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Estimating the Money Demand Function and a Demystification of the Endogeneity-Exogeneity Nexus of Money Supply: The Case of Zimbabwe (1991-2008)

Dzingirai Canicio[1*]

[1]*Department of Economics, Midlands State University, Zimbabwe P Bag 9055, Gweru, Zimbabwe.*

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

The main aims of this paper is to fill the gap in monetary economics literature of whether money demand function is static or time-variant overtime and whether money supply is exogenous or endogenous during hyperinflationary episodes in less developed countries setting. It employs both static and dynamic models and a Granger Causality procedure respectively on quarterly data to achieve the two aims. The static model results indicated that money demand, to a larger extend is positively influenced by the rate of inflation and negatively determined by financial innovation, exchange rate and national income and a dynamic model revealed that financial innovation, lagged money demand and national income have negative and, again inflation has a greater positive effect on money demand. Interest rates and exchange rate and, only interest rates were not significant determinants of money demand in the dynamic and static models respectively. The dynamic model gave superior results to the ones from the static one. In both models money demand was found to have an inelastic response to all explanatory variables included. On the other hand, the Granger Causality result found that the money supply endogenously responded to inflation, lagged money stock and the level of financial innovation in the economy but exogenously determined by national

**Corresponding author: E-mail: Dzingiraic@msu.ac.zw, 768253@students.wits.ac.za, caniciod@gmail.com, caniciod@yahoo.com;*

income level and the rate of interest rates. The overall conclusion derived from the endogenous-exogenous nexus was that money supply for Zimbabwe over the period 1991 to 2008, when the hyperinflation reached its climax, was endogenous and time variant which explains why it was very difficult for the authorities to tame the hyperinflation bubble. The researcher recommended that, to guarantee the efficiency and potency of monetary policy it is critical for the central bank to be independent from central government and governments also must desist from financing their budget deficits and expenditure through printing notes and minting coins (i.e., seigniorage). Furthermore, endogenous money supply poses more harm to the welfare of citizen of a country when compared to an exogenous one. Therefore, monetary authorities must try by all means to stick to their mandates and not involved in quasi-fiscal operations. In addition, to have policy credibility, there must be clear policy coordination between monetary and fiscal policies and these policies must be consistent. Policy credibility and consistency, in macroeconomic theory, are the cornerstone requirements and pre-requisites to boost most stakeholders' confidence within the economy.

Keywords: Zimbabwe; money demand; exogeneity; endogeneity; static; dynamic; granger causality.

1. INTRODUCTION

The money demand function and exogeneity of money supply are the central engines of most relationships in macroeconomic theory and drivers of growth especially in developing countries (IMF) [1] where according to World Bank report, more that 70% of world's population under abject poverty resides (World Bank) [2]. However, changes in the structure of the financial sector can substantially change the reliability of aggregate measures, and thus the efficiency and potency of the monetary policy. In this regard, the main thrust of this research was to unravel the determinants of money demand for Zimbabwe over the period 1991 (when ESAP was adopted) to 2008 (when Zimbabwe completely abandoned its currency and adopted a multiple currency regime, using the US$ as the dominant currency in 2009). Furthermore, this research seeks to unravel the possible drivers of the hyperinflation environment that Zimbabwe experienced given the adverse effects it posed on the Zimbabwean dollar, ultimately leading to its abandonment in 2009. More and above, this research also seeks to set the base on what should be done or not be done in future if the RBZ re-introduces a local currency to avoid similar experienced threat incurred on the Zim-dollar prior the 2009 era. From standard IS-LM models and their extensions to open economies in the Mundell-Fleming manner to international monetary models, money plays a central role in determining economic activities. In criticism of the various analytical approaches commonly used in policy assessments, it is frequently questioned whether the demand for money is indeed stable and predictable; money supply exogenously determined and predictable, particularly in developing countries like Zimbabwe. These suppositions emanates from findings that traditional specification of money demand functions in a number of developed /industrialised countries displayed temporal instability and money supply also show traits of endogenous response to other macroeconomics phenomena such as hyperinflation, balance of payments deficits, budget deficits, terms of trade, unemployment, to mention just a few, especially in the 1970s [3-8].

In addition, it is critical to add more knowledge in the body of existing literature focusing on under-developing economies where more than 70% people are under extreme poverty (World Bank) [9,2]. In light of the above, this paper provided empirical work on developing countries such as Zimbabwe to find whether standard specifications encountered similar problems. If there is no consensus on the actual specification and stability of money demand, and worse more on the exogeneity-endogeneity nexus of money supply of developed economies, especially under hyperinflationary periods, what more on emerging economies such as the so called 'four Asian Tigers' and developing ones in Africa, Zimbabwe included [10,11]. Therefore, it's imperative and of paramount importance, to try to unravel such controversies in the existing body of literature, using case studies of African countries as a way of trying to close this gap. In Africa, Zimbabwe has been of much interest or a focal point, especially given that it is currently the only African country that had completely abandoned its currency in February 2009 and adopted a multiple currency system and it also might fully re-introduce its own currency in the future. On the 19th of December 2014 'bond coins' were introduced with an initial monetized value of $50million (Reserve Bank of Zimbabwe (RBZ), [12], as a way of trying to addressing one of the characteristics of money of divisibility and induce competitiveness. This implies that, the RBZ currently has a partial influence on the money supply which it has lost since 2009.

Furthermore, the controversy was stoked by empirical findings that there have been difficulties with persistent over-prediction and mis-specification of the money demand function, in so-called missing money episodes, wrong functional form adoption, parameter estimates that were often plausible and highly autocorrelated errors [10]. Such errors seriously compromised the potency and effectiveness of monetary policies especially in the case of emerging and developing economies which are normally characterized by policy missing targets of large proportions and huge policy gaps. The major question pondering the minds of most academic and policy makers to be addressed with this research are: How is money demand determined? Is it significantly affected by interest rates and/or income, as per theory? What other factor affect money demand other than the ones propounded theoretically, i.e., interest rate and/or income? Is money supply endogenously or exogenously determined? How does money demand move or evolve overtime? Is the money demand function static (time invariant) or dynamic (time variant) overtime?

2. BACKGROUND OF THE STUDY

In the spirit with Cagan's pioneering study of the money demand during hyperinflation [13], quite a number of academics and policy makers have reexamined Cagan's model and estimations under differing alternative assumptions related to expectations formation, notably Barro [14], Sargent and Wallace [15] Sargent [16], Abel et al. [17], Salemi and Sargent [18], Christiano [19], Taylor [20] and Michael et al. [11] The main thrust of Cagan's analysis was that under the conditions of hyperinflation, movements in prices are at a supergeostrophic speed than that of movements in real macroeconomic aggregates. Cagan ([13], p. 25) stated that "relations between monetary factors can be studied, therefore, in what almost amounts to complete isolation from the real sector of the economy".

The conditions in Zimbabwe from March 2007 to January 2009 eminently qualified as hyperinflation according to Cagan [13] definition. Cagan defined:

> *"hyperinflation as beginning in the month the rise in price exceeds 50 percent and as ending in the month before the monthly rise in prices drops below that amount and stays below for at least a year" (p. 25).*

The trends of hyperinflation in Zimbabwe can be traced back to early 2007. Based on RBZ [21] and Zimbabwe Statistical Agency [22] data, the Zimbabwe's month on month inflation rate reached the 51% mark in March 2007, this month on month rate was well above 100% by April 2007, though it temporarily declined through May and November of the same year, reaching the trough of 11.8% in August, before jumping to rates higher than 240% by December 2007. Based on RBZ [21][1] data, by May 2008, the rate was squarely at 433.4%, and shoots up to 839.3% the following month. Since June 2008, the month on month rate has been skyrocketing to figures well above 2000%; with the upward trend reaching the highest last officially reported rate during the Zimbabwean-dollar era of 2600.24% which directly contributed to an annual rate of 231million percent by July 2008. Borrowing from Keynes [23] suggestions, namely that 'even the weakest government can enforce inflation when it can enforce nothing else'; evidence indicates that Zimbabwean government has been good at using the money printing machines, which according to Hayo and Voigt [24], extremely compromise the independence of the central bank. Coorey et al. [25: 8] point out that 'Accelerating inflation in Zimbabwe has been fueled by high rates of money growth reflecting rising fiscal and quasi-fiscal deficits'.

