The Effect of Financial Innovations on Demand for Money in Ghana

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Abstract:
This paper aimed at analyzing the effect of financial innovations on demand for money function in Ghana using quarterly time series data, 1990Q1 – 2021Q4. The unit root test of all the variables showed that the variables were integrated of order one, hence, Dynamic OLS regression was applied in estimating the long run parameters. It was found that the introduction of financial innovations variables help explained the variation in demand for money functions more and also, aid in the stabilization the functions estimated. Also, interest rate, inflation, exchange rate, real income, M2+/M1 ratio, dummy variable for mobile banking and domestic credit to private sector were variables that influenced demand for money. Finally, the M2+/M1 ratio and the introduction of ATM encouraged increasing monetization of the economy and financial depending while the introduction of mobile banking and domestic credit to private sector helped in encouraging institutional and technological advancement in the nation.

Keywords: financial innovations, demand for money, Dynamic OLS.

JEL Classification: E41, E44

Introduction
The function of demand for money has been the subject of empirical investigation in economics literature. This is as a result of its significance in monetary policy effectiveness; that is, seigniorage, inflation and other important aspects of macroeconomic policy. The issue of demand for money and its stability is extremely vital in the formulation of monetary policy. However, there are a lot of criticism in the literature regarding the empirical approaches to demand for money used for policy assessment. There is important research which had been done to find out whether the function of demand for money is stable and predictable or not. The issue arose as a result of some findings which indicated that demand for money was unstable in a number of countries during the 1970s (Goldfeld, Fand, & Brainard (1976); Darrat (1986).

However, most studies on demand for money ignored the institutional aspect of the financial sector. But changes in the structure of financial sector can objectively change the reliability of monetary aggregates and also the efficiency of the monetary policy. During the last three decades in the world, the impact of financial innovations on demand for money has been profoundly investigated. Apart from the stability problems, the traditional specification of demand for money usually derives parameter estimates that are not economically plausible and error terms are subject to the serial correlation problem. Consequently, this turns into persistent over-prediction of demand for money. According to Siklos (1993), the traditional
specification of the demand for money does not cointegrate in several industrial countries, which ultimately suggests misspecification of demand for money. Therefore, there is the need to find out other variables which impacts were lumped up in the error term.

In most cases, a close examination of the raw data of M1 and M2 reveal continuous movements in the real money balances. In the literature, the continuous movements in real money balances have been attributed to financial liberalization, broadly defined here to encompass financial innovations and institutional/regulatory changes (James, 2005). Financial innovations can refer to either a new product or a new process for supplying an existing product or market arrangement (Lewis & Mizen, 2000). Product innovation is the emergence of a new product in the market, such as money market mutual funds, money market accounts and sweep accounts, among others. Process innovation on the other hand is associated with changes or improvements in existing products, such as facilitating transactions through automated teller machines, point-of-sale terminals and electronic funds transfer. In brief, financial liberalization comprises of all improvements in the financial sector that are alternative to currency and demand deposits. Thus, a dramatic increase in demand for money was observed in economies that undertook financial liberalization.

The traditional specification of the demand for money equation does not fully encompass financial market developments (Tobin, 1965). In Ghana most of the studies on the demand for money also do not incorporated financial innovation (Kelfala, (1992); Sanusi, (2010); Havi, et al (2014).). It is appropriate that financial innovations not be considered as part of non-stationary error term, as these innovations have led to permanent shifts in real money balances.

To correct the drawback in the demand for money function the empirical estimation is carried out by introducing a proxy for financial innovation in addition to the usual explanatory variables while estimating the demand for money function. The objective of this paper is to analyze the impact of financial innovation on demand for money function in Ghana using quarterly time series data. It is expected that as financial innovation increases demand for money should decrease. The financial sector of Ghana is relatively small in comparison with the size of overall economy. However, Ghana financial sector is represented by more than 60 percent by the banking sector. James (2005) noted that there are several ways to incorporate the proxy for financial liberalization in the demand for money equation: by including dummy variables, a time trend (Dekle & Pradhan, 1999; Moore, Porter, & Small, 1990), institutionally related variables (Akhtar, 1983; Siklos, 1993), or by adjusting monetary indices (Binner, et al., 2004). Therefore, this study will incorporate a proxy for financial innovation as an explanatory variable in the demand for money function, such as the ratio of M1/ M2+, dummy variables (one for ATM cards and another for mobile banking) and domestic credit to the private sector. This study will also carry out normality, serial correlation and heteroscedasticity tests on the error term and cointegration test on the results from the estimation. This study will contribute to knowledge in economics literature as far as demand for money and financial innovations are concern.

The rest of the paper is arranged in the following order. The section two presents the literature based on the effect of in-cooperating financial innovation into the demand for money function. Section three presents the data sources, the variables used and the method used in this study while section four presents the empirical findings and discussion. Finally, section five presents a summary, conclusion and policy recommendations.

