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Empirical Evaluation of the Relationship Between Bitcoin and Domestic Currencies in Africa

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DECLARATION

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the Research Project contains no material previously published or written by another person except where due reference is made in the Research Project itself.

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ABSTRACT

Bitcoin trading has gained momentum in the African continent as well as in the world. As is so, it is crucial to understand how the development of bitcoins would affect a given economy, especially because the operation of bitcoins is beyond the governing eye of any Central Bank. This research seeks to study Bitcoin as a currency and establish what impact it would have on the domestic currencies of nations which have significant Bitcoin trading activity in Africa. This impact will be evaluated using the Random Effects method of estimation. The research will further evaluate the long-term relationship, if any, between bitcoins and selected domestic currencies in Africa using the Kao and Perdoni residual cointegration tests. The countries of focus in this research include Kenya, Morocco, Nigeria and South Africa, which were observed between 2014 and 2017. The choice of these countries and the duration of observation is due to the ease of availability of data on Bitcoin trading. Results confirmed the existence of a statistically significant relationship between the amount of bitcoins in circulation and macroeconomic variables such as exchange, interest and inflation rates. No long-term relationship was established and the Vector Autoregressive test was performed to capture the linear interdependencies among the variables. The conclusion drawn from this study is that as the number of bitcoins increases in a given economy, the domestic currency suffers devaluation. Due to this, governments are recommended to keep a watchful eye over bitcoin transactions in their respective economies as well as looking into the development of competitive central backed cryptocurrencies over which they would have total control.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BTC: Denomination of the Bitcoin currency

PPP: Purchasing Power Parity

USD: United States Dollar

OLS: Ordinary Least Squares

ECT: Error Correction Term

PMG: Pooled Mean Group

VAR: Vector Autoregressive

1 INTRODUCTION

1.1. Background of the Study

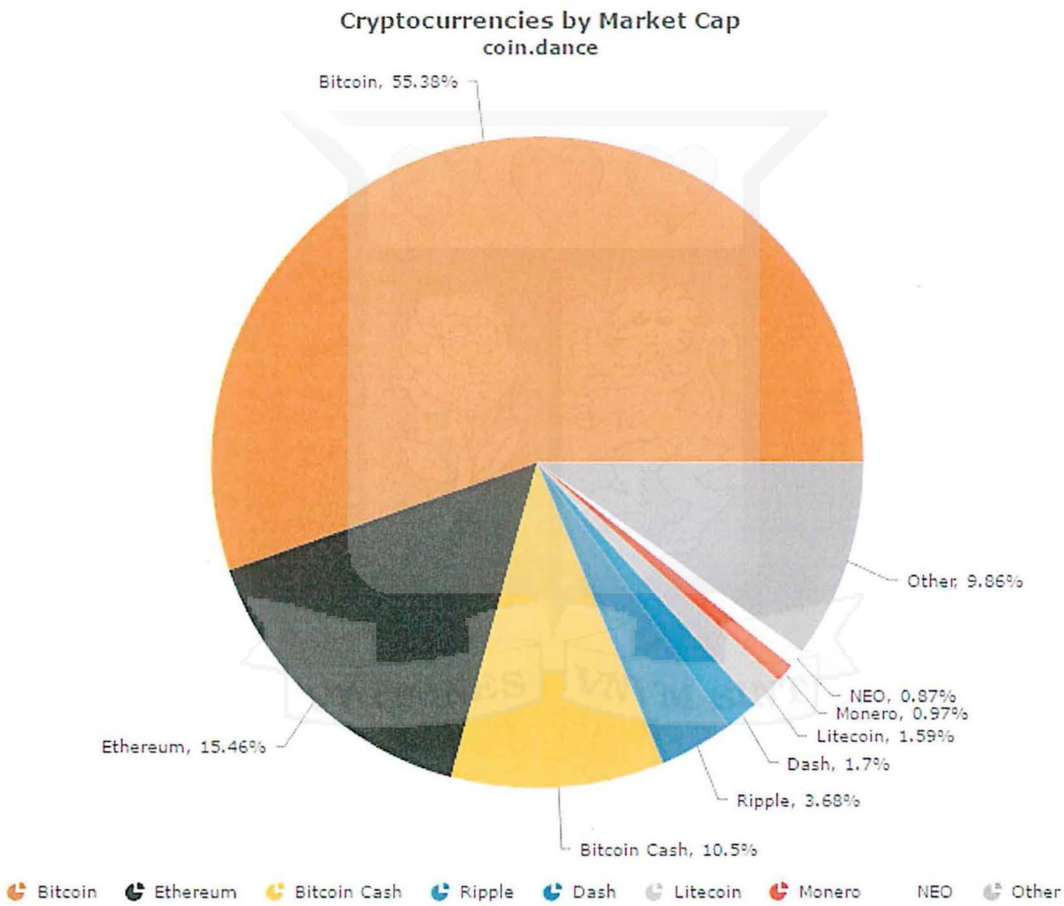
1.1.1 Evolution of Money

At the dawn of humanity, barter trade was used in lieu of money to exchange goods and services. The lack of a common currency facilitated the growth of this trading system, with communities exchanging what they needed for what they already had in surplus. In the African economy, close communities exchanged pastoral and agricultural commodities for local consumption while precious stones and metals, rhinoceros horns and ivory were shipped overseas (Centrak Bank of Kenya, 2017). There was an advancement of the barter system to the use of cowrie shells. The Central Bank of Kenya traces this advancement to 1200BC which was mainly to solve the problem of subdivision in the barter system. Cowrie shells had appealing qualities such as being durable, easily portable and divisible (Glyn, 2002). By 1000 B.C, cowrie shells were already being replaced by the use of precious metals. Such metals included bronze, copper, electrum, silver and gold (Gascoigne, 1993). These early metal monies developed into primitive versions of round coins, which had the faces of various gods and emperors as marks of their authenticity (Apsell, 1996). Coins further evolved into bank notes around 1661 AD. From coins and notes was birthed credit and debit cards which were introduced in 1946. Since then, fiat currency has mostly taken the form of coins and bank notes. Coinage, in our digital age, has since developed from tangible coins through to digital coins (Callander, 2014).

1.1.2 The Advent of Digital Currencies

Digital currencies, also known as cryptocurrencies, are the most recent invention of money. A digital currency is a virtual coinage system. It functions more like the conventional currency, enabling users to provide virtual payment for goods and services free of a financial intermediary as well as a central trusted authority. Digital currencies also perform the functions of money of being a medium of exchange, a store of value and a unit of account. The cryptocurrency market, even though having a short lifespan, has evolved at an unprecedented speed (Farell, 2015). Since the release of the pioneer cryptocurrency, Bitcoin, in 2009, more than 700 other cryptocurrencies have been developed, majority of which have had only a pinch of success (CoinMKTCap, 2017). In studying digital currencies, this research will focus solely on Bitcoin, the first successful decentralized cryptocurrency. The focus on Bitcoin is also due to its popularity and it having the largest market share of 56.97% in relation to the entire cryptocurrency market. Figure 1 below shows these statistics.

Figure 1: Cryptocurrencies by Market Share



Source: (Coin Dance, 2017)

1.1.3 Bitcoin and How It Works

Bitcoin is a decentralized global currency system which was initially designed and developed by Satoshi Nakamoto[1] (Barber, Boyen, Shi, and Uzun, 2012). The units of currency of Bitcoin are called bitcoins, or BTC, and are used to store and transmit value among participants in the Bitcoin network. Essentially the main difference between Bitcoin and bitcoins is that Bitcoin, capitalized, refers to the technology and network, as well as the currency, whereas bitcoin(s) refer to the unit of account. Unlike conventional currencies bitcoins have no physical manifestation as they exist only in the form of computer codes. These codes are designed such that they are publicly accessible and can be inspected, modified and enhanced. Bitcoin uses peer to peer technology with no regulator or financial intermediary[2]. Management of transactions and the issuing of bitcoins is carried out collectively by the network. Bitcoin, like any other currency, serves the purpose of facilitating the exchange of goods and services. However, unlike other traditional currencies, it is neither issued nor controlled by a state or even a single authority (Decker and Wattenhofer, 2013).

Since its invention in 2009, Bitcoin has enjoyed a rapid growth, both in value and in volumes[3]. In mid-2010, one bitcoin exchanged for approximately 0.08 USD. This exchange rate has since experienced an upward shift with one bitcoin exchanging for as much as 8257.47 USD in November 2017[4]. The number of bitcoins has also been growing and there are approximately 16.6 million bitcoins in circulation as of September 2017. This success can be attributed to bitcoins being highly liquid, having low transaction costs, ease of sending payments quickly across the internet, and being used for micropayments. Even though the Bitcoin economy is gradually flourishing, there are concerns over the

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[1] The name 'Satoshi Nakamoto' is assumed to be fake by some, and the person bearing that name has neither been seen nor heard from since April 2011

[2] In this peer to peer technology, transactions do not require authorization by a third party like PayPal, Western Union or Visa

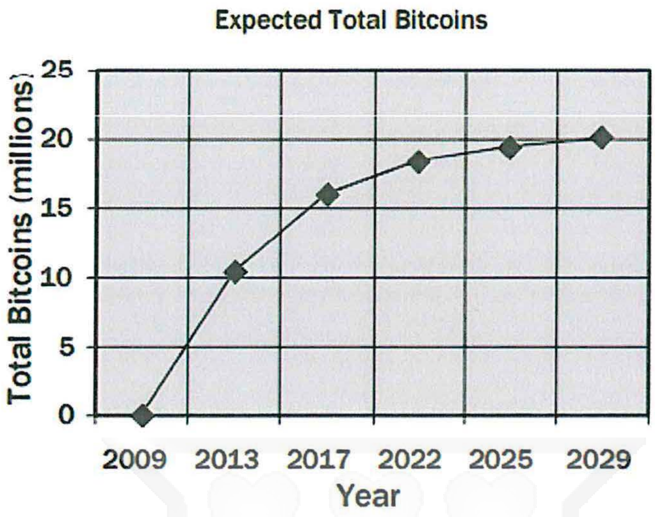
[3] See Appendices B and C in the Appendix section. They show graphical representations of the growth of Bitcoin in value and volumes.

[4] Appendix A in the Appendices section shows the bitcoin to US dollar exchange rate as at November 2017

legal status of Bitcoin and its ability to facilitate money laundering, tax evasion and trade in illegal drugs and activities (Grinberg, 2011). Moreover, there are security risks with companies that trade bitcoins recording huge losses when they were hacked (Agoya, 2015) and their bitcoins stolen (Pagliery, 2014).

The process of producing more bitcoins is called mining. Mining is equivalent to the printing of fiat money by central and federal banks. This process is carried out by 'miners'. The Bitcoin system is based on mathematics and the entire process of mining revolves around using mathematical formula to solve some complex mathematical problems. Miners are required to use their computing prowess to solve these problems. Once these problems are solved, and the solutions approved by all the other miners then new bitcoins are produced. Any miner who successfully solves any of the math problems is rewarded with a certain number of bitcoins. This usually serves as an incentive to allow more miners to engage and compete in the mining process. An interesting fact about the bitcoin mining process is that as the number of miners in the bitcoin network changes, the mathematical problem difficulty adjusts to ensure that bitcoins are created at a predetermined rate and not faster or slower. Grinberg (2011) explains that as of 2011, about 50 bitcoins were being issued every ten minutes. The rate was halved to 25 bitcoins in 2013 and further halved every four years thereafter. At these rates, 10.5 million bitcoins were created in the first four years, half that amount in the following four years, half that amount in the years thereafter, and so on. This process and time intervals will allow for the number of bitcoins to approach their upper limit of 21 million by 2040 as illustrated in *figure 2* below.

