Cryptocurrencies in the Future of Money and Monetary Policy

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Cryptocurrencies in the Future of Money and Monetary Policy

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DECLARATION

Title of Thesis: Cryptocurrencies in the Future of Money and Monetary Policy

In accordance with Rule G5.6.3, I, Henry Brandon Brown (213404745) hereby declare that the above-mentioned thesis for Masters of Commerce (Economics) to be awarded, is my own work and has not previously been submitted for assessment or completion of any post graduate qualification to another University or for another qualification.

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Henry Brandon Brown

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August 2019

EDITING CERTIFICATE

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M. W. RANDELL

ABSTRACT

The idiosyncratic allure of cryptocurrencies, in particular Bitcoin, has attracted widespread, if reticent, attention in the financial markets. Since Bitcoin's introduction in 2008 there has been a growing interest in digital assets possibly supplanting traditional payment methods. Two conceptual questions raised regarding cryptocurrencies are firstly, whether cryptocurrencies meet the traditional functions of money; secondly, what is the future of cryptocurrencies? This dissertation seeks to examine the future of cryptocurrency by reference to money and monetary policy. The further question, whether cryptocurrencies meet the traditional functions of money, is tested via a combination of theoretical and empirical analysis. The study explores both statistical and empirical models, in illustrative comparative detail, provided by analysis which included ADF and KPSS test models, alongside an ARMA(p,q)-GARCH(1,1) model.

Cryptocurrencies present both significant benefits, alongside immense shortcomings. They provide the novel ability to conduct anonymous international transactions on a decentralised platform with lower transaction fees. However the very nature of that anonymity could provide their downfall as much as they open a market for illicit activities. In addition, cryptocurrency's significant energy consumption through the mining of cryptocurrencies is of concern to environmentalists.

The empirical section of the dissertation consists of a comparative analysis between Bitcoin/USD time series to the Rand/USD time series, with specific attention devoted to the level of volatility of each time series. This was important in determining whether cryptocurrencies fulfil the store of value function of money. The dissertation concluded that Bitcoin/USD time series exhibited identifiable adverse characteristics of autocorrelation and ARCH effects, thus suggesting that Bitcoin/USD is strongly associated with volatility. The Rand/USD signified the same effects although of significantly lesser order than that of Bitcoin/USD. Consequently, cryptocurrencies are seen to act more as an asset than a currency.

Nonetheless, cryptocurrencies seem likely to grow as a medium of exchange as more and more businesses gain knowledge of the innovation and seek to adopt innovative ways to become more efficient and follow technology trends. Currently, fiat currencies remain superior in the financial market, simply because cryptocurrencies are perceived not to fulfil the traditional functions of money. However in the future, the market share of cryptocurrencies is likely to increase, and so the future of the financial markets will surely include a coexistence of both fiat and cryptocurrencies, as people's preferences determine where they feel safe to hold their money.

Key words: Bitcoin, cryptocurrencies, functions of money, monetary policy, Augmented Dickey-Fuller, and Kwiatkowski, Phillips, Schmidt and Shin, AR(1)-GARCH(1,1).

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ABBREVIATIONS

ACF	Autocorrelation
AR	Autoregressive
ADF	Augmented Dickey-Fuller
ARCH	Autoregressive Conditional Heteroscedasticity
AML/CFT	Anti-Money Laundering and Countering Financing of Terrorism
ARMA	Autoregressive-Moving-Average
ARMA-GARCH	Autoregressive-moving-average Generalised Autoregressive Conditional Heteroscedasticity
CRA	Canada Revenue Agency
DW	Durbin Watson
ECB	European Central Bank
GARCH	Generalised Autoregressive Conditional Heteroscedasticity
GDP	Gross Domestic Product
HMRC	Her Majesty's Revenue and Customs
IFWG	Intergovernmental Fintech Working Group
IMF	International Monetary Fund
IRS	Internal Revenue Service
JB	Jarque-Bera
KPSS	Kwiatkowski, Phillips, Schmidt and Shin
LM	Lagrange Multiplier
MA	Moving-Average
PACF	Partial-autocorrelation
SARB	South African Reserve Bank
SARS	South African Revenue Services
U.A.E	United Arab Emirates
UK	United Kingdom

CHAPTER ONE: INTRODUCTION

1.1. Introduction and Background to the Research

In 2008 the world experienced the most gripping financial crisis to date. The US stock market crashed, alongside many businesses and banks. Through such difficult times central banks and governments reacted by bailing out commercial banks. This rescue of the financial system led to the perception that governments and central banks can control the economy. It was rightly argued that even though the crisis had been averted, the core problem (being money itself) had not been addressed. Central banks and governments' control over financial systems posed itself as the real problem and not the financial markets themselves (Salsman, 2013).

Over the past 15 years major technological breakthroughs have taken place in an ever-globalizing world. Within those years society has revolutionised profoundly. Technology advancements have brought about changes to people's lifestyles and the way in which they communicate, learn and purchase products, constantly discovering new ways to solve everyday problems to improve the lives of people. Here the internet presides (Rogojanu & Badea, 2014). By introducing the world to digitalisation, the internet reaches into every facet of society today, changing our very way of life. It has developed a new level of efficiency and triggered a race for yet further innovation. Digitalisation has elevated every day activities to online status, from listening to music, watching movies and shopping. CD and DVD technology has slowly receded, replaced with online streaming through platforms like Netflix for movies, and Spotify for music. Now it has even encroached upon the way in which the world looks at money as a medium of exchange. What would the future be like if no government or agencies controlled money, or if such authorities were unable to interfere with or influence daily financial transactions or the value of a currency? This question was answered by the digital breakthrough which was the introduction of the first cryptocurrency in 2008.

Krüger and Godschalk (1998) wrote that progression in technology and innovation in payment systems would result in a decline in both transaction and information costs which could result in a viable alternative currency. Although the 2008 crisis presented an opportunity for real change, the question is whether central governments and banks turned a blind eye or whether they faced a misjudgement regarding interest rates. This question goes beyond the scope of the study. Their influence dictated the option of rather repairing a mismanaged system, over changing one. This crisis was the key motivator behind Sakatishi Nakamoto developing the first decentralised cryptocurrency. Digital or virtual currencies first emerged in the 1980's with the introduction of systems such as Flooz and DigiCash. However, their existence was short-lived due to failures which included fraud and other financial problems. The crypto-market remained stagnant until the first decentralized cryptocurrency "Bitcoin" emerged in 2008. Its creator Nakamoto (2008), referred to it as 'A Peer-to-Peer Electronic Cash System'. The purpose behind the development of cryptocurrencies was to develop a system that avoided commissions associated with money transfers. The decentralised nature of cryptocurrencies meant that there was no intervention from third parties for example, the governments or banks. Therefore no central server recorded the transactions, which instead were recorded on a digital public ledger known as the block chain (Lighter, 2017). The view was held that support for this peer to peer system became evident as a result of the current markets' need for a swifter and more secure payment system. The eradication of third party interference with crypto-payments and their increased anonymity, attracted significant support for the use of the crypto-system (Dow, 2018). The question is whether cryptocurrencies may potentially substitute fiat currencies in the same way as E-mails have substituted postal services and by extension, whether monetary authorities could thereby lose control over their monetary policies (Ramey, 2012).

The technology evolution emerging in the currency world, with its resultant global uncertainty, presents the conundrum whether fiat money is set to evolve into a complete digital or virtual form. Economists, governments and central banks are left unsure as to what the future holds for fiat currencies and their influence within monetary systems. Cryptocurrency has become a perennial topic and its popularity has risen significantly, even being referred to by many as the money of the future. Bill Gates, the co-founder of Microsoft stated "Bitcoin is exciting because it shows how cheap it can be. Bitcoin is better than currency in that you don't have to be physically in the same place and, of course, for large transactions, currency can get pretty inconvenient" (Elkins, 2017). Eric Schmidt the executive chairman of Google believes Bitcoin represents a major achievement for the financial markets and will generate significant value. Bitcoin will form an important element in the creation of business (Millet, 2014). However, before one can regard cryptocurrency as the future global currency, it first has to satisfy the three functions which money performs. The Greek philosopher Aristotle identified four characteristics and three functions for something to qualify as ‘money’. Money must be durable, portable, divisible and must have intrinsic value (Franco, 2015:21).

Acknowledged functions of money in a modern economic system suggest that:

- It must be a medium of exchange
- It must have a store value, and
- It must be a unit of account

(Franco, 2015:21)

1.2. Problem Statement

A monetary policy system assigns control of money to the government. Therefore, with cryptocurrencies being decentralised and with no third party influence, their popularity could increase in the future, especially in countries with unstable governments and monetary authorities lacking in trust. At the same time it is impossible for banks and governments to ignore the economic and technological advancements cryptocurrencies have to offer, for example, the concept of ‘blockchain’. However there are a few unanswered questions regarding cryptocurrencies’ effect on monetary policies. Such questions include where cryptocurrencies actually fit in within monetary policy systems and could they ultimately replace such policies, or will cryptocurrencies become regulated by government? Or do cryptocurrencies portend a new high-tech payment system; alternatively, are they just a speculative fad?

Due to the emerging nature of cryptocurrencies, limited information on the topic has been published. The focus of the limited research literature has been principally on the legal implications of Bitcoin; the factors influencing Bitcoin’s volatility; and statistically analysing Bitcoin data to determine the volatility of cryptocurrencies (e.g. Grinberg, 2011; Niblaeus & Nylund, 2014; Estrada, 2017; Brown, 2014). Research is even more limited in determining whether cryptocurrencies are able to fulfil the functions of traditional money. Thus, determining the reaction from both contemporary and traditional monetary authorities, is an area yet to be researched so as to assess whether central banks will seek to take control of the potential effect of cryptocurrencies on monetary systems. A major concern with cryptocurrencies is their volatility and instability in the market. Fluctuations in cryptocurrencies are affected by many factors, not least of all that no cryptocurrency is backed by an index. For now, with cryptocurrency still being regarded as an asset in its infancy stage, the question whether cryptocurrencies can be regarded as a store of value lingers crucially.

1.3. Selected Prior Research on Cryptocurrencies

Niblaeus and Nylund (2014) conducted a study assessing the viability of Bitcoin as a form of currency and an alternative investment. They concluded that Bitcoin exhibited features more similar to alternative assets than to traditional currency. However they discovered conflicting features that make Bitcoin an attractive investment but also conversely, obstructed the functionality of Bitcoin as a currency.

Similarly, Brown (2014) conducted an analysis of Bitcoin's market efficiency through measures of short-horizon return predictability and market liquidity. He examined the changes in availability of predictable outsized returns and market liquidity over time. Constraints identified included the inability to measure the magnitude of the change. This was as a result of limitations in analysis efficiency. Nevertheless, the study proved that over the duration of the study, significant short-horizon price predictability existed.

Estrada (2017) analysed Bitcoin's price and volatility through the use of the Granger-causation relationship among pairs of time series. The following relationships were examined: Bitcoin price realized volatility and the S&P 500; Bitcoin price realized volatility and the VIX; and Bitcoin price and Blockchain Google Trends. The results obtained indicated that Bitcoin's price has no causal relationships to financial instruments such as the S&P 500. These findings were consistent with those obtained by Ciaian et al. (2014). A more comprehensive literature survey and review is conducted in Chapter Two, followed by a focused empirical analysis in Chapter Four.

1.4. Aim and Objectives of Research

The aim of the research is to gain a clearer understanding of the nature and the operation of cryptocurrencies and how they compare with fiat currencies and monetary systems. As cryptocurrencies have experienced significant volatility in value making (proof submitted in the analysis to follow in the dissertation), some economists have characterised them holistically as a 'bubble'. However, cryptocurrencies have showed growth again and again, which will be shown in the literature section in the dissertation. With the central banks striving for financial stability, the risk associated with cryptocurrencies for price and financial stability are major concerns for economies. These facts warrant an assessment as to whether cryptocurrencies have a place in the financial world and whether monetary authorities and central banks will follow the growing trend by adopting the underlying technology. This prompts the further motivation to determine whether cryptocurrencies are able to serve the same functions of traditional money and enjoy the same general acceptance.

Further objectives of the research:

- To gain an understanding of the nature of real money and cryptocurrency and why they were introduced;
- To assess whether cryptocurrency could become the money of the future;
- To assess the volatility of cryptocurrency;
- To determine the effect of cryptocurrencies on the way traditional monetary policy is conducted;
- To analyse the reactions of both traditional and contemporary monetary authorities; and
- To analyse the impact cryptocurrencies have in a developing country such as Venezuela.

1.5. Hypothesis of Research

Given that a hypothesis could be defined as a tentative statement about the relationship between two or more variables and a supposition or explanation that is provisionally accepted to interpret a certain event and as a guide for further investigation (Cherry, 2016), Salkind (2012:27) posits the descriptive historical research method which analyses existing written material with the aid of a research question which is then applied as a hypothesis. Salkind's method is considered suitable to adopt in this dissertation.

Hypothesis 1

Can cryptocurrencies serve similar functions as those of traditional money?

To test the above question, one needs to determine whether cryptocurrencies meet the functions of traditional money which include:

- Medium of exchange;

- Unit of account; and
- Store of value

(Franco, 2015:21)

A comparative analysis will be conducted to assess whether cryptocurrencies satisfy the traditional functions of media of exchange and units of account. To test whether cryptocurrencies satisfy the function store of value, one needs to undertake a qualitative analysis of the available time series. Therefore, a second hypothesis is postulated.

<u>Hypothesis 2</u>

H_0: The respective price series does not store value, thereby not meeting one function of traditional money.

H_1: The respective price series does store value, thereby meeting one function of traditional money.

1.6. Significance of the Research

It was indicated before, but for the context, it is briefly re-stated that cryptocurrencies have become a hot global topic over the past two years. Questions have been raised as to whether or not cryptocurrencies could become the currency of the future and whether or not cryptocurrencies are viable enough to be considered as a medium of exchange. Over the past few years many countries and businesses have approved cryptocurrencies as a form of payment, where others have not engaged in adopting cryptocurrency. The opinions on cryptocurrency's future have been poles apart, and continue to be so.

A survey was conducted with forty-eight top European Economists who included Michael McMahon, professor of Economics at University of Oxford; Richard Portes from London Business School; and Thorsten Beck from Cass Business School to name a few, for their opinions regarding cryptocurrency. The results of the study revealed that 73% of economists disagreed or strongly disagreed with the statement that cryptocurrencies pose a threat to the stability of financial systems, whereas 21% agreed or strongly agreed. The remaining 6% neither agreed nor disagreed with the statement (Den Haan et al, 2017). Those economists in favour believed that cryptocurrencies can operate as an important tool when it comes to transfer of funds between parties, offering minimal fee charges compared with those charged by banks. A defining feature of cryptocurrencies is their organic nature. The currency is immune to any government interference because it is not issued by a central authority. Conversely, those who are not in favour of cryptocurrencies assert that cryptocurrencies are too volatile and open to illegal financial activities such as money laundering (Den Haan et al, 2017).

A recent instance where cryptocurrency materialised as an alternative currency is Venezuela. The reason for the crisis has been linked to overt political influence. This crisis has opened the door for the adoption of a decentralised currency such as cryptocurrency. It is worth reviewing what led up to the Venezuelan crisis and how cryptocurrency became seen as an alternative currency. Notably it has the distinction of being the most recent case where cryptocurrency emerged as an alternative currency in the course of a crisis.

Since 2012 Venezuela has found itself in an unprecedented economic crisis. The International Monetary Fund (IMF) expected the Venezuelan Gross Domestic Product (GDP) to drop by 15% in 2018, as it did in the previous two years (Werner, 2018). But then in February 2018 Venezuela's vice president announced the launch of Venezuela's own cryptocurrency, the Petro, which was backed by Venezuela's oil reserves and was officially accepted as a form of payment towards taxes, fee contributions and public services (Samson, 2018). One is currently driven to ask whether the launch of this cryptocurrency will be able to drive the country out of its economic crisis, or conversely, is the Petro a distraction tool diverting attention from the nation's real problems (Zuluaga, 2018)? If the reason is the former, the Venezuelan government would effectively have introduced a new form of currency in a monetary system through the introduction of cryptocurrency.

In December 2016 the Russian Ministry of Finance drafted laws regarding cryptocurrency and developed a cryptocurrency called 'Cryptorouble'. The Russians' sudden interest in cryptocurrencies may conceivably have something to do with gaining some legal or financial advantage over competitive rival countries or to circumventing or countering sanctions imposed on Russia from the west (McIntosh, 2018). "This instrument suits us very well for sensitive activity on behalf of the State. We can settle accounts with our counterparties all over the world with no regard for sanctions", was the reasoning advanced by the Russian President's economic advisor Sergei Glazev. He also stated that positioning government tenders and bank loans on blockchains would enhance the transparency of state institutions (Arnold & Seddon, 2018).

Although G20 members such as Germany and France are opposed to the crypto-world, a country such as Switzerland has opened its arms to the crypto-revolution. Switzerland's Minister of Economic Affairs Johann Schneider-Ammann strongly believes that cryptocurrency is the one of the most innovative moments in the financial industry and has referred to it as the fourth revolution. The Swiss city Zug, also referred to as the 'Crypto Valley', has seemingly become the core of the cryptocurrency market (Atkins, 2018).

Even though countries are adopting forms of virtual payments, limited research is available recognising cryptocurrencies as a credible form of currency. If it does retain its credibility the world could be entering an era of total transformation in the way people look at money or it could adopt a totally new form of world currency, replacing existing monetary systems completely. This hype of cryptocurrencies makes it impossible for banks to ignore the crypto-trend as it offers major economic and technological advancements.

1.7. Research Design and Methodology

1.7.1. Research Methodology and Data Collection

Research methodology is the way of sourcing, organising and analysing data which is dependent on the nature of the research question (Polit & Hungler, 2004:49). According to Burns and Grove (2003:488), methodology involves the design, the sample selected, methodological limitations of the research and the collection of data and analysis methods in a research study.

A study of the volatility of cryptocurrencies will greatly assist in understanding the store of value function of money. The data used to test for volatility in the research consists of daily closing market capitalisation balances for Bitcoin/USD and Rand/USD. The data is sourced from the Federal Reserve Bank of St Louis and is collected on a daily frequency using closing level prices for the period 01 December 2014 to 22 March 2019. The outputs obtained in the dissertation are computed through the use of statistical software namely Eviews 9. The following models are likely to be applied to detect trend and volatility. They include two statistical models, the Augmented Dickey-Fuller (ADF) test and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test. In addition, an empirical model is employed namely, the Autoregressive-moving-average Generalised Autoregressive Conditional Heteroscedasticity model (ARMA(p,q)-GARCH(1,1)).

1.7.2. Data Analysis

The research methodology to be applied and analysed will be historical and statistical in nature. Within the non-experimental qualitative method a correlational research approach will be adopted. Such a method combines both a descriptive research and historical research approach. A descriptive approach according to Salkind (2012:10-11) enables one to describe the characteristics of an existing phenomenon, where the historical past relates to events that have already occurred. This research will in the first instance, follow the historical research approach, because according to Busha and Harter (1980:91) the historical research method provides a clearer understanding of the topic of study. The application of a correlational descriptive historical method thereafter will provide the option of making use of both quantitative and qualitative methods to source information.

The historical research method approach involves the following six steps which will be applied in conducting research through the historical method (Salkind, 2012:222).

- Firstly, to identify and define the research problem;
- Secondly, to formulate a hypothesis. Salkind (2012:222) allows a hypothesis to be formulated and expressed in the structure of a question;
- The third step in the historical method approach involves the collection of data from a variety of sources. A researcher can make use of two research methods, labelled as Qualitative and Quantitative. Qualitative research is an approach that involves questions and procedures; data collected from participants and the researcher making interpretations from the data gathered. This research method is used to explore and understand the meaning individuals or groups assign to a human or social problem (Creswell, 2014:205). Quantitative research is an approach testing the objective of theories by investigating the relationship among the variables;
- The third and fourth steps can be combined, in the sense that step four evaluates the evidence establishing the authenticity of the data obtained in step three. In the fourth, the data obtained from step three will be organised and integrated to orientate information;
- The fifth step in the historical method is to synthesize and integrate the information gathered; and
- Lastly, the sixth step involves interpreting the results and drawing conclusions and integrating the findings with the original problem statement in step one.

Potential constraints exist with the use of the historical research method approach. Firstly, research should not be restricted to single points of view or place emphasis only on one source. To obviate such a limitation, a variety of sources should be observed and utilised to gain a wider perspective on the topic researched. If not, it will result in the research being viewed as biased towards a particular source (Busha & Harter 1980:99-100). Salkind (2012:222) identifies two shortcomings with the implementation of the historical approach. Firstly, the availability of data could be of limited ambit, leading to restricted findings available to apply to another time or setting. Secondly, due to the historical form of approaches, the data obtained is primarily derived from secondary data. These shortcomings could compromise the credibility of the data. It is submitted however, that one should not simply ignore historical data types out of hand, but thoroughly assess the credibility of the data obtained.

The empirical analysis of the research will primarily investigate volatility and trending in Bitcoin/USD and Rand/USD closing prices, implementing unit root testing models, in order to test for properties of stationarity and non-stationarity. Conversely if a time series reveals characteristics of long run mean reversion, the time series will be regarded as stationary. If a time series contains characteristics of large deviations from the long run trend, the time series is regarded as non-stationary and possesses a unit root. The unit root models implemented will be the Augmented Dickey-Fuller test and the Kwiatkowski, Phillips, Schmidt and Shin test.

The ADF test identifies for stationarity and non stationarity in a data time series and utilizes two or more lags to provide a result of greater accuracy (Zivot & Wang, 2003). In addition the most common test applied for stationarity is the KPSS test which is implemented to complement the ADF test. The KPSS test implies the hypothesis opposite to the ADF test. The null hypothesis (H_0) infers that the time series exhibits stationarity. Therefore the alternative hypothesis (H_1) represents non-stationarity (Arltová & Fedorová, 2016:52).

As a section of the study emphasizes the importance of measuring volatility, the model referred to above as the ARMA(p,q)-GARCH(1,1) model, will be employed to analyse the time series. One of the properties of a financial asset is clustering, which indicates that no consistency can be observed over time. With the study set out to test for volatility in a time series, this model will be ideal for testing the level of volatility for each time series. The ARMA(p,q)-GARCH(1,1) process is a combination of two models- the Autoregressive-Moving-Average (ARMA) model popularised by Box and Jenkins (1976) and the

Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model introduced by Bollerslev (1986). To provide a full understanding of the origin of the combination ARMA(p,q)-GARCH(1,1), Chapter Three will discuss the ARCH, GARCH and ARMA models in finer detail.

There are many extensions of the GARCH model and one which will be focused on is the ARMA(p,q)-GARCH(1,1) model. Box and Jenkins (1976) popularised the multivariate ARMA model which is favoured for its simplicity and uncomplicated implementation and being applicable only for stationary time series. The ARMA is a combination of an Autoregressive process AR(p) and a Moving-Average process MA(q). The AR(p) process explains the momentum and mean reversion effects, whilst the MA(q) process captures the shock observed in the error terms, thus enabling the ARMA model to capture both these effects when modelling a time series. However before implementing the ARMA(p,q)-GARCH(1,1), an Autoregressive Conditional Heteroscedasticity (ARCH) effect test will be conducted to confirm that the ARMA(p,q)-GARCH(1,1) is a suitable model to be implemented (Nugroho & Simanjuntak, 2008).

1.8. <u>Chapter Scope</u>

Chapter One will provide an introduction to the research topic and a background to the intended research along with an explanation of the significance of the research, methodology, scope and objectives of the study and the research hypotheses.

Chapter Two, the literature section of the dissertation, begins with providing a background to monetary policy, followed by an explanation of why cryptocurrencies were introduced. The chapter will also offer cases and reasons why and where cryptocurrencies have not succeeded and how traditional and contemporary monetary authorities have reacted to the introduction of cryptocurrencies. An overview is also provided of how cryptocurrencies work. The chapter will conclude with an explanation of the functions served by cryptocurrencies, their legality and the purpose they serve.

Chapter Three describes the data and methodologies implemented in the research study. It will explain the data sources employed in the study and in addition, the time frames of the data sourced. The econometric methodologies implemented while conducting the research will also be documented in detail.

In Chapter Four the quantitative results from the methodologies will be explored and an analysis conducted on those results. The results will be summarised in this chapter in order for conclusions to be drawn in the final chapter.

A summary and conclusion regarding the study will be provided in Chapter Five. Knowledge gained from preceding chapters will enable the reader to draw summarised conclusions and further provide some recommendations. In addition, conclusions will be drawn on whether or not cryptocurrencies fulfil the traditional functions of money and what effect cryptocurrencies have on the existence and implementation of traditional monetary policy. Finally, the possible future of cryptocurrencies will be considered as an exercise in predictability.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

It has been 27 years since the first development of a digital currency in the form of DigiCash designed by David Chaum (1983) which was introduced in 1982. In 1998 his company declared bankruptcy. However more recent developments have included cryptocurrency which was the first global digital currency that achieved widespread adoption. This changed the way the world saw money. The evolvement and development of digital currencies, resulted in the emergence of cryptocurrencies, which could potentially pose a threat to currencies controlled by monopolistic central institutions. This dissertation will make reference to one cryptocurrency throughout, namely Bitcoin, juxtaposing it with the origins and definition of money. It will further discuss the limitations of central banks in conducting monetary policy and the traditional functions of money will be explained in reference thereto. To understand the capacity of cryptocurrencies such as Bitcoin fulfilling the functions of money, this dissertation will examine Bitcoin's potential to fulfil the three main functions of money. The dissertation will conclude with a case study on Venezuela. It is important to reiterate that the reason for only focusing on Venezuela is due to the country's recent experience of a financial crisis occurring as it did in the age of cryptocurrency.

2.2. Definition and Origin of Money

Definitions of money proliferate. The economist from Chicago School, Milton Friedman defined money as "money is what money does" (Bain and Howells, 2003:27). Thereby money is defined by the functions it performs. One can also say that money buys goods and goods buy money; however goods do not buy goods. In Economics money is defined as an asset which functions as a generally accepted medium of exchange or anything that is generally accepted as a form of payment for goods or services or repaying of debt (Mishkin, 1992:7).

Pham (2017) traced the first introduction of money to the 5th century, invented by King Alyattes in Sardis, Lydia (known as Turkey today). Since then the material form of money has changed considerably. In barter trade the surplus of one commodity served as a medium of exchange to obtain another commodity in short supply. The "money" of the time was thus something tangible and visible. When coins and banknotes eventually replaced the barter of one commodity for another the money of the time remained likewise tangible and visible.

In modern times money assumed the form of banknotes and deposits at banks and other financial institutions. Whether it is a tangible object or a computer entry, the money of the time needs to be something people are prepared to accept for the value it represents. Money serves as an exchange element of all financial transactions that take place amongst individuals where the double coincidence of wants does not exist to the extent that a trade transaction cannot take place. Traditional elements used in trade transactions include a combination of notes, coins and negotiable instruments such as promissory notes, cheques and electronic transfers of bank deposits for common commercial transactions. Notes and coins are issued by the State, which obliges individuals to use a certain currency in a particular area. This form of money is regarded as fiat currency. A country either has its own fiat currency or it adopts a fiat currency of another country. One feature which all fiat currencies share in common is that they operate on the principle of trust.

Bain and Howells (2003:3-6) indicate the various definitions given to the term ‘money’, defining it similarly in a functional way. One can define money purely as the value seen in the eye of the beholder. That value depends on the confidence of the person using it with reference to the three traditional functions of money. Money is otherwise defined as a part of an individual’s wealth. This interlinks with the economist’s definition of money, whereby money is seen to be used as a commerce form (the exchange of goods and services) and to be the most liquid form of wealth. Money is also defined as a generally acceptable form of asset used as payment for goods and services and so a transaction can occur without the physical exchange of assets through the use of debit cards and cheques. Friedman and Schwartz (1970:16) stated that money is a temporary abode of purchasing power. Therefore any asset seen as an acceptable means of payment acquires purchasing power from the initial day the individual became the owner of that asset until the day the asset is used in a transaction to purchase a commodity or service.

2.3. Evolution of Money

In the world today, money has become a high-tech exchange system and money forms have developed closely in connection with technological developments in economies and society.

As economies have become more complex, money has followed suit to adapt to the different economic circumstances.

