BANK OF GHANA

PAYMENT SYSTEMS DEPARTMENT

IMPACT OF MOBILE MONEY ON THE PAYMENT SYSTEM IN GHANA: AN ECONOMETRIC ANALYSIS

AUGUST, 2017

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DIAGNOSTIC TESTS

Abstract

This study investigates the impact of mobile money on Ghana's Payment System. The result shows that there exists long-run stable relationships among the four variables under study. The study suggests that improvement in the mobile money sub sector leads to development of the payment ecosystem, deepening of financial inclusion and promotion of cash-lite economy. The empirical study also shows that factors that promote mobile money usage lead to deepening of the financial system and promote a cash-lite economy. The study therefore emphasizes the need for the Bank of Ghana to continue to deepen the payment system by leveraging on the widespread usage of mobile phones as alternative channels for access to finance to help support improvement in the monetary policy transmission mechanism.

Chapter One

1.0 INTRODUCTION

Generally, a well-functioning payment system is imperative for ensuring the safety, stability, and soundness of a financial system. Efficient payment system facilitates timely completion of financial transactions to enhance job creation, economic growth and improved standard of living. Overall improvement in payment systems reflects in the entire economy through its inter-linkages with the fiscal, external and the real sectors.

The payment systems in Ghana consist of an array of institutional arrangements and processes that facilitate movement of monetary claims between two or more economic entities. These institutional arrangements and processes include payment streams such as Real Time Gross Settlement (RTGS), Cheque Codeline Clearing (CCC), and Ghana Automated Clearing House (GACH) consisting of Direct Credit and Direct Debit. Others are payments cards, E-zwich, Mobile Money (MM) and other payment service providers.

1.1 Background of the Study

Mobile Money (MM) is gradually becoming a major means of payment for the unbanked and the underserved in Ghana. The rapid growth in MM usage in Ghana is partly on account of increasing penetration and application of mobile phones particularly in the rural areas. The widespread proliferation of MM among the unbanked and underserved is premised on recent advances in handset functionality, chip and mobile network technologies, and upgrade in Point-Of-Sale (POS) infrastructure. These developments have improved the environment for MM solutions, and brought together different industry players, such as banks and mobile money operators to establish MM businesses. The use of MM services as a means of payment brings a number of benefits to the user including convenience, speed, flexibility and affordability (GSMA, 2013).

MM may be described as electronic cash backed by equivalent amount of the Bank of Ghana notes and coins stored using the Subscriber Identification Module (SIM) in a mobile phone as an identifier. MM is issued by Mobile Money operators (MMOs) who keep the electronic account on the SIM in the mobile phone for the users of MM.

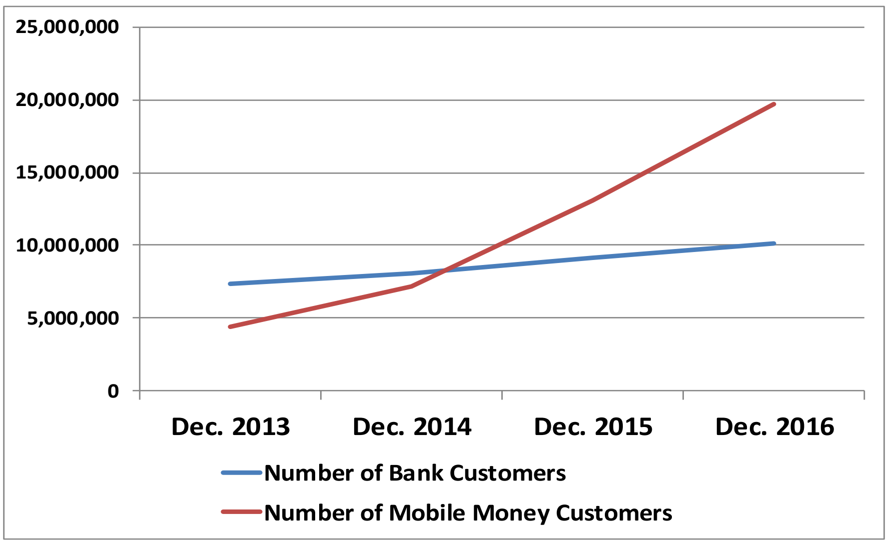
GSMA (2013) defines MM as a transformational service that uses ICT and non-bank retail channels to extend the delivery of financial services to clients who cannot easily be reached profitably with traditional branch-based financial services. Examples of MM services include electronic-wallets that are used to make peer-to-peer (P2P) transfer, or to receive salary and governments to person payments (G2P). Globally, the average daily value of the P2P transactions on a MM platform is estimated by GSMA to be about USD35.00 (GH¢150.00) (GSMA, 2013).

In Ghana, the mobile money wallet is mainly used to transfer value from one person to another person (P2P), for payment of goods and services such as buying airtime, paying for utility bills, Gold and DSTV bills, salaries of some workers, taxi fares, micro-credit, savings and micro-insurance. The store of value function of MM leads to quarterly payments of interests on balances on mobile money float. Total float balance was GH¢1,257.40 million at end-December, 2016 compared to a float balance of GH¢547.96 million at end-December, 2015, reflecting a growth of 129.5 per cent (PSD 2016). Total interest paid to holders of electronic money wallets in 2016 amounted to GH¢24.79 million.

The MM industry creates jobs for the MM agents, service providers and users including Fintech companies, merchants, retailers, and aggregators. The number of MM agents at end-December, 2016 was 107, 415; with MTN mobile money contributing 54.0 per cent, TIGO Cash 24.9 per cent, Airtel Money 11.0 per cent and Vodafone Cash 10.1 per cent (PSD Prudential Returns, December 2016).

The Bank of Ghana in 2016 reported that mobile money volume of transactions registered a growth rate of 737.4 per cent from 2012 to 2016. The marked increase in mobile money usage is not unique to Ghana. Nigeria, Kenya, Uganda, and South Africa also registered significant growth in mobile money transactions (Diniz, Albuquerque and Cerney, 2011). Chart 1 provides the number of mobile money customers compared with the number of bank customers from 2013 to 2016. The purpose of this paper is to evaluate how the surge in mobile money usage impacts on the payment systems in Ghana.

Chart 1: Number of mobile money and bank customers; 2013 - 2016



Chapter Two

2.0 MOBILE MONEY BUSINESS IN GHANA

This section provides an overview of the role of stakeholders in the mobile money sub-sector and also describes the existing tariffs, services structure and provides a review of the literature on mobile money.

2.1 Role and Motivation of Players in the MM Industry

The Mobile Money Operators (MMOs) provide mobile infrastructure, customer base and agents' network. The MMOs are profit-maximizing entities which issue electronic-money which is held in the banks. Banks provide infrastructure for flow of money between two parties and therefore provide physical custody of the electronic money. Every unit of electronic money that is issued by the Mobile Network Operators (MNO) is backed by an equivalent amount of Bank of Ghana notes and coins held in a bank to ensure equilibrium in the MM market.

The Bank of Ghana regulates, supervises and oversees the activities of the banks and Specialized Deposits-taking Institutions (SDIs) to ensure that the banking sector and the payment ecosystem are safe, reliable and efficient. The Bank focuses on key issues relating to Anti-Money Laundering Countering Financing of Terrorism (AML/CFT); consumer protection; promotion of competitive practices, assets quality, solvency, liquidity, earnings, systems and control and management with respect to oversight of the mobile money sub-sector.

The National Communication Authority (NCA) oversees security of customers' data; and integrity of MM technologies. It regulates and oversees the activities of the Mobile Network Operators which own the Mobile Money Companies.

The Mobile Money Operators' agents facilitate cash-in (converting cash into electronic form) and cash-out (issuing cash on demand) to ensure convertibility between MM and cash. Agents are effectively liquidity managers in the MM sub-sector.

Merchants and retailers accept MM payments in exchange for different products and services. Fintech companies also provide a wide array of support services including mobile phone manufacturing, network equipment vendors and software.

2.2 Equilibrium Tariffs and Services

MM users are generally subscribers or non-subscribers of mobile network operators. A prospective user of MM approaches an MNO and procures SIM card which is also used for mobile money transactions.

Users may be linked to bank accounts for various services such as investment, ATM and for bill payments. For convenience of the user, mobile money wallets are linked to bank accounts to provide the user with unique consumer experience in terms of providing access to variety of financial services which are designed to meet the needs of the poor and the unbanked.

Users are also able to access innovative and affordable financial services in the form of micro-loans and repayment schemes designed specifically to suit the needs of the poor, the unbanked and the underserved. An example is the award-winning product by Ecobank Capital Advisors TBILL4ALL which was launched in October 2016 and has since attracted international attention on account of being the first of its kind anywhere in the world. The product was nominated for the World Summit Award in 2014. (Commerce and Business, 2014).

