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Original Research Article

Monetary and financial innovations and stability of money multiplier in Rwanda

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The objective of this paper was to assess the stability of money multiplier, one of the key pillars of the current monetary policy framework in Rwanda. As most of recent empirical studies on money multiplier, we have used Engle Granger cointegration techniques to test the existence of long run relation between the broad money (m) and reserve money (b) in Rwanda. However, these tests have low power to reject the hypothesis of no cointegration for short sample and / or when a structural break is ignored. In addition, assuming a time invariant structural relationship between the two variables may not be realistic given that important developments have happened in the Rwandan banking sector. In addition to the Engle Granger cointegration test, we have tested the time invariance of the cointegrating vector using Gregory – Hansen cointegration test and Hansen (1992) test. The paper concludes that, the long run relationship between m and b holds over some period of time, and then has shifted to a new long-run relationship after 2010 as a result of changes in monetary policy framework and financial sector development. In terms of policy implications, the result indicates that the money multiplier in Rwanda is stable over long time horizon with reasonable degree of accuracy even when there is shift in money multiplier relation. However, the structural change in the relationship between the two variables may reduce the prediction capacity of the money multiplier model and limit the controllability of money supply using reserve money as operating variable.

Key words: money multiplier, cointegration, structural breaks

INTRODUCTION

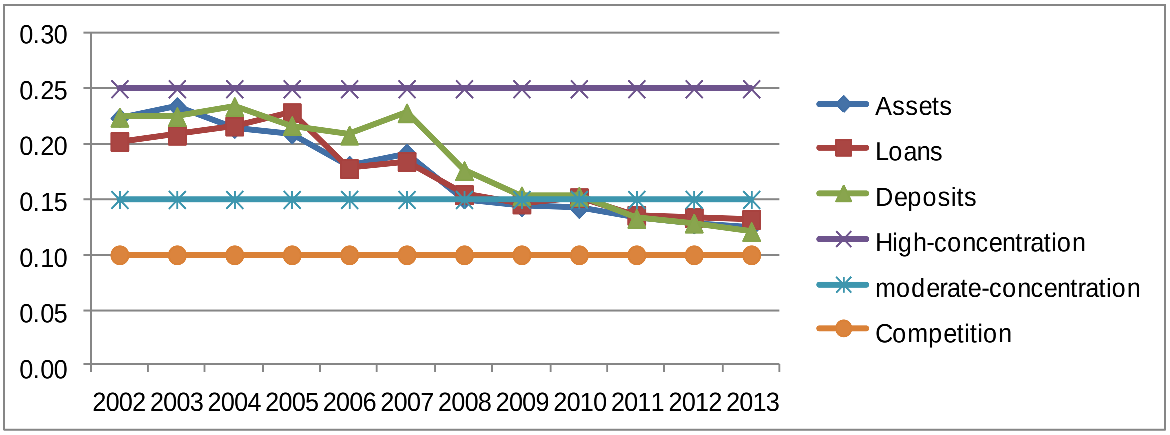
The National Bank of Rwanda (BNR) implements a monetary targeting regime using the broad monetary aggregate (M3) as an intermediate target to achieve the objective of price stability. In this framework, the monetary transmission mechanism sets out from the quantity of monetary base (B) as an operational target and moves towards inflation through the money supply (M3). The framework is based on two important assumptions: the existence of a strong and reliable relationship between M3 and inflation, and the controllability of M3 by BNR, assuming that there is a stable long- run relationship between M3 and B.

The conventional money multiplier model relates in changes monetary aggregates (M3) to reserve money (B) changes by assuming a stable and predictable money multiplier. In this context, the monetary authority could control the overall liquidity situation in the economy so long as the reserve money is kept at a level consistent with desired broad money expansion.

However, the stability of money multiplier is a debatable issue because it depends on the behavior of monetary authority, commercial banks and the public in the process of money creation[1]. With a financial sector becoming more modern, central banks rely more on market-based monetary policy instruments which have significant impact

[1] A money multiplier model for Rwanda is presented in annex1, showing the contribution of different entities in the money creation process.

Figure 1. Development Herfindah Index (HI) of the banking sector in Rwanda



Source: Own calculation based on data from BNR

on day-to-day interest rate movements. This influences the portfolios management of banks and households. In addition, changes in relative rates of return, risk, technology in financial markets, income and preferences of agents affect their portfolio behavior which in turn influences money multiplier (Goodhart, 1989).