Figure 2 Expected Total Supply of Bitcoins



Source: Hastings Science & Technology Law Journal [vol. 4.1], Pg. 164

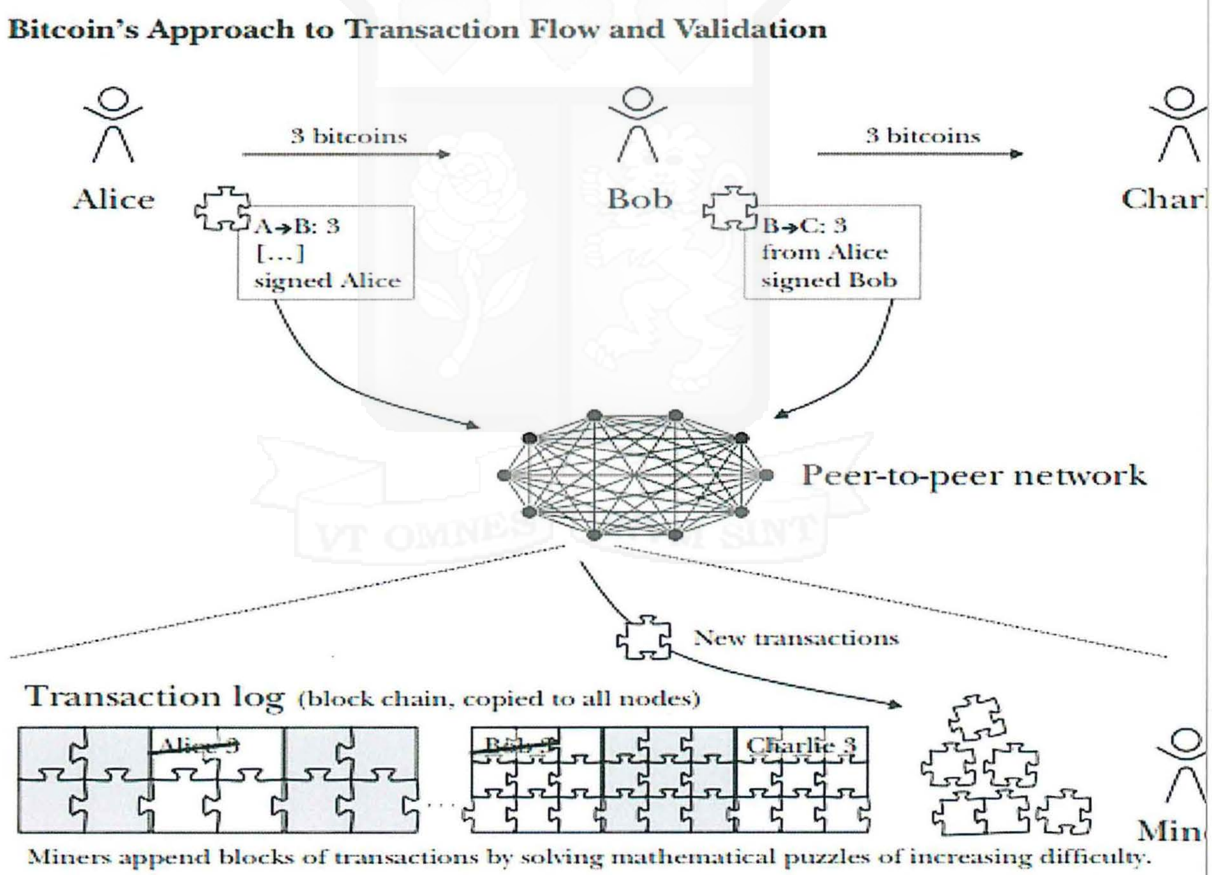
Mining is an important part of the Bitcoin system as it ensures integrity, stability, safety and security of the bitcoin network. It is also worth noting that bitcoins are divisible to eight decimal places, with the smallest unit being: 1 Satoshi=0.00000001 BTC (Szczepanski, 2014).

1.1.4 Blockchain and Bitcoin Transactions

People send bitcoins to each other over the Bitcoin network all the time. Due to lack of a central governing authority to keep record of the transactions, the bitcoin network self-sufficiently collects all the transactions made during a set period into a list called a block. The miners have the responsibility to confirm these transactions, and compile different blocks into a general ledger known as the 'blockchain'. The blockchain therefore is a long list of all the transactions that occurred on the Bitcoin network. This blockchain is also available to everyone who participates in the network so that they all know what is going on. For every transaction, it can publicly be seen from whom bitcoins were received and to whom they were sent to, but the personal information about the parties involved in the transactions is never disclosed (Szczepanski, 2014).

Participants in the Bitcoin network do not just "hold" bitcoins, rather they participate in a transaction that can be verified publicly showing from whom they received the bitcoins and to whom they are sent to. For instance, according to an example by (Bohme, Nicolas, Benjamin, and Moore, 2015) two users, Charlie and Bob carry out Bitcoin transactions. These transactions like any other are recorded in the blockchain. Charlie is able to verify from the public records on the blockchain that Bob could make payment with regards to the transaction because there was a prior transaction in which Bob received three bitcoins from Alice, and there was no prior transaction in which Bob spent these three bitcoins. In general, bitcoin transactions are ordered recursively by having the input of one transaction refer to the output of a previous transaction. *Figure 3* further explains this example.

Figure 3: Bitcoin's Approach to Transaction Flow and Validation



Source: Journal of Economic Perspectives-Vol 29(2015)-page 216

"Bitcoin cannot be deposited in a bank, and instead it must be possessed through a system of digital wallets" (Yermack, 2013). Every user of bitcoins is assigned a wallet which would contain the bitcoins owned, a public and a private key. The public key is seen as the public address of the owner. It is through this address that another party is able to send bitcoins to the owner of the wallet. The private key acts like a personal identification number to a bank account. It is what enables the wallet's owner to send his own bitcoins to someone else (Prentis, 2015). As an analogy, the public key is your postal address, and the private key is the key to your front door; others can send mail to your house with just your physical address, but no one can remove your belongings without your permission (Turpin, 2014).

1.1.5 Digital Money Services and Bitcoin Acceptance

Since its invention, Bitcoin has caused a stir in many economies globally, the main issue being whether or not to accept it as legal tender. Another issue is brought about by the nature of bitcoins. The Central Bank or Federal Reserve of any economy cannot control bitcoins in the way they do with transactions and taxation of other currencies. As a result, a certain part of the monetary system operates outside of the regulators' authority and that threatens the stability of the financial system of the country (Alina, 2016). With this in mind, there are some countries that have indirectly assented to the usage of bitcoins, however it is not legally acceptable as a substitute for the country's legal tender. Such countries include: The United States, Canada, Australia, Finland, Belgium, the United Kingdom, Bulgaria and Germany among others. On the other hand, there are those nations that have out-rightly banned this digital currency. Such include: Iceland, Vietnam, Ecuador, Bolivia, Kyrgyzstan, China, and Russia (Bajpai, 2015).

Digital currencies have also gained momentum in Africa with nations such as Ghana, Kenya, Morocco, Nigeria, South Africa and Tanzania, among others being indulged (CoinPursuit, 2014). Bitcoin in Africa has been made easier by companies such as BitPesa which exchanges bitcoins for the Kenyan/Ugandan/Tanzanian Shillings, as well as for Nigerian Naira (BitPesa, 2014). Kitiwa is a similar service that operates in Ghana. Other digital money services include Bitrefill which allows users to top up any prepaid mobile phone using bitcoin (Bitrefill, 2015). There is also a Bitcoin ATM in South Africa, which converts cash into bitcoins.

1.2. Problem Statement

Due to digital currencies being a fairly new concept, much of the research done in this field focuses on explaining what these digital currencies are, how they work, their pros and cons and their legality issues. The few empirical studies include (Alina, 2016), who carries out a regression analysis of cryptocurrency influence on the US Dollar. A similar research was done by (Loseva, 2016), who also analyzed the influence of cryptocurrency on the Russian economy. These studies have been very informative to policy makers in their respective countries. Closer home, a research (not yet published) titled "Adoption of Bitcoin in Kenya, A Case Study of BitPesa" was done by (Njuguna, 2014). This study focused on Bitcoin as a system of transferring funds in relation to other money transfer services.

There has been no research seeking to study the relationship that exists between the circulation of bitcoins and the effect on currencies of different countries in Africa. It is important to evaluate this relationship because bitcoins are currencies which are viewed to be more attractive than traditional fiat currencies. What is uncertain is whether or not the Bitcoin system will eventually replace fiat currency. This research seeks to evaluate empirically the relationship that exists between bitcoins and the currencies of some selected African economies.

1.3. Research Objectives

This research seeks to achieve the following objective:

i. To evaluate the relationship between the circulation of bitcoins and selected domestic currencies in Africa (Kenya, Morocco, Nigeria and South Africa)

1.4. Research Questions

The following research question will be answered in line with meeting the objective of this study:

i. What is the relationship between the circulation of bitcoins and domestic currencies in Africa (Kenya, Morocco, Nigeria and South Africa)?

1.5. Scope of the Study

The scope of this study will be on Kenya, Morocco, Nigeria and South Africa. This is because these are the leading countries in Africa in terms of adoption and trading of bitcoins (CoinDance, 2017). The choice of these four economies was also due to the ease of availability of data on volumes of bitcoin traded since 2013, when they gained traction in Africa, to date.

1.6. Significance of the Study

The use of digital currencies and most commonly bitcoins is a new concept not only in Africa but also globally. This suggests that it is crucial to understand how the development of bitcoins would affect any given economy. This research seeks to provide information to policy makers and the government on the possible effects to the financial sector brought about by usage of bitcoins. The government will therefore be able to effectively respond to their spread and establish ways of using them for the purposes of improving the entire economy.

Secondly, this research seeks to lay a foundation for more extensive research in this field which may also be used as a reference by other researchers to build on it.

2 LITERATURE REVIEW

2.1 Introduction

In the most simple terms, an exchange rate shows how much units of a foreign currency can be purchased with one unit of domestic currency. Exchange rates play a significant role in determining the volumes of international trade for any country. The main objective therefore for every country is to maintain stable exchange rates and to protect itself, if possible, from the risk of exchange rate fluctuations. These exchange rates, if highly fluctuating, can influence the decisions of policy makers,and affect the allocation of goods, reserve money, exports, imports and balance of payments (Abar, 2015).

This section seeks to establish the conventional factors that influence exchange rates and include a possible consideration of any other factor(s) that could affect exchage rates but has(have) not been taken into account by previous literature in this field.

In reviewing other literature, inclusivity was given to research papers that narrowed their scope of study to different countries(regions). This was to show that there is an overall acceptance and agreement by researchers on the possible list of factors that affect exchange rates. This approach is used to also show how different factors have a more significant impact than others in different regions.

2.2 Theoretical Literature

In this section, theories of exchange rate determination have been reviewed. The focus is more on the general theories surrounding exchange rates and much less about the proponents of these theories.

2.2.1 Traditional Flow Model

Early literature in the field of exchange rates emphasized that the primary determinants of exchange rates was international trade flows (Pearce, 1983). This was due, in part, to the fact that most governments maintained tight controls on international financial capital flows. Exchange rates had a role in eliminating international trade imbalances. This role was played out where countries with trade surpluses were expected to have appreciating currencies whereas those with deficits should have depreciating currencies. Such exchange rate changes would then lead to changes in international relative prices that would work to eliminate the trade imbalance. In recent years, however, the traditional flow model seems not to hold much water. For instance, financial liberalization has led to the volumes of international trade in financial assets exceeding trade in goods and services. In other instances, there have been countries whose currencies are appreciating even though they have trade deficits.

2.2.2 Purchasing Power Parity (PPP) Theory

The purchasing power parity hypothesis states that there exists a proportional relationship between the exchange rates and the foreign to domestic price ratio (Stockman, 1980). The PPP theory holds if the law of one price is true. There are two forms of the PPP theory. The first is the Absolute form of PPP which states that, "the equilibrium exchange rate between currencies of two countries is equal to the ratio of the price levels in the two nations". In other words, the prices of the same products in two different countries should be equal when measured using a common currency. If, there exists any difference then the demand should shift from one country to another in such a way that the prices will have to converge. Realistically, this theory may not actually hold due to market imperfections brought about by factors such as different levels of technology, costs of production and taxation.

The second form is the Relative form of PPP theory, which states that changes in the exchange rate over a certain period of time should be proportional to the relative changes in the price levels in the two nations over the same time period. This form of the PPP theory accounts for market imperfections as it allows the prices of similar commodities in two different countries to not necessarily be the same, even when measured in a common currency. When both countries experience some inflation, then the exchange rate will automatically adjust itself in such a manner that the difference in the rate of inflation will be offset.

The PPP theories therefore bring out the relationship between inflation and the exchange rates of given countries.