Literature Review
Financial Innovation and Demand for Money

Traditional Theories of Demand for Money

There are many theories that explained how the demand for money works in the real economy. Clear understanding of these theories will
contribute to the assessment of the possible implications that financial innovation might have on the demand for money and eventually monetary policy.

Considering the classical theorists, it was argued that demand for money is mainly dependent on the volume of transactions in the economy as reflected in Fisher’s quantity theory of money. This definition implied by the theory assumes that the velocity of money depends on the quantity of money in circulation and nominal income of the economy (Tillers, 2004). It further follows that the velocity of money is influenced by institutional and technological factors, whose effects adjust slowly over time. As a result, if the velocity of money is constant in the short run, the quantity of money depends on nominal income only.

The Keynesian theorists emphasized the importance of interest rates in determining the demand for money and advocate that individuals hold money for transaction, precautionary and speculative motives. Laidler (1977) suggested that both transaction and precautionary motives depend on the level of income, whereas the speculative motive for holding money arises from the desire to maximize wealth, which in turn depends on interest rates.

Post-Keynesian theorists such as the Baumol–Tobin model view money as a medium of exchange and infers that the demand for money is dependent on the interest rate (Gonda, 2003). In addition, the Baumol–Tobin theory highlights that an increase in income will lead to larger investments in bonds enabling the investors to enjoy the benefits of economies of scale. Moreover, the theory deems the transactions component of the demand for money to be negatively related to the level of interest rates (Gonda, 2003).

Friedman’s modern quantity theory of money rests on the concept that demand for monetary assets is directly related to permanent income and indirectly related to the expected differential returns from bonds and stocks (equities). In this regard, Friedman believed that money would increase or decrease as the return on bonds and stocks and goods increased or decreased and that interest rates did not matter much. In this way, Friedman’s theory proved superior to Keynes as it was based on various forms of wealth, tastes and preferences of asset holders (Friedman and Schwartz, 1983).

Financial Innovation and the Demand for Money

As a result of innovations in financial sectors, there are new payment systems that have emerged over the period; these included automated teller machines (ATMs), Electronic Funds Transfers (EFTs) between bank accounts, Electronic Funds Transfer at point of sale (EFTPOS) systems, automatic bill payer accounts, credit cards, mobile money and others. Such payment systems could have an effect on the demand for money function especially M1 which is used as a medium of exchange through their effect on cash and demand deposits. This is because individuals can either substitute cash with bank deposits; checking deposits with savings deposits or even increase cash demand and this alters demand for M1. According to Fisher (1911), from the equation of exchange demand for money function can be written as:

\[ M'V = PY \]  

where V is velocity of money demand, PY the nominal value of transactions and M' the quantity of money supply. This can be re-written as

\[ V = \frac{PY}{M'} \]  

M' is fixed by the monetary authority. Assuming equilibrium in the money market such that \( M' = M'^d \), the demand for money function can be written as;

\[ M'^d = k(Y) + L(r) \]
where $M^d$ is demand for money, $k(Y)$ is money demand for the transaction and the precautionary motive which depend on the level of income ($Y$) and $L(r)$ is money demand for speculative motive which depends on the interest rate. Keynsians emphasize that the demand for real money balance is negatively related to interest rate. However, the demand for real money balance is positively to the real income.

On the basis of Arrau et al. (1991), any change in $V$ will affect demand for money. For instance, new payment technological changes; the way people carry out their transactions by increasing the rate at which transactions are done. If technology increased the number of times a given cedi of money is spent in a year (velocity), demand for money for transactions purpose will reduce.

The effect of financial innovation on demand for money depends on the form of innovations taking place. Dunne and Kasekende (2016) postulate that different forms of financial innovations can have different effects on money demand. For instance, ATMs or derivative financial instruments may potentially enhance efficiency and reduce transaction costs, as cash that would have been carried in wallets is substituted by these innovations and this could lead to a decline in demand for cash. On the contrary, financial innovations could potentially lead to an increase in demand for money if payment systems improve but economic agents demand more liquid assets. This would occur where individuals demand electronic money and cash through the use of cellphone technology but do not necessarily move away from more liquid assets to less liquid assets.

**Empirical Review**

The demand for money is important in the conduct and determination of the effectiveness of monetary policy. In any given economy, stable demand for money functions allow the monetary authorities to make for proper monetary policies. In the area of demand for money there are several empirical studies that had been carried out. Some of those empirical studies which included the effect of financial innovation on demand for money are review and summarized below.

Arrau and Gregorio (1991) examined the role of financial innovation on demand for money in ten developing countries using quarterly data for Chile and Mexico. In a panel cointegration model specified, a deterministic trend, the ratio of $M_1$ to $M_2$, and a stochastic trend as various proxies for financial innovation was applied. It was found that the deterministic trend was significant in six out of ten countries examined. However, there was continuous lack of cointegration which suggested that a time trend was not a good proxy for financial innovation. The ratio of $M_1$ to $M_2$ as well, did not give any clear results. The stochastic trend modeled financial innovation in terms of permanent shocks to demand for money and when time-invariant parameters of the demand for money function were derived, the results were better than those obtained using a deterministic trend. Therefore, it was concluded that financial innovation was quantitatively important in determining the demand for money and its fluctuations.