For the advocates on money multiplier approach, while in short- run the variations in money multiplier may dominate the variations in money stock due to change in public and banks' behavior, these variations become relatively stable and predictable in long- run (Brunner, 1997).

The objective of this paper is to asses if the money multiplier in Rwanda is stable considering different changes introduced in the monetary policy framework as well as recent development in financial sector.

Indeed, while BNR continues using monetary base or reserve money as operating target, the Bank introduced the use of Key Repo Rate (KRR) in August 2008, initially to support commercial banks to improve their management of short- term liquidity. However, since 2010, the KRR has become a tool of not only better managing liquidity in the banking system; but also as a way of moving short term interest rates in direction considered by BNR as appropriate and signal of the Bank monetary policy stance to the public[2]. In addition, the reserve money program in Rwanda has been progressively adjusted to introduce more flexibility in monetary policy implementation.

Prior to 2010, targets on reserve money were set using end period stocks, which led to high fluctuations in money market rates as monetary policy actions were more concentrated at the assessment programme periods, particularly end of quarters. To overcome these challenges, average reserve money was adopted in 2010 to distribute policy actions over time. Furthermore, in a bid to improve the monetary transmission mechanism, BNR moved to a more flexible monetary targeting regime in October 2012, by introducing a reserve money band of $\pm 2\%$ around a central reserve money target. This has contributed to more flexibility in money market rates, the development of the interbank market and to ensure that BNR interventions on the money market is guided by development in market forces rather than just the need of achieving given targets on reserve money (National Bank of Rwanda, 2014).

The Bank has also significantly improved its communication strategy with the banking sector and the public since 2010 with the objective of improving the monetary transmission mechanism in Rwanda.

In the financial sector, we observe an increase in the banking competition in Rwanda since 2010, due to the upgrading of one microfinance institution to a cooperative bank, three microfinance institutions to microfinance banks and the entry of two regional banks in Rwanda in 2010 and 2011 respectively. In addition, commercial banks have significantly extended their networks out of Kigali to increase their market shares.

This situation has led to an increase in the banking sector competition as indicated by the Herfindahhl- Hirschman Index (HHI) constructed based on total deposits, total loans and total assets of the banking sector from 2002 to 2012. As shown in the Figure 1, development in HHI indicates that the competition in the Rwandan banking sector has been improving over time, from high concentration (between 2002 and 2009) to moderate concentration since 2010.

There are two BNR working papers which have assessed the stability of money multiplier in Rwanda. The paper of Ananias Gichondo at al. (2008) applied cointegration techniques to analyze the stability of money multiplier, using monthly data covering the period from January 1995 to December 2006. The second paper (Rusuhuzwa and

[2] The KRR is reviewed on quarterly basis by the Monetary Policy Committee of the Bank.

Irankunda, 2011) followed Adam Chris and Kessy (2011) methodology proposed for East African Community member countries. It first analyzed principal components of the money multiplier in Rwanda to understand how developments in the economy have influenced the link between the broad money and reserve money in Rwanda; before testing the existence of long- run relationship between M3 and B using cointegration techniques. The paper used monthly data from January 2001 to December 2011. The two papers conclude that there exist long- run relationship between the broad monetary aggregates (M3) and the base money (B) in Rwanda.

The common problem with conventional tests for cointegration is that they have low power to reject the null hypothesis of no cointegration when a structural break is ignored. In addition, they assume a time invariant structural relationship among variables. However, this assumption is very strong, particularly when analyzing the link between the broad money and base money in countries where important changes have been introduced in monetary policy framework and/ or in the financial sector.

This paper re-examines the stability of money multiplier in Rwanda by taking into consideration possible impact of recent changes in monetary policy framework and developments in financial sector. To achieve this objective, we use Engle and Granger (1987) two stage model and Gregory and Hansen (1996) cointegration techniques to take into consideration possible structural breaks. Data will cover the period from January 2000 and June 2014. This is very important because the rejection of the null hypothesis of no cointegration by Engle Granger test may be interpreted as instability of money multiplier while the rejection may only be due to structural breaks. In addition, if the null hypothesis is rejected, this means that there is a time invariant cointegrating vector between the broad money and the reserve money.