2.2.3 Asset Approach Theory

The asset approach theory is a form of modern exchange rate theory which put emphasis on financial-asset markets. This theory serves as an improvement to the hypothesis held by the traditional flow model of exchange rates. Exchange rates under this model, are viewed as adjusting to equilibrate international trade in financial assets. Exchange rates will therefore change frequently in response to changes in the demand for and supply of financial assets of different nations. This is so because prices in financial markets adjust way faster than in goods market. This theory assumes perfect capital mobility, which simply means that there are no barriers to international capital flows.

The asset approach theory is further broken down to the **monetary approach theory** (Frenkel, 1976) and the **portfolio-balance approach theory** (Kouri, 1978). The monetary approach theory holds that the relative demand and supply of money between two countries is the key determinant of the exchange rate between these countries. An increase in domestic money supply would drive prices up and hence reducing the exchange rate. An increase in domestic real income causes excess money demand, with a fixed nominal money supply, results in a reduction in domestic prices and hence pulls the exchange rate up. An increase in the domestic interest rate, which is assumed to reflect higher expected inflation, lowers the demand for money, increases prices and lowers the exchange rate (Pearce, 1983). Changes in foreign variables would also have the same effects. In summary therefore, an increase in foreign money supply leads to a corresponding increase the domestic exchange rate. Reducing real foreign income and increasing foreign interest rate would also have the same effects on the domestic exchange rate.

The portfolio-based approach on the other hand holds that the demand and supply of relative bonds as well as relative money-market conditions are determinants of the exchange rate. Under this model, households in every country are assumed to distribute their net financial wealth among three assets: domestic government bonds, domestic monetary base and net foreign bonds denominated in foreign currency. The domestic and foreign bonds are assumed to be imperfect substitutes; thus, the desired proportions of these assets depend on their respective yields. An increase in the domestic (foreign) interest rate causes investors to increase the desired proportion of their wealth in domestic (foreign) bonds and to lower the desired proportions in the monetary base and foreign (domestic) bonds. As the supply of domestic bonds rises relative to foreign bonds, there will be an increased risk premium on the domestic bonds that will cause the domestic currency to depreciate. An increase in net holdings of foreign bonds resulting from a current account surplus would increase domestic wealth and disturb portfolio equilibrium. In this case, domestic wealth holders would want to hold some of the wealth increment in the form of domestic assets. This would lead to a fall in the domestic interest rate and an appreciation of the exchange rate (Pearce, 1983).

2.3 Empirical Literature

2.3.1 Factors affecting Exchange Rates

In doing an extensive analysis of research done in different regions or countries with respect to the factors affecting exchange rate, the regions will be divided into two. The first section will consist an analysis of the various factors that affect exchange rates in other regions that are not part of the African continent. This includes Asia, Europe and America. The section that will follow will consist of the same analysis done in the context of the African region.

2.3.2 The case of Non-African regions

Research by (Patel, JPatel, and R.Patel, 2014) in the paper titled " Factors Affecting Currency Exchange Rate, Economical Formulas and Prediction Models" clearly listed out the various factors affecting currency movements and their characteristics. At the top of this list was inflation. This paper explains that a lower rate of inflation tends to result in currency appreciation. Taking an example, suppose that the price levels in country X reduce by 30%, while the price levels of its foreign trading partners remain relatively stable. The goods in country X will seem cheaper thus increasing the volumes of exports. This will appreciate the currency of country X.

Another key factor that is seen to affect exchange rates is interest rates. If the interst rates in country X are rising relative to other countries' rates, more investors will want ot invest in country X due to the higher returns they will receive on their investments. This causes an increase in demand of Country X's currency and therefore an appreciation in its value.

Capital account balance is another factor. Countries having a surplus can attract more capital from other countries and can see an appreciation in the currecny value relative to other countries with a deficit. Other factors that affect the exchange rates include public debt, role of speculators, gross domestic product(GDP), unemployment rate, relative strength of other countries, macroeconomic and geopolitical events.

In further studying these factors, (Patel et al., 2014) applied some economical formulas in testing the parity conditions among currencies as well as to check currency valuation and its effects. Some of the models used were the Purchasing Power Parity (PPP) and the Interest Rate Parity (IRP) models, which are based on the law of one price. There was also the Balance of Payments Theory model which is based on balance of payments.

Even though the scope of study under this paper was India, (Patel et al., 2014) concludes by advising individual countries to monitor closely the above litsed factors to ensure they have a favourable exchange rate, as these factors are not only specific to India but also to every other country as well. In this research, (Patel et al., 2014) clearly brings out the factors affecting exchange rates but fails to relate these factors to the Indian Economy even though it is mentioned that the study was done in India. The empirical analysis in this research, fails to actually run the models listed in the paper. Real data is not used to prove whether the selected models are actually sufficient in checking for currency valuation and its effects, and it is therefore not possible to see the extent to which the factors listed affect the Indian rupee.

Further research by (Abdoh, Yusuf, Zulkifli, Bulot, and Ibrahim, 2016)also studies the macroeconomic factors that influence exchange rate fluctuations. This study was carried out in the ASEAN countries also agrees that exchange rates are very important. This is because they facilitate international trade and commerce, the transfer of funds between countries as well as allowing for the comparison of prices of the same goods across countries. This research focused on inflation and interest rates as the factors having effect on exchange rate fluctuations. Another factor that was added in this research was the volume of exports. The research by (Abdoh et al., 2016) used actual data to test the effects of these three variables on the exchange rates. The data was collected for 10 years which started from 2005 until 2014 for Darussalam, Malaysia, Philippines, singapore, Thailand, Indonesia, Cambodia, Laos and Vietnam.

To analyze the factors that affect the exchange rate movement, (Abdoh et al., 2016) used a multiple regression analysis. The dependent variable in this case was exchange rate and the independent variables: volumes of export, interest rates and inflation rates. The results of this research were that volumes of exports show a modest relation to the exchange rate at a statistical significance of 5%. There is therefore a positive significant relationship between exports and exchange rates. For inflation and interest rates there was found to be a statistically insignificant dependence, and as such there is indeed no significant relationship between inflation and interest rates, and the exchange rates. These two variables were also found to have an inverse relationship with exchange rates.

To conclude, (Abdoh et al., 2016) established that only one variable, which is volume of exports has shown significant relationship with the exchange rate. This means that for the ASEAN countries, the volume of exports is an important variable in influencing the exchange rate movements.

Even though the research by (Abdoh et al., 2016) is consistent with (Patel et al., 2014) on the factors that affect exchange rates, only 3 factors are brought out to affect exchange rate. This research is limiting as there are numerous factors that would have effect on the exchange rates. This is further backed by the R^2 value from the regression of only 4.24%, indicating that the model only explains upto 4% of the variability in exchange rates leaving out 95.26% which is explained by other macroeconomic variables that were left out in this model.

Abdullah (2010) further contributed to this field of study by researching on the existing relationship between inflation and real exchange rates. Unlike other researchers, Abdullah (2010) focused solely on inflation rather than multiple factors. This study was centred around a comparative analysis in Asia, EU and North America. The research was carried out using secondary annual data in the period of 1991-2005.

Exploratory data analysis was used to study the behavior of data with respect to graphical comovement between inflation and the exchange rates. The Granger-causality test was then employed to explore the direction of the causal relationship between the two variables. In the final step, a panel data model was used to show whether there are differences in the relationship between the two variables in Asia, the EU and North America.

From the exploratory data, it was clearly seen that there existed a correlation between the inflation and real exchange rate movements, even though the the two variables are seen to be more volatile after the Asian financial crisis of 1997.

From the Granger Causality Test, it was seen that there existed a bi-causal relationship between inflation and changes in the nominal exchange rates. This means that the depreciation of the nominal exchange rate would have effect on inflation and the inflation will cause the nominal exchange rate to depreciate. Similar results were also recorded for the relationships between real exchange rates and inflation. When the regions were separated however, into Asia and non-Asia, the results obtained were different. In the Asia region, the relationship between exchange rates and inflation was unidirecctional. The depreciation in the exchange rate had a significant impact on inflation but the converse was not true. In the non-asia regions however, inflation was recorded to have a significant omapct on the exchange rates, and the converse did not hold. These results indicate that Asian countries have a higher vulnerability to exchange rates shocks in comparison to European and North American countries.

Panel data analysis performed in this study, showed that inflation is significantly influenced by the lag of real exchange rates and domestic inflation, nominal exchange rates and foreign inflation. Coefficients of the model suggest that foreign and domestic inflation have a stronger impact in comparison to real and nominal exchange rates. A one percentage increase in foreign inflation, for example, would lead to a corresponding 0.46% increase in domestic inflation. A one percentage depreciation in the exchange rates, on the other hand, would lead to a corresponding decrease of about 0.05% in inflation rates.

Furthermore, the results from the study also showed that the behaviors of inflation in the Asia Region differed with those of the European Union and North America.

Abdullah (2010) concludes that there exists a strong relationship between inflation and real exchange rates in Asian countries, but no such relationship is seen in the non-Asia region (EU and North America). Another conclusion is that the Asian financial crisis was seen to have more local impact in Asian countries, than globally in the EU and North America.

This research by Abdullah (2010) brings out very important aspects. It clearly explains that the extent to which different factors affect the exchange rate may vary depending on the economy or region of study. This research also factors in a larger scope of study therefore making it easier to do a comparison on how different countries are afected by the same factors.

2.3.3 The Case of the African region

In the context of African continent, studies concerning the relationship between inflation, among other factors, and exchange rates have also been done to end up with consistent results as previous works in this field of study.

Ndung'u (1999), in his research, 'A Dynamic Model of Inflation for Kenya'showed that the level of domestic inflation and exchange rate changes affect each other. This was shown using the Granger Causality Test based on Kenyan data during the period of 1970-1993. The conclusion from this research was that the levels of inflation and changes in exchange rate affect each other and changes in exchange rates and reserve changes affect each other. Ndung'u (1999)'s research does not exclusively focus on exchange rates but it does contribute to this study, and gives conclusions that other researchers mentioned in this analysis have proven to be true.

Further, research by (Mavee, Perrelli, and Schimmelpfennig, 2016) on the drivers of volatility in the South African rand/USD exchange rate(rand volatility) shows other possible factors that affect exchange rates. To analyse rand volatility, daily data from August 2009 to August 2015 is used. Implied measures of volatility were used to measure rand volatility, such that implied rand volatility is a funtion of macroeconomic surprises, commodity price volatility, volatility index and domestic political uncertainty. This reseach finds out that all the variables in the model had a significant impact on rand volatility and thus adding new factors to the list of factors that affect exchange rates.

A similar research was done by (Proti, 2013) in Tanzania to explore the exchange rate fluctuations in the country. Analysis is done using panel data from 1999 to 2009, and the statistical regression analysis model, Ordinary Least Squares model was used. Variables regressed against the exchange rate were inflation, real interest rates, national debt, real GDP growth, political stability, exports and imports. The variables used were found to have a significant impact on the exchangre rate. Proti (2013) also mentions that in the case of Tanzania, there is poor control by the proper authorities on the value of the currency leaving it depreciating consecutively without appreciating against other foreign currencies.

Lyons (2001) has a different view on the factors that actually affect exchange rates. According to this author, macroeconomic variables as the ones previously discussed do not adequately account for exchange rate behavior over short time horizons. Lyons (2001) further states that short-run exchange rate movements are attributed to market microstructure factors, including inventory management and information aggregation by foreign exchange delears.

2.3.4 Bitcoin: A New Perspective?

As cryptocurrencies have gained momentum and popularity, there have been some considerations that these digital currencies might add to the list of factors that affect exchange rates. As this is a fairly new concept, most of the research done under this subject is mainly aimed at explaining the concept of cryptocurrencies and how they work.

However, research done by (Alina, 2016) is one of its kind in taking an empirical approach in analyzing cryptocurrencies. In the research, (Alina, 2016)'s objective is to estimate the impact of the circulation of bitcons (the most commonly used cryptocurrency)on the US dollar. The goal of this research was achieved by running a regression analysis of the exchange rate(EUR_USD) against the amount of bitcoins, the market price of bitcoins, inflation rates, interest rates, unemployment rates and public debt. This regression was run using variables for the period from 2009 to 2016. The R^2 value obtained from running this regression was 0.783, which means that 78.3% of the values of the dependent variable are explained by the model used.