Commissions paid to agents and tariffs are reported to the Bank of Ghana by the mobile money operators. Mobile money operators prefer to pay one monthly lump-sum commission to agents using MM platform. The commissions are derived from the two-way transaction cost paid by users of MM services.

Commissions and tariffs charged by mobile money operators in Ghana as at December 2016 were shown in Appendix 5.

2.3 Choice of Economic Variables

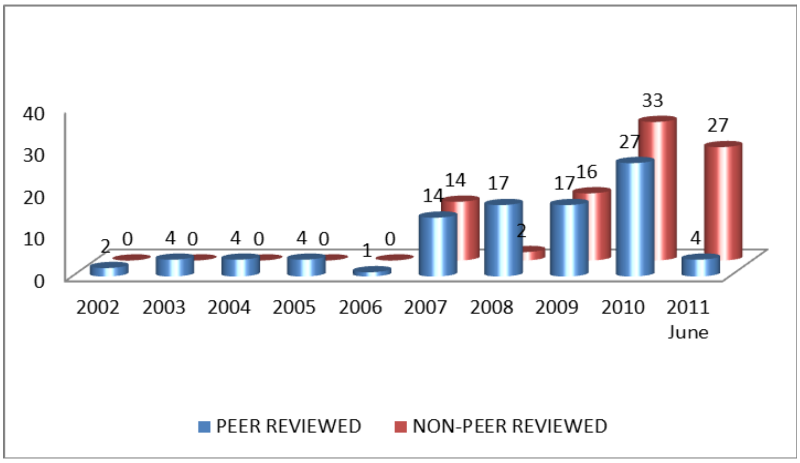
Four endogenous variables consisting of volume of mobile money transactions, volume of payment system transactions, value of mobile money transactions and value of payment system transactions were chosen for the study. The volume of mobile money transactions and volume of payment system transactions were taken as proxies to capture financial inclusion while the value of mobile money transactions and value of payment system transactions represented progress towards cash-lite society. A priori restriction imposed is that financial inclusion is positively related to progress toward cash-lite regime.

2.4 Literature Review

Dahlberg et al. (2008) analyzed 73 peer-reviewed papers on the theme 'mobile money and payments'. This paper was published by various journals between 2001 and 2011. The focus of the analyses was to contribute to the existing body of knowledge on mobile money and payments. Duncombe and Boateng, (2009) updated the work of Dahlberg et al. (2008) by reviewing additional 43 papers comprising 17 peer-reviewed papers and 26 non-peer-reviewed papers.

Diniz, et al. (2011) updated the body of knowledge on 'mobile money and payments' by reviewing 186 papers comprising 94 peer-reviewed and 92 non-peer-reviewed papers in 2011. The methodology applied in reviewing the papers included the year of publication, geographical location and methodology used for the research. The findings from this study are summarized in Charts 2 and 3:

Chart 2: Chronological Account of Published Papers

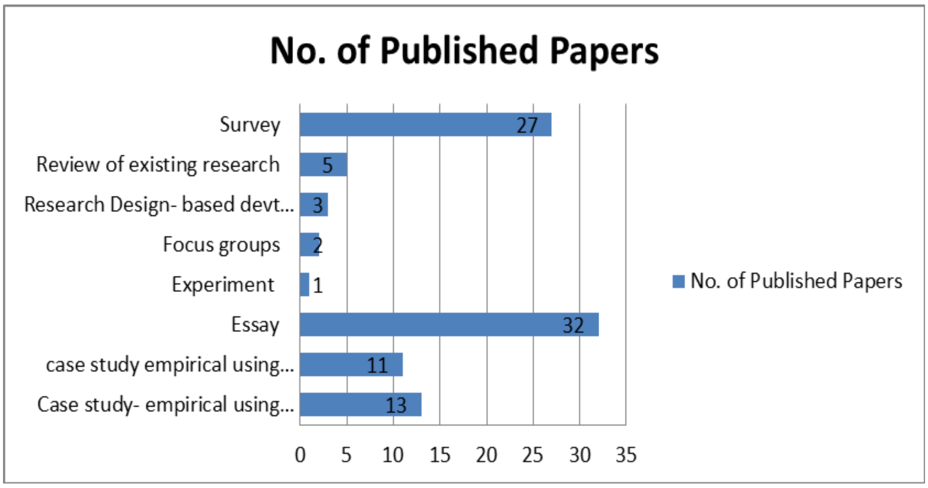


On the basis of geographical location of the reviewed papers, Africa received 17 per cent of authors' attention in spite of the remarkable strikes that was made by the continent in the field of mobile money and payments in Africa. This is shown in Chart 2.

Chart 3: Coverage of the reviewed papers

Out of the 94 publications reviewed, 5 studies used review of the existing research methodology as shown in the Chart 4.

Chart 4: Methodology of Published Papers



Bishop et al, (1999); Butler, (2005); Elijah and Ogunlade, (2006); Srivastava, (2008); Sewanyana, (2007); and Etim, (2011), (2012) found a link between the numbers of mobile adopted in Sub-Saharan Africa (SSA) and use of mobile money for transfers and payments.

Bold et al, (2012); Jenkins, (2008), Porteous, (2006); and Ehrbeck, (2012) reported that there is a positive relationship between mobile money adoption and financial inclusion.

Jenkins (2008) noted that mobile money facilitates financial inclusion as it is used for transfers of money, payments for utilities, government revenue and others. The paper found that mobile money integrates the excluded into the formal financial system which is a critical prerequisite for effective market participation and development.

Ehrbeck (2012) found that emerging collaboration between banks and mobile network operators (MNOs) in Sub-Saharan Africa (SSA) is a marked indication of a positive move towards financial inclusion for the 80 percent of the Africa's unbanked population. The paper put Kenya as the leading country in terms of mobile money in SSA and indicated that the West Africa sub-region is forging ahead towards financial inclusion but remained behind the Eastern and South African regions.
Bold, et al, (2012) also found that in SSA the use of mobile phones for mobile money services is the main driving force behind the recent progress made towards financial inclusion.

Weber and Darbellay, (2010); Porteous, (2006) and Dias and McKee, (2010) have sub-divided mobile money into mobile banking (m-banking) and mobile payment (m-payment) models in SSA region which they described as additive and transformative models respectively. These papers explained that the additive models allow bank account owners to use their mobile phones to access their existing bank accounts and associated services such as checking account balances, transfer funds between accounts or view cheque images while the transformative models allow the unbanked to access financial products without existing bank accounts, mainly through their mobile phones based on services provided by mobile money operators, microfinance institutions and non-bank agencies.

Dias and McKee, (2010) found that mobile subscribers in Kenya and South Africa who do not have bank accounts are now using mobile money for banking-related transactions such as bill payment, payroll deposits, international remittances, loan receipts and payments, airtime purchases, groceries, bus tickets and a whole range of other financial services.

Etim, (2013) collaborated Dias and McKee, (2010) findings that mobile phone owners have actually exceeded the number of people who own bank accounts in SSA region confirming the effectiveness of the transformative models as a tool to help include the unbanked in the formal financial industry. Jack and Suri, (2011) and Martinez and Mckay, (2011) analyzed M-PESA growth trend and noted that M-PESA gained 2.37 million subscribers in the first year of implementation and in a 2008 survey of households in Kenya; about 43 percent indicated they used M-PESA. The study was repeated in 2009, and nearly 70 per cent of households were found to be M-PESA users.

Wakoba, (2012) identified that by July 2012, Safaricom's M-PESA had over 185 billion Kenya Shillings, about 2.15 billion US dollars and controls 68 per cent of the Kenya's mobile money market. In 2010, Safaricom had more than 12 million M-PESA customers and 16,000 agents (Dias and McKee, 2010).

Chapter Three

3.0 METHODOLOGY, ESTIMATION PROCEDURES AND ANALYSIS

This section focuses on a battery of diagnostic tests carried on the data set, general-to-specific estimation procedures for the regressions and analyses of the estimation results. The diagnostic tests included graphing of raw data to check for outliers, the Jarque–Bera test to determine goodness-of-fit of the sample data. Tests were also conducted to check whether the sample data have skewness and kurtosis. The study used Schwarz Selection Criteria to determine optimum lag length. The correlogram test undertaken was to check for the randomness in the data set. Other diagnostic tests conducted were stationarity test using Augmented Dickey Fuller and cointegration tests.

3.1 Choice of Econometric Approach

Single equation regression model, simultaneous equations regressions models, Vector Error Correction Model (VECM) and Vector AutoRegressions (VAR) model (Bhasin, 2010, AERC) were considered in the determination of suitable econometric approach to use for the impact analysis. Each of these approaches has its strengths and weaknesses and an evaluation of the strengths and weaknesses of each approach precedes the analyses.

MM variables have bi-directional granger causality relationship with payments system variables. They are endogenous variables hence using the single equation regression approach, will provide biased estimates for the parameters.