The term money originates from the Latin word 'Moneta'. It was a title provided to two goddesses, the goddess of memory Mnemosyne and an epithet of Juno known by Juno Moneta. The term 'Moneta' in English, Russian and Italian is associated with the word 'coin'. As mentioned earlier the introduction of money occurred in the 5th century, invented by King Alyattes in Sardis. Before this time the barter system was in existence where money was referred to as commodity money. People engaged in exchanges of merchandise for merchandise. Across the world different commodities were used by different countries and within different cultures and according to the economic standard of the society. Societies determined the value of the commodities according to the intrinsic value they held. Common examples of commodities used in barter included animal skins, livestock, tobacco and shells. However any commodity in demand could be exchanged for something someone else supplied. These commodities were seen in the same way we see money today. However difficulties existed in determining the value of commodities. In addition, certain commodities were unable to store their value as they became easily perishable (Alhassan, 2008:7). This led to the introduction of precious metals (gold, silver, copper or tin), as a form of payment. Each of these metals grew significantly in value as a result of their divisibility, ability to be easily transported and not to perish as easily. In addition, metals needed to be weighed, divided and their quality assessed. This resulted in King Alyattess manufacturing the first rounded coin in the 5th century. These gold coins were promptly accepted as a convenient method of exchange as they sought to have intrinsic value. Gold coins were melted in order to earn more from the coin. As gold became more scarce the value of gold increased. The gold content of the coin became worth more in the gold trade than its face value as a coin (Alhassan, 2008:8).

During the late 18th century gold became a common medium of exchange and was regarded as the era of the Gold Standard. Goldsmiths were sought after as people where gold could safely be deposited for safekeeping. In return the depositors were given a receipt; these receipts issued to the depositors of gold became negotiable instruments, the birth of what we know as banknotes. The intention of the gold standard was so that people could trade the paper money for actual gold, thus the receipt (represented by money) was backed by the gold. In 1914 with the onset of World War one, money was needed to print in order to compensate for the military, leading to many countries abandoning or suspending the gold standard. However, abandoning gold resulted in hyperinflation, decreasing the value of domestically produced goods thereby reviving the gold standard in 1945. The return to the gold standard generated a period of stability, but in addition, also deflation. Countries realised that backing currency with gold brought stability to a currency (Alhassan, 2008:8).

The ending of the gold standard led to the development of bank notes which were issued by central banks. As gold's demand increased the convertibility of bank notes for gold declined. This led to the advancement to fiat currency. Fiat money is an inconvertible currency by which the value is backed by the issuing authority which has declared it as legal tender. Fiat currency was based on the trust placed in the government that issued the currency. Fiat money differs from commodity money which is backed by a physical commodity such as silver or gold. The term 'fiat money' is a Latin term which means 'it shall be'. Fiat money does not hold intrinsic value and is only used as a means of payment. Its real value is derived from demand and supply of the commodities for sale (Hall, 2015).

2.4. Functions of Money

According to Alhassan (2014:9) money is seen as a commodity, the purpose of which is to facilitate the exchange of goods and services. The Greek philosopher Aristotle identified four characteristics to qualify an object as 'money'. Money he insisted, must be durable, portable, divisible and must have intrinsic value (Franco, 2015:21). Jevons was the first to describe the functions of money in 1875. He defined money having four distinct functions which include medium of exchange, unit of account, store of value and standard of deferred payment. However the Austrian school of thought believed in a single function of money which is medium of exchange (von Mises, 1981).

This dissertation will discuss four functions of money, divided according to primary and secondary functions. Special focus will be placed on the three primary functions of money namely, money as a medium of exchange; money as a unit of account and lastly money as a store of value. It is important to have an understanding of the core functions of money in order to formulate a model against which to test whether cryptocurrencies can perform such core functions.

- Primary Functions

  The primary functions of money include:

  - Money as a medium of exchange,

- Money as a unit of account, and
- Money as a store of value

- Secondary Function

  The secondary function of money includes:

  - A standard of deferred payments

2.4.1. **Money as a Medium of Exchange**

This is regarded as the most important function of money. As a result of this function many other functions emerge. Money regarded as a medium of exchange will remove the concept of a dual coincidence of wants, for a transaction to take place. It also allows the transaction between buyer and seller of the commodity to be conducted without the requirement of either of them being at the same place or making payment at the same time (von Mises, 1953:34).

By defining money as a medium of exchange, money has to be generally accepted in the exchange for commodities or services. Money becomes the intermediary between the buyer and the seller to complete a transaction. It offers freedom of choice to the buyer. Money simplifies the transaction process by exchanging goods for money. Money grants economic independence and allows buyers to bargain, increasing competition and broadening the market (Alhassan, 2008:24).

Leshoro et al (2014:7) identified a few problems with regard to general acceptance of money. Firstly, what is generally regarded as an acceptable form of money differs from country to country. Another problem area arises with defining money as a medium of exchange, as the word 'exchange' means that an exchange between two people will take place contemporaneously. However transactions can also be conducted on credit. Thus the seller provides the goods or service to the buyer who buys on credit, resulting in payment of the actual money to occur at a later date. Therefore credit is regarded as the intermediary between final exchanges. Credit comes in many forms such as credit cards, bank overdrafts and trade credit to name a few.

2.4.2. Money as a Unit of Account

The second primary function of money is to act as a unit of account. Without money all transactions would have been conducted through means of barter, involving the direct exchange of one commodity or service for another. The barter system is impractical in today's monetary systems, because in order to obtain a particular commodity or service from a supplier, one has to possess a particular commodity or service of equal value, which the supplier desires. Accordingly, money plays an important role in simplifying economic transactions through expressing commodities via monetary unit measures (Alhassan, 2008:25).

A unit of account in Economics is a nominal monetary unit of measure or currency used to represent the real value of any economic item. Money as a unit of account refers to the currency of a specific area, for example, the Dollar in the United States and the Pound in the United Kingdom. The biggest advantage of money as a unit of account is that it provides a yardstick to compare prices. Without such a unit of account it becomes almost impossible to compare the value of goods. Money needs to serve this function, in order for individuals to purchase goods or services of which the value is represented in units of money. Expressing commodities in monetary units eradicates the problem of measuring the exchange value of goods in the market (Alhassan, 2008:25).

Money enables anyone who has it to participate in the market equally. When consumers use money to purchase an item or service they are essentially making a bid in response to the asking price. This creates order and predictability in the market place. Producers know what to produce and how much to charge and consumers can plan their budgets around predictable pricing (Leshoro et al, 2014:9-10).

Further, when money, as represented by a currency, is no longer viable as a medium of exchange or its monetary units can no longer be accurately valued, predictability is lost and along with it, all ability to plan and to gauge supply and demand. In short the markets become volatile, prices are driven up for fear of a lack of security and uncertainty, and supply is diminished because of hoarding behaviour and the inability of producers to replace supplies quickly enough. Therefore currencies serve an important role in economic calculations with regards to estimation of costs and profitability in projects (Alhassan, 2008:25).

2.4.3. <u>Money as a Store of Value</u>

Commodities, currencies or capital which are tradable can be stored for future use without deteriorating or wasting. They are fundamental components of the economic system as they allow trade to occur with items that have inherent value. As mentioned before, with money serving this function the individual owning the money gains purchasing power until the money is spent. What makes money serve this function is the fact that it is an asset that can be exchanged, saved and retrieved in the future. What gives money its store of value is its demand for the underlying asset. Money's liquidity also contributes to it serving this function as it can easily be exchanged for goods or services. (Alhassan, 2008:26).

Metals such as gold which were utilised as exchangeable commodities in earlier times, store their value based on unique physical characteristics. Firstly, gold is chemically stable. Secondly gold as a natural element is impossible to synthesize from other materials and can only be extracted from its unrefined ore, which is extremely rare. For these reasons, supply of gold is predictable and the price is determined by its supply and demand.

There is an important link between price stability and the store value function of money. If people struggle to believe that an asset can serve as a store of value, so will they struggle to accept it as a means of payment. Money serves the function as a store of value which is determined by the demand in an economy which in turn is affected by the level of inflation. If the general price level rises, measured by a commonly agreed index, a situation known as inflation will occur. Inflation will result in one's purchasing power declining, and therefore the value of one's money decreasing. Individuals will demand more money to spend, as future money is perceived to lose purchasing power as a result of the inflation and decrease in the amount of money being saved. Therefore with general price stability comes an increase in confidence to hold assets such as currency (Leshoro et al, 2014:8).

If money is seen to serve as a store of value it also serves as a way of storing wealth. Money is however unique in terms of its liquidity. So far, for money to be seen as a medium of exchange, money must hold its value over time. As a store of value, money is not that unique. Many other stores of value exist such as land, art and stamps. Money may not even be the most desirable store of value because it depreciates with inflation. However money is more liquid than most other stores of value because as a medium of exchange it is readily accepted everywhere. Furthermore money is an easily transported store of value that is available in a number of convenient denominations (Leshoro et al, 2014:9). Money as a store of value is compared with the analysis of cryptocurrency as a store of value, as considered under heading 2.7.2 below, with specific reference to Bitcoin data.

2.4.4. Money as a Standard of Deferred Payments

This function simply means money simplifies all credit transactions. These include borrowing by consumers, borrowing by firms and banks, buying and selling of shares, debentures and securities. It simplifies the taking and repayment of debt, because the unit of account is durable. In this regard money defines the value of the debt at the time of the repayment. Debt or assets are indicated by their values fixed as at a specified date. However price fluctuations result in money being a poor unit of account for transactions requiring deferred payment, because as a debt increases over time creditors will gain through value exaltations and debtors will face higher repayments on the loans to their detriment. To overcome or manage this problem contracts are concluded fixing the current purchasing power of the buyer in the future (Alhassan, 2008:26).

It is important to understand how central banks influence both the demand and supply of money through the use of instruments and regimes available and imposed by them. The functions of money mentioned above are regulated by a government monopoly most likely situated in the central bank. It therefore is necessary to present a brief overview of central banks. This will facilitate a focus on the eventual relationship between central banks and cryptocurrencies. The origins and roles of central banks and an outline of the tools utilised by central banks in order to achieve stability in the economy will be discussed. Central banks impose monetary policy in order to exert certain controls and measures such as economic growth, inflation through inflation targeting and interest rates in an economy. These influences will be pondered later when counterpointed with conceivable comparable cryptocurrency influences.

2.5. Origins and Roles of The Central Banks

This section of the dissertation will examine central banks with respect to the importance of their origin, role and the effects they have within an economy. This aspect is important as central banks are the controllers of money and implement monetary policy in an economy, so as to maintain stability. This section will in brief give a background of central banks and the monetary policies they implement with special reference to inflation targeting. In addition it will investigate the negative impact of central banks' control over currency in their economies. This is imperative when comparing the control nature of central banks with the decentralised nature of cryptocurrencies.

Central banks' genesis began in 1647. Dutch financier Johan Palmstruch opened a private bank known as Stockholm's Banco. The bank issued banknotes in exchange for copper and silver. Banknotes became a popular commodity to own; however, due to the lack of the enforcement of rules limiting loans issued by the bank, Stockholm's Banco's loans surpassed the value of copper and silver held by the bank. Society began to lose confidence in the banknotes and their demand declined. In turn their value fell. The bank was unable to meet the demand to exchange banknotes for copper or silver, resulting in the first Swedish banking crisis. This paved the way for the first central bank to emerge in 1668, later to become known as Riksbank. Since then, many central banks have emerged across the world (Orszag, 2018).

In South Africa, the South African Reserve Bank (SARB) was established in 1921. Prior to its establishment, the gold price in the United Kingdom (UK) rose above that in South Africa, resulting in South Africans converting banknotes into gold so as to profit by then selling the gold in the UK. This led to commercial banks buying gold at higher prices in the UK than the price received in South Africa to convert banknotes for gold (to provide backing for banknotes in South Africa). It was referred to as the 'obligation to trade a loss'. This posed a threat to financial stability, causing commercial banks to request the Government to release them from issuing banknotes for gold on demand. This state of affairs precipitated the convening of the Gold Conference in 1919. Recommendations from the conference were to establish a central bank acknowledging responsibility for issuing banknotes and retaining the gold held by commercial banks. The South African parliament accepted the recommendations leading to the creation on the SARB in June of 1921 (Rossouw, 2009).

The role of central banks according to Paiman Ahmad (2016) is to serve in facilitating and provisioning efficient supplies of money in the economy and determining how much the economy needs. One of the criteria for assessing the performance of central banks is the degree of independence from political interference they enjoy. Their role differs amongst countries depending on economic conditions in that particular country. Developing countries' central bank's focus is on promotion of sustainable economic development, achieved through the implementation of instruments and procedures such as:

- Open market transactions;

- Repurchase rate and discount rate; and
- Cash reserve requirements.

However developing countries are constricted in their ability to implement certain instruments mentioned. On the other hand developed countries' central banks are exposed to more tools than central banks in developing countries. Ahmad (2016) states that developing nations' central banks struggle to become independent from political interference. Governmental influence in the business cycle can lead to misguided interventions resulting in economic recession. In observing that governmental interference in the central bank in any country (developed or developing), can drive an economy into recession, this is not to deny the obvious wisdom of incorporating proper oversight and controls.

The central bank serves numerous functions in order to facilitate, oversee and control indicators in the financial system. It acts as a monopoly and has three common important functions. The main function is to achieve monetary stability through formulating and applying monetary policies. Secondly, to entrench supervisory and regulatory functions (Ortiz, 2009:28-36). Other functions include the issuing of currency, controlling credit and money supply and acting as a banker to the Government and as a clearing house**.** Central banks then, self-evidently play an essential part in a country's financial and economic system (Amadeo, 2018).

In summary, functions of the central bank include:

- Achieving monetary stability through influence over credit and money supply;
- Issuing of currency;
- Acting as an advisor and banker to the government; and
- Acting as a clearing house.

All central bank functions can be filtered down to three core functions according to Kashkari (2016)(President and CEO of the Federal Reserve Bank in Minneapolis), namely; to create long term monetary stability; to respond to economic shocks; and to influence short term economic performance and activities. Ensuring and maintaining a stable monetary environment is important in any society as this serves to ensure inflation stabilization (Kashkari, 2016). This leads to the next section explaining the most popular monetary policy approach by central banks in securing inflation stability in order to protect the value of a currency.

2.5.1. Inflation Targeting

Economists and central bankers have shown greater interest in inflation targeting as a new approach to monetary policy. According to Bernanke et al. (1999:20-22) inflation targeting is a framework for monetary policy which is characterised by a public announcement of the official quantitative targets for the inflation rate over a certain period of time. New Zealand became the first country to launch such a policy in 1990, prompted by its poor price stability track record during the 1970's and 1980's. In 1986 officials were requested by the Minister of Finance, Roger Douglas, to explore options to reform New Zealand's monetary framework with the aim of reducing inflation through reduced political influence. Their recommendations resulted in the adoption of an inflation targeting approach negating political influence.

Under inflation targeting a central bank publicly pre-announces an inflation target that it is determined to achieve. This involves the active and direct advanced detection of inflation expectations. Central banks use a monetary committee to determine the stance of monetary policy based on a consideration of a series of factors and the effect of these factors on future inflation. Such a decision-making scheme involves the use of much more information than merely the exchange rate or monetary aggregates. The regime covers the labour market, import prices, producer prices, the output gap, nominal and real interest rates, public budgets, and the nominal and real exchange rates (Amadeo, 2018b).

The first step would be the announcement of a numerical inflation target statement by the central bank or government of a country. Although central banks jointly decide with the government on the targets for inflation, they are independent in choosing the most appropriate monetary policy instruments. The announcement should indicate the path by which the central bank or government will attain price stability which is the ultimate goal towards the second step. Price stability is the main objective of the monetary policy. Thus inflation targeting plays a pivotal role in achieving sound monetary policy. When the monetary policy is based on an inflation target, no other possible targets such as fixed exchange rates or a specified growth in money supply are used. However given the key role that the central bank's inflation target plays in a monetary policy, the forecast itself can be thought of as an intermediate target. The experience of countries adopting inflation targeting seems positive. This occurs as a result of the flexibility authorized and conferred upon the central bank. However this comes at a cost, as instability can arise in policy formulation in employment, output and real exchange rates, as such macro-economic variables reside outside the scope of the central bank (Leshoro et al, 2014:190-191). If the inflation rate is set to rise above the rate targeted, the central bank will increase interest rates to reduce the demand for credit as the cost of borrowing funds has increased. By increasing interest rates, the inflationary pressure is reduced (Beggs, 2017).

For many years the main criticism of formal inflation targets has been the fact that for example, unlike the exchange rate or narrow money, central banks have incomplete control over inflation. Factors beyond their control such as the labour market conditions can have short term effects on inflation (known as cost-push inflation). Central banks then struggle to keep inflation within the target range. It is important for central banks to consider and analyse all information that could affect the desired inflation target in order to get as close as possible to the desired target (Leshoro et al, 2014:192).

The advantage of inflation targeting similar to monetary targeting is that it entitles monetary policy to respond to domestic shocks. A key advantage similar to that of exchange rate targeting is its transparency to the public. Inflation targeting provides enhanced clarity of the objective of monetary policy which is conducive to sound planning in both private and public sectors. Other advantages include providing a framework for improved accountability of central banks and acting as an anchor for inflation expectation, as also price and wage setting, thus reducing the friction which arises from widely divergent inflation expectations (Leshoro et al, 2014:192-193).

Nevertheless there are numerous issues with regard to central banks which have a bearing on the theme of the dissertation. These issues are discussed below under paragraphs 2.5.2 and 2.5.3. Central banks should be independent although they have often become exposed to governmental influence. These sentiments correspond with renowned economist Milton Friedman's viewpoint of central banks vs. modern central banks.

2.5.2. <u>Friedman's Views on Modern Central Banks</u>

Milton Friedman, American economist and Nobel laureate, played a significant role in the evolution of monetary policy. He recorded in an interview that a drastic change within the monetary system had occurred on August 15, 1971, when Richard Nixon ended the Bretton Woods International Monetary Systems. This ended a monetary system which had prevailed since the origin of money where commodities with a certain value attached to them were used. Since this date no national currency in the world has been based on a commodity system.

Friedman reshaped monetary policy through his presidential address, delivered in December 1967 and published in March 1968 by the American Economic Review (Cochrane, 2013). A presidential address to the American Economic Association is generally regarded as a remarkable occasion, granted to individuals who have been honoured by the broad economic profession. Milton Friedman's presidential address "The Role of Monetary Policy" laid the foundation for the monetary policies of today. The year 2017 marked the 50^{th} anniversary of this presidential address.

Friedman's views on monetary policy and what central banks' targets should be, have however, eroded somewhat over time. As mentioned before, Friedman (1968) stated that central banks' targets should be the growth rate in monetary aggregates, as he saw the function of monetary policy to represent price stability. In modern times price stability remains the focus of monetary policy, however central banks have shifted their focus to instruments such as inflation targeting and factors such as interest rates. Countries have selected their levels of inflation according to how quickly they want it to be achieved. Friedman believed that it would be difficult to achieve price targets. Nevertheless countries have been successful in hitting targets. Another shift in focus from monetary aggregates has been the nominal interest rate. The notion of modern central bankers having control over a pre-determined interest rate (which in turn affects other interest rates), has persuaded countries to embrace interest rates as the important policy tool.

A recommendation by Friedman was to implement strict rules guiding monetary policy; nevertheless very few modern central bankers have adopted a strict rule for monetary policy. They have instead found other ways to show transparency, through public speeches and publishing of reports to justify actions (Blinder et al., 2008). The lack of strict rules has provided central banks with flexibility in interpreting inflation targets, thus, allowing deviations from set targets. Friedman (1968) stated that "too late and too much has been the general practice", meaning that the monetary authorities were too impatient for the full effect of monetary policy actions to impact the economy. Modern central bankers have agreed with the statement however, through the adoption of 'inflation forecast targeting' meaning the development of policies in order to bring the forecasted inflation towards the target (Woodford, 2007).

One of the biggest contrasts between how Friedman viewed traditional central banks compared with those that exist today, is the actions of the central banks during times of recession. Friedman believed monetary policy was limited in assisting to offset major disturbances in the economic system. The contrast became evident with the actions of the US Federal Reserve during the 2008 financial crisis. To prevent banks from collapsing, the issuing of emergency credit and raising bank reserves were actions taken by the central banks to ensure that the money supply (M2) did not deteriorate. Friedman would undoubtedly have approved of this step. The Federal Reserve also paid considerable attention towards interest rates and implementing quantitative easing policies, which arguably prevented a collapse and assisted in the economy's recovery, particularly by resisting Friedman's sceptics regarding monetary policy's ability to respond to disturbances (Mankiw & Reis, 2017).

2.5.3. The Negative Effects of Central Banks

Central banks have a significant influence on the financial systems of their countries through the implementation of payment systems. The biggest problem however, is that central banks exercising monopoly powers create money artificially out of thin air, so to say, not utilising a reserve banking method. Monetary policy implemented by central banks, consists of a system of instruments, regimes and procedures at the disposal of the central authorities, such as governments or central banks, aimed at managing the level of liquidity (money supply) in the respective economies (Amadeo, 2018a). This system consists of policies to provide either contraction or expansion. A contractionary policy will reduce the size of the money supply or increase interest rates in the economy. An expansionary policy increases money supply and reduces interest rates in the economy. Furthermore, monetary policies are considered to be accommodative, neutral or tight, depending on the relative intentions of the central authorities (Leshoro et al, 2014:201). Such policies include open market operations, changing reserve ratios and discount policies which manipulate interest rates to control money supply.

The control over the supply of fiat currency by central banks enables them to manipulate price signals. The distortion of price signals through manipulation of monetary tools according to Morgan (2009) may be the cause of bubbles compelling economies to endure financial crises. As price signals influence consumers' behaviour in the market place, prices should ideally be determined by demand and supply. However the influence of central banks through the setting of interest rates distorting the market, results in the market either experiencing a surplus or a shortage. Therefore politics and governmental influence in the market can result in monetary mistakes from which countries can take years to recover. Such mistakes are becoming more and more frequent for example, Venezuela which will be elaborated upon further in the chapter, under heading 2.9 below.

Another point to note is the extent to which central banks can become a hazard to the financial economy of the country through the control of printing money. Printing more money does not generate economic growth or output necessarily. It is actually an illusory action. If the central bank decides to increase the supply of money in circulation, this would result in inflation if output does not increase correspondingly. When output remains constant and the amount of money in the economy increases, goods and services become more expensive. The illusion is simply predicated upon the false belief that more money of the same value is available, whereas the consumer is actually worse off as prices for goods and services have increased (Pettinger, 2017).

When an economy is experiencing inflation it in turn undermines the purchasing power of consumers and their ability to save. Therefore the medium of exchange function is adversely affected as well as the store of value (Morgan, 2009). This becomes relevant as to whether cryptocurrencies suffer the same problems. In this, it is important to discuss how central banks function to protect the value of their currencies.

It has become clear that central banks and governments have the significant influence within economies through instruments, regimes and procedures. Through mismanagement of policies and central authorities agenda, has lead to not always acting in the best interest of the economy. This raises the question could cryptocurrency's decentralised nature pose a significant threat to controlled fiat currencies?

2.6. Cryptocurrency

The second section of the literature provides a short introduction to the origin of cryptocurrencies. In order to gain a clear understanding of cryptocurrencies, an examination of the differences between cryptocurrencies and fiat currencies with respect to money supply, regulation and taxation, and pseudonymity is necessary. The objective of this section is to provide an overview of cryptocurrency and to investigate whether cryptocurrencies meet the three core functions of money. The section will also identify and explain the drawbacks that potentially restrict cryptocurrencies from becoming a global currency. The section will conclude with a case study on Venezuela.

2.6.1. Origin of Cryptocurrency

Braudel (1992:9-10) believes that money is able to establish itself wherever and that it could change its shape but not its function. In the world today people are induced to talk about money and show its various shapes. In November 2008 Satoshi Nakamoto published details of the first established cryptocurrency (Bitcoin) which has since become the topic of the day. The rise of Bitcoin came after a period of economic unrest and the criticisms on monetary governance. Nakamoto (2008) believed the world was in need of an innovative alternative exchange system, to that which existed.

It was the first development of a Peer-to-Peer Electronic Cash System. In the publication the 43 year old Japanese citizen, introduced and described the ground-breaking design of a cryptocurrency system. He provided a solution to the problem of double spending which presented a flaw within digital cash schemes where tokens could be spent more than once. Nakamoto's development drew considerable attention due to its decentralised characteristics and evolved technology applied. The view held by Dabrowski & Janikowski (2018:6) is that Nakamoto's drive behind the revolution of the world's first cryptocurrency came about as a result of frustration shown towards third parties (banks and financial institutions) exerting unfettered control over all transactions. In consequence, Nakamoto developed a currency that is decentralised in nature thereby removing any third party involvement over transactions so as to generate a more liberal market (Dabrowski & Janikowski, 2018:6). Nakamoto referred to the system as a trustless system which has become a resonance widely. Bitcoin became the first decentralized (no central authority) Peer-to-Peer electronic payment system and spawned the debate around whether such technology advancements could render central banks obsolete. Before Bitcoin, online transactions differed in the sense that a trusted third party facilitated the concluding of the transactions. Nakamoto developed a futuristic digital currency by harnessing the financial system aimed at generating a global adoption that would in time become a substitute for sovereign fiat currency (Hodge, 2018).

Milton Friedman mentioned in an interview in 1999, that "The one thing that's missing, but that will soon be developed, is a reliable e-cash, a method whereby on the Internet you can transfer funds from A to B, without A knowing B or B knowing A." Nine years later the prescient idea of Friedman came to fruition through Nakamoto. In addition Friedman mentioned that such a form of money would enjoy the characteristic of anonymity (Ljung, 2013).

The popularity of Bitcoin rose due to the nature of its characteristics. Being decentralised and operating with no central authority control, its protocol allows no interference and operates using cryptographic proof of authenticity. All transactions are recorded on a public ledger known as the 'blockchain'. The underlying technology 'blockchain', moves away from a centralised controlled system, providing a decentralised underlying trusted digital ledger system, exhibiting immutability and transparency - much needed attributes in struggling monetary systems. With no trusted third party, all transactions are verified by network nodes or 'miners' who are compensated for verifying each transaction. (Dabrowski & Janikowski, 2018:6). The first Bitcoin transaction conducted was valued at $0.07. To date of writing the dissertation the total market value of Bitcoin was just under $60 billion with 17.5 million Bitcoins in circulation (Coinmarketcap, 2019).

Cryptocurrencies, and more in particular Bitcoin, have been labelled as potentially the first ever existing global currency. However some believe Bitcoin to be just a fad passing through and will become valueless (The Economist, 2015). Paul Krugman in particular, believes the latter and in an article published in the New York Times, said "Bitcoin is evil". He argues that Bitcoin cannot be regarded as a currency and it would not be successful (Krugman, 2018). Whether such a characterisation within the product of Keynesian thinking, (depicting a resolute opposition to any money not created and managed by the State), one cannot say. Krugman views the shift to cryptocurrency as odd, given that through the broad sweep of monetary history, two clear changes have occurred over time. One has been the reduction in the frictions of doing business, and a second, the reduction in the resources needed to deal with such frictions. For example, gold and silver required strict security and large amounts of resources to produce. All the way to the creation of fiat currency, fewer resources were progressively required for such currencies to be produced. A further shift has been towards credit and debit cards which again required fewer resources. All the development of such monetary modes occurred in order to reduce the complexity and friction involved in consummating transactions. Krugman poses the question why protagonists of cryptocurrency would seek to move the monetary system back 300 years. His reasons for the question are that cryptocurrency transactions require a complete history of past transactions and in addition entail resource intensive mining methods which become costlier by the day. The anonymous nature of cryptocurrencies according to Krugman, decreases the level of confidence in their purchasing power in relation to government fiat currencies. He believes that cryptocurrency systems disregard the developments within the traditional monetary system (Krugman, 2018a).

And so, the question arises where does cryptocurrency fit in and what impact will its volatility have in regarding it as a currency? Yet further, what impact will it have on a monetary system?