The use of Gregory and Hansen (1996) cointegration techniques will help to assess if the cointegrating vector has shifted to new equilibrium in the sample. This has important policy implication: While the existence of long run relationship between M and B indicates that central banks may influence the development of M though the control of the base money, the structural change in the relationship between the two variables may reduce the prediction capacity of the money multiplier model.

This paper also contributes to the East African Community (EAC) central banks' effort to understand the characteristics of their monetary policy frameworks before adopting the common currency in next ten years. The used methodology may be applied to assess the stability of money multiplier in other EAC countries.

The rest of the paper is organized as follows. Section 2 presents a summarized literature review on stability of money multiplier. Section 3 presents the methodology used and the empirical results are presented in section 4, before the conclusion.

Stability of money multiplier: Summarized literature review

Most of the empirical research on the stability and predictability of money multiplier use time series techniques such as time series forecasting techniques and cointegration framework. Recent many researches on this topic have used the cointegration approach where the existence of cointegration between monetary aggregates and reserve money is interpreted as stability of money multiplier (e.g. Christopher Adam, at al, 2011; Cem Saatcioglu, at al, 2006; Vrmani, 2004; Darbha, 2002; Gangadhar Darbha, 2000,),

The money multiplier model can be written as follow:

$$M_t = kB_t \qquad (1)$$

This equation indicates that money stock is in proportion with money base, with k, the proportionality factor called money multiplier. In logarithm form, the money multiplier model can be written as

$$LnM_t = \beta_0 + \beta_1 LnB_t + \varepsilon_t \qquad (2)$$

Where β_0 is the logarithm of k and ε the error term. For the multiplier model to be valid as a stable long run equilibrium relationship, LnM and LnB have to be cointegrated and $\beta_0 = 0; \beta_1 = 1$.

Most of recent studies have used conventional cointegration tests such as Johansen and Juselius (1988) and the Engle-Granger (1987) two-step method to test for cointegration between monetary aggregates and base money. In this framework, if the money multiplier is stable, there must be a long-run relationship between money stock and reserve money and this relation should be time invariant.

Assuming a time invariant structural relationship among variables may be very restrictive, particularly when there are structural changes in used time series. Indeed, a linear combination of non-stationary variables may be stationary, but this linear combination may have shifted at one or more than one points in the sample. Different studies on money multiplier stability have used non stationarity and cointegration techniques which allow structural breaks to be taken into consideration.

Darbha (2002) used the residual based cointegration approach developed by Gregory and Hansen (1996) to test the the existence of long run relationship between M and B in India. He find a stable but time varying cointegrating relationship between the two variables.

Downes at al (2006) examined the stability of money multiplier for six African coutries using non stationarity tests without and with structural breaks. They find that, when structural breaks are ignored, the null of unit root hypothesis is accepted while it is rejected when structural breaks are taken into consideration.

Another important element in the money multiplier model which has been analyzed by a number of researches is the direction of causality between M and B in implementing a reserve money program, to ensure that the growth rate of B is not an endogenous variable in such a way that causality runs from money supply to monetary base. This is the case for example when the monetary base is essentially influenced by currency to deposit ratio and the private sector portfolio decisions (e.g. Rusuhuzwa and Irankunda, 2011; Komaromi, 2007; Haghighat, 2011).

METHODOLOGY

The money multiplier relation to be used in this paper is:

$$m_t = \alpha + \beta b_t \qquad (3)$$

Where m= log(M3) and b= log(B); $\alpha = \log(k)$; t= January 2000 to June 2014.

Before performing cointegration tests, we test the existence of unit root in the two variables used in the model (m and b) using the detailed Augmented Dickey Fuller test (ADF) procedureWe first test unit root based on the general model with trend and intercept

$$\Delta Y_t = \mu + \beta t + \phi Y_{t-1} + \sum_{i=o}^{p} \theta_i \Delta Y_{t-i} + \varepsilon_t \qquad (4)$$

If the null hypothesis $H_o : \phi = 0$ is accepted against the alternative $H_1 : \phi \neq 0$, we test the joint hypothesis $H'_0 : \phi = \theta = 0$ using F- statistics, to check if the trend is present in the series. If H'_0 is rejected we conclude that Y is stationary, otherwise, we test for unit root using the model with intercept only:

$$\Delta Y_t = \mu + \phi Y_{t-1} + \sum_{i=0}^{p} \theta_i \Delta Y_{t-i} + \varepsilon_t \qquad (5)$$

