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An econometric analysis of money demand function in Sudan, 1960 to 2010

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This study is an attempt to test the existence of a stable money demand function in Sudan during the period, 1960 to 2010. The money demand function includes real money balances, real GDP (as scale variable), the rate of inflation and exchange rate (as opportunity cost of holding money balances variables). The study applies cointegration and error correction models to examine the behavior of money demand during the period of analysis, all included variables have been expressed in logarithmic form (with the exception of inflation rate). Based on time series data (annually observations), cointegration results reveal that there is a long-run relationship between real money balances and the explanatory variables. In this long-run relationship, the estimated coefficients are consistent with the economic theory behind the demand for money. Error correction model (ECM) has been used to estimate the short-run money demand function, in which the estimated coefficients are also consistent with the economic theory and generally weaker in magnitude than those related to the long-run equilibrium. In this study, after incorporating the stability tests, the empirical results show that the money demand function is stable between 1960 and 2010. The study concludes that it is possible to use the narrow money aggregate as target of monetary policy in Sudan.

Key words: Money demand, cointegration, error correction, stability, Sudan.

INTRODUCTION

Over the last few decades, modeling, estimating and examining the stability of money demand function in an economy has become a fertile area for research that have attracted most attention of economists, researchers and policy makers in both developed and developing countries [for the cases of developed countries, Arango and Nadiri (1981), McNown and Wallace (1992), Hoffman et al. (1995), Bohl (2000) and Gerlach and Svensson (2004). For developing countries, for examples includes, Weliwita and Ekanayake (1998), Arize et al. (1999), and Bahmani-Oskooee and Tanku (2006)], this is simply because empirical estimation of this function is of crucial importance, particularly to the policy makers, in ensuring that monetary policies can be conducted effectively.

According to Friedman (1956), money demand function assumes that there is a stationary long-run equilibrium relationship between money balances, real income, and the opportunity cost of holding real balances that formulated the demand for money function. Since the introduction of cointegration analysis by Engle and Granger (1987), this relationship has received a renewal attention, particularly the stability issue of economists who have warred about changes in the demand for money, since demand shocks can affect output variability and have implications for monetary policy; for example, Kontolemis (2002) expresses, stability of long run money demand function is an important factor of long run growth rates of monetary variables.

There has always been an extensive literature examining the stability of money demand functions in the context of developing and developed countries, nevertheless, until recently, there was very little research on money demand estimation in the context of Sudan

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economy. Two earlier works were done by Domowitz and Elbadawi (1987) and Abdel-Rahman (1993), and to the best of our knowledge, since that time, the stability issue has not been probed in the Sudanese context, this paper aims to address this shortcoming and contribute to the literature on the stability/instability of the demand for money in developing countries for the period 1960 to 2010.

The main purpose of this paper is to reconsider the demand for money in Sudan and test not only its cointegration properties but also for its stability over time. More specifically, the paper tries to answers the question: Is there a stable demand function for money in Sudan during the period 1960 to 2010? The money demand is constructed by means of cointegration using annually data, followed by an error correction model.

LITERATURE REVIEW

There has been a vast number of empirical studies that has investigated the demand for money in both developed and developing countries. Bahmani-Oskooee and Malixi (1991) estimate the demand for money function in 13 developing countries as a function of inflation, real income and the real effective exchange rate. They conclude that, *ceteris paribus*, depreciation in real effective exchange rate results in a fall in the demand for domestic currency. Kallon (1992) investigate the stability of Ghanaian demand for real money balances during 1966 to 1986 period. The results failed to reject the null hypothesis of structural stability. The study also finds evidence of the nominal adjustment specification as the appropriate short-run adjustment mechanism for the demand for real M1 balances. Further suggestion of foreign interest rates not having any significant effect on the demand for money in Ghana was evidenced. Simmons (1992) investigated the demand for narrow money for five African countries (Democratic Republic of the Congo, Cote d'Ivoire, Mauritius, Morocco and Tunisia) within an ECM framework. This study emphasizes the role of opportunity cost variables including the domestic interest rate and expected exchange- rate depreciation. His empirical results indicate that the domestic interest rate is an important determinant of the demand for money functions for three of the five countries, whereas external opportunity cost variables are significant for only one of the others. He also finds that in four out of five cases inflation plays an extremely important role in determining the demand for money. Pradhan and Subramanian (1997) suggested that money demand function is stable not only with M1 but also with M3 and the error correction term for both M1 and M3 money supply definitions was found out to be negative and significant. Nachega (2001) applies a cointegration analysis and error correction modeling to investigate the behavior of broad money demand in Cameroon over 1963/64 to 1993/1994. The cointegrated VAR analysis identified a stable money demand function and an excess aggregate demand relationship for Cameroon. Further empirical estimates provided support for both purchasing power parity (PPP) and an internationall Fisher parity between Cameroon and France. Mohsen and Charikleia (2005) examined the stability of the demand for monetary aggregates M1 and M2 in Greece using quarterly data for the period 1975I to 2002IV. The estimation methodology employed the cointegration analysis approach and the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests for the stability of the money demand function. The econometric model included a vector of interest rates and the real income as the determinant factors. The estimation results showed that both monetary aggregates are cointegrated with income and interest rate. The income elasticity is positive while the interest rate elasticity is negative. However, the stability tests revealed that only M1 is a stable function but not M2. Qayyum (2005) estimated the dynamic demand for money (M2) function in Pakistan by employing cointegration analysis and error correction mechanism. The parameters of preferred model were found to be super-exogenous for the relevant class of interventions. It was also found that the rate of inflation is significant determinant of money demand in Pakistan. The analysis reveals that the rates of interest, market rate, and bond yield are important for the long-run money demand performance. Ranani (2007) estimated the demand for money in Iran using the autoregressive distributed lag (ARDL) approach to cointegration analysis. The empirical results showed that there is a unique cointegrated and stable long-run relationship among M1 monetary aggregate, income, inflation and exchange rate. The study also found that the income elasticity and exchange rate coefficient are positive, while the inflation elasticity is negative. After incorporating the cumulative sum (CUSUM) and CUSUMSQ tests, results reveal that the M1 money demand function is stable between 1985 to 2006. Recently, empirical results of Inoue and Shigeyuki (2008) indicate that an equilibrium relation in money demand exists only when money supply was defined as M1 and M2, not for M3. Cointegration test result indicates that a co-integrating vector is detected among real money balance, interest rates, and output when money supply is represented by M1 and M2 but no long-run equilibrium relationship is found for M3. Shigeyuki (2008) analyzed the money demand function in Sub-Saharan African, his empirical results revealed that there exists a cointegrating relationship of the money demand function in the Sub-Saharan African region. In other words, there is a close relationship between the money supply and the real economy over the long term, and monitoring money supply promises to play an important role in stabilizing the level of prices in this region. Han and Pei-Tha (2009) indicated that ECM

clearly showed that there is a long-run relationship between real money balances and its determinants.

For the case of Sudan, the stability of money demand was firstly investigated by Domowitz and Elbadawi (1987) and Abdel-Rahman (1993). Domowitz and Elbadawi implement an error-correction approach to check the stability of money demand function over the period 1956 to 1982 using two metrics based on out – of – sample forecasting performance. The stability tests of the model proved that stable demand for money in Sudan exists. While Abdel-Rahman studied the demand for narrow money balances to investigate the effects of high inflation on the formulation of adjustment and error correction mechanisms governing basic money demand function; the empirical results showed that sources of instability in money demand stem from the occurrence of a high and rapidly accelerating inflation.

SPECIFICATION OF MONEY DEMAND MODEL IN SUDAN

While investigating the money demand function, a critical point to consider is the identification problem. By this notion, we mean the non-observability of the money demand. We can only measure the quantity of money supplied. And in this point, we have to make an important supposition that the quantity of money supplied and demanded equal each other, thus assuming equilibrium in the money market (Laidler, 1973). Demand for money refers to the functional relationship between the quantity of money demanded and its determining factors. There is an extensive literature on the theory of this relationship, the general agreement in the literature is that a money demand function should contain a scale variable relating to the level of transactions in the economy and a variable representing the opportunity cost of holding money. The principal issues in constructing a demand for money function, therefore, relate to the definition of the money stock (monetary variable) and the appropriate specification of scale "income" and opportunity cost variables, besides some other variables that might systematically affect the demand for money function.

Monetary variable

The definition of money which will be taken to deal with in the estimation of money demand function in Sudan is a narrow one, M_1, including currency in circulation plus demand deposits, as defined by the Central Bank of Sudan. The reason is that the analytical work on M_1 was more amenable to control by the monetary authorities, also studies on a number of developing countries indicate that the models using narrow definition of money better than those employing broad money reflecting the weak banking system and low level of financial sector development (Moosa, 1992; Hossain, 1994).

Scale variable

The first determinant of the money demand function is the scale variable measuring the level of economic activity. The holding of money and thus the demand for money are related to the volume of the transactions, using the fact that the amount of the transactions is proportional to the level of income. Either a wealth variable or an income variable can be used as a scale variable. Generally, when wealth data is not available, an income variable like the Gross National Product (GNP) or Gross Domestic Product (GDP) can be taken into consideration. In our case, the scale variable which will be used in the estimation process is the Sudanese Gross Domestic Product (GDP), which is based on the national income account.

Opportunity cost variable

An opportunity cost variable in a demand for money function is intended to measure the yield on money against other assets that might be held. In financially developed economies, this variable is usually an interest rate. However, when dealing with the case of developing country like Sudan, where interest rates were abolished within Islamization package for the economy effected in 1984, it would be useful to make use of inflation rate as the proxy for the interest rate variable (Many researchers often use the inflation rate as the proxy for the interest rate variable for example, Bahmani-Oskooee and Tanku (2006) and Budina et al. (2006).

The relationship between inflation and the demand for money has been studied widely. If there are high fluctuations in prices, the rate of inflation becomes an important determinant of the money demand function. Money demand (in real terms) is inversely related to expected inflation rate, since an increase in inflation increases the cost of holding money. Because the Sudanese economy is subject to not only a high degree of price level but also a high variability in the prices, the price level has a considerable impact on the return of financial assets; as money holders will have difficulties in predicting the prices, the risk in saving money will raise and consequently the holding of money will tend to decrease.

Other variables

Moreover, taking the currency substitution phenomenon into account, many studies on the demand for money in developing countries often include exchange rate variable in money demand function. This inclusion of exchange rate variable in the standard function of money demand is first suggested by Mundell (1963). Accordingly, the general specification of money demand function is assumed to take the following functional form:

$$\frac{M}{P} = f(y \quad , \quad INF \quad , \quad Exch)$$

where M/P is the demand for real money balances founded by dividing nominal money balances (M1) to price index (P); y is the real income level which represents the scale variable. INF and $Exch$ are respectively the inflation and real exchange rates. The exchange rate, here, is defined as the amount of domestic currency per unit of foreign currency. Therefore, the increase (decrease) of $Exch$ is interpreted as the depreciation (appreciation) of domestic currency against foreign currency. The long-run money demand function, when log transformed, reads as follows:

$$Log\left(\frac{M}{P}\right) = \beta_0 + \beta_1 Log(y_t) + \beta_2 (INF_t) + \beta_3 Log(Exch_t) + \varepsilon_t$$

where ε represents an error term which is assumed to be a white

Table 1. Augmented Dickey-Fuller (ADF) test for variables in levels.

Variable	Intercept		Trend and Intercept	
	t-test statistics	Lag length	t-Test statistics	Lag length
Log M/P	-1.903	4	-3.21*	0
Logy	-1.593	1	-3.140	0
INF	-1.531	1	-1.361	1
Log exchange	-1.011	2	-2.745	2

* indicates rejection of the null hypothesis of unit root at 10% significant level.

Table 2. Augmented Dickey-Fuller (ADF) test for variables in first difference.

Variable	Intercept		Trend and Intercept	
	t-test statistics	Lag length	t-test statistics	Lag length
Log M/P	-7.413**	2	-	-
Logy	-2.734*	1	-2.952**	1
INF	-5.086**	2	-9.672**	0
Log exchange	-4.751**	0	-4.768**	0

* and ** indicates rejection of the null hypothesis of unit root at 10 and 1% significant level, respectively.

noise error. Based on the conventional economic theory, the income elasticity coefficient, β_1, is expected to be positive; the coefficient of inflation, β_2, is expected to be negative. For the elasticity coefficient on the exchange rate variable (β_3), it can be either positive or negative. If the increase in exchange rate (depreciation) is perceived as the increase in wealth and leads to the rise of domestic money, the coefficient of exchange rate is positive. But, if the increase in exchange rate leads to the decrease in domestic money demand (currency substitution), then the coefficient of exchange rate is negative. The coefficients of variables in logarithms specify the long run elasticities (that is, income elasticity and exchange rate elasticity), where as the coefficient of the inflation, which is not expressed in logarithm form, is the long-run semi-elasticity.

The short-run specification of the demand for money in Sudan will be of the following form:

$$\Delta Log\left(\frac{M}{P}\right)_t = \alpha_0 + \alpha_1 \Delta Log\left(\frac{M}{P}\right)_{t-1} + \alpha_2 \Delta Log\ (y_{t-1}) + \alpha_3 \Delta (INF_{t-1}) + \alpha_4 \Delta Log\ (Exch_{t-1}) + \alpha_5 ECM_{t-1}$$

where variables are as defined earlier. ECM_{t-1} is the error correction term (lagged one period).

Data issue

The data which will be used in estimating money demand function in Sudan are annual observations over the period 1960 to 2010, on real narrow money M1, real GDP, exchange rate (official), and inflation rate. These four series were obtained from the Central Bank of Sudan (CBoS) statistical annual reports.

EMPIRICAL RESULTS

In the first step, the variables are tested for stationarity using Augmented Dickey-Fuller (ADF) tests. The second step involves testing for cointegration among the integrated variables. In this paper, the Johansen (1991) maximum likelihood procedure is used. Provided that one or more cointegrating relationships exist, the third step of the standard procedure involves the estimation of a VEC specification containing the cointegrating relationship(s), lagged first differences of the variables in the cointegrating relationship(s), and any stationary variables thought to influence money demand.

Testing for stationarity

At the first step, the Augmented Dickey –Fuller (ADF) (Dickey and Fuller, 1981) unit root test is applied to all the variables to test for the stationarity of these variables. The test is applied to both the original series (in log form) and to the first differences. Results of this test are reported in Tables 1 and 2, respectively.

The results, reported in Table 1, indicate that all the series are non-stationary at their level when the model only included intercept and also when including trend and

Table 3. Johansen cointegration test of the demand for money in Sudan for the period 1960 to 2010.

Eigen value	Likelihood ratio	5% critical value	1% critical value	Hypothesized no. of CE(s)
0.596169	73.70229	47.21	54.46	None**
0.392425	34.71167	29.68	35.65	At most 1*
0.220738	13.28562	15.41	20.04	At most 2
0.057820	2.561052	3.76	6.65	At most 3

*(**) denotes rejection of the hypothesis at 5% (1%) significance level.

Table 4. Normalized cointegrated coefficients.

Log M/P	Log y	Log exchange	Inflation	Constant
1.0000	-0.985548	0.490386	1.028274	-23.08868

intercept. The only exception is that Log M/P is stationary in the latter case. On the other hand, when taking the first difference of the variables, Table 2 shows that the variables become stationary which mean that, these series are integrated of order one, I(1).

Cointegration analysis of real money demand function in Sudan 1960 to 2010

The cointegration results are presented in Table 3. According to the results, the hypothesis that "no cointegrating vector exists" is rejected in favor of "at least one cointegrating vector exists" both at 5 and 1% significance level, on the other hand the existence of at most two cointegrated vectors is not rejected at 5% level. Based on this model, the cointegrating vector representing the long-run money demand function for real M1 is as shown in Table 3.

According to the results shown in Table 3, LR indicates 2 cointegration equations at 5% significant level.

Based on the results shown in Table 4, the cointegrating vector representing the long-run money demand function for real M1 is as follows:

$$Log\left(\frac{M}{P}\right)_t = 23.0887 + 0.9855\ Log\ (y_t) - 1.0283\ (INF_t) - 0.4903\ Log\ (Exch_t) + \varepsilon_t$$

The estimation results of log-run elasticities of the demand for money are compatible with economic theory behind the demand for money. The long-run money demand function has approximately unit income elasticity. The real exchange rate has also a negative sign; as an increase in the real exchange rate implies an appreciation of Sudanese Pound, when the domestic currency appreciates, the demand for real money balances tends to decrease. On the other hand, money demand is negatively affected by the annual rate of inflation since it shows the return on real assets. The semi-elasticity of the inflation rate is -1.028, which means that the impact of the expected inflation on real balances is substantially important in the model.

Dynamic error correction model

After the determination of the cointegrating relationship, the next step is to estimate the short-run demand for broad money using an error correction model (ECM). The short-run model coefficients measure the dynamics of the model, the ECM measures the speed of adjustment to the long run equilibrium which is taking place. A one year lag was applied. The results of error correction model are presented in Table 5.

Based on the ECM results appearing in Table 5, a full model is constructed in the form of a single equation for the analysis of the short-run dynamics of real money balances.

Being the first difference of log real M1 on the left hand side of the equation, the right hand side comprises one lagged term of differenced log real M1, first differences of other variables, and one lag of the stationary error term.

$$\Delta Log\left(\frac{M}{P}\right)_t = 0.5412 - 0.3816\Delta Log\left(\frac{M}{P}\right)_{t-1} + 0.3524\Delta Log(y_{t-1}) - 0.0022\Delta(INF_{t-1}) - 0.0002\Delta Log(Exch_{t-1}) - 0.4348ECM_{t-1}$$

Table 5. Short-run model of the demand for money in Sudan, 1960 to 2010.

Variable	Coefficient	S.E	T. Statistic
Constant	0.541192	-	-
$\Delta LogM_{1t-1}$	-0.381582	0.21602	-1.76638
$\Delta Logy_{t-1}$	0.352440	0.25765	1.36792
$\Delta LogExch_{t-1}$	-0.000241	0.04594	-0.00525
ΔINF_{t-1}	-0.002210	0.00103	-2.15350
ECM_{t-1}	-0.43484	0.10104	-4.30350

Now, all the estimated coefficients of included variables are consistent with economic theory, that is, income elasticity is positive and the exchange and inflation rates have a negative elasticities. Beside, the error correction term has the expected sign. The negative coefficient of the error correction term is significant, assuring that the cointegration relationship between the included variables is valid. Looking at the other coefficients, we conclude that the income elasticity falls to 0.352440, whereas the impacts of exchange rate and the annual inflation rate decrease considerably in the short run.

Parameter constancy

Parameter constancy is a critical issue for money demand equations. In particular, to be able to interpret the estimated equation as a money demand equation, it is necessary to assure that the parameters are stable over the estimation period. To achieve this, the study implemented the methodology based on the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMSQ) tests proposed by Brown et al. (1975). The advantage of such a test over some other tests (Like Chow test) is that the former test requires the specification of the break points, while the latter test uses the cumulative sum of recursive residuals based on the first n observations and is updated recursively and plotted against break point (Ouattara, 2004). On the other hand, CUSUMSQ test uses the squared recursive residuals in the same manner as CUSUM test.

The decision about the parameter stability relies on the position of the plot relative to the 5% critical bound. The CUSUM test is based on the cumulative recursive sum of recursive residuals. The CUSUMSQ test, on the other hand, is based on the cumulative sum of squares of recursive residuals. Both the CUSUM and CUSUMSQ test statistics are updated recursively and plotted against break points in the data. For stability of the short-run dynamics and the long-run parameters of the real money demand function, it is important that the CUSUM and CUSUMSQ statistics stay within the 5% critical bound (represented by two straight lines whose equations are detailed in Brown et al., 1975 aforementioned). A graphical presentation of these two tests is provided in Figures 1 and 2.

As it can be seen from Figures 1 and 2, neither the CUSUM nor CUSUMSQ plots cross the 5% critical lines, therefore, we can safely conclude that the estimated parameters for the short-dynamics and long-run of the real *M1* money demand function in Sudan are stable. In other words, a stable real *M1* demand function exists over the entire sample period.

SUMMARY AND CONCLUSIONS

This study has examined both the determinants and the stability of the demand for money function in Sudan over the period 1960 to 2010. The Johansen Maximum Likelihood procedure shows that there is a long-run relationship for real money in Sudan. In this long-run relationship, the empirical findings stress the existence of a positive relationship between money aggregates and the level of income, also the income elasticity is found to be near unity, a result that is consistent with the economic theory; in addition to that, both the inflation rate and exchange rate are found to negatively affect M1. The negative effect of inflation rate on M1 supports the theoretical expectation that as the inflation rate rises, the demand for money falls. This indicates that people prefer to substitute physical assets for money balances. The results of stability tests reveal that M1 money demand in Sudan is stable over the period of the study. These results suggest that it is possible to use the narrow money aggregate as target of monetary policy in Sudan.

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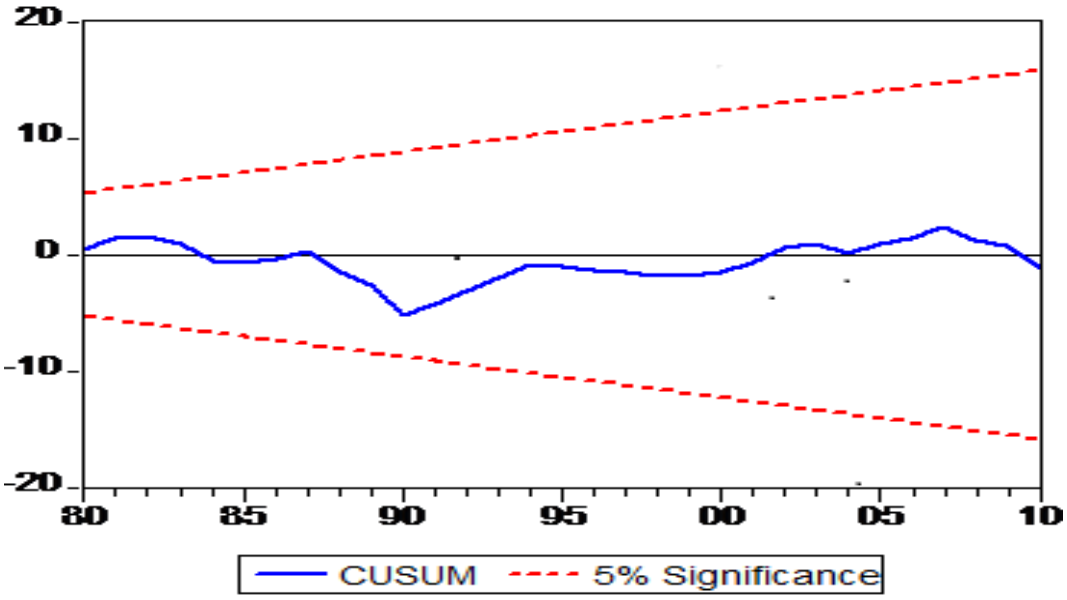

Figure 1. CUSUM of recursive residuals of the demand for money function for Sudan (1960 to 2010).

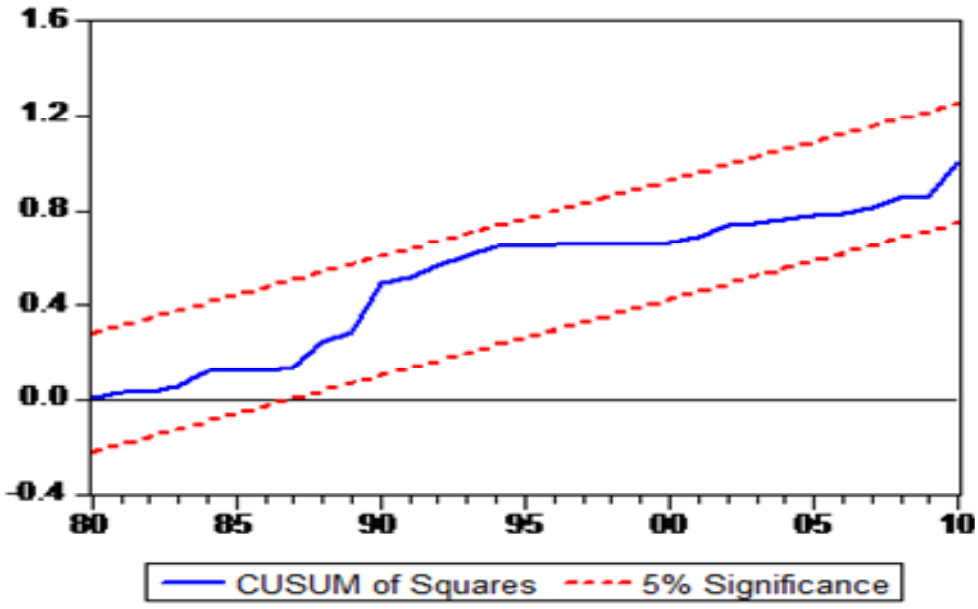

Figure 2. CUSUM of squares of recursive residuals of the demand for money function for Sudan (1960 to 2010).

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