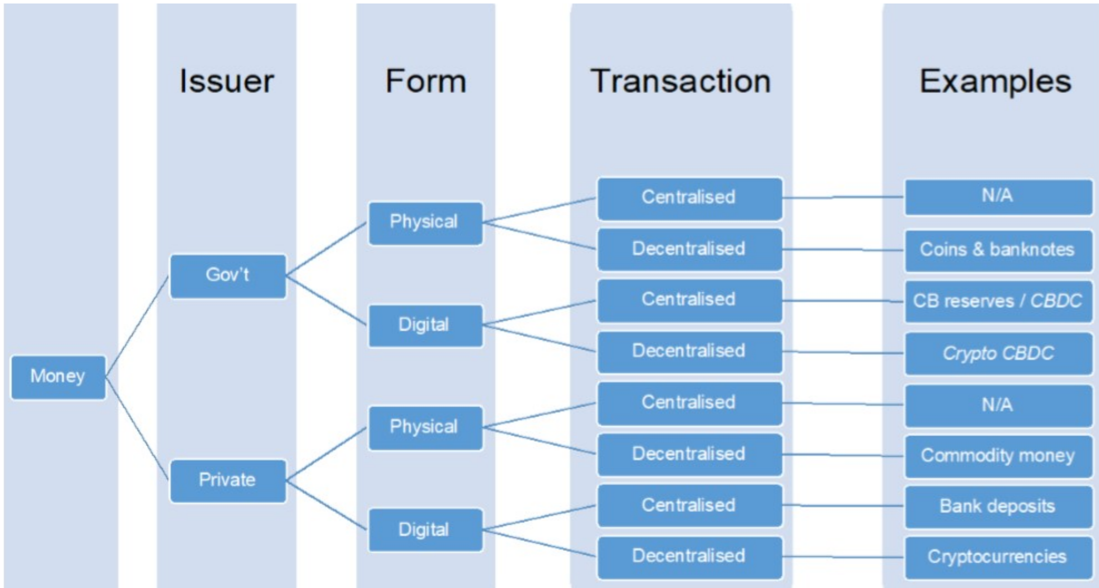
2.6.2. Cryptocurrency vs Fiat Currency

It is essential to draw the comparison between Fiat currency and Cryptocurrency in order to gain an understanding of what real money and cryptocurrencies really are and why they were introduced.

The traditional functions of money have already been discussed, but it is important in reaching a meaningful definition of a virtual/digital currency to examine how cryptocurrency differs from the various other currency forms. Bech and Garrat (2017:57-59) explain money forms according to 3 broad criteria: a) the issuer (being government or private); b) the form it takes (either physical or digital); and c) how the transaction is concluded (centralised or decentralised). This is explained further using Figure 2.1 as an illustration and is explained below.

There are various definitions of what constitutes a cryptocurrency. The European Banking Authority's (EBA), the European Central Bank's (ECB) and the Financial Action Task Force's definitions of what constitutes a cryptocurrency can be summarised as follows:- Cryptocurrencies are unregulated digital currencies with no central authority control attached to them. They are digitally represented and traded, and are accepted by the specific digital community members as a means of exchange. However they do not have legal tender status (i.e. when tendered to a creditor as a valid and legal offer of payment) in any commercial jurisdiction (Dabrowski & Janikowski, 2018:7-8).

Figure 2.1: Different Forms of Money



Source: Bech & Garatt (2017).

According to Figure 2.1 above, one can see that cryptocurrencies represent a form of money which is privately issued and comes in a digital form. The nature of the transaction of cryptocurrencies being decentralised between peers, ensures anonymity of the transaction which in turn ensures relative privacy. This advantage has resulted in an increase in crypto popularity as a form of payment. However the volatility in the value of cryptocurrencies (with respect to Bitcoin) has increased the risk of using such a "currency".

There are some key and significant differences between Bitcoin and fiat currency. These differences include:

- **Money supply:**

A comparison of cryptocurrencies with fiat currencies is important for providing context to analysing cryptocurrencies. Fiat currency being issued through a centralised system means that the money supply is controlled and regulated, and at any given period is controlled by the central authority. This authority alters the amount of money in the economy through the monetary policy tools at its disposal (adjusting interest or discount, open market transactions, cash reserve requirements or quantitative easing). The problem with a monetary policy system is that it raises the issue of the political independence of the monetary authority because populist political pressure may lead to expansionary monetary policy which fuels the fires of inflation (Amadeo, 2018a). To put the supply growths between cryptocurrencies and fiat currencies in perspective, a comparison will be conducted. The World Bank (2018) provides data on broad money growth for 209 countries over the period between 1960 and 2018. The data revealed that of those 209 countries, the average growth of broad money supply was 9.21% for 2018. This is a 0.2% increase from 2017; however since 2008 the average annual money supply growth rate has declined by 7.63%. This decline could be an indicator of the shift from fiat currency to digital currency. The results provided by the World Bank are upward skewed by inflationary periods because during such periods, Wesley (2019) the head editor at CPI Inflation Calculator, believes individuals abandoned their national currencies for international reserve currencies, commodities or gold.

Table 2.1: Selected Countries' Broad Money Supply Growth (1961-2018)

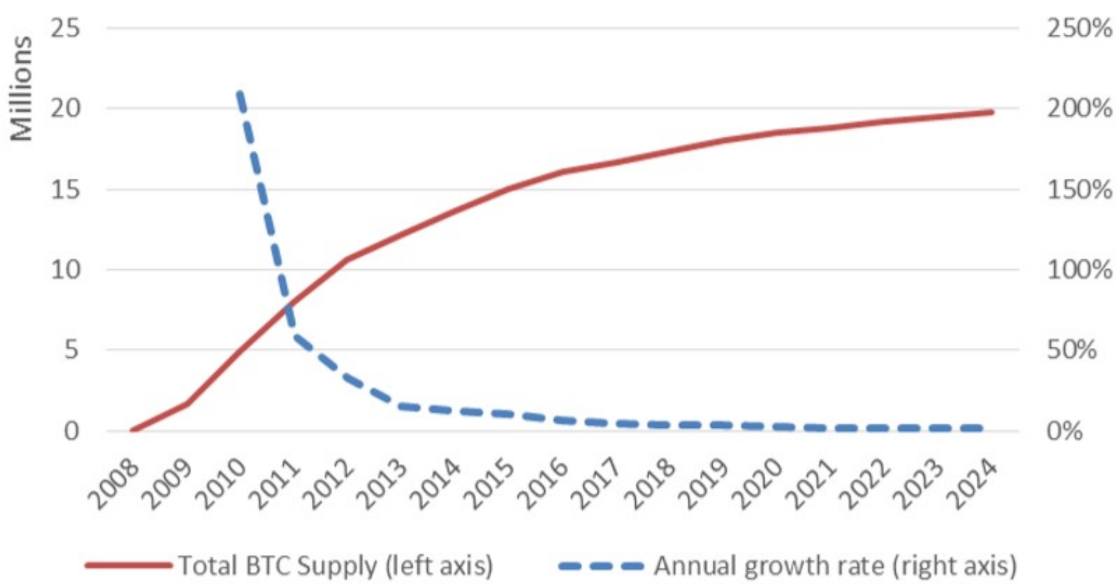
Currency	Average Annual Supply Growth (%)
Australia	10.35
China	20.86
Singapore	11.75
South Africa	13,44
Venezuela	27.62

Source: Researcher's calculations sourced from The World Bank (2018).

The World Bank (2018) data demonstrates that major currencies from developed nations have lower supply growths compared with currencies of developing countries. Developed countries experienced broad money growth rates between 5% and 13%. In contrast, developing economies experienced significantly erratic broad money supply growth rates of between 13% and 45%, reflecting financial instability. The direct link between increasing money supply and inflation leads to a lack of trust in currency controlled by Central Banks. Wesley (2019) considers this could in turn lead to cryptocurrencies being a potential alternative currency in developing economies with high money supply. Certainly, their decentralised nature and fixed supply makes them a viable alternative.

When Nakamoto designed the Bitcoin framework in 2008, the supply of Bitcoins was capped at 21 million digital coins. Although it is believed that Bitcoin creations will continue until 2140, the exact date has not been determined. The supply curve of Bitcoins is illustrated in Figure 2.2. The reasoning behind capping Bitcoin, and the most significant difference between cryptocurrency and fiat currency, is that central bank control the supply of money, which invariably renders an economy vulnerable to inflation. By capping Bitcoin the rarity of the digital coins is enhanced, thus increasing their value correspondingly (Vaidya, 2016). Currently 84,39% of Bitcoins have been mined leaving just over 3000 digital coins left to mine (Buy Bitcoin Worldwide, 2019). Figure 2.2 illustrates a declining Bitcoin supply growth rate as the number of Bitcoins mined reaches the 21 million cap.

<u>Figure 2.2: Supply of Bitcoins (2008-2024)</u>



Source: Ammous, 2016.

Being capped at 21 million means that the model is deflationary which is in contrast with world practices. As more Bitcoins are mined the fewer there will be in the future, thus increasing their worth. Bitcoins' deflationary character could be its biggest downside, posing for its holders the conundrum "do I spend the Bitcoin or do I hold it for future gains which will generate an opportunity cost?" (Vaidya, 2016).

- **Regulation and taxation:**

The most notable difference is that fiat currency is declared by a central authority as legal tender. The central banks controls and regulates the supply of currency in circulation in an economy. Residents in the particular country use the currency issued to conduct payments such as taxes, imposed by governments and payable by law, whereas Bitcoin protocol makes it impossible to emulate, as the peer-to-peer network prohibits any governmental interference. In addition, its pseudonym users are impossible to identify or link to transactions. This has led to the large interest in Bitcoin and other cryptocurrencies. To whatever extent this may advantage Bitcoin, it could also constitute its downfall as the system is prone to abuse, facilitating illegal activities such as fraud, money laundering and payment towards terrorism which is discussed in more detail further along in the chapter (Christin, 2012).

One such reported case of fraudulent activity occurred in an anonymous market known as the 'Silk Road'. This market place facilitated illegal activities that could only be accessed through the dark web that required specialised software. Here, anything could be purchased through Bitcoins which would ordinarily be regarded as illegal in the real world. The market place was shutdown in 2013. Upon closure, in excess of $1.2 million in Bitcoins had been spent. This led to certain countries such as Iceland, Bolivia and China banning Bitcoin. (Santori, 2017).

In many countries the laws are unclear whether or not cryptocurrency exchanges should be taxed. The two most popular tax approaches by countries include income tax or capital gains tax. Countries that tax cryptocurrency as income tax, see cryptocurrencies as earnings through mining or trading, and therefore adopt an income tax approach. However to qualify as income, cryptocurrency transactions must be received as a form of payment for the purpose of making a profit.

The second tax approach treats earnings as capital gains. The reasoning is that cryptocurrencies are seen to be acquired and traded similarly to stocks. Cryptocurrencies are only deemed taxable as capital gains if sold at a higher price than initially purchased. The tax status and regulation of cryptocurrencies in respective countries is discussed below.

United States

The US generally follows the capital gains tax approach, although the view of what is regarded as cryptocurrencies and their exchange differs from State to State within the US. The most common approach is the capital gain tax approach. The Internal Revenue Service

(IRS) and the Securities and Exchange Commission in the US regard cryptocurrency exchanges as legal and regard them as securities. However cryptocurrencies themselves are not regarded as legal tender, meaning that the US does not by law permit cryptocurrencies to be used for payment of public or private debt or to redeem any financial obligation. This makes them subject to capital gains tax either long term or short term depending on the duration of the holding before cashing out. The percentage capital gains tax applicable depends on the user's tax bracket (Paul, 2019).

In April 2019 US lawmakers investigated and posed a question to the IRS on how residents should pay taxes on cryptocurrencies. The lack of tax guidance by the IRS, evident through only one public notice being released, led to the US Congress auditing the IRS in order to serve as a form of protection for crypto users (Paul, 2019).

Canada

The Canada Revenue Agency (CRA) has taxed cryptocurrencies since 2013 according to both tax approaches, depending on the circumstances. Canada treats cryptocurrency as an alternative currency, however it does not regard it as legal tender in the country. Generally the CRA treats cryptocurrency as a commodity, thereby taxing it under the Income Tax Act. In distinguishing the income derived from cryptocurrency the following criteria are provided to assist in identifying under which tax approach they fall; if the disposition of cryptocurrency is of a business nature or part of trade and considered as business income, then the income tax approach will be implemented; if the sale of cryptocurrency is not pursuant to a business, the gains on the selling of cryptocurrency will be regarded as capital gains, thus adhering to the capital gains approach; The tax treatment on the income generated from mining cryptocurrency depends on whether the activity of mining is a personal activity or business activity; if it is business related it will be taxed as such, whereas personal activity will not be taxed.

Cryptocurrencies are regulated under the Canadian Proceeds of Crime (Money Laundering) and Terrorist Act. The Canadian authorities are planning to implement further amendments to the Act in order for it to be applicable to cryptocurrency (Government of Canada, 2019).

Australia

In Australia cryptocurrencies are seen as legal tender and since 2017 cryptocurrency exchanges have been regarded as legal. The Australian government refers to cryptocurrencies as property, thereby making them subject to capital gains tax. Previously cryptocurrencies were taxed under controversial double taxation. The move by the government to capital gains tax indicates its progressive approach. The exchanging of cryptocurrency requires one to register with the Australian Transaction Reports and Analysis Centre in an attempt to enable the Australian government to regulate the market to some degree. Registration requires the production of the user's identification documents, in addition to maintaining records of transactions and reports to the Anti-Money Laundering and Countering Financing of Terrorism (AML/CFT) (Australian Government, 2018).

United Kingdom

Her Majesty's Revenue and Customs (HMRC) department in the UK, does not classify cryptocurrencies as currency or money or regard them as legal tender. The exchange thereof requires registration with the Financial Conduct Authority. Cryptocurrencies in the UK are taxable depending on the activity for which they are used and the parties involved and therefore will be taxed accordingly (Government of the United Kingdom, 2018).

The financial trading of cryptocurrency according to HMRC will be taxed according to the Income Tax Act, similar to the trading of shares and other financial products. If an individual invests profitably in cryptocurrency without trading them, he will be accountable to pay Capital Gains Tax (Government of the United Kingdom, 2018).

As miners are rewarded for mining cryptocurrency, the taxable category depends on the following factors:

- degree of activity
- organisation
- risk
- commerciality.

If the mining activity does not amount to a trade of cryptocurrency the gains from mining will be subject to Income Tax. Mining of cryptocurrencies in the UK since the 2017/2018 tax year, allows a £1,000 tax free income. However any income amount over and above the £1,000 will becomes subject to Income Tax (Government of the United Kingdom, 2018).

South Africa

The rules and regulations regarding cryptocurrency currently in South Africa remain an unclear topic. No clear tax rules have been implemented and the regulations framework is still pending review.

According to a report by South African Revenue Services (SARS) (2018), the normal income tax rules are applied to cryptocurrency gains or losses in accordance with their taxable income. SARS has laid the onus on taxpayers to come forward and declare their gains or losses, with those who fail to do so being subject to interest or penalties (or both) payable in addition to their standard tax. SARS regards cryptocurrencies as a tangible asset which therefore will not be taxed in accordance with a capital gains tax approach or income tax. The SARB sees cryptocurrencies without legal tender status and does not recognise them as electronic money.

With regards to regulating cryptocurrencies South Africa has not implemented any framework as of yet. However the Financial Intelligence Centre, Financial Sector Conduct Authority, National Treasury, South African Revenue Service and the South African Reserve Bank joined in establishing what is known as Intergovernmental Fintech Working Group (IFWG). They proposed that any user of cryptocurrency is required to register with the IFWG and comply with the provisions of the Financial Intelligence Centre ACT. The forming of this group (the IFWG) shows South Africa's intent to explore the crypto-market. However in doing so, South Africa will require a proper regulatory framework for the use of cryptocurrencies. The SARB consultation paper stresses the importance of regulation to enhance the trust of consumers or potential consumers and stability in the market (SARB, 2019). The regulation objectives sought to be achieved by IFWG are listed below:

- To ensure that the financial system and market is safe and efficient;
- To ensure consumer protection;
- To combat any illicit activities using cryptocurrencies (money laundering, tax evasion and terrorism); and
- To minimise the opportunity of regulatory arbitrage (SARB, 2019).

Other countries' legality status regarding cryptocurrencies as legal tender and cryptocurrency exchanges can be found below in Table 2.2.

Table 2.2: Countries' Legality Status on Cryptocurrencies

Country	Legality of Cryptocurrency as Legal Tender	Legality of Cryptocurrency as a Medium of Exchange
China	Not legal tender	Illegal
Estonia	Not legal tender	Legal
India	Not legal tender	Illegal
Luxembourg	Not legal tender	Legal
Malta	Not legal tender	Legal
Singapore	Not legal tender	Legal
South Korea	Not legal tender	Legal
Switzerland	Legal	Legal

Source: Comply Advantage (2019).

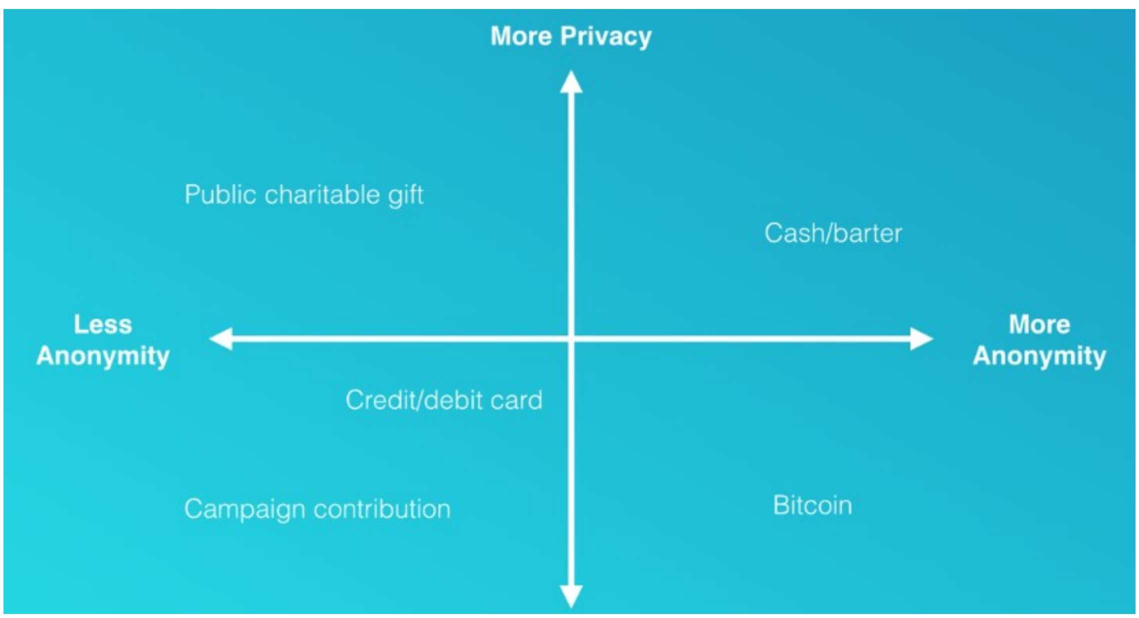
From Table 2.2 it seems clear that the majority of countries in this table do not see cryptocurrencies as legal tender. This could possibly be attributed to governments ensuring that their country's national currencies remain superior to cryptocurrencies. The trading of cryptocurrencies is more diverse amongst the selected countries in Table 2.1, with some allowing it and regulating it and others proclaiming it to be illegal. The reasoning labelling the exchange as illegal could be attributed to an inability of the country to put in place suitable regulations.

- **Pseudonymity:**

A misperception regarding Bitcoin is the general belief that it is exclusively anonymous, as the network is pseudonymous with users operating under one or more pseudonyms. Although this belief is largely true, transactions are not entirely private nor exclusively anonymous. As mentioned earlier, all transactions can be viewed on the public ledger (blockchain) (Reid & Harrigan, 2012). An alias name, under which the user operates, is the public key. This public-private key system functions by linking a person to a private key, used to verify that the individual is the owner of the Wallet (the user's account) when conducting a transaction. All transactions made under that key can be publicly viewed on the ledger. The act of owning Bitcoins remains anonymous as long as the transaction is perfected without physical delivery or communication. However exchanging fiat money for Bitcoins or purchasing goods and services using Bitcoins, requires certain information to be declared such as one's physical identity, an address or a bank account number (Reid & Harrigan, 2012).

This characteristic makes Bitcoin more anonymous than credit or debit cards, however, less private. Payments using one's debit or credit card are not published, but rather kept confidential between the payer and his/her bank. Below in Figure 2.3 is a graphical illustration between Bitcoin, debit cards, credit cards and cash transactions with regards to privacy and anonymity.

Figure 2.3: Illustration of Bitcoins' Privacy and Anonymity to Other Forms of Currency



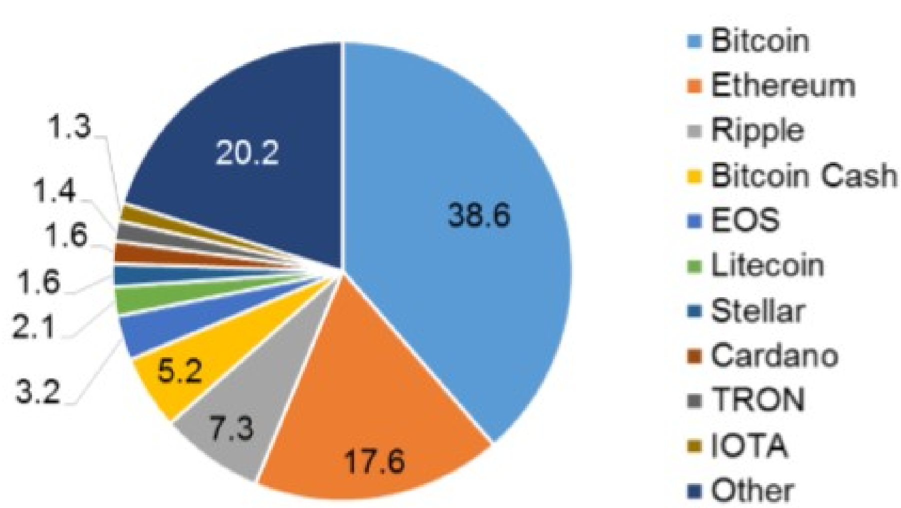
Source: Mazer (2015).

One can thus compare where Bitcoin lies in comparison with other forms of payment. Cash and Barter provide the most privacy and anonymity, whereas debit and credit card payments ought to be the opposite, providing less privacy and anonymity than Bitcoin. Bitcoin falls in between cash and debit and credit cards. As explained, Bitcoin as a payment form is compromised in providing privacy due to the public key attached to a user.

2.7. Cryptocurrencies' Function as Money

Against the functional background of fiat currencies, the question arises whether cryptocurrencies serve those same functions. It is important to reiterate that the reasoning for focusing only on one cryptocurrency (Bitcoin) is due to the paucity of information on other cryptocurrencies. Bitcoin was identified for the study as the largest contributor to the total market capitalisation of the cryptocurrency market, acquiring over 38.6% of the total cryptocurrency market cap (Coinmarketcap, 2018).

Figure 2.4: Market Capitalisation of Major Cryptocurrencies



Source: Coinmarketcap (2018).

Since the world's first introduction to cryptocurrencies, over 1500 cryptocurrencies have been developed, although many have fell in decease. At the end of 2018 cryptocurrencies represented around $330 billion in terms of market value, with Bitcoin accounting for the largest market share of 38.6% (Coinmarketcap, 2018).

To qualify a commodity as money it must necessarily meet the three functions of money explained earlier. With these three functions thoroughly explained, the dissertation will examine how Bitcoin has been implemented and performed under these same functions since its inception in 2008, so as to provide a clear understanding of whether or not Bitcoin and other cryptocurrencies may be regarded as potential future currencies.

2.7.1. Cryptocurrency as a Medium of Exchange

For any commodity, whether virtual, digital or physical, to be regarded as a medium of exchange it has to be generally accepted in society (Alhassan, 2008:24). According to the Austrian school of thought, the primary function of money is to act as a medium of exchange. Von Mises believes that the other functions of money arise from this function of medium of exchange (von Mises, 1981).

Since the advent of cryptocurrencies the vast majority of companies and individuals have not yet explored them as a payment option. Potential reasons why individuals and companies have not yet adopted the technology advancement with specific reference to the function of medium of exchange, include the numerous occurrences of fraud and security breaches, with investors losing significant amounts of money. Perhaps the most significant reason is the volatility associated with cryptocurrencies. With the value of a Bitcoin being unpredictable this could have a negative impact on the financial security of either the holder of the Bitcoin or the company issuing goods and services in Bitcoin. In addition, the stance taken by governments plays a definite role in companies' decision-making in adopting cryptocurrencies. The imposition of taxes on cryptocurrencies is one method for governments to manipulate adoption. These downfalls of cryptocurrencies are discussed in more detail below. Having said that, and as mentioned in Table 2.3, a significant number of companies have shown an interest in the crypto-market which could pave the way for future adoption by more companies, despite government influence in their adoption. Today any person with internet access is able to invest in and purchase the likes of Bitcoin, Ethereum, Litecoin and Dash; however there is only a niche group of goods and services to spend their cryptocurrency on. This has encouraged certain businesses accessing this opportunity to offer crypto-payment services to owners of cryptocurrency within existing monetary systems.

An advantage which cryptocurrencies have is that they offer anonymity while allowing transactions across borders to be cleared and settled quickly with no third party involvement.

This has resulted in a growing number of companies accepting cryptocurrency as a form of payment in exchange for goods and services offered by the respective company. Below, Table 2.3 indicates eight well known companies and the various forms of cryptocurrencies they accept:

Table 2.3: Companies Accepting Cryptocurrencies

Company Name:	Accepted Cryptocurrencies:
Expedia	Bitcoin for online travel bookings.
Overstock	Bitcoin, Ethereum, Dash, Litecoin and Dash
Subway	Bitcoin,
PayPal	GoCoin, Coinbase and BitPay
Microsoft	Bitcoin, users can purchase on Windows and Xbox.
Steam	Bitcoin
Virgin Galactic	Bitcoin
The Dallas Mavericks	Bitcoin, CyberMiles Tokens, Ethereum

Source: Nasdaq (2018) & Cawley (2018).

As Table 2.3 demonstrates, Bitcoin emerges as the leader in adoption of cryptocurrencies as a medium of exchange. With the crypto-market being a niche phenomenon and a recent innovation, this leaves the market open to companies to explore options to improve payment systems.

In recent years the popularity of Bitcoin has risen as a payment option with companies backing Bitcoin as a currency. Examples include companies such as Overstock and MasterCard/Visa.

On 17 July 2018 MasterCard was triumphant in attaining the patent to their technology bid to allow payments to be concluded using cryptocurrency. Previously, MasterCard holders could only make payments using currency declared by governments as legal tender. The patent approved for Master/Visa debit cards allows users to convert their Bitcoins for cash in Euros, Pounds or Dollars. The card is effective in any country and is accepted in all card facilitated stores or for any online purchases. The card is a standard debit card which allows Bitcoin users the convenience of converting their Bitcoins for cash on the card and provides availability for withdrawals at all ATM's. The card comes with its set of benefits and flaws. The benefits include eliminating the inconvenience of moving or exchanging the money first into one's bank account before spending. A significant benefit which attracts many users to the crypto debit card is its anonymity and security of user's information. This benefit is however, offset to some extent by the delayed transaction time compared with fiat currency payments. Fiat currency payments are approved within nanoseconds and thus offer greater security of the individual's funds. The MasterCard crypto transactions could be delayed for up to 15 minutes before being fully processed (Ell, 2018).

Expedia, regarded as one of the world's largest online travel booking agencies, has since 2014 accepted Bitcoin as a form of payment towards any hotel bookings. This payment option is however limited to only hotel bookings although Expedia is looking to expand the payment option towards flights and other activities offered on the online (Nasdaq, 2018).

More recent acceptance of cryptocurrencies has been Facebook, the world's largest social media platform, which has announced the development of its own cryptocurrency 'Libra'. Facebook's entry into the digital market could potentially play a significant role in increasing the acceptance of cryptocurrencies. Facebook developed the Libra currency, as it envisaged the opportunity of enticing its 2.4 billion users, in using this new currency to make global transaction payments (Paul, 2019a).

In creating Libra tokens, Facebook has drawn the attention of the likes of Uber and Visa who have invested into the project. The Libra Association is based in Geneva, Switzerland, and will not be run by Facebook alone, but will be spurred by a collaboration of 28 companies that have shown interest in investing in Libra and becoming part of the Libra Association.