Alina (2016) established that the more bitcoins there are in circulation, the lesser the content of the dollar in one euro. More specifically, as the number of bitcoins in circulation increases by 1 million, the EUR/USD rate rises by 6.1%, that is, the amount of dollars to buy 1 Euro increases. This suggests that the distribution of bitcoins weakens the US dollar. The other variables in the model were also found to have a highly significant impact on the exchange rate with a probability of 99%.

This research by (Alina, 2016), brings fresh thoughts to this field of study on the factors that affect exchange rates. It extends the already conventional knowledge to incorporate the new concept of cryptocurrecnies. Similar research has not been done to back up her conclusion, but even so she has set the stage for further research to be done with respect to whether bitcoins would actually add to the list of factors that affect exchange rates in any given country.

2.4 Conceptual Framework

Figure 4: Relationship Between Exchange Rate and factors that affect it

The variable at the center, Exchange rate, serves as the dependent variable for this research. The independent variables include volume of bitcoins(Btc_Amt), the price of Bitcoin(Btc_price), Inflation and Interest rates. The independent variables include a set of variables that may cause volatility in the exchange rates of a given country. Interest and Inflation rates are measured as percentages where as Btc_Amt and Btc_price is measured using the common currency, USD.

2.5 Research Gap

Most scholars, in studying the factors affecting exchange rates consider only the conventional macroeconomic variables as evidenced in section 2.3. Minimal research has been done to test whether Bitcoin along with the other macroeconomic variables has an effect on exchange rates. Such research has only been done in the United States yet Bitcoin usage has gained traction in many other countries including countries in Africa.

This study aims to fill this gap by studying what impact Bitcoin will have on some African currencies. The effect of Bitcoin on exchange rates will be tested to see whether or not it can suffice to be added to the conventional list of factors. This study will further test for the presence of a long-run relationship between Bitcoin and the exchange rate.

3 METHODOLOGY

This chapter highlights the research design, population and sample of the study, variables to be used in order to meet the objective of this study, and the analysis method(s) used.

3.1 Research Design

The research design followed by this study was an exploratory design. An exploratory approach was taken because the subject on Bitcoin and cryptocurrencies in general is fairly new and there are few studies that have been done to address this subject. This exploratory approach focused on bringing more insights and familiarity on the concept of Bitcoin. Quantitative analysis was also used to formulate facts and uncover the patterns around data associated with Bitcoin.

3.2 Population and Sample

The population considered for this study is Africa, more specifically, countries that trade in Bitcoin in Africa. These include South Africa, Zimbabwe, Tanzania, Kenya, Nigeria, Ghana and Morocco. Of the seven countries, the study focused on South Africa, Kenya, Nigeria and Morocco, which formed the sample study. The choice of these four countries was because data on the variables of study was easily and readily available. The sample size considered included panel data of monthly observations of five different variables in the four countries under study for the period of January 2014 to June 2017.

3.3 Data Collection

The study used secondary data. Macroeconomic data on interest and inflation rates, volumes of bitcoins traded as well as exchange rates of the US dollar to the Kenyan shilling, Moroccan dirham, Nigerian naira and the South African rand was used. The data for the macroeconomic variables was collected from the individual country's Central Bank websites, while data concerning bitcoins was collected from CoinDance.com, which is one of the main websites that provide data on Bitcoin. Only monthly variables were used in this study.

3.4 Data Analysis

A quantitative analysis approach was used to make computations on the data. Various statistical models were considered to fully analyze data and bring out meaningful characteristics about this data. The models used are further discussed below in more detail.

3.4.1 Panel Data Regression Analysis

Data collected for this research had both time series and cross-sectional elements, and as such considered as panel data. The objective of this study was to estimate the impact of the circulation of bitcoins on selected domestic currencies. Panel data regression analysis was used to achieve this objective. The hypothesis being tested was as follows:

H0: Bitcoin circulation in the economy has no significant effect on the domestic currency

H1: Bitcoin circulation in the economy has a significant effect on the domestic currency

The dependent and independent variables are identified in the table below.

Table 1 Description of the Dependent and Independent Variables for Regression Analysis

Dependent Variable	Description	Data Source
USD_X	The USD_X exchange rate (the content of X in one USD), where X represents the domestic currency (KES, ZAR, NGN, MAD)	Central Bank of Kenya, Federal Reserve Bank of South Africa, Central Bank of Nigeria, Bank Al-Maghrib,

To evaluate the phenomenon of 'weakening of domestic currency', the individual countries' exchange rates were measured against the US dollar, to monitor their fluctuations.

Independent Variables	Description	Data Sources
btc_amount	The total amount of bitcoins in circulation per given country	Coin Dance Website
btc_price	Average market price of bitcoins	Coin Dance Website

Inflation rate	Prevailing inflation rates	Central Bank of Kenya, Federal Reserve Bank of South Africa, Central Bank of Nigeria, Bank Al-Maghrib,
Interest Rate	Central bank rates	Central Bank of Kenya, Federal Reserve Bank of South Africa, Central Bank of Nigeria, Bank Al-Maghrib,

Given the above variables, the regression equation will therefore be:

$$\mathbf{log\ USD\_X_{it}} = \boldsymbol{\alpha_i + \beta_1 log\ btc\_amt_{it} + \beta_2 log\ btc\_price_{it} + \beta_3 inflation_{it} + \beta_4 interest\ rate_{it} + \varepsilon_{it}}$$

Where,

$\boldsymbol{log\ USD\_X_{it}}$ is the dependent variable, where *i=country* and *t=time*

$\boldsymbol{\alpha_i\ (i = 4)}$ is the unknown intercept for each country

$\boldsymbol{\beta_i\ (i = 4)}$ is the coefficient for that independent variable

$\boldsymbol{\varepsilon_{it}}$ is the error term

In assessing the impact, the coefficients of the variables were studied after the regression was run. Logarithm transformations were made on some of the variables to help in rescaling the data so that the variances in the series are stabilized. Log transformations are also directly interpretable as approximate proportional differences. In running the regression, there were two models that were used; the fixed effects model which assumes correlation between the explanatory variables and the error term, and the random effects model which assumes the absence of a correlation between the error term and the explanatory variables. The decision on which of the models to use was made using the Hausman Test, which allows the decision to be made using the following hypothesis:

Ho: random effects are uncorrelated with the explanatory variable

Ha: random effects are correlated with the explanatory variable.

The null hypothesis basically holds that the random effects model is most suitable whereas the alternative hypothesis holds that the fixed effects model is more appropriate.

3.4.2 Modelling Long-term Relationships

In modelling long term relationships, a series of tests was run so as to capture the different characteristics of this data. The first step in analyzing this data was to test for stationarity. For any tests to be carried on this data, the data first ought to be stationary. A series is said to be stationary if it exhibits time-invariant mean and variance properties for each lag. An examination of whether a series can be viewed as stationary or not is essential because the stationarity or otherwise of a series can strongly influence its behavior and properties. Any analysis done on non-stationary series gives spurious or non-sense results. When the first difference of a nonstationary process is stationary, the process is said to be integrated of order one, $I(1)$. When a linear combination of several $I(1)$ series is stationary, the series are said to be cointegrated (Engle and Granger, 1987). Cointegration tests imply the existence of a long-run relationship in $I(1)$ series. Long-run simply means that the series moves together over time.

3.4.2.1 Panel Unit Root Tests

The panel unit root test is the first step in the panel based cointegration technique. These tests are essential in testing for presence or lack thereof of stationarity. The stationarity tests that will be used are the Levin-Lin-Chu unit root test (Levin, Lin, and Chu, 2002). The null and alternative hypotheses are as follows:

Ho: Panels contain unit roots

Ha: Panels are stationary

To confirm the results, the IM, Pesaran & Shin W-Stat, ADF_Fisher Chi-square and PP_Fisher chi-square panel stationary tests were run.

3.4.2.2 Cointegration Analysis

After the precondition of unit root test is met, cointegration tests are then carried out. The test of focus will be the (Kao, 1999) test of cointegration. Other tests such as (Perdoni, 1999) and (Westerlund, 2005) tests of cointegration, will be used as confirmatory tests to the (Kao, 1999). The null and alternative hypotheses are as follows:

Ho: Panels are not cointegrated

Ha: All panels are cointegrated

The panel regression model presented by (Kao, 1999) is

$$Y_{it} = X'_{it}\beta_i + Z'_{it}\gamma_i + \varepsilon_{it}$$

Where Y_{it} and X_{it} are $I(1)$ and nonintegrated. X_{it} represents the covariates which are required in this test not to be cointegrated among themselves. β_i denotes the cointegrating vector, γ_i is a vector of coefficients on Z'_{it}, which is the deterministic term that controls for panel-specific effects and linear time trends, and ε_{it} is the error term.

Having established a cointegrating relationship, the next step is to estimate the long run equilibrium relationship given by the Error Correction Term (ECT). The ECT is a measure of the extent by which the observed values in time *t-1* deviate from the long-run equilibrium relationship. Since the variables are cointegrated, any such deviation at time *t-1* should induce changes in the values of the variables in the next time point in an attempt to force the variables back to the long-run equilibrium relationship. The model used in this test will be the error correction-based pooled mean group estimator (PMG) developed by (Pesaran, Shin, and Smith, 1997) represented as follows:

$$\Delta Y_{i,t} = \emptyset\left(Y_{i,t-1} + \gamma X_{i,t}\right) + \sum_{j=1}^{p} \alpha_j^y \, \Delta Y_{i,t-j} + \sum_{s=0}^{q} \beta_j^y \Delta X_{i,t-s} + \varepsilon_{i,t}$$

Where $\emptyset$ is the error correction speed of adjustment parameter to be estimated, γ is a $(kx1)$ vector of parameters, $\left(Y_{i,t-1} + \gamma X_{i,t}\right)$, is the error correction term, α are p parameters to be estimated and β are q parameters to be estimated, p and q represent the number of lags for the variables and $\varepsilon_{i,t}$ is the error term.

3.4.2.3 Vector Autoregressive Model (VAR)

The VAR model is the second step for building a Granger causality model with a dynamic error correction term. The VAR model will be used when the panel data is found not to be cointegrated. VAR is used to capture the linear interdependencies among multiple time series. Panel VARs are particularly suited to analyzing the transmission of idiosyncratic shocks across units and time. In VAR models, all variables are treated as endogenous and independent. Each of these variables is explained by its own lagged values, the lagged values of other model variables and an error term (Ciccarelli, 2013). The appropriate number of lags is therefore determined by using the Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC). The representation of VAR for a panel data is

$$\boldsymbol{Y}_{it} = \boldsymbol{A}_1\boldsymbol{Y}_{it-1} + \boldsymbol{A}_2\boldsymbol{Y}_{it-2} + \cdots + \boldsymbol{A}_p\boldsymbol{Y}_{it-p} + \boldsymbol{B}\boldsymbol{X}_{it} + \mathcal{E}_{it}$$

Where $\boldsymbol{Y}_{it}$ is a 1xk vector of dependent variables, $\boldsymbol{X}_{it}$ is a 1xl vector of exogenous covariates and $\mathcal{E}_{it}$ is a vector of innovations. The kxk matrices $\boldsymbol{A}_1, \boldsymbol{A}_2, \dots, \boldsymbol{A}_p$ and the lxk matrix $\boldsymbol{B}$ are matrices of coefficients to be estimated.

The vector of endogenous variables to be used in this study is defined as:

$$X_t = \lfloor btc_{amount}, btc_{price}, inflation, intrest\ rate \rfloor$$

3.4.2.4 Variance Decomposition Analysis

Variance decompositions give the proportion of the movements in the dependent variables that are due to their 'own' shocks, versus shocks to other variables (Brooks, 2008). From the variance decompositions, it is usually observed that own series shocks explain most of the error variance of the series in a VAR. The variance decomposition was used to aid in the interpretation of the results from running the VAR model.

4 DATA ANALYSIS AND FINDINGS

This chapter presents the results of the methodology described above as well as an analysis and discussion of the generated results and findings.

4.1 Descriptive Statistics

Descriptive statistics are used to describe the basic features of the data used in this study. These statistics, together with graphic plots[5], provide simple summaries about the sample and form the basis of the quantitative analysis that will be carried out on the data. The various descriptive statistics used to generally describe the sample data are presented in the table below.