Use of simultaneous equation regression approach for empirical work, although will yield unbiased parameter estimates, it cannot be used to analyze the impact of unanticipated shocks on the endogenous variables, that is, it will not allow impulse response functions analysis to be done. Secondly, identification of the relative importance of each variable in explaining the variations in endogenous variables, Variance decomposition, analysis cannot be done.

VAR approach and VECM specification, however, will provide the impact of unanticipated mobile money innovations on the payment ecosystem and the transaction channels for each innovation to be identified. Similarly, when the relevant variables are non-stationary and co-integrated then VECM specification will be appropriate. Adam (1992) shows that VECM model encompasses all other models.

The VECM and VAR approaches are generally used in VAR studies. The first step is the use of structural VAR which allows specification and estimation of a structural economic model. Identification problem in the structural model is resolved by employing a more general model that does not require a priori restriction. The structural VAR model can be specified as:

$ß(L)X_t = \mu t, \quad t = 1,2,3......,n$ (1)

Where X_t is an mx1 vector of jointly determined variables. The term L is a lag operator. The order of ß(L) is an mxm and U's are the innovations for X, which are normally distributed with mean zero and covariance matrix $E(\mu_t \mu_t') = \sigma$ and $E(\mu_t \mu_t\text{-}i') = 0$ for $i \neq 0$.
From the structural model specified in equation 1 above, the B matrix is inverted so that each endogenous variable is expressed as a linear combination of its own innovations and the lagged innovations of all the other variables in (2) below:

$X_t = [B(L)]\text{-}^1U_t.$ (2)

The contemporaneous covariance matrix, ∑ needs to be decomposed into variable specific shocks, that is, it must be orthogonalized in order to investigate the dynamic structure of the model. This is achieved by expressing the contemporaneous model as:

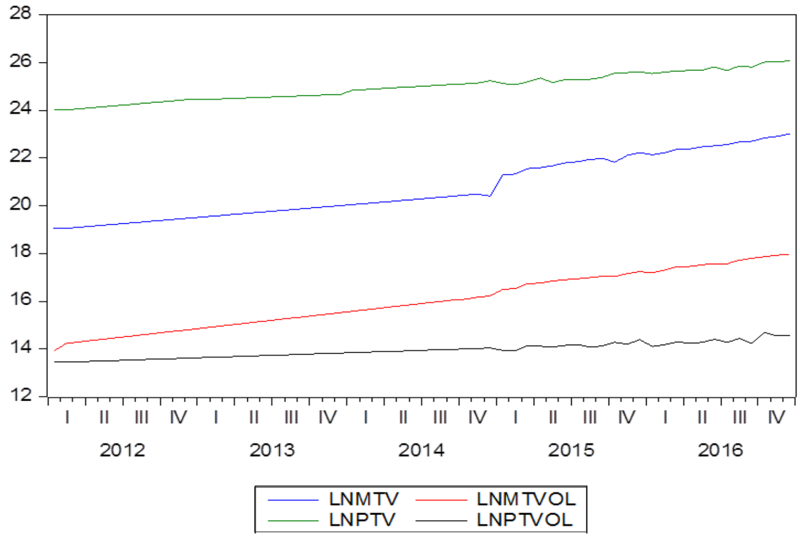
$\varepsilon=AU_t$ (3)

Such that $A \sum A' = I$, where I is an identity matrix and ε_t are the innovations of the reduced form VAR model. The innovations Ut is mutually orthogonal. However, there is no unique way of orthogonalizing ∑. Bernanke's structural orderings of innovations or Choleski's orderings could be used to obtain the reduced form innovations.

3.2 Estimation Procedures - Diagnostic Testing

Graph of the variables to check for outliers are shown in diagnostic Test 1. No indication existed that there was an outlier in the sampled data series. The vertical axis in diagnostic Test 1 indicates log values of the variables while the horizontal axis represents time horizon.

Diagnostic Test 1: Trend Analysis to Check for Outliers



3.3 Descriptive Statistics

The sampled raw data was transformed into logarithms to determine (i) whether it possesses properties of a normal distribution and (ii) to provide opportunity to interpret the regression results in elasticity or percentages. The descriptive statistics of the sample data in Diagnostic Test 2 indicating the probability values of the Jarque–Bera test generally show that the skewness and kurtosis of the sample data match a normal distribution.

Diagnostic Test 2: Skewness, Kurtosis and Normality of Sampled Data

	LNMTV	LNMTVOL	LNPTV	LNPTVOL
Mean	20.72935	16.01796	24.98203	13.93879
Median	20.29261	15.90529	25.01001	13.92972
Maximum	23.00854	17.96839	26.07423	14.68259
Minimum	19.05309	13.92307	24.01581	13.44621
Std. Dev.	1.271935	1.158653	0.573599	0.311660
Skewness	0.358420	0.069711	0.107105	0.280594
Kurtosis	1.619020	1.751465	1.957662	2.321351
Jarque-Bera	6.052416	3.945693	2.830886	1.938740
Probability	0.048499	0.139060	0.242818	0.379322
Sum	1243.761	961.0778	1498.922	836.3274
Sum Sq. Dev.	95.45134	79.20618	19.41196	5.730797
Observations	60	60	60	60

3.4 Schwarz Selection Criteria

In determining optimum lag length for the analysis, the rule of thumb is to select the lower Akaike AIC value or Schwarz SSC value by comparing AIC value with SSC value. Running VAR model for the VAR system, indicates a lower system SSC value. Hence Schwarz Selection Criteria (SSC) was employed to determine the optimum lag length. The results of running eight VAR models starting from lag 8 through to lag 1 resulted in system estimates of -10.25, -8.70, -8.84, **8.53**, -8.55, -9.27, -9.93 and -9.72 respectively indicating that the optimum lag length is **5**.

3.5 Correlogram of Variables

Correlogram tests carried out on each of the selected variables failed to reject the null hypothesis that the variables were autocorrelated and therefore violated the randomness assumption underlying the linear regression model. Nevertheless, the correlogram of the first difference of each variable, however, failed to support the null hypothesis and suggested that first difference of the sample variables met the randomness assumption of the linear regression model. The sample variables by inspection are likely to be integrated of first order (I1).

3.6 Stationarity of Variables

Based on results from the correlogram, both Augmented Dickey-Fuller unit root test and Phillips Perron unit root test with a constant was applied and the results suggested that each of the four variables was integrated of first order (I1). Put differently, the variables were non-stationary in levels confirming the results from the correlogram tests. Both Phillips Perron and Augmented Dickey-Fuller test failed to reject the null hypotheses that each series contain a unit root. Results of Augmented

Dickey-Fuller unit root test for each series are shown below:

Diagnostic Test 3: Augmented-Dickey Fuller Test for LNMTV

1. Null Hypothesis: **LNMTV has a unit root**
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.611412	0.9889
Test critical values:	1per cent level	-3.546099	
	5per cent level	-2.911730	
	10per cent level	-2.593551	

*MacKinnon (1996) one-sided p-values.

Diagnostic Test 4: Augmented-Dickey Fuller Test for LNMTVOL

2. Null Hypothesis: **LNMTVOL has a unit root**
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.254773	0.9738
Test critical values:	1per cent level	-3.548208	
	5per cent level	-2.912631	
	10per cent level	-2.594027	

*MacKinnon (1996) one-sided p-values.

Diagnostic Test 5: Augmented-Dickey-Fuller Test for LNPTV

3. Null Hypothesis: **LNPTV has a unit root**
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.249156	0.9735
Test critical values:	1per cent level	-3.548208	
	5per cent level	-2.912631	
	10per cent level	-2.594027	

*MacKinnon (1996) one-sided p-values.

Diagnostic Test 6: Augmented-Dickey Fuller Test for LNPTVOL

4. Null Hypothesis: **LNPTVOL has a unit root**
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.671166	0.9905
Test critical values:	1per cent level	-3.550396	
	5per cent level	-2.913549	
	10per cent level	-2.594521	

*MacKinnon (1996) one-sided p-values.

The Augmented Dickey-Fuller unit root tests on first difference of each sample variable suggested that first difference of each of the sample variables was stationary or integrated of order zero (I0) and therefore the null hypotheses that first difference of each of sample variable has unit root was not accepted. We therefore conclude that sampled variables were stationary in first difference. The results of the first difference of sampled variables are shown below:

Diagnostic Test 7: Augmented Dickey Fuller Test for D(LNMTV)

1. Null Hypothesis: **D(LNMTV) has a unit root**
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-9.472530	0.0000
Test critical values:	1per cent level	-3.548208	
	5per cent level	-2.912631	
	10per cent level	-2.594027	

*MacKinnon (1996) one-sided p-values.

Diagnostic Test 8: Augmented-Dickey Fuller Test for D(LNMTVOL)

2. Null Hypothesis: **D(LNMTVOL) has a unit root**
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.27410	0.0000
Test critical values:	1per cent level	-3.548208	
	5per cent level	-2.912631	
	10per cent level	-2.594027	

*MacKinnon (1996) one-sided p-values.