As a result of that, the very high inflationary trend that the country has been experienced during Zimbabwean dollar era was a direct result of, among other factors, massive money printing to finance government expenditures and government deficits. For instance, according to Makochekanwa [26], the unbudgeted government expenditure of 1997 (to pay the war veterans gratuities); the publicly condemned and unjustifiable Zimbabwe's intervention in the Democratic Republic of Congo (DRC)'s war in 1998; the expenses of the controversial land reform (beginning 2000), the parliamentary (2000/2005) and presidential (2002) elections, introduction of senators in 2005 (at least 66

[1] *For detailed month on month and annual inflation rates see http://www.rbz.co.zw/about/inflation.asp*

posts) as part of 'widening the think tank base' and the international payments obligations, especially since 2004, all resulted in massive money printing by the government. Above these highlighted and topical expenditure issues, the printing machines has also been the government's 'Saviour' for such expenses as civil servants' salaries. Just after 2008 mid-year the hyperinflation official rate reached a peak of 231 million percent and it take long before Zimbabwe Statistical Agency (Zimstat) published monthly statistics, that is, Zimbabwe's month on month inflation rate statistics for the period August to December 2008 are not publicly available. On 19th of February the government completely abandoned the Zimbabwean dollar and adopted the multiple currencies regime (MCR). Furthermore, on the 18th of December 2014, the central bank introduced bond coins denominated in 1c, 5c, 10c, 25c and 50c, with a monetized par or one as to one value with the US cents, as a way of addressing the divisibility characteristic of money. The major concern with these bond coins is on monitoring and accounting of the actual amount injected into the economy since it is a jealously guided secrete from the public, which pose a serious problem especially on policy transparency which is bedrock for building public confidence [27]. The behavior of money supply and Zimbabwe's inflation rate are shown on Fig. 1.

One characteristic of hyperinflation is the tendency for real cash balances to decline. This real money behaviour is shown in Fig. 1. Another way to illustrate this characteristic is by the reciprocal of the real cash balances. An increase in this ratio means that the rise in price is proportionately much greater than the rise in the money supply. The trends of money supply and inflation growth for Zimbabwe over the period 1980-2008 on Fig. 1 indicates that money supply might have violated the economic theoretical postulation that money supply is exogeneous and independent to other macroeconomic fundamentals. The figure illustrate that in Zimbabwe over the period 1999-2008 there was endogeneity dependency between money supply and inflation since they oscillate in the same direction. The research is divided into five sections; section 3 dwell much on literature review, section 4 looked at data, methodology and results analysis and lastly section5 wrap-up the research by looking at conclusion and proffer policy recommendations and/or implications.

3. LITERATURE REVIEW

Theoretically and empirically, the link between the demand for money and its determinants is considered as a fundamental issue in most theories of macroeconomic behavior. However, in most cases, theoretical and macro-econometric models ignore the institutional aspect of financial sector (monetary shocks) and capture financial sector through the supply and demand for money.

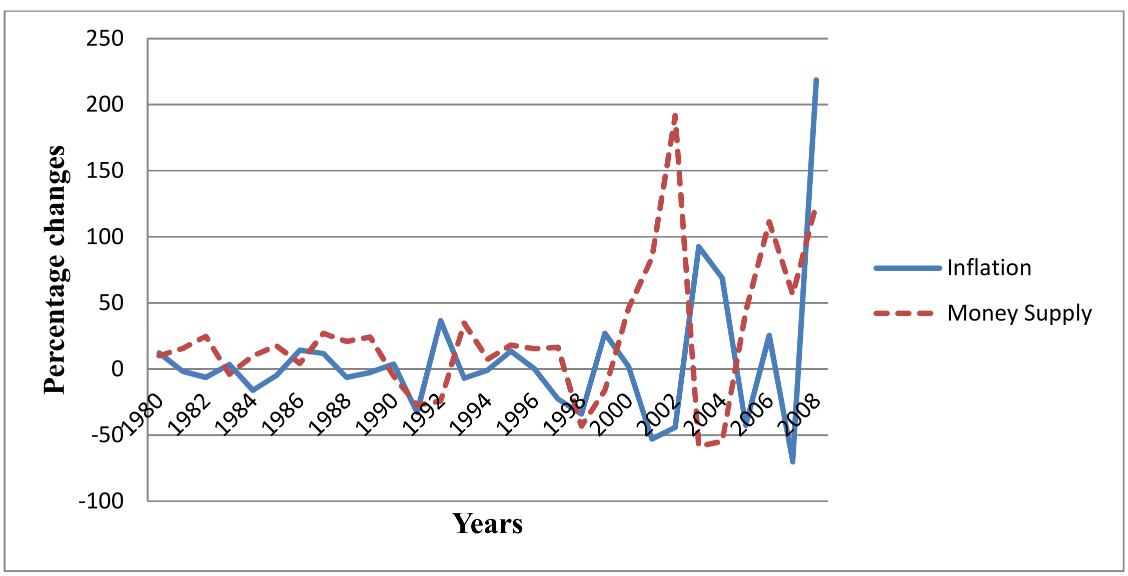

Fig. 1. Inflation and money supply growth rates (%) for the period 1980 to 2008
Source: World Bank Economic Indicators

3.1 Theoretical Literature Review

3.1.1 The traditional classical approach

A number of theories have been brought forward to try to explain why people hold money and what factors influence the quantity of money held. They can be classified into two broad categories namely the traditional and new classical approaches. The traditional approach comprise of Keynesian, Monetarists and Cambridge school of thought, that is, Classical Quantity Theory of Money, Keynes' Liquidity Preference Theory and Friedman's Modern Quantity Theory of Money. The main thrust or fundamental questions based on these theories are: How is money demand determined? Is it significantly affected by interest rates and/or income? Is the money supply endogenously or exogenously determined? How does money demand move or evolve overtime? Is the money demand function static (time invariant) or dynamic (time variant) overtime?

Classical Quantity Theory of Money was propounded by Fisher [28,29] with the intention to examine the link between total money supply (M^S) and the total amount of spending on final goods and services produced in a given period (*PY*). Velocity of money, which is the average number of times per year that a dollar is spent in purchasing goods and services, was assumed constant, that is:

$$V = \frac{PY}{M^S} \quad (1)$$

From Exchange Equation to Quantity Theory, using the statement of the classical theory, the equation of exchange becomes:

$$M^S V = PY \quad (2)$$

Fisher [28,29] assumed that velocity was fairly constant in the short run. Velocity *(V)* is determined by transaction technology factors (e.g. rise of credit and debit cards use intensity, mobile banking, mobile money transfer systems (MMTs) and other e-payment channels and systems through the interoperability between the financial, ICT and retail sectors); as people use cash less often, so less money is needed to transact, money supply falls, and velocity rises. He also assumed that transaction technology changes slowly and that *V* is constant, such that the nominal income is determined only by movements in money supply, via changes in price (*P* - quantity theory). Therefore, movements in the price level result only from changes in money supply. This also implies that, Quantity Theory of Money Demand when market for money is in equilibrium yields:

$$M^D = M^S \quad (3)$$

Substitute this into the theory equation, one get:

$$M^D V = PY$$

$$M^D = \frac{PY}{V} \quad (4)$$

That is, Money demand is proportional to nominal income (*V* – constant) and interest rates have no effect on demand for money. Conclusively, the underlying supposition of the theory is the belief that people hold money only for transactions purposes.

The Cambridge school of thought was concerned with the volume of money held given the number of transactions carried out. They argue that the greater the number of transactions the greater the amount of money held. They developed the Cambridge cash balance theory, which argue that the amount of money held by individuals depends upon the convenience and security yields which it generates, interest rates, existing wealth holdings and the expectations of future economic events.