Table 2: Summary of Descriptive Statistics

	X_USD	BTC_AMT	BT_PRICE	INFL_RATE	INT_RATE
MEAN	89.8167	56250499	139203.6	6.5256	7.8750
MEDIAN	51.3017	483442.3	32042.42	6.4050	7.7500
MAX	362.4491	1.24E+09	3410433	18.7200	14.0000
MIN	8.1077	248.0000	2083.888	-0.3000	2.2500
STD. DEV	99.7894	2.13E+08	406738.9	4.6186	3.9858
SKEWNESS	1.1894	4.2365	5.4683	0.8730	-0.0222
KURTOSIS	3.4595	20.5185	36.4847	3.5522	1.7058

The above table gives a summary of the measures used to describe the sample data. It is seen that on average, one-dollar exchanges for 89.8167 of the domestic currencies. The mean amount of bitcoins across the sample is 56250499, which sell at an average price of 139203.6. It is also seen that the inflation and interest rates average to 6.5256 and 7.8750 respectively across the selected countries. Skewness is a measure of symmetry and more precisely, it measures the lack of symmetry. All the variables except the interest rate exhibit positive values for the skewness statistic. This means that the data is skewed to the right and therefore lacks symmetry. Interest rates are seen to be negatively skewed as they

[5] The line plots of the different variables are displayed in the appendix section

report a negative value of skewness. The summary results from the Kurtosis statistic show that the exchange, interest and inflation rates have light tails whereas the amount and price of bitcoins variables exhibit fat tails. This means that the data fails to follow a normal distribution.

4.2 Stationarity Tests: Unit Root Testing

Stationarity tests were run individually on each variable. The software used for this analysis(EViews) was able to run stationary tests using four different tests: the (Levin, Lin, & Chu, 2002), (Pesaran, Shin, & Smith, 1997), ADF-Fisher Chi-Square and PP-Fisher Chi-Square. The results were as follows:

Table 3: Summary of Panel Stationarity Tests

LEVIN LIN CHU TEST	**AT LEVEL**	**1ST DIFFERENCES**
Inflation rate	Non-stationary	Stationary
Interest rate	Non-stationary	Stationary
Log_btcamt	Non-stationary	Stationary
Log_btcprice	Non-stationary	Stationary
USD_X	Non-stationary	Stationary

IM, PESARAN & SHIN W-STAT	**AT LEVEL**	**1ST DIFFERENCES**
Inflation rate	Non-stationary	Stationary
Interest rate	Non-stationary	Stationary
Log_btcamt	Non-stationary	Stationary
Log_btcprice	Non-stationary	Stationary
USD_X	Non-stationary	Stationary

ADF_FISHER CHI-SQUARE	**AT LEVEL**	**1ST DIFFERENCES**
Inflation rate	Non-stationary	Stationary
Interest rate	Non-stationary	Stationary
Log_btcamt	Non-stationary	Stationary

Log_btcprice	Non-stationary	Stationary
USD_X	Non-stationary	Stationary

PP_FISHER CHI-SQUARE	**AT LEVEL**	**1ST DIFFERENCES**
Inflation rate	Non-stationary	Stationary
Interest rate	Non-stationary	Stationary
Log_btcamt	Non-stationary	Stationary
Log_btcprice	Non-stationary	Stationary
USD_X	Non-stationary	Stationary

The results of the stationarity tests were consistent across the four tests. All the data was found to be non-stationary at level but stationarity was present in the data upon taking first differences. This means that any further statistical analyses performed on the data should be performed when first differences of the data have been taken. This will enable the results make statistical sense and, portray the true behavior and properties of the data[6].

4.3 Correlation Test

A correlation test was performed to check for multi-collinearity. Multi-collinearity arises if there exists a high correlation between any two independent variables. Checking and correcting for multi-collinearity is important because it may interfere in determining the precise effect of each independent variable. The results of the correlation test are outlined in table 4 below.

[6] http://www.eviews.com/help/helpintro.html#page/content%2Fpanel-Panel_Estimation_Examples.html%23

Table 4: Correlation among Independent Variables

	BTC_AMT	BTC_PRICE	INFL_RATE	INT_RATE	USD_X_LN
BTC_AMT_LN	1.0000	0.6303	0.4811	0.4991	0.3738
BTC_PRICE_LN	0.6303	1.0000	0.1035	0.0705	-0.0871
INFL_RATE	0.4811	0.1035	1.0000	0.8729	0.6278
INT_RATE	0.4991	0.0705	0.8729	1.0000	0.7456
USD_X_LN	0.3738	-0.0871	0.6277	0.7456	1.0000

There was seen to be a high correlation of 87% between inflation and interest rates. This is so because any change on the rates of interest will also have an effect on the inflation rate, even though indirectly. There was also relatively high correlation of 74% between interest rates and the exchange rates. This is in line with theory which holds that an increase in interest rates would lead to an increase in exchange rates as well. The interest rate variable is therefore an important variable in determining the outcomes of both the inflation and exchange rates.

The test for multi-collinearity usually requires that one of the variables between those with high correlations be dropped. In this case however, because interest rates are correlated to both an independent variable (inflation rate) and the dependent variable (exchange rate), then we fail to drop this variable so as to avoid committing the Omitted Variable Bias(OVB). The OVB happens when a variable that is correlated to both the independent and dependent variables is excluded from the model of estimation (Buck, 2014). Exclusion of interest rates from the model of estimation will lead to estimation of biased coefficient. Therefore, to avoid the OVB, the interest rates will be included in the model estimation.

4.4 Regression Analysis

The purpose of this regression was to check the relationship between the exchange rate(USD_X), which forms the dependent variable, and the other independent variables, that is, inflation rate, interest rate, bitcoin amount and bitcoin prices. In selecting a suitable regression model, both the fixed effects and random effects models were run, and the

Hausman test performed thereafter to determine the most appropriate model of the two. The results of the Hausman test are tabled below.

Table 5: Hausman Test Results

Test Summary	Chi-sq. Statistic	Chi-sq. d.f	P-value
Cross-section random	2.995877	4	0.5585

The value of interest is the *p-value* which is compared to the 5% significant level to determine whether or not the null hypothesis under this test will be rejected. The *p-value* of 0.5585 is greater than 0.05, and the decision rule is therefore to fail to reject the null hypothesis. This means that the random effects model of regression is appropriate. The summary of the results from the random effects regression analysis are tabled below.

Table 6: Summary of Regression Analysis Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.830790	0.590927	4.790422	0.0000
BTC_AMT_LN	0.011128	0.003363	3.308860	0.0011
BTC_PRICE_LN	0.007233	0.008853	0.817022	0.4150
INFLATION_RATE	0.045344	0.003130	14.48741	0.0000
INTEREST_RATE	0.045084	0.008720	5.170001	0.0000

When replaced back in the regression equation being tested, the output is as follows:

$$\textbf{log USD\_X}_{it} = \mathbf{2.830790} + \mathbf{0.011128}\boldsymbol{log\ btc\_amt_{it}} + \mathbf{0.007233}\boldsymbol{log\ btc_{price}}_{it} + \mathbf{0.045344}\boldsymbol{inflation_{it}} + \mathbf{0.045084}\boldsymbol{interest\ rate_{it}} + \boldsymbol{\varepsilon_{it}}$$

The main objective of running this regression was to observe the relationship, magnitude and significance of the effect of the independent variables on the dependent variable. It can be seen that the all the independent variables have a direct relationship with the dependent variable. This means that an increase in either of the independent variable results in a corresponding increase in the dependent variable.

The coefficient of determination (R^2) of the model is quite high, and is equal to 0.7222, which means that 72.22% of the variations of the dependent variable are explained by the independent variables. This means that the model is a good fit.

Further, the F-statistic which tests for the joint significance of all the coefficients has a *p-value* of less than 0.05 which implies that all the variables used, jointly contribute to describing the behavior of the dependent variable.

4.4.1 Regression Coefficients

From the above results, the coefficient column depicts the estimated coefficient values of the variables listed in the variables column. These coefficients measure the marginal contribution of each of the independent variable to the dependent variable, holding all the other variables constant. The first component 'C' in the list of variables, which corresponds to the first value under the coefficients column, represents the intercept in this regression.

Taking *btc_amt_ln* variable, the interpretation of the results would be as follows: holding all other variables constant, a one percent increase in the number of bitcoins (*btc_amt_ln*) leads to a corresponding increase of 0.01% in the exchange rate. Similarly, the result for the *btc_price_ln* variable coefficient would be interpreted as mentioned above; that a one percent change in the price of bitcoins(*btc_price_ln),* holding all the other variables constant would lead to a 0.007% increase in the exchange rate. There is a slight difference in the interpretation of the results of the inflation and interest rate variables. This is because the variables are not in their natural logarithm form and so the coefficient interpretation for the inflation rate will be as follows: holding all other variables constant, a one percentage point increase in the inflation rate (*inflation_rate)* leads to a corresponding increase of 4.53% in the exchange rate. Additionally, holding all other variables constant, a one percentage point increase in the interest rates(*interest_rate*) leads to a corresponding 4.51% increase on the exchange rate.

4.4.2 Probability (*p-value*)

The probability is also known as *p-value.* Given a *p-value*, it is then easy to tell whether to reject or fail to reject the null hypothesis that the coefficient is zero (insignificant). The *p-value* is compared against a 5%(0.05) significance level. A *p-value* lower than 0.05 is taken as evidence to reject the null hypothesis of a zero coefficient. The *p-values* from the regression results are all less than 0.05, apart from the *p-value* of the price of bitcoins(*btc_price_ln*) variable. The null hypothesis that equates the coefficients to zero is rejected for the variables: *btc_amt_ln, inflation_rate and interest_rate,* and fails to be rejected for the *btc_price_ln*) variable. This implies that the coefficients are significant and can sufficiently describe the variations in the dependent variable. This implication does not hold for the *btc_price_ln* variable which in accordance to the results is seen to be insignificant and therefore cannot sufficiently describe the variations on the dependent variable.

4.4.2.1 Normality Test

A series of diagnostic tests are run on the regression residuals. The first test is the Jarque-Bera Test, which is a test for normality. The residuals are seen to follow a normal distribution with the *p-value* of 0.058 being greater than the significance level of 0.05. The null hypothesis that residuals are normally distributed is thus not rejected. The plot of the errors is on appendix D.

4.5 Panel Cointegration

Cointegration tests were performed after the data was found to have met the cointegration condition. This precondition requires that the data be non-stationary at level, but stationary upon taking first differences. There were four cointegration tests that were performed on the data. These tests were run to check for the existence of a long run relationship mainly between the number of bitcoins in an economy and the exchange rates. The variables of interest therefore are the *btc_amt_ln* and the exchange rate. There was consistency of results in all the four tests for Cointegration. The table below summarizes the results.

Table 7: Summary of Panel Cointegration Tests

Test	Result
Perdoni Residual Cointegration tests (No Deterministic Trend Assumption)	Do not reject Null Hypothesis; No cointegration

Perdoni Residual Cointegration tests (Deterministic Intercept and Trend Assumption)	Do not reject Null Hypothesis; No cointegration
Perdoni Residual Cointegration tests (No Deterministic Intercept or Trend Assumption)	Do not reject Null Hypothesis; No cointegration
Kao Residual Cointegration Test	Do not reject Null Hypothesis; No cointegration

From the above summary of results, it is clear that there is no cointegration between the exchange rate and the number of bitcoins in a given economy. This is the consistent conclusion across all the models with all the results returning *p-values* of greater than 5% which causes an acceptance of the null hypothesis on no cointegration.

4.6 Vector Autoregressive Model (VAR)

A VAR model is performed once panel data is confirmed to have no cointegration. From the results outlined in table 7 above, it has been confirmed that there is no existence of long run relationships. The unrestricted VAR model is used in this study. The lag order of the model was determined using the Schwarz and Akaike Information criteria. The test suggested that two lags were suitable.[7]

The results from VAR do not display the *p-values* and therefore it is difficult to establish the significance of the coefficient estimates. However, further regressions are run on the individual VAR equations to get *p-values* of all the coefficients. The corresponding *p-values* are outlined in the table below.

Table 8: P-values of the VAR model coefficients

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.179666	0.073863	15.97100	0.0000
C(2)	-0.183989	0.073909	-2.489403	0.0130
C(3)	-0.004891	0.002880	-1.698409	0.0898

[7] The summary table of the VAR results is outlined in the Appendix section.

