreign financial assets. The exchange rate fluctuation and Libor were found to significantly influence the holding of cash in hand by the public, which means that the behaviour of these variables must be taken into consideration while setting up and running monetary policy. In such a context, an intervention policy intended to stabilize the exchange rate and maintain positive real interest rates in order to curb the substitution of the local currency by the foreign would be appropriate.

The short-term model has shown that the rate of adjusting the cash in hand to its long-term level is relatively slow, which is an indication of the persistence of monetary disequilibrium in the economy. This is useful information for monetary authorities, because a permanent liquidity excess in the economy can be a major obstacle to the effectiveness of the monetary policy.

Another important result obtained in this study concerns the non-significant role of interest rates in the demand for money in Rwanda. This suggests that the refinancing rate and BNR's key interest rate have no effect on the composition of people's portfolios. This is not surprising, as interest rates have for a long time been controlled. However, specific studies should be conducted focusing on the period after the liberalization of interest rates and the introduction of the money market in order to verify whether the interest rate still has no effect on the demand for money.

In conclusion, I would like to say that the results of the study should be updated because, now that BNR has decided to review monetary aggregates by integrating other non-banking financial institutions, notably microfinance institutions, into the country's monetary situation, it will be necessary to assess the impact such a change could have on the models estimated here.

## Notes

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1. The usual sources of information on parallel exchange rates were consulted but the series of data for Rwanda was not complete for the period covered by the present study. These sources are the following: the work by Reinhart and Rogoff (2002); Cowitt, P. World Currency Yearbook (various issues). New York: International Currency Analysis Inc. At the National Bank of Rwanda, data on the parallel exchange rate have been recorded since 1997.
2. Hendry and Ericsson (1991) used a similar dummy variable to capture the effect of the introduction of “Competition, regulation of credit and fluctuating exchange rates” in Great Britain’s economy in 1971–1975. And Adam’s (1999) study on the demand for money in Zambia included in the specification of the model used a dummy variable intended to capture the possible effect of the change of system in the demand for money following the liberalization of the economy. Armour et al., (1996) also used a dummy variable of this type to integrate into their model on inflation the introduction and progressive dissemination of financial innovations in the Canadian economy since the 1980s.
3. The method proposed by Gandolfo (1981) uses the following formula to find the data for every quarter; the annual data are represented by the symbol  $y_t$ :

$$\text{1st quarter: } y_t^{(1)} = 0.0546875y_{t-1} + 0.234375y_t - 0.0390625y_{t+1}$$

$$\text{2nd quarter: } y_t^{(2)} = 0.0078125y_{t-1} + 0.265625y_t - 0.0234375y_{t+1}$$

$$\text{3rd quarter: } y_t^{(3)} = -0.0234375y_{t-1} + 0.265625y_t + 0.0078125y_{t+1}$$

$$\text{4th quarter: } y_t^{(4)} = -0.0390625y_{t-1} + 0.234375y_t + 0.0546875y_{t+1}$$

where  $y_t$  is the value for the current period

$y_{t-1}$  is the lagged value for one period

$y_{t+1}$  is the value of one period ahead

Using Monte Carlo simulation technique, Smith (1998) examined the effects of linear interpolation on the results of Johansen’s (1988) approach to cointegration: he concluded that the method did not introduce any bias into estimations of cointegration vectors even with series covering relatively short periods.

4. It can be noted for this effect that in none of the studies mentioned on money demand in Rwanda, inflation was used as a determining variable.
5. It must be stressed, though, that when there are only two variables, the combination of the variables  $I(1)$  and  $I(0)$  will be excluded.
6. All the estimations were done using the econometrics software PcGive 11 developed by Doornik and Hendry (2006).
7. In order to have coefficients representing the elasticities of the variables *Lib* and *DEPAN*, the values of the semi-elasticities were multiplied by the mean of the two variables.



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