Contrary to the classical Quantity Theory of money, the Keynesian theory also known as the Liquidity Preference Theory rejects the notion that velocity of circulation is constant and deals with the desire to hold money rather than other forms of wealth for example stocks and shares. Keynes [30] emphasizes three reasons why people hold money, namely, transactions demand – proportional to income, precautionary demand – for unexpected expenses proportional to income and speculative demand – holding money as a store of wealth. Under Speculative Demand for Money people can hold wealth as money or bonds (a composite of all other assets that pay interest) the expected returns to both affect how much one want to hold of each, assuming money pays zero interest return on bonds consists of interest and expected capital rate of capital gain if interest rates are low, and one expect them to rise, this will lead to potential capital loss on bonds – hold more money and if interest rates are high, hold less money. Conclusively, according to Keynes, money demand is negatively affected by interest rates and if this is combined with the loanable funds theory, equilibrium interest rate are endogenously determined by money demand and exogenously respond to money supply since the money supply function is perfectly inelastic to changes in interest rates. Therefore, the magnitude of the changes in equilibrium interest rates depends of the interest rate elasticity of money demand. Money demand is also endogenously determined by the national income or GDP level but money supply is assumed to be exogenous determined by GDP and other macro-variables.

According Liquidity preference theory the money demand function can be stated as:

$$\frac{M^D}{P} = f(Y, i) \tag{5}$$

And the Relationship between liquidity preference and velocity:

$$V = \frac{PY}{M^S} = \frac{Y}{f(Y.i)} \tag{6}$$

Thus, when interest rates go up, velocity also goes up. Keynes's theory predicts fluctuation in velocity and it can also explain why velocity is somewhat pro-cyclical.

Baumol-Tobin Money Demand Model(s) further developed the Keynesian theory based on variations in each type of money demand, that is, transaction demand is also affected by interest rates, so is precautionary demand and speculative demand is affected not only by interest rates but also by relative riskiness of available assets therefore, the bottom line is, demand for money is still positively related to income and interest rates, but through multiple channels.

The Monetarist Theory, which is based on Friedman's [31,32] restatement of the Quantity Theory of money is premised on the assertion that the demand for money is affected by same factors as demand for any other asset such as wealth (permanent income), relative returns on assets (which incorporate risk), and individuals hold their wealth as: Money, bonds, equity and real assets (e.g. housing, cars, etc). According to this theory the functional form of the money demand function can be stated as:

$$\frac{M^D}{P} = f(Y_P, r_b - r_m, r_e - r_m, \Pi^e - r_m) \tag{7}$$

Where Y_P is permanent income, r_e, r_b, r_m, are returns on equity, bonds and money market instruments and Π^e is the expected or anticipated rate of inflation. If $r_b - r_m$ and $r_e - r_m$ are both positive people will prefer holding bonds and equity instruments respectively rather than money, that is, they demand less cash and cash equivalents since their returns are less lucrative as compared to returns on capital and money market instruments and the opposite is also true. Permanent income- Y_p (Friedman's measure of wealth) is the present expected value of all future income, which fluctuates less than output with, say, business cycles, because a lot of business cycle fluctuation is temporary. Expected Returns on Money is affected not only by interest paid on deposits, but also by services provided by a bank for holding your money there (e.g. electronic bill payment, cheque processing, etc.).

If interest rates in the economy increase, banks make more profit on loans, so – to get more customers – also increase interest rates on deposits. Hence, r_m moves and need not to be constant, unlike in Keynes's approach. Even if banks cannot increase interest rates by regulation, they can improve services which may still keep holding money in a bank relatively attractive. Friedman's main insight (unlike Keynes) is that interest rates should have little effect on money thus, the main message of Friedman is that, he believed that correlation between interest rates and money demand is weak and contemporaneous, since relative incentive to hold money does not change very much. This is in stark contrast to Keynes. Friedman also believed that random fluctuations in the demand for money should be small, and thus that his money demand equation predicts well money demand, and hence, velocity. If so, a change in the quantity of money should produce a predictable change in aggregate spending/ price level. Finally, it can also account for pro-cyclical behavior of velocity.

3.1.2 The new classical approach

The theory is based on the money demand function developed by Newcomb [33] and latter popularized by Lieberman [34]. The approach introduces the concept of financial innovation on money demand function which was recognized as the gap left out by the traditional theorists and believed to be the main cause of financial crises, endogeneity of money stock and money demand instability. The new classical theory postulates that financial innovation is a key determinant of the money demand function. The school of thought argued that financial sophistication affects the money demand function through multiple channels such as financial deepening, the development of new financial products, financial engineering, deposit substitutes and technological advancements in payments and transactions systems. The creation and growth of money substitutes has made the demand for money more interest elastic. It was argued that increased use of credit, more intensive use of money substitutes, better synchronization of receipts and expenditures, and more efficient payments mechanisms will tend to decrease permanently the transaction demand for money over time [34]. Sharma and Ericsson [35] and Pradhan and Subramanian [36] further argued that financial advancement, such as the rapid introduction of interest-bearing assets and rapid development of financial infrastructure can cause the money demand function to become unstable. Arrau et al. [10] assert that the intensive use of money substitutes and efficient payment mechanisms decrease the transaction demand for money through lower transactions costs and therefore reduce income elasticity. However, even if financial development starts from a low base, rapid monetization and higher savings in the form of time deposits, and ensuing financial innovation may increase demand for money [37]. Money demand instability is the unpredictability of money demand, that is, money demand shifts erratically in a stochastic and random manner leading to policy formulation and precision impossible and implementation ineffective. It's a further development of the Cambridge school of thought theory which states that the greater the number of transactions the greater the amount of money held by adding an element brought about by technological advancement and adaptability of the financial sector due to the presence of low transaction and technological costs. Their money demand function is states as:

$$M^D = f(SV, OC) \quad (8)$$

Where M^D is demand for money, *SV* is scale or transaction variable (real economy side) and *OC* represents a set of variables representing opportunity cost of holding money (nominal interest rate, in transition economies, expected inflation, expected exchange rates, level of financial progress and level of dollarization). They argue that their equation presumes a positive relationship between real money balances and scale variables and a negative one with opportunity cost.

3.2 Empirical Evidence on Demand for Money

Is demand for money sensitive to changes in interest rates? If not, velocity is more likely to be a constant, and then money supply has a tight link to aggregate spending. The more sensitive, the more increasingly volatile *V* (velocity of circulation) will be. Extreme situation: Liquidity trap – perfectly/infinitely elastic money demand (with respect to interest rates). Is money demand stable? If yes, velocity would be unpredictable. It helps central bank to decide whether to target money growth or inflation. Based on literature and available data, money demand is becoming more unstable with time (i.e., dynamic rather than static due to financial innovation), though it is also hard to measure.

The main objective of Hu's [38,39] research papers were to study the demand for money, especially the magnitudes of the price expectation and cash balance adjustment in the demand for money, during the Chinese inflation, for the period covering September 1945 to May 1949. After modifying the Cagan [13] model by estimating an extra real cash balance adjustment model, over and above the price expectation model, the following results were found in Hu's two studies. The demand elasticity of real cash balances with respect to the rate of change in price level was -0.119, while the elasticity of demand with respect to the interest rate was -0.316. Thus these two estimates implied that during the hyperinflation period both the rate of change in prices and the interest rate have negative effects on demand for real cash balances. On the other hand, the estimated elasticity of price expectation, α, was 0.412. This elasticity of price expectation meant that an individual only expected 41.2 percent of the price level increase to be permanent. The results from the real cash adjustment model showed that the demand elasticity with respect to the cost of holding money was -0.174, while the elasticity of cash balance adjustment was 0.278. With these results he interpreted the positive elasticity of adjustment as supporting the hypothesis concerning the influence of past behavior on

current cash holdings (favour a dynamic case).
Following Hu's [38,39] researches, Michael et al. [11] reexamined the demand for money during German's hyperinflation period. The study showed that a remarkably well-defined demand for real cash balances existed for the German hyperinflation episode, including the final months which have previously been considered as outliers. The study's econometric analysis exploited the theory of cointegration, given the obvious non-stationarity of the time-series data that it used. The study also pointed out income variability and the necessity to distinguish between the high inflation and hyperinflation episodes, as two potential sources of model misspecification.

Through demonstration of the fact that, under only very weak assumptions concerning expectations formation (the stationarity of forecasting errors), Taylor [20] study showed that the hyperinflation model of money demand put forward by Cagan [13] requires cointegration between real money balances and current inflation when both inflation and real money balances are nonstationary series. Taylor's cointegration analysis results provided some support for the Cagan model of money demand, particularly as applied to Poland in the interwar period, as well as to Austria and Hungary. Nevertheless, the analysis suggested rejection of the null hypothesis that the authorities in these countries expanded the money supply in order to maximize the inflation tax revenue. Further, the study used the above results to test the hyperinflation model under the hypothesis of rational expectations (HMRE) which was a dynamic approach, in trying to find out if money demand is static overtime. Overall, the findings indicated a rejection of the HMRE which was in favour of the static money demand as opposed to a dynamic money demand case.