C(4)	0.004845	0.002888	1.677553	0.0938
C(5)	-0.004142	0.014158	-0.292547	0.7699
C(6)	0.002402	0.014253	0.168540	0.8662
C(7)	0.010437	0.004540	2.298732	0.0218
C(8)	-0.009383	0.004584	-2.046805	0.0410
C(9)	-0.004427	0.006115	-0.723932	0.4693
C(10)	0.005428	0.006022	0.901344	0.3677
C(11)	0.026477	0.024387	1.085728	0.2779
C(12)	-2.342638	1.842224	-1.271636	0.2038
C(13)	2.184495	1.843369	1.185056	0.2363
C(14)	0.670034	0.071823	9.328969	0.0000
C(15)	0.236056	0.072027	3.277317	0.0011
C(16)	0.770578	0.353124	2.182176	0.0294
C(17)	-0.675965	0.355482	-1.901543	0.0576
C(18)	0.041960	0.113237	0.370550	0.7111
C(19)	-0.047969	0.114332	-0.419562	0.6749
C(20)	0.188712	0.152511	1.237367	0.2163
C(21)	-0.101742	0.150206	-0.677347	0.4984
C(22)	0.401982	0.608227	0.660908	0.5088
C(23)	-0.257161	0.390333	-0.658825	0.5102
C(24)	0.299699	0.390576	0.767326	0.4431
C(25)	0.001110	0.015218	0.072952	0.9419
C(26)	0.030421	0.015261	1.993368	0.0465
C(27)	1.014140	0.074820	13.55433	0.0000
C(28)	-0.022013	0.075320	-0.292260	0.7702
C(29)	-0.020307	0.023993	-0.846357	0.3976
C(30)	0.025048	0.024225	1.033958	0.3014
C(31)	-0.011743	0.032314	-0.363413	0.7164
C(32)	-0.018498	0.031826	-0.581210	0.5613
C(33)	-0.209814	0.128872	-1.628077	0.1039
C(34)	1.589260	1.141722	1.391986	0.1643
C(35)	-1.546302	1.142431	-1.353519	0.1762
C(36)	-0.110294	0.044512	-2.477816	0.0134
C(37)	0.129918	0.044639	2.910406	0.0037
C(38)	-0.149382	0.218849	-0.682582	0.4951
C(39)	0.126127	0.220311	0.572494	0.5671
C(40)	1.363142	0.070179	19.42382	0.0000
C(41)	-0.406482	0.070858	-5.736602	0.0000
C(42)	-0.005563	0.094519	-0.058851	0.9531
C(43)	0.033055	0.093091	0.355088	0.7226
C(44)	-0.065627	0.376950	-0.174100	0.8618
C(45)	3.294828	0.890702	3.699136	0.0002
C(46)	-3.064653	0.891256	-3.438579	0.0006
C(47)	0.003613	0.034726	0.104029	0.9172
C(48)	0.003804	0.034825	0.109225	0.9130
C(49)	-0.379183	0.170733	-2.220917	0.0266
C(50)	0.425567	0.171873	2.476050	0.0135
C(51)	0.080129	0.054749	1.463566	0.1437
C(52)	-0.060183	0.055279	-1.088723	0.2766

C(53)	0.895741	0.073738	12.14760	0.0000
C(54)	0.001253	0.072624	0.017258	0.9862
C(55)	-0.717768	0.294073	-2.440780	0.0149

Whether the coefficients are significant in explaining the dependent variables or not is determined by observing the respective *p-values*. The total number of coefficients sums up to 55 because the model had 5 regression equations each with 11 independent variables. To establish the significance of each of the coefficients, the *p-values* are compared against the 5% (0.05) significance level and checked against the decision rule of whether to reject or fail to reject the null hypothesis. From the results tabled above, it is seen that when having the exchange rate as the dependent variable, only the lags of the exchange rate and the inflation rates have a statistically significant effect on the exchange rate.

4.6.1 Variance Decomposition

The variance decomposition analysis allocates the proportion of the movement in the dependent variables that are due to their own shocks and shocks due to the other variables. The summary and discussion of results are outlined in the section below.

4.6.1.1 Variance Decomposition of USD_X_LN

Table 9: Variance Decomposition Analysis for the exchange rate(USD_X_LN)

Period	S.E.	USD_X_LN	BTC_AMT_LN	BTC_PRICE_LN	INTEREST_RATE	INFLATION_RATE
1	0.034198	100.0000	0.000000	0.000000	0.000000	0.000000
2	0.053204	98.31357	0.529799	0.004756	0.104560	1.047310
3	0.068187	96.91768	0.679635	0.004337	0.132077	2.266275
4	0.080857	95.80988	0.751210	0.015234	0.115481	3.308198
5	0.092039	94.94606	0.772521	0.045471	0.091542	4.144411
6	0.102174	94.23326	0.771720	0.096183	0.075334	4.823505
7	0.111533	93.60841	0.761695	0.167496	0.073396	5.389006
8	0.120299	93.03142	0.749106	0.258683	0.088305	5.872490
9	0.128602	92.47775	0.737488	0.368670	0.120641	6.295455
10	0.136534	91.93267	0.728768	0.496236	0.169923	6.672400

From Table 10, it can be seen that the exchange rate (USD_X_LN) explains its own variability up to 100% in month one and loses the power of explanation to about 91% in month 10. After 3 months, changes in the exchange rate are still greatly attributed to itself, with only 0.67% attributed to *btc_amt_ln*, 0.004% attributed to the price of bitcoins, 0.13% to interest rates and 2.27% to inflation.

In a period of 10 months, the major external explanation for the variability in exchange rate remains to be the inflation rate which contributes to about 6.67% of variations in the exchange rate. The number of bitcoins, bitcoin prices and exchange rates still contribute minimally to variation in the exchange rate of about 0.73%, 0.49% and 0.17% respectively.

4.6.1.2 Variance Decomposition of BTC_AMT_LN

Table 10: Variance Decomposition Analysis for the amount of bitcoins(BTC_AMT_LN)

Period	S.E.	USD_X_LN	BTC_AMT_LN	BTC_PRICE_LN	INTEREST_RATE	INFLATION_RATE
1	0.852936	0.041014	99.95899	0.000000	0.000000	0.000000
2	1.044099	0.366947	97.53971	1.508632	0.540756	0.043957
3	1.209451	0.378879	97.12015	1.635186	0.830177	0.035605
4	1.340174	0.382592	96.60351	1.891567	1.090471	0.031858
5	1.449710	0.377038	96.12704	2.144340	1.322172	0.029414
6	1.543880	0.367759	95.65608	2.419087	1.528912	0.028168
7	1.626491	0.357032	95.18337	2.720245	1.711444	0.027910
8	1.700210	0.345909	94.70520	3.050755	1.869594	0.028540
9	1.766972	0.334953	94.21894	3.412666	2.003434	0.030012
10	1.828238	0.324446	93.72270	3.807159	2.113395	0.032299

From Table 11, it can be seen the *btc-amt-ln* variable explains its own variability up to 99.95% in the first month and loses the power of explanation to about 93.72% after 10 months. The major external explanation for this variability is the price of bitcoins (BTC_PRICE_LN), as it explains 0% in the first month and increases to 3.8% after 10 months. The exchange rates also contribute to the variations in the amount of bitcoins, although minimally. In the first three months, the exchange rate contributes up to 0.38% of variations in the amount of bitcoins. This percentage slightly reduces to 0.32% after 10 months. This implies that in the exchange rate causes minimal variations in the amount of bitcoins in a given economy given a period of 10 months. The contribution of the interest rates is seen to increase from 0.83% in 3 months to 3.8% after 10 months. The amount of bitcoins is seen to be least sensitive to variations in the inflation rates. In a period of three months, variations due to the inflation rate amount to just 0.035%. this rate is seen to slightly reduce and then increase to 0.032% after ten months.[8]

[8]The variance decomposition results of *btc_price_ln* , *inflation_rate and interest_rate* are in the Appendix section labelled *Table 11, Table 12* and *Table 13* respectively.

5 DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

The objective of this research was to evaluate the relationship between the circulation of bitcoins and selected domestic currencies in Africa. The Random effects regression model was used to analyze the relationship between the exchange rates and variables such as the amount and price of bitcoin, interest and inflation rates. The random effects model exploited the direction of the relationship between these variables, the magnitude and significance of this relationship. In addition, the test of cointegration was performed to check for the existence of any long run relationships between the variable. The cointegration tests confirmed the absence of a long run relationship and this conclusion led to the use of the VAR and Variance decomposition models. The VAR model was used to analyze the endogeneity of the variables and explore the effects of lagged independent variables on the dependent variable. The variance decomposition analysis was an analysis extension of the VAR model. It explored the sensitivity of one variable to its own shocks and those of other variables in the VAR system. It also showed how long the shocks would last within the VAR system.

5.1.1 Discussion of the Regression Findings

It is clearly seen from the regression results displayed in table 6 that there exists a direct relationship between the exchange rates and the all the independent variables used in the regression model. The increase in the exchange rate by 0.01% due to a percentage change in the amount of bitcoins means that more of the domestic currency will be required to exchange for one dollar, thus indicating a loss in value of the domestic currency. On a general note, increase in the exchange rate in this context means a depreciation of that currency. This is because more of the domestic currency will be required to exchange for one dollar. The results also showed a direct relationship between the exchange rates and the interest and inflation rates. Economic theory holds that countries with higher inflation typically see depreciation in their currency in relation to the currencies of their trading partners.

The inflation regression results are consistent with this economic theory; a percentage increase in the inflation rate leads to a corresponding increase of 4.53% in the exchange rate, which means that the domestic currency depreciates with respect to the dollar. Economic theory holds that increasing interest rates attract foreign capital and thus leads to appreciation of the exchange rate. This means that theoretically, there exists an inverse relationship between interest and exchange rates. This is not the case with the regression results. The results from this model show that interest and exchange rates have a direct relationship, with an increase in interest rates resulting in a corresponding increase (depreciation) of the exchange rate. These can be said to be contrary to what economic theory stipulates. The relationship between the exchange rates and the prices of bitcoins is also a direct one. The coefficient of this result is however considered insignificant in explaining the dependent variable because the *p-value* was greater than the level of significance, and therefore the null hypothesis that deemed the coefficient insignificant failed to be rejected.

Except for the minimal amount of bitcoins and small effect of 0.01% on the exchange rate, the results of this research are found to be consistent with those of (Alina, 2016), who also performed a regression analysis of the exchange rate against the amount of bitcoins traded in the United States. The research titled, *'A Regression Analysis of Cryptocurrency Influence on the Us Dollar'*, yielded similar results with a percentage increase in the amount of bitcoins resulting to a corresponding and larger effect of a 6.1% increase on the exchange rate. The conclusion drawn from this research was that the increased distribution of bitcoins weakened the US dollar.

The conclusion made from this research therefore is that, the increased distribution of bitcoins across African countries, that is, Kenya, Morocco, Nigeria and South Africa, weakens the domestic currencies in the respective countries.

5.1.2 Summary of the VAR and Variance Decompositions Findings

The results from the VAR and variance decomposition tests further explored the relationship between bitcoins and exchange rates. These results contribute further to the objective of this study of evaluating the relationship between the circulation of bitcoins and the exchange rates.

5.1.2.1 Summary of VAR results

The results show that only the lags of the exchange rate and those of the inflation rate have a statistically significant relationship with the exchange rate. This means that a critical observation of the lags of the exchange and inflation rates would give meaningful information about the current value of the exchange rate.

When the *btc_amt_ln* variable became the dependent variable, it was seen that there was only a statistically significant relationship between *btc_amt_ln* with its lags and those of bitcoin prices. It is therefore concluded that observing the lags of the amount of bitcoins and those of the prices of bitcoins would inform on the current value of the amount of bitcoins.

Having the *btc_price_ln* variable as the dependent variable showed that it only has a statistically significant relationship with its own lags, hence observing the lags of the bitcoin prices would greatly inform the current price of bitcoins. When the inflation rate became the dependent variable, it was seen to have a statistically significant relationship with its own lags and those of the *btc_amt_ln* variable.

Finally, setting interest rates as the dependent variable showed that it has statistically significant relationships with its own lags, those of the bitcoin prices and the exchange rates as well. This means that observing the lagged values of the interest and exchange rates, and the bitcoin prices would inform on the current value of interest rate.