Diagnostic Test 9: Augmented-Dickey Fuller Test for D(LNPTV)

3. Null Hypothesis: **D(LNPTV) has a unit root**
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.80108	0.0000
Test critical values:	1per cent level	-3.548208	
	5per cent level	-2.912631	
	10per cent level	-2.594027	

*MacKinnon (1996) one-sided p-values.

Diagnostic Test 10: Augmented-Dickey Fuller Test D(LNPTVOL)

4. Null Hypothesis: **D(LNPTVOL) has a unit root**
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=5)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-8.987402	0.0000
Test critical values:	1per cent level	-3.550396	
	5per cent level	-2.913549	
	10per cent level	-2.594521	

*MacKinnon (1996) one-sided p-values.

3.7 Cointegration Test

The Augmented Dickey-Fuller test suggests integration of sampled variables of same order one (I1), and the study focuses on more than two variables hence Johansen's cointegration methodology comes in handy to test for possible existence of stable long-run relationships among the sampled variables (Johansen, 1991), (Hamilton, 1994), (Johansen, 1995) and (Hayashi, 2000). This approach involves Trace Test Statistics and Maximum Eigenvalue Test Statistics which results did not reject the null hypotheses that there was: (i) no cointegration equation and (ii) at most 1 cointegration equation. Nevertheless, the tests upheld the null hypotheses that there were (iii) at most 2 cointegration equations; and (iv) at most 3 cointegration equations. Details of the Johansen's tests results are reported below:

Diagnostic Test 11: Johansen's Cointegration Tests for LNMTV, LNMTVOL, LNPTV and LNPTVOL

Date: 03/10/17 Time: 08:25
Sample (adjusted): 2012M07 2016M12
Included observations: 54 after adjustments
Trend assumption: Linear deterministic trend
Series: LNMTV LNMTVOL LNPTV LNPTVOL
Lags interval (in first differences): 1 to 5

Unrestricted Co-integration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.424548	62.09702	47.85613	0.0013
At most 1 *	0.363507	32.25664	29.79707	0.0255
At most 2	0.119298	7.860460	15.49471	0.4804
At most 3	0.018358	1.000543	3.841466	0.3172

Trace test indicates 2 co-integrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.424548	29.84038	27.58434	0.0252
At most 1 *	0.363507	24.39618	21.13162	0.0167
At most 2	0.119298	6.859917	14.26460	0.5058
At most 3	0.018358	1.000543	3.841466	0.3172

Max-eigenvalue test indicates 2 co-integrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values.

The long-run relationship for the volume of payment system transactions is expressed as:

$LNPTVOL=-0.75-0.07LNMTVOL+0.65LNPTV+\varepsilon_1$............(2)

where ε_1 is the error term for the payments system volume of transactions defined in (3):

$\varepsilon_1=LNPTVOL+0.75+0.07LNMTVOL-0.65LNPTV$...........(3)

Similarly, the long-run relationship for the volume of mobile money transactions is expressed in equation (4) below:

$LNMTVOL=-29.27+0.06LNMTV+1.77LNPTV+\varepsilon_2$...........(4)

where ε_2 is the error term for the mobile money volume of transactions defined in (5):

$\varepsilon_2=LNMTVOL+29.27-0.06LNMTV-1.77LNPTV$.......... (5).

The vector error correction model below provides basis for the long-run equations.

Diagnostic Test 12: Two Co-integrating Equations

Vector Error Correction Estimates
Date: 03/15/17 Time: 18:33
Sample (adjusted): 2012M07 2016M12
Included observations: 54 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2
LNPTVOL(-1)	1.000000	0.000000
LNMTVOL(-1)	0.000000	1.000000
LNMTV(-1)	0.072393	-0.056342
	(0.02639)	(0.08753)
	[2.74304]	[-0.64370]
LNPTV(-1)	-0.647919	-1.766545
	(0.06014)	(0.19946)
	[-10.7734]	[-8.85668]
C	0.748765	29.27299

The long-run cointegrating relationship equation (2) indicates that a 100 per cent change in the payment systems' volume of transactions is attributed to 65 per cent change in value of payment system transactions. Similarly, equation (4) implies that a 100 per cent increase in the volume of mobile money transactions is explained by 6 per cent change in value of mobile money transactions. Also, value of payment systems transactions increase by 177 per cent with a 100 per cent increase in the volume of payment system transactions.

3.8 Vector Error Correction Model (VECM)

The Johansen's co-integration test results indicated that there were two cointegrating equations. The first system equation of interest is the one with payment systems volume of transactions variable as the endogenous variable and second, with MM volume of transactions as endogenous variable. These are equations (1) and (4) in Appendix 1.

The VECM model contains both long-run and short-run information. Long and short-run information on impact of mobile money on the payments ecosystem in Ghana are obtained by determining the two system equations in Appendix 1. The precise system equations are (1) and (4) and the results were shown in Appendix 3. The results indicated that there are long-run impact and short-run impact from volume of payment system transactions to MM transactions volumes.

The long run impact was captured by parameters C(73) and C(75) in the VECM model in Appendix 3 and from Johansen's cointegration econometric theory C(73) and C(75) are expected to have negative signs and be significant. Appendix 3 shows C(73) and C(75) bearing the right sign and are significant. We therefore conclude that there is long-run impact running from payment system developments to volume of MM transactions.

Parameter C(73) is referred to as speed of adjustments. The estimated VECM specification for MM system equation suggests that the speed of adjustment of the MM market towards its long-run equilibrium when disturbed by disequilibrium in the payment system is 0.58 per cent per month and by its own market is 4.06 per cent per month; resulting in total speed of adjustments of 4.64 per cent per month or 55.68 per cent per annum (Appendix 4).

The speed of adjustment of MM market of 55.68 per cent in Ghana compares favourably with speed of adjustments estimated in other sectors in Africa for instance Kenya (11.7per cent in 1997, 18.4per cent in 1998; Ndung'u, 1997, 1998), and Uganda (43.86 per cent; Atingi-Ego, 2000).

Secondly, to measure the short-run impact of mobile money on the payment system, we use Wald Test to check whether first difference of each variable; lagged from one to five, has zero impact on the payment systems. These exercises involve testing the following restrictions: C(76)=C(77)=C(78)=C(79)=C(80)=0 for impact emanating from log of volume of payment systems transactions; C(81)=C(82)=C(83)=C(84)=C(85)=0 for impact coming from log of payment system value of transactions; C(86)=C(87)=C(87)=C(88)=C(89)=0 impact relating to log value of MM transactions and C(90)=C(91)=C(92)=C(93)=C(94)=0 impact relating to log volume of MM transactions.

The Wald Test (i); the F-statistic and Chi-square statistic indicated probability values of 0.0498 and 0.0262 respectively which were less than 5per cent therefore we reject the null hypothesis that there was no short-run impact from volume of payment systems transactions to mobile money transactions and concluded that in the short run, volume of payment system transactions impact positively on MM transactions in Ghana and consequently deepens financial inclusion. The results are shown in Appendix 2.

The Wald Test (ii); probability value of F-statistic of 0.0885 and that of Chi-square of 0.0583 are more than 5per cent, and we cannot reject the null hypothesis that there was no short-run impact running from value of payment systems transactions on MM transactions. In the short run, value of payment system transactions impact on MM transactions in Ghana and financial inclusion.

In terms of change in log value of MM transactions, (i); the probability values of F-statistic and Chi-square of 0.0126 and 0.0035 respectively were less than 5 per cent therefore we reject the null hypothesis that there is no short-run impact emanating from values of MM transactions to volume of MM transactions and on the contrary, conclude that in the short- run, value of MM transactions impact positively on volume of MM transactions in Ghana. The probability values of F-statistic and Chi-square of 0.0126 and 0.0035 respectively were less than 5 per cent and therefore we reject the null hypothesis and accept the alternative hypothesis that past successful MM transactions impact positively on current volume of MM transactions and financial inclusion. The unbanked recommend MM to their peers based on their past experiences with MM.

3.9 Variance Decomposition

In the long run, it is expected that the Ghana payment systems will be stable, safe and efficient. Hence after the estimation of the VAR model, variance decomposition is used to determine forecast error by using Sim's recursive Choleski method to identify the most effective instrument for each targeted variable. The targeted variables in this model are volume of mobile money transactions (DLNMTVOL), value of mobile money transactions (DLNMTV), volume of payment systems transactions (DLNPTVOL), and value of payments systems transactions (DLNPTV); all in first difference. The VAR model is applied with five lags to decompose the innovations of the endogenous variables into portions attributable to its own innovations and to innovations in the other variables. The results of the forecast error variance decomposition of the endogenous variables at various months are generated by the four-variable, reduced form VAR model and shown in Appendix 6.