Such companies include Visa, Mastercard, Spotify, Paypal, eBay, Coinbase and Women's World Banking, who all expressed eagerness to take advantage of Libra's open-sourced platform for improving payment efficiency and accessibility, and reducing transaction fees necessitated by sending money abroad. They argued that "moving money around the world should be as easy and cheap as sending a text message" (Yago, 2019).

Facebook also saw an opportunity to generate an income using its social platform through its relationship with 90 million small business owners and 7 million advertisers. With large fluctuations experienced in the largest two cryptocurrencies (Bitcoin and Ethereum), Facebook set out to generate a coin or token that will reduce transaction fees and eliminate fluctuations. In order to align itself with the pseudonymous nature similar to other cryptocurrencies, Facebook is set to launch a subsidiary company named Calibra that will act as a digital wallet to users. Calibra will store all information and financial data. To prevent any fraudulent activities Calibra will implement anti-fraudulent processes that will monitor activity (Yago, 2019).

Libra has certain similar traits as Bitcoin, however differs in the sense that only Libra Association members are able to mine the coins or tokens. The reasoning behind this is Facebook's belief that this will ensure a degree of stability which Bitcoin and other cryptocurrencies lack. Libra also has the upper hand over Bitcoin with its extensive user base and with powerful companies backing Libra and joining the association, Facebook is set to generate an income through interest of money cashed in and held as reserve in their wallets, in turn, ensuring Libra's stability as a cryptocurrency. Libras will be anonymously bought, held or exchanged online, at stores or on the Calibra app. Allied platforms will include Whatsapp, Facebook Messenger and Facebook itself (Yago, 2019).

It is however conceivable that Facebook's plans could potentially meet some resistance as regulators and Banks scrutinise the new currency, especially in the turbulent wake of the privacy court case against Facebook. Questions have been raised by both US lawmakers and regulators in the European Union regarding the regulation of the currency against money laundering and other illicit activities and the way in which users remain anonymous.

Facebook's quest is to gain the trust of the consumer. It has done so by manipulating the trust of consumers through attracting a significant number of large companies in joining the Libra Association, and thus generating an image of support from large companies (Brandom, 2019).

Even though companies have adopted this innovated currency, many still favour receiving fiat currency as a form of payment for goods and services. This becomes notable when one compares the number of Bitcoin transactions with leading fiat currencies in the world, such as the Euro and the Dollar. However the global influences exerted by broad based companies such as Facebook could potentially induce other companies to become involved within the crypto-market. Some factors that influence cryptocurrency as a medium of exchange are discussed below.

2.7.1.1. Lack of Acceptance

Even though there is the potential for cryptocurrencies to be treated as a medium of exchange as noted earlier, the level of acceptance across the world needs to first increase. The likes of Bitcoin have been around for over 10 years and yet only a handful of merchants accept cryptocurrencies as a medium of exchange for goods and services. With the significant fluctuations in Bitcoin as an example, individuals became millionaires overnight, however were limited as to where they could spend their Bitcoins, thus suppressing their value. So in order for cryptocurrencies to be seriously regarded as a medium of exchange they need to gain wider acceptance for example, in retail and food stores. Davis (2011) advanced a relevant example showing what is needed for a cryptocurrency to gain the function of a medium of exchange. He suggested that "We trust that dollars will be valuable tomorrow, so we accept payment in dollars today. Bitcoin is similar: you have to trust that the system will not get hacked, and that Nakamoto will not suddenly emerge to somehow plunder it all. Once one believes in it, whether the actual cost of a Bitcoin is five dollars or thirty, depends on factors such as how many merchants are using it, how many might use it in the future and whether or not governments ban it". So by cryptocurrencies rectifying their shortcomings, they could increase their strength as a medium of exchange. However with the mentioned list of companies agreeing to accept certain cryptocurrencies as a payment source, such a collective intent could spark interest from other companies to follow suit, as their credibility increases.

2.7.1.2. Illicit Activity

Warren Buffet and Charlie Munger have shown little reticence in sharing their opinions on Bitcoin, referring to Bitcoin as, "Rat poison", "worthless artificial gold" and "illicit activity"

(Crippen, 2018). These remarks have been backed by headline articles of cryptocurrencies being cited for providing an unimpeded conduit for financing illegal activities. Cryptocurrencies' distinctive advantage could ironically be their largest downfall, labelling them as exhibiting a dark side. By encompassing the feature of anonymity they have generated the largest unregulated market in the world for the exchange of illegal activities. A study conducted by Foley, Karlsen and Putnins (2018), identified that illegal activity is attributable to 25% of all crypto users. This included 44% (24 million users) of Bitcoin transactions with a value of $72 billion. Illicit activities in the crypto-market include money laundering, fraud and terrorist funding.

Could the crypto-market be the next generation of terrorism financing? There have been numerous reported cases of illicit activities. A report published by CNBC recorded that a women pleaded guilty to transferring $150 000 in cryptocurrency to global terror organisation ISIS in 2017. In Japan alone 7000 cases of suspected money laundering activities were linked to cryptocurrency in 2018 (Mangan, 2018).

A known reported case implicated Ross Ulbricht who created Silk Road, a black market website on the dark web, where illegal transactions take place. On Ulbricht's website all payments were concluded in Bitcoin. Ulbricht was arrested in October 2013 and sentenced to life in prison (O'Neill, 2019).

The security of wallets where cryptocurrencies are stored on exchange platforms is a noteworthy problem within the cryptocurrency network and has been a problem for some years now. In 2014, $433 million worth of Bitcoin was stolen from a cryptocurrency exchange platform MT.Gox. Similarly in 2017, $523 million was stolen from consumer accounts attached to Tokyo company CoincheckInc (Rooney, 2018a). In 2018 a hacker gained access to a resident's Coinbase and Gemini accounts drawing $1 million. Coinbase, an online exchange platform in its "State of Blockchain" report, reflected a loss of $1.6 billion by the end of June 2018 (Rooney, 2018). Other examples of fraud include Benbit, an apparently well known start-up cryptocurrency platform, which perpetrated an exit scam, stealing what was believed to be $4 million from investors. Another incident worth mentioning was a cryptocurrency operator, Pincoin which, via a similar exit scam made off with $660 million of investors' funds. Traders had been promised a not unimpressive 48% return (Osborne, 2018).

2.7.1.3. Government Risk and Regulation

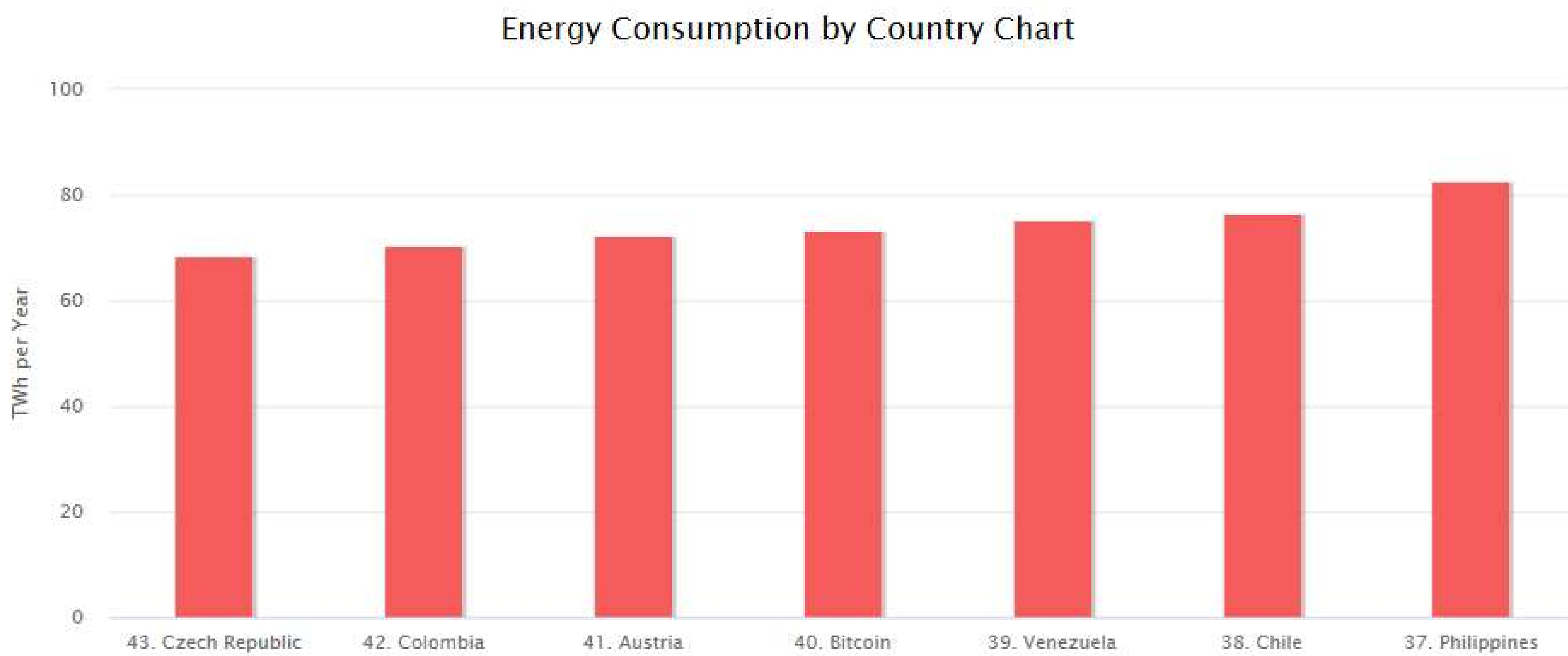
The risks associated with Bitcoin documented earlier in the dissertation, almost certainly account for banks having avoided implementing cryptocurrencies within their systems. In particular, two significant risks stand out. Volatility and fragile security. For example, if banks allowed customers to purchase cryptocurrency using their credit cards in the hope that the value of purchases would appreciate, whereas Bitcoin experienced instead a price drop, the bank would be unable to retrieve its credit.

Bitcoin and other cryptocurrencies do pose significant limitations in their systems and such drawbacks have led to Bitcoin's dubious relationship with the term 'bubble'. The issue of cyber security, where investors have lost millions of dollars, has been of significant concern to the adoption of cryptocurrency within the banking industry. This has led to governments installing regulatory frameworks in order to gain some sort of control over the crypto-market, and the use of cryptocurrencies. As indicated earlier, the stance adopted by various countries intent upon regulating cryptocurrencies, commonly trends towards requiring users to register with some sort of authority in order to control their activity and gain information concerning the users of cryptocurrencies. Reasons advanced for regulating cryptocurrencies include combating illicit activities (further explained below), and protecting consumers and investors against fraud and other abuses and ensuring the integrity of markets and payment systems so as to procure overall financial stability. Another effort of governments seeking to impose themselves upon the crypto-market is through taxation of the cryptocurrency trade, which obviously will diminish the gains from trading cryptocurrencies and could potentially bring a very new market to its knees (Auer & Claessens, 2018).

2.7.1.4. Environmental Impact

The inordinate energy usage by Bitcoin mining has drawn significant attention, especially given the world's concern in reference to climate change. The sheer volume of transactions, increasing to between 350 and 400 thousand per day, has raised alarm amongst the media and environmental economists, because Bitcoin requires algorithms called "proof-of-work" to validate all transactions on its network, through the solving of mathematical equations. This requires miners to commit prodigious computer hardware resources which require astonishing amounts of electricity to operate. By solving the equations miners are incentivised to generate a solid income stream. This has engendered a sense of greed for people to grab a piece of the proverbial pie, leading to the purchase and running of power-hungry mining machines (Smith, 2018). Below one can observe that Bitcoin operation hardware consumes even more energy than certain countries, as reported by the International Energy Agency (see Figure 2.5).

Figure 2.5: Energy Consumption Comparison by Countries and Bitcoin



Source: Digiconomist (2019).

It is estimated by Digiconomist (2019) that the collective Bitcoin mining behemoth, accounts for 0.24% of the world's annual electricity consumption. The mining of a single Bitcoin block consumes as much energy as it would take to power 15.89 households. Bitcoin's equivalent usage could power up to almost 5 million households. The annual electricity consumption by Bitcoin transactions ranges between 41.95 tera-watts to 53 tera-watts. It is also important to note what source of energy is utilised in order to generate power for miners. Even though Bitcoin constitutes only 0.24% of annual energy consumption, its annual carbon footprint amounts to 25,173 kilo-tons (223.31 kilograms per transaction). Of that 0.24%, just over half of the energy is mined from a specific coal power region in China known as Sichuan. However the region, being an underdeveloped region compared with high-tech cities like Beijing and Shanghai, has taken steps to minimise the use of coal power electricity production, through 50 planned and currently in construction hydro electric power sources.

According to Digiconomist (2019), the forecast of Bitcoin's Energy Consumption Index, envisages that 60% of revenues made by miners would go towards electricity costs. This could lead to the collapse of the digital mining of Bitcoins as it would become unprofitable and so the only miners who could survive are miners whose power is generated from green renewable energy sources.

Even though Bitcoin does negatively impact the environment, it is important to compare it with current banking systems. As Bitcoin requires no hiring of employees, building of offices, avoiding the need to take international business trips, Bitcoin provides a global financial service without such an extensive expense matrix with its own self-evident environmental impact. A significant advantage Bitcoin mining has over traditional banks is its flexibility to set up anywhere where the greenest energy source can be located. In comparison, banks need to set up in financial hubs, restricting them to locations that potentially don't run off renewable energy (Devoe, 2018).

2.7.1.5. Transaction Costs

Figure 2.6 compares the Euro and Bitcoin in terms of number of and value of transactions. It is important to note that the Euro transactions only include transactions conducted as a result of the exchange of goods and services, and exclude monetary financial institutional exchanges, whereas Bitcoin includes all blockchain ledger transactions, making its number upward biased, because financial institutional money transactions are excluded. Upon observation one can see that the total value of transactions in Euros amounted to 148,105 billion (cash and Non-cash) in 2017 compared with Bitcoin's 3,583 billion, thus indicating that companies are still reluctant to accept Bitcoin as a currency for payment and still have a long way to go to equal or overtake major currencies like the Euro and the USD (Dabrowski & Janikowski, 2018:9).

Figure 2.6: Euro and Bitcoin Transactions and Value of Transactions

		Number of transactions (in billion) per year	Average transaction value	Value of all transactions (in billion) per year
Euro area (in €)	Non-cash (exc. MFI)	79	1,860	146,452
	Cash	129	13	1,653
Bitcoin	in €	0.1	34,228	3,582
	in XBT	0.1	9	0.9

Source: Dabrowski & Janikowski (2018:9).

With fiat currency there is a mere possibility of no transaction fee being incurred. This occurs through the direct physical handover of physical fiat currency from one individual to another. However another way to transmit currency to someone else is via the internet. Conversely this will incur a transaction fee as intermediaries are required for such transactions to be concluded. Such transaction fees are even higher when concluded between banks from different countries or currencies (Kim, 2015). This is where cryptocurrency commands an advantage over fiat currencies, as cryptocurrencies have minimal transaction fees either for domestic or for international transactions. Transactions in the Bitcoin network take place directly from one party to another. Before May 2015 a transaction fee was optional, however it was seen as an incentive to attract 'miners' to accelerate the completion of the transaction. As with fiat currencies transactions made in store or online are documented by banks by way of physical receipts or online receipts respectively. The same effect is achieved with crypto-miners. The mining process is defined as the protocol applied to software in order to manage the network (Sterry, 2012:10). Miners make use of highly specialised computer systems in order to solve computational equations allowing the chaining of transaction blocks. They are ordinary individuals who engage themselves in 'mining' cryptocurrencies such as Bitcoins as an incentive for their efforts to secure the crypto network, and to validate and process transactions, thus eliminating double spending. Crypto-miners also verify each other's blocks to secure the entire network and continue building on the blockchain (Sterry, 2012:11-13). These specialised computers are referred to as nodes. They run the Bitcoin software with a designated capacity to download 145GB in size. The miners group outstanding transactions into blocks and by solving complex mathematical equations, add the transactions to the blockchain. The reward for miners is an agreed fee of 0.0001 Bitcoin or $0.002 per transaction. This makes Bitcoin transaction fees significantly less than those charged by traditional intermediaries (Grinberg, 2011). The peer to peer electronic cash systems' future is unclear however, although the technology of blockchain does have the potential to revolutionise payment systems in certain sectors in the economy. Bitcoins' uniqueness is not attributed to its character as a virtual currency, but its novelty arises due to its nature of not being controlled by a single entity.

A worthy study to take note of is one which indicates the growing level of adoption across the world, was one performed by Jani (2018:11-15), according to which a rating was devised by the governments of 21 countries on their level of friendliness in adopting cryptocurrencies. Jani rated each country under the comparative criteria of being friendly, neutral or hostile. He concluded that 15 of the 21 countries were friendly in the sense that they regulated cryptocurrencies in their respective countries. These included Australia, Canada, Iran, Italy, Japan and Mexico to name a few. Two countries (Brazil and China) were hostile towards the adoption of cryptocurrencies, with four countries re-acting neutrally toward cryptocurrencies, which included France, Germany and Britain (Jani, 2018:11-15).

One is driven to conclude that internationally Bitcoin is manifestly growing as a medium of exchange, although it is doubted whether it can yet be regarded as a prominent force in the financial market. More and more cryptocurrencies are being developed as developers create more sustainable, stable and efficient cryptocurrencies than what has previously been produced. Table 2.3 suggests clearly that the adoption of cryptocurrencies is ever-increasing, with the world constantly looking for innovative ideas to improve current systems, rendering Bitcoin and also other cryptocurrencies ever more attractive, as they gain support from a large sector of the world. The concept certainly seems set to improve its status as a viable medium of exchange (Cookson, 2017).

2.7.2. Cryptocurrency as a Store of Value

The term 'store of value' fails linguistically to convey its real meaning. Certainly, it should conceptually be associated with stability. Storing something, involves its safe placement in a repository or a metaphorical box. The existence of such a box and the value attached to it only endures as long as others can also identify the value of its contents. That is what store value means. Its value doesn't reside in the box itself but rather what people perceive the box and its contents are capable of accomplishing or producing.

Metals earned their status as exchange mechanisms in earlier times, because they were rare, difficult to extract and difficult to counterfeit. The individuals who initially benefitted from the discovery of these metals were the founders. The value of the metals upon discovery was initially unstable. However, as the world started to understand the properties of the metals the sentiment towards them would change. Only then could the metal as a store of value be realised, as everyone would be using the metal for a uniform purpose. Once people's sentiment and understanding of the metal became general knowledge, stability in the price of the metal followed. Up to that point, the price of the metal was to be driven by fear and volatility (Pakiam, 2017).

There are more asset classes than just metals which qualify as stores of value. Such assets include art, fixed property and Persian carpets for example. These asset classes' store of value is found in the fact that their nominal monetary value may increase with inflation. However, the purchasing power of the initial money spent by the owner on the purchase of these assets will only be realised when the owner succeeds in liquidating such an asset and thus realises the cash available to use as a medium of exchange. In the case of money, its store of value is undermined by inflation, although to some extent is compensated through the supplementation of interest. With cryptocurrency, for example if three individuals accept silver as an accepted form of payment amongst each other, this means the silver cannot be regarded as a useful medium of exchange as it is only traded amongst three individuals. If one person decides to stop accepting silver as a form of payment then the utility, and thereby the value attached to the silver decreases. Therefore the value of money is established in its flexibility, ubiquity and the understanding that it is the common facilitator of transactions. Cryptocurrency's insufficient ability to satisfy the function medium of exchange links to its inability to satisfy the function of store of value. To improve cryptocurrency as a store of value, businesses and consumers facilitating in the transaction needs believe that cryptocurrency's are the better form of facilitating transactions.

A key characteristic distinguishing reliable forms of money is that there is a strong predictability in their supply, which guarantees to holders that there will be no unexpected decline in purchasing power of the currency, thus making them an attractive store of value. In the case of gold, the guarantee is contained in the physical qualities of gold. In the case of national currency, this is reliant on a central bank's credibility. Countries where central banks maintain credibility and predictability in the growth of money supply allowed by the banks, reassure users to operate with confidence that the currency functions as an excellent store of value.

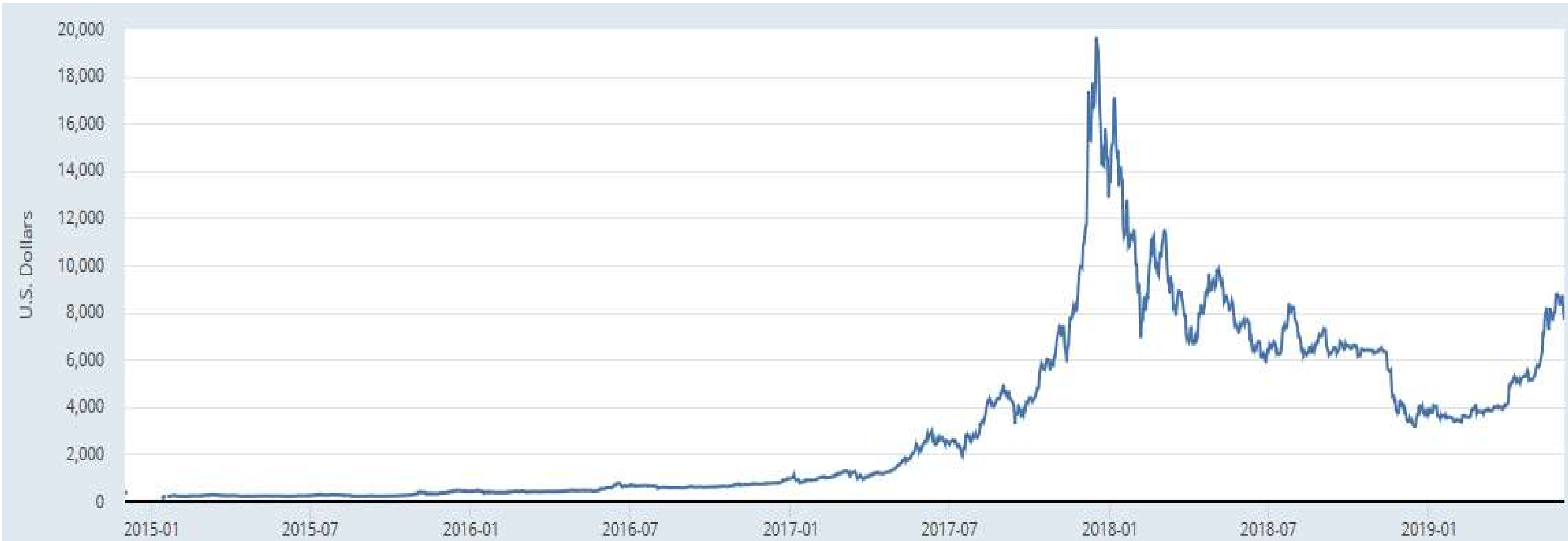
Since the birth of Bitcoin in 2008, the questions raised were as to whether Bitcoin as a cryptocurrency could become a currency similar to fiat currency. According to a report by Goldman Sachs entitled 'Fear and Wealth', gold and Bitcoin were compared as against the key properties of money (durability, portability, intrinsic value and unit of account). The conclusion drawn was that gold was superior to Bitcoin. The report posited that uncertainty results in individuals increasing investment exposure in gold, thereby concluding that fear drives gold's short term prices (Pakiam, 2017).

Bitcoin's price is currently driven by fear and volatility and therefore doesn't meet the functional criteria of store of value. Since its inception in 2008 it has soared in popularity as a result of a sharp rise in value measured in USD. Fear on the other hand, was demonstrated as a result of significant decreases in value relative to the USD within a single year between 2017 and 2018, as indicated in Figure 2.7 below. Strong volatility characterises cryptocurrencies, including Bitcoin as their value is determined by their demand. The crypto-market is a niche market and it doesn't take a lot to change the value of Bitcoin making it extremely volatile. "The evolution of Bitcoin's exchange rate shows how an immature and illiquid currency can almost completely disappear within minutes, causing panic to thousands of users" (European Central Bank, 2012). Certain cryptocurrencies such as Bitcoin have a fixed supply of coins with Bitcoin's cap being twenty one million digital coins. So if its popularity increases so will its value as the holders of the coins will be able to sell their coins at a premium. Another feature of high volatility is unpredictability and unreliability and Bitcoin is a clear example. Bitcoin's price hit a record high on 17 December 2017, valuing at $20,000. Exactly one year later the value of Bitcoin was trading at $3,230. This shows the level of volatility with a decrease in value of 86% within a year (Godbole, 2018). This becomes evident in Figure 2.7. There is another example of cryptocurrencies' volatility worth noting. China ordered the cessation of cryptocurrency exchanges and blocked all new registrations of cryptocurrencies, as its government feared that financial problems could arise as a result of the large number of consumers entering the niche market (Bitcoin market). The announcement resulted in a same day 40% fall in Bitcoin's value from $5,000 to under $3,000 (Neate, 2017).

Goldman Sachs opines that Bitcoin as a cryptocurrency will not retain its value, and that Bitcoin's price will decline further into the future, as the currency form does not fulfil the three traditional functions of currency. The chief investment officer at Goldman Sachs, Sharmin Mossavar-Rahamani stated that the future decline will have no impact on broader financial assets as it only represents 0.3% of world GDP (Rapier, 2018).

James Faucette from Morgan Stanley suggested that cryptocurrencies such as Bitcoin are too difficult to have a value ascribed to them, and therefore difficult to establish what kind of asset they are. A similar view is taken by the chief of the investment team at the Swiss Bank UBS. He believes that the sharp price increases raise speculation of a bubble. However the UBS team has shown interest in the underlying technology of cryptocurrencies, namely, blockchain. They believe it could have a significantly positive impact on various industries. This was further echoed by Belinda Boa from BlackRock and Jamie Dimon from JP Morgan (Martin, 2018). A similar stance on Bitcoin worth noting was that of Ray Dalio, the founder of the largest hedge fund in the world. He noted that unlike gold, Bitcoins volatility makes it unattractive to store value. He also stated that "Bitcoin is a highly speculative market. Bitcoin is a bubble" (Kim, 2017).

Figure 2.7: Time Series of Bitcoin price from January 2015 to January 2019



Source: Fred Economic Data (2019).

Bitcoin has spent much of its 2018 in middling territory, at least if one compares it with its thunderous highs in late 2017. However in 2019 there has been some growth again. The exchange rate of Bitcoin is affected by speculation, regulations and rumours, causing its price to fluctuate radically as shown in Figure 2.7. Even though such factors influence other exchange rates as well, the fluctuations of traditional currencies are of narrower amplitude. To determine whether Bitcoin meets this function of traditional money, this dissertation will further investigate the daily closing prices of Bitcoin/USD compared with the Rand/USD to determine the price volatility by comparing Bitcoin with fiat currency. This investigation will be conducted in Chapter Four with the use of econometric techniques.

The view held on whether cryptocurrencies satisfy the function, store of value, argues that Bitcoin does not hold its value. This became evident in the significant price fluctuations experienced in Bitcoin/USD prices since its inception in 2008. Therefore cryptocurrencies have been linked to amorphous terms such as 'fad' and a 'bubble'.

2.7.3. <u>Cryptocurrency as a Unit of Account</u>

To regard any money as a unit of account, the money must be able to serve the function of accounting, meaning that one can attach a certain amount of money to an item after it has been valued. This is to create a common measure to value goods and services. A definition worth mentioning is that given by Krawisz (2015) - "A unit of account is something such that to gain, it is considered to be profit and to lose, it is considered to be loss." This function generates a significant obstacle to a mass adoption of cryptocurrency, as fiat currency still reigns supreme across the world. There are different views as to whether or not Bitcoin serves the function "unit of account" and views differ depending on how one interprets the function of unit of account.

Bitcoin's primary value is derived from its utility as money. Its underlying value lies within the tangible software and hardware network which promotes characteristics of reliability, security and resilience. Therefore for as long as the internet continues to exist and the Bitcoin network remains useful and scarce, a value will be attached to Bitcoins. According to von Mises in the 'Theory of Money and Credit' the more a commodity's value increases the more it will be used as money. It is Bitcoin's primary role serving as money, exhibiting favourable qualities compared with those of fiat currencies, that makes it a credible form of money.