On a developing country's perspective, Makochekanwa [26] estimated Zimbabwe's hyperinflation money demand model from February 1999 to December 2006, using quarterly time series data. The research attempts to empirically study the demand for money, especially the magnitudes of the price expectation and real cash balance adjustment for Zimbabwe. He employed an error correction model (ECM) estimation method and found out that both the interest rate and the rate of change in prices are relevant variables for explaining the variations in the demand for real cash balances in Zimbabwe. Overall, the findings suggest that the Zimbabwean hyperinflation does not appear to have been a self-generating process independent of money supply which was used as a proxy of money demand, that is, money supply was rather exogenously determined which was in line with *a priori* expectation in macroeconomics.

Furthermore, Munoz [40] investigated the relationship between suppressed inflation and money demand for Zimbabwe for the period 1980-2004 employing recursive estimation methodology. Variables included in the model includes interest rates, proxied by three-month time deposit rates, wealth proxied by real income, broad money M3 and parallel exchange rate and found that, except for 2004, a stable demand for money as a function of parallel market exchange rate, inflation and real output can be found in Zimbabwe. Employing Chow break stability test the researcher concludes that the money demand function for Zimbabwe was stable irrespective of the inertia or sluggish nature of the data due to the hyper-inflationary environment which prevailed.

On a broader angle, Hamori [41] empirically investigated the money demand function for sub-Saharan Africa, covering 35 countries with Zimbabwe included for the period 1980-2005 using log-linear, OLS estimation procedure with both M1 and M2 as dependent variables and real GDP and interest rates as regressors. It was concludes that there exists a cointegrating relationship of the money demand function in the Sub-Saharan African region and it is stable, that is, 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.

On the other hand, Kovanen [42] estimated a different set of extensive specification of long-run money demand for Zimbabwe from 1980-2001 using the official exchange rate, inflation, financial innovation, real GDP and different money aggregates (currency, narrow money and broad money (M2) all variables were found to be significant and a stable money demand function was only found to exist during 1980-1995 but unstable for the later periods due to high inflationary episodes. Furthermore, Nyawata [43] examines the demand for money in Zimbabwe using quarterly data for the period 1998:1-2004:12 and established long-run relationship between money demand, the price level for currency, bank deposits, narrow and broad money. Results proved the existence of a stable money demand function determined by inflation, interest rates, income and exchange rates. More and above that, Kwashirai [44] also estimated the money demand function for Zimbabwe for the period 1980:2-1989:4. The research considered all definitions of money, namely M1, M2 and M3 applying cointegration and error correction models. The study found that interest rate was a statistically significant variable, M1, M2 and M3 were cointegrated with income, but inflation was insignificant and money demand function was found to be stable.

Conclusively, even though several studies have been conducted on the stability of the money demand basing on static models, just to mention a few, Deckle and Pradhan [45] and Kararach [46] Bahmani-Oskooee and Gelan [47], Hamori [41] and Salisu et al. [48], there is still scant literature that has examined the exogeneity of money supply, concentrate on the impact of financial innovation on the stability of money demand. Worse, in the case of Zimbabwe literature is limited especially in terms of modifying the traditional money demand function to account for financial innovations using a dynamic model. Over and above, the comparisons between the innovations before and after the economic reforms (1980-2008) and the special attention to a hyperinflationary environment under political instability have not been fully researched. Even though, more recently Nyamongo and Ndirangu [49] analyzed the effect of financial innovation on effectiveness and potency of monetary policy in Kenya over the period 1998-2012, the model do not account for the financial innovation and the dynamic evolution of money demand overtime in their money demand function which could be insightful on the stability of the money demand. In addition, most researches done on Zimbabwe on this topical issue do not include the years where the hyperinflationary era reached a peak, leading to the complete abandonment of the Zimbabwean dollar in favour of more stable currencies under the banner 'multiple currency regime'. In addition, the issue of determining whether money demand is exogenous were not given full attention, especially given that the central bank has just introduced the so called 'Bond Coins' as a way of enforcing the divisibility characteristic of money. The major concern of the citizen is on the monitoring of the actual amount of bond coins in circulation, given that historical experience have shown that it was a jealously and closely guided secret from the public and also it take much longer for Zimstat to publish inflation statistics in 2008 after it has reached 213 million mark.

4. DATA, METHODOLOGY AND RESULTS ANALYSIS

There are diverse theories on the money demand function. For example, Kimbrough [50, 51] and Faig [52] put forth the following money demand function by explicitly considering transaction costs.

$$\frac{M^D}{P} = f(\ln Y_t, \ln R_t) \quad \text{lnY} > 0\ ,\ \text{lnR} < 0 \qquad (9)$$

But following Portes and Winter [53] one must start by assuming that households are in equilibrium, that is, they are not constrained in the amounts of goods they can buy or labor they can sell so that money can be modeled with the standard log-linear function for desired balances. This is a very strong assumption given the economic situation in Zimbabwe. Given this assumption, the only way one can consider the possibility of disequilibrium behavior, for example, households holding more money than their 'notional' demand, because they cannot buy all the goods they want, this is meant to inspect the results of the estimation. If one cannot explain money holdings well, one might suspect that he/she is not actually observing unconstrained behavior, or that the parameter estimates might suggest excessive money-holding. Before specifying the money demand function for Zimbabwe, the major question that ponders every researcher's mind is what factors account for the explosive behavior of real money balances and velocity of money in Zimbabwe over the period 1999-2008? The observed outcome could reflect (i) A historically unstable money demand relationship; (ii) A sharp movement in some independent variable within a stable money demand relationship; or (iii) An aberration or structural break within a historically stable money demand relationship iii) An endogenous and opposed to an exogenous money stock/supply to some macroeconomic fundamentals, especially the rate of inflation, which decelerates most of macroeconomic indicators through the multiplier effect.

Given the above accession to explore these questions, one must employ Friedman's [31,32] model of demand for money which was late modified by Hu [38] as a Cobb-Douglas function as follows:

$$\frac{M^D}{P} = AR_t Y_t EX_t U_t \quad (10)$$

where R_t , Y_t EX_t represent interest rate, national income and exchange rate respectively at time t; A = intercept and U = white noise error term

Following the model by Hu [38] as well as the previous argument concerning the demand for real cash balances it can be hypothesized that the demand for real cash balances is a function of the interest rate and the expected rate of change in prices. To this end, the slightly modified Hu [38:454-456] function can be stated as follows:

$$M_t^D = f(R_t, P_t^*, Y_t, \varepsilon_t) \quad (11)$$

Where: M_t = amount of real cash balances $\left(\frac{M2}{P}\right)$ demanded at time *t*.

R_t = money interest at time *t*.

P_t^* = expected rate of price change at time *t*.

ε_t = random disturbance term at time *t*.

Y_t = real income at time *t*

The relationship between the demand for real cash balances and the expected rate of change in prices is assumed to take the following representation:

$$\ln M_t = \beta \ln P_t^* \quad (12)$$

Employing Hicks' [54,55,56] concept of unit elasticity of price expectation and backward induction, the algebraic relations between actual and expected rate of price changes can be formulated following Nerlove [57] as:

$$\frac{(\ln P_t^* - \ln P_{t-1}^*)}{(\ln P_t - \ln P_{t-1})} = \alpha \quad (13)$$

Where *0 < α < 1* is the elasticity of expectation with respect to the rate of change in prices.

