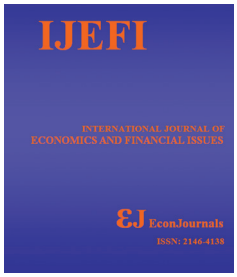

International Journal of Economics and Financial Issues

ISSN: 2146-4138

available at http: www.econjournals.com

International Journal of Economics and Financial Issues, 2020, 10(2), 87-98.

Velocity of Money Income and Economic Growth in Sudan: Cointegration and Error Correction Analysis

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Received: 06 November 2019 **Accepted:** 05 February 2020 **DOI:** https://doi.org/10.32479/ijefi.8944

ABSTRACT

This study explores the linkages between velocity of money and economic growth in Sudan using conitegration and error correction methods in the context of the quantity theory of money (QTM) without inclusion of institutional factors. Cointegration analysis confirms existence of a long run equilibrium relationship between velocity of money and economic growth. The empirical analysis shows that velocity of money is significantly and positively affected by GDP and broad money, validating the QTM. Velocity of money is also found to be positively affected by trade openness, government deficit but negatively affected by inflation and investment. Granger causality test shows unidirectional relationships running from GDP, inflation and financial development to velocity of money. A bidirectional causality between velocity and trade openness is detected. These findings suggest that velocity of money is driven mostly by expansionary monetary policy and monetization of government deficit, which should be controlled.

Keywords: Velocity of Money, Gross Domestic Product, Inflation, Financial Development, Unemployment, Trade Openness
JEL Classifications: C32, E10, E40, E63

1. INTRODUCTION

Understanding the velocity of money income and its determining economic and behavioral factors is vital for credible monetary policy and for the overall macroeconomic stability and economic growth. Addressing this issue is particularly important in the context of low income countries including Sudan, at least for three reasons. First, in these countries fiscal and monetary expansion and macroeconomic instability and inflationary pressures are high. Secondly, highly volatile macroeconomic indicators reflect volatile and unstable money supply and velocity of money which in turns indicate incredible monetary policy. Thirdly, weak institutions which undermine implementation of monetary and financial policies even if these policies are well designed. Study of the determinants of velocity of money and economic growth has gained momentum and empirical studies are vast from both developed and low income countries. The recent history of investigation of the velocity of money is back dated to Milton Friedman's (1956) influential contribution where the velocity is formulated on the basis of economic theory of the permanent income hypothesis. Friedman (1983 and 1984) linked velocity to economic uncertainty, arguing that velocity falls when economic uncertainty increase, since people would hold money as a precaution. However, uncertainty may cause, or result from, money and volatility of money in circulation. Thus, it is expectable that the permanent income is positively relates to the velocity of money income and increases in permanent income lead to increases in the number of transactions in the economy thereby affecting the velocity positively.

According to Bordo and Jonung (1990) a positive but less than unity coefficient of the relationship between velocity and money income would indicate that the velocity moves pro-cyclically and would be consistent with the Friedman's permanent income hypothesis and the transitory income would increase the demand for money, because cash balances serve as a buffer stock. In the long run these transitory balances would then be worked off implying a unity coefficient. With a given level of income, the real interest rate is also expected to have a positive effect on

velocity as an increase in it would decrease the demand of real money balances. The impact of the inflation on velocity could be positive or negative depending upon its relative influence on money balances and income growth. However, the velocity of money in circulation can induce inflation when it is high or deflation when it is low and thus, the velocity is a vital constraint on the value of money and output growth. Emphasizing the role of modeling choice, Granger and Uhlig (1990) investigated the effect of interest rates and inflation on the velocity of money together with gross national product and variability of money. They show that different models allow for different conclusions within the top 20% range of R^2 as change in the behavior of the velocity of money coincides with shift of real interest rates from negative values to positive values and also with money-base variability but with no clear effect on velocity. Also, according to Fisher as stated in Humphrey (1993) when interest rates rise, cashholders avoid carrying too much money thus prompting a rise in velocity. Expected inflation creates a tendency among owners of money to spend it speedily which results in raising prices by increasing the velocity of circulation. And on real income, the rich spend money faster and if a nation grows richer per capita, the velocity of circulation of money will increase. Other strand of literature on velocity uses the conventional money demand function have followed Arango and Nadiri (1981) approach which has been severely criticized for being ad hoc and lacking theoretical foundation. In fact velocity is another way in which money demand function can be expressed (Siklos, 1993). Siklos (1993) emphasized the role of institutional factors beside other conventional determinants of velocity of money. He applies tests of cointegration to assess whether institutional factors, income and an interest rate, explain the long run behavior of velocity using annual data over the period 1870-1986 from five industrialized countries. The author finds that institutional characteristics make a significant contribution to the determination of velocity in all the countries and generally rejects the hypothesis of cointegration between velocity and its traditional determinants but the same hypothesis cannot be rejected when velocity is also modeled as a function of institutional changes.

The role of monetary policy on money and its circulation has been widely debatable among economists, particularly from macroeconomics perspective. Broadly, the Keynesians argue that money does not matter and hence irrelevant to influence economic growth, the Monetarists argue that money matters, and thereby urging for the use of monetary policy to influence economic growth. The classical economic theory argues that money in neutral stating that changes in the aggregate money supply affect nominal variables, rather than real variables, and as a result, an increase in the money supply would increase all prices and wages proportionately, but has no effect on real GDP, unemployment levels or real prices. However, the neutrality of money is considered a plausible scenario over long-term economic cycles, but not the short run cycles. In contrast, the New Keynesians argue that in the short-run, changes in the money supply affect real variables such GDP and employment levels because of price rigidity and stickiness.