Ibrahim (2001) examined the roles of financial factors in the behaviour of $M_1$ and $M_2$ demands for Malaysia. The study focused on the possible changes in the elasticities of the $M_1$ and $M_2$ money demands in the environment of financial innovations and on the influence of real stock prices on the holdings of monetary assets. The results also confirmed that the presence of the long-run $M_1$ and $M_2$ money demands and structural instability in the dynamic specification of the $M_1$ demand. However, the study identified stable error-correction model for the post-1986 $M_1$ demand and for the $M_2$ demand. The results also indicated the reduction in the long-run income and exchange rate elasticities of the money demands. Meanwhile, the interest rate sensitivity of the demands becomes more inelastic.

Rinaldi (2001) studied the effect of payment cards on the demand for cash in Belgium. Using an Error Correction Model on annual data spanning from 1960 to 1999 found ATMs having a strong negative effect on demand for
currency. It was asserted that although cash purchases were still about 75 percent, Belgium is among the countries with the most extensive use of cards. This could explain a strong negative relationship between demand for cash and ATMs.

Nabiddo (2007) using quarterly data estimated the demand for money functions for both M1 and M2 in Uganda, using and Error Correction Model. A dummy variable as a proxy for financial innovation that took place since the liberalization of the financial sector and the results showed a negative effect. The implication was that financial innovations on average reduced the amount of money demanded by individuals.

Yu and Gan (2009) investigated the dynamic relationship between demand for money and financial innovation in the case of ASEAN-5 by utilizing a monthly timespan from 1987: M1 to 2007: M4. The Engle-Granger two-step cointegration technique (1987) and ECM conclude that there exists a long run relationship among the variables particularly after financial innovation which showed that financial innovation variables helped to overcome the problem of misspecification.

Fujiki and Tanaka (2009) investigated the effect of financial innovation on demand for money in Japan. Specifically, the effect of electronic money on cash demand using unique household-level survey data from Japan. Using instrumental variable methods, it was established that average cash balances increased with the adoption of electronic money, however, those households at the lower quantiles of the cash balance distribution held more cash after the adoption of electronic money. In this study, such households held cash balances mainly for transactions motives.

Kampusü (2011) estimated the effect of financial innovation on currency demand in Turkey from 2002:01 to 2010:12 using monthly time series data. He employed Polynomial Distributed lags (PDL) and the Error Correction model (ECM) to estimate the demand for currency. Using the number of ATMs and credit cards as proxies, it was found that financial innovations had negative effect on currency demand. The implication is that individuals do not need to carry more cash as it is convenient to withdraw money anytime when need arises.

Adegboye et al (2010) examined whether the financial innovations that occurred in Nigeria after the Structural Adjustment Programme of 1986 had affected the demand for money. The M2 was used as the dependent variable, while GDP, nominal interest rates, CPI and a dummy variable (representing the financial innovation that had taken place in Nigeria since the sweeping reforms of the Structural Adjustment Programme (SAP) embarked upon by Nigeria in 1986 served as independent variables. In addition, the Engle and Granger Two-Step Cointegration technique was used, with data from 1970-2008. The results from the study showed that the financial sector liberalization which was one of the goals of the SAP, did not lead to financial innovation which would have benefitted banking customers, deepened the money market and affected the effectiveness of monetary policy. It was concluded that financial innovation had no significant impact on the demand for money in Nigeria.

The above literature indicates that there exists a stable demand for money function after incorporating a proxy for financial innovation in the demand for money equation. Due to the changes in financial markets it is assumed that instability in the demand for money functions can be attributed to the non-inclusion of these financial innovations in the demand for money equation for different countries. Therefore, this paper include proxy for innovation in the financial market in the demand for money equation for a case study of Ghana. Also, this study will also carry out diagnostics tests on the error term and cointegration test on the results from the estimation.

**Methodology**

The aim of this paper is to find out the impact of financial innovation on demand for money function in Ghana using quarterly time series data, 2000Q1 to 2021Q4. The data was obtained
from World Development Indicators and the Bank of Ghana were converted to quarterly frequency using Eviews frequency convection. The stationarity of the variables will be checked with Augmented Dickey-Fuller (ADF), Phillip-Parron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests. If all the variables are integrated of order zero, then OLS will be applied, also, if all the variables are integrated of order one then dynamic OLS or VAR will be applied but if the order of integration varies then autoregressive distributed lag (ARDL) will be applied. From this study all the variables are integrated of order one and considering both dynamic OLS and VAR, dynamic OLS best fit the data. Therefore, dynamic OLS is used in this study to estimate the single cointegrating vector the will show the long run relationship between the dependent variable and independent variables.