5.1.2.2 Summary of Variance Decomposition Analysis

The variance decomposition analysis showed that the variations in the exchange rate attributed to changes in the amount of bitcoins are relatively small, with a value of 0.73%. These results however show an increase followed by a decrease in the proportion of variation that is accounted for by the amount of bitcoins. Although results show the existence of sensitivity between these variables over time, the value of this sensitivity is quite low and could be considered almost negligible.

When the variables are interchanged, the results show that over a period of 10 months, the variations in the amount of bitcoins that can be attributed to the exchange rates equal to a value of 0.32%. This value is seen to be decreasing minimally over the ten-month period.

It is clearly seen that there exists some relationship between the amount of bitcoins and the exchange rates over time. The variations brought on the exchange rate by the amount of bitcoins in circulation are inconsistent over time, with periods of an increasing effect followed by periods of a decreasing effect. On the other hand, the variations in the amount of bitcoins due to the exchange rates are seen to be consistently decreasing over time.

Research done by (Asmah, 2013) on the Sources of Real Exchange Rate Fluctuations in Ghana, established that the exchange rate variable is highly endogenous and therefore it accounts for a great percentage of its own variations. This further supports why very minimal changes in the exchange rate are attributed to exogenous variables.

5.2 Conclusion of the Study

The results from this study clearly show that there exists a relationship between the exchange rates and the amount of bitcoins. From empirical testing, it can be concluded that as the amount of bitcoins increase in any economy, the domestic currency in that economy is seen to depreciate. This effect however is very minimal and almost negligible. This could be attributed to the few bitcoins that are in circulation in the countries of study. A similar research when carried out in the United States of America, had the same conclusions but with the amount of bitcoins having a greater impact on the exchange rate due to a larger number of bitcoins in circulation in that economy.

The results further show that the amount of bitcoins in circulation in any given economy would also cause minimal variations to the exchange rates, interest rates and inflation rates in that economy.

5.3 Limitations of the Study

The main limitations to this study are as follows. The variable, *btc_amount_ln*, registered minimal data. There was limited data on the amount of bitcoins in Africa. This is because there is still much uncertainty around the concept of Bitcoin and its usage. Bitcoin is not as popular in African countries as in other westernized countries. Most African countries did not register any volumes of bitcoins in their economies. The countries that did have Bitcoin trading, had very minimal volumes, and some did not even have records of this kind of data.

The other limitation was that this research was done over a relatively short time period. The sample was of monthly data collected from 2014 to 2017. This time period was so because it was not until 2014 that the Bitcoin system started to gain popularity and some momentum in Africa. This is a relatively short period of examination in which data characteristics may not be fully exploited.

5.4 Recommendations

5.4.1 Policy Recommendations

The exchange rate of any economy is important for the purposes of international trade as well as investments. From this study, an increase in the amount of bitcoins in a given economy is seen to weaken the domestic currency of that economy. This raises the need for governments to keep a watchful eye over the Bitcoin system that is slowly gaining momentum in African economies. This research concluded that this impact on the domestic currencies by Bitcoin is almost negligible. This has been attributed to the minimal volumes of bitcoins in most African countries. However, as more people become more familiar with the Bitcoin system, the volumes are bound to shift upwards, thus causing more significant impacts.

Governments should monitor the traction that the Bitcoin system is gaining in the respective economies and come up with risk management measures given that the operations of Bitcoin are beyond the monetary and fiscal policies. Governments should also seek to establish ways through which they could incorporate the Bitcoin system so as to improve operations within their countries. One approach to this is for central banks to develop their own central-bank-backed cryptocurrencies. Some central banks that have already taken this up include the central banks of Canada, China, Estonia, Eucador, Japan, Russia, Senegal, Singapore, Sweden, and Tunisia (Enzozo, 2017). This way, central banks will continue to have full control over the monetary system operations. Even in developing their own cryptocurrencies, central banks should greatly focus on how the cryptocurrency system will be designed, built and maintained, and how it could affect the country's financial stability.

Another approach is to explore the technology on which the Bitcoin system is built; the blockchain technology which is an online distributed database. The blockchain can be

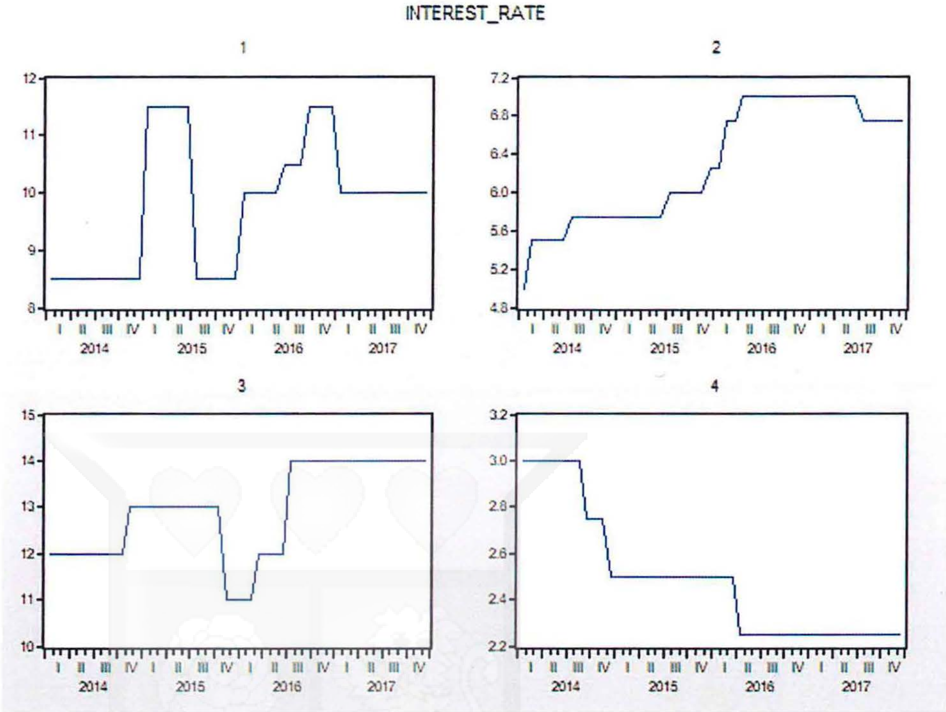
adopted in improving public sector operations with the aim of improving the resilience of digital infrastructure. A country such as Estonia is already taking pride in being the first 'crypto-country' in the world, and has adopted the blockchain in public sector services. These include adopting an online voting system, payment of health benefits, and an e-residency program which allows people around the world to be virtual citizens of Estonia (Althauser, 2017). Countries could borrow from what Estonia has done and try to adopt and incorporate the blockchain to improve the efficiency of their operations.

5.4.2 Recommendations for Further Research

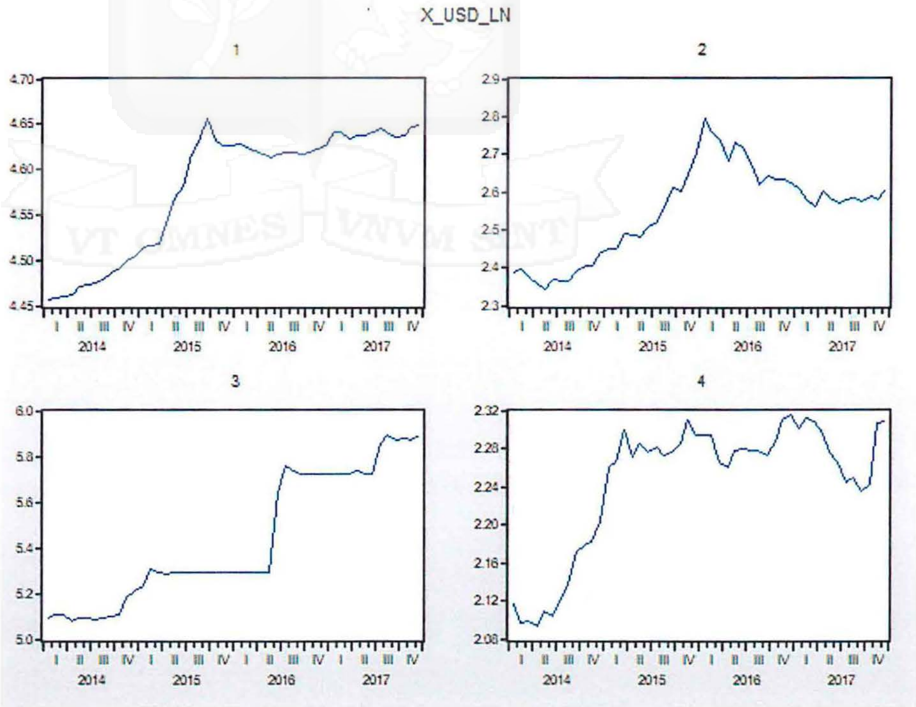
There are two main recommendations for further research. The first is that, the sample selected should include a majority of countries in which the Bitcoin system has taken root and found acceptance. This will allow for more volumes of bitcoins to be registered and hence more significant characteristics of Bitcoin can be explored.

The final recommendation is that; the sample period should be extended to more than four years. This will also allow empirical tests to fully explore and capture the behaviors of Bitcoin over a longer period.