Analysis of the velocity of money and economic growth has been widely treated within the context of the equation of exchange involving money supply, velocity, price level and output. In the classical context, given velocity and output a change in money supply induces a proportional change in the price level. According to the classical thought when the economy produces at full employment, output may be constant, but a constant velocity is harder to justify. Marshall (1923) suggested that velocity may be slow to change because habit determines the share of income that people spend. In contrast, modern theories of velocity tend to explain why velocity changes. The institutional approach attributed to Bordo and Jonung (1981) and later Siklos (1993) focuses on monetization, innovation and stability. The argument is that at first, monetization increases the ratio of money supply to spending, so velocity declines; over time, financial innovations accumulate and the economy stabilizes, increasing the efficiency of spending and consequently velocity. Bordo and Jonung (1981; 1987 and 2004) using long term data examined the behavior of velocity among a number of developed economies, find that velocity declined in these economies in phase of monetization and then recovered with the financial innovations and deregulations. Bordo and Jonung (1990) suggest that in an economy where interest rate is not free to respond to the market forces the expected inflation should be included in the demand function. As a tool for empirical analysis, the authors used ordinary least square in most of their studies. Later, Bordo et al. (1997) provide methodological support to their institutional hypothesis using cointegration and the error correction techniques. Another approach is computational approach which attributes the volatility of velocity to the household's smoothing decisions of consumption over time (Cao-Alvira, 2012).

In econometric models, the velocity of money income has been commonly expressed as a function of interest rates, equity yields, expected inflation, wealth, real income, tastes and technology variables, including degree of monetization, spread of banking, money substitutes, and confidence in the future stability of the economy (Humphrey, 1993). In enumeration of these factors affecting velocity, Humphrey provides a thorough historical overview of the origins of the velocity of circulation from William Petty through Irving Fisher to Melton Friedman. In particular, in the context of the equation of exchange model due to Fisher (1911), relative contributions of the variations of output, prices and money supply to the variations of velocity can be easily computed. However, modeling velocity and income growth is hard partly because of its link to lagged money volatility.

On the other hand, a considerable number of studies have explained the causal effects of money supply or its velocity of circulation on fluctuations of macroeconomic variables in both transitional and emerging economies. A general outcome of these studies is that the low level of economic growth in some African countries for example can partly be traced to the failure of the monetary authorities to sustain disciplined monetary policies capable of controlling and managing inflows of cash assets in circulation. Montiel (1995) and Emenuga (1996) argue that the possible effects of money in circulation on growth can manifest in three different channels, namely, increasing the rate of savings; improving the efficiency of financial intermediations and the efficiency of capital

stocks. Also, the modern macroeconomic theories in relation to money and economic development seem to agree that there is a systematic relationship between money and growth (Bemanke and Blinder, 1992). Earlier studies such as Cagan (1956), Sims (1972) and Wachtel and Rousseau (1995) have found a strong support for a positive relationship between money and growth and also replicated by Mansor (2005) for Malaysia and Owoye and Onafowora (2007) for Nigeria. Recently, Richard et al. (2016) offer a single model that tracks the velocity of broad money (M2) since 1929, including the Great Depression and recession and the global financial crisis emphasizing the roles of changes in uncertainty and risk premia, financial innovation, and banking regulations. Their findings suggest an enhanced role of a broad, liquid money aggregate as a policy guide during crises. They conclude that following crises, policymakers face the challenge of not only unwinding their balance sheet so as to prevent excess reserves from fueling a surge in M2, but also countering a fall in the demand for money as risk premia return to normal amid velocity shifts with financial reforms.

On the light of the above discussions, the objective of this study is to investigate the behaviour of velocity of money in Sudan in relation to economic growth and to major internal and external factors but without explicit inclusion of political institutional factors.

2. LITERATURE REVIEW

Empirical literatures explain the behaviour of velocity of money against actual data seek to identify its determinants and its relations and causation with macroeconomic variables including economic growth rates and policy variables, monetary, fiscal and financial. This section provides unexhaustive review of the empirical literature on velocity of money income, economic growth and most commonly used other macroeconomic and policy variables. The literature surveyed comes within and extensions of the quantity theory of money (QTM) which either seeking causal relationships or more generally how velocity responds to its believed determining factors and the role of monetary policy.

Within the context of the QTM the strength as well direction of relationship between inflation and money supply in particular has been much investigated empirically. For Bangladesh, Taslim (1982) revealed that agricultural food prices contribute to the inflationary pressures, but growth in money stock remained the major factor behind severity of the price-hike. Lee and Li (1983) investigating the relationship between money and inflation in Singapore found a unidirectional relationship between growth in money supply and price levels. Joshi and Joshi (1985) found bidirectional causality between money and income in India. Yet, advances in the QTM claim that there exist proportional relationships between the growth rate of money supply and price level and that money must be neutral resulting from stationary velocity of money and unaffected real output in the long-run following permanent changes in the growth rate of money supply. Nachane and Nadkarni (1985) examined causality among money, output-inflation taking quarterly data for the period 1960 to 1981 for India. Their empirical results confirmed presence of unilateral relationship running from growth of money supply to the prices. Hall and Noble (1987) tested for Granger causality in United States data and concluded that the log of narrow money velocity was caused partly by its own lags and by lags of the volatility of money growth. Fisher and Serletis, (1989) find that Friedman hypothesis holds strongly in the USA using monthly data on nine measures of velocity over the period 1970-1985. Already, Thornton and Batten (1985) concluded that Granger causality estimates often depend on the lengths of the lags. Other studies indicated that these results might vary with the period studied, since the monetary environment evolves due to regulation and inflation (Brocato and Smith, 1989; Mehra, 1989). In a more elaborate way (Grauwe and Polan, 2005) argue that real output and velocity changes must be orthogonal to the growth rate of the money stock. Theoretical underpinnings of the QTM are examined for example by Friedman and Kuttner, (1992), Fisher and Seater (1993), King and Watson (1997) and Bullard (1999) among others. Thornton (1995) studying nine industrial countries finds evidence supporting Friedman's hypothesis for three of the nine countries, but only in certain time periods, arguing that the Friedman hypothesis would appear to have little general applicability.

Serletis and Krause (1996) and Serletis and Koustas (1998) using data from ten developed countries over 100 years give support for the long-run neutrality of money proposition. Serletis and Shahmoradi (2006) tested the Friedman hypothesis that money supply volatility Granger-causes velocity using both M1 and M2 of monetary aggregation, with quarterly data from 1959:1 to 2004:3. Their conclusion is that the Friedman hypothesis cannot be rejected if money supply volatility is modelled explicitly. Payne and Ewing (2011) re-examined the Friedman hypothesis that uncertainty about the future course of money supply growth influences velocity focusing on the relationship between money market rate variability and the income velocity of money in nine industrialized countries. After establishing cointegration between money market rate and velocity, they apply error correction techniques. They find that in eight of the nine countries (except Canada) there is statistical relationship between the variability of money market rate and the income velocity of money. Pinno and Serletis (2016) examined the relationship between money growth variability, velocity, and stock market return by estimating a trivariate VARMA, GARCH model for the United States using monthly data for the period 1967:1 and 2015:08. They calculate velocity as the CPI multiplied by industrial production index divided by monetary aggregate. Their empirical evidence shows that variability of money growth predicts velocity and stock market volatility has positive and significant effects on monetary velocity. They conclude that Friedman's money supply volatility hypothesis is alive and well.