**Dynamic Ordinary Least Square (OLS) Regression**

According to Stock and Watson (1983) an individual simple regress the dependent variable onto contemporaneous levels of the independent variables with leads and lags of the first differences and a constant using OLS. The Stock-Watson DOLS model is specified as follows;

\[
Y_t = \alpha_0 + \beta X_t + \sum_{j=1}^{p} d_j \Delta X_{t-j} + \mu_t \]  \hspace{1cm} (04)

Where \(Y_t\) - dependent variable, \(X_t\) - the matrix of the explanatory variables \(\beta\) - cointegrating vector that represent the long run cumulative multiplier or the long run effects of a change in \(X_t\) on \(Y_t\), \(p\) - lag length, \(q\) - lead length. The lag and the lead terms are included for the purpose of making the stochastic error term independent of all pass innovations in the stochastic regressors. Also, the residuals of the DOLS estimation will be tested for unit root. If the residual is non-stationary the then DOLS estimation is spurious, Choi et al (2008).

In this study, the following demand functions will be estimated.

\[
M_t = \alpha_0 + \alpha X_t + \sum_{j=1}^{p} d_j \Delta X_{t-j} + \mu_t \]  \hspace{1cm} (05)

\[
M_t = \beta_0 + \beta Z_t + \sum_{j=1}^{p} d_j \Delta Z_{t-j} + \nu_t \]  \hspace{1cm} (06)

Where \(M_t\) - demand for money (M1, M2)

\(X_t\) - interest rate, inflation, exchange rate and real income;

\(Z_t\) - interest rate, inflation, exchange rate, real income, financial innovation proxies such as M2+/M1 ratio, the dummy variables for ATM, the dummy variables for mobile banking and domestic credit to private sector.

\(\alpha\) - cointegrating vector that represent the long run cumulative multiplier or the long run effects of a change in \(X_t\) on \(M_t\).

\(\beta\) - cointegrating vector that represent the long run cumulative multiplier or the long run effects of a change in \(Y_t\) on \(M_t\).

\(\mu_t\) and \(\nu_t\) are respective error terms.

Real Narrow Money (M1): Nominal narrow money is defined as the addition of quasi money such as currency with the public, other deposits with central bank and demand deposits. The nominal monetary aggregate is then deflated by the consumer price index (CPI) to obtain the real narrow money.

Real Broad Money (M2): Nominal broad money is defined as the addition of time deposit into the narrow money definition. The nominal broad money is deflated by (CPI) to obtain the real broad money.

Interest Rate (R): the interest rate indicates the rate at which customers borrow money from the commercial banks. It was used in the money demand function since it influences money demand. It is often used to capture the effect of

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the opportunity cost of holding money on demand for money. According to economic theory, it is expected to have negative effect on demand for money.

**Inflation (I):** Consumer price index (CPI) is annual percentage change and it was used to measure inflation in Ghana. According to Patnaik (2010) CPI is a statistical time series measure of a weighted average of prices of a specified set of goods and services purchased by consumers. It is a price index that tracks the prices of a specified basket of consumer goods and services, providing a measure of inflation.

**Exchange Rate (EX):** Effective exchange rate is used in this study as opportunity cost variable. Robert Mundell (1963) propose that the demand for money can also depend on the exchange rate. Since then, several studies have included the exchange rate into the demand for money function. When the coefficient of the exchange rate positive it implied currency substitution effect while the negative sign signified a wealth effect.

**Real Income (Y):** Gross Domestic Product at constant price of 2010 is used as a proxy for real income. According to economic theory, it is expected to have positive effect on demand for money function.

**Financial innovation:** The following variables are used as proxy for financial innovation.

The M2+/M1 ratio (FI). This variable was justified by Dunne and Kasekende (2016) by stating that as financial innovation grow individuals tend to move away from more liquid asserts which is reflected in M1 to less liquid asserts which are reflected in the non-M1 part of M2 which is taken to signified financial innovation.

The dummy variables for ATM (ATM) and mobile banking (MB) are also included to capture financial innovation. In Ghana, the two important breakthrough considered are cards and mobile banking. Cards become more prevalent after 1995Q1 (www.grin.com) while mobile banking as after 2009Q3 (www.gsma.com). As a result, the dummy variable (0,1) is used to capture the effects of cards on demand for money: cards consist of credit cards and debit cards and their usage at the ATM and POS. Also, the dummy variable (0,1) is used to capture the effects of mobile banking on demand for money.

**Domestic credit to the private sector (DCPS).** This is domestic credit from the financial sector to the private sector which is expressed as a percentage of GDP. This is used as a proxy for financial innovation.

Also, according to Dekle and Pradhan (1999), financial innovation may be positive sign which indicates increasing monetization of the economy and financial deepening or negative sign showing institutional and technological advancement.