Even though there are a growing number of companies mentioned in Table 2.3 accepting Bitcoins as a payment platform, the prices posted are given nonetheless in U.S Dollars or Euros. There are two reasons companies do this. Firstly, these businesses employ such payment platforms to eliminate the high volatility associated with Bitcoin price relative to currencies. And so the consumer will purchase goods at the rate for example, between the USD and Bitcoin at the current time of payment. Through such acts the company eliminates any connection of its prices to the volatility levels experienced by Bitcoin or any cryptocurrency. Alongside companies not offering prices in Bitcoin, are lenders, because they do not use Bitcoins as the unit of account for consumer credit, vehicle finance, or mortgages (Gartz and Linderbrant, 2017).

Secondly, the high price of Bitcoin generates the problem of quoting and displaying goods and services at values fixed in Bitcoins. As goods and services that cost small decimal amounts, the conversion to Bitcoin will result in prices becoming 4 to 5 decimals depending on the exchange rate of Bitcoin and the local currency. For example at a time when the Bitcoin/Rand exchange rate equates with R10, quoted in Bitcoins the price would be displayed as 0.0862 Bitcoins.

Local fiat currencies are deeply entrenched within society and citizens are reluctant to leave their currency to adopt a new one. However according to Cookson (2017a) the level of unit of account attached to cryptocurrencies depends on various circumstances which include the level of trust in government backed currency, and the level of inflation in the economy. A country lacking trust and experiencing high inflation could raise the level of unit of account attached to a potential alternative currency such as cryptocurrency. Serious Bitcoiners believe that the world will undergo a period of "HyperBitcoinization". This is a period where countries experience hyper-inflation and lose trust in government-backed currency (Cookson, 2017a).

The view held on whether cryptocurrencies serve the function of unit of account, argues that cryptocurrencies more specifically Bitcoin's price fluctuations makes it a poor unit of account. The significant fluctuations of exchanges from day to day will result in retailers needing to recalculate prices frequently, thus generating confusion between buyers and sellers. Modern accounting systems accommodate two decimal places for pricing of goods, however prices in Bitcoin would require considerably more decimals, thus complicating the pricing of goods.

2.8. Monetary Policy Theory and Cryptocurrency

Today cryptocurrencies coexist alongside fiat currencies. They have challenged the paradigm of state-issued currencies and the role central banks and institutions play in the implementation of monetary systems. Nakamoto developed Bitcoin in order to ameliorate the imperfections in existing monetary systems. Its development was fuelled by the world finding itself at the brink of a financial collapse. The crisis itself and the concomitant bailing out of large financial institutions raised scepticism about central banks' monopoly systems. According to Benigno (2019) the existence of cryptocurrencies could conceivably jeopardise the primary function of central banking, which is the creation of stability through the control of inflation. Wide-scale adoption could have negative effects on economies resulting in monetary instability.

The intrusion of cryptocurrency into the financial market raises two pertinent questions. First, how will monetary policies react in a world of cryptocurrencies? Secondly, what would be the effect of currency competition? Both questions are linked to the ability of cryptocurrencies to fulfil the functions of money, since in order to be considered as a competitor in the currency market one first needs to meet the three functions of money. This section will seek to answer the above questions.

2.8.1. Currency Competition

Governments have historically dictated the issue of currencies in order to be able to exert a certain degree of manipulation, both economically and politically. Cryptocurrencies now challenge this regime. Hayek (1976:32) questioned the *status quo* of governments functioning as the only issuers and regulators of currency. Hayek was concerned that political constraints prohibited central banks from tackling inflation. He believed that the currency market should be opened to market forces and that government controls on the provision of means of exchange, should be abolished. Hayek opined that competition from private monies would induce central banks to act more conservatively when implementing monetary policy and ensure a stable means of exchange. Thus, could cryptocurrencies (private money) be the answer to making monetary authorities accountable for their policy actions, ensuring sounder monetary policy implementation and the generation of economic stability?

Views on whether currency competition benefits an economy differ profoundly. A study conducted by Benigno (2019) analysed competing currencies and concluded that currency competition is healthy for an economy. His reasoning is that it would drive central banks to achieve lower inflation rates, enabling them to compete with private monies. Entrenching competition will serve to restrict authorities from manipulating interest rates and prices which has historically been their self-proclaimed domain. He also noted that the fading of national borders in favour of a worldwide web, promotes a problem for central banks, prompting them to study digital currencies with a view to issuing their own.

Similarly, Dohle (2017) believes that competition in the currency market should be of benefit to improving government issued currency. The characteristics of cryptocurrencies undermine the implementation of standard monetary policies and generate significant challenges for monetary authorities to remain a force in the financial markets. In particular, monetary authorities face the dilemma that arises due to the global and decentralised nature of cryptocurrencies, enabling them to bypass sovereign jurisdictions. For traditional monetary policies to remain superior they would need to become more globally coordinated to compete with cryptocurrencies. The sensible reaction for monetary authorities one would think, should be to implement correct monetary policies to achieve low inflation.

In contrast, Fernandez-Villaverde and Sanches (2017) generated a model of competition among private currencies. They concluded that the competition among private monies would not generate currency stability, ostensibly because private monies are issued by profit-maximising entrepreneurs selecting to maximise the real value of the currency. The many cost functions that exist when minting currency; it does not ensure a stable currency. Hayek's (1976) postulation was rejected by Fernandez-Villaverde and Sanches.

The value and stability of money is what enables societies and their economies to function well and is a concomitant of the choices governments make when formulating policies. It is therefore also part of what constitutes the social agreement between the principal (the citizen) and the agent (the government). Manipulating a currency through monetary policies has historically been a powerful means of enabling a government to pursue certain objectives. In other words, the power of controlling money can be used and abused. A modern democracy that controls a currency is evaluated according to how well it sticks to the social contract agreed upon through democratic procedures. Control over the value of money is a very significant power to possess. This is why those who are given the power are subject to systems of checks and balances designed through social contracts. Taking this power outside the system of checks and balances by rendering it anonymous and automatic could pose a real threat to society's stability. The stability of currencies necessary for the development of an economy relies on the trust sanctified by universal agreements. Trust in turn is built on the ability of a central bank to monitor, review and change. While cryptocurrencies could evolve into a legitimate private means of payment and a competitor to fiat currencies, they will not evolve in a way that will overtake fiat currencies (Fernandez-Villaverde and Sanches, 2017).

The challenge central banks face from digital private currencies, which will threaten their monopoly issuance, is if society gravitates away from fiat currencies, individuals and business will not gain access to risk-free central bank money. Central banks issue interest-bearing liabilities (reserves) and position policy in terms of this risk-free interest rate. In addition, a central bank's position of strength arises from its ability to offer its users cash-in-advance facilities through overdraft protection and credit lines. In contrast, cryptocurrencies do not exhibit this form of interest-bearing security and are unable to offer cash-in-advance facilities to its users. The biggest concern is that cryptocurrency has no fiscal backing, and can become worthless if everyone believes it to be so. Not having an underlying fiscal backing exposes the currency to counterparty, stability and exchange rate risks. Conversely, fiat currency issued by a central bank has the fiscal backing of the central bank itself. This confers a definite value upon the currency (Tobais & Tommaso, 2019).

In addition, and as mentioned before, cryptocurrencies attract minimal transaction fees and so, with no borders or limits the owner of the coins is in full control. Moreover, and even though cryptocurrencies carry the attraction of lower international transaction costs, they are also seen as an asset. For example, money converted to cryptocurrency sent from individual A in country A_1 to individual B in country B_1 is not necessarily spent in the cryptocurrency form in country B_1. In many cases individual B exchanges the cryptocurrency for domestic fiat currency, as cryptocurrencies are not accepted in country B_1. This makes cryptocurrency less a medium of exchange and more an asset. In saying that, if more and more companies, Governments and central banks do adopt the innovation it could lead to further acceptance of cryptocurrencies and assist in fulfilling their function as a medium of exchange (Zhao, 2015).

In order for cryptocurrency to act as an influential currency competitor, it needs to improve as a medium of exchange and secure a certain degree of backing to provide price stability. Consequently cryptocurrencies currently act as a safe haven asset in countries experiencing a financial crisis.

2.8.2. The Reactions of Authorities

Currency competition is not a recent phenomenon. The use of plastic, metal and paper money is disappearing quickly and being replaced by electronic payments as governments, banks and businesses enter the fintech race. Central banks have been unable to ignore the financial innovation. With cryptocurrency as a competitor, threatening the survival of monetary policy and therefore the existence of central banks, it is important to investigate central banks' reaction to the prevalence of cryptocurrencies in the financial world.

Cryptocurrencies constitute 1.3% of the world's $7.6 trillion in coins and bank notes; 1.3% of the world's $77 trillion in gold; 0.13% of the world's $73 trillion in total stocks; and only 0.11% of the world's $90.4 trillion broad money supply. However this could change in the future if more businesses adopt cryptocurrency as payment options and the level of trust in cryptocurrencies by the public increases. The vice chair of the U.S. Federal Reserve Bank in a financial conference stated that digital currencies may not pose major concerns at their current levels of use, however more serious financial stability issues may result if they achieve wide-scale usage. Accordingly in the event of another financial crisis a cryptocurrency asset could potentially become an attractive alternative safe haven, compared with gold for instance, with cryptocurrencies proving that they are easier to access and hold (O'Sullivan, 2018).

Central banks have become alert to the challenge of a competing currency and some have embraced and others prohibited the issue of cryptocurrencies. Some have experimented with the technology behind cryptocurrency, more specifically the use of the distributed ledger technology (blockchain).

Central authorities, governments and businesses have two options. Firstly, to create their own cryptocurrency as legal tender by providing a digital means of payment would function as a claim on the central bank. The advantage generated through this option is the efficiency in the payment system and the management of risks in the deposit accounts. Having direct access to central banks' accounts and opening up access to all accounts would create a centralised ledger. This would assist in expediting payment settlements as all accounts would be managed on the same system. A single centralised system would also benefit the efficiency of cross-border transactions, as there would only be one centralised system per country and countries could even go further by opening the system to non-residents, thus removing any negative international spill-overs.

Secondly, to adopt the underlying 'blockchain' technology of cryptocurrencies or to reconfigure their current monetary policies. Governments and central banks have realised that as technology has progressed over the years, money is doing the same. Below are examples of the reactions of both central banks and governments that have explored the technology innovation.

Sweden is rapidly becoming a cashless society and the Riksbank is considering the introduction of a digital currency, namely E-Krona. As with Bitcoin, the currency will be anonymous. J.P. Morgan a major bank in the United States, has shown its own interest in the crypto-market by launching its own 'JPM Coin'. The motive behind the launch comes as J.P. Morgan prepares for a future eliminating global capitalism, from cross-border transactions to corporate debt issuance, by moving to blockchain technology (Son, 2019).

Leaders in adopting such technology have been the Bank of Canada and the Monetary Authority in Singapore, who have implemented similar blockchain structures. Even though these developments are still in their trial phases, if successful, they could herald the dawn of upgrading monetary administrations (O'Sullivan, 2018). In addition, several central banks are considering launching and implementing their own central bank digital currency. Such countries include the Bahamas, China and Ukraine. These countries are in the testing phase of their digital currencies. Another leader in adopting this innovation worth noting, is the United Arab Emirates (U.A.E), which by 2020 expects all visa applications, bill payments and license renewal payments to be concluded through the technology of blockchain. This will increase productivity and efficiency and generate a paperless government. U.A.E's advanced technological systems have made it easier for it to adopt such a change and it is possible that in the process, developing countries may be assisted in following suit. Therefore it is important for governments to consider the system used in integrating cryptocurrencies into their current monetary policies, as the characteristics of pegged supply can pre-commit inflation and thus improve trade payments across borders (Wetzel, 2018).

The IMF and World Bank have shown their interest in the crypto-market through the launching of their very own cryptocurrency namely 'Learning Coin'. The purpose of the launch was for the IMF and the World Bank to gain an understanding of the underlying technology of cryptocurrency and to use it as an educational programme or test, granting employees incentives in the form of coins for any educational milestones. After the testing period the IMF and the World Bank look to utilise the blockchain technology to combat money laundering and enhance transparency in the financial market (Berman, 2019).

The European Central Bank published a paper on 17 May 2019, explaining that cryptocurrencies pose no tangible threat on the real economy and monetary policy. The ECB said that cryptocurrencies do not stratify the traditional functions of money, “The high price volatility of crypto-assets, the absence of central bank backing and the limited acceptance among merchants prevent crypto-assets from being currently used as substitutes for cash and deposits, as well as making it very difficult for crypto-assets to fulfil the characteristics of a monetary asset in the near future.” In the report the ECB did not dismiss the possibility of launching its own cryptocurrency for internal use (Khatri, 2019).

Fiat currencies are not merely going to disappear to be replaced by cryptocurrency, because cryptocurrencies only represent a small and experimental corner of the financial markets of the world and will find it difficult to restrain central bank’s monetary policies. The trust which citizens have in government backed currencies is considerably stronger than with cryptocurrencies which exhibit significant shortcomings. Nonetheless, there is a need for economic restructuring in order to prevent the recurrent collapse of financial markets. The technological innovation of cryptocurrencies and their backing blockchain technology could augment current deficiencies in the monetary system. All this portends economic reform necessitating the removal of government and political influence, as the two main influencers leading to economic crises. The future of the financial market seems set to have fiat and cryptocurrencies operating in co-existence. Both will be influential in a hybrid economy. Policymakers face a decision to consider whether the current system, which allows banks to charge more to build up reserves in order to protect themselves in times of crisis, is preferable to a more competitive system where transaction costs are lower but the resilience of the financial system is less well known. Therefore three viewpoints appear to have emerged portraying the future of cryptocurrencies - Firstly, there have been those indifferent to cryptocurrencies, believing them to pose no threat to fiat currencies. Secondly, those espousing the viewpoint that they pose no threat to the currency market however, showing an interest in the underlying technology ‘blockchain’. Lastly, there are those seeking to adopt or create their own cryptocurrencies believing the concept to be the first global currency.

A significant example where politically influenced monetary policy has failed is Venezuela. An analysis in identifying the root causes that led to the hyperinflation in Venezuela, is set out below.

2.9. The Importance of Cryptocurrency for Developing Countries

An example where monetary policy has failed, creating the opportunity for cryptocurrencies to step in is Venezuela. Even though one cannot refer to Bitcoin as a currency as of yet, this does not mean that there is no place of value for it in today's world. Analysts from Goldman Sachs describe Bitcoin as a legitimate wide spread form of money and that cryptocurrencies can be a variable alternative for developing nations whose supply of currency is inadequate (Martin, 2018). A Bitcoin advocate Andreas Antonopoulos believes that the adoption of Bitcoin as the first global currency won't happen steadily, but rather will be the only alternative for countries experiencing unstable currencies caused by abusing corrupt governments, such as Venezuela and Zimbabwe.

This dissertation will make reference to and review the case of a single country, namely Venezuela, assessing the potential factors leading up to the Venezuelan crisis so as to discern whether cryptocurrencies can potentially and successfully be implemented as an alternative currency..

Venezuela went from a stable country into a hyperinflation crisis in a matter of 20 years. The current economic collapse experienced by the country descended upon it as a result of two successive corrupt political regimes leading to a struggle to provide the necessities to the people of Venezuela. The country is blessed with the largest petroleum reserves dating back to 1922. Revenue from petroleum exports account for up to 50% of GDP and 95% of total exports (Lieuwen, 2017). Venezuela's top exports consist of petroleum (crude and refined) and precious metals. The oil reserves in Venezuela account for 20% of global reserves (Simoes, 2018).

The economy of Venezuela is oil price driven. An example was noted by Hausmann (2017) in the 1980's when oil prices were at a then high of $28.95 a barrel with the economy booming. However the economy came to near collapse when the oil price dropped in 1986 to $10.85 a barrel. The Venezuelan economy status was then very much dependent on global oil prices.

Hugo Chavez, a populist, was elected as president in 1998. He initiated the 'Bolivarian Revolution'. He implemented policies with the intention of reducing poverty and inequality. Numerous social programmes were developed to improve both economic and social conditions through redistribution of wealth, setting of price controls and restructuring the economy. With government intervention, petroleum exports increased from 68.78% to

96.28% (Hausmann, 2017). Chavez was able to initiate such populist economic policies and for a decade the country experienced prosperity with the increase in oil prices, escalating government revenues. An increase in government spending and borrowing followed, together with increasing minimum wages. Government spending in fact increased from $5.6 billion to $16 billion and the minimum wage was raised by 20%. Money was spent on numerous social programmes. Following Chavez's accession to power, social spending rose by 5.4% of GDP within 8 years (Weisbrot and Sandoval, 2007).

However an oil strike in 2003 halted the production of oil, crippling the economy. The government fired 17 000 striking workers replacing them with unqualified personnel. The GDP dropped by 27% within the first quarter of 2003. Even though Chavez's economic policy interventions were aimed at helping the Venezuelan economy, one fundamental mistake was made. The economy was too reliant on oil, as it accounted for 95% of export earnings and 50% of budget revenue. Chavez was too concentrated on one sector of the economy leading to underinvestment in other sectors of the economy. The 2014 drop in oil prices had a considerable effect on government revenues. Figure 2.8 demonstrates the precipitous fall, expressed in U.S Dollars. As one can see, the significant volatility in oil prices, combined with predicating Venezuela's revenue almost solely on the price of oil, made the economy susceptible to boom and bust economic cycles, thus generating unstable and volatile government revenues (Hausmann, 2017). The administration's response to the deficit generated from the drop in oil prices, was to print more currency in order to close the deficit. This led to a high acceleration in the inflation rate, as can be identified in Figures 2.9 and 2.10.

Figure 2.8: Oil Prices (USD)

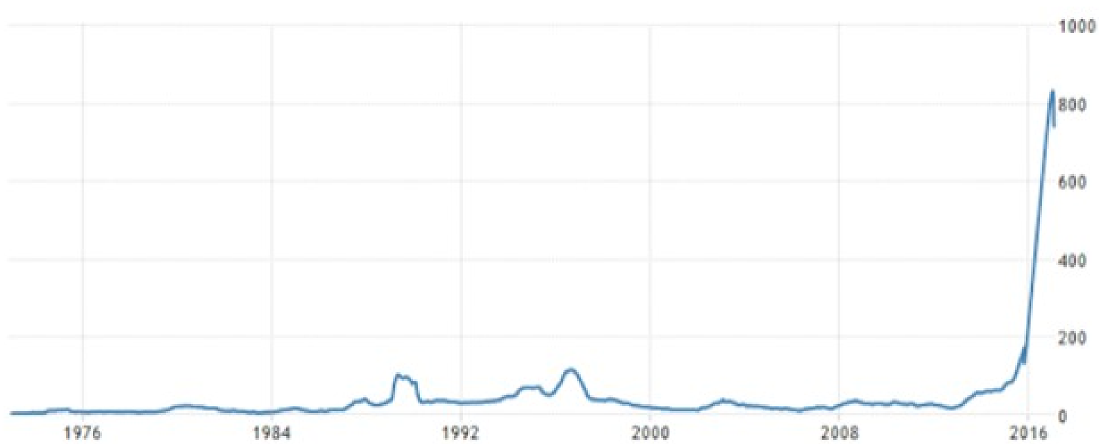
Source: Macrotrends (2018).

Chavez passed away in March 2013. He was replaced by Maduro, whose administration implemented even stricter populist policies. Such policies were directed towards foreign businesses. This hostile mentality led to the exiting of major companies out of Venezuela in 2017 namely; General Motors, United and Pepsi, Coca-Cola and Colgate, fearing the seizure of their assets and exposed to the policies the government had put in place (Zuñiga, 2016). Other policy implementations under Maduro's regime included price control measures, a continual increase in wages of the working class, overvaluing of exchange rates and government control exerted over oil reserves and production (Tarver, 2018).

Whilst a government controlling prices can work to the good to keep prices down, in a free market, prices are determined by supply and demand. The price charged for goods and services should satisfy both the consumer and the supplier. The price controls initiated by the Venezuelan government distorted the economy, as no market prices could be determined, resulting in surpluses and shortages. Excessive shortages assailed the country, leaving its economy in a state of disaster, with Venezuelans being unemployed and starving, and left with no option but to riot (Tarver, 2018).

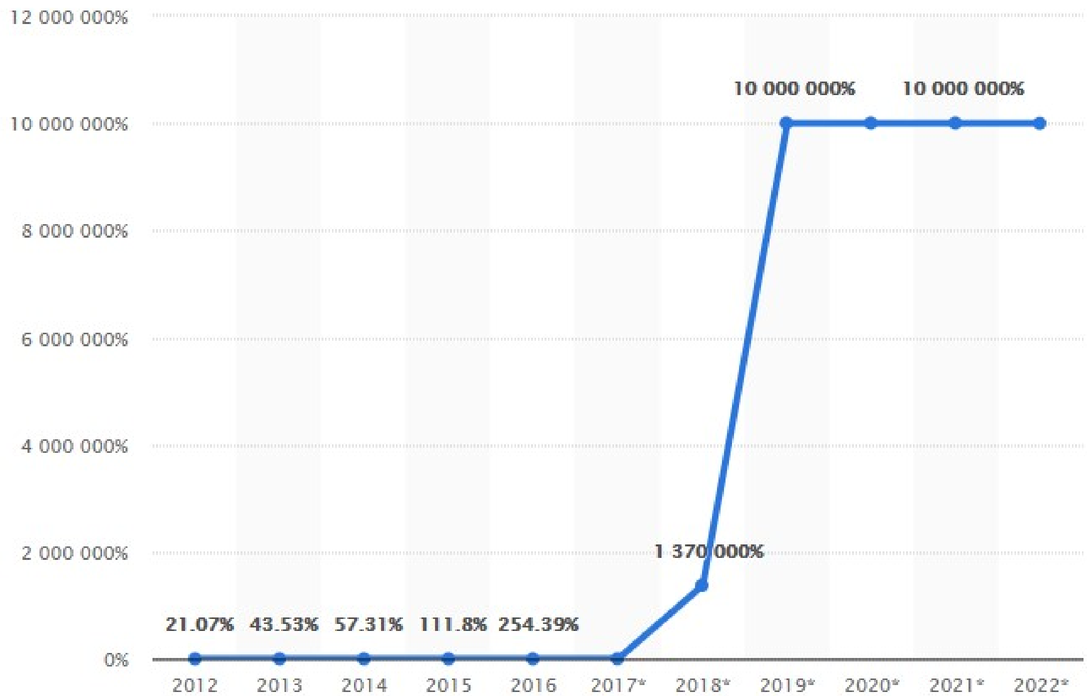
The populist policies implemented by Chavez and Maduro provided the seeds for a crisis of extreme hyperinflation resulting in the Bolivar (the Venezuelan currency) losing the functionality of the core three functions of money. The extent of the hyperinflation can be viewed in Figure 2.9. According to Gillespie (2017) at the start of 2017, one USD = 3,100 Bolivars; on 1st November 2017, one USD = 41,000 Bolivars and on the 21st November 2017, one USD = 84,000 Bolivars. The three core economic policies implemented by both Chavez and Maduro precipitating the crisis in Venezuela were all tainted by political influence. The first factor was that the government sought to control and take over imports and exports and the restructuring of the economy. Secondly, economic policies confiscating private companies generated a hostile environment, making it unbearable for businesses to operate efficiently. The last factor that played a significant role leading to the crisis was the irresponsible spending by government and its lack of saving. Again these economic policies were all driven by the government. Due to a lack of trust in the government and the economic turmoil in which the Venezuelan economy found itself, the public began turning to alternative currencies, especially cryptocurrencies. The adverse impact which these two leaders' policies had on the economy is depicted in Figure 2.9 below reflecting Venezuela's inflation rate from 1976 to 2016. An extended forecast to 2022 can be found in Figure 2.10.

Figure 2.9: Inflation Percentage Levels for Venezuela (1976-2016)



Source: Holodny (2017).

Figure 2.10: Inflation Percentage Levels for Venezuela (2012-2022)



Source: Statista (2019).

In February 2018 Venezuela's vice president announced the launch of the country's own cryptocurrency, the Petro, which was backed by Venezuela's oil reserves and is accepted as a form of payment towards taxes, fee contributions and public services (Samson, 2018). However, before this announcement, citizens of Venezuela had already accessed the crypto-market in search for an alternative currency. According to Joseph Young (2017), between June 2017 and September 2017 the trading volumes of Bitcoins on an exchange platform Local, increased from 9 billion to 40 billion Bolivars. With few options for the public of Venezuela to protect themselves against soaring inflation, they looked at options such as the Petro, Bitcoin and other cryptocurrencies. Fortunately, not all countries experienced a backward monetary system such as Venezuela. The Venezuelan crisis should elicit a wakeup call to central banks and governments to ensure that responsible monetary systems are guaranteed. Cryptocurrencies have become a safe haven for people experiencing financial strictures, acting as a bail-out from holding government backed currency (O'Sullivan, 2018). Developing nations consisting vastly of rural-remote areas and assailed by a lack of access to resources such as banking institutions and ATM's, will popularise cryptocurrencies. This is reiterated by the co-founder of La Maison, Manuel Valente, who stated that "In many countries in Africa, there are far more cell phones than bank accounts," "For Bitcoin, all you need is a phone." In addition, countries that have poorly governed monetary systems leading to high levels of inflation, induce citizens to seek alternative currencies. This is where Bitcoin and cryptocurrencies will succeed (Brand et al, 2017). For economies in crisis such as Venezuela, cryptocurrencies may present real economic solutions.

2.10. Conclusion

The objectives of this Chapter were firstly, to convey an understanding as to the complex nature of cryptocurrencies in relation to fiat currencies. This was essential in order to gain a perspective of both the differences and similarities between the two.

Secondly, it sought to determine whether cryptocurrencies satisfy the functions of money. Extensive research was done on two of the three functions (namely medium of exchange and unit of account). The third important function of money requires further statistical and empirical research in order to assess whether cryptocurrencies satisfy all functions of money. Cryptocurrencies adoption by countries in crisis will depend on the adoption of cryptocurrencies by goods and service providers. Through more businesses across the world adopting cryptocurrencies as an alternative payment option, cryptocurrency popularity is likely to grow and its usage will thus escalate which in turn, will assist in conferring credibility as a medium of exchange.

Thirdly, this chapter set out to analyse both traditional and contemporary monetary authorities' reactions to cryptocurrency's potential threat as a global competitor. The stances which significant financial institutions have taken on cryptocurrencies remain unclear as viewpoints have been inconsistent. The chapter summarised the viewpoints into three categories. First, those who believe cryptocurrency pose no threat, second, those who believe cryptocurrency pose no threat however show interest in the underlying technology, and third, those that believe that cryptocurrencies have the capacity to become the first global currency and a significant competitor within the currency sector.

Lastly, Chapter Two assessed and analysed the impact of cryptocurrency in the selected case study of a developing nation (Venezuela). The case study is an important example showing the potential importance of cryptocurrencies, especially in developing nations experiencing hyper-inflation and currency instability. It also shows the effect of mismanagement of monetary policies on economies and how significantly such mismanagement can contribute to an economic crisis.

The following chapter provides the statistical and empirical framework employed in the study in order to determine whether cryptocurrencies satisfy the third function of money, store of value.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter will consider the procedures and methodologies applied in order to assess stochastic properties and formulate the empirical research and to better understand and motivate the data, models and econometric tests applied in the dissertation. The methodology employed will facilitate the study in determining the level of volatility between Bitcoin/USD and Rand/USD. Comparing the rating of Bitcoin to the USD and the Rand to the USD will provide an indication of the level of volatility of Bitcoin, compared with traditional fiat currencies. The sequencing of the chapter will commence by defining the data sourcing and reasoning for the selection of variables in section 3.2 below. Thereafter, the econometric methods employed will be discussed and explained. The dissertation employs several unit root tests in order to assess stochastic properties, namely; an Augmented Dickey-Fuller test and a Kwiatkowski-Phillips-Schmidt-Shin test.

The second part of the chapter explains the volatility model employed, namely ARMA(p,q)-GARCH(1,1) which falls within the family of ARCH models. The collection of statistical and econometric models employed will allow a broad formulation in determining the level of volatility of Bitcoin in order to conclude whether Bitcoin satisfies the function of store of value.