Or, it can be expressed that the expected change in P_t in one period is:

$$\ln P_t^* - \ln P_{t-1}^* = \alpha(\ln P_t - \ln P_{t-1}) \quad (14)$$

Substituting (14) into (12) and rewriting gives:

$$\ln M_t = \beta\alpha \ln P_t + (1-\alpha)\ln M_{t-1} \quad (15)$$

Therefore, the explicit dynamic function of equation (15) is:

$$\ln M_t = \beta_0 + \beta_1 \alpha \ln P_t + (1-\alpha)\ln M_{t-1} + \varepsilon_t \quad (16)$$

From the above model, if we add the version of the traditional and the new classical theory, that is, financial innovation and assume rational expectation holds, implying current price as expected by the consumers, alpha disappears and the model in static form finally becomes:

$$\ln\left(\frac{M_t}{P_t}\right) = \beta_0 + \beta_1 \ln INF + \beta_2 \ln R_t + \beta_3 \ln FI + \beta_4 \ln EX_t + \beta_5 \ln Y_t + \varepsilon_t \quad (17)$$

And the dynamic model becomes:

$$\ln\left(\frac{M_t}{P_t}\right) = \beta_0 + \beta_1 \ln INF + \beta_2 \ln R_t + \beta_3 \ln FI + \beta_4 \ln EX_t + \beta_5 \ln Y_t + \beta_6 \ln\left(\frac{M_{t-1}}{P_{t-1}}\right) + \varepsilon_t \quad (18)$$

In the above models, M_t represents nominal money supply *(M2)* for time *t*; P_t represents the price index for time *t* (Proxied by GDP deflator); Y_t represents the output (current GDP in US$) for time *t*; FI_t represents financial innovation time t (Proxied by $\frac{M_0}{M_1}$); EX_t represents official exchange rate at time t, R_t represents the real interest rate at time t, *INF* represents inflation (proxy CPI using 2000 as base year) and M_{t-1} is lagged money supply. M2 was used as a proxy of money demand assuming equilibrium condition and furthermore it was preferred its liquidity state since it is composed of notes and coins, demand deposits and time deposits. Increases in output yield increases in money demand, and increases in interest rates lead to decreases in money demand. Financial innovation reduces the demand for real cash balances especially transactionary and precautionary purposes since people can use financial technologies such as mobile banking facilities and plastic money such as debit cards (VISA or MasterCard) Therefore the model by Hu is the most appropriate one for developing countries that experience low growth rate and high inflation episodes (Hu [38]). It is also the one adopted by Hamori [41] for Sub-Saharan Africa and the one recommended by Cagan [13] for countries that experienced hyperinflation episodes.

The Chow Break point test must be applied, since there are two different inflation episodes. Period from 1999-2008 is characterized by hyperinflation and before that it was reasonable. The period starts from 1991 in order to capture the ESAP era and also with the intention of excluding the pre-ESAP era. To cater for chow structural break-test, only two important eras were identified, the 1999-pre and post land reform and opposition party formation eras. To test whether money supply was exogenously or endogenously determined by inflation over the period 1991-2008, the following granger causality model was used:

$$\ln M_t^S = \sum_{i=2}^{n} \alpha_i \ln M_{t-i}^S + \sum_{j=2}^{n} \beta_j \ln INF_{t-j} + \mu_{1t} \quad (19)$$

$$\ln INF_t = \sum_{i=2}^{n} \lambda_i \ln M_{t-i}^S + \sum_{j=2}^{n} \gamma_j INF_{t-j} + \mu_{2t} \quad (20)$$

Equation (19) postulates that current money supply level is related to past values of itself as well as that of inflation and (20) postulates a similar behavior for inflation level. These regressions are expressed in nominal forms, M^s and INF, meaning that all variables are in actual rates from sources. The above models can yield four distinct cases as follows:

i) Unidirectional causality from M^S to INF is indicated if the estimated coefficients on the lagged M^S in (19) are statistically different from zero as a group (i.e., $\alpha_i \neq 0$) and the set of estimated coefficients on the lagged INF in (20) is not statistically different from zero (i.e., $\gamma_i = 0$).
ii) Conversely, unidirectional causality from INF to M^S exists if the set of lagged M^S coefficients in (19) is not statistically different from zero (i.e., $\alpha_i = 0$) and the set of the lagged INF coefficients in (20) is statistically different from zero (i.e., $\gamma_i \neq 0$).
iii) Feedback, or bilateral causality, is suggested when the sets of M^S and INF coefficients are statistically significantly different from zero in both regressions.
iv) Finally, independence is suggested when the sets of M^S and INF coefficients are not statistically significant in both the regressions.
v) The same procedure was done on other variable, that is, R, FI, M(-1) and Y

More generally, according to Gujarati [58], since the future cannot predict the past, if variable X (Granger) causes variable Y, then changes in X should precede changes in Y. Therefore, in a regression of Y on other variables (including its own past values) if we include past or lagged values of X and it significantly improves the prediction of Y, then we can say that X (Granger) causes Y. A similar definition applies if Y (Granger) causes X.

Based on theoretical postulations, the researcher expect condition (iv) to hold, since economic theory asserts that money stock is exogenously determined since is it is controlled by the Central bank, that is, RBZ in the current case, which is supposed to be independent from external influence. Money supply in the research is proxied by monetary base (M_0), that is, notes and coins in circulation, which is the money stock printed or minted by the RBZ. Because the researcher cannot find already published quarterly data, the Lisman and Sundee's [59] method of interpolation was used to transform annual data obtained from ZimStat, RBZ, IMF and World Bank to quarterly data.

4.1 Results Analysis and Interpretations

4.1.1 Diagnostic tests results

It's critical and of paramount importance to diagnose the data to ascertain whether it satisfy crucial econometric assumptions in order to guarantee the efficiency, constituency and reliability of results [60,58,61,62]. The diagnostic check tested includes unit root, cointegration, autocorrelation, multicollinearity, hetero-skedasticity, normality, model specification, optimal lag length determination, Chow prediction failure test and Chow parameter stability test.

4.1.2 Unit root and cointegration tests

Table 1 below shows unit root test results obtained using Ng and Perron [63] test. The Ng and Perron was employed based on three reasons; i) the ADF test was found to have a power weakness ii) Philips and Perron test was found to suffer from size problem iii) structural breaks were significant [64,65-67,63]. Though there is no consensus among researchers on the best unit root test approach that one can use, there is veritable literature to support that the Ng-Perron unit root test to have advantages to overcome the three aforementioned weaknesses found to be plagued with traditional unit root tests. The Ng-Perron unit root test results are presented in Table 1.

The results in Table 1 has shown that all variables in logarithm form are non-stationary but are difference stationary, that is, they become stationary after being differenced once. If series are non-stationary or integrated of order one i.e. I(1), Gujarati [58] recommends the carrying out of the Johansen cointegration test procedure to determine whether the variables in the model are on the same wavelength in the long run, especially if variables in the model are more than two. In the cointegration literature, if variables in the model are more than two one cannot employ Engle and Granger's [68,69] and Engle et al.'s [70] methodology.

The Johansen cointegration test results in Table 2 indicates that the variables are cointegrated and the model have at most four cointegration equations. That is, although the variables are individually non-stationarity, they are cointegrated, showing that they move on the same wave length in the long run and estimating them at their levels yields results which are unbiased and efficient in small sample, as well as asymptotically unbiased, asymptotically efficient and consistent in large sample. This also guarantees the researcher that the model would not suffer from contemporaneous or spurious regression (Granger and Newbold, [71]; Gujarati, [58]).

The F-statistic and the log likelihood ratio for the Chow breakpoint Test in Table 3 are significant at 5% as shown by their p-value with are less than 0.05. This implies that at 5% the null hypotheses of no structural change in the structure of the Zimbabwean economy in 1999 was rejected in favour of the alternative hypothesis the there was a structural change.

In addition, the money demand function's stability was tested using the Chow Forecast Test. The period was broken down into two Forecasts periods, that is, 1991 to 1999 and from 1999 to 2008, in order to capture the paramount structural break, whose results are depicted in Table 4.

F-statistic and the log likelihood ratio shown in Table 4 are insignificant at 5% as indicated by their p-value with are greater than 0.05. This implies that at 5% the alternative hypotheses of parameter instability of the Zimbabwe's money demand function before and after the 1999 era was rejected in favour of the null hypothesis that it's stable.

The model was also tested for autoregressive of order one (AR(1)) serial autocorrelation of residuals using the Breusch-Godfrey Serial Correlation LM Test, and the null hypothesis of no autocorrelated residuals was not rejected at all levels of significant. The results are presented in Table 5.