If $H_o : \phi = 0$ is accepted, we test the joint hypothesis $H'_0 : \phi = \mu = 0$ using F statistics to check if the drift is present in the series. We conclude that Y is not stationary if H'_0 is rejected; otherwise we test the unit root using a model without trend and intercept

$$\Delta Y_t = \phi Y_{t-1} + \sum_{i=0}^{p} \theta_i \Delta Y_{t-i} + \varepsilon_t \qquad (6)$$

The procedure is implemented using the RATS procedures called ARAUTO.

If m and b are both integrated with order one, we perform residual based tests for cointegration using first Engle and Granger (1987) two stage model. As the objective of this study is to assess possible impact on the stability of money multiplier in Rwanda of recent changes in monetary policy framework and developments in financial sector, we also perform the Gregory and Hansen (1996) cointegration test.

To perform Gregory and Hansen (1996) cointegration test, we modify the equation (3) as follow:

$$m_t = \mu_0 + \mu_1 \varphi_t + \alpha b_t + \varepsilon_t \qquad (7)$$

$\varphi_{t\tau} = 0$ if $t \le [n\tau]$ and 1 if $t \succ [n\tau]$. $\tau \in T = (0,1)$ is the timing of the change point and $[.]$ denotes integer part. μ_0 and μ_1 represent the intercept before the shift and change in intercept respectively. The model (7) describes a shift in level. Another possibility is to introduce a time trend into the level shift model, which describes level shift with trend.

$$m_t = \mu_0 + \mu_1 \varphi_t + \beta t + \alpha b_t + \varepsilon_t \qquad (8)$$

The last model allows structural changes in both intercept and slop (regime shift model)

$$m_t = \mu_0 + \mu_1 \varphi_t + \alpha_1 b_t + \alpha_2 \varphi_t b_t + \varepsilon_t \qquad (9)$$

In these three models, the null hypothesis is the absence of cointegration against an alternative hypothesis of cointegration with structural break. The residual based cointegration tests of ADF t-statistic (τ) and Phillips-Perron Z(τ) and Zt(τ) are computed using the standard formulae for each of the models and for each value of τ, and the smallest values are selected since they constitute evidence against the null hypothesis of no cointegration.

$$Z^*_{\alpha} = \inf_{\tau \in T} Z_{\alpha}(\tau)$$

$$Z^*_{t} = \inf_{\tau \in T} Z_{t}(\tau)$$

$$ADF^* = \inf ADF(\tau)$$

The asymptotic distribution and the appropriate critical values of these statistics are reported in Gregory and Hansen (1996).

Three possible cases are considered. Either the two tests (Engle Granger, and Gregory Hansen) reject the existence of a long run relationship between m and b; either Engle Granger test does not reject H0 of no cointegration but Gregory Hansen does (in that case there is structural change in the cointegrating vector) or both tests reject Ho. In this case we will apply Hansen (1992) tests to determine whether the cointegrating relationship has been subject to a regime shift.

Hansen (1992) provides three test statistics (supF, meanF and Lc) for parameter stability in cointegrated relationships based on the residuals of a Fully Modified OLS regression. The supF statistictests for the null of cointegration with no regime shifts against the alternative of cointegration with a discrete shift in the parameter vector at an unknown point. The meanF and Lc statistics test for the null of cointegration against the alternative of a random walk type in the parameter vector. In this paper we use LC statistics to assess if the variation in the cointegrating vector defining long-run money multiplier relation is better described by a discrete one-time shift due to changes introduced in monetary and financial sectors in Rwanda.