3.2 Data, Data Sources and Reasoning for Utilising Specific Variables

To reiterate, the purpose of the dissertation is to gauge whether or not Bitcoin satisfies the traditional functions of money. The literature demonstrates that the function of store of value requires specific analysis to understand the level of volatility of cryptocurrencies. As indicated earlier, the dissertation will only conduct an empirical analysis on one cryptocurrency namely Bitcoin. It will conduct a comparison between Bitcoin/USD and the Rand/USD. The data used to test for volatility in the research consists of daily open market capitalisation balances for Bitcoin/USD and Rand/USD. The advantage of using daily series is that important information could become misplaced if lower frequencies were to be used (Edwards, 1998).

As cryptocurrency is a relatively new topic for research, a significant limitation to the study has been access to the Bitcoin data which is available to the public. Both Bitcoin/USD and

Rand/USD data were obtained from the U.S Federal Reserve Bank of St Louis. All available data at the time of writing has been used in order to avoid the bias, which choosing a smaller sample might attract. The sample period runs from 01 December 2014 to 22 March 2019. A total of 2664 observations were implemented, divided into 1539 observations emanating from Bitcoin/USD data, and 1124 observations from Rand/USD data. The outputs are obtained through the use of statistical software, namely Eviews 9. The data used comprises two forms namely, market price series and market return series, formulated via logarithmic analysis.

The usage of logarithmic returns is well documented in financial research, for example by Rahmani (2016:10) and Poon (2005:10), as it offers the advantage of the data being normalised and normally distributed.

Brooks (2008:7-8) presents the natural logarithmic return formula utilised:

$$R_t = 100 \times log\ (P_t/P_{t-1}) \tag{3.1}$$

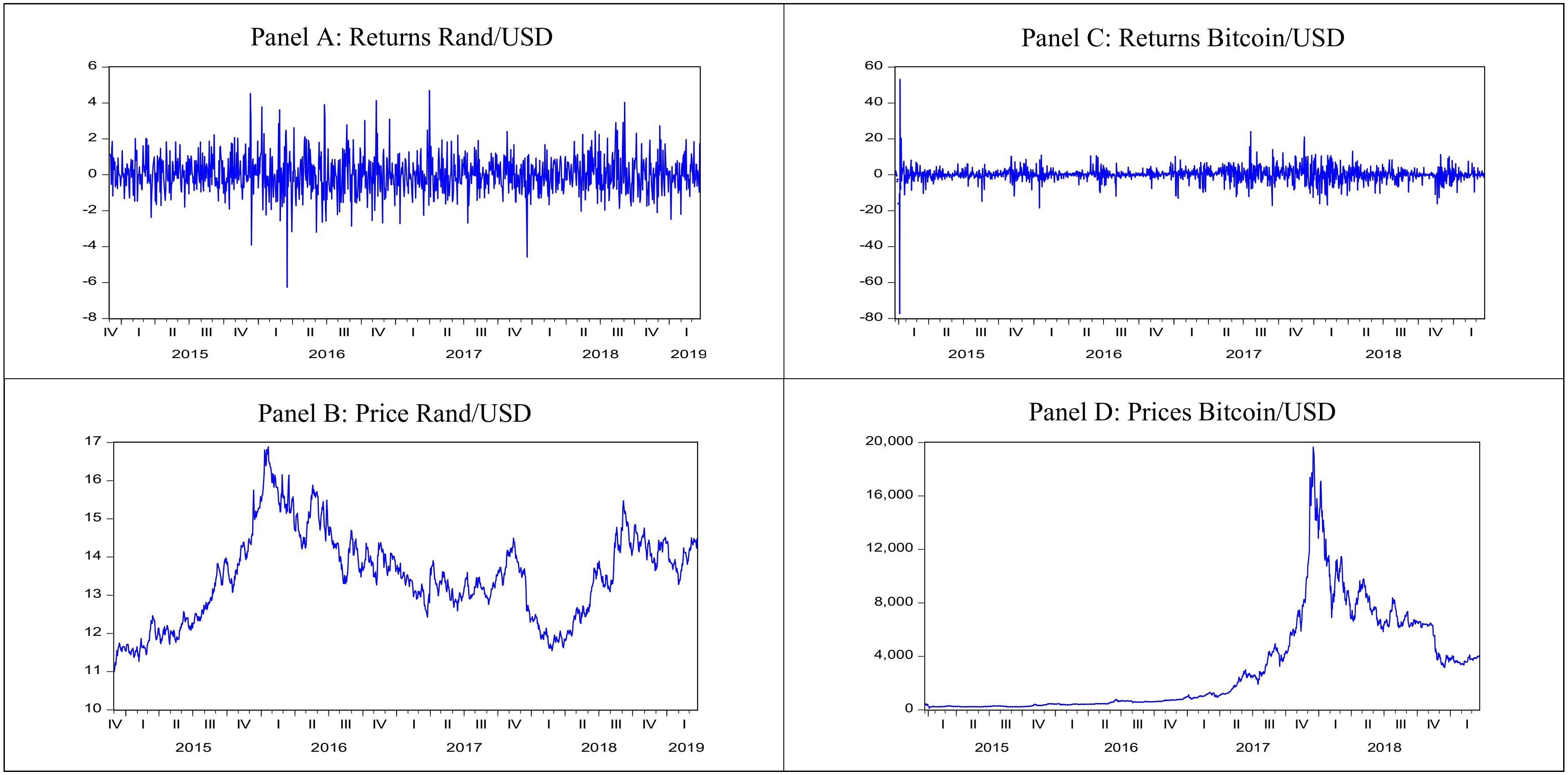
Where: R_t= denotes the monthly natural logarithm return at point (t)

P_t = is the market index price at time (t)

P_{t-}= is the market index price at time ($t-1$)

Table 3.1 illustrates the time series of Rand/USD and Bitcoin/USD price and return function below.

Table 3.1: Time Series of Rand/USD and Bitcoin/USD's Price and Returns[1]



[1] Table 3.1 presents the Return and Price of Rand/USD and Bitcoin/USD results formulated using Eviews Version 9.5.

A visual analysis of the respective price and return series' above, exemplifies the extreme volatility behaviour of Bitcoin/USD (Panel C & D) experienced in relation to the Rand/USD (Panel A & B), indicating that a GARCH model is appropriate to model the time series (Inani, 2016). GARCH/ARCH models according to Bahmani-Oskooee & Hegerty (2007:213) are popular models in measuring volatility of exchange rates and more accurate forecasting models of exchange rate volatility.

Various similar techniques have been used by various researchers to determine the level of volatility of exchange rates. Such techniques include standard deviation (Mpofu & Nikolaidou, 2018), Ordinary Least Squares (OLS) (Kim, 2005), VAR (Grossmann et al, 2014), VECM (Nyahokwe & Ncwadi 2013), GARCH (Kearney & Patton, 2000), (Hwang & Lee, 2005), (Del Bo, 2009), (Feldmann, 2011), (Vieira et al, 2013). Vieira et al (2013) utilised the ARMA(p,q)-GARCH(1,1) which will be used in this dissertation to compare the volatility levels of Bitcoin/USD with the Rand/USD. However in the Vieira et al (2013) paper the authors failed to test for 'ARCH effects', in order to test whether the model was suitable or not. The tests and models used in this dissertation are important in determining whether cryptocurrencies fulfil the store value function of traditional money in order to be able to classify them as currencies.

3.3. Data Analysis/Statistical Analysis

3.3.1. Descriptive Statistics

According to Frank (1971:1) descriptive statistics is described as a method of statistical measurement that allows the organisation and summarisation of large quantities of data with the intention that it can be easily understood. The aim of descriptive statistics is to describe basic information about the nature of a variable of the time series and highlight potential relationships between variables.

Descriptive statistics provide the following information in reference to a time series:

- Information regarding the variability or uncertainty of the time series; and
- Indications of unexpected patterns or trends to assist in conducting a formal analysis.

In the dissertation, three forms of descriptive statistics will be employed to analyse the data and draw conclusions. These include measure of central tendency, the measure of variability or dispersion and the measure of divergence from normality (Frank, 1971:7).

3.3.1.1 Measures of Central Tendency

A measure of central tendency refers to one number that best summarises or describes an entire data set. It measures the average value of a sample of data. There are three types of measures of central tendency, namely, the mean, median and mode. Focus will be placed on the mean and the median only, since the mode is irrelevant to the objective of the study.

Mean

The mean, also known as the arithmetic average, represents the centre of gravity of distribution. It is the average value of all the values in the sample of data (Frank, 1971:7).
The formula is defined as:

$$\frac{X_1+X_2+X_3}{n} = \frac{\sum_{i=1}^{n} X_1}{n} \qquad (3.2)$$

(Frank, 1971:7)

Median

The median is described as being a positional average, as it divides the distribution into two equal parts. The middle point value(s) of the ordered series is referred to as the median, thus dividing the data set into two equally sized groups (Frank, 1971:8).

The formula is defined as:

$$X_{(n+1)/2} \quad \text{when} \quad X_{i+1} \geq X_1 \qquad (3.3)$$

(Frank, 1971:8)

Mode

The mode is the most recurrent value in the time series. The mode will not be utilised in the dissertation as it contains no significance to the objective of the study.

3.3.1.2 Measurements of Variability or Dispersion

The second aspect of descriptive statistics is the measuring of the extent of the spread around the mean value of a time series. The techniques employed in the dissertation include the standard deviation which is expressed as a positive value and is the most common method of determining data dispersion (Aron et al., 2008:40). The formula is stated below:

$$\sigma = \frac{1}{n}\sum_{i=1}^{n}(X_i - \overline{X})^2 \quad (3.4)$$

(Frank, 1971:16)

3.3.1.3 Measure of Divergence from Normality

Normal distribution series parameters include skewness, kurtosis, the mean value and standard deviation. The assumption of normality ($u_t \sim N(0, \sigma^2)$ exhibits symmetry about the mean, and accepts a kurtosis coefficient equal to three, and a skewness coefficient equal to zero (Brooks, 2008:161).

Skewness

Brooks (2008:161) explains that a time series' mean, median and mode will not always display a symmetric distribution; therefore such a distribution is known as a skewed distribution and not symmetric about its mean. A positively skewed distribution signifies a distribution concentrated on the left tail of the distribution while it contains a longer and flatter right tail as indicated below.

A negatively skewed distribution value is concentrated towards the upper values (right tail) while it contains a longer and flatter left tail, indicating a median value greater than the mean (Brooks, 2008:161)

Kurtosis

The Kurtosis indicates the amplitude of the distribution of the series which is benchmarked at 3, indicating a normal distribution (Mesokurtic). Any value below 3 indicates a negative kurtosis (Platykurtic) which in turn, indicates that a distribution is less peaked at the mean and contains thinner tails. A value above the benchmark signifies a positive kurtosis (Leptokurtic) which suggests a distribution containing flatter tails and is more peaked at the mean and variance compared with a normally distributed random variable with the same variance and mean (Brooks, 2008:162).

Jarque-Bera (JB) Test

The most commonly applied tests for normality is the Jarque-Bera test, which signifies the measure of whether the coefficients of both the skewness and the kurtosis are jointly zero. This is accomplished by each variable being tested against those from a normal distribution variable in order to detect normality or non-normality in a time series. The JB test follows under the null hypothesis that the distribution is normal, thereby being mesokurtic and symmetric (Brooks, 2008:163). The formulas for skewness and kurtosis are expressed below respectively:

$$\beta_1 = \frac{E\,(u^3)}{(\sigma^2)^{\frac{3}{2}}} \tag{3.5}$$

$$\beta_2 = \frac{E\,(u^4)}{(\sigma^2)^2} \tag{3.6}$$

Where: $u =$ the errors

$\sigma^2 =$ denotes the variance (Brooks, 2008:163)

The error terms are required in order to determine the expected values of β_1 and β_2. Once β_1 and β_2 are ascertained the JB test can be formulated.

The Jarque-Bera test statistic is expressed as follows:

$$W = T\,[\frac{b_1^2}{6} + \frac{(b_2-3)^2}{24}] \tag{3.7}$$

Where: $W=$ the JB test statistic and,

$T=$ the sample size (Brooks, 2008:163)

3.3.2. Unit Root/Stationarity Tests

Statistical analysis and presumptions from time series models are generally based on the assumption of stationarity. Financial time series such as stock prices and exchange rates exhibit trending behaviour, whereas stationarity time series properties have no linkage to time at which the series is observed. In order to determine the level of integration of the selected time series, the time series properties require testing through stationarity/unit root tests. A unit root test determines whether a time series exhibits stationarity or not. A stationary process time series implies that the data does not contain a unit root and the statistical properties (mean, variance and autocorrelation) do not change over time. In other words no trend or periodic fluctuations exists and the time series will appear the same at any period of time. On the other hand if a time series exhibit a non-stationary process the properties change over time (Asteriou & Hall, 2011:335). The unit root tests that will be applied in the dissertation include the ADF and KPSS. The hypothesis testing of JB Test is as follows:

H_0: $p > 0$

H_1: $p < 0$

Implying a JB test with a probability value greater than 0.5, accepts the null hypothesis. Consequently, a JB test with a probability value less than 0.5, rejects the null hypothesis.

- Augmented Dickey-Fuller (ADF) Test

The Augmented Dickey-Fuller test is applied to test the existence of unit root in the time series of price changes in the Bitcoin data. The ADF came about to provide a solution to solve the deficiency in the Dickey-Fuller test of the presence of autocorrelation. This gave rise to the ADF test through the extension of the test procedure including an extra lag of the dependent variable, thus eliminating autocorrelation (Asteriou & Hall, 2011:344). The ADF test is mainly used to test the stationarity of the time series. It is estimated from the equation through OLS as follows:

$$\Delta P_t = \alpha_0 + \alpha_1 t + p_0 P_{t-1} + \sum_{i=1}^{q} p_i \Delta P_{it-i} + \varepsilon_{it} \qquad (3.8)$$

Where: $\alpha_i =$ the estimated coefficient for the trend

$\varepsilon =$ is the error term

$t =$ the trend term

$q =$ represents the number of lagged terms

P_t represents a given price at a time t, which is the trend term. $\Delta P_t = P_t - P_{t-1}$, p_i are coefficients to be estimated. The null hypothesis is H_0: $p_0 = 0$. Therefore it contains a unit root or is non-stationary. The alternative hypothesis is H_1: $p_0 < 0$, and therefore stationarity is present. In determining the lags q, one can either start with q_{max} and delete any insignificant lags, and then estimate the possible models or ensure that there is no autocorrelation through decision-making using the information criteria.

The critical values of MacKinnon (1994) are used to determine the significance of the t-statistic associated by p_0. Once a value for the test statistic is computed using the formula, the value is compared with the relevant critical values of 1%, 5% and 10% significance.

The test-statistic is computed using the following formula:

$$t_{p0} = \frac{p_0}{(se(p_0))} \tag{3.9}$$

If the result of the t-statistic is less than the critical value, the null hypothesis is rejected and no unit root (stationarity) is present. However in the case where the t-statistic is greater than the critical value the time series will exhibit a unit root (non stationary) (Borges, 2008).

The main critisim of the ADF test is in regard to the power of the test. When testing H_0 it has been argued that the ADF test has low power if the process is near H_0: $p_0 = 0$ with a large autoregressive root. This means the process is stationary but with a root near the boundry to H_0: $p_0 = 0$ (non-stationary).

- Kwiatkowski, Phillips, Schmidt and Shin (KPSS) Test

To circumvent the limitation of the ADF test, the second unit root test used to test for stationarity, is the KPSS et al (1992) test. The KPSS test is regarded as a robust stationarity test with a hypothesis opposite to the ADF test. In a KPSS test the null hypothesis γ_t suggest the presence of trend (stationarity), therefore the alternative hypothesis suggest non-stationarity.

The KPSS is a Lagrange-Multiplier (LM) test and the test statistic can be formulated by regressing the dependent variable γ_t. The KPSS is based on the residuals from the OLS regression of γ_t (Arltová & Fedorová, 2016:52).

The test statistic is expressed as:

$$LM = \sum_{t=1}^{T} s_t^2 \,/\, \hat{\sigma}_\varepsilon^2 \tag{3.10}$$

Where $s_t = \sum_{t=1}^{t} \hat{\varepsilon}_t$, $t = 1, 2, ..., T$, and $\hat{\sigma}_\varepsilon^2$ is the estimated error of the variance $\hat{\sigma}_\varepsilon^2$ of process ε_t from equation (3.11) (Arltová & Fedorová, 2016:52).

$$\gamma_t = \alpha + \varepsilon_t \quad \text{or} \quad \gamma_t = \alpha + \beta_t + \varepsilon_t \tag{3.11}$$

The KPSS acts as a complementary test in order to confirm the accuracy of the conclusions obtained by the ADF unit root test.

3.4. Empirical Models

In the dissertation only one empirical model was applied, however it is important to discuss the origin of the model to gain an overview of the model as it forms part of a family of ARCH models. The empirical model applied in the dissertation is an ARMA(p,q)-GARCH(1,1) model.

3.4.1. ARCH Model

The ARCH model was introduced by Engle (1982); it is a model that describes the conditional volatility of a time series and is widely implemented in financial institutions. It describes the variances of the regression model's current error term as a linear function of the error terms of the previous time period. An ARCH model can be written as follows:

$$a_t = \sigma_t \varepsilon_t \quad (3.12)$$

$$\sigma t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \, a_{t-i}^2 \quad (3.13)$$

Where: ε_t represents independent and identical distributed random variables with a mean and variance of zero, $\alpha_0 > 0$, $\alpha_i \geq 0$ for $i > 0$

3.4.2. GARCH(1,1) Model

Engle's (1982) ARCH model however, contained two distinct problems. Firstly, the model required a large number of lags of the square variance in order to capture all the dependence in the conditional variance. To rectify this problem Bollerslev (1986) extended it by introducing the GARCH(1,1) model. The GARCH(1,1) model is now extensively used as it facilitates in capturing volatility clustering and is regarded as the superior model of the two (Brooks, 2015:423).

The conditional variance is represented in a linear function of its own lags:

Mean equation $r_t = \mu + u_t$ (3.14)

Where: r_t = return of the asset at time t

μ = average return

u_t = residual returns, defined as:

$$u_t = \sigma_t Z_t \tag{3.15}$$

(Poon, 2005:38)

In equation 3.15, Z_t represents the standardised residual returns where σ_t is the conditional variance. The mean equation is a function of a constant error term.

And so, the conditional variance equation is expressed as:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{P} \alpha_1 u_{t-1}^2 + \sum_{j=1}^{q} \beta \sigma_{t-1}^2 \tag{3.16}$$

Where: $\alpha_1 \geq 0$ and $\beta_1 \geq 0$ required to ensure the conditional variance (σ_t^2) is positive

σ_t^2 = conditional variance

p = number of autoregressive lags

q = number of moving average lags

$\sum_{i=1}^{P} \alpha_1 u_{t-1}^2$ represents information about volatility during previous periods

$\sum_{j=1}^{q} \beta \sigma_{t-1}^2$ represents the fitted variance from previous periods

α_1, β = the GARCH(1,1) parameters

(Poon, 2005:38)

The GARCH(1,1) model is regarded as a short term model, as volatility shocks disappear over time at an exponential rate. In the standard GARCH(1,1) equation (3.15), the sum (p) of the coefficients α_i and β_j, measures the volatility persistence which is the level at which shocks to volatility endure in the future. The closer the sum of α_i and β_j is to one, the persistence of shocks to volatility becomes greater. (Thupayagale and Jefferis, 2011:78).

If:

- $p = 1$, the volatility persistence is permanent.
- $p < 1$, a conditional variance exists that after the shock the constant unconditional mean will return to its constant value.
- $p > 1$, variance persistence is regarded as explosive, in the sense that the volatility in one period triggers an even greater volatility in the following period (Thupayagale and Jefferis, 2011:78).

3.4.3. ARMA(p,q) Model

Box and Jenkins (1976) popularised the Autoregressive-Moving-Average (ARMA) model, commending the model's ability in providing a sound forecast of volatility. The model's popularity arose through its ability to capture volatility movements and is favoured for its simplicity and uncomplicated implementation. As indicated earlier, the ARMA (p,q) is a combination of an Autoregressive process AR(p) and a Moving Average process MA(q).

The AR(p) process explains the momentum and mean reversion effects. It explains the current value of a price series by regressing on its past lagged values. Whilst the MA(q) process captures the shock observed in the white noise terms, thus enabling the ARMA (p,q) model to capture both these aspects when modelling a time series. The MA(q) process also regresses on its previous lagged values but differs from the AR(p) process in the sense that it includes error terms (Nugroho & Simanjuntak, 2008). Equation (3.22) and (3.23) express an AR(p) and MA(q) process respectively.

In the AR(p), the term μ_t represents the white noise with zero mean and variance. The term p signifies the non negative integer that determines the number of lags to include in the AR(p) model. Jointly Y_{t-1} , $i = 1$ and p determines the conditional expectations of Y_t with respect to the previous values (Tsay, 2010:38).

Similar to the AR(p) process, in the MA(q) process, the u_{t-1} signifies the white noise with zero mean and variance. The q represents the non negative integer that determines the number of lags to include in the MA(q) model (Tsay, 2010:44). According the Tsay (2010:44) the MA(q) process being a linear combination of a white noise sequence, formulates the model to always be weakly stationary.

The ARMA(p,q) model consists of two components and may be expressed in the following general form:

$$r_t = \mu + \sum_{i=1}^{P} \emptyset_i Y_{t-1} + \sum_{i=1}^{q} \emptyset_i u_{t-1} + \mu_t \qquad (3.17)$$

In the equation it becomes clear that the first section of the equation represents the AR(p) process and the second section the MA(q) process.

3.4.4. ARMA(p,q)-GARCH(1,1)

The results of both the Q-statistic and LM tests discussed under 3.4.5 will indicate whether ARCH effects are present in the data and thus provide evidence whether volatility clustering (autocorrelation) exists or not. If a time series exhibits 'ARCH effects' then it is said to contain conditional heteroskedasticity and confirms that volatility clustering and unequal variance exist, implying that an ARMA(p,q)-GARCH(1,1) model is appropriate. The ARMA(p,q) supplements the ARCH effects test result in determining autocorrelation. If no 'ARCH effect' is exhibited, then the variance σ^2 is utilised in order to determine the level of volatility in the time series.

The existence of 'ARCH effects', allows an ARMA(p,q)-GARCH(1,1) model to be applied, which is expressed as a combination of the ARMA(p,q) and GARCH(1,1) models follows:

$$r_t = \mu + \sum_{i=1}^{P} \emptyset_i Y_{t-1} + \sum_{i=1}^{q} \emptyset_i u_{t-1} + \mu_t , \tag{3.18}$$

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{P} \alpha_1 u_{t-1}^2 + \sum_{j=1}^{q} \beta \sigma_{t-1}^2 \tag{3.19}$$

Where: $\alpha_0 > 0$

$\alpha_0 \geq 0$

$\beta \geq 0$

3.4.5. Lagrange Multiplier, Ljung-Box Q statistics, Correlograms and Durbin Watson Statistic

In order to see if an ARMA(p,q)-GARCH(1,1) model is appropriate the study firstly tests if the data exhibits 'ARCH effects'. Engle's ARCH test involves a regression on the squared residuals, with a null hypothesis stating that all coefficients are equal to zero. As to heteroskedasticity the dissertation will implement a Lagrange Multiplier test and a Ljung-Box Q-statistic to determine whether the time series contains 'ARCH effects'. This will be computed using Eviews 9.

The Ljung-Box Q statistic is used in order to tests for autocorrelation at different lag m, a null hypothesis suggesting that there is no autocorrelation.

Hypothesis testing:

$H_0: p_1 = p_2 = \ldots = p_m = 0$

$H_1: p_I \neq 0$, for some $i\varepsilon$ $(1, ...,m)$

(Tsay, 2010:32-33)

The Ljung-Box Q statistic may be defined as:

$$Q(m) = N(N + 2)\sum_{l=1}^{m} \frac{p_l^2}{N-l} \quad (3.20)$$

Where: N = the sample size

p_l^2 = autocorrelation at lag l

m = the maximum number of lags

The Q-statistic is disseminated similarly to that as a Chi-square, thus having the null hypothesis determining that all p_l^2 autocorrelation coefficients are equal to zero. The Q-statistic examined individual lags of up to 36 lags (Tsay, 2010:32-33).

The Lagrange Multiplier test proposed by Engle (1982) is a commonly used test to examine whether a series of data exhibits ARCH effects in residuals. The LM test is expressed as follows:

$$\text{LM or Obs*R-squared} = T * R^2 \quad (3.21)$$

Where: R^2 = represents the suitability of fit in accordance with the model implemented

T = represents the number of observations

The LM test also follows a Chi-square distribution $TR^2 \sim X_m^2$, and will implement individual lags of up to 3 lags.

The correlogram is considered in order to determine (p,q). Asteriou and Hall (2011:267) explain three primary characteristics of stationarity. The dissertation will focus on the last characteristic which implies a stationary series, exhibit a theoretical correlogram that either experiences a geometrically declining autocorrelation function (ACF) or exhibits a geometrically declining partial-autocorrelation (PACF).

The correlogram is an important measure in the study as it forms the base in determining the best suited model for the time series. It measures and provides a graphic display of the ACF and a PACF processes at all 36 lags, which in turn assists in explaining whether a time series is an auto-regressive (AR) process, a moving-average (MA) process or a combined time series referred to as an autoregressive-moving-average (ARMA) process.

The AR(p) process is formulated as follows by Brooks (2008:215):

$$Y_t = \mu + \sum_{i=1}^{P} \emptyset_i Y_{t-1} + \mu_t \quad (3.22)$$

Brooks (2008:215)

The MA(q) process is expressed by Brooks (2008:211) as:

$$Y_t = \mu + \sum_{i=1}^{q} \emptyset_i u_{t-1} + \mu_t \quad (3.23)$$

Brooks (2008:211)

The ACF represents the degree of similarity between a time series Y_t and the lagged term. If the ACF represented by the correlogram becomes less geometrical when lag p increases, it indicates that the series follows an AR(p) process, indicating a mean reverting time series. In contrast if the ACF decreases to zero after a small number of lags, it indicates that the time series follows an MA(q) process (Brooks, 2008:215-216).

The PACF represents the correlation between the two known variables. If the PACF cuts off at lag p, the time series would follow an AR(p) process of order p. In contrast, if the PACF gradually decreases to zero with each additional lag, it is said that the time series follows an MA(q) process (Fabozzi et al, 2007:250). The characteristics of an ACF and a PACF is summarised in the Table 3.2 below:

<u>Table 3.2: Characteristics of an ACF and PACF Process</u>

Model			
	AR(*p*)	**MA(*q*)**	**ARMA(p,q)**
ACF	Geometrically declining	Cuts off after p lags	Geometrically declining
PACF	Cuts off after p lags	Geometrically declining	Geometrically declining

Source: Fabozzi et al, 2007:250.

The Durbin Watson (DW) statistic is tested using Eviews 9. The DW tests between an error and its immediately previous value. The statistic indicates the level of autocorrelation. The statistic will always be a value between zero and four. The null hypothesis for a DW test is as follows:

H_0: $p = 0$ (no evidence of first order autocorrelation)

H_1: $p \neq 0$ (first order autocorrelation exist)

The test statistic can be measured using the following formula:

$$DW = \frac{\sum_{t=2}^{T}(\hat{u}_t - \hat{u}_{t-1})^2}{\sum_{t=1}^{T}\hat{u}_t^2} \quad (3.24)$$

(Brooks (2008:144)

Where: $u_t = pu_t - 1 + v_t$

Any value between two and four indicates negative autocorrelation and values between zero and four represent positive autocorrelation. If a test ranges between 1.5 and 2.5 the values are considered to be inconclusive (Brooks, 2008:144).

3.5. <u>Conclusion</u>

The statistical and empirical framework is the foundation of the study in analysing the price series distributions, to determine whether cryptocurrencies fulfil the third function of money, store of value.

The statistical techniques utilized in the study include the ADF and KPSS models, with the intention to determine the level of integration of the selected time series whether the respective time series exhibits stationarity or not. As mentioned a stationary process time series implies that the data does not contain a unit root and the statistical properties (mean, variance and autocorrelation) do not change over time. In other words no trend or periodic fluctuations exists and the time series will appear the same at any period of time. On the other hand if a time series exhibit a non-stationary process the properties change over time.

The empirical techniques employed in the study include the ARMA-GARCH model. The model outputs will provide confirmation on the degree of autocorrelation for the respective price series. This is critical in order to draw conclusions on the objective in determining whether cryptocurrencies satisfy all three functions of money.