The results indicate that the predominant source of variations in the volume of MM transactions is "own shocks" which account for more than 75 per cent during the first five months of the shock. The innovations of payment systems volume of transactions and value of mobile money transactions are other important sources of the forecast error variance of the volume of mobile money transactions. The source of least forecast error variance of the volume of mobile money transactions is innovation resulting from value of payment systems transactions.

The variance decomposition forecast error of the DLNMTV and DLNPTVOL follow the same trend as DLNMTVOL while the variance decomposition forecast error of DLNPTV indicates that in the first month of the innovation, own shocks account for only 46 per cent and innovations of 37.2 per cent and 12.5 per cent emanated from DLNPTVOL and DLNMTVOL respectively. In the fifth month, however, innovations from DLNMTVOL increased to 36.1 per cent while other sources including own shocks declined. It can be deduced that volume of mobile money transactions is playing a dominant role in the Ghanaian payment ecosystem.

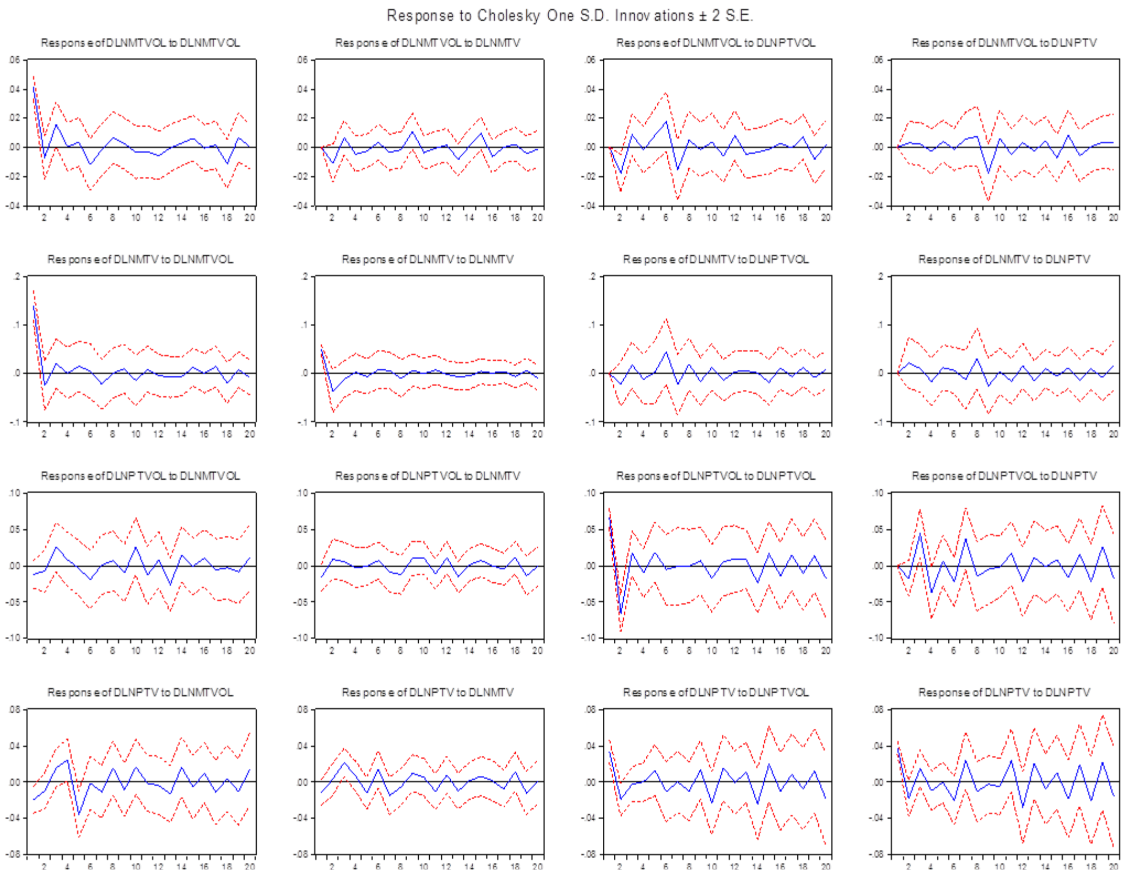
3.10 Impulse Response Functions

The effect of unanticipated shocks to the volume of mobile money transactions, value of MM transactions on stability and efficiency of the payment systems in Ghana can be ascertained from the impulse response functions of a reduced form VAR model. Generally, if the response is of the type that the short-run values converge to its long-run values, then it means that stability can be achieved for the payment and mobile money ecosystem in the event of an exogenous shock to the payment system or mobile money operations.

The objective for undertaken this analysis is to assess the impact of these shocks on the stability, safety and efficient operations of the Ghana payment ecosystem. This information will enable the monetary authorities to predict the consequences of unanticipated shocks and respond appropriately to maintain the stability and efficiency of the payment ecosystem. The impulse responses of the four variables to one standard deviation shock in one of the innovations of all the endogenous variables as presented in Diagnostic Test 13.

The results indicate that response to own innovation for all the variables becomes negative after two months of the shock and thereafter converges to its long-run value within 24 months.

Diagnostic Test 13: Impulse Response Functions



CHAPTER FOUR

4.0 CONCLUSIONS AND POLICY RECOMMENDATIONS

This session provides summary, conclusions and policy recommendations.

4.1 Summary and Conclusions

The purpose of this study was to investigate the impact of mobile money on the payment system in Ghana. The paper found that in the short-run, value of mobile money transactions impact positively on the volume of mobile money transactions.

Similarly, the empirical investigations also showed that there are stable long-run relationships among volume of payment systems transactions, value of payment systems transactions, volume of MM transactions and value of MM transactions. The co-integrating relationship between volume of mobile money transactions and value of mobile money transactions suggests that there is a long-run relationship between deepening of financial inclusion and progress towards cash-lite economy. This means that factors that promote use of mobile money foster financial inclusion and facilitate progress towards cash-lite economy.

The study also found long-run impact from volume of payment system transactions and value of MM transactions to volume of MM transactions. There is also short-run impact from volume of payment payments transactions and value of MM transactions to volume of MM transactions.
The results from variance decomposition indicated that own shocks were the predominant sources of variations in the volume of MM transactions accounting for more than 75 per cent during the first five months of a shock. The innovations of payment systems volume of transactions and value of mobile money transactions are other important sources of the forecast error variance of the volume of mobile money transactions respectively.

The results indicate that response to own innovation for all the variables becomes negative after two months of the shock and thereafter converges to its long-run value before end of twenty-forth month.

4.2 Policy Recommendations

The study reveals that development of the mobile money sub-sector encourages financial inclusion and deepens the payment systems. Mobile money sub-sector is therefore one of the key drivers of the payment systems in Ghana. Also, the number of successful mobile money transactions encourages customers to undertake future transactions. The department will therefore continue to:

i. Require MMOs and banks to act honestly, by presenting all terms and information about their MM products in a clear and accurate way to aid consumer decision-making;
ii. Demand MMOs and banks to treat every consumer fairly and not discriminate against customer;
iii. Require all MMOs and banks to strengthen their complaints' handling and redress mechanisms so that the processes become easily accessible, independent, fair, accountable, timely and efficient;
iv. Require MMOs and banks to provide adequate internal dispute resolution mechanisms, financial literacy education for the public and strengthen internal controls to minimized MM related and cyber fraud;
v. Require MMOs and banks to put in place appropriate and effective procedures for receiving, considering and resolving complaints; and also
vi. Play a leading role in addressing issues pertaining to AML/CFT, cybercrimes, MM interoperability and agents' distribution networks which would afford users the benefits of affordability, flexibility, simplicity and convenience associated with MM usage.

Reference

Adam C. and Walker S. E.J 2015' Mobile Money and Monetary Policy in East African Countries' University of Oxford.

Amediku S. and Blay C. 2016 March, Mobile Financial Services in Ghana, Bank of Ghana. https://www.theigc.org/wp-content/uploads/2016/03/Ghana.pdf

Amediku S. 2011, Was Basel III necessary and will it bring about prudent risk management in banking? WP/MPAFSD/BOG-2011/01. Bank of Ghana

Bishop, A. P.; Tidline, T. J.; Shoemaker, S. & Salela, P. (1999). Public libraries and networked information services in low-income communities. Library & Information Science Research, 21(3), 361-390.

Bold, C., Porteous, D. and Rotman, S. (2012). Social cash transfers and financial inclusion: Evidence from four countries. Consultative Group for Assisting the Poor (CGAP), February, 1-20.

Butler, R. (2005). Cell phones may help "save" Africa. Mongabay.com. Retrieved April 14, 2006, from http://news.mongabay.com/2005/0712-rhett_butler.html.

Dahlberg T., Guo J. and Ondrus J, (2008). "A critical Review of Mobile Payment Research" Xian Jiaotong University, China, School of Finance and Economics

Dias, Denise and Katharine McKee 2010. "Protecting Branchless Banking Consumers: Policy Objectives and Regulatory Options." CGAP Focus Note No. 64.