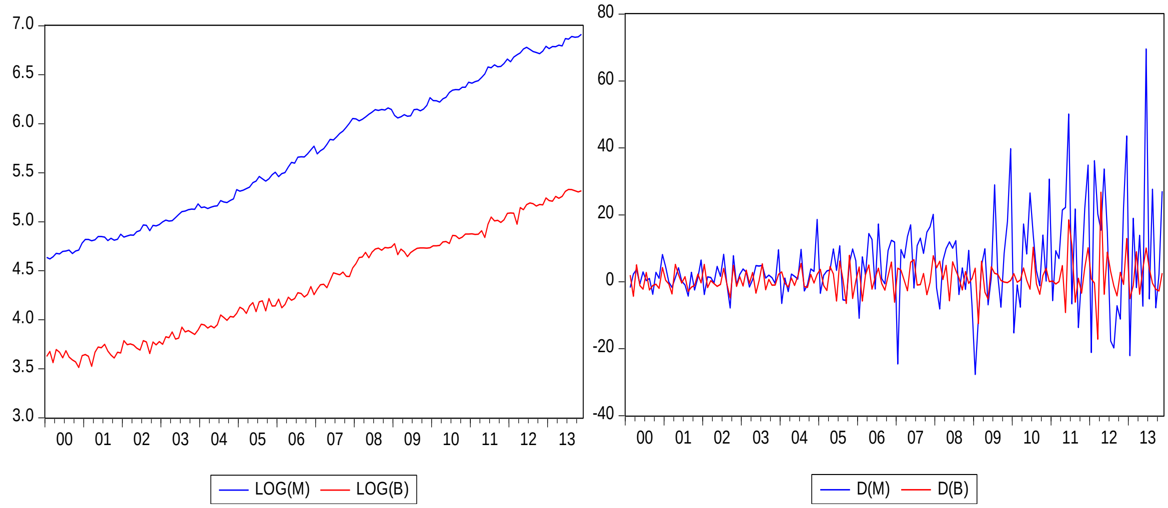


Figure 2: Development in m and b as well as their variations

Empirical results

The variables used in this study are the broad money (M3) and base money (B). All data are from the National Bank of Rwanda.

The Figures 2 above shows that in short term (monthly changes) changes in M3 are not necessary related to changes in base money. In the period under review, the two variables have moved in opposite directions 82 times out of 174 months in the sample. As reported in Tables 1 and 2 below, broad money (m) and reserve money (b) are integrated with order one.

We then test for cointegration between m and b using Engle - Granger test. Results reported in Table 3 indicate that the test fails to reject the null hypothesis of absence of cointegration between the two variables. Based on these results, we can conclude that there exist a long-run and time invariant relation between m and b. However, using the Gregory – Hansen test (Table 4), it appeared that the cointegration relation between m and b holds over some period of time, and then has shifted to a new long-run relationship after 2010 as a result of changes in monetary policy framework and financial sector development as indicated before. The Gregory Hansen test was implemented using the program which available in RATS.

As it can be observed, the two tests (Engle Granger and Gregory Hansen tests) have rejected the null hypothesis of no cointegration (Enger Granger model being a special case of Gregory Hansen model). We use Hansen (1992) to confirm if the cointegration relationship has been subject to a regime shift.

The results reported in Table 5 indicate that Lc tests fail to reject the null of cointegration against the alternative of random walk type in parameters at 5%. This results show that there is a structural change in the cointegrating vector defining long-run money multiplier relation and the shift is better described by a discrete one-time shift resulting from changes introduced in monetary policy framework and in financial sector.

Conclusion and policy recommendation

The stability of money multiplier is important for the effectiveness control of money supply by the monetary authorities. Most empirical studies have examined it by testing the existence of long-run stable relation between monetary aggregates and reserve money using Engle Granger cointegration tests. However, these tests have low power to reject the hypothesis of no cointegration for short sample and / or when a structural break is ignored. In addition, they assume a time invariant structural relationship among variables which may not be realistic in Rwanda given important changes introduced in monetary policy framework and development in the financial sector.

Engle - Granger test indicates that there exist a long-run relationship between m and b, and Gregory – Hansen test shows that the n relation between m and b holds over some period of time, and then has shifted to a new long-run relationship after 2010 as a result of changes in monetary policy framework and financial sector development. To confirm the instability of the cointegrating vector we have used the Lc tests of Hansen (1992), which fail to reject the null of cointegration against the alternative of random walk type variation in parameters at 5%. The study conclude that there is a structural change in the cointegrating vector defining long-run money multiplier relation and the shift is better described by a discrete one-time due to innovations changes introduced in monetary policy framework and in financial sector.

In terms of policy implications, the result indicates that

Table 1. ADF tests (in level) for unit root3

Variables	Model	ADF test statistics for Ho	Critical value	F test statistics for joint hypothesis H'_0	Critical value	Conclusion
m	Model with trend and intercept.	1.49412	-3.41000	9.32493	6.25000	Use the Model with intercept only
	Model with intercept only.	4.036624[4]	1.9			Cannot reject unit root
	Model without trend and intercept.					
b	Model with trend and intercept.	0.21010	-3.41000	10.80359	6.25000	Use the Model with intercept only
	Model with intercept only.	4.65728	1.9			Cannot reject unit root
	Model without trend and intercept.					

Table 2. ADF tests (in first difference) for unit root

Variables	Model	ADF test statistics for Ho	Critical value	F test statistics for joint hypothesis H'_0	Critical value	Conclusion
m	Model with trend and intercept.	-5.43472	-3.41000			Series has no unit root.
b	Model with trend and intercept	-9.08354	-3.41000			Series has no unit root.

Table 3. Engle Granger cointegration test

Cointegration test-Engle Granger		
	Value	**Probability**
Engle-Granger tau statistic	-3.92	0.011
Engle-Granger Z-statistic	-31.8	0.003

*: significant at 5%. Critical value for the test at 5% of significance are -5.5; -4.9 and -4.61 for the three models

Table 4: Gregory - Hansen cointegration test

Model	$Z_t - stat$		Break
Model with level shift	ADF procedure	-5.9*	2010:11
	Phillips procedure	-8.6 *	2010: 10
Model with level shift with trend	ADF procedure	-5.6*	2010:10
	Phillips procedure	-81*	2010: 10
Model with regime shift	ADF procedure	-6.01*	2010:10
	Phillips procedure	-8.6*	2010:10

Table 5.Cointegration Test - Hansen Parameter Instability

	Stochastic	**Deterministic**	**Excluded**	
Lc statistic	**Trends (m)**	**Trends (k**	**Trends (p2)**	**Prob.***
0.495477	1	0	0	0.0416

*Hansen (1992b) Lc(m2=1, k=0) p-values, where m2=m-p2 is the number of stochastic trends in the asymptotic distribution

[3] The lag selection in ADF test for each variable is made using Schwarz information criteria.
[4] Use normal distribution.

the money multiplier in Rwanda is stable over long time horizon with reasonable degree of accuracy even when there is shift in money multiplier relation. However, while the existence of long run relationship between m and b indicates that central banks may influence the development of m though the control of the base money, the structural change in the relationship between the two variables may reduce the prediction capacity of the money multiplier model and limit the capacity of central bank to control the money supply in the economy using reserve money as operating variable.

As recommendation, the National Bank of Rwanda should continue building necessary requirements for the use of interest rates as operating target by 2017 as recommended by East African Monetary Affairs Committee. These requirements include the development of financial market to help banks to invest their short term liquidity in securities with long maturity. The development of financial market will also contribute to increase the substitution between bank deposits and other money market instruments of the same maturity like treasury bills, and between bank lending and other types of financing like equity and bonds. This will improve the interest rate pass through in Rwanda, which describes how market rates (deposit and lending rates) react to changes in the monetary policy rate.

REFERENCES

Adam C, Kessy P (2011), "Assessing the stability and predictability of the money multiplier in the EAC: the case of Tanzania"

András K (2007). "The effect of the monetary base on maney supply – Does the quantity of central bank money carry any information?", MNB Bulletin, June 2007.

Aucremanne LJB, Vergote O (2007), "Interest rate policy or monetary base policy:implications for a Central bank's balance sheet"

Baghestani H, Mott T (1997). "A Cointegration analysis of US money supply process". J. Mac. Econ. 19:269-283.

Bomho E (1977). "Predicting the Money Multiplier". J. Monetary Econ. 3:325-346.

Brunner K (1997). "High-powered money and the monetary base"In: T.Lys (ed.), Monetary Theory and Monetary Policy: The selected essays of Karl Brunner. Edward Elgar, UK.

Darbha G (2002), "Testing for Long-run Stability – An Application to Money Multiplier in India", Appl. Econ. Letters, 9:33-37

Downes D, Moore W, Jackson D (2006). "Financial Liberalization and the Stationarity of Money Multiplier", Int. Econ. J., 20:227-260.

Ford JL, Morris JL (1996). "The Money multiplier, Simple sum, divisia and information-divisia monetray aggregates: cointegration tests for UK". Appl. Econ. 28:705-714.

Gichonde A, Pascal M, Adha A (2008). "The satability of money multiplier and monetary control in Rwanda". BNR Econ. Rev. n003, pp 50-74

Goodhart C (1989) "The Conduct of Monetary Policy", Econ. J. 99:293-346.

Gregory AW, Hansen BE (1996). "Residual-based tests for cointegration in models with regime shifts". J. Econ. 70:99-126.

Gregory AW, Hansen BE (1996), " Residual – based tests for cointegration in models with regime shifts. J. Econ. 70:99-126

Gregory AW, Nason JM Watt DG (1996). "Testing for structural breaks in cointegrated relationships". J. Econ. 71:321-341.

Haghighat J (2011). " How Much Control Dose Central Bank of Iran over Money Supply?" J. Knowl. Manag., Econ. Information Technol.

Hansen BE (1992), " Testing for parameter instability in linear models", J. Pol. Modeling

Jayaraman TK, Ward BD (2003). Is money multiplier relevant in a small, open economy? Empirical evidence from FIJI, USPEC working paper,

Johannes MJ, Rasche RH (1981). "Can the Reserve Approach to monetary control really work" J. Money, Credit and Bank. 13:298-313.

Khan MA (2009). "Testing of money multiplier model for Pakistan: Does monetary base carry any information?", Economic analysis working papers,9TH volume number 02

Nachane DM, Ray D (1989). "Money multiplier: A re-examination of the Indian evidence". Indian Econ. J. 37:56-73.

National Bank of Rwanda (2014). "National Bank of Rwanda and the recovery of a nation" Fountain Publishers

Perron P (1997). " Further evidence on breaking trend functions in macroeconomic variables". J. Econ. 80: 355-385

Rangarajan C, Singh A (1984). "Reserve Money: Concepts and Policy implications for India". Reserve Bank of India Occassional Papers 5:1-26.

Rusuhuzwa TK, Irankunda J (2011). "Assessing the stability of money multiplier in Rwanda". BNR Econ. Rev. 5:41-55

Saatcioglu C (2006). "Stability Of Money Multipliers". Evidence From Turkey. J. Bus. Econ. Res. 4:10-31

Şahinbeyoğlu G (1995). " the stability of money multiplier:A test for cointegration" discussion paper no:9603

Virmani V (2004). "A Re-look at the Long-Run Stability of the Money Multiplier

Appendix 1: Money multiplier model for Rwanda

The money multiplier, denoted by K, is defined as the ratio of the money supply (M3) to base money (B).

$$K = \frac{M}{B} = \frac{D+F+C}{C+R} \qquad (1)$$

Where B is base money, consisting of currency in circulation out the banking system(C) plus bank reserves with the Central bank (R), including cash in vault in banks. M is the broad money composed of currency in circulation out the banking system (C) , deposits in RFW (both demand and time deposits) denoted by D, and foreign currency deposits ($F = e.FC$) where e is the nominal exchange rate, FC foreign currency deposits and F foreign deposits expressed in RWF.

Total reserves can be partitioned between required reserves (RR), as defined by BNR and the excess (EX) held over this requirement. The money multiplier becomes:

$$K = \frac{M}{B} = \frac{D+F+C}{C+RR+EX} \qquad (2)$$

The reserve requirement is also portioned between reserve requirement in foreign currency and reserve requirement in domestic currency:

$$RR = r^d D + r^f F \qquad (3)$$

Where r^d and r^f are reserve requirement or statutory reserve requirement ratios defined as percentage of total deposits D and F respectively. Because foreign and domestic deposits attract the same reserve requirement in Rwanda, $r^d = r^f = r$ therefore

$$RR = rD + rF = r(D+F) \qquad (4)$$

The money multiplier becomes:

$$K = \frac{D+F+C}{C+r(D+F)+EX} \qquad (5)$$

Dividing through by D, the money multiplier can be expressed in terms of four ratios.

$$K = \frac{1+f+c}{c+r(1+f)+ex} \qquad (6)$$

When $c = \frac{C}{D}; f = \frac{F}{D}; ex = \frac{E}{D}$

The first two ratios: c and f describe private sector portfolio behavior, between cash and deposits and between foreign and domestic deposits respectively;

r is a policy measure by decided by BNR, and ex reflects the banks ‘discretionary portfolio behavior.