Karfakis (2002; 2004) and Ozmen (2003) examine the validity of the QTM relationship for the case of Greece and find contradictory results in that a change in money supply followed by a proportional change in price level is not supported especially for the exogeneity/endogeneity characteristic of the money. Grauwe and Polan (2005) state that in the long-run, relationship between money growth and inflation is not a surprising phenomenon. They tested the causality between money supply and inflation using time series data of 30 years from 1969 to 1999 on a sample of 160 countries. Their empirical findings revealed a strong positive relationship, although not proportional between money supply and the inflation

as described by the QTM. Herwartz and Reimers (2006) in a panel based study analyse the dynamic relationships between money, real output and prices for an unbalanced panel of 110 economies and find that particularly for high inflation countries there is a homogeneous relationship between prices money cannot.

Khan and Siddiqui (1990) investigate the relationship between money, income and prices in Pakistan, using Granger causality approach. Their empirical results show existence of bidirectional relationship between money stock and inflation, as well as unidirectional relationship operating from income to money stock growth. Bilquees and Shehnaz (1994) document a slowdown in velocity between 1974-1975 and 1991-1992 in Pakistan. Using the number of bank branches as proxy for the financial development they conclude that financial development has significantly affected the velocity of money in Pakistan. Khan and Schimmelpfennig (2006) tested the applicability of QTM in Pakistan taking monthly data from January 1998 to June 2005 on monetary variables as well as wheat prices and found that inflation is a monetary matter, having no link with the food price growth in the long run, although food support prices were found to be a determinant of inflation in the short run. Mohammad et al., (2009) investigate the long run relationship among broad money, prices, fiscal policy and economic growth in Pakistan over the period 1977 to 2007, applying Johansen cointegration technique find presence of four cointegrating vectors among these variables. They show a long run bidirectional Granger causality relationship operating from money supply to prices and from prices to money supply. Omer, (2010) explores the stability of velocity of money in Pakistan. Their results show that the base and broad money velocities are independent of the interest rate fluctuations. It also found that velocities of M0, M1, and M2 have stable relationship with their determinants which validate use of monetary aggregates as nominal anchor. Azam and Salim (2015) analyze the significance of the monetarist explanation of inflation in Pakistan. They find slight effects of money supply on inflation while structural factors represented by wheat, oil and import prices have more substantial effects. They recommend that policy makers need to smoothen the supply of food and to moderate import prices.

Sakib (2011) tested applicability of the QTM in case of Bangladesh using time series data on policy variables from 1976 to 2006. Their study finds three cointegrating vectors between the money supply and price level, hence verifying the QTM. Applying Granger causality, their study finds unidirectional relationship between money supply and the prices. Abdullah et al. (2012) examined the impact of inflation on the change in real GDP and the relation between inflation and monetary policy over the period 2000 and 2011 in Bangladesh. The authors found a positive co-relation between inflation and the rate of change in real GDP and a negative co-relation between inflation and changes in money supply. Shams (2012) investigates the causality and direction of relationship among income, money and prices, taking yearly data from 1972-1973 to 2009-2010 for Bangladesh. Cointegration analysis indicates presence of long run causal relationship and their empirical results also show existence of unidirectional relationship operating from money supply to prices. Hussain and Mahfuzul (2017) assess the relationship between money supply and per capita GDP Growth rate in Bangladesh over the period 1972 and 2014 using a VECM. They used the percentage of broad money to GDP (BMGDP), the real interest rate (RIR) and the annual per capital GDP growth rate (GRGDP). Their findings suggest that steady BMGDP is associated with GRGDP, money supply has important impact on the growth rate of output in the long run and recommend that the government should allow money supply to increase at a steady rate keeping pace with the economic growth which helps to avoid the inefficiencies that result from execution of discretionary policy.

Masih and Masih (1997) investigate the dynamic Granger causalities among real output, money, interest rate, inflation and the exchange rate in Indonesia using Johansen cointegration test, VECM, variance decompositions and impulse response functions. The authors argue that where the real output was vulnerable to vicissitudes of the agricultural sector and exports (particularly oil), output was relatively the leading variable being the most exogenous of all, and all other variables including money supply, rate of interest, exchange rate, and prices bear adjustments endogenously in order to accommodate that real shock. Their findings from Granger causality test suggest that real output leads (rather than lags) money supply and the other three endogenous variables, which is consistent more with the real business cycle theory than with the Keynesian and the monetarist views. Ghazali and Samsu (2008) investigated the validity of QTM in Malaysia taking monthly data from 1974:1 to 2006:3. They apply cointegration and Toda-Yamamoto methods in order to test for causality. Their empirical findings show existence of a long run and unidirectional relationship between money supply and general price. Mohsen and Maysam (2010) investigate the causal association among money supply, income and prices in Iran over the period 1960-2008 using the Gregory and Hansen (1996) cointegration approach. They find evidences supporting existence of long run relationship among these variables. Furthermore, long run Granger causality test shows existence of a unidirectional relationship operating from GDP and inflation to the money supply, but they find a weak unidirectional relationship running from money supply to the general price level in the short run. Using data from the Philippines, Baunto (2011) find strong evidence in favor of Friedman's hypothesis on uncertainty in money supply and money demand over the period 1982:Q2 to 2006:Q4. Using GARCH model with structural breaks in velocity, their study shows that high variability of money growth is linked with diminishing income velocity of money and high level of inflation Granger-causes high variability of inflation, which is Granger-causes a diminution of the potential output.