4.1.3 Heteroskedasticity test

Is a situation where by error variances appearing in the population regression function (PRF) are not constant, that is, all disturbances terms have different and time variant-variances. Heteroskedastic error terms results in inefficient estimators both in small samples and large samples, that is, it yields parameters which are no-longer Best, though they are Linear and Unbiased (i.e. they are LUE and not BLUE) (Gujarati, [58]). The test is carried out based on the null hypothesis that there is no heteroskedasticty against the alternative that there is heteroskedasticity. To test for homoskedasticity of the error terms in my model I used both the Breusch-Pagan-Godfrey (BPG) test and the White's test with unrestricted residuals and the results are presented in Tables 6 and 7.

White's test regressed squared-residuals on the cross product of the original regressors and a constant whilst the Breusch-Pagan-Godfrey (BPG) test regresses the squared residuals on the original regressors by default. Therefore, the two tests test heteroskedasticity based on two different assumptions, that is, the BPG test heteroskedasticity base on a linearity of original regressors and White's test assumes that heteroskedasticity arise as a result of both linear and curve-linear relationship of regressors.

Table 1. Unit root tests results

Variable	Ng-Perron test statistics				Intercept	Trend	Oder of integration
	MZa	MZt	MSB	MPT			
lnM2	-27.0671***	-3.6794***	0.1359***	0.9050***	Yes	No	I(1)
lnY	-23.1286	-3.4003***	0.14702**	3.94219**	No	No	I(1)
lnR	-80.6126***	-6.0719***	0.0753**	2.25343**	No	No	I(1)
lnEX	-38.1807***	-3.6245***	0.0949*	6.1004***	Yes	No	I(1)
lnP	-35.4942***	-4.21272***	0.1187*	2.5674*	No	Yes	I(1)
lnINF	-32.8794***	-3.9863***	0.1212	3.1567	No	No	I(1)
lnFI	-29.3337**	-3.8295**	0.1306**	3.1077**	Yes	Yes	I(1)
lnM2(-1)	-26.6019***	-3.6469***	0.1371***	3.4262***	Yes	Yes	I(1)

NB: where (***), (**) and (*) shows stationariry at 1%, 5% and 10% respectively

Table 2. Johansen cointegration test results

Hypothesized number of cointegration equation(s)	Eigen value	Trace statistics	5 percent critical value	1 percent critical value
None **	0.5904	111.9178	94.15	103.18
At most 1**	0.3126	79.9016	68.52	76.07
At most 2**	0.2239	69.5333	47.21	54.46
At most 3**	0.1324	43.0556	29.68	35.65
At most 4**	0.0441	23.8237	15.41	20.04
At most 5	0.0136	13.8892	14.76	16.65

*NB: *(**) denotes rejection of the hypothesis at the 5% and 1% level respectively*

Table 3. Structural break test results

F-statistic	2.805093	Probability	0.047667
Log likelihood ratio	24.54282	Probability	0.000914

Table 4. Stability test for the parameters of the function pre-and-post 1999

	Value	Degrees of freedom	Probability value
F-statistic	0.4831	(37, 26)	0.9809
Likelihood Ratio	35.7390	37	0.5281

Table 5. Breusch-Pagan serial correlation LM test results

F-statistic	0.182144	Probability-value	0.674096
Observations*R-squared	0.252700	Probability-value	0.615180

The BPG and White's test results in Tables 6 and 7 indicates the probability-values of the F-statistic greater than 0.1, 0.05 and 0.01, which gives a no rejection decision on the null hypothesis of homoskedasticity at all level of significance even if the squared residuals are restricted on linear regressors (BPG's approach) or unrestricted them on non-linear regressors (White's approach). These three tests' results indicated the absence of heteroskedasticity, an indication that the variance of the residuals is constant or homoskedastic and give efficient standard errors which gives more precise, valid and reliable confidence intervals and hypothesis testing results [60,62]; Gujarati, [58]). The result in Tables 5-7 are complemented by the insignificant autocorrelation and partial autocorrelation up to lag 28, tested using the Q-statistic shown on Table 8.

4.1.4 Normality test

The results in Table 9 indicate that the mean value of the residuals of 1.16×10^{-12} is close to zero. But the null hypothesis of mesokurtic data was not rejected since the probability value of the kurtosis was insignificant. This implies that the peakedness of the distribution of the data was not leptokurtic or platkurtic but mesokurtic. The normality test results indicates that, though the data is slightly positively skewed, overally, the residuals are normally distributed, since the null hypothesis of normality based on the Jarque-Bera test-statistic of 0.7025 with a corresponding p-value of 0.87898 which is greater than the 0.01, 0.05 and 0.1 critical values. Furthermore, the kurtosis value of 3.0487 is closer to 3 (than zero or any other higher value), a value that corresponds to a normally distributed error term. This implies that the null hypothesis of kurtosis of 3 ($(H_0 : K = 3)$ was not reject and that the alternative hypothesis of kurtosis value of smaller or greater than 3. $(H_1 : K \neq 3)$ was rejected. This validates the use of t-test and z-score tests for determining the significance of the parameters, given that they are based on the normal distribution or normality assumption, since the error term is identically and independently distributed (i.e. $\varepsilon_t \approx IID(0, \sigma_\varepsilon^2)$ with a mean of zero and constant variance (Gujarati, [58]).

4.1.5 Multicollinearity test

According to Gujarati [58] multicollinearity is the existence of ideal or perfect linear correlation among some or all exogenous variables of a regression model and results in large variance and covariance, making precise estimation difficult. It also results in much wide confidence interval leading to higher chances of committing type II error that is, not rejecting the null hypothesis that the true population coefficient is zero, when it is supposed to be rejected. Furthermore, t-ratios of most parameters in the model will be statistically insignificant. Presence of multicollinearity invalidates the application of the *ceteris paribus* assumption when interpreting the coefficients of explanatory variables. This will render the essence of variable interpretations contemporaneous. Correlations and variance inflation factors are mostly used as indicators of severe multicollinearity. Correlations between explanatory variables in excess of 0.8 in absolute terms are considered an indication of severe multicollinearity (Maddala and Lahiri, [62]; Gujarati, [58]). Correlation matrix Table 10 indicates no correlations above 0.8 indicating no severe multicollinearity in the empirical model.

In multiple regression, computationally, the variance inflation factor (VIF) is defined as the reciprocal of tolerance: 1 / (1 - R^2). Ceteris paribus, researchers desire lower levels of VIF, as higher levels of VIF are known to affect adversely the results associated with a multiple regression analysis. In fact, the utility of VIF, as distinct from tolerance, is that VIF specifically

Table 6. Breusch-Pagan-Godfrey test results

F-statistic	**0.6327**	**Probability- F (6, 60)**	**0.6755**
Observations*R-Squared	3.8990	Probability-Chi-square (6)	0.5640
Scaled Explained Sum of Squares	37.0107	Probability-Chi-square (6)	0.0000

Table 7. White's test with cross terms

F-statistic	**0.7546**	**Probability- F (27, 39)**	**0.5859**
Observations*R-squared	3.2990	Probability-Chi-square (27)	0.6540
Scaled explained sum of squares	31.3149	Probability-Chi-square (27)	0.0000

indicates the magnitude of the inflation in the standard errors associated with a particular beta weight that is due to multicollinearity. Various recommendations for acceptable levels of VIF have been published in the literature. Kennedy [72-76] argued that the most common value of 10 has been recommended as the maximum level of VIF. The VIF recommendation of 10 corresponds to the tolerance recommendation of 0.10 (that is, $1/0.10=10$). However, Rogerson [77] recommended that the maximum VIF value of 5 and even 4 [78] can be found in the literature [79]. Individual VIF values of all variables are within the 0-10 range and the average VIF value for this research in Table 11 of 3.79 are less than the ones stated in literature above, an indication of less severe multicollinearity, complementing the results shown in Table 10.