Diniz, H. Alburquerque J and Cernev K. (2011). Mobile Money and Payment: A literature review based on academic and practitioner-oriented publications (2001-2011). Proceedings of SIG GlobDev Fourth Annual Workshop, Shanghai China.

Duncombe R. and Boateng R. (2009). Mobile Phones and Financial Services in Developing Countries: A review of Concepts, Methods, Issues, Evidence and Research Directions. University of Manchester, UK, Institute of Development Policy and Management.

Ehrbeck, T., Pickens, M. and Tarazi, M. (2012). Financially Inclusive Ecosystems: The roles of government today. CGAP, February.1-11.

Elijah, O. & Ogunlade, I. (2006). Analysis of the uses of ICT for gender empowerment and sustainable poverty alleviation in Nigeria, International Journal of Education and Development…(IJEDICT), 2(3), 45-69

Etim A (2011). Bottom-up business development: Empowering low income societies through microfinance and mobile technologies. International Journal of Humanities and Social Sciences 1 (13) 1-11

Etim A (2012). The Emerging Market of Sub-Saharan Africa and technology adoption: Features, users desire in mobile technologies, International Journal of ICT Research and Development in Africa 3(1), 14-16.

Etim A. (2012). Mobile Technology adoption for micro finance delivery in Sub-Saharan Africa, Research in Business and Economics Journal (RBEJ) 7

GSMA. 2013. The Mobile Economy 2013, ATKearney. http://gsma.com/newsroom/wp- content/uploads/2013/12/GSMA-Mobile-Economy-2013.pdf

GSMA. 2016. State of Mobile Money in West Africa. www.gsma.com/mobilemoney.

Jack, W. and Suri, T. (2011). Mobile money: The economics of M-PESA, NBER working Paper, No. 16721.Retrieved August 2, 2012 from http://www.microfinancegateway.org/gm/document-/mobile_money.pdf

Jenkins, B. 2008. Developing mobile money ecosystems, IFC, World Bank and Harvard Kennedy School of Government. http://www.hks.harvard.edu/m- rcbg/CSRI/publications/report_30_MOBILEMONEY.pdf.

Johansen, S. 1988. "Statistical analysis of cointegrating vectors". Journal of Economic Dynamics and Control, vol. 12: 231–54.

Johansen, S. 1991. "Estimation and hypothesis testing of co-integration vectors in Gaussian Vector autoregressive models". Econometrica, vol. 59: 1551–80.

Jong-Moon J. and Hyunju P. 2016 ' Mobile Money in Sub-Saharan Africa and its implications'.ISSN 2233-9140. Korea Institute for International Economic Policy.

Mbiti, I. and Weil, D., (2011). Mobile Banking: The impact of M-Pesa in Kenya. NBER Working Paper 17129.

Ndung'u, N. 1997. Price and Exchange Rate Dynamics in Kenya: An Empirical Investigation (1970–1993). Research Paper No. 58. African Economic Research Consortium, Nairobi.

Nortey, S., 2000 'Static and Dynamic Interactions Among Price, Exchange Rate and Output in Ghana', University of Cape Coast, Cape Coast.

Ojijo 2016 '26 Legal Issues in Mobile Money Transactions'.(+256776100059). ojijo@lawpronto.comMobile.

Perron, P. 1990. "Testing for a unit root in a time-series with a changing mean". Journal of Business and Economic Statistics, vol. 8: 153–62.

Pesaran, M.H. and Y. Shin. 1996. "Co-integration and speed of convergence to equilibrium". Journal of Econometrics, vol. 71: 117–43.

Porteous, D. (2006). The enabling environment of mobile banking in Africa. London: Department for International Development (DFID) Retrieved September 5, 2012 from http://www. gsma.com/mobilefordevelopment/wp -content/uploads/2012/

PSD, 2016. Payment Systems Department Annual Report 2016, Bank of Ghana.

Sewanyana , L (2008) ICT access and poverty in Uganda, International Journal of Computing and ICT Research 1(2), 10-19.

Srivastava L (2008). The mobile makes its mark. In Katz J.E Handbook of Communication Studies, Cambridge, Massachusetts, The MIT Press, 15-27

Villasenor J. D, West D. M, and Robin J. Lewis J. R., 2016 'Advancing Financial' Ecosystem 2016 Brookings Financial and Digital Inclusion Project Report.

Weber, Rolf H. and AlineDarbellay 2010. "Legal Issues in Mobile Banking." Journal of Banking Regulation 11, no 2 (2010): 129 -145.

Wakoba, S. (2012). World Bank calls for mobile money integration. Human IPO, http://www.humanipo.com/news/972/World-Bank-calls-for-mobile-money-integration.

Appendix One

MAKE SYSTEM EQUATION BY VARIABLES

i. D(LNPTVOL) = C(1)*(LNPTVOL(-1) - 0.267692563725*LNMTVOL(-1) - 9.6484375384) + C(2)*(LNPTV(-1) - 0.532118897195*LNMTVOL(-1) - 16.4544699525) + C(3)*(LNMTV(-1) - 1.06471294194*LNMTVOL(-1) - 3.64627535541) + C(4)*D(LNPTVOL(-1)) + C(5)*D(LNPTVOL(-2)) + C(6)*D(LNPTVOL(-3)) + C(7)*D(LNPTVOL(-4)) + C(8)*D(LNPTVOL(-5))+ C(9)*D(LNPTV(-1)) + C(10)*D(LNPTV(-2)) + C(11)*D(LNPTV(-3)) + C(12)*D(LNPTV(-4)) +C(13)*D(LNPTV(-5)) + C(14)*D(LNMTV(-1)) + C(15)*D(LNMTV(-2)) + C(16)*D(LNMTV(-3)) +C(17)*D(LNMTV(-4)) + C(18)*D(LNMTV(-5)) + C(19)*D(LNMTVOL(-1)) + C(20)*D(LNMTVOL(-2))+ C(21)*D(LNMTVOL(-3)) + C(22)*D(LNMTVOL(-4)) + C(23)*D(LNMTVOL(-5)) + C(24)

ii. D(LNPTV) = C(25)*(LNPTVOL(-1) - 0.267692563725*LNMTVOL(-1) - 9.6484375384) + C(26)*(LNPTV(-1) - 0.532118897195*LNMTVOL(-1) - 16.4544699525) + C(27)*(LNMTV(-1) - 1.06471294194*LNMTVOL(-1) - 3.64627535541) + C(28)*D(LNPTVOL(-1))+ C(29)*D(LNPTVOL(-2) + C(30)*D(LNPTVOL(-3)) + C(31)*D(LNPTVOL(-4)) + C(32)*D(LNPTVOL(-5)) + C(33)*D(LNPTV(-1)) + C(34)*D(LNPTV(-2)) + C(35)*D(LNPTV(-3)) +C(36)*D(LNPTV(-4)) + C(37)*D(LNPTV(-5)) + C(38)*D(LNMTV(-1)) + C(39)*D(LNMTV(-2)) +C(40)*D(LNMTV(-3)) + C(41)*D(LNMTV(-4)) + C(42)*D(LNMTV(-5)) + C(43)*D(LNMTVOL(-1))+ C(44)*D(LNMTVOL(-2)) + C(45)*D(LNMTVOL(-3)) + C(46)*D(LNMTVOL(-4)) + C(47)*D(LNMTVOL(-5)) + C(48)

iii. D(LNMTV) = C(49)*(LNPTVOL(-1) - 0.267692563725*LNMTVOL(-1) - 9.6484375384) + C(50)*(LNPTV(-1) - 0.532118897195*LNMTVOL(-1) - 16.4544699525) + C(51)*(LNMTV(-1) - 1.06471294194*LNMTVOL(-1) - 3.64627535541) + C(52)*D(LNPTVOL(-1))+ C(53)*D(LNPTVOL(-2)) + C(54)*D(LNPTVOL(-3)) + C(55)*D(LNPTVOL(-4)) +C(56)*D(LNPTVOL(-5)) + C(57)*D(LNPTV(-1)) + C(58)*D(LNPTV(-2)) + C(59)*D(LNPTV(-3)) +C(60)*D(LNPTV(-4)) + C(61)*D(LNPTV(-5)) + C(62)*D(LNMTV(-1)) + C(63)*D(LNMTV(-2)) +C(64)*D(LNMTV(-3)) + C(65)*D(LNMTV(-4)) + C(66)*D(LNMTV(-5)) + C(67)*D(LNMTVOL(-1))+ C(68)*D(LNMTVOL(-2)) + C(69)*D(LNMTVOL(-3)) + C(70)*D(LNMTVOL(-4)) + C(71)*D(LNMTVOL(-5)) + C(72)

iv. D(LNMTVOL) = C(73)*(LNPTVOL(-1) - 0.267692563725*LNMTVOL(-1) - 9.6484375384) + C(74)*(LNPTV(-1) - 0.532118897195*LNMTVOL(-1) - 16.4544699525) + C(75)*(LNMTV(-1) - 1.06471294194*LNMTVOL(-1) - 3.64627535541) + C(76)*D(LNPTVOL(-1))+ C(77)*D(LNPTVOL(-2)) + C(78)*D(LNPTVOL(-3)) + C(79)*D(LNPTVOL(-4)) +C(80)*D(LNPTVOL(-5)) + C(81)*D(LNPTV(-1)) + C(82)*D(LNPTV(-2)) + C(83)*D(LNPTV(-3)) +C(84)*D(LNPTV(-4)) + C(85)*D(LNPTV(-5)) + C(86)*D(LNMTV(-1)) + C(87)*D(LNMTV(-2)) +C(88)*D(LNMTV(-3))+C(89)*D(LNMTV(-4))+C(90)*D(LNMTV(-5))+C(91)*D(LNMTVOL(-1)) + C(92)*D(LNMTVOL(-2)) + C(93)*D(LNMTVOL(-3)) + C(94)*D(LNMTVOL(-4)) + C(95)*D(LNMTVOL(-5)) + C(96)

Appendix Two

Diagnostic Test 14: Wald Test to Dynamic Impact of Volume of Payment System Transactions

i. Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	2.537068	(5, 30)	0.0498
Chi-square	12.68534	5	0.0265

Null Hypothesis:
C(76)=C(77)=C(78)=C(79)=C(80)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(76)	0.787287	0.516305
C(77)	0.944840	0.489503
C(78)	0.514433	0.368233
C(79)	0.775703	0.345428
C(80)	0.551630	0.188614

Restrictions are linear in coefficients.

Diagnostic Test 15: Wald Test to Dynamic Impact of Value of Payments System Transactions.

ii. Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	2.134146	(5, 30)	0.0885
Chi-square	10.67073	5	0.0583

Null Hypothesis: C(81)=C(82)=C(83)=C(84)=C(85)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(81)	0.002796	0.176607
C(82)	-0.003801	0.166388
C(83)	0.266936	0.163318
C(84)	-0.203090	0.161790
C(85)	0.100251	0.129782

Restrictions are linear in coefficients.

Diagnostic Test 16: Wald Test to Determine Dynamic Value of Mobile Money Transactions

iii. Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	3.525135	(5, 30)	0.0126
Chi-square	17.62567	5	0.0035

Null Hypothesis:
C(86)=C(87)=C(88)=C(89)=C(90)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(86)	-0.306754	0.124062
C(87)	0.250261	0.118400
C(88)	-0.302452	0.144584
C(89)	0.222451	0.136310
C(90)	-0.175203	0.098077

Restrictions are linear in coefficients.

Diagnostic Test 17: Wald Test for Dynamic Impact of Volume of Mobile Money Transactions

iv. Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	2.753957	(5, 30)	0.0366
Chi-square	13.76979	5	0.0171

Null Hypothesis: C(91)=C(92)=C(93)=C(94)=C(95)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(91)	0.882307	0.377394
C(92)	-0.625362	0.358467
C(93)	0.967982	0.386354
C(94)	-0.771304	0.421661
C(95)	0.028428	0.139106

Restrictions are linear in coefficients.

Appendix Three

Diagnostic Test 18: VECM Model

i. VECM MODEL

Dependent Variable: D(LNMTVOL)
Method: Least Squares
Date: 03/13/17 Time: 14:27
Sample (adjusted): 2012M07 2016M12
Included observations: 54 after adjustments
D(LNMTVOL) = C(73)*(LNPTVOL(-1) - 0.267692563725*LNMTVOL(-1) -9.6484375384) + C(74)*(LNPTV(-1) - 0.532118897195*LNMTVOL(-1) - 16.4544699525) + C(75)*(LNMTV(-1) - 1.06471294194*LNMTVOL(-1) - 3.64627535541) + C(76)*D(LNPTVOL(-1)) + C(77)*D(LNPTVOL(-2)) + C(78)*D(LNPTVOL(-3)) + C(79)*D(LNPTVOL(-4)) + C(80)*D(LNPTVOL(-5)) + C(81)*D(LNPTV(-1)) + C(82)*D(LNPTV(-2)) + C(83)*D(LNPTV(-3)) + C(84)*D(LNPTV(-4)) + C(85)*D(LNPTV(-5)) + C(86)*D(LNMTV(-1)) + C(87)*D(LNMTV(-2)) + C(88)*D(LNMTV(-3)) + C(89)*D(LNMTV(-4)) + C(90)*D(LNMTV(-5)) + C(91)*D(LNMTVOL(-1)) + C(92)*D(LNMTVOL(-2)) + C(93)*D(LNMTVOL(-3)) + C(94)*D(LNMTVOL(-4)) + C(95)*D(LNMTVOL(-5)) + C(96)

	Coefficient	Std. Error	t-Statistic	Prob.
C(73)	-1.181134	0.545898	-2.163653	0.0386
C(74)	0.098352	0.132793	0.740638	0.4647
C(75)	-0.173250	0.066727	-2.596389	0.0145
C(76)	0.787287	0.516305	1.524848	0.1378
C(77)	0.944840	0.489503	1.930202	0.0631
C(78)	0.514433	0.368233	1.397031	0.1727
C(79)	0.775703	0.345428	2.245633	0.0322
C(80)	0.551630	0.188614	2.924659	0.0065
C(81)	0.002796	0.176607	0.015831	0.9875
C(82)	-0.003801	0.166388	-0.022843	0.9819
C(83)	0.266936	0.163318	1.634459	0.1126
C(84)	-0.203090	0.161790	-1.255270	0.2191
C(85)	0.100251	0.129782	0.772455	0.4459
C(86)	-0.306754	0.124062	-2.472592	0.0193
C(87)	0.250261	0.118400	2.113687	0.0430
C(88)	-0.302452	0.144584	-2.091879	0.0450
C(89)	0.222451	0.136310	1.631951	0.1131
C(90)	-0.175203	0.098077	-1.786372	0.0842
C(91)	0.882307	0.377394	2.337893	0.0263
C(92)	-0.625362	0.358467	-1.744545	0.0913
C(93)	0.967982	0.386354	2.505429	0.0179
C(94)	-0.771304	0.421661	-1.829206	0.0773
C(95)	0.028428	0.139106	0.204363	0.8395
C(96)	-0.017253	0.048514	-0.355626	0.7246

R-squared	0.625614	Mean dependent var	0.064771
Adjusted R-squared	0.338585	S.D. dependent var	0.046944
S.E. of regression	0.038178	Akaike info criterion	-3.392007
Sum squared resid	0.043727	Schwarz criterion	-2.508014
Log likelihood	115.5842	Hannan-Quinn criter.	-3.051085
F-statistic	2.179617	Durbin-Watson stat	2.295223
Prob(F-statistic)	0.022986		

Diagnostic Test 19: VECM Model

ii. Dependent Variable: D(LNPTVOL)

Method: Least Squares
Date: 03/13/17 Time: 14:09
Sample (adjusted): 2012M07 2016M12
Included observations: 54 after adjustments
D(LNMTVOL) = C(73)*(LNPTVOL(-1) - 0.267692563725*LNMTVOL(-1) -9.6484375384) + C(74)*(LNPTV(-1) - 0.532118897195*LNMTVOL(-1) - 16.4544699525) + C(75)*(LNMTV(-1) - 1.06471294194*LNMTVOL(-1) - 3.64627535541) + C(76)*D(LNPTVOL(-1)) + C(77)*D(LNPTVOL(-2)) + C(78)*D(LNPTVOL(-3)) + C(79)*D(LNPTVOL(-4)) + C(80)*D(LNPTVOL(-5)) + C(81)*D(LNPTV(-1)) + C(82)*D(LNPTV(-2)) + C(83)*D(LNPTV(-3)) + C(84)*D(LNPTV(-4)) + C(85)*D(LNPTV(-5)) + C(86)*D(LNMTV(-1)) + C(87)*D(LNMTV(-2)) + C(88)*D(LNMTV(-3)) + C(89)*D(LNMTV(-4)) + C(90)*D(LNMTV(-5)) + C(91)*D(LNMTVOL(-1)) + C(92)*D(LNMTVOL(-2)) + C(93)*D(LNMTVOL(-3)) + C(94)*D(LNMTVOL(-4)) + C(95)*D(LNMTVOL(-5)) + C(96)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.709249	0.914254	-1.869556	0.0713
C(2)	-0.053545	0.222398	-0.240761	0.8114
C(3)	-0.109559	0.111753	-0.980373	0.3347
C(4)	0.661058	0.864692	0.764501	0.4505
C(5)	0.365143	0.819805	0.445403	0.6592
C(6)	0.204044	0.616705	0.330861	0.7430
C(7)	0.856675	0.578511	1.480826	0.1491
C(8)	0.807425	0.315884	2.556077	0.0159
C(9)	-0.407847	0.295776	-1.378904	0.1781
C(10)	0.733130	0.278661	2.630899	0.0133
C(11)	0.300008	0.273519	1.096844	0.2814
C(12)	-0.429864	0.270961	-1.586443	0.1231
C(13)	-0.594549	0.217356	-2.735375	0.0104
C(14)	-0.604694	0.207774	-2.910339	0.0067
C(15)	-0.137094	0.198293	-0.691369	0.4946
C(16)	-0.403315	0.242145	-1.665594	0.1062
C(17)	-0.113961	0.228287	-0.499200	0.6213
C(18)	-0.484162	0.164257	-2.947588	0.0061
C(19)	1.209731	0.632048	1.913987	0.0652
C(20)	0.354424	0.600350	0.590362	0.5594
C(21)	1.474092	0.647054	2.278161	0.0300
C(22)	0.210539	0.706184	0.298136	0.7677
C(23)	-0.186382	0.232971	-0.800024	0.4300
C(24)	-0.102213	0.081250	-1.258012	0.2181