Finally, diagnostic tests for accuracy, stability and predictability of the model estimated will be done. Also, the residuals term will be checked for serial correlation, heteroscedasticity, unit root and normality.

**Results and Discussion**

This section reported the results; that is, the summary statistics, correlation matrix, time series properties of the variables used, the models estimated as well as the discussions. Table 1 showed the summary statistics of the variables used in the analysis. From the table, log of demand for real narrow money (log(M1)), log of demand for real broad money (log(M2)), log of interest rate (log(R)), log of inflation (log(I)), log of real exchange rate (log(EX)), log of real income (log(Y)), financial innovation proxies such as M2+/M1 ratio (FI), the dummy variables for ATM (ATM), the dummy variables for mobile banking (MB) and domestic credit to private sector (DCPS) were 5.17, 6.18, 2.79, 2.79, 2.79, 4.43, 4.43, 24.02, 2.15, 0.36, 0.83 and 11.06, respectively, with standard deviation 1.78, 1.99, 0.43, 0.65, 0.24, 0.49, 0.12, 0.48, 0.37 and 3.82. All the variables were positively skewed except inflation, the dummy variables for mobile banking and domestic credit to private sector as a percentage of GDP. All the variables were not normally distributed except M2+/M1 ratio.
### Table 1. The Summary Statistics of the Variables Used in the Analysis

<table>
<thead>
<tr>
<th></th>
<th>Log(M1)</th>
<th>Log(M2)</th>
<th>Log(R)</th>
<th>Log(I)</th>
<th>Log(EX)</th>
<th>Log(Y)</th>
<th>FI</th>
<th>MB</th>
<th>ATM</th>
<th>DCPS</th>
</tr>
</thead>
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<tr>
<td><strong>Mean</strong></td>
<td>5.17</td>
<td>6.81</td>
<td>2.79</td>
<td>2.79</td>
<td>4.43</td>
<td>24.02</td>
<td>2.15</td>
<td>0.36</td>
<td>0.83</td>
<td>11.06</td>
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<tr>
<td><strong>Median</strong></td>
<td>4.42</td>
<td>6.74</td>
<td>2.65</td>
<td>2.77</td>
<td>4.44</td>
<td>23.95</td>
<td>2.16</td>
<td>0</td>
<td>1.00</td>
<td>12.13</td>
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<tr>
<td><strong>Maximum</strong></td>
<td>8.63</td>
<td>10.23</td>
<td>3.59</td>
<td>4.13</td>
<td>5.03</td>
<td>24.87</td>
<td>2.52</td>
<td>1.00</td>
<td>1.00</td>
<td>15.99</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>2.11</td>
<td>3.64</td>
<td>2.14</td>
<td>0.39</td>
<td>4.15</td>
<td>23.29</td>
<td>1.86</td>
<td>0</td>
<td>0</td>
<td>3.58</td>
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<tr>
<td><strong>Std. Dev.</strong></td>
<td>1.90</td>
<td>1.99</td>
<td>0.43</td>
<td>0.24</td>
<td>0.24</td>
<td>0.49</td>
<td>0.12</td>
<td>0.48</td>
<td>0.37</td>
<td>3.82</td>
</tr>
<tr>
<td><strong>Skewness</strong></td>
<td>0.41</td>
<td>0.26</td>
<td>0.39</td>
<td>-0.30</td>
<td>0.58</td>
<td>0.24</td>
<td>0.06</td>
<td>0.60</td>
<td>-1.80</td>
<td>-0.66</td>
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<tr>
<td><strong>Kurtosis</strong></td>
<td>1.90</td>
<td>1.67</td>
<td>1.96</td>
<td>4.22</td>
<td>2.58</td>
<td>1.72</td>
<td>3.71</td>
<td>1.37</td>
<td>4.25</td>
<td>2.05</td>
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<tr>
<td><strong>Jarque-Bera</strong></td>
<td>9.39</td>
<td>10.1</td>
<td>8.54</td>
<td>9.35</td>
<td>7.76</td>
<td>9.37</td>
<td>2.61</td>
<td>20.84</td>
<td>73.35</td>
<td>13.41</td>
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<tr>
<td><strong>Probability</strong></td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>0.01</td>
<td>0.27</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td>604</td>
<td>824</td>
<td>337.4</td>
<td>536.5</td>
<td>2906.8</td>
<td>260.1</td>
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<td>101.0</td>
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<td><strong>Sum Sq. Dev.</strong></td>
<td>380</td>
<td>476</td>
<td>22.08</td>
<td>50.58</td>
<td>6.87</td>
<td>28.33</td>
<td>1.68</td>
<td>27.7</td>
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<td>1747.6</td>
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<tr>
<td><strong>Observations</strong></td>
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</table>

**Unit Root Tests**

The results of AugmentedDickey-Fuller (ADF), Phillip-Parron (PP) and Kwaiatkpwski-Philips-Schmidt-Shin (KPSS) unit root tests statistic for the variables are shown in the Table 2(Appendix 1). From the table, considering ADF test, demand for real narrow money, demand for real broad money, interest rate and inflation are integrated of order zero, I(0) while all the variables were integrated of order one, I(1) except real gross domestic product. From the table, considering PP test, only interest rate, was integrated of order zero, I(0) while all the variables were integrated of order one, I(1). From the table, considering KPSS test, interest rate and exchange rate were integrated of order zero, I(0) while all the variables were integrated of order one, I(1). Therefore, considering ADF, PP and KPSS tests, it was concluded that all the variables are integrated of order one, I(1). As a result, DOLS regression is applicable to estimate the long run parameters.