Table 8. Residual Autocorrelations (AC) and Partial-Autocorrelations (PAC)

Lag	Auto correlation (AC)	Partial autocorrelation (PAC)	Q-statistic	Probability-value
1	-0.096	-0.096	0.6494	0.420
4	0.030	0.042	1.2012	0.878
7	-0.002	-0.004	1.2769	0.989
12	-0.006	-0.033	3.2149	0.994
17	-0.044	-0.040	3.6413	1.000
22	-0.034	0.006	4.6553	1.000
27	-0.077	-0.070	11.300	0.997
28	-0.045	-0.041	11.544	0.997

Table 9. Normality test results

Jarque-Bera statistic	Probability-value (Jarque-Bera statistic)	Kurtosis	Skewness	Mean	Standard deviation
0.7025	0.8789	3.0487	0.1234	$1.16*10^{-12}$	14.5536

Table 10. Correlation matrix

Variable	lnFI	lnEX	lnR	lnY	lnINF	lnM2(-1)
lnFI	1.0000	-0.7056	-0.6345	0.6264	0.4034	-0.3650
lnEX	-0.7056	1.0000	0.7748	-0.7682	-0.7690	0.7404
lnR	-0.6345	0.7748	1.0000	-0.7025	-0.6689	0.6149
lnY	0.6264	-0.7682	-0.7025	1.0000	0.6355	-0.5508
lnINF	0.4034	-0.7690	-0.6689	0.6355	1.0000	-0.6736
lnM2(-1)	-0.3650	0.7404	0.6149	-0.5508	-0.6736	1.0000

Table 11. Variance inflation factor

Variable	VIF	1/VIF
lnR	7.71	0.129659
$lnM^S(-1)$	5.35	0.187005
lnEX	4.89	0.204517
lnINF	1.87	0.534911
lnEX	1.68	0.594839
lnFI	1.24	0.804384
Mean VIF	3.79	

4.1.6 Model specification test

Post estimation checks of the model to determine whether the correct functional form has been adopted, that is, whether the model has not been under or over-fitted, error of measurement was not committed and model mis-specification or specification error was not committed, it is advisable to carry out the Ramsey RESET test [79,58]. When carrying out this test the null hypothesis of correct model specification is carried out against the alternative of model mis-specification. The results of this test are presented in Table 12.

The results in Table 12 indicate that the model is correctly specified, since all the test statistics and the likelihood ratios are insignificant, implying a no rejection decision on the null hypothesis.

4.1.7 Model estimation results

After an estimation of the static and dynamic models, the results for the money demand function for Zimbabwe in Tables 13 and 14 respectively, were was found.

The static money demand function show that autonomous money demand was Z$1 967 441 884, and as expected based on *a priori* assertion; the current money demand is negatively and significantly determined by the current national income level and, financial innovation and positively determined by inflation rate and current exchange rate. Interest rate is not a determinant of money demand in both static and dynamic models which supports Keynesians' postulation that the demand for money for precautionary and transaction motives is perfectly interest rate inelastic. This also occurs along the liquidity trap where the interest rate elasticity of money demand is infinite. Both static and dynamic models are of good fit, though the dynamic model is better when compared to the static model since it has a better fit when degrees of freedom are taken into consideration. For the static model, 69.41% of the changes in money demand are endogenously explained by inflation, exchange rate, GDP, interest rate, financial innovation, whilst on the dynamic model case, 87.1% is endogenously determined by lagged money demand, in addition to the aforementioned variables after the adjustments for degrees of freedom are taken into consideration. On interest rate, both model supports Friedman's assertion that the relationship between money demand and interest rates is weak and contemporaneous and in stark contrast with Keynes' believe that there is a strong relationship. By the same token, the significance of financial innovation in both the static and dynamic money demand models supports the new classical economists' assertion that exclusion of financial innovation renders tradition money demand functions mis-specified, posing a lot of reservations on their parameters since they no-longer satisfy all the properties of good estimators and on top of that, they belong to an under-fitted model. The addition of the dynamic variable improves the fit, explanatory and significance of the model since F-statistics, R-squared and adjusted R-squared improves significantly. Based on Frisch's [80] Confluence or Bunch Map Analysis, the results indicated that, the variable that capture the dynamic component (M2(-1)) is useful and its omission has detrimental consequences on the model. The major determinant of money demand in both models is inflation since it is the one with the highest significance on the bases of the t-statistic criterion. This is an indication that people mind much about the purchasing power of their money balances, that is, the downward risk posed on the monetary value. Relating these results to Granger and Newbold's [71], Gujarati's [58] and Enders' [81] assertions, the validity and reliability of both models was guaranteed, since they do not suffer from spurious or contemporaneous regression problem given that their Durbin-Watson (DW) statistics were greater than R-squared.

Table 12. Ramsey RESET test for model specification

	Value	Degrees of freedom	Probability value
t-statistic	0.6950	62	0.4896
F-statistic	0.4831	(1, 62)	0.4896
Likelihood ratio	0.5356	1	0.4643

Table 13. Static model estimation results

Variable	Coefficient	Standard error	t-Statistic	Probability value
Constant	21.3803	5.1537	4.1486	0.0001
lnY	-0.2826	0.0865	-3.2663	0.0024
lnR	0.1105	0.1879	0.5884	0.5584
lnINF	0.1491	0.0169	8.8033	0.0000
lnFI	-0.4199	0.0748	-5.6148	0.0000
lnEX	0.3346	0.1099	3.0459	0.0034
R-squared	0.7313	**F-statistic**	14.285	
Adjusted R-squared	0.6941	**Prob (F-statistic)**	0.0000	
Durbin-Watson stat	1.8457			

Table 14. Dynamic model estimation results

Variable	Coefficient	Standard error	t-statistic	Probability
Constant	27.51088	15.51023	1.773725	0.0906
lnFI	0.678769	0.158833	4.273475	0.0004
lnEX	0.048454	0.063606	0.761782	0.4547
lnR	-0.156634	0.108899	-1.438339	0.1651
lnY	-0.832783	0.261295	-3.187137	0.0047
lnINF	0.920510	0.215036	4.280724	0.0003
lnM2(-1)	0.594220	0.193287	3.074280	0.0058
R-squared	0.87627	**F-statistic**	24.78723	
Adjusted R-squared	0.84092	**Prob(F-statistic)**	0.000000	
Durbin-Watson stat	2.01021			

The dynamic money demand function can be represented in a linear for as follows:

$$\hat{M}_t = 27.51 + 0.68\ln FI + 0.05\ln EX - 0.16\ln R - 0.83\ln Y + 0.92\ln INF + 0.59\ln M_{t-1}$$

4.2 Endogeneity-Exogeneity Nexus of Money Supply Results

For the purpose of determining whether Zimbabwe's money stock was exogenously or endogenously responded to macroeconomic fundamentals especially government expenditure induced-inflation due to seigniorage-financed budget deficit, a Granger causality procedure was estimated paying particular attention on current and lagged money stock on inflation, interest rate, national income/GDP and financial innovation.

4.3 Optimum Lag-Length Determination

The key element in a model is to determine the correct lag length. Several studies in this area demonstrate the paramount importance of selecting a correct lag length. Estimates of the model would be inefficient in small samples as well as asymptotically inefficient and inconsistent in large samples if the selected lag length is different from the true/optimum lag length [63,79,62,73,81]. Selecting a higher order lag length than the true one over-estimate the parameter values and increases the forecasting errors and selecting a lower lag length usually underestimate the coefficients and generates autocorrelated errors [79]. Therefore, accuracy of parameters and forecasts heavily depend on selecting the true lag length. There are several statistical methods used to select the correct lag length which includes Hannan and Quinn, Schwarz (SIC) and Akaike Information (AIC) criteria. Akaike Information Criterion (AIC) developed by Hirotugu Akaike in 1971, [79] has been found to be nearly unbiased estimator of selecting lag order and also it's a large sample size measure of thirty or more items, while the Schwarz Information Criterion (SIC) is a small sample measure of less than thirty observations [65,63]. These tests have been found to suffer from size and power weakness. In order to circumvent these weaknesses and guarantee good size and power properties of all parameters, Ng and Perron [63] suggested the use of modified information criteria of any of the three criteria mentioned above. Therefore, to reduce the problems specifically faced by each criterion, the modified version of the three criteria has been used to determine the optimum lag-length in this research. In this research, the ordinary least Squares regression model was run using the autoregressive distributed lag model (ARDL) procedure, starting with lag zero going upwards, since according to Nerlove [57] and Engle et al. [70] it is the mostly used and recommended methodology used to determine the lag length. The lag that provides the first minimum value of any of the three modified criteria value was chosen as the optimal lag length.