R-squared	0.789909	Mean dependent var	0.019641
Adjusted R-squared	0.628840	S.D. dependent var	0.104952
S.E. of regression	0.063940	Akaike info criterion	-2.360655
Sum squared resid	0.122648	Schwarz criterion	-1.476662
Log likelihood	87.73770	Hannan-Quinn criter.	-2.019734
F-statistic	4.904155	Durbin-Watson stat	1.754165
Prob(F-statistic)	0.000035		

Appendix Four
SPEED OF ADJUSTMENT

The speed of adjustment is most often measured by the 'half-life', that is, the time needed in order to eliminate 50 per cent of the deviation. This is calculated as follows:

t_halftime=ln2/ϒ≈0.69/ϒ≈0.69/0.17+0.69/1.81=4.06+0.58=4.64 months ………… (1)

Where ln2=0.69 (2 decimal places) and ϒ is the estimated value of the negative error terms that are significant.

From Appendix 3, C(73)=1.81 and C(75) =0.17;
By substitution into equation (1) above:
We have; $t_{halftime}$=0.69/0.17+0.69/1.81 ;
Simplifying; $t_{halftime}$=0.58+4.06=4.64.

Since we used monthly series for the regression, then our results is read as 4.64 months. Therefore whenever the mobile money market is in disequilibrium, it takes about four and half months (18 weeks or 135 days) to adjust back to equilibrium.

APPENDIX FIVE

MOBILE MONEY OPERATORS COMMISSIONS AND TARIFFS AS AT DECEMBER, 2016

Type of Transaction	VODAFONE			AIRTEL			TIGO			MTN		
	Range (GH¢)		Fees/ charges (GH¢)	Range (GH¢)		Fees/ charges (GH¢)	Range (GH¢)		Fees/ charges (GH¢)	Range (GH¢)		Fees/ charges (GH¢)
Send money from a registered customer to another registered customer (same network)	1	50	0.5	1	50	free	1	50	0.5	1	50	0.5
	50.01	75	0.75	51	100	free	50	100	1	51	1000	1%
	75.01	100	1	101	250	free	100	250	1.5	1000 and above		Ghs 10 Flat
	100.01	250	1.5	251	500	free	250	500	2			
	250.01	500	2	501	1000	free	500	1000	2.5			
	500.01	1000	2.5	1000	3100	free	1000	2000	5			
	1000.01	2000	5									
	2000.01	3000	6									
Send money from a registered customer to unregistered customer	1	50	1.5	1	50	GH¢1.00	1	50	1.3	1	50	1.5
	50.01	75	2.5	51	100	2%	50	100	2.5	51 & Above		3%
	75.01	100	2.5	101	250	2%	100	250	4.3			
	100.01	250	4.5	251	500	2%	250	500	6			
	250.01	500	6	501	1000	2%	500	1000	8.5			
	500.01	1000	10				1000	2000	17			
	1000.01	2000	20									
	2000.01	3000	30									
Send money from an unregistered customer to an unregistered customer	Nil	Nil	Nil	1	50	2.5	1	50	2	1	50	2.5
	Nil	Nil	Nil	51	100	5.00%	50	100	4	51 & above		5%
	Nil	Nil	Nil	101	250	5.00%	100	250	8			
	Nil	Nil	Nil	251	500	5.00%	250	500	17			
	Nil	Nil	Nil	501	1000	5.00%	500	1000	32			
	Nil	Nil	Nil				1000	2000	50			
	Nil	Nil	Nil									
Withdrawal by registered customer	1	50	0.5	1	50	0.8	1	50	0.8	1	50	0.5
	50.01	75	1.5	51	100	1.25	50	100	1.5	51	1000	1%
	75.01	100	1.5	101	250	1%	100	250	2.8	1000 and above		Ghs 10 Flat
	100.01	250	2.5	251	500	1%	250	500	4			
	250.01	500	4	501	1000	1%	500	1000	6			
	500.01	1000	6	1001	3100	1%	1000	2000	12			
	1000.01	2000	10									
	2000.01	3000	5									
Withdrawal by unregistered customer	Nil	Nil	Nil	1	50	free	1	50	Free	1	50	Free
	Nil	Nil	Nil	51	100	free	50	100	Free	51	1000	Free
	Nil	Nil	Nil	101	250	free	100	250	Free			
	Nil	Nil	Nil	251	500	free	250	500	Free			
	Nil	Nil	Nil	501	1000	free	500	1000	Free			
	Nil	Nil	Nil				1000	2000	Free			

Appendix Six
VARIANCE DECOMPOSITION

Variance Decomposition of DLNMTVOL:

Period	S.E.	DLNMTVOL	DLNMTV	DLNPTVOL	DLNPTV
1	0.041089	100	0	0	0
2	0.046734	79.50774	5.527926	14.52427	0.440065
3	0.050613	77.61931	6.512258	15.29693	0.571508
4	0.050925	76.67816	7.226876	15.22172	0.873242
5	0.051937	74.19948	7.191769	17.17483	1.433921
6	0.056285	67.68546	6.485619	24.55605	1.272867
7	0.058782	62.12456	6.287118	29.51068	2.077648
8	0.059899	61.12643	6.12536	29.12433	3.623881
9	0.063466	54.59463	8.466545	26.00963	10.9292
10	0.064079	53.82648	8.615953	25.86708	11.69048

Variance Decomposition of DLNMTV:

Period	S.E.	DLNMTVOL	DLNMTV	DLNPTVOL	DLNPTV
1	0.149025	89.14709	10.85291	0	0
2	0.158445	81.41945	14.84707	1.887042	1.846441
3	0.161418	79.98054	14.86406	2.958256	2.19715
4	0.162748	78.67953	14.64873	3.433737	3.238006
5	0.164009	78.29737	14.58718	3.413009	3.702444
6	0.170528	72.50245	13.7041	10.24491	3.548534
7	0.174056	71.21318	13.27675	11.56995	3.940127
8	0.178124	67.99954	13.01094	12.21746	6.772057
9	0.181112	66.06654	12.72555	12.63793	8.569982
10	0.1822	65.93577	12.57443	12.97173	8.518067

Variance Decomposition of DLNPTVOL:

Period	S.E.	DLNMTVOL	DLNMTV	DLNPTVOL	DLNPTV
1	0.068951	3.160769	5.454284	91.38495	0
2	0.097758	2.105616	3.582821	91.09508	3.216482
3	0.111631	6.793209	2.975155	72.28933	17.94231
4	0.118502	6.538158	2.689039	64.87487	25.89793
5	0.120228	6.448156	2.618391	65.46079	25.47267
6	0.124071	8.460398	2.775255	61.6371	27.12724
7	0.129857	7.728281	2.975635	56.27078	33.0253
8	0.131421	7.805871	3.803766	54.9442	33.44616
9	0.132517	8.286881	4.349826	54.31829	33.045
10	0.13663	11.51788	4.702678	52.67842	31.10103

Variance Decomposition of DLNPTV:

Period	S.E.	DLNMTVOL	DLNMTV	DLNPTVOL	DLNPTV
1	0.055617	12.49439	4.265729	37.22803	46.01185
2	0.062355	12.39711	3.65735	39.02452	44.92102
3	0.069472	15.08257	12.51134	31.57316	40.83293
4	0.074516	23.73404	11.69591	27.44329	37.12677
5	0.08448	36.13619	11.23097	23.74681	28.88603
6	0.088636	32.84564	12.72147	22.9903	31.44259
7	0.093695	30.75335	13.99554	20.57565	34.67546
8	0.096227	31.75043	13.58313	20.61121	34.05523
9	0.098052	31.35508	14.1098	21.67566	32.85946
10	0.10237	31.42641	13.21054	24.96754	30.39551

Cholesky Ordering: DLNMTVOL DLNMTV DLNPTVOL DLNPTV www.bog.gov.gh