Other empirical techniques incorporated in the study Lagrange Multiplier, Durbin Watson, correleograms and Ljung-Box Q-statistic. The intention of these tests is to measure the degree of autocorrelation appended to the respective price series. The presence of autocorrelation connotes that a 'ARCH effects' (volatility) exists and that the ARMA(p,q)-GARCH(1,1) model is appropriate.

The chapter to follow implements the econometric models discussed and provides the results drawn from each model. The results will aid the study in determining whether cryptocurrencies satisfy the function of store of value.

CHAPTER FOUR: EMPIRICAL RESULTS

4.1. Introduction

Chapter Three outlined the methodology and procedures employed in fulfilling the objective of determining whether cryptocurrencies fulfil the function of store of value. This chapter presents the empirical results of the tests applied, mentioned in Chapter Three. The findings are explained below. It is important to reiterate that all findings were conducted using market price series.

4.2. Descriptive Statistics

The descriptive statistics describing the distribution properties of the respective price series for both the Bitcoin/USD prices and Rand/USD can be seen in Table 4.1 below.

Table 4.1: Descriptive Statistics of Bitcoin/USD and Rand/USD[2]

	Bitcoin/USD	Rand/USD
Mean	3129.252	13.48560
Median	1016.320	13.51000
Maximum	19650.01	16.88450
Minimum	120.0000	10.99400
Std. Dev.	3678.417	1.153416
Skewness	1.499815	0.220568
Kurtosis	5.098647	2.6655152
Jarque-Bera	859.4097	14.37767
Probability	0.000000	0.000755
Observations	1539	1124

[2] Table 4.1 shows the Descriptive Statistics for Bitcoin/USD and Rand/USD of Price results formulated using Eviews Version 9.5.

Table 4.1 indicates the results for the price forms of Bitcoin/USD and Rand/USD data. The statistical outputs are generated from the sample period of 01 December 2014 to 22 March 2019. By reviewing Table 4.1 it is clear that the Bitcoin/USD variable does not mirror a normal distribution as its skewness of 1.499815, but reflects a positive skewness or a long-right tail, implying that the observations are centred on the lower bound of the price series with the median being less than the mean. Bitcoin/USD series exhibit strong leptokurtic traits at 5.098647, implying that the data sample is more peaked at the mean, thus implying volatility. The skewness and kurtosis of the Bitcoin/USD time series both indicate non-normality. This is further supported by the Jaque-Bera statistic with a p of < 0.5, signifying non-normality in the series, and therefore rejecting the H_0 at a 5% level significance.

The same can be said regarding the Rand/USD price series, however it presents a near perfect symmetric time series with a coefficient of 0.220568. In contrast to the Bitcoin/USD time series, the Rand/USD series demonstrate platykurtic traits. Similar to the Bitcoin/USD time series, the probability of 0.000755 for the Jarque-Bera tests rejects the null hypothesis and suggests that the series are not normally distributed at 5% level significance, making both series probabilities highly statistically significant.

The most distinct difference between the two variables occurred in their respective standard deviation outputs. Bitcoin/USD's movements signified the highest level of volatility compared with that of the Rand/USD. These results are consistent with the results obtained from the skewness and kurtosis of the respective price series.

4.3. <u>Unit Root and Stationarity Tests</u>

The unit root and stationarity tests applied in the dissertation were carried out for both the level and first difference. In this sub-section the ADF and KPSS results are found (in Tables 4.2 and 4.3) and discussed. The stationarity tests are applied only as to the price series and are tested according to the following parameter formats: constant, constant and trend, and none. Testing for the existence of unit roots is an important component in the study in understanding the behaviour of cryptocurrencies relative to fiat currencies. The presence of unit roots would imply that the time series is non-stationary. If a unit root does not exist, this would suggest that the time series is stationary. The results of the ADF and KPSS test are summarised and explained below.

4.3.1. <u>Augmented Dickey-Fuller (ADF) Test Results</u>

The price series for Bitcoin/USD and Rand/USD was tested to determine the order of integration using the ADF test, and Table 4.2 presents a summary of the ADF test results for both time series. The summary in Table 4.2 is constructed from the test results in Appendix A. According to Brooks (2008:328) for the ADF test, the null hypothesis of a unit root is rejected in favour of stationary (alternative hypothesis), if the test statistic is more negative than the critical value at 1%, 5% and 10% levels.

Upon observation of Table 3.1, Panel C and D, one can already suspect that the time series for Bitcoin/USD would be non-stationary. The result from the ADF test revealed that Bitcoin/USD accepts the null hypothesis at level, therefore suggesting that the time series is non-stationary (unit root) at all three levels of significance taken at the level. At first difference, the Bitcoin/USD series rejects the null hypothesis, as the probability value is less than zero.

The Rand/USD series rejects the null hypothesis at 1% and 5% significance level but fails to reject the null hypothesis at 10% significance level. Similarly to the Bitcoin/USD series at first difference, the Rand/USD series rejects the null hypothesis, as the probability value is less than zero.

Table 4.2: ADF Test Results for Level and First Difference (Market Price)[3]

Variable	Test Statistics (Level)		
	None	Constant	Constant & Trend
Bitcoin/USD	-1.260306	-1.910210	-2.468393
Rand/USD	0.477028	-2.616121*	-2.564934

Variable	Test Statistics (First Difference)		
	None	Constant	Constant & Trend
Bitcoin/USD	-7.303135***	-7.306313***	-7.308875***
Rand/USD	-32.29324***	-32.29160***	-32.28316***

Note: Asterices represent violations of the null hypothesis at respective significance levels. * denotes significance at 10%, ** denotes significance at 5% and *** denotes significance at 1%. H_0: non-stationarity (unit root). Lag length selection is based on Schwarz's Information criterion.

4.3.2. Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) Test Results

The results of the KPSS test are found in Table 4.3. If The LM statistic is greater than the critical values at 1%, 5% and 10%, then the null hypothesis is rejected and the unit root is non stationary. Thus, the null hypothesis (H_0) is regarded as exhibiting stationarity (no unit root). The test is run in accordance with both constant and constant and trend parameters.

In terms of Bitcoin/USD the LM statistic value that can be found in Appendix B, indicates that the time series rejects the null hypothesis, thereby exhibiting a unit root (non-stationary). This result means movements are apparent and confirms the test results obtained in the ADF test outcome. In terms of the first difference, again it confirms the ADF test, as the outcomes indicate the presence of stationarity (no unit root) at all levels of significance.

The Rand/Bitcoin rejects the null hypothesis at 1% and 5% significance level and accepts it at 10% level significance. This supports the results obtained in the ADF test.

[3] Table 4.2 shows the Augmented Dickey-Fuller Test results formulated using Eviews Version 9.5.

Table 4.3: KPSS Test Results for Level and First Difference (Market Price)[4]

Variable	Test Statistics (Level)	
	Constant	Constant & Trend
Bitcoin/USD	2.952839	0.359395
Rand/USD	0.447686	0.452984

Variable	Test Statistics (First Difference)	
	Constant	Constant & Trend
Bitcoin/USD	0.088061	0.081698
Rand/USD	0.112975	0.083346

Note: Asterices represent violations of the null hypothesis at respective significance levels. * denotes significance at 10%, ** denotes significance at 5% and *** denotes significance at 1%. H0: stationarity (no unit root). The decision to reject null hypothesis is made at 5% level of significance. Lag length selection is based on Schwarz's Information criterion.

4.4. ARCH Effect Test Results

In this dissertation both price series are tested for ARCH effects, in order to determine whether an ARMA(p,q)-GARCH(1,1) model is applicable. The objective in testing for ARCH effects is to determine the presence of volatility clustering in the exchange rate process in order to build the most fitting model. Upon observation of Table 3.1 (Panel B and C), one could already identify that autocorrelation is exhibited in the Bitcoin/USD time series indicating that ARCH effects do exist in the time series. This was empirically supported through the LM and Ljung-box Q-statistic tests. Below one will find the results of the LM tests. Results of the Ljung-box Q-statistic will be discussed below under the heading Correlograms.

[4] Table 4.3 shows the Kwiatkowski-Phillips-Schmidt-Shin Test results formulated using Eviews Version 9.5.

Table 4.4: ARCH Effects Test Results of Bitcoin/USD Price Series[5]

Lag	(1)	(2)	(3)
Obs*R-squared	250.9374	252.1365	280.5829
Probability	0.0000	0.0000	0.0000

Table 4.5: ARCH Effects Test Results of Rand/USD Price Series[6]

Lag	(1)	(2)	(3)
Obs*R-squared	17.31550	36.20785	39.80016
Probability	0.0000	0.0000	0.0000

According to Table 4.4, the LM statistics are high with probabilities of zero in each respective lag, suggesting that Bitcoin/USD is significant, and indicating the presence of heteroskedasticity. Therefore the null hypothesis is rejected as the time series exhibits ARCH effects. The presence of ARCH effects is corroborated with the F-statistics and t-statistics found in Appendix B.

Similarly, in Table 4.5, the LM statistics at all three lags are high with low probabilities signifying the presence of ARCH effects. The null hypothesis is thereby rejected implying the presence of heteroskedasticity. Similar to Bitcoin/USD, the Rand/USD's F-statistics and t-statistics correspond with the conclusion drawn from Table 4.4. The t-statistic, tests the significance in order to test the truth or falsity of the sample results. The t-statistic measures how much the coefficient has deviated from zero. The t-statistic output of Bitcoin/USD one can deduce that the first and third lags are significant at 1% level and there is insufficient evidence to conclude that the second lag is significant in this specification of the model, thereby complementing the LM statistic by rejecting the null hypothesis.

The t-statistic results of the Rand/USD are all significant at 1% level except at lag 3 which is significant at 10% level. Consequently this results corresponding to the LM static's conclusion that the null hypothesis is rejected and that the time series exhibits ARCH effects.

The F-statistic in Appendix B indicates the model accuracy to the data sample. For both Bitcoin/USD and the Rand/USD the F-statistic provides sufficient evidence to conclude that

[5] Table 4.4 shows the ARCH Effect Test results for Bitcoin/USD formulated using Eviews Version 9.5.
[6] Table 4.5 shows the ARCH Effect Test results for Rand/USD formulated using Eviews Version 9.5.

the model fits the selected data sample. The F-statistic probability for both Bitcoin/USD and the Rand/USD is less than 1%, implying that both samples are significant at all levels. This result corresponds to the conclusion drawn from that ARMA(*p*,*q*)-GARCH(1,1) model is appropriate for both times-series.

As mentioned the testing for ARCH effects provide a reference to the level of volatility for the respective time series. Even though both time series proved to exhibit ARCH effects, it is important to distinguish between the two time series' levels of ARCH effects, in order for conclusions regarding the level of volatility of each time series to be drawn. Bitcoin/USD proved to have a significantly higher level of volatility with respect to the Obs-R-squared values at all three lags in comparison with the RAND/USD. This further compliments that the ARMA(*p*,*q*)-GARCH(1,1) model is appropriate for both times-series (Bitcoin/USD and Rand/USD).

4.5. <u>Correlogram Results</u>

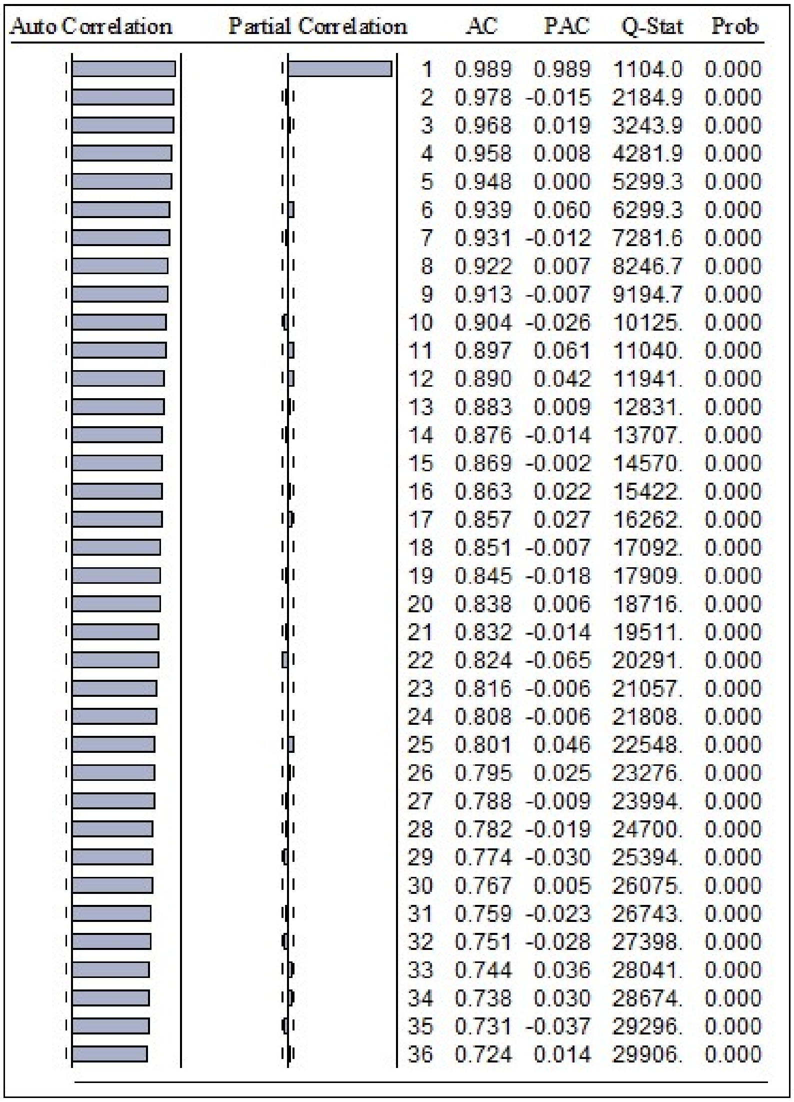
Below, Figures 4.1 and 4.2 provide the correlograms for the respective price series. To reiterate the correlogram is important to distinguish whether the model follows an AR process, MA process or an ARMA process as explained on page 85 and 86. Table 3.2 (see page 86) explains how one determines which process is best suited for the time series. The outputs were developed using Eviews 9 and implementing a 36 lag period.

Figure 4.1: Correlogram of Bitcoin/USD Price Series[7]

	AC	PAC	Q-Stat	Prob
1	0.997	0.997	1533.5	0.000
2	0.994	-0.064	3058.4	0.000
3	0.991	0.021	4575.1	0.000
4	0.988	-0.002	6083.7	0.000
5	0.985	0.036	7584.7	0.000
6	0.982	-0.146	9075.8	0.000
7	0.978	0.063	10558.	0.000
8	0.975	0.037	12032.	0.000
9	0.972	-0.047	13497.	0.000
10	0.969	-0.048	14952.	0.000
11	0.964	-0.131	16395.	0.000
12	0.960	-0.015	17826.	0.000
13	0.956	0.033	19246.	0.000
14	0.952	0.121	20656.	0.000
15	0.949	0.037	22056.	0.000
16	0.946	0.028	23449.	0.000
17	0.943	0.091	24834.	0.000
18	0.940	-0.087	26211.	0.000
19	0.937	-0.015	27580.	0.000
20	0.933	-0.069	28940.	0.000
21	0.929	-0.121	30287.	0.000
22	0.924	-0.025	31623.	0.000
23	0.920	-0.045	32947.	0.000
24	0.916	0.053	34260.	0.000
25	0.912	0.016	35563.	0.000
26	0.908	-0.011	36854.	0.000
27	0.904	0.026	38135.	0.000
28	0.900	0.069	39407.	0.000
29	0.896	0.027	40669.	0.000
30	0.893	0.021	41921.	0.000
31	0.889	0.021	43163.	0.000
32	0.885	0.039	44396.	0.000
33	0.882	0.035	45620.	0.000
34	0.878	-0.125	46836.	0.000
35	0.875	-0.022	48042.	0.000
36	0.872	0.027	49241.	0.000

[7] Figure 4.1 shows the Correlogram results for Bitcoin/USD formulated using Eviews Version 9.5.

Figure 4.2: Correlogram of Rand/USD Price Series[8]



Auto Correlation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.989	0.989	1104.0	0.000
		2	0.978	-0.015	2184.9	0.000
		3	0.968	0.019	3243.9	0.000
		4	0.958	0.008	4281.9	0.000
		5	0.948	0.000	5299.3	0.000
		6	0.939	0.060	6299.3	0.000
		7	0.931	-0.012	7281.6	0.000
		8	0.922	0.007	8246.7	0.000
		9	0.913	-0.007	9194.7	0.000
		10	0.904	-0.026	10125.	0.000
		11	0.897	0.061	11040.	0.000
		12	0.890	0.042	11941.	0.000
		13	0.883	0.009	12831.	0.000
		14	0.876	-0.014	13707.	0.000
		15	0.869	-0.002	14570.	0.000
		16	0.863	0.022	15422.	0.000
		17	0.857	0.027	16262.	0.000
		18	0.851	-0.007	17092.	0.000
		19	0.845	-0.018	17909.	0.000
		20	0.838	0.006	18716.	0.000
		21	0.832	-0.014	19511.	0.000
		22	0.824	-0.065	20291.	0.000
		23	0.816	-0.006	21057.	0.000
		24	0.808	-0.006	21808.	0.000
		25	0.801	0.046	22548.	0.000
		26	0.795	0.025	23276.	0.000
		27	0.788	-0.009	23994.	0.000
		28	0.782	-0.019	24700.	0.000
		29	0.774	-0.030	25394.	0.000
		30	0.767	0.005	26075.	0.000
		31	0.759	-0.023	26743.	0.000
		32	0.751	-0.028	27398.	0.000
		33	0.744	0.036	28041.	0.000
		34	0.738	0.030	28674.	0.000
		35	0.731	-0.037	29296.	0.000
		36	0.724	0.014	29906.	0.000

The null hypothesis for the Q-statistic states that autocorrelation occurs in the price series. Given the results in Figures 4.1 and 4.2, with respect to the Q-statistic, the conclusion can be drawn that autocorrelation/trend exists in both time series, as the probability values equal 0, therefore rejecting the null hypothesis. The probability for both time series being 0 for all 36 lags is very significant, as it is less than the 5% level suggesting that autocorrelation does exist, thus supporting the LM test that ARCH effects exist in both series of data.

[8] Figure 4.2 shows the Correlogram results for Rand/USD formulated using Eviews Version 9.5.

In addition, one can conclude that for both time series there is a gradual decline towards zero in the autocorrelation function, thus indicating an AR(*p*) to be the fitted model for both times series (Bitcoin/USD and Rand/USD) implying that both time series contain a predictive power. The partial-autocorrelation function supports the conclusion of the ACF as the PACF does not decline gradually to zero, as it cuts off at lag *p*, implying that an AR(*p*) process may be applied. In both time series the PACF cuts of after lag 1 implying an AR(1)-GARCH(1,1) model will be applied as the MA process does not fit the time series.

Based on the results above the appropriate AR(1) model can be found below in Tables 4.6 and 4.7. The AR(1) model is represented as follows for each time series:

Table 4.6: AR(1) Model Result of Bitcoin/USD Price Series[9]

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2837.605	3867.143	0.733773	0.4632
AR(1)	0.997065	0.001299	767.8395	0.0000
SIGMASQ	69281.60	614.0998	112.8182	0.0000

R-squared	0.994876	Mean dependent var	3129.252
Adjusted R-squared	0.994870	S.D. dependent var	3678.417
S.E. of regression	263.4709	Akaike info criterion	13.99105
Sum squared resid	1.07E+08	Schwarz criterion	14.00146
Log likelihood	-10763.11	Hannan-Quinn criter.	13.99492
F-statistic	149125.5	Durbin-Watson stat	1.861515
Prob(F-statistic)	0.000000		

The AR(1) process for Bitcoin/USD may be expressed as follows:

$Y_t = 0.994870y_{t-1} + 2837.605$

[9] Table 4.6 shows the AR(1) Model for Bitcoin/USD test results formulated using Eviews Version 9.5.

Table 4.7: AR(1) Model Result of Rand/USD Price Series[10]

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.33456	0.464240	28.72339	0.0000
AR(1)	0.993045	0.002704	367.2615	0.0000
SIGMASQ	0.021930	0.000557	39.36606	0.0000

R-squared	0.983501	Mean dependent var	13.48560
Adjusted R-squared	0.983471	S.D. dependent var	1.153416
S.E. of regression	0.148287	Akaike info criterion	-0.972868
Sum squared resid	24.67169	Schwarz criterion	-0.959467
Log likelihood	550.2384	Hannan-Quinn criter.	-0.967804
F-statistic	33440.85	Durbin-Watson stat	1.922458
Prob(F-statistic)	0.000000		

The AR(1) process for Rand/USD may be expressed as follows:

$Y_t = 0.983471 y_{t-1} + 13.33456$

The results from the AR(1) process correspond to what was concluded from the ARCH effect tests. Both time series are significant with the *p* value being less than 0.5. As concluded in the ARCH effect tests, Bitcoin/USD exhibits a higher degree of autocorrelation in comparison with the Rand/USD series, as indicated by the DW test results. However the resultant value falls within the non-conclusive range.

4.6. AR(1)-GARCH(1,1) Test Results

Since the presence of ARCH effects has been identified in the dissertation, thus implying the GARCH model is appropriate, and that a AR(*1*) process is best fitted for both time series, an AR(1)-GARCH(1,1) process may consequently be employed. Tables 4.8 and 4.9 present the AR(1)-GARCH(1,1) estimates for the respective time series.

[10] Table 4.7 shows the AR(1) Model for Rand/USD test results formulated using Eviews Version 9.5.

Table 4.8: AR(1)-GARCH(1,1) Model Results of Bitcoin/USD Price Series[11]

	Coefficient	**AR(1)-GARCH(1,1)**
Constant (Mean Equation)		469.3170
AR(1)		0.999999
Constant (Variance Equation)	α_0	1.079198
RESID(-1)^2	α_1	0.172438
GARCH(-1)	β	0.875359
Durbin Watson	DW	1.864704
Log-likelihood		-8180.572

[11] Table 4.8 shows the AR(1)-GARCH(1,1) Model for Bitcoin/USD test results formulated using Eviews Version 9.5.

Table 4.9: AR(1)-GARCH(1,1) Model Results of Rand/USD (Market Prices Series)[12]

	Coefficient	**AR(1)-GARCH(1,1)**
Constant (Mean Equation)		13.07508
AR(1)		0.999998
Constant (Variance Equation)	α_0	0.000293
RESID(-1)^2	α_1	0.050364
GARCH(-1)	β	0.937625
Durbin Watson	DW	1.926457
Log-likelihood		608.2575

The constant in the variance equation α_0, represents the long run average variance. For both time series the $p = 0$ for the constant term in the variance equation, indicating significance at 1% level (refer to Appendix C). The constant of the mean equation for both time series provides insufficient evidence that they are significant, suggesting that the mean is not constant over time.

The Durbin Watson results for each time series shown in Table 4.8 and Table 4.9 are important to highlight, as they are relevant in drawing conclusions from the respective time series. The DW results indicate the level of autocorrelation. The DW values indicate that both time series exhibit positive autocorrelation and the null hypotheses are rejected. This supports the result from the ARCH effect tests conducted earlier in the chapter. The 1.864704 and 1.926457 DW statistics for Bitcoin/USD and Rand/USD respectively, indicate that both series fall within the 'inconclusive' section of the test. This means that the previous exchange

[12] Table 4.9 shows the AR(1)-GARCH(1,1) Model for Rand/USD test results formulated using Eviews Version 9.5.

value can be used to predict the current exchange value and the current value can be used to predict tomorrow's value, signifying a forecasting power.

The residuals (α_1) represent the variance in the dependent variables and how much they contribute towards volatility. One can thus conclude that the Bitcoin/USD residuals contribute 17.2438% towards volatility, which is significantly higher than Rand/USD's 5.0364% as presented in Tables 4.8 and 4.9. The β term represents how past volatility effects current volatility. As noted in Chapter Three, the p statistic represents the sum of $\alpha_1 + \beta$, which is important in analysing an economic scenario. The Bitcoin/USD's p statistic equates to 1.047797, implying that the volatility in one period triggers an even greater volatility in the following period. The Rand/USD's p statistic equals 0.987989, indicating that a conditional variance exists, and that after an economic shock the constant unconditional mean will revert to its constant value.

4.7. Conclusion

A significant objective of the dissertation was to determine whether Bitcoin satisfies the function store of value. This was achieved through various volatility tests in order to answer the key objective, whether Bitcoin satisfies the store value function of traditional money. The analysis employed descriptive statistics, unit root and stationarity models as also an empirical model. The ADF and KPSS econometric modelling of the respective level price series proved to be non-stationary, indicating the series to be mean reverting from the time period 01 December 2014 to 22 March 2019. From the onset the intended model to measure the level of volatility was the ARMA-GARCH. However according to the findings from the correlograms, it was discovered that an MA(q) process did not fit both time series. As a result, an AR(1)-GARCH(1,1) was applied. The main findings revealed that significant volatility exists in the Bitcoin/USD series compared with the results from the Rand/USD series. These AR(1)-GARCH(1,1) model results are consistent with the ARCH effect tests which proved that both series exhibited ARCH effects, and therefore both series show volatility. This was further supported by the DW values indicating positive serial correlation, signifying that volatility exists in both time series. The difference was that the Bitcoin/USD series had a significantly higher LM value than the Rand/USD series in the ARCH effect test, suggesting that the Bitcoin/USD experiences higher volatility. As referred to in the literature, volatility is linked to the money function store of value. Consequently, the high volatility of Bitcoin/USD, implies that Bitcoin performs poorly as a store of value; and so the null hypothesis (H_1) is accepted for the research hypotheses one and two. The chapter to follow will combine and summarise the results from the historical approach, collected in Chapter Two with the analytical results obtained in Chapter Four, in order to draw final conclusions.

CHAPTER 5: SUMMARY, CONCLUSION AND FUTURE RESEARCH

5.1. Introduction

The final chapter provides a summary of the purpose of the study, the approach applied and the findings discovered through theoretical and empirical work. These findings are juxtaposed with the hypothesis and objectives as described in Chapter One. In addition, the chapter explains the future of cryptocurrency and concludes by suggesting potential future research.

5.2. Summary and Conclusion

Since the introduction of Bitcoin in 2008, the peer to peer electronic cash system has played a significant role in the advancement of digital currency systems. Nakamoto's idea of a decentralised currency revolutionised the currency industry. As the 11th year of the existence of Bitcoin is celebrated and the emergence of cryptocurrency remains in the public domain, one question that continues to bring focus to the underlying nature of cryptocurrency as a whole remains. Can cryptocurrency be referred to as a currency and could it replace fiat currency in commerce?

Bitcoin and the veritable plethora of other cryptocurrencies certainly had their fair share of success. Bitcoin has taken on the mantel of the 'Gold Standard of Cryptocurrency'. However in doing so, it has morphed into something it was never intended to be – a commodity asset. In 2018 Morgan Stanley reported that Bitcoin had become a new institutional investment class like property, bonds or commodities. However, given its many currency constraints, cryptocurrency cannot be referred to as previously by the European Central Bank as a crypto-asset, as in reality, a good asset class contains the characteristic of being a reliable store of value. The research has made it clear that this function cannot be characterised alongside Bitcoin. It is suggested that such a conclusion supports the analysis undertaken of Bitcoin.

The primary objective of the study was to understand cryptocurrencies and to conduct an analysis to gauge whether or not they serve the three traditional functions of money, by assessing the differences between fiat currencies and cryptocurrencies. The critical analysis of Bitcoin specifically, was intended to provide an insightful judgement of the future of cryptocurrencies generally, and serve to facilitate their usefulness in practice and even their improvement or refinement. The conventional econometric tests were applied to the data in order to ensure the econometric validity and thus reliability of the data analyses carried out. A brief review of these tests is presented here.

The research employed two methods in determining the above-mentioned objective. The first, to fully understand whether cryptocurrencies meet the function store of value. An empirical analysis was conducted on the level of volatility of Bitcoin, using the closing market prices between the periods 01 December 2014 to 22 March 2019. In addition, a stationarity test was concluded to test for a unit root, employing standard models. In order to detect the level of volatility and stationarity in Bitcoin data, the research employed the following models: Augmented Dickey-Fuller, the Kwiatkowski, Phillips, Schmidt and Shin and an Autoregressive GARCH model, whose results for both volatility and stationarity, were tabulated for ease of illustration.