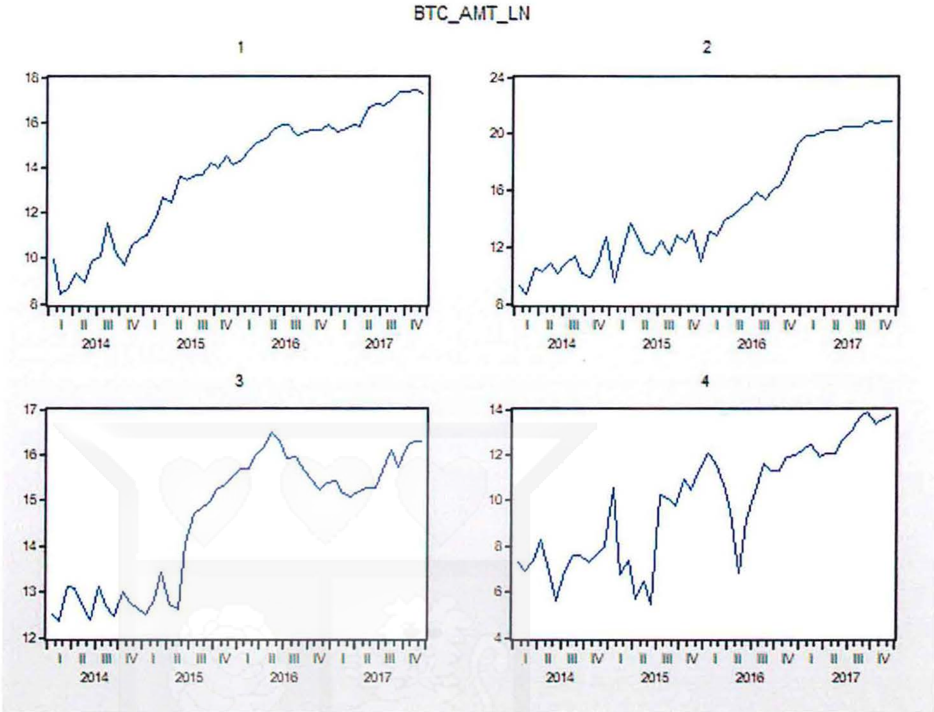
2. **INTEREST_RATE**



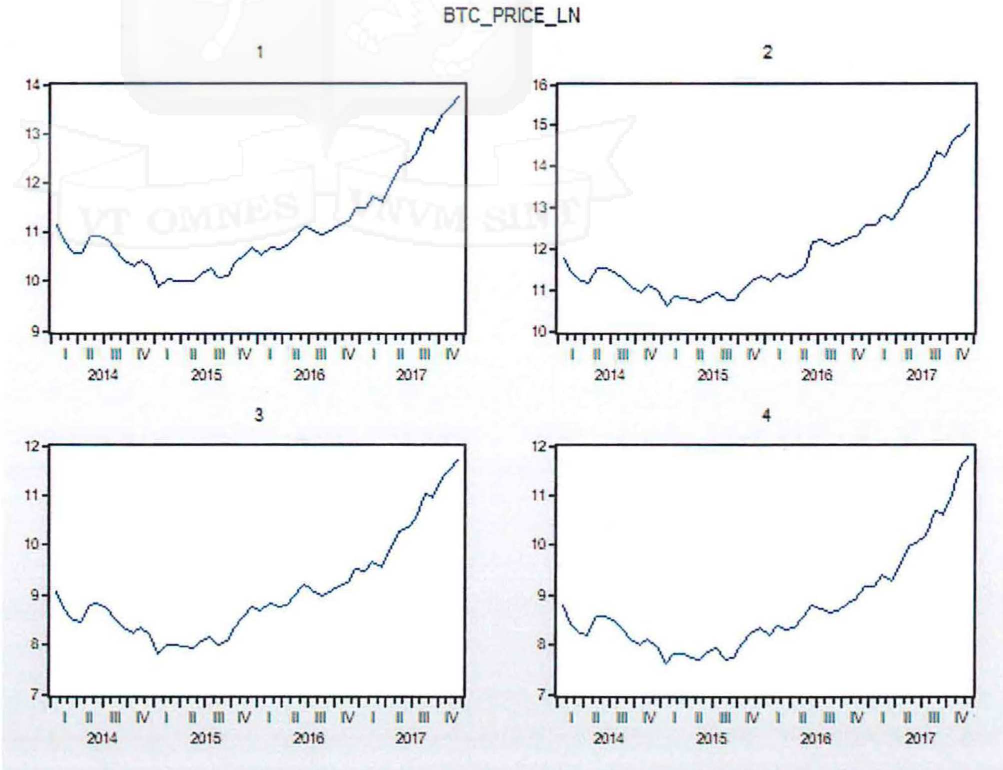
3. **X_USD EXCHANGE RATE**



4. **BTC_AMT_LN**

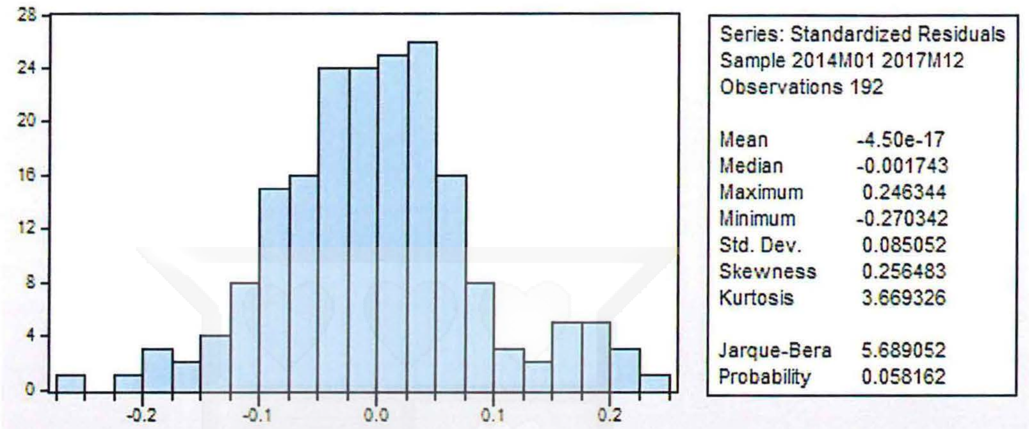


5. **BTC_PRICE_LN**



From all the graphs: 1, 2, 3, and 4 represent the four cross sections which are Kenya, Nigeria, south Africa and Morocco respectively.

Appendix D: Histogram; Normality Test for Regression Residuals



Appendix E: VAR and Variance Decomposition Tables

Table 11: Summarized Results of the VAR Model

	X_USD_LN	BTC_AMT_LN	BTC_PRICE_LN	INFLATION_RATE	INTEREST_RATE
X_USD_LN(-1)	1.179666	-2.342638	-0.257161	1.589260	3.294828
	(0.07386)	(1.84222)	(0.39033)	(1.14172)	(0.89070)
	[15.9710]	[-1.27164]	[-0.65882]	[1.39199]	[3.69914]
X_USD_LN(-2)	-0.183989	2.184495	0.299699	-1.546302	-3.064653
	(0.07391)	(1.84337)	(0.39058)	(1.14243)	(0.89126)
	[-2.48940]	[1.18506]	[0.76733]	[-1.35352]	[-3.43858]
BTC_AMT_LN(-1)	-0.004891	0.670034	0.001110	-0.110294	0.003613
	(0.00288)	(0.07182)	(0.01522)	(0.04451)	(0.03473)
	[-1.69841]	[9.32897]	[0.07295]	[-2.47782]	[0.10403]
BTC_AMT_LN(-2)	0.004845	0.236056	0.030421	0.129918	0.003804
	(0.00289)	(0.07203)	(0.01526)	(0.04464)	(0.03482)
	[1.67755]	[3.27732]	[1.99337]	[2.91041]	[0.10922]
BTC_PRICE_LN(-1)	-0.004142	0.770578	1.014140	-0.149382	-0.379183
	(0.01416)	(0.35312)	(0.07482)	(0.21885)	(0.17073)
	[-0.29255]	[2.18218]	[13.5543]	[-0.68258]	[-2.22092]
BTC_PRICE_LN(-2)	0.002402	-0.675965	-0.022013	0.126127	0.425567
	(0.01425)	(0.35548)	(0.07532)	(0.22031)	(0.17187)

	[0.16854]	[-1.90154]	[-0.29226]	[0.57249]	[2.47605]
INFLATION_RATE(-1)	0.010437	0.041960	-0.020307	1.363142	0.080129
	(0.00454)	(0.11324)	(0.02399)	(0.07018)	(0.05475)
	[2.29873]	[0.37055]	[-0.84636]	[19.4238]	[1.46357]
INFLATION_RATE(-2)	-0.009383	-0.047969	0.025048	-0.406482	-0.060183
	(0.00458)	(0.11433)	(0.02422)	(0.07086)	(0.05528)
	[-2.04681]	[-0.41956]	[1.03396]	[-5.73660]	[-1.08872]
INTEREST_RATE(-1)	-0.004427	0.188712	-0.011743	-0.005563	0.895741
	(0.00611)	(0.15251)	(0.03231)	(0.09452)	(0.07374)
	[-0.72393]	[1.23737]	[-0.36341]	[-0.05885]	[12.1476]
INTEREST_RATE(-2)	0.005428	-0.101742	-0.018498	0.033055	0.001253
	(0.00602)	(0.15021)	(0.03183)	(0.09309)	(0.07262)
	[0.90134]	[-0.67735]	[-0.58121]	[0.35509]	[0.01726]
C	0.026477	0.401982	-0.209814	-0.065627	-0.717768
	(0.02439)	(0.60823)	(0.12887)	(0.37695)	(0.29407)
	[1.08573]	[0.66091]	[-1.62808]	[-0.17410]	[-2.44078]

Note: Standard errors in ( ) and t-statistics in [ ]

Table 1: Variance Decomposition Analysis for the price of bitcoins(BTC_PRICE_LN)

Period	S.E.	USD_X_LN	BTC_AMT_LN	BTC_PRICE_LN	INTEREST_RATE	INFLATION_RATE
1	0.180722	0.366065	0.049461	99.58447	0.000000	0.000000
2	0.256954	0.190206	0.048873	99.55453	0.036407	0.169982
3	0.318506	0.123964	1.090283	98.20047	0.281885	0.303402
4	0.375992	0.101515	2.581834	96.34779	0.624616	0.344247
5	0.431086	0.109615	4.497530	94.02991	1.019384	0.343557
6	0.485101	0.137782	6.660128	91.45860	1.420744	0.322746
7	0.538625	0.178586	8.957341	88.76971	1.799638	0.294726
8	0.591983	0.227029	11.30723	86.06065	2.139326	0.265759
9	0.645343	0.279728	13.65199	83.39768	2.431982	0.238623
10	0.698795	0.334371	15.95210	80.82348	2.675707	0.214342

Table 2:Variance Decomposition Analysis for the inflation rate(INFLATION_RATE)

Period	S.E.	USD_X_LN	BTC_AMT_LN	BTC_PRICE_LN	INTEREST_RATE	INFLATION_RATE
1	0.528609	0.010532	0.528134	2.039951	0.017849	97.40353
2	0.891481	0.241045	0.411864	1.451415	0.013115	97.88256

3	1.179199	0.617270	0.310382	1.036766	0.012195	98.02339
4	1.408671	0.906342	0.240958	0.807502	0.031038	98.01416
5	1.592823	1.139847	0.189089	0.653675	0.080549	97.93684
6	1.742903	1.339439	0.163841	0.548276	0.167354	97.78109
7	1.867282	1.519393	0.166706	0.478562	0.293381	97.54196
8	1.972041	1.688315	0.194620	0.437522	0.457493	97.22205
9	2.061585	1.851412	0.242521	0.420434	0.656748	96.82888
10	2.139132	2.011906	0.304903	0.423636	0.887179	96.37238

Table 3 Variance Decomposition Analysis for the interest rate(INFTEREST_RATE)

Period	S.E.	USD_X_LN	BTC_AMT_LN	BTC_PRICE_LN	INTEREST_RATE	INFLATION_RATE
1	0.412389	0.004150	0.222360	3.188089	96.58540	0.000000
2	0.576324	3.370834	0.260279	6.587465	89.25529	0.526129
3	0.686515	5.942775	0.193347	6.942112	85.01556	1.906202
4	0.771295	7.744131	0.153719	6.776286	81.86843	3.457433
5	0.839931	9.144651	0.131424	6.486953	79.32075	4.916223
6	0.897051	10.30720	0.116491	6.162917	77.17630	6.237096
7	0.945544	11.31849	0.105049	5.840576	75.30689	7.428995
8	0.987383	12.22633	0.096537	5.533941	73.63105	8.512133
9	1.023987	13.05898	0.091887	5.249039	72.09564	9.504454
10	1.056413	13.83389	0.092714	4.988291	70.66562	10.41948

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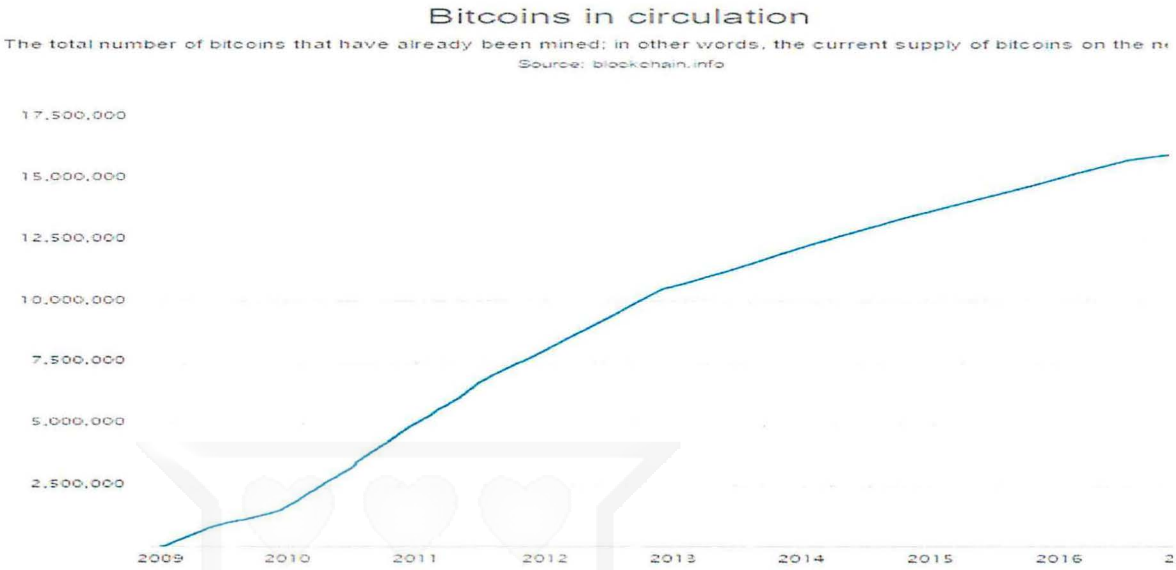
7 APPENDICES

Appendix A: BTC/USD Exchange Rate

Source: (XE Currence Converter, 2017)

Appendix B: Bitcoin Price History Chart

Appendix C: Total Number of bitcoins in Circulation



Source: (BlockChain, 2017)

Appendix C: Line Graph Plots of the Sample Variables across the Four Crossections.

1. **INFALTION_RATE**