The results in Table 15 coincidentally indicates that the three criteria attained their minimum values at lag one in the following order; modified Akaike, Hannan-Quinn and Schwarz respectively. The granger causality results at the optimum lag-length (1) are in Table 16.

Table 15. Optimum lag-length determination

Lag-length	Information criterion		
	Modified Akaike	Modified Schwarz	Modified Hannan-Quinn
0	3.1784	3.3758	3.2566
1*	**1.5909***	**1.9957***	**1.7504***
3	1.6077	2.2307	1.8519

Table 16. Granger causality test results at optimum lag-length

Direction of causality	F-statistic	Probability-value	Decision
$\ln M^S \Rightarrow \ln INF$	15.4846***	0.0002	Reject H_0
$\ln INF \Rightarrow \ln M^S$	7.3317***	0.0086	Reject H_0
$\ln M^S \Rightarrow \ln FI$	6.9068**	0.0107	Reject H_0
$\ln FI \Rightarrow \ln M^S$	0.1286	0.7209	Do not reject H_0
$\ln M^S \Rightarrow \ln R$	2.6032	0.1116	Do not reject H_0
$\ln R \Rightarrow \ln M^S$	2.2742	0.1365	Do not reject H_0
$\ln M^S \Rightarrow \ln Y$	3.1375*	0.0812	Do not reject H_0
$\ln Y \Rightarrow \ln M^S$	0.8558	0.3583	Do not reject H_0
$\ln M^S \Rightarrow \ln M(-1)$	1.8133	0.1829	Do not reject H_0
$\ln M(-1) \Rightarrow \ln M^S$	564.060***	$4\text{x}10^{-33}$	Reject H_0
$\ln M(-1) \Rightarrow \ln R$	0.0957	0.7581	Do not reject H_0
$\ln R \Rightarrow \ln M(-1)$	1.6029	0.2102	Do not reject H_0
$\ln M(-1) \Rightarrow \ln Y$	7.1177***	0.0097	Reject H_0
$\ln Y \Rightarrow \ln M(-1)$	0.8639	0.3561	Do not reject H_0
$\ln M(-1) \Rightarrow \ln INF$	6.9725**	0.0104	Do not reject H_0
$\ln INF \Rightarrow \ln M(-1)$	0.0507	0.8227	Do not reject H_0
$\ln M(-1) \Rightarrow \ln FI$	6.2809**	0.0148	Reject H_0
$\ln FI \Rightarrow \ln M(-1)$	3.8434**	0.0543	Do not reject H_0

*Note: *(**) (***) imply significance at 10%, 5% and 1% respectively. The rejection decision was based on the minimum of 5% level, i.e., 95% confidence level*

The results presented on Table 16 shows a highly significant strong bi-directional or feedback causal relationship between money supply and inflation. This indicates that there is endogeneity dependency between money supply and inflation, that is, inflation was a directly results of money supply growth and money supply growth also directly responded to hyperinflation trajectory. These results support the Keynesians' assertion of inflation being a monetary phenomenon rather than a fiscal phenomenon and in stark contrast with the monetarists' view that inflation is a fiscal phenomenon rather than a monetary one. The Keynesians' assertion is also supported by the no causality results between income/GDP and money supply which violets the quantity theory of money assumption of a direct relationship between output and money supply an indication that there was too much money chasing after too few goods, which is demand-pull inflation. The result of no causality or independent relationship between interest rates and money supply, though in contrast with Chou [82], conform to the loanable funds theory that money supply is exogenously determined by the level of interest rate and that changes in equilibrium interest rate is endogenously determined by the shift of the money demand function around a perfectly inelastic money supply function. Moreover, it supports Friedman's belief that the correlation between money supply and interest rate is weak, in stark contrast with Keynes' ideology.

Furthermore, there is a uni-directional causal relationship between lagged money stock and succeeding money sock, that is, money stock have a long memory over itself such that money stock in the previous quarter determines money stock in the following quarter and not vice versa. In the same manner, the level of financial innovation responds to the money stock, since the uni-directional causal relationship runs from money supply (M^S) to financial innovation (FI) and not vice versa. This might imply that too much money especially accompanied by large denominations force citizens to introduce more technologically advanced payment systems such as point of sales, use of plastic money and electronic payment systems for convenience and as a way of trying to avoid carrying large sums of money for precautionary, transactionary and speculative decisions. This situation normally occurs in hyperinflationary environment like the one experienced in Zimbabwe, especially over the period 2007-2008. On the same vein, there is uni-directional causal relationship between lagged money stock (M(-1)) and the level of financial innovation with the possible reason being that history in most cases teach people on the best way of keeping their money to avoid loss of value and make payments (transactions). Also, the previous stock of money drives the current level of inflation. This assertion is supported by the unidirectional causal relationship between lagged money stock (M(-1)) and inflation rate (INF). The causality runs from lagged money stock to inflation and not vice versa. Overally, it was found that money supply function for Zimbabwe was endogeneous rather than exogeneous a result in contrast with macroeconomic postulation that money supply is vertical and resistant to external influence. This supports the assertion that the Reserve bank of Zimbabwe is not independent from the central government in its operations and formulation of monetary policy.

5. CONCLUSIONS AND POLICY IMPLICATIONS AND / OR RECOMMENDATIONS

The results have shown that inflation proxied by CPI was a major determinant of money demand in Zimbabwe since it is a highly significant as compared to all other variables in both static and dynamic models and caries a positive sign as expected. Furthermore, the coefficients of inflation is less than unit, an indication that elasticity of money demand is price or inflation inelastic and both money demand and inflation behave like complements since their behaviour reinforce each other. This confirms results found by Cagan [13] that inflation induces rational expectations which increases motives for holding money. Financial innovation was also a major determinant confirming the assertion by Arrau et al. [10] and Choi and Oh [37] that most of money demand functions of developing countries are mis-specified, that is, they suffer from model under fitting, due to omission of an important variable which capture financial innovation. This might have led to inefficient and inconsistent parameter estimates and plausible and highly autocorrelated errors. The results has also shown that the money demand for Zimbabwe in static form, was determined by financial innovation, income, inflation, and in dynamic form by financial innovation, income, inflation, lagged money demand, which are the only significant variables. Interest rates and exchange rates were found to be insignificant determinants of money demand in the dynamic model and only interest rates were insignificant in the static model. Money demand for Zimbabwe for the period 1991-2008 was found to have an inelastic response to all the explanatory variables included in both models which is a typical case for most developing countries, whose different economic sectors are not well integrated and intertwined. The money demand was also found to portray structural break reflecting the change in the structure of the economy due to the inception of the controversial land reform programme in 1999 and the formation of the opposition party also introducing political instability. Even though there was an impulse response of the economy in 1999 due to the two aforementioned reasons, the parameters of the money demand were found to be stable pre and post the structural break year, implying stability of both models. On top of that, the dynamic model yields superior results when compared to a static model, this implies that there is a dynamic response of money demand over time and also policy must evolve over time to overcome lagged policy gaps which reduces policy forecast precision and results in enormous policy missing targets. Finally the money supply stock was found to be endogenously responding to inflation, lagged money stock and the level of financial innovation in the economy exogenously responding to the national income level and the rate of interest.

The overal conclusion derived from this research is that money supply for Zimbabwe over the period 1991 when ESAP was implemented to 2008 when the hyperinflation reached its climax, was endogenous and time variant. This implies that the money stock was following a trajectory process and trending upwards responding mainly to the rate of inflation induced by government's insatiable appetite for spending and also inflation responded to money supply growth. For the efficiency and potency of monetary policy, it's critical for the central bank to be independent from central government and governments also must desist from financing their budget deficits as well as quenching their thirsty for spending through printing notes and minting coins (i.e., seigniorage). Endogenous money supply poses more harm to the welfare of the citizen of a country when compared to an exogenous one. Therefore, monetary authorities must try by all means to stick to their mandates and not involved in quasi-fiscal operations. In addition, to have policy credibility, there must be clear policy coordination between monetary and fiscal policies and these policies must be consistent. Policy credibility and consistency are the cornerstones requirements and pre-requisites for boosting all stakeholders' confidence and in future, Zimbabwean authorities especially the ministry of finance and the RBZ must take this into consideration in order to guarantee the strength of her currency, provided she manages to have one given the current economic quagmire bedeviling the economy.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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