Two stationarity tests were employed, characterised as having opposite null hypotheses. This was to ensure that the outputs from each test were significantly conclusive. The stationarity models convincingly concluded that both time series were non-stationary, implying that their statistical properties exhibit a long run trend, long memory and autocorrelation. This was further supported by the ARCH effect test.

The ARCH effect test was employed in order to understand whether the GARCH model followed an AR, MA or ARMA process and to understand the level of volatility associated with the respective time series. In determining the existence of ARCH effects in the respective time series, the study employed the Lagrange Multiplier, Ljung-Box Q test and Correlogram. The LM tests revealed Bitcoin/USD exhibiting significant levels of ARCH effects in relation to the Rand/USD. In addition, the ARCH effect tests revealed significant levels of volatility, which would not augur well for cryptocurrencies to meaningfully compete with or to supplant fiat currencies. The study progressed to analyse the properties of sequential data observations of the respective time series. Correlograms supported the LM and Ljung-Box tests suggesting that autocorrelation exists in the respective time series. This was portrayed as a geometrically declining ACF with a one lag cut off of the PACF coefficient for both series, suggesting long memory relating to the conclusion drawn from the stationarity tests. This designated the AR(1) process as the appropriate model, and therefore an AR(1)-GARCH(1,1) model was employed, which further supported the notion that Bitcoin/USD exhibits higher autocorrelation in relation to the Rand/USD through the Durbin Watson Statistic. These findings supported the validity of the objective of determining whether significant volatility exists in Bitcoin time series, consequently further supporting Bitcoin's inability to fulfil the function of store of value.

It is suggested however, that one ought not to simply discount Bitcoin as a currency, solely on account of its high volatility, because there are certainly other currencies with significantly higher volatility levels. A balanced look at all three functions of money has hopefully served to clarify whether cryptocurrencies can meaningfully be accommodated within the rubric of a currency or an asset. The second research method employed in the dissertation is the historical method approach to determine whether cryptocurrencies considered as meeting the functions of a medium of exchange and a unit of account. From the many opinions and conclusion drawn from the analysis, it is suggested that one cannot as of yet proclaim cryptocurrencies as currencies. They certainly seem more comfortable occupying the role of assets. In theory cryptocurrencies fulfil the various functions of money to a certain degree only, because in reality they lack certain features, such as stability, protection measures against illicit activities, and the realistic acceptance levels necessary to regard cryptocurrencies as money and moreover, impact negatively on the environment.

According to the literature cited, money's acceptance follows a generalised trust and expectation that people and businesses will accept it. This mechanism could represent a self fulfilling prophecy, protected by a third party (such as government), who fulfils the responsibility of this social commitment. The aforementioned criterion is lacking within the crypto-system. As indicated in Table 2.3, cryptocurrencies are growing in stature but have not reached an acceptance level to fulfil the function as a medium of exchange. The number of merchants accepting cryptocurrencies remains tentatively in the minority. The literature provided the following potential impediments: Firstly, they are too complex for the ordinary person to understand, both in their novelty and their complex algorithms, in addition to having a finite supply of tokens or coins and being deflationary, all making cryptocurrencies highly speculative and emasculating them as a real medium of exchange. Secondly, the significant number of illicit activities associated with Bitcoin, downgrades it as a medium of exchange. In more recent times with the world yearning for "green", Bitcoin's environmental impact has been cast into sharp focus. The literature found Bitcoin's average energy consumption per year to be higher than countries such as Austria, the Czech Republic and Colombia, making Bitcoin environmentally unfriendly compared with current fiat currencies. This said however, in five to ten years one might form a different opinion on whether cryptocurrencies become a tool of commerce. Cryptocurrencies are in their formative stage -

evident in Table 2.2 where only a handful of countries regard cryptocurrencies as legal tender. Crypto-miners could of course convert to renewable energy sources in order to minimise their environmental impact. This could certainly make them more attractive to the public.

Nevertheless their level of acceptance is growing across the globe and like many disruptive technologies before them, their change and full acceptance will take time. They are however, undoubtedly on the move.

The function 'unit of account' requires cryptocurrency to satisfy the other two functions. However by not having any acknowledged authority to control their supply, and not satisfying the functions of medium of exchange and store of value, one must conclude that cryptocurrencies serve as a poor unit of account. The inferior position, in which cryptocurrencies find themselves, for serving this function, is linked to the lack of trust and knowledge the public has of the system. The literature suggests that without knowledge and trust in a currency, players will not conclude daily transactions. The existing level of trust and knowledge in domestic fiat currencies probably remains too sturdy to be replaced anytime soon.

One is driven then to conclude that Bitcoin does not have a store of value in comparison, for example, with the Rand. Referring to the main objective of the study, today's cryptocurrencies cannot be referred to as money, if their current use is to serve as any barometer.

5.3. The Future of Cryptocurrencies

Cryptocurrencies have attracted great interest and have demonstrated to the financial market ways to improve current systems in place. Even though they do not meet the three traditional functions of money, more and more institutional players each day are exploring ways to improve systems within their businesses. The future of cryptocurrencies will be complex; however technology has opened the door to new opportunities and solutions in industries. Taking into account the evolution of money, society has moved from trading, to bartering to cash and credit. This evolution occurred as a result of human nature building and developing that which is ordinarily only dreamed of. With technology improving, the use of cryptocurrency in the future looms more real, and with countries and cities racing to achieve ‘smart status’ in the world, cryptocurrencies and the blockchain technology portend favourably for them to achieve the status of ‘smartest city’ or ‘smartest country’.

A further corollary is whether cryptocurrencies could impose themselves upon the world, especially in developing countries. In line with the case study in the literature, cryptocurrencies have established themselves (at least in the case of Venezuela) and will further in the future, as a bailout tool. They can become an important facilitation to assist countries in crisis. Time and time again countries have experienced problems, most notably inflation as a result of poor governance and political influences. Examples include Venezuela and Zimbabwe. A cynical question could be posed. What prevents governments from manipulating cryptocurrencies? Theoretically, monetary policy tools and cryptocurrency systems can interlink and through quantitative easing, advanced blockchain coding could be written ahead of time to protect against manipulation of prices, since the blockchain can only be written once. Another precaution would include having regional oversight (for example the EU) or international oversight (for example the United Nations) to supervise countries that have adopted a cryptocurrency as an official currency, for example Venezuela.

According to the literature, cryptocurrencies will surely play a pivotal role in the financial markets in the future, whether functioning as global currencies or assets or through their underlying technology. A crucial part of Chapter Two was achieving the objective of gauging the response by authorities through the historical method approach. Cryptocurrency has laid down the metaphorical gauntlet, challenging the rules and restrictions immortalised by central banks, casting a new perspective on how the world looks at money, how it is stored; who should control its production; and how it is transmitted and managed. Cryptocurrencies could potentially play an important role in the transparency of how monetary authorities implement monetary policies. By acting as competing currencies, they could assist in tempering sound monetary policy implementation and ensuring economic stability. As one would expect however, the reactions of authorities have been unsupportive of cryptocurrencies. Many Governments and central banking authorities have taken and are taking significant measures to render cryptocurrencies unattractive through the registration of personal data on government controlled data bases and by initiating tax policies on cryptocurrency gains. This is in order for Governments to remain in control of their respective currencies generally. The greatest challenge in this theatre where central banks currently wield the baton, will be to retain the trust of the public; trust in the currencies issued by them and trust in the institutions which hold and manage these currencies. Central banks and Governments will find it difficult to accept that they are potentially not the sole traders of currency. They will need to yield to currency competition in the interest of ensuring sound implementation of monetary policy.

Even though the prospect of any cryptocurrency superseding fiat currency in the next ten years must be very slim, central banks should continue to strive for more stability and running monetary policies more effectively. Countries struggling economically must be open to adopting new ideas and not close their doors to integrating or restructuring monetary policy structures through blockchain technology. The next ten years will be interesting in potentially witnessing the adoption and acceptance by Governments and the general public of innovative cryptocurrencies, in order to test their monetary policies and stabilize their domestic economies. This will determine whether Governments and central banks are able to bring cryptocurrencies under their spheres of control. Cryptocurrencies will not overnight become global currencies replacing the likes of the Euro, USD and Yen or become integrated within every country's monetary system. Time will however tell of their passage.

5.4. Suggested Areas for Future Research

Potential future research with regard to the main determinant of the volatility of exchange rates could usefully compare Bitcoin with an even more volatile currency such as the Venezuelan Bolivar or any other economy experiencing hyperinflation, as this could assist in providing a clearer understanding to where Bitcoin lies with respect to volatility levels. In addition, one could empirically analyse a multiplicity of cryptocurrencies in order to gain a wider perspective of the behaviour of cryptocurrencies collectively and comparatively. Regionally developed cryptocurrencies aimed at serving more parochial needs may also find relevance in the future and provide scope for further study.

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APPENDIX

Appendix A:Unit Root and Stationary Tests

BITCOIN/USD ADF Tests

Level intercept

Null Hypothesis: P has a unit root

Exogenous: Constant

Lag Length: 20 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.910210	0.3278
Test critical values:	1% level	-3.434451	
	5% level	-2.863238	
	10% level	-2.567722	

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

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(P)

Method: Least Squares

Date: 05/23/19 Time: 15:32

Sample (adjusted): 1/25/2015 3/22/2019

Included observations: 1518 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
P(-1)	-0.003379	0.001769	-1.910210	0.0563
D(P(-1))	0.059982	0.025624	2.340877	0.0194
D(P(-2))	-0.030892	0.025619	-1.205843	0.2281
D(P(-3))	0.014601	0.025629	0.569695	0.5690
D(P(-4))	-0.008692	0.025525	-0.340514	0.7335
D(P(-5))	0.164691	0.025386	6.487521	0.0000
D(P(-6))	-0.035180	0.025714	-1.368139	0.1715
D(P(-7))	-0.034890	0.025701	-1.357531	0.1748
D(P(-8))	0.065136	0.025528	2.551594	0.0108
D(P(-9))	0.012540	0.025554	0.490744	0.6237
D(P(-10))	0.118710	0.025547	4.646766	0.0000
D(P(-11))	0.025495	0.025557	0.997556	0.3187
D(P(-12))	-0.043325	0.025564	-1.694755	0.0903
D(P(-13))	-0.117305	0.025539	-4.593200	0.0000
D(P(-14))	-0.044811	0.025701	-1.743593	0.0814

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(P(-17))	0.093434	0.025519	3.661279	0.0003
D(P(-18))	0.016033	0.025634	0.625444	0.5318
D(P(-19))	0.066140	0.025624	2.581174	0.0099
D(P(-20))	0.128354	0.025638	5.006303	0.0000
C	12.43748	8.504311	1.462491	0.1438

R-squared	0.120026	Mean dependent var	2.466258
Adjusted R-squared	0.107673	S.D. dependent var	265.2017
S.E. of regression	250.5176	Akaike info criterion	13.89932
Sum squared resid	93887561	Schwarz criterion	13.97650
Log likelihood	-10527.59	Hannan-Quinn criter.	13.92806
F-statistic	9.716649	Durbin-Watson stat	2.007880
Prob(F-statistic)	0.000000		

Level Trend and intercept

Null Hypothesis: P has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 20 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.468393	0.3440
Test critical values:	1% level	-3.964101	
	5% level	-3.412773	
	10% level	-3.128365	

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

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(P)

Method: Least Squares

Date: 05/23/19 Time: 15:33

Sample (adjusted): 1/25/2015 3/22/2019

Included observations: 1518 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
P(-1)	-0.006262	0.002537	-2.468393	0.0137
D(P(-1))	0.061489	0.025629	2.399235	0.0166
D(P(-2))	-0.029143	0.025630	-1.137089	0.2557
D(P(-3))	0.016334	0.025640	0.637049	0.5242

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(P(-4))	-0.006720	0.025543	-0.263103	0.7925
D(P(-5))	0.166415	0.025396	6.552715	0.0000
D(P(-6))	-0.033291	0.025728	-1.293955	0.1959
D(P(-7))	-0.033150	0.025712	-1.289300	0.1975
D(P(-8))	0.066540	0.025530	2.606358	0.0092
D(P(-9))	0.013962	0.025557	0.546320	0.5849
D(P(-10))	0.120177	0.025551	4.703484	0.0000
D(P(-11))	0.027434	0.025573	1.072744	0.2836
D(P(-12))	-0.041343	0.025582	-1.616080	0.1063
D(P(-13))	-0.115262	0.025558	-4.509728	0.0000
D(P(-14))	-0.043035	0.025712	-1.673732	0.0944
D(P(-15))	-0.040837	0.025715	-1.588075	0.1125
D(P(-16))	-0.098659	0.025404	-3.883573	0.0001
D(P(-17))	0.095146	0.025529	3.726939	0.0002
D(P(-18))	0.017964	0.025650	0.700342	0.4838
D(P(-19))	0.067994	0.025638	2.652079	0.0081
D(P(-20))	0.130458	0.025660	5.084116	0.0000
C	-4.530823	13.67131	-0.331411	0.7404
@TREND("12/01/2014")	0.033370	0.021058	1.584685	0.1132

R-squared	0.121501	Mean dependent var	2.466258
Adjusted R-squared	0.108574	S.D. dependent var	265.2017
S.E. of regression	250.3912	Akaike info criterion	13.89896
Sum squared resid	93730117	Schwarz criterion	13.97965
Log likelihood	-10526.31	Hannan-Quinn criter.	13.92900
F-statistic	9.398500	Durbin-Watson stat	2.008633
Prob(F-statistic)	0.000000		

Level None

Null Hypothesis: P has a unit root

Exogenous: None

Lag Length: 20 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.260306	0.1914
Test critical values:	1% level	-2.566486	
	5% level	-1.941032	
	10% level	-1.616559	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(P)
Method: Least Squares
Date: 05/23/19 Time: 15:34
Sample (adjusted): 1/25/2015 3/22/2019
Included observations: 1518 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
P(-1)	-0.001687	0.001339	-1.260306	0.2078
D(P(-1))	0.059597	0.025632	2.325071	0.0202
D(P(-2))	-0.031416	0.025626	-1.225928	0.2204
D(P(-3))	0.014108	0.025637	0.550311	0.5822
D(P(-4))	-0.009291	0.025532	-0.363907	0.7160
D(P(-5))	0.164202	0.025393	6.466361	0.0000
D(P(-6))	-0.035853	0.025719	-1.394012	0.1635
D(P(-7))	-0.035474	0.025708	-1.379904	0.1678
D(P(-8))	0.064712	0.025536	2.534202	0.0114
D(P(-9))	0.012080	0.025562	0.472574	0.6366
D(P(-10))	0.118194	0.025554	4.625245	0.0000
D(P(-11))	0.024697	0.025561	0.966217	0.3341
D(P(-12))	-0.044170	0.025568	-1.727581	0.0843
D(P(-13))	-0.118142	0.025542	-4.625365	0.0000
D(P(-14))	-0.045453	0.025707	-1.768160	0.0772
D(P(-15))	-0.042982	0.025715	-1.671474	0.0948
D(P(-16))	-0.101201	0.025394	-3.985176	0.0001
D(P(-17))	0.092959	0.025527	3.641592	0.0003
D(P(-18))	0.015407	0.025640	0.600889	0.5480
D(P(-19))	0.065530	0.025630	2.556711	0.0107
D(P(-20))	0.127600	0.025643	4.975988	0.0000

R-squared	0.118768	Mean dependent var	2.466258
Adjusted R-squared	0.106994	S.D. dependent var	265.2017
S.E. of regression	250.6129	Akaike info criterion	13.89943
Sum squared resid	94021795	Schwarz criterion	13.97310
Log likelihood	-10528.67	Hannan-Quinn criter.	13.92686
Durbin-Watson stat	2.007578		

1st Difference Trend

Null Hypothesis: D(P) has a unit root
Exogenous: Constant
Lag Length: 19 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.306313	0.0000
Test critical values:	1% level	-3.434451	
	5% level	-2.863238	
	10% level	-2.567722	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(P,2)
Method: Least Squares
Date: 05/23/19 Time: 15:36
Sample (adjusted): 1/25/2015 3/22/2019
Included observations: 1518 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(P(-1))	-0.724775	0.099199	-7.306313	0.0000
D(P(-1),2)	-0.216471	0.096989	-2.231904	0.0258
D(P(-2),2)	-0.248878	0.094224	-2.641346	0.0083
D(P(-3),2)	-0.235745	0.091332	-2.581172	0.0099
D(P(-4),2)	-0.246142	0.087641	-2.808526	0.0050
D(P(-5),2)	-0.082901	0.084594	-0.979989	0.3273
D(P(-6),2)	-0.119828	0.081536	-1.469635	0.1419
D(P(-7),2)	-0.156270	0.078727	-1.984968	0.0473
D(P(-8),2)	-0.092330	0.076663	-1.204362	0.2286
D(P(-9),2)	-0.081032	0.074748	-1.084075	0.2785
D(P(-10),2)	0.036341	0.072629	0.500371	0.6169
D(P(-11),2)	0.059950	0.069586	0.861528	0.3891
D(P(-12),2)	0.014649	0.066323	0.220881	0.8252
D(P(-13),2)	-0.104665	0.062293	-1.680196	0.0931
D(P(-14),2)	-0.151114	0.058408	-2.587217	0.0098
D(P(-15),2)	-0.195000	0.054692	-3.565407	0.0004
D(P(-16),2)	-0.297273	0.048856	-6.084706	0.0000
D(P(-17),2)	-0.205270	0.042776	-4.798676	0.0000
D(P(-18),2)	-0.190917	0.034999	-5.454925	0.0000
D(P(-19),2)	-0.126422	0.025641	-4.930437	0.0000
C	1.814815	6.439869	0.281809	0.7781

R-squared	0.526936	Mean dependent var	0.003966
Adjusted R-squared	0.520616	S.D. dependent var	362.1433
S.E. of regression	250.7391	Akaike info criterion	13.90044
Sum squared resid	94116562	Schwarz criterion	13.97411
Log likelihood	-10529.43	Hannan-Quinn criter.	13.92787

F-statistic	83.37398	Durbin-Watson stat	2.007176
Prob(F-statistic)	0.000000		

1^{st} Difference Trend and Intercept

Null Hypothesis: D(P) has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 19 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.308875	0.0000
Test critical values:	1% level	-3.964101	
	5% level	-3.412773	
	10% level	-3.128365	

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

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(P,2)

Method: Least Squares

Date: 05/23/19 Time: 15:36

Sample (adjusted): 1/25/2015 3/22/2019

Included observations: 1518 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(P(-1))	-0.725753	0.099297	-7.308875	0.0000
D(P(-1),2)	-0.215547	0.097082	-2.220263	0.0266
D(P(-2),2)	-0.248008	0.094310	-2.629704	0.0086
D(P(-3),2)	-0.234931	0.091412	-2.570014	0.0103
D(P(-4),2)	-0.245388	0.087714	-2.797592	0.0052
D(P(-5),2)	-0.082204	0.084661	-0.970984	0.3317
D(P(-6),2)	-0.119178	0.081598	-1.460550	0.1443
D(P(-7),2)	-0.155668	0.078784	-1.975898	0.0483
D(P(-8),2)	-0.091774	0.076716	-1.196285	0.2318
D(P(-9),2)	-0.080518	0.074796	-1.076501	0.2819
D(P(-10),2)	0.036817	0.072673	0.506613	0.6125
D(P(-11),2)	0.060387	0.069627	0.867300	0.3859
D(P(-12),2)	0.015052	0.066361	0.226820	0.8206
D(P(-13),2)	-0.104301	0.062328	-1.673429	0.0945
D(P(-14),2)	-0.150794	0.058438	-2.580396	0.0100
D(P(-15),2)	-0.194724	0.054719	-3.558622	0.0004
D(P(-16),2)	-0.297051	0.048878	-6.077390	0.0000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
R-squared	0.526959	Mean dependent var		0.003966
Adjusted R-squared	0.520318	S.D. dependent var		362.1433
S.E. of regression	250.8170	Akaike info criterion		13.90171
Sum squared resid	94112120	Schwarz criterion		13.97889
Log likelihood	-10529.40	Hannan-Quinn criter.		13.93044
F-statistic	79.35786	Durbin-Watson stat		2.007160
Prob(F-statistic)	0.000000			

1^{st} Difference None

Null Hypothesis: D(P) has a unit root

Exogenous: None

Lag Length: 19 (Automatic - based on SIC, maxlag=23)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.303135	0.0000
Test critical values:	1% level	-2.566486	
	5% level	-1.941032	
	10% level	-1.616559	

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

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(P,2)

Method: Least Squares

Date: 05/23/19 Time: 15:37

Sample (adjusted): 1/25/2015 3/22/2019

Included observations: 1518 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(P(-1))	-0.723754	0.099102	-7.303135	0.0000
D(P(-1),2)	-0.217434	0.096899	-2.243918	0.0250
D(P(-2),2)	-0.249781	0.094140	-2.653285	0.0081
D(P(-3),2)	-0.236586	0.091256	-2.592570	0.0096
D(P(-4),2)	-0.246919	0.087571	-2.819651	0.0049
D(P(-5),2)	-0.083618	0.084530	-0.989208	0.3227
D(P(-6),2)	-0.120493	0.081477	-1.478866	0.1394
D(P(-7),2)	-0.156886	0.078672	-1.994173	0.0463
D(P(-8),2)	-0.092902	0.076613	-1.212610	0.2255
D(P(-9),2)	-0.081562	0.074701	-1.091849	0.2751

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(P(-11),2)	0.059496	0.069546	0.855500	0.3924
D(P(-12),2)	0.014233	0.066286	0.214714	0.8300
D(P(-13),2)	-0.105039	0.062260	-1.687097	0.0918
D(P(-14),2)	-0.151442	0.058378	-2.594153	0.0096
D(P(-15),2)	-0.195281	0.054666	-3.572250	0.0004
D(P(-16),2)	-0.297498	0.048834	-6.091997	0.0000
D(P(-17),2)	-0.205433	0.042759	-4.804414	0.0000
D(P(-18),2)	-0.191025	0.034986	-5.460036	0.0000
D(P(-19),2)	-0.126477	0.025633	-4.934205	0.0000

R-squared	0.526911	Mean dependent var	0.003966
Adjusted R-squared	0.520911	S.D. dependent var	362.1433
S.E. of regression	250.6621	Akaike info criterion	13.89918
Sum squared resid	94121555	Schwarz criterion	13.96934
Log likelihood	-10529.47	Hannan-Quinn criter.	13.92530
Durbin-Watson stat	2.007189		

RAND/USD ADF Tests

Level Intercept

Null Hypothesis: P has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=21)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.616121	0.0899
Test critical values:	1% level	-3.435952	
	5% level	-2.863902	
	10% level	-2.568078	

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

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(P)

Method: Least Squares

Date: 05/23/19 Time: 18:37

Sample (adjusted): 12/02/2014 3/22/2019

Included observations: 1124 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
P(-1)	-0.010013	0.003827	-2.616121	0.0090
C	0.138131	0.051801	2.666567	0.0078

R-squared	0.006063	Mean dependent var	0.003106
Adjusted R-squared	0.005177	S.D. dependent var	0.148343
S.E. of regression	0.147958	Akaike info criterion	-0.981996
Sum squared resid	24.56242	Schwarz criterion	-0.973055
Log likelihood	553.8816	Hannan-Quinn criter.	-0.978617
F-statistic	6.844088	Durbin-Watson stat	1.919066
Prob(F-statistic)	0.009013		

Level Trend and Intercept

Null Hypothesis: P has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic - based on SIC, maxlag=21)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.564934	0.2967
Test critical values:	1% level	-3.966233	
	5% level	-3.413815	
	10% level	-3.128983	

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

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(P)

Method: Least Squares

Date: 05/23/19 Time: 18:39

Sample (adjusted): 12/02/2014 3/22/2019

Included observations: 1124 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
P(-1)	-0.009945	0.003877	-2.564934	0.0104
C	0.138079	0.051826	2.664292	0.0078
@TREND("12/01/2014")	-1.54E-06	1.38E-05	-0.111987	0.9109

R-squared	0.006074	Mean dependent var	0.003106
Adjusted R-squared	0.004301	S.D. dependent var	0.148343
S.E. of regression	0.148023	Akaike info criterion	-0.980228

Sum squared resid	24.56214	Schwarz criterion	-0.966817
Log likelihood	553.8879	Hannan-Quinn criter.	-0.975159
F-statistic	3.425303	Durbin-Watson stat	1.919218
Prob(F-statistic)	0.032880		

Level None

Null Hypothesis: P has a unit root

Exogenous: None

Lag Length: 0 (Automatic - based on SIC, maxlag=21)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.477028	0.8179
Test critical values:	1% level	-2.567021	
	5% level	-1.941105	
	10% level	-1.616510	

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

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(P)

Method: Least Squares

Date: 05/23/19 Time: 18:39

Sample (adjusted): 12/02/2014 3/22/2019

Included observations: 1124 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
P(-1)	0.000156	0.000327	0.477028	0.6334

R-squared	-0.000236	Mean dependent var	0.003106
Adjusted R-squared	-0.000236	S.D. dependent var	0.148343
S.E. of regression	0.148360	Akaike info criterion	-0.977458
Sum squared resid	24.71808	Schwarz criterion	-0.972987
Log likelihood	550.3312	Hannan-Quinn criter.	-0.975768
Durbin-Watson stat	1.926449		

1st Difference Intercept

Null Hypothesis: D(P) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=21)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-32.29160	0.0000
Test critical values:	1% level	-3.435957	
	5% level	-2.863904	
	10% level	-2.568079	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(P,2)
Method: Least Squares
Date: 05/23/19 Time: 18:40
Sample (adjusted): 12/03/2014 3/22/2019
Included observations: 1123 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(P(-1))	-0.964760	0.029876	-32.29160	0.0000
C	0.002894	0.004427	0.653632	0.5135

R-squared	0.481917	Mean dependent var	0.000110
Adjusted R-squared	0.481455	S.D. dependent var	0.205995
S.E. of regression	0.148337	Akaike info criterion	-0.976883
Sum squared resid	24.66627	Schwarz criterion	-0.967936
Log likelihood	550.5200	Hannan-Quinn criter.	-0.973502
F-statistic	1042.747	Durbin-Watson stat	1.996121
Prob(F-statistic)	0.000000		

1st Difference Trend and Intercept

Null Hypothesis: D(P) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=21)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-32.28316	0.0000
Test critical values:	1% level	-3.966240	
	5% level	-3.413819	
	10% level	-3.128985	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(P,2)
Method: Least Squares
Date: 05/23/19 Time: 18:41
Sample (adjusted): 12/03/2014 3/22/2019
Included observations: 1123 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(P(-1))	-0.965007	0.029892	-32.28316	0.0000
C	0.006403	0.008877	0.721346	0.4708
@TREND("12/01/2014")	-6.23E-06	1.37E-05	-0.456179	0.6484

R-squared	0.482014	Mean dependent var	0.000110
Adjusted R-squared	0.481089	S.D. dependent var	0.205995
S.E. of regression	0.148389	Akaike info criterion	-0.975288
Sum squared resid	24.66168	Schwarz criterion	-0.961868
Log likelihood	550.6243	Hannan-Quinn criter.	-0.970216
F-statistic	521.1095	Durbin-Watson stat	1.996012
Prob(F-statistic)	0.000000		

1^{st} Difference None

Null Hypothesis: D(P) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=21)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-32.29324	0.0000
Test critical values:	1% level	-2.567023	
	5% level	-1.941105	
	10% level	-1.616510	

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

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(P,2)
Method: Least Squares
Date: 05/23/19 Time: 18:41
Sample (adjusted): 12/03/2014 3/22/2019
Included observations: 1123 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(P(-1))	-0.964379	0.029863	-32.29324	0.0000

R-squared	0.481720	Mean dependent var	0.000110
Adjusted R-squared	0.481720	S.D. dependent var	0.205995
S.E. of regression	0.148299	Akaike info criterion	-0.978283
Sum squared resid	24.67567	Schwarz criterion	-0.973810
Log likelihood	550.3061	Hannan-Quinn criter.	-0.976593
Durbin-Watson stat	1.996097		

Results for KPSS tests

KPSS BITCOIN/USD

Level Intercept

Null Hypothesis: P is stationary

Exogenous: Constant

Bandwidth: 31 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		2.952839
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	13521957
HAC corrected variance (Bartlett kernