MONEY AND INTEREST RATES IN UGANDA

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Abstract
The paper analyses the influence of money on interest rates in Uganda within the 1983 to 2007 period. Theoretical analysis is conducted with the intention of investigating the influence of money on both the nominal and real interest rates. The theoretical analysis involves the idea that the lenders of money make their decisions based on real interest rate, the nominal money supply and the future value of the money supply because their aim is to make profits in real terms. The other idea states that the borrowers of money make their decisions based on the real money balance (i.e. demand for money), nominal interest rate and the future value of the real money balance because their aim is to use the borrowed money to spend on the goods and services they demand for investment or executing their planned activities. To the borrowers the nominal interest rate is the price of money, whereas to the lenders the real interest rate is the price of money. Both the lenders and borrowers desire to earn income using the money supplied or borrowed and the future value of either the real money balance or money supply is directly proportional to aggregate income. Based on results from the relevant regressions conducted the paper finds that (a) money supply has a positive influence on the nominal interest rate, but a negative effect on real interest rate (b) the demand for money has a positive influence on real interest rate, but a negative effect on the nominal interest rate and (c) real income has a positive influence on either nominal or real interest rate.
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Key Words: Real Interest Rate, Nominal Interest Rate, Real Money Balance, Money Supply, Real Income.

1. INTRODUCTION

The paper examines the influence of money on interest rates in Uganda within the 1983 to 2007 period. In an economy nearly all aggregate stock of money passes through the financial markets in terms of lending and borrowing. We argue that the borrowers make their decisions based on the real money balance and nominal interest rate; while the lenders make their decisions based on the real interest rate and the nominal money supply. The value of aggregate money demanded within a given period of time is taken to be proportional to the value of aggregate money supply issued by the financial institutions.

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Empirical evidence got support the following propositions: (a) growth in nominal money supply has a positive influence on nominal interest rate, but a negative influence on real interest rate and (b) growth in real money balance has a negative influence on nominal interest rate, but a positive influence on real interest rate.

The research study is motivated by Fisher's (1907) definition of interest rate as an index of preference for a dollar of present over a dollar of future income. In the paper, Fisher's definition is restated as an index of future value of money over the present value of money. Thus either the present value of money is in terms of demand for money or supply of money and is proportional to the real income. Real income is considered because money plays an indirect role of other mightier factors. In other words, the fundamental causes at work in a money market are economic, not monetary at all. Thus the holders of money determine the way it is spent, such as for buying goods and services or investment. Therefore, the amount of available funds for loan purposes is merely a sign of more fundamental causes operating upon the rate of interest.

The paper takes advantage of Lucas (1990) methodology that captures liquidity and loanable funds effects. The methodology allows us to aggregate the stock of money while avoiding the wealth effect problems. In the paper we attempt to reconcile the liquidity preference theory of interest with the loanable funds theory. The econometric models tested were developed from the theoretical models based on the equilibrium conditions existing between the present value of aggregate money supply and present value of aggregate demand for money.

2. LITERATURE REVIEW

Irving Fisher (1896) distinguished between nominal and real interest rates and empirically examined the influence of inflationary expectations that had not been known. Yet, before 1966, most people strongly believed in the Keynesian liquidity preference approach that faster monetary growth meant declining interest rates. The rising interest rates made it impossible to continue accepting the stable Keynesian liquidity preference function relating the nominal quantity of money to be inversely related to nominal interest rates as an adequate tool for analyzing the effect of money changes on interest rates (Friedman, 1968). Friedman (1982) found an inverse relationship between nominal interest rate (Rn) and real money balance $(M = Mn/P)$ or Mn/Y. He therefore, showed that the inverse relation between nominal interest rate (Rn) and nominal money supply (Mn) was wrong. Keynes failed to distinguish the nominal from the real money supply because he assumed prices to be rigid and that any effect on income would influence real income (Friedman, 1982, pp.771-797).

In the paper we argue that Keynes could have been right if he had taken the relation between nominal interest rate and money supply to be positive. That is because increase in money supply (or increase in aggregate supply of loans) causes the nominal interest rate to fall (say from Rn_0 to Rn_1) within a brief period of time to a new equilibrium level. It is this fall in nominal interest rate that causes the demand for money to rise in the long–run (i.e. within a given period or year). Consequently, persistent increase in demand for money drives up the nominal interest rate to a final equilibrium level in the money market so that the final interest rate (say Rn_2) is less than the original one (Rn_0).

In the paper we also argue that Friedman (1982) was right in two ways. One, the quantity demanded of money rises as nominal interest rate falls since the demand curve is downward sloping. Two, the rise in demand for money (i.e. a shift in the demand curve outwards) is accompanied by a rise in interest rate in a brief period of time and to the new market equilibrium.

It is this rise in interest rate (say from Rn_0 to Rn_1) that causes the supply curve of money to shift to the right to the new market equilibrium. As a result, in the long run (i.e. within the course of a year), the persistent increase in money supply causes the interest rate to fall (say to Rn_2) below the original interest rate (Rn_0).

Pinna (2002) defines interest rate as the profit overtime due to financial instruments. In a loan structure, the interest rate is the deference in percentage between money paid back and money got earlier, taking into account the duration of time that has elapsed. All over the world, banks establish interest rate to the public by making reference to the percentage they charge more than the central bank base lending (Pinna, 2002).

Interest rate is defined as the amount a borrower pays in addition to the principal of loan to compensate, the lender for use of the money. Interest rate therefore, is the expression of interest as a percentage of the principal, while lending is the principal business activity for most commercial banks. Banks execute one of their most important functions by accepting deposits for the purpose of lending. Whenever deposits are accepted, the banks agree to repay the amount of deposits with interest to the depositor on maturity. Banks recover loan amounts and advances and use them to repay deposit amounts to the customers on maturity (Nakayizi, 2013, pp.33-37).

Branson (2003, pp.58-62), contend that the speculative and transactions demand for money cannot be separated. To avoid putting together the speculative and transactions demand for money in one equation, we split our market into one depicting the borrowers' and lenders' markets. Fisher (1907, p.3) defines the rate of interest to be an index of preference for a dollar of present over a dollar of future income.

In the paper our theories of interest rate have been directly motivated by Fisher's definition of interest rate in terms of future value of money. We then modify this Fisher's definition and redefine interest rate to be an index of preference for a dollar of future income over the present dollar i.e. future value of money, $FV(1+R)$ over the present value of money $Mn,$ where R is the real interest rate. The revised definition is more accurate because from the lender's point of view, the interest rate is the future value of money, $FV = Mn(1+R)$ over the present value of money (Mn) and can be expressed as $1+R = Mn(1+R)/Mn.$ In other words, the interest rate is defined as future aggregate income βY or $FV = \beta Y$ of lenders over the present value of the aggregate stock of money supply (Mn) within the banking system, i.e. $1+R = \beta Y/Mn.$ Likewise, from the borrower's point of view, the interest rate is defined as a future income, $FV = M(1+Rn)$ over the present value of demand for money M, i.e. $1+Rn = \alpha Y/M$.

When the expectations of borrowers and lenders are at par then $\alpha Mn(1+R) \equiv Y \equiv \beta M(1+Rn),$ implying (a) the inverse relationship between nominal interest rate (Rn) and real money balance (M), (b) positive relationship between nominal (Rn) interest rate and money supply (Mn), (c) inverse relation between real interest rate (R) and Money supply and $(Mn),$ and (d) positive relation between real interest rate (R) and real money balance (M). It is a well known fact that monetary injections occur through the financial institutions. These financial institutions intermediate between borrowers and savers and they act as the channel through which the central bank injections occur. The monetary injections make the borrowers relatively cash rich and it stimulates their demand for goods and services they purchase, consequently pushing up the nominal interest rates (Fuerst, 1990). Otherwise, the monetary injections (i.e. growth in money supply), lower the real interest rate and increases next period’s capital stock and level of output. These analyses focus mainly on wealth effects where borrowers bid up asset prices and decrease real interest rates (Grossman and Weiss, 1993; Rotenberg, 1984; Weiss, 1986; Kehoe, Levine and Woodford, 1988).

The common problem in earlier approaches is the small set of monetary policies that can be analyzed. In the paper we make generalizations to eliminate entirely problems associated with wealth effects, by employing a methodology suggested by Lucas (1990). The method involves aggregating all the sectors of the economy into one gigantic household. In each sector cash is used to carry out transactions in separate markets and is subject to within period liquidity resulting from monetary injections. The advantage of the Lucas (1990) methodology is that cash injections can be modeled, while capturing the liquidity and loanable funds effects. The methodology enables us to isolate the liquidity and loanable funds effects so that the paper is absolutely free from the wealth effect problems (Fuerst, 1990).

Interest rate (i.e. the price of loans) is determined by supply and demand for loans, or by supply and demand for money where loans are given and taken (Tsiang, 1980). Tobin believes that the demand for money is sensitive to interest rates and found an inverse relationship between interest rates and idle balances. Additional empirical evidence confirm the inverse relationship between demand for money and nominal interest rates (Laider, 1963, 1966, 1993; Friedman, 1959; Brunner and Meltzer, 1963). Tsiang (1956), calls for reconciliation of liquidity preference theory of interest with the loanable funds theory. That is because not only Keynesians and Neo-Keynesians, but also the Chicago monetarists continue to formulate the demand for money as a function of income and interest rate. Furthermore, if aggregate planned expenditure is substituted for money demand function, it makes the liquidity preference theory of interest come to the same thing as the loanable funds theory. It is therefore, the total planned expenditure that should be regarded as the primary determinant of transactions demand for money (Tsiang, 1980).

Monetary policy is very close to reality and that it is less abstract than most economic theory (Hicks, p.156). In the real world, money comes into existence along with debts occurring typically as contracts for differed payment (Friedman, 1971, p.3). The existence of financial institutions, normally operate under the state control. It is the state that provides the assurances of continuity between the present and future that is important for holding money as a store of value. What gives money its purchasing power is its intimate relationship to provide contracts in general and contracts involving labor offers specifically (Davison, 1972).

In economics, interest rate theory is composed of loanable funds theory, liquidity theory, the IS-LM model determination of interest rate and the more recent general equilibrium-based models of interest rate determination. Each of these theories are based on factors that determine interest rates. The disadvantage of dealing with the theories individually is that each of the theories emphasizes a particular determinant, thus causing it to misrepresent other causes of interest rates, resulting in confusing those trying to understand them. Loanable funds theory is a theory of choice for characterization of how interest rates depend on savings. Liquidity preference theory refers to changes in money demand linked to interest rates and how money demand affects the bonds market and other debt securities. In liquidity theory, the asset modeled is money. The general equilibrium-based interest theories determine interest rates together with the equilibrium aggregate level of output in an economy (Elwood, 2007). The new dimension of interest rate theory was introduced in form of the IS-LM model advanced by Grossman and Weiss (1983) and Roternberg (1984). Recent contributions by Lucas (1990), Fuerst (1992), Christiano and Eichenbaum (1995) have clearly shown that the new standard interest rate theory should be within a dynamic, general equilibrium framework. The liquidity preference theory and loanable funds theory cannot be easily integrated (Keynes, 1936; Tsiang, 1980; Foley, 1975; Buiter, 1980, Davison, 1978; Mayer, 1996; Hicks, 1939; Bilow, 2000; Leijonhafvud, 1981). Most text books having both theories, present them separately (Bernanke, 2007; Lieberman, 2006 and Mankiw, 2003 as sighted in Elwood, 2007).

Elwood (2007), observes that the IS curve and its representation of goods market equilibrium involves real interest rate, while the LM curve and its representation of financial market equilibrium depends on the nominal interest rate. The most common textbook approach to addressing the controversy is to force the two rates to be equivalent by assuming that inflation is zero. The IS-LM model also suffers the loanable funds problem of being unable to represent the impact of pre-existing debt securities at the beginning of the period being modeled. Yet the LM curve that incorporates liquidity preference theory in the IS-LM model, offers no better accounts for the prevailing stock of debt securities than the liquidity preference theory does. More recent interest rate theory has not attempted to discover a better equilibrium approach in the model of loanable funds or liquidity preference theory. Instead the recent interest rate theory has concentrated on models that improve upon the joint determination of output and interest rates as found in the IS-LM model.

Real business cycle theory has effectively established the supremacy of dynamic models of output over static models. As a result, for more than two decades now, journals have examined output using dynamic models. Many of these models are concerned with how monetary shocks (i.e. change in liquidity) influence output as well as interest rates (Lucas, 1990; Fuerst, 1992; Christiano and Eichenbaum, 1995).

3. THEORETICAL ANALYSIS

If within a year the aggregate demand for money (i.e. real money balance) in the economy is M and the prevailing nominal interest is $Rn+1$, then the future value of the demand for money FV_1 is given by

$$M(Rn+1)=FV_1 \qquad (1)$$

In our analysis we therefore define nominal interest rate $(Rn+1)$ in terms of future value of demand for money as a ratio of demand for money.

$$Rn+1=FV_1/M \qquad (2)$$

In our interest rate theory analysis we reason that the aggregate future value of demand for money (i.e. money held by the investors and needed for purchasing goods and services) is proportional to the aggregate demand for goods and services (or aggregate income).

$$FV_1=\alpha Y \qquad (3)$$

Substituting Equation (7) in Equation (6) provides

$$Rn+1=\alpha Y/M \qquad (4)$$

If within a year the aggregate money supply (i.e. real money balance) in the economy is Mn and the prevailing real interest is $R+1$, then the future value of the money supply FV_2 is given by

$$Mn(R+1)=FV_2. \qquad (5)$$

In our analysis we therefore define real interest rate $(R+1)$ in terms of future value of money supply as a ratio of money supply.

$$R+1=FV_2/Mn \qquad (6)$$

In the interest rate theory analysis being advanced we reason that the aggregate future value of money supply (i.e. money issued by the financial institution to the investors and consumers required for purchasing goods and services) is proportional to the aggregate level of income.

$$FV_2 = \beta Y \text{ .... (7)}$$

Substituting Equation (7) in Equation (6) provides

$$R + 1 = \beta Y / Mn \text{ .... (8)}$$

Within the economy of a country, the nominal interest rate, aggregate money supply, real interest rate and aggregate demand for money are connected by the real income.

$$Mn(Rn+1)/\beta = Y = M(R+1)/\alpha \text{ .... (9)}$$

Equation (10) provides the equilibrium relationship between money and interest rates.

$$\alpha Mn(Rn+1) \equiv \beta M(R+1) \text{ .... (10)}$$

Equation (11) implies that in the long–run, real money balance has a positive influence on real interest rate, but money supply has negative influence on the real interest rate.

$$\ln(R+1) = \ln(\alpha/\beta) + \ln(Rn+1) + \ln(M) - \ln(Mn) \text{ .... (11)}$$

Equation (12) implies that in the long–run, real money balance has a negative influence on real nominal rate, but money supply has positive influence on the nominal interest rate.

$$\ln(Rn+1) = \ln(\beta/\alpha) + \ln(R+1) + \ln(Mn) - \ln(M) \text{ .... (12)}$$

We combine Equations (4) and (8) to constitute an equilibrium condition given by

$$(Rn+1) - \alpha Y / M \equiv (R+1) - \beta Y / Mn \text{ .... (13)}$$

Equation (14) shows that the nominal interest rate is positively related to the aggregate income of financial institutions (Y/Mn) that lend money, but negatively related to the aggregate income (Y/M) of the borrowers of money from the financial institutions.

$$Rn+1=(R+1)+\alpha(Y/M)-\beta(Y/Mn)\text{.............................} \quad (14)$$

We transform Equation (14) to enable us determine the relationships between nominal interest rate and money, i.e. money in terms of money supply as a ratio of real income and money in terms of demand for money as a ratio of real income.

$$Rn+1=(R+1)+\alpha(M/Y)^{-1}-\beta(Mn/Y)^{-1}\text{...............................} \quad (15)$$

After transformation of Equation (15) into logarithm it becomes clear the nominal interest rate is positively related to money supply, but negatively related to demand for money.

$$\ln(Rn+1)=(\ln R+1)-\alpha\ln(M/Y)+\beta\ln(Mn/Y)\text{.............................} \quad (16)$$

Equation (17) shows that the real interest rate is positively related to the aggregate income of borrowers from the financial institutions (Y/M) that lend money, but negatively related to the aggregate income (Y/Mn) of the financial institutions involved in lending money.

$$R+1=(Rn+1)+\alpha(Y/M)-\beta(Y/Mn)\text{..............................} \quad (17)$$

We transform Equation (17) to enable us determine the relationships between real interest rate and money, i.e. money in terms of money supply as a ratio of real income and money in terms of demand for money as a ratio of real income.

$$R+1=(Rn+1)+\alpha(M/Y)^{-1}-\beta(Mn/Y)^{-1}\text{...............................} \quad (18)$$

After transformation of Equation (17) into logarithm it becomes clear the real interest rate is negatively related to money supply, but positively related to demand for money.

$$\ln(R+1) = \ln(Rn+1) + \alpha \ln(M/Y) - \beta \ln(Mn/Y) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(19)}$$

Furthermore, we split the variable real money balance as a ratio of income into demand for money and real income to enable us determine the influence of real income and demand for money on nominal interest rate. As can be discerned from Equation (20), the relationship between income and nominal interest is positive.

$$\ln(Rn+1) = \ln(R+1) - \alpha \ln(M) + \alpha \ln(Y) + \beta(Mn/Y) \ldots\ldots\ldots\ldots\ldots \text{(20)}$$

Similarly, we split the variable money supply as a ratio of income into money supply and real income to enable us determine the influence of real income and money supply on nominal interest rate. As can be discerned from Equation (21), the relationship between income and real interest is positive.

$$\ln(R+1) = \ln(Rn+1) + \alpha \ln(M/Y) - \beta \ln(Mn) + \ln(Y) \ldots\ldots\ldots\ldots\ldots \text{(21)}$$

Alternatively, we may take the influence of money on nominal interest rate to be purely a phenomenon of monetary growth. To do that we express the future value of demand for money FV_3 in the previous year in terms of the previous year's demand for money M_{t-1} and nominal interest rate $Rn+1$.

$$M_{t-1}(Rn+1) = FV_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(22)}$$

We take the future value of demand for money held a year ago to be directly proportional the level of demand for money in the current year.

$$FV_3 = \alpha M_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(23)}$$

Substituting Equation (23) in Equation (22) give rise to Equation (24)

$$Rn+1 = \alpha M_t / M_{t-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(24)}$$

Once more we may take the influence of money on real interest rate to be purely a phenomenon of monetary growth. To do that we express the future value of money supply FV_4 in the previous year in terms of the previous year's money supply Mn_{t-1} and real interest rate $R+1$.

$$Mn_{t-1}(R+1) = FV_4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(25)}$$

Similarly, we take the future value of money supply issued a year ago to be directly proportional the level of money supply in the current year.

$$FV_4 = \beta Mn_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(26)}$$

Substituting Equation (25) in Equation (24) give rise to Equation (26)

$$R+1 = \beta Mn_t / Mn_{t-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(27)}$$

We then combine Equations (24) and (27) to provide an equilibrium condition existing in the money market expressed by Equation (28).

$$Rn+1-\alpha M_t / M_{t-1} \equiv (R+1) - \beta Mn_t / Mn_{t-1} \ldots\ldots\ldots\ldots\ldots \text{(28)}$$

Equation (28) can be rewritten in terms nominal interest rate as a function of real interest rate, money supply growth and growth in demand for money.

$$Rn+1 = (R+1) - \alpha M_t / M_{t-1} + \beta Mn_t / Mn_{t-1} \ldots\ldots\ldots\ldots\ldots \text{(29)}$$

Therefore, growth in demand for money raise nominal interest rate, but money supply growth causes reduction in nominal interest rate.

$$Rn+1 = (\alpha - \beta) + (R+1) - \alpha(M_t - M_{t-1}) / M_{t-1} + \beta(Mn_t - Mn_{t-1}) / Mn_{t-1} \ldots\ldots \text{(30)}$$

Also Equation (28) can be rewritten in terms real interest rate as a function of nominal interest rate, money supply growth and growth in demand for money.

$$R+1=(Rn+1)+\alpha M_t/M_{t-1}-\beta Mn_t/Mn_{t-1}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (31)$$

Hence, growth in demand for money raise nominal interest rate, but money supply growth causes reduction in nominal interest rate.

$$R+1=(\beta-\alpha)+(Rn+1)+\alpha(M_t-M_{t-1})/M_{t-1}-\beta(Mn_t-Mn_{t-1})/Mn_{t-1}\ldots\ldots \quad (32)$$

4. METHODOLOGY

Under the methodology section we develop the econometric models to be tested from the theoretical models that have been built for theoretical analyses. The models that appear below come to be established as a result of (a) developing them and (b) eventually modifying them after having successfully conducted reliable empirical tests.

The Econometric model i.e. Equation (33) was developed from Equation (12).

$$\ln(Rn_t+1)=\beta_1+\beta_2\ln(R_t+1)+\beta_3 d\ln(M_t)+\beta_4 d\ln(Mn_t)+\varepsilon_t\ldots\ldots\ldots\ldots\ldots\ldots \quad (33)$$

Where $\beta_1=0, \beta_2>0, \beta_3<0, \beta_4>0.$

The Econometric model i.e. Equation (34) was developed from Equation (11).

$$\ln(R_t+1)=\beta_1+\beta_2\ln(Rn_t+1)+\beta_3 d\ln(M_t)+\beta_4 d\ln(Mn_t)+\varepsilon_t\ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

Where $\beta_1=0, \beta_2>0, \beta_3>0, \beta_4<0.$

The Econometric model i.e. Equation (35) was developed from Equation (16).

$$\ln(Rn_t+1)=\beta_1+\beta_2(\ln R_t+1)+\beta_3 d\ln(M_t/Y_t)+\beta_4 d\ln(Mn_t/Y_t)+\varepsilon_t\ldots\ldots\ldots\ldots \quad (35)$$

Where $\beta_1=0, \beta_2>0, \beta_3<0, \beta_4>0.$

The Econometric model i.e. Equation (36) was developed from Equation (19).

$$\ln(R_t + 1) = \beta_1 + \beta_2 \ln(Rn_t + 1) + \beta_3 d\ln(M_t / Y_t) + \beta_4 d\ln(Mn_t / Y_t) + \varepsilon_t \ldots\ldots\ldots\ldots \quad (36)$$

Where $\beta_1 = 0,\ \beta_2 > 0,\ \ \beta_3 > 0,\ \beta_4 < 0.$

The Econometric model i.e. Equation (37) was developed from Equation (20).

$$\ln(Rn_t + 1) = \beta_1 + \beta_2 \ln(R_t + 1) + \beta_3 d\ln(M_t) + \beta_4 d\ln(Y_t) + \beta_5 d(Mn_t / Y_t) + \varepsilon_t \ldots\ldots \quad (37)$$

Where $\beta_1 = 0,\ \beta_2 > 0,\ \ \beta_3 < 0,\ \beta_4 > 0,\ \ \beta_5 > 0.$

The Econometric model i.e. Equation (38) was developed from Equation (21).

$$\ln(R_t + 1) = \beta_1 + \beta_2 \ln(Rn_t + 1) + \beta_3 d\ln(M_t / Y_t) + \beta_4 d\ln(Mn_t) + \beta_5 d\ln(Y_t) + \varepsilon_t \ldots \quad (38)$$

Where $\beta_1 = 0,\ \beta_2 > 0,\ \ \beta_3 > 0,\ \beta_4 < 0,\ \beta_5 > 0.$

The Econometric model i.e. Equation (39) was developed from Equation (30).

$$Rn_t + 1 = \beta_1 + \beta_2 (R_t + 1) + \beta_3 (M_t - M_{t-1}) / M_{t-1} + \beta_4 (Mn_t - Mn_{t-1}) / Mn_{t-1} + \varepsilon_t \ldots \quad (39)$$

Where $\beta_1 = 0,\ \beta_2 > 0,\ \ \beta_3 < 0,\ \beta_4 > 0.$

The Econometric model i.e. Equation (40) was developed from Equation (32).

$$R_t + 1 = \beta_1 + \beta_2 (Rn_t + 1) + \beta_3 (M_t - M_{t-1}) / M_{t-1} + \beta_4 (Mn_t - Mn_{t-1}) / Mn_{t-1} + \varepsilon_t \ldots \quad (40)$$

Where $\beta_1 = 0,\ \beta_2 > 0,\ \ \beta_3 > 0,\ \beta_4 < 0.$

The Econometric model i.e. Equation (41) was developed from Equation (27).

$$\ln(R_t + 1) = \beta_1 + \beta_2 d\ln(Mn_t) + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (41)$$

Where $\beta_1 = 0,\ \beta_2 < 0.$

The Econometric model i.e. Equation (42) was developed from Equation (8).

$$\ln(R_t + 1) = \beta_1 + \beta_2 d\log(Y_{t-1}) + \beta_3 d\ln(Mn_{t-1}) + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (42)$$

Where $\beta_1 = 0,\ \beta_2 > 0,\ \ \beta_3 < 0.$

The Econometric model i.e. Equation (43) was developed from Equations (30) and (41).

$$\ln(Rn_t + 1) = \beta_1 + \beta_2 d\ln(Mn_t) + \beta_3 d\ln(M_t) + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(43)}$$

Where $\beta_1 = 0, \beta_2 > 0, \ \beta_3 < 0.$

The Econometric model i.e. Equation (44) was developed from Equation (19).

$$\ln(R_t + 1) = \beta_1 + \beta_2 \ln(Rn_t + 1) + \beta_3 d\ln(Y_t / Mn_t) + \beta_4 d\ln(Y_t / M_t) + \varepsilon_t \ldots\ldots\ldots \text{(44)}$$

Where $\beta_1 = 0, \beta_2 > 0, \ \beta_3 > 0, \beta_3 < 0.$

The Econometric model i.e. Equation (45) was developed from Equation (20).

$$\ln(Rn_t + 1) = \beta_1 + \beta_2 \ln(R_t + 1) + \beta_3 d\ln(Y_t / Mn_t) + \beta_4 d\ln(Y_t / M_t) + \varepsilon_t \ldots\ldots\ldots \text{(45)}$$

Where $\beta_1 = 0, \beta_2 > 0, \ \beta_3 < 0, \beta_4 > 0.$

The Econometric model i.e. Equation (46) was developed from Equations (28).

$$Rn_t - R_t = \beta_1 + \beta_2 d\ln(Mn_t) + \beta_3 d\ln(M_t) + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(46)}$$

Where $\beta_1 = 0, \beta_2 > 0, \ \beta_3 < 0.$

The Econometric model i.e. Equation (47) was developed from Equations (14).

$$Rn_t - R_t = \beta_1 + \beta_2 d\ln(Y_t / Mn_t) + \beta_3 d\ln(Y_t / M_t) + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(47)}$$

Where $\beta_1 = 0, \beta_2 > 0, \ \beta_3 < 0.$

Having got the econometric models they are confronted with money data on money supply, interest rates real GDP for Uganda for the 1983–2007 period. With respect for testing the adequacy of the models presented we first of all express the model as a k-variable regression model in the form given by

$$Y_i = \beta_1 + \beta_2 X_{t1} + \beta_3 X_{t3} + ... + \beta_3 X_{tK} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(48)}$$

With respect to testing the significance of the parameters, we state the hypothesis that the true value of the parameter in question is equal to zero i.e.

$$H_0 : \beta_K = 0 \qquad (K = 2,3,...., K).$$

The hypothesis is tested against a two–sided alternative and the statistic to be used is given by

$$t = \beta_0 / \sqrt{Var(\beta_K)} \sim t_{\alpha/2,n-k} \qquad (K = 2,3,...., K) \ldots\ldots\ldots\ldots\ldots\ldots \text{(49)}$$

When $K = 1,$ it implies that the intercept is equal to zero, meaning that the regression line passes through the origin. When $K = 2,3,...., K;$ the hypothesis that $\beta_K = 0$ means that the variable X_{tK} has no influence on the mean of Y_t. If the computed t value exceeds the critical t value at a given level of significance (say α), the null hypothesis (H_0) is rejected, otherwise it is accepted. Alternatively, if the computed p value of t obtained is low, we reject the H_0. The estimated $P-$value of t is the probability of obtaining a given computed t value or greater.

The F-distribution provides a more extensive statement of the null hypothesis in that none of the explanatory variables has an influence on the mean of Y_t, and it is stated as

$$H_0 : \beta_2 = \beta_3 = ... = \beta_K = 0 \qquad (K = 2,3,...., K)$$

against the alternative hypothesis that the null hypothesis is untrue i.e.

H_0 :Not all slope coefficients are simultaneously zero.

If null hypothesis (H_0) is true, then the variation of Y_t from observation to observation is not affected changes in any of the explanatory variables, but is purely random. If that is correct, then the observed value of explained sum of squares (ESS) differs from zero only because of sampling. If the null hypothesis is true then

$$F = \frac{ESS / df_n}{RSS / df_d} = \frac{ESS / (K-1)}{RSS / (n-K)} = \frac{R^2 / (K-1)}{(1-R^2)/(n-k)} \sim F_{\alpha, K-1, n-K} \qquad (50)$$

Where $ESS =$ explained sum of squares, $RSS =$ residual sum of squares, $df_n = K-1 =$ degrees of freedom of numerator, $df_d = n-K =$ degrees of freedom of denominator, $R^2 =$ coefficient of determination, and $\alpha =$ level of significance. If the computed $F-$Statistic is higher than the tabulated critical $F_{\alpha, K-1, n-K}-$value, we reject the null hypothesis and conclude that all the independent variables have joint effect on the dependent variable. Alternatively, if the $P-$value of F obtained is low, we reject H_0. The estimated $P-$value of F is the probability of obtaining a given computed F value or greater (Gujarati, 2004, 146; Kmenta, 1971, p.369).

In testing for hetroscedasticity, the Koenker–Bassett (KB) test for heteroscedasticity is used. The KB test for heteroscedasticity is based on squared residuals, e_t^2. The squared residuals are regressed on the estimated values of the independent variable, $\hat{Y}_t^2$.

If the original model is

$$Y_t = \beta_1 + \beta_2 X_{t2} + \beta_3 X_{t3} + ... + \beta_{tK} + e_t \qquad (51)$$

The model can be estimated by getting e_t the from the model and then estimate

$$\hat{e}_t^2 = \alpha_1 + \alpha_2 (\hat{Y}_t)^2 + e_t \qquad (52)$$

Where $\hat{Y}_t$ are the estimated values from the model. Here $H_0 : \alpha_2 = 0$. If that is the case we accept the null hypothesis and conclude that there is no heteroscedasticity. The null hypothesis is then tested by the usual $t-$test or the $F-$test, where $F_{1.K} = t_K^2$ (Gujarati, 2004, p.415).

In testing for the absence of autocorrelation we use the Durbin–Watson test. In this case we test the hypothesis that there is no autocorrelation, i.e.

$$H_0 : \rho = 0,$$

against the alternative hypothesis that there is positive autocorrelation, i.e.

$$H_0 : \rho > 0.$$

We apply the test by calculating the value of a statistic d expressed as

$$d = \sum_{t=2}^{n}(e_t - e_{t-1})^2 / \sum_{t=}^{n} e_t^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(53)}$$

Where the error terms e_t represent the ordinary least squares residuals. If the computed d is less than the lower limit d_L we reject the H_0. If the d_L is greater than d_U we accept Ho. If the d, falls within the range of $d_L \leq d \leq d_U$, the test is inconclusive (Kmenta, 1971, pp.294-395).

Lastly, adequacy of models is tested by conducting Augmented Dickey–Fuller (ADF) unit roots tests for stationary on R, Rn, M, Mn and Y data. The decision rule used in testing for stationary states that: If the computed ADF statistic is more negative than the critical values at certain levels of significance, then reject the null hypothesis, implying that that the series in question has no unit root problem and the series is stationary. A unit root problem exists when the ADF test statistic is not more negative than the critical values. We then corner the unit root problem by conducting the Johansen cointegration tests in order to avoid producing spurious regressions. All the variables used in the 15 regression equations here have been found to be cointegrated. The traditional methodology is appropriate to data involving nonstationary time series. "A test for cointegration can be thought of as a pretest to avoid spurious regression situations," (Granger, 1989, p.226; Gujarati, 2004, pp.800-830).

5. RESULTS

In this present section, fifteen results are presented along with fifteen regression models. Econometric and statistical tests are conducted to establish the adequacy of the regression models to be used in drawing conclusions involving the relationships between money and interest rate variable. The tests conducted are (a) t–test i.e. test of the individual effects on the dependent variables, (b) F–test i.e. the test for the joint effects of the respective dependent variables on the independent variables by using the Fisher's statistic, (c) test for presence of autocorrelation by using the Durbin Watson (D.W.) Statistic and (d) test for presence of heteroscedasticity by using the Koenker Bassett test. The R–square (R^2) is very high in all the regressions and ranges from 0.83 to 0.94. It therefore implies that each of the regression lines can explain almost all the variations in the given independent variable. Also the joint effect of the independent variables on the dependent variables is extremely high because the probability of the F–statistic is zero for all regressions presented.

Lastly, adequacy of models are tested by conducting tests for stationary on data set of the respective variables by conducting unit roots tests, in particular by conducting the Augmented Dickey–Fuller unit roots tests on R, Rn, M, Mn and Y. Unit root tests show that R and Rn are not stationary but are I(1) and require no differencing for conducting regressions. For M, Mn and Y, their first differences are not stationary but are I(2) and their first differences can be used in making adequate regressions.

The Rn series is not stationary because the computed $ADF-$test statistic (-2.07) is negative than the critical values (-3.75, -3.00 and -2.64) at 1%, 5% and 10% level of significance respectively. A first difference makes Rn stationary because the computed $ADF-$test statistic (-

4.26) becomes more negative than the critical values (-3.77, -3.00 and -2.64) at 1%, 5% and 10% level of significance respectively.

Also, the R series is not stationary because the computed $ADF-$test statistic (-1.42) is less negative than the critical values (-3.75, -3.00 and -2.64) at 1%, 5% and 10% level of significance respectively. A first difference makes R stationary because the computed $ADF-$test statistic (-4.48) becomes more negative than the critical values (-3.77, -3.00 and -2.64) at 1%, 5% and 10% level of significance respectively.

The Mn series is also not stationary because the computed $ADF-$test statistic (-4.13) is not less negative than the critical values (-3.74, -3.00 and -2.64) at 1%, 5% and 10% level of significance respectively. Differencing the Mn series once still does not make it stationary because the computed $ADF-$statistic (1.72) still does not becomes more negative than the critical values (-3.77, -300 and -2.64) at 1%, 5% and 10% level of significance respectively. The second differencing makes Mn stationary because the computed $ADF-$test statistic (-4.58) becomes more negative than the critical values (-4.47, -3.65 and -3.26) at 1%, 5% and 10% level of significance respectively.

The M series is not stationary because the computed $ADF-$statistic (3.46) is not more negative than the critical values (-3.75, -3.00 and -2.64) at 1% level of significance respectively. Differencing the M series once still does not make it stationary because the computed $ADF-$statistic (-0.81) does not becomes more negative than the critical values (-3.77, -3.00 and -2.64) at 1%, 5% and 10% level of significance respectively. The second differencing makes the M series stationary since the $ADF-$test statistic (-5.55) becomes more negative than the critical values (-3.79, -3.01 and -2.65) at 1%, 5% and 10% level of significance respectively.

Lastly, the Y series is not stationary because the computed $ADF-$ statistic (3.09) is not more negative than the critical value (-3.75, -3.00 and -2.64) at 1%, 5% and 10% level of significance respectively. Differencing the Y series still does not make makes it stationary because the computed $ADF-$ statistic (-0.87) does not becomes more negative than the critical values (-3.77, -3.00 and -2.64) at 1%, 5% and 10% level of significance respectively. The second differencing makes the Y series stationary because the computed $ADF-$test statistic (-4.15) becomes more negative than the critical values (-3.79, -3.01 and -2.65) at 1%, 5% and 10% level of significance respectively.

In Table 1, each of the computed t statistic $(t = 4.49, 11.97, -6.42)$ is greater than the critical t statistic $(t_{0.005,21} = 2.83)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,2,21} (= 5.78)$ statistic is less than the calculated $F(= 54.55)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 1.84)$ is greater than the critical upper value of the $D.W.(= 1.41)$ statistic at 1 percent level of significance. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 0.55)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 1, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 2, each of the computed t statistic $(t = 4.59, -9.07, 8.69)$ is greater than the critical t statistic $(t_{0.005,21} = 2.83)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,2,21} (= 5.78)$ statistic is less than the calculated $F(= 84.52)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 2.08)$ is less than the critical upper value of the $D.W.(= 1.41)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 1.50)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 2, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 3, each of the computed t statistic $(t = 4.96, 11.76, -7.13)$ is greater than the critical t statistic $(t_{0.005,21} = 2.83)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,2,21}(= 5.78)$ statistic is less than the calculated $F(= 59.21)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 2.12)$ is greater than the critical upper value of the $D.W.(= 1.41)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 1.34)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 3, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 4, each of the computed t statistic $(t = 4.96, -9.20, 7.95)$ is greater than the critical t statistic $(t_{0.005,21} = 2.83)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,2,21}(= 5.78)$ statistic is less than the calculated $F(= 82.61)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 2.18)$ is less than the critical lower value of the $D.W.(= 1.41)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 2.90)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 4, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 5, each of the computed t statistic $(t = 4.15, 9.32, -6.76, 4.26)$ is greater than the critical t statistic $(t_{0.005,20} = 2.85)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,3,20}(= 4.94)$ statistic is less than the calculated $F(= 39.58)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 2.16)$ is less than the critical upper value of the $D.W.(= 1.53)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 1.23)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 5, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 6, each of the computed t statistic $(t = 4.15, -8.78, 3.26, 7.12)$ is greater than the critical t statistic $(t_{0.005,20} = 2.85)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,3,20}(= 4.94)$ statistic is less than the calculated $F(= 39.58)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 2.12)$ is greater than the critical upper value of the $D.W.(= 1.53)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 1.81)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 6, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 7, each of the computed t statistic $(t = 12.51, 13.19, -6.71)$ is greater than the critical t statistic $(t_{0.005,21} = 2.83)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,2,21} (= 5.78)$ statistic is less than the calculated $F (= 50.19)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 1.97)$ is greater than the critical lower value of the $D.W. (= 1.41)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 1.29)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 7, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 8, each of the computed t statistic $(t = 4.51, 13.18, -6.71)$ is greater than the critical t statistic $(t_{0.005,20} = 2.85)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,4,20} (= 4.43)$ statistic is less than the calculated $F (= 50.10)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 1.70)$ is greater than the critical upper value of the $D.W. (= 1.53)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 2.03)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 8, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 9, each of the computed t statistic $(t = 8.43, -13.41)$ is greater than the critical t statistic $(t_{0.005,22} = 2.82)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,1,22}(= 7.95)$ statistic is less than the calculated $F(= 179.82)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 1.97)$ is greater than the critical upper value of the $D.W.(= 1.30)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 1.02)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 9, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 10, each of the computed t statistic $(t = 7.33, -12.42)$ is greater than the critical t statistic $(t_{0.005,22} = 2.82)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,1,22}(= 7.95)$ statistic is less than the calculated $F(= 142.18)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 1.81)$ is greater than the critical lower value of the $D.W.(= 1.30)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 4.05)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 10, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 11, each of the computed t statistic $(t = 13.97, 5.87, -5.14)$ is greater than the critical t statistic $(t_{0.005,21} = 2.83)$ in absolute terms, at 1 percent level of significance. The critical

$F_{0.01,2,21}(=5.78)$ statistic is less than the calculated $F(=47.31)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 1.91)$ is greater than the critical upper value of the $D.W.(=1.41)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 5.2)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 11, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 12, each of the computed t statistic $(t = 4.96, 9.20, -7.96)$ is greater than the critical t statistic $(t_{0.005,21} = 2.83)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,2,21}(=5.78)$ statistic is less than the calculated $F(=82.62)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 2.18)$ is greater than the critical upper value of the $D.W.(=1.41)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 2.90)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 12, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 13, each of the computed t statistic $(t = 4.96, -11.76, 7.13)$ is greater than the critical t statistic $(t_{0.005,21} = 2.83)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,2,21}(=5.78)$ statistic is less than the calculated $F(=59.21)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 2.12)$ is greater than the critical upper value of the $D.W.(=1.41)$ statistic. By testing for hetroscadasticity using the Koenker–

Bassett method, the computed F–Statistic $(F = 1.35)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 13, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 14, each of the computed t statistic $(t = 22.01, -8.08)$ is greater than the critical t statistic $(t_{0.005,22} = 2.82)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,1,22}(= 7.95)$ statistic is less than the calculated $F(= 340.49)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 2.11)$ is greater than the critical upper value of the $D.W.(= 1.30)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 1.87)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 14, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

In Table 15, each of the computed t statistic $(t = 8.28, -16.00)$ is greater than the critical t statistic $(t_{0.005,22} = 2.82)$ in absolute terms, at 1 percent level of significance. The critical $F_{0.01,1,22}(= 7.95)$ statistic is less than the calculated $F(= 222.08)$ statistic at 1 percent level of significance. The computed Durbin Watson statistic $(D.W = 1.95)$ is greater than the critical lower value of the $D.W.(= 1.30)$ statistic. By testing for hetroscadasticity using the Koenker–Bassett method, the computed F–Statistic $(F = 1.71)$ is less than the critical F–statistic $(F_{0.01,1,3} = 10.1)$ at 1 percent level of significance or $(F_{0.05,1,3} = 34.1)$ at 5 percent level of significance. Therefore, based on the results presented in Table 15, the regression model presented in the table is adequate and the conclusions that can be drawn from it are reliable.

DISCUSSION OF RESULTS

Other things equal a 1 percent rise in real interest rate might have caused the nominal interest rate to rise within the range of 0.7 and 0.77 percent (see Tables 1, 3, 5, and 13). On the other hand a 1 percent rise in the nominal interest rate could have caused the nominal interest rate to rise within the range of 0.65 to 0.71 percent (see Tables 2, 4, 6, and 12). The reverse effects between real and nominal interest rates appear to be the same because the interest rates tend to move together.

A 1 percent growth in nominal money supply was followed by increase in nominal interest rate within the range of 1.08 to 1.25 percent (see Tables 1, 3, 5, and 14). That is because with the nominal interest rate on the vertical axis and demand for money (i.e. real money balance) on the horizontal axis; increase in money supply causes the supply curve to shift to the left from the first equilibrium to the second equilibrium and the interest rate falls. It is this fall in interest rate that causes the demand for money (e.g. loans to rise) in the short–run. Thus causing the demand curve to shift to outwards to a third equilibrium, where the equilibrium interest rate is higher than the first equilibrium interest rate. Therefore, in the long–run, monetary (nominal money supply) growth causes an increase in nominal money supply.

A 1 percent increase real money balance could have led to reduction in nominal interest rate within the range of 1.47 to 1.64 percent (see Tables 1, 3, 5, 11 and 14). This empirical evidence is in line with the argument that given the nominal on the vertical axis and real money balance (.e. demand for money) on the horizontal axis, increase in demand for money would cause the demand curve to shift outwards in the short–run from the first equilibrium position to the second one, but at a higher equilibrium interest rate. As a result increase in the interest rate would attract the financial institutions lending money to provide more loans (i.e. supply more money) to the borrowers. Consequently, the supply curve shifts to the left to a third equilibrium position, but at a lower interest rate than the first equilibrium interest rate. Hence, in the long–run growth in demand for money leads to a reduction in nominal interest rate.

A 1 percent growth in real money balance could have brought about a rise in real interest rate within the range of 1.08 and 1.54 percent. This empirical evidence is in agreement with the argument that when we have the real interest rate on the vertical axis and the nominal money supply on the horizontal axis, any increase in demand for money in the long–run would cause the demand curve to shift to the left to a new equilibrium position, but at a higher interest rate level. Therefore, the conclusion reached is that growth in demand for money leads to an increase in the real interest rate.

Increase in nominal money supply was accompanied by reductions in real interest rate within the range of 1.05 to 1.13 percent (see Tables 2, 4, 6 and 9). This empirical evidence is supported by the argument that when we have the real interest rate on the vertical axis and the nominal money supply on the horizontal axis, any increase in aggregate money supply in the long–run would cause the supply curve to shift to the left to a new equilibrium position, but at a lower interest rate level. Therefore, the conclusion reached is that growth in money supply leads to a reduction in real interest rate.

This liquidity theory, therefore, is compatible with the loanable funds theory that the study is advancing. Thus, given an exogenous shock, the system maintains itself at full employment by changes in equilibrium interest rate. Any fall in supply of money (e.g. lending) would perfectly be offset by an increase in real interest rate and vice versa. Similarly, any shift in demand for real money balance (e.g. borrowing) will cause via interest rate an offsetting change in money supply (e.g. lending) so as to cause full employment.

By regressing one lag of money supply on interest rate, the monetary timing evidence reveals how the rate of money growth moves relative to the real interest rate. Timing evidence is based on the principle that if one event occurs after another, the first event must have caused the second one (Mishkin, 2014, p.611). Over the study period the money supply growth occurred before real interest rate did. In fact a 1 percent money supply growth in every past one year could have caused the current real interest rate to fall within the range of 0.76 to 1.05 percent per annum on average (see Tables 9 and 10). The conclusion that we reached on the basis of this evidence is that money growth caused reductions in real interest rate within the 1984 to 2007 period, but affected the real interest rate with lag of one year. This finding proves wrong the criticism shared by many Post Keynesians such as Lavoire (1994) who reject the liquidity preference theory on the grounds that it involves the assumption of exogenous money supply. The Post Keynesians believe that in a modern credit economy, the money supply is caused by the demand for it, as a result, any change in demand automatically brings about a change in supply (Moore, 1988a, p.252). Their rejection of the idea of interest rate as a price coordinating the demand and supply of money is therefore found to be baseless.

Aggregate income had a positive influence on both the real and nominal interest rates. A 1 percent growth in aggregate income causes nominal interest and real interest rate to increase by 1.2 and 1.4 percent respectively within the 1984–2007 period (see Tables 5, 6 and 10). Moreover, a 1 percent growth in aggregate income in the past one year could have caused the current real interest rate to rise by 3.36 percent per annum (see Table 10). These two sets of evidence on aggregate income reveals that people demand money (or borrow) because they would like to make transactions to satisfy their individual wants or run some projects in order to earn some income.

A 1 percent growth in income of lenders' as a percent of nominal aggregate money supply led to 1.13 and -1.22 percent growth in nominal interest rate and real interest rate respectively. This finding is supported by the arguments that increase in the lenders' income reflects the capacity of the financial institutions to supply more money and that in the financial markets the lenders make their decisions based only on real interest rate and the nominal money supply. Similarly, a 1 percent increase in the borrowers' income as a percent of real aggregate demand for money (i.e. real money balance i.e. money held by the public) might have raised the real interest rate and the nominal interest rate by -1.54 and 1.55 respectively (see Tables 12 and 13). That is because increase in the borrowers' income reflects increase in demand for money and the borrowers make their decisions based only on real money balance and nominal interest rate.

Inflation comes about if growth in supply of money is greater than the growth demand for money. The argument is supported by a 1 percent growth in money supply and real money balance that might have caused 1.08 and -1.5 percent growth respectively in inflation (see Table 14). Therefore, it is the growth in aggregate money spent not the aggregate money stock saved that is responsible for inflation. This conclusion is confirmed by the fact that a 1 percent growth in the borrowers' spending and lenders' savings caused 2.33 and -1.47 percent rise in inflation respectively within the given period (see Table 15). These two sets of empirical evidence are based on the fact that growth in money supply causes increase in nominal interest, and growth in demand for money leads to a rise in real interest rate. Yet, the inflation rate is the nominal interest rate less real interest rate.

7. CONCLUSION

The definition of interest rate as a ratio of future value of money to present value of money of future income helped us in developing some theoretical models and propositions that were econometrically tested and found to be reliable. Therefore, it was worthwhile for the research to be motivated by the Fisher's (1907) definition of interest rate as an index of the preference for present value of money over the future value of money income. Empirical evidence reveled that: (i) money supply had a positive influence on nominal interest rate and a negative effect on real interest rate. (ii) demand for money had a negative influence on nominal interest rate, but a positive influence on real interest rate and (iii) income had a positive influence on both real and nominal interest rates in Uganda within the period from 1984 to 2007. Money supply and real income were found to affect real interest rate with a lag of one year. Hence, it was right for us to treat money supply as an independent variable and interest rate as a dependent variable. Thus, money supply as an independent variable could be used to control real interest rate.

Further, empirical evidence revealed that increasing incomes of borrowers was inflationary, but increasing incomes of the financial institutions as lenders was not. Hence, government could control inflation by expanding the financial sector and improving upon their capacity to issue more long term loans to the public.

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LIST OF TABLES

Table 1 Nominal Interest Rate as Function of Real Interest Rate and Money

$\log(Rn+1)$	$=$	$0.77\log(R+1)$	$+$	$1.25d\log(Mn)$	$-$	$1.47d\log(M)$
t		4.59		10.97		-6.42
$\Pr ob.$		0.0002		0.0000		0.0000
		$R^2=0.84$		$D.W.=1.84$		$N=24$
		$Adj.R^2=0.82$		$F=54.55$		$1984-2007$

Table 2 Real Interest Rate as a Function of Nominal Interest Rate and Money

$\log(R+1)$	$=$	$0.65\log(Rn+1)$	$-$	$1.11d\log(Mn)$	$+$	$1.47d\log(M)$
t		4.59		-9.08		8.69
Prob.		0.0002		0.0000		0.0000
		$R^2 = 0.89$		$D.W. = 2.08$		$N = 24$
		$Adj.R^2 = 0.88$		$F = 84.52$		1984–2007

Table 3 Nominal Interest Rate as a Function of Money

$\log(Rn+1)$	$=$	$0.76\log(R+1)$	$+$	$1.22d\log(Mn/Y)$	$-$	$1.55d\log(M/Y)$
t		4.96		11.76		-7.13
Prob.		0–0001		0.0000		0.0000
		$R^2 = 0.85$		$D.W. = 2.12$		$N = 24$
		$Adj.R^2 = 0.84$		$F = 59.21$		1984–2007

Table 4 Real Interest Rate as a Function of Real Interest Rate and Money

$\log(R+1)$	$=$	$0.71\log(Rn+1)$	$-$	$1.13d\log(Mn/Y)$	$+$	$1.54d\log(M/Y)$
t		4.96		-9.20		7.95
Prob.		0–0002		0.0000		0.0000
		$R^2 = 0.89$		$D.W. = 2.18$		$N = 24$
		$Adj.R^2 = 0.88$		$F = 82.61$		1984–2007

Table 5 Nominal Interest Rate as a Function of Real Interest Rate, Income and Money

$\log(Rn+1)$	$=$	$0.70\log(R+1)$	$+$	$1.16d\log(Mn/Y)$	$-$	$1.51d\log(M)$	$+$	$1.93d\log(Y)$
t		4.15		9.32		-6.76		4.26
prob.		0.0005		0.0430		0.0015		0.0000
		$R^2 = 0.86$		$Adj.R^2 = 0.83$		$N = 24$		
		$D.W. = 2.16$		1984–2007		$F = 39.58$		

Table 6 Real Interest Rate as a Function of Nominal Interest Rate, Income and Money

$\log(R+1)$	$=$	$0.66\log(Rn+1)$	$-$	$1.11d\log(Mn)$	$+$	$1.40d\log(Y)$	$+$	$1.49d\log(M/Y)$
t		4.15		-8.78		3.26		7.12
prob.		0.0005		0.0000		0.0039		0.0000
		$R^2 = 0.86$		$Adj.R^2 = 0.83$		$N = 24$		
		$D.W. = 2.12$		1984–2007		$F = 39.58$		

Table 7 Nominal Interest Rate as a Function of Real Interest Rate and Money

$Rn+1$	$=$	$0.93(R+1)$	$+\ 2.32d(Mn)/Mn$	$-\ 2.34d(M)/M$
t		12.51	13.18	-6.71
Prob.		0.0000	0.0000	0.0000
		$R^2 = 0.83$	$D.W. = 1.97$	$N = 24$
		$Adj.R^2 = 0.81$	$F = 50.19$	1984–2007

Table 8 Real Interest Rate as a Function of Real Interest rate and Monetary Growth

$R+1$	$=$	0.64	$+\ 0.40(Rn+1)$	$-\ 0.62d(Mn)/Mn(-1)$	$+\ 1.08d(M)/M$
t		4.51	3.60	-8.30	4.40
Prob.		0.0002	0.0018	0.0015	0.0003
			$F = 50.10$	$R^2 = 0.88$	1984–2007
			$N = 24$	$Adj.R^2 = 0.86$	$D.W. = 1.70$

Table 9 Real Interest Rate as a Function of Demand for Money

$\log(R+1)$	$=$	0.31	$-\ 1.05d\log(Mn(-1))$	
t		8.43	13.41	
Prob.		0.0000	0.0000	
		$R^2 = 0.90$	$Adj.R^2 = 0.89$	$D.W. = 1.97$
		$N = 24$	$F = 179.82$	1984–2007

Table 10 Real interest Rate as a Function of Income and Money Supply

$\log(R+1)$	$=$	$3.36d\log(Y(-1))$	$-\ 0.76d\log(Mn(-1))$	
t		7.33	-12.42	
Prob.		0.0000	0.0000	
		$R^2 = 0.87$	$D.W. = 1.81$	$N = 24$
		$Adj.R^2 = 0.86$	$F = 142.18$	1984–2007

Table 11 Nominal Interest Rate as a Function of Money

$$Rn+1 = 0.18 + 0.92 d\ln(Mn) - 1.64 d\log(M)$$

t	13.97	5.87	−5.14
Prob.	0.0000	0.0000	0.0000
	$R^2 = 0.82$	$D.W. = 1.91$	$N = 24$
	$Adj.R^2 = 0.80$	$F = 47.31$	1984−2007

Table 12 Real Interest Rate as a Function of Borrowers' and Lenders' Incomes

$$\log(R+1) = 0.71\log(Rn+1) + 1.13 d\log(Y/Mn) - 1.54 d\log(Y/M)$$

t	4.96	9.20	−7.96
Prob.	0.0000	0.0000	0.0000
	$R^2 = 0.89$	$D.W. = 2.18$	$N = 24$
	$Adj.R^2 = 0.88$	$F = 82.62$	1984−2007

Table 13 Nominal Interest Rate as a Function of Real Interest Rate and Incomes

$$\log(Rn+1) = 0.76\log(R+1) - 1.22 d\log(Y/Mn) + 1.55 d\log(Y/M)$$

t	4.96	−11.76	7.13
Prob.	0.0001	0.0000	0.0000
	$R^2 = 0.85$	$D.W. = 2.12$	$N = 24$
	$Adj.R^2 = 0.84$	$F = 59.21$	1984−2007

Table 14 Difference in Interest Rates (Inflation) as a function of Monetary Growth

$$dP/P = 1.08 d(Mn)/Mn(-1) - 1.50 d(M)/M(-1)$$

t	22.01	−8.08	
Prob.	0.0000	0.0000	
	$R^2 = 0.94$	$Adj.R^2 = 0.94$	$D.W. = 2.11$
	$N = 24$	$F = 340.49$	1984−2007

Table 15 Inflation as a Function of Incomes of Borrowers and Lenders of Money

$$dP/P = 2.33 d(Y/M)/(Y(-1)/M(-1)) - 1.49 d(Y/Mn)/(Y(-1)/Mn(-1))$$

t	8.28	−16.00	
Prob.	0.0000	0.0000	
	$R^2 = 0.91$	1984−2007	$D.W. = 1.95$
	$Adj.R^2 = 0.91$	$F = 222.08$	$N = 24$