**DOLS Regression Results of Demand for Money**

The result of DOLS regressions with log of demand for real narrow money (log(M1)) in model 1and 2 and log of demand for real broad money (log(M2)) in model 3 and 4 as dependent variable with log of interest rate (log(R)), log of inflation (log(I)), log of real exchange rate (log(EX)), log of real income (log(Y)), financial innovation proxies such as M2+/M1 ratio (FI), the dummy variables for ATM (ATM), the dummy variables for mobile banking (MB) and domestic credit to private sector (DCPS) as independent variables, are shown in table 3 and 4 below. Model 1 and 3 were estimated without the financial innovations variables while Model 2 and 4 were estimated without the financial innovations variables.

From the diagnostics results for the four models estimated, by the use of Hansen Parameter Instability test the series used in the model are cointegrated, the unit root test shows that the residuals are integrated of order zero, I(0). Using the correlogram, the residuals are free from serial correlation except the models 1 and 3 which were estimated without financial innovations variables. From Jack-Bera statistics from the histogram test the residuals were normally distributed. Finally, the Wald test showed that all the coefficients in all the models were not equal to zero. These showed that the result of DOLS regressions of demand for real narrow money and demand for real broad money on the independent variables are not spurious. The demand for money functions estimated with financial innovations variables were stable. The $R^2$ adjusted from the estimated models 2 and 4 were 0.9944 and 0.9957, that is, independent variables explained 99.44 and 99.57 percent of the variation in dependent variables, respectively. Only 0.56 and 0.43 percent of the variation in dependent variables were attributed to other factors. However, the $R^2$ adjusted from
the estimated models 1 and 3 were 0.9230 and 0.9579, that is, independent variables explained 92.3 and 95.79 percent of the variation in dependent variables, respectively. The variation in dependent variables which attributed to other factors was 7.7 and 4.21 percent, respectively. Therefore, the inclusion of financial innovations variables helped reduce the variation attributed to other factors which are included in the error term. [These results are shown in the appendix for review purposes]

**DOLS Regression Results of Demand for Real Narrow Money**

Since model 1 had serial correlation problem, model 2 with financial innovations variables are considered for interpretation. From the result, the coefficients interest rate is negative 2.896 with t-stats (6.4) and p-value of zero and it consistent with economic theory. Since the p-value is less than 0.05, interest rate is significant. This implies that as interest rate increases by one percent demand for real narrow money will decrease by 2.9 percent; that is, interest rate is elastic. Therefore, monetary authority can control the demand for real narrow money in the economy by using the interest rate. Also, the coefficients of inflation is negative 0.5569 with t-stats (2.8) and p-value of 0.01. Since the p-value is less than 0.05, inflation is significant. This implies that as inflation increases by one percent demand for real narrow money will decrease by 0.56 percent; that is, inflation is inelastic. From the result, the coefficient of exchange rate is positive 0.019 with t-stats (0.01) and p-value of 0.986. Since the p-value is greater than 0.05 exchange rate is not significant. In addition, the coefficients of real income is positive 1.317 with t-stats (2.79) and p-value of 0.01 and it consistent with economic theory. Since the p-value is less than 0.05 real income is significant. This implies that as real income increases by one percent demand for real narrow money will increase by 1.3 percent; that is, real income is elastic.

Considering the proxy variables for financial innovation, the coefficient of M2+/M1 ratio is positive 5.11 with t-stats (26) and p-value of 0.015. Since the p-value is less than 0.05, M2+/M1 ratio is significant. This implies that as of M2+/M1 ratio increases by one unit demand for real narrow money will increase by 5.11 unit. The positive coefficient shows that the M2+/M1 ratio encouraged increasing monetization of the economy and financial depending. The coefficients of the dummy variable for mobile banking is negative 0.9965 with t-stats (1.8) and p-value of 0.08. Since the p-value is greater than 0.05, the dummy variable for mobile banking is not significant to explain the variation in the demand for real narrow money. The coefficients of the dummy variable for ATM is positive 2.07 with t-stats (2.9) and p-value of 0.007. Since, the p-value is less than 0.05, the dummy variable for ATM is significant. This showed that the introduction of ATM facilities causes demand for real narrow money to increase as compared to the period of no ATM facilities. The positive coefficient shows that the introduction of ATM encouraged increasing monetization of the economy and financial depending. The coefficient of domestic credit to private sector as percentage of GDP is negative 0.386 with t-stats (6.79) and p-value of zero. Since the p-value is less than 0.05 domestic credit to private sector as percentage of GDP is significant. This implies that as domestic credit to private sector as percentage of GDP increases by one unit the demand for real narrow money will decrease by 0.386 unit. The negative coefficient shows that the domestic credit to private sector helped in encouraging institutional and technological advancement in the nation. The constant term is -37.45 with t-stats (2.1) and p-value of 0.045. Since the p-value is less than 0.05, the constant term is significant. If all variables are equal to zero then the demand for real narrow money will be 5.452E-17 units [exp(-37.448)].