Gaurang (2010) investigates the causal relationship between money supply, real GDP and prices in India using vector autoregressive (VAR) and Granger Causality approaches on annual data from 1951 to 2005 testing the Monetarists as opposed to the Keynesian's view. Their findings strongly support the Monetarist's view as it is described in the QTM. Chaitipa et al. (2015) study the relationship between money supply and economic growth of 8 ASEAN countries including Thailand, Indonesia, Singapore, Malaysia, Philippines, Vietnam, Lao PDR and Cambodia. The macro variables comprise GDP growth rates and money supply, consisting of M1 and demand deposits and their long and short run relationships are using data covering the period from 1995 to 2013, applying panel unit root and panel ARDL of Pooled Mean Group Estimator (PMGE). Their

results showed that M1, demand deposits, and GDP growth rates were stationary with I(0) and I(1) levels and that money supply were associated with economic growth in long run. Budina et al. (2002) analyzed the validity of QTM in case of Romania using time series data from 1992 to 2000, through investigating the casual relationship among money stock, output and prices and found that price-hike was largely due to growth in money stock. Alikhanov and Taylor (2015) investigate the volatility of money velocity in Kazakhstan through the impacts of money supply, output and the price level in a stochastic version of the quantity theory of exchange They find that price shocks affect the volatility of velocity more than do monetary or real shocks, by several orders of magnitude and thus the results contribute to improve central bank forecasts of the effects of monetary policy. Due to scarcity of data and changing institutions the paper points out that in early transition of post-Soviet economies to markets, velocity can be hard to estimate and that Citrin, (1995) while a Monte Carlo simulation may accomplish this, it would be informative to relate the variations of velocity to those of its main determinants.

Anoruo (2002) examines the stability of money demand function of Nigeria using Johansen and Juselius multivariate cointegration method and documents that there is long-run relationship between money, output and real discount rate. Nwaobi (2002) also adopts this technique and finds that long-run relationship exists between money supply, real GDP, inflation and interest rate and they conclude that the supply of money is a strong factor that maintains long-run influence on Nigerian macroeconomic activities. Omanukwue (2010) employs the Engle-Granger two-stage cointegration approach to investigate the long run relationship between money, prices, output and interest rate as well as the ratio of demand deposit to time deposit as a proxy for financial development, and finds a long run relationship among the variables confirming the QTM. The study finds evidence of weak unidirectional causality between money supply and CPI with direction of flow from money supply. Nwafor (2007) uses Johansen-Jesulius multivariate cointegration technique positing that there is existence of long run aggregate money demand in Nigeria in line with the Keynesian liquidity preference theory. The author argues that to initiate and sustain a long run economic growth in Nigeria, stability of money is inevitable. Akinlo (2012) on financial development and income velocity in Nigeria; used cointegration and error correction mechanism, showed a positive relationship between income growth and velocity and a negative relationship between exchange rate and velocity in the short run. Interest rate and expected rate of inflation were found to have no significant on velocity in the short run. They explain the positive effect of financial development in terms of demand deposit-time deposit ratio from the fact that financial innovation encourages the use of money substitutes or quasi-money that reduces the demand for money and, thus, raises the speed of velocity of money. He, therefore, concluded that any attempt to exercise greater command over resources by printing more money would precipitate inflationary pressures. Arewa and Nwakanma (2013) empirically test the Polak model using annual time series data from Nigeria over the period 1985 to 2011. They document bidirectional causality between money and national income, net foreign domestic credit and export in Nigeria. They find the marginal velocity of money in circulation is as high as 300% suggesting that the Nigerian economy is inflationary. Okafor et al. (2013) investigate the determinants of income velocity of money in Nigeria, using quarterly time series from 1985:1 to 2012:4. They find that both growth of income and interest rate have positive and statistically significant relationship on the velocity of money, while the growth rate of stock market capitalization has a negative relationship with the income velocity of money. The variance decomposition and impulse response results identified inflation rate as the most significant variable to innovations in the income velocity. They also conclude that the monetary authority cannot obtain additional leverage by issuing more money without generating high inflationary pressure.

In the case of Sudan, velocity of money in relation to economic growth has not been much investigated. Sudan economy has been characterized by internal and external imbalances, with monetary expansion and inflation playing major roles in instability of the macroeconomic framework and policy performance (Elwasila 2016). In addition, the informal economic activity has been large, a fact which undermines construction and estimation of reliable macroeconomic modeling for Sudan. Using a simple model of demand for money balances in addition to the velocity Elbadawi (1988) estimated the size of the "missing" income generated in the parallel economy, based on the findings of Domowitz and Elbadawi (1987). He argued that there are two opposing factors that have been working on the velocity of money in Sudan. One is the increased urbanization of the economy besides the successive monetization of the agricultural and the services sectors and their combined effect according to him is supposed to slow down the velocity of money. On the other hand, the increased number of banking and financial institutions in the country is supposed to increase the efficiency in the use of money where a lesser amount of money is needed to support a given level of transaction, thus causing a rise in velocity. He demonstrates that the accelerated rate of domestic inflation and the expectations of future exchange rate devaluation in Sudan were supposed to reduce the demand for money, but since the stock of money is given, the level of transaction must rise hence, velocity should rise. He argued that the slow dawn of velocity can only be explained by the existence of a large and expanding parallel economy in Sudan.

Hassanain (1991) finds that the monetary variables affect output in Sudan in a new structuralist's manner, while they affect aggregate demand through the monetarist impact. He found that the real bank loans have significant positive impact on output, while the rate of depreciation in the black market exchange rate has statistically significant negative impact on output, whereas the real wage rate and imported intermediate input were found to have statistically significant positive and negative impact on output, respectively. The author concludes that one of the main constraints imposed on stabilization policies through their effect on inflation and unemployment is the existence of unofficial credit markets in Sudan and argued that monetary reform and building up of efficient economy-wide monetary intermediaries are of crucial importance if conventional macro policy is to play a major role in Sudan. Altayee and Mustafa (2017) examine the impact of financial development on velocity of money under interest-free financing in the Sudan over the period 1992-2012. They employed VAR

approach, and Johansen cointegration test combining per capita income, financial development; narrow money supply (M1), rate of return (margin of murabahah instrument) as a substitute to rate of interest, inflation, and the spread of commercial bank branches as proxy for financial development. They show that the velocity of M1 was volatile and persistent in mid 1990s and more stable and predictable after 2000. The paper confirms the existence statistically significant relation between financial development and velocity of M1. The cointegration test result indicates existence of long run relationship between velocity of money and the other variables.

3. ECONOMETRIC ANALYSIS

3.1. Model Specification

The general econometric model to explain the relationship between velocity of money income (VMC) and economic growth in Sudan includes the main determinants contained in the QTM without explicit inclusion of institutional factors but taking into account the possible effects of investment, deficit finance, financial development, and trade openness written in natural logarithms (L) as:

$$L(VMC) = \alpha + \beta_1 L(GDP) + \beta_2 L(M2R) + \beta_3 L(INF) + \beta_4 L(INV) + \beta_5 L(DCP) + \beta_6 L(TOP) + \beta_7 (GBG) + \mu \quad (1)$$

The model variables are defined as follows:

VMC is the velocity of money income measured as the value of nominal GDP divided by broad money M2. VMC is a reflection of the amount of money needed for functioning of the economy. According to Jevons (1909), as quoted in Mary (2006) if we knew the amount of exchanges affected and the quantity of currency used, we might get by division the average numbers of times the currency is turned over. According to this definition, the average velocity of money circulation over the period 1969-2016 for Sudan is estimated at 5.62, meaning that money circulates once every 73 days.

GDP is current gross domestic product in US dollars and stands for economic growth.

M2R is the broad money as percentage of international reserve. The interaction of broad money and international reserves reflects in part the performance of the external sector along with monetary and trade policy which are expected to affect VMC and economic growth.

INF is inflation rate measured by CPI. When inflation is increasing people prefer to hold real assets over monetary assets and money is spent as soon as received so velocity of money increases. Interest rate is not included in this model because of data unavailability. Inclusion of GDP, inflation, broad money and velocity of money enables us to test for the applicability of the QTM in the case of Sudan.

INV is growth investment financed from all sources including domestic savings and foreign savings. Higher the investment is expected to lead to low velocity of money.

DCP is the domestic credit provided by banks to the private sector and used as a measure of the financial development. The higher the DCP the lower the money circulated outside the banking system. The way economic transactions are performed and the relative importance of demand deposits versus time deposits are expected to have negative effect on VMC. Effect of velocity of money itself on economic growth can be modeled in the context of Montiel (1995) and Emenuga (1996) who argue that the possible effects of money in circulation on growth can manifest in three different channels; increasing the rate of savings (represented by investment); improving the efficiency of financial intermediations (represented by financial development) and the efficiency of capital stocks.

TOP is trade openness defined as the sum of exports and imports as percentage of GDP. TOP interacts with international reserve as trade deficits reflects lower international reserve and thus higher M2R, which is expected to positively affect VMC.

GBG is the government budget deficit and included in the model to take in to account the effect of deficit finance mostly through money printing which affects the quantity of money.

Inclusion of investment, trade openness and government budget deficit takes into account the effect of the level of utilization of resources.

Data on all variables is sourced from the World Bank (2017), World Development Indicators. The study departs with investigation of statistical properties of the model variables. Table 1 presents the basic descriptive statistics of variables. According to Jarque-Bera J-B statistics, the model variables are not normally distributed except INV, DCP and TOP.

Table 1: Descriptive statistics

	VMC	GDP	M2R	INF	INV	DCP	TOP	GBG
Mean	5.62	23853.81	76.72	33.72	19.00	8.35	26.99	−1004.62
Median	5.02	12330.58	34.92	23.04	16.34	9.66	27.66	−501.34
Maximum	11.66	108354.3	505.73	132.82	37.19	13.96	47.58	374.81
Minimum	3.05	2144.33	2.78	1.30	7.29	1.62	11.09	−5713.23
Std. dev.	2.276	26802.20	103.30	33.87	7.33	3.83	9.52	1459.49
Skewness	1.42	1.67	2.19	1.64	0.67	−0.44	0.137	−2.00
Kurtosis	4.10	4.69	8.15	4.78	2.46	1.87	2.30	6.00
J-B	18.58	27.91	91.24	27.96	4.20	4.09	1.13	49.82
Probability	0.0001	0.0000	0.0000	0.0000	0.1223	0.1291	0.5686	0.0000
Observations	48	48	48	48	48	48	48	48

As from the correlation matrix in Table 2, VMC is mostly and negatively affected by DCP. Only GDP and GBG are found to be highly negatively correlated independent variables

Given the non-normal distribution of the study variables and the likelihood that the model variables are I(1) process, the study proceeds to dynamic econometric methods.

3.2. Stationarity of Variables

For meaningful estimation of time series econometric models the stationarity of the variables needs to be established otherwise, estimation may be spurious. The Augment-Dickey Fuller (ADF) and the Phillips-Perron (PP) test are carried out to check for stationarity of the variables. The estimated ADF and PP statistics are compared with the simulated MacKinnon (1991) critical values for arbitrary sample sizes. The ADF and PP statistics must be larger than critical values in absolute value and have a minus sign. Using the ADF and PP unit root tests, with the assumption of constant only, all variables included in the study are found to be nonstationary at level I(0), but they all turn to be stationary at first difference I(1) as presented in as presented in Table 3.

Table 2: Correlation matrix

	VMC	GDP	M2R	INF	INV	DCP	TOP	GBG
VMC	1.00							
GDP	−0.13	1.00						
M2R	−0.41	−0.03	1.00					
INF	0.22	−0.12	0.23	1.00				
INV	0.42	−0.05	−0.25	0.04	1.00			
DCP	−0.83	0.18	0.12	−0.49	−0.35	1.00		
TOP	−0.25	0.07	−0.49	−0.63	0.20	0.58	1.00	
GBG	0.09	−0.94	0.00	0.04	0.10	−0.11	0.07	1.00

Table 3: ADF and PP stationarity test results

Variable	ADF		PP		Order of integration
	ADFI (0)	ADF I (1)	PP I (0)	PP I (1)	
L (VMC)	−1.364	−5.157*	−1.637	−5.106*	I (1)
L (GDP)	−0.448	−6.289*	−0.474	−6.289*	I (1)
L (M2R)	−1.867	−7.471*	−1.839	−7.471*	I (1)
L (INF)	−2.785	−8.821*	−2.671	−9.476*	I (1)
L (INV)	−3.054	−6.482*	−2.901	−12.272*	I (1)
L (DCP)	−1.439	−5.055*	−1.570	−5.069*	I (1)
L (TOP)	−1.886	−8.454*	−1.858	−8.338*	I (1)
GBG	2.043	−10.226*	1.424	−9.591*	I (1)

*indicates stationary at 5% level

3.3. Cointegration Analysis

The long run nature of the relationship between velocity of money, economic growth and other control variables included in the model is tested by Johansen cointegration method. With the assumption of intercept without trend in data, both the trace statistics and the maximum Eigen value statistic indicate existence of two cointegrating vectors, while with the assumption of intercept and trend there are three cointegrating vectors as summarized in Table 4.

Establishment of cointegrating relationships between the model variables indicates that velocity of money can be explained reliably within the context of the QTM along the real side economic variables using vector error correction model VECM. In order to select the appropriate lag length for estimation of the VECM, we estimated a general unrestricted VAR model. A lag order of 1 is selected on the basis of the SC and HQ criteria as presented in Table 5.

3.4. VECM Estimation

The VECM is specified as follows:

$$\Delta L(VMC)_{t-i} = \beta_0 + \alpha_1 L(VMC)_{t-1} + \alpha_2 L(GDP)_{t-1} + \alpha_3 L(M2R)_{t-1} + \alpha_4 L(INF)_{t-1} + \alpha_5 L(INV)_{t-1} + \alpha_6 L(DCP)_{t-1} + \alpha_7 L(TOP)_{t-1} + \alpha_8 (GBG)_{t-1} + \beta_1 \sum_{j=1}^{k-1} \Delta L(VMC)_{i-j} + \beta_2 \sum_{j=1}^{k-1} \Delta L(GDP)_{t-j} + \beta_3 \sum_{j=1}^{k-1} \Delta L(M2R)_{t-j} + \beta_4 \sum_{j=1}^{k-1} \Delta L(INF)_{t-j} + \beta_5 \sum_{j=1}^{k-1} \Delta L(INV)_{t-j} + \beta_6 \sum_{j=1}^{k-1} \Delta L(DCP)_{t-j} + \beta_7 \sum_{j=1}^{k-1} \Delta L(TOP)_{t-j} + \beta_8 \sum_{j=1}^{k-1} \Delta (GBG)_{t-j} + \sum ECT_t + \varepsilon_t \quad (2)$$

Table 4: Cointegration rank test

H_0	H_1	Intercept				Intercept and trend			
		Trace statistics		Maximum Eigen value		Trace statistics		Maximum Eigen value	
		Trace stat.	0.05 critical value	Max-Eigen stat.	0.05 critical value	Trace stat.	0.05 critical value	Max-Eigen stat.	0.05 critical value
r=0	r=0	194.679*	159.530	55.494*	52.363	250.478*	187.470	73.978*	56.705
r≤1	r=1	139.185*	125.615	50.689*	46.231	176.500*	150.559	52.799*	50.600
r≤2	r=2	88.495	95.754	29.723	40.078	123.702*	117.708	45.748*	44.497
r≤3	r=3	58.772	69.819	21.414	33.877	77.953	88.804	23.328	38.331
r≤4	r=4	37.358	47.856	15.519	27.584	54.625	63.876	19.021	32.118
r≤5	r=5	21.839	29.797	14.870	21.132	35.604	42.915	15.507	25.823
r≤6	r=6	6.969	15.495	6.852	14.265	20.097	25.872	13.921	19.387
r≤7	r=7	0.117	3.841	0.117	3.841	6.176	12.518	6.176	12.518

Intercept only: (2 cointegrating equations); Intercept and Trend (3 cointegrating equations); *denotes rejection of the null hypothesis at the 0.05 level

Δ is the difference operator, ECT is the error correction term which indicates the speed of adjustment to equilibrium in the long run in response to short run shocks of the system of variables and ε is the white noise error term. The VECM specified in equation (2) is estimated and its results are summarized in Table 6.

The VECM equation is represented as follows:

$$dL(VMV) = -0.44L(VMC)_{t-1} + 0.24L(GDP)_{t-1} + 0.27L(M2R)_{t-1} - 0.06L(INF)_{t-1} - 0.25L(INV)_{t-1} + 0.18L(DCP)_{t-1} + 0.66L(TOP)_{t-1} + 0.00(GBG)_{t-1} - 6.35 + 0.37dL(VMC)_{t-1} - 0.07dL(GDP)_{t-1} + 0.13dL(M2R)_{t-1} + 0.02dL(INF)_{t-1} + 0.08dL(INV)_{t-1} + 0.07dL(DCP)_{t-1} - 0.13dL(TOP)_{t-1} - 0.00D(GBG)_{t-1} - 0.01 \quad (3)$$

The VECM test results show that in the short run velocity of money is significantly and positively affected by its own lagged value and only by broad money as percentage of international reserve M2R. However, in the long run, velocity of money is significantly and positively affected by GDP, M2R but negatively affected by inflation confirming the QTM. VMC is also found to be positively affected by trade openness, government budget but negatively by investment, conforming a priori assumptions. These results indicate that changes in velocity of money income are largely a long run phenomenon and affected by both the monetary and real sides of the economy. The ECT indicates that the velocity of money income restores back to equilibrium position in the long run by a factor of 44% in response to short run shocks in the system. Thus, the results urge for credible and sound coordination between financial, fiscal and monetary policies in Sudan. Short run Granger causality associated with VECM shows that GDP and investment are not correctly adjusting to equilibrium in the long run. This means that changes in GDP and investment do contribute to steady state of velocity of money in the long run. Other variables correctly adjust to equilibrium position in the long run and in particular, shocks to the government budget deficit have the largest influence on the behaviour of velocity on money as shown in Table 7. Financial development is found to be Granger causing VMC in the short run with no feedback effect, while VMC is found to cause money expansion.

The effects on VMC and its volatility in response to external shocks are also investigated through the impulse response function (IRF). Table 8 shows that VMC behaviour is largely responding positively to its own value and to INF, negatively to DCP, followed by INV, and TOP with the least contribution coming from M2R and GBG.

Exogeneity of variables is also tested through the Wald test exogeneity test. As presented in Table 9, VMC, GDP, and DCP are highly significantly endogenous lagging variables while M2R, INF, INV and GBG are the highly exogenous leading variables, which to large extent consistent with the VECM, IRF and variance decomposition results. The results also indicate that VMC is mostly affected by and affecting economic growth and financial development.

In the context of Granger (1969), long run causality is also applied and the results are summarized in Table 10.

As in Table 10 there exists a unidirectional causal relationship running from INF to VMC as well as from DCP to VMC while a causal relationship is found to run from VMC to M2R, and from VMC to INV. A bidirectional causal relationship is found between VMC and TOP. No causal relationship is found between economic growth and velocity.

Table 5: Lag order selection criteria

Lag	LL	LR	FPE	AIC	SC	HQ
0	−547.051	NA	7.142	24.669	24.990	24.789
1	−293.231	406.112	0.002	16.232	19.123*	17.310*
2	−219.781	91.404	0.001	15.813	21.273	17.848
3	−122.690	86.303*	0.001*	14.342*	22.371	17.335

*indicates lag order selected by the criterion, LR: Sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion

Table 6: VECM summary results

VECM short run dynamics					VECM long run equilibrium			
Variable	Coeff.	Std. error	t. stat.	Prob.	Variable	Coeff.	Std. error	t. stat.
ECT_{t-1}	−0.44	0.109	−4.091	0.000***	$L(VMC)_{t-1}$	1.000		
$DL(VMC)_{t-1}$	0.37	0.174	2.140	0.033**	$L(GDP)_{t-1}$	0.24	0.039	6.088***
$DL(GDP)_{t-1}$	−0.07	0.100	−0.745	0.457	$L(M2)_{t-1}$	0.27	0.033	8.159***
$DL(M2R)_{t-1}$	0.13	0.035	3.632	0.000***	$L(INF)_{t-1}$	−0.06	0.029	−2.009*
$DL(INF)_{t-1}$	0.02	0.022	0.905	0.366	$L(INV)_{t-1}$	−0.25	0.084	−2.955**
$DL(INV)_{t-1}$	0.08	0.063	1.270	0.205	$L(DCP)_{t-1}$	0.18	0.077	2.386**
$DL(DCP)_{t-1}$	0.07	0.120	0.566	0.572	$L(TOP)_{t-1}$	0.66	0.165	3.979***
$DL(TOP)_{t-1}$	−0.13	0.097	−1.374	0.171	$(GBG)_{t-1}$	0.00	0.000	5.081***
$D(GBG)_{t-1}$	−0.00	0.000	−0.104	0.917	C	−6.35		
C	−0.01	0.019	−0.283	0.777				

R-squared=0.47; Adj. R-squared=0.34; SER=0.116; SSR=0.487; SD dependent=0.144; Mean Dependent=−0.003; DW=2.10; F. stat.=3.917, P (0.000); LL=39.347; AIC=−1.276; SC=−0.878

Diagnosis tests	Test stat.	P value
Autocorrelation	Chi-square 152.19	P (0.958)
Heteroskidasticity	Chi-square: 652.70	P (0.441)
Normality: Joint	Jarque-Bera 22.87	P (0.117)
Stability	VECM imposes 7 roots none of them is out the unit circle	

***.**, and * indicates significance at 1%, 5% and 10% level respectively

Table 7: VECM granger causality test results

Variable	Short run dynamics								Long run equilibrium
	ΔL (VMC)	ΔL (GDP))	ΔL (M2R)	ΔL (INF)	ΔL (INV)	ΔL (DCP)	ΔL (TOP)	Δ(GBG)	ECT_{t-1}
$\Delta L (VMC)_{t-1}$		−0.22 (−0.986)	−0.62 (−0.517)	−0.88 (−0.774)	−0.28 (−0.573)	−0.77 (−2.719)**	0.54 (1.901)	−13 (−1.850)*	−0.44 (4.091)***
$\Delta L (GDP)_{t-1}$	−0.07 (−0.745)		0.24 (0.345)	0.16 (0.241)	0.04 (0.135)	0.32 (1.964)	0.12 (0.750)	26.35 (0.064)	0.01 (0.085)
$\Delta L (M2R)_{t-1}$	0.13 (3.632)**	0.002 (0.049)		−0.44 (−1.922)*	0.01 (0.092)	−0.12 (−2.127)*	−0.08 (−1.416)	17.03 (0.116)	−0.17 (−0.701)
$\Delta L (INF)_{t-1}$	0.02(0.905)	−0.04 (−1.488)	−0.14 (−0.948)		0.02 (0.325)	−0.02 (−0.515)	−0.02 (−0.418)	−93.33 (−1.016)	−0.23 (−1.556)*
$\Delta L (INV)_{t-1}$	0.08(1.270)	−0.09 (−1.044)	−0.09 (−0.203)	−0.002 (−0.004)		−0.13 (−1.254)	0.01 (0.117)	−26.68 (−0.103)	0.07 (0.371)
$\Delta L (DCP)_{t-1}$	0.07(0.566)	0.45 (2.856)**	0.38 (0.461)	−0.76 (−0.968)	−0.50 (−1.468)		0.26 (1.322)	−1021.82 (−2.051)*	−0.03 (0.176)
$\Delta L (TOP)_{t-1}$	−0.13 (−1.374)	−0.38 (−2.990)**	−0.02 (−0.030)	−0.31 (−0.483)	0.04 (0.153)	0.10 (0.657)		604.41 (1.509)	−0.27 (−1.700)*
$\Delta(GBG)_{t-1}$	−0.000 (−0.104)	−0.000 (−2.038)*	−0.000 (−0.314)	0.000 (1.297)	0.000 (1.575)	0.000 (0.791)	0.000 (2.514)*		−0.44 (−3.132)**

***.** and * indicates significance at 1%, 5% and 10% level respectively

Table 8: IRF of VMC

Period	L (VMC)	L (GDP)	L (M2R)	L (INF)	L (INV)	L (DCP)	L (TOP)	GBG
1	0.116	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.146	0.008	0.017	0.030	0.041	−0.011	−0.049	−0.027
3	0.136	−0.001	−0.020	0.045	0.055	−0.048	−0.046	−0.027
4	0.155	−0.013	−0.035	0.047	0.061	−0.062	−0.041	−0.018
5	0.172	−0.014	−0.026	0.053	0.071	−0.069	−0.045	−0.020
6	0.178	−0.015	−0.026	0.057	0.080	−0.077	−0.049	−0.020
7	0.183	−0.017	−0.030	0.060	0.084	−0.084	−0.050	−0.020
8	0.187	−0.019	−0.031	0.062	0.087	−0.088	−0.051	−0.020
9	0.190	−0.020	−0.031	0.063	0.090	−0.091	−0.051	−0.020
10	0.192	−0.020	−0.031	0.064	0.092	−0.093	−0.052	−0.020

Cholesky Ordering: L (VMC) L (GDP) L (M2R) L (INF) L (INV) L (DCPS) L (TOP) GBG

Table 9: VECM granger causality block exogeneity test

Dependent Variable	Chi-sq	DF	Prob.	Decision
L (VMC)|L (GDP), L (M2R), L (INF) L (INV), L (DCP), L (TOP), GBG	21.55	7	0.003	Reject
L (GDP)|L (VMC), L (M2R), L (INF) L (INV), L (DCP), L (TOP), GBG	27.54	7	0.000	Reject
L (M2R|L (GDP), L (VMC), L (INF) L (INV), L (DCP), L (TOP), GBG	2.23	7	0.945	Accept
L (INF)|L (GDP), L (M2R), L (VMC) L (INV), L (DCP), L (TOP), GBG	6.98	7	0.431	Accept
L (INV)|L (DCP), L (M2R), L (INF) L (VMC), L (DCP), L (TOP), GBG	4.99	7	0.661	Accept
L (DCP)|L (GDP), L (M2R), L (INF) L (INV), L (VMC), L (TOP), GBG	16.62	7	0.020	Reject
L (TOP)|L) GDP), L (M2R), L (INF) L (INV), L (DCP), L (VMC), GBG	11.84	7	0.106	Accept
GBG|L (GDP), L (M2R), L (INF) L (INV), L (DCP), L (TOP), L (VMC)	6.70	7	0.461	Accept

4. DISCUSSIONS

This study has investigated the dynamic linkages between velocity of money income and economic growth in Sudan applying cointegration, VECM, IRF, variance decomposition and Granger causality methods. The study finds a long run equilibrium relationship between velocity of money, economic growth and associated variables without explicit inclusion of institutional factors thus invalidating the claim of Siklos (1993) that cointegration cannot be established without inclusion of institutional factors in investigations of velocity. In the short run, velocity of money is found to be significantly and positively affected by its own lagged value and by broad money as percentage of international reserve M2R. In the long run, velocity of money is significantly and positively affected by GDP, M2R, confirming partly the quantity theory of money. Velocity of money is also found to be increasing with trade openness and government budget deficit but decreasing with inflation and investment. These results indicate that changes in velocity of money are largely a long run phenomenon and affected by both the real and nominal monetary sides of the economy in a low income and small open economy. Granger causality test shows that inflation causes the velocity of money, and GDP growth also causes velocity of money, a finding which is also consistent with the quantity theory of money. Financial development is found to cause velocity of money, while velocity of money is found to be Granger causing broad money as percentage of international reserve. Moreover, a bidirectional relationship is found between

Table 10: Long run granger causality results

H_0: Dependent VMC	F-statistic	Prob.	Decision	Direction of causality
H_0: L (GDP) does not Cause L (VMC)	0.011	0.917	Accept	None
H_0: L (VMC) does not Cause L (GDP)	0.503	0.482	Accept	None
H_0: L (M2R) does not Cause L (VMC)	2.054	0.159	Accept	None
H_0: L (VMC) does not Cause L (M2R)	6.478	0.015	Reject	VMC to M2R
H_0: L (INF) does not Cause L (VMC)	11.786	0.001	Reject	INF to VMC
H_0: L (VMC) does not Cause L (INF)	1.632	0.208	Accept	None
H_0: L (INV) does not Cause L (VMC)	0.833	0.367	Accept	None
H_0: L (VMC) does not Cause L (INV)	4.109	0.049	Reject	VMC to INV
H_0: L (DCP) does not Cause L (VMC)	6.266	0.016	Reject	DCP to VMC
H_0: L (VMC) does not Cause L (DCP)	2.063	0.158	Accept	None
H_0: L (TOP) does not Cause L (VMC)	9.691	0.003	Reject	TOP to VMC
H_0: L (VMC) does not Cause L (TOP)	4.510	0.039	Reject	VMC to TOP
H_0: GBG does not Cause L (VMC)	0.001	0.972	Accept	None
H_0: L (VMC) does not Cause GBG	0.556	0.460	Accept	None
H_0: Independents	**F-Statistic**	**Prob.**	**Decision**	**Direction of causality**
H_0: L (M2R) does not Cause L (GDP)	5.793	0.020	Reject	M2R to GDP
H_0: L (INF) does not Cause L (GDP)	3.224	0.079	Reject	INF to GDP
H_0: L (TOP) does not Cause L (GDP)	5.433	0.024	Reject	TOP to GDP
H_0: L (GDP) does not Cause GBG	5.498	0.024	Reject	GDP to GBG
H_0: L (M2R) does not Cause L (INF)	7.514	0.009	Reject	M2R to INF
H_0: L (DCP) does not Cause L (M2R)	5.704	0.021	Reject	DCP to M2R
H_0: L (M2R) does not Cause L (DCP)	8.732	0.005	Reject	M2R to DCP
H_0: L (M2R) does not Cause L (TOP)	12.380	0.001	Reject	M2R to TOP
H_0: L (INF) does not Cause L (DCP)	13.950	0.001	Reject	INF to DCP
H_0: L (TOP) does not Cause L (INF)	7.028	0.011	Reject	TOP to INF
H_0: L (INF) does not Cause L (TOP)	3.492	0.068	Reject	INF to TOP
H_0: L (DCP) does not Cause L (INV)	6.064	0.018	Reject	DCP to INV
H_0: L (TOP) does not Cause L (DCP)	11.529	0.002	Reject	TOP to DCP

velocity of money income and trade openness. These results indicate velocity of money is driven mostly by expansionary monetary policy and monetization of deficit finance which are expected to have sizeable negative effect on economic growth in Sudan. Thus for stable velocity of money and economic growth, the study recommends the followings:

i. Money expansion should be controlled with disciplinary monetary policy
ii. Deficit finance through money printing should be reduced and be consistent with stable velocity of money
iii. Monetary and fiscal policy tools should be tidily coordinated.

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