In conclusion, money demand function with financial innovations variables explained 99.44 percent while money demand function without financial innovations variables explained 92.3 percent of the variation in demand for narrow money. Considering the variables, interest rate, inflation, gross domestic product, M2+/M1 ratio, dummy variable for ATM and domestic credit to private sector as percentage of GDP are
significant to explain the variations in the demand for narrow money.

Table 3. DOLS Regression Results of Demand for Narrow Money with Financial Innovations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>Std. Error</td>
</tr>
<tr>
<td>Log(R)</td>
<td>-1.6030</td>
<td>0.4978</td>
</tr>
<tr>
<td>Log(I)</td>
<td>0.7461</td>
<td>0.4980</td>
</tr>
<tr>
<td>Log(EX)</td>
<td>5.0218</td>
<td>1.4479</td>
</tr>
<tr>
<td>Log(Y)</td>
<td>5.2252</td>
<td>0.7303</td>
</tr>
<tr>
<td>FI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMATM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCPS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>-140.9374</td>
<td>24.1198</td>
</tr>
</tbody>
</table>

DOLS Regression Results of Demand for Real Broad Money

Since model 3 had serial correlation problem model 4 with financial innovations variables are considered for interpretation. From the result, the coefficients of interest rate is negative 1.556 with t-stats (7.4) and p-value of zero and it consistent with economic theory. Since the p-value is less than 0.05, interest rate is significant. This implies that as interest rate increases by one percent demand for real broad money will decrease by 1.556 percent; that is, interest rate is elastic. Therefore, monetary authority can, also, control the demand for real broad money in the economy by using the interest rate. Also, the coefficients of inflation is positive 0.5424 with t-stats (4.4) and p-value of zero. Since the p-value is less than 0.05, inflation is significant. This implies that as inflation increases by one percent demand for real broad money will increase by 0.5424 percent; that is, inflation is elastic. From the result, the coefficient of exchange rate is positive 1.931 with t-stats (4.84) and p-value of zero. Since the p-value is less than 0.05, exchange rate is significant. This implies that as exchange rate increases (depreciates) by one percent demand for real broad money will increase by 1.931 percent; that is, exchange rate is elastic. The positive sign of the exchange rate indicated currency substitution effect; the US dollar being substituted for the Ghana cedi. In addition, the coefficients of real income is positive 5.522 with t-stats (18) and p-value of zero and it consistent with economic theory. Since the p-value is less than 0.05, real income is significant. This implies that as real income increases by one percent demand for real broad...
money will increase by 5.522 percent; that is, real income is more elastic.

Considering the proxy variables for financial innovations, the coefficient of M2+/M1 ratio is positive 2.64 with t-stats (2.25) and p-value of 0.03. Since the p-value is less than 0.05, M2+/M1 ratio is significant. This implies that as M2+/M1 ratio increases by one unit demand for real broad money will increase by 2.64 unit. The positive coefficient indicates that the M2+/M1 ratio encouraged increasing monetization of the economy and financial depending. The coefficients of the dummy variable for mobile banking is negative 0.6327 with t-stats (2.5) and p-value of 0.018. Since the p-value is less than 0.05, the dummy variable for mobile banking is significant. This shows that the introduction of mobile banking facilities causes demand for real broad money to decrease as compared to the period of no mobile banking facilities. The negative coefficient indicates that the introduction of mobile banking encouraged institutional and technological advancement in the nation. The coefficients of the dummy variable for ATM is positive 0.1361 with t-stats (0.3588) and p-value of 0.7221. Since, since the p-value is greater than 0.05, the dummy variable for ATM is not significant in explaining the variation in the demand for real broad money. The coefficient of domestic credit to private

sector as percentage of GDP is negative 0.1339 with t-stats (4.87) and p-value of zero. Since the p-value is less than 0.05, domestic credit to private sector as percentage of GDP is significant. This implies that as domestic credit to private sector helps in encouraging institutional and tecnological advancement in the nation. The constant term is -135.7 with t-stats (17.1) and p-value of zero. Since the p-value is less than 0.05, the constant term is significant to explain the variation in the demand for real broad money. If all variables are equal to zero then the demand for real broad money will be 1.124E-59 units \[ \exp(-135.7) \].

In conclusion, money demand function with financial innovations variables explained 99.57 percent while money demand function without financial innovations variables explained 95.79 percent of the variation in demand for broad money. Considering the variables, interest rate, inflation, exchange rate, gross domestic product, M2+/M1 ratio, dummy variable for mobile banking, domestic credit to private sector as percentage of GDP are significant to explain the variations in the demand for broad money.

### Table 4. DOLS Regression Results of Demand for Real Broad Money

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>Std. Error</td>
</tr>
<tr>
<td>Log(R)</td>
<td>-1.5874</td>
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<tr>
<td>Log(I)</td>
<td>0.6859</td>
<td>0.3409</td>
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<tr>
<td>Log(EX)</td>
<td>3.2508</td>
<td>0.9904</td>
</tr>
<tr>
<td>Log(Y)</td>
<td>4.8831</td>
<td>0.4625</td>
</tr>
<tr>
<td>FI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMMB</td>
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</tr>
<tr>
<td>DMATM</td>
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</tr>
<tr>
<td>DCPS</td>
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<td></td>
</tr>
<tr>
<td>C</td>
<td>-122.7924</td>
<td>15.1981</td>
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<tr>
<td>R-squared</td>
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<tr>
<td>Adjusted R-squared</td>
<td>0.9579</td>
<td></td>
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<tr>
<td>S.E. of regression</td>
<td>0.4088</td>
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</table>
Conclusion and Policy Recommendations

The effect of financial innovations on demand for money in Ghana was analyzed using the narrow money and broad money as dependent variables with interest rate, inflation, exchange rate, gross domestic product, financial innovations proxies such as M2+/M1 ratio, the dummy variables for ATM, the dummy variables for mobile banking and domestic credit to private sector as independent variables. The objective of this paper is to analyze the impact of financial innovations on demand for money function in Ghana using quarterly time series data, 1990Q1 – 2021Q4. Using ADF, PP and KPSS tests to check the unit root of the variables showed that all the variables are integrated of order one, I(1). As a result, DOLS regression was applied in estimating the long run parameters.

It was found that the introduction of financial innovations variables help explained the variation in demand for money functions and also, aid in the stabilization the demand for money functions estimated. Considering the demand for narrow money function, interest rate, inflation, real income, M2+/M1 ratio, dummy variable for ATM and domestic credit to private sector were variables that explained the variations M1. While in the demand for broad money function, interest rate, inflation, exchange rate, real income, M2+/M1 ratio, dummy variable for mobile banking and domestic credit to private sector were variables that explained the variations M2. Finally, the M2+/M1 ratio and the introduction of ATM encouraged increasing monetization of the economy and financial depending while the introduction of mobile banking and domestic credit to private sector helped in encouraging institutional and technological advancement in the nation. Therefore, it is recommended that the financial innovations be encouraged in Ghana and more domestic credit should go to the private sector. Government should give incentives for more innovations in the financial sector. Also, researchers estimating demand for money function should include financial innovations variables into demand for money functions for stability of the function that will be estimated.

References


### Table 2. Unit Root Tests Statistic for the Variables

<table>
<thead>
<tr>
<th>Test</th>
<th>Vars</th>
<th>Level</th>
<th>First Difference</th>
<th>Order of Integration</th>
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<td></td>
<td></td>
<td>none</td>
<td>intercept</td>
<td>inter &amp; trend</td>
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<td>ADF</td>
<td>log(M1)</td>
<td>1.968</td>
<td>0.988</td>
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<td></td>
<td>log(M2)</td>
<td>1.922</td>
<td>0.987</td>
<td>-0.458</td>
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<tr>
<td></td>
<td>log(R)</td>
<td>-1.127</td>
<td>0.24</td>
<td>-2.826</td>
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<td>0.50</td>
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<td>log(Y)</td>
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<td>PP</td>
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<tr>
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<td>2.665</td>
<td>0.998</td>
<td>-0.769</td>
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<td>0.220</td>
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<td></td>
<td>Fi2</td>
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<td></td>
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<td>t-crit</td>
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<td>t-crit</td>
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<tr>
<td></td>
<td>log(M1)</td>
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<td>0.463</td>
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<tr>
<td></td>
<td>log(M2)</td>
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<td>log(R)</td>
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<td>0.463</td>
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<td></td>
<td>0.587</td>
<td>0.463</td>
<td>0.046</td>
<td>0.146</td>
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<tr>
<td>log(I)</td>
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<tr>
<td>log(EX)</td>
<td>1.060</td>
<td>0.463</td>
<td>0.134</td>
<td>0.146</td>
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<td>log(Y)</td>
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<td>0.146</td>
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<tr>
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<td>DCPS</td>
<td>0.812</td>
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<td>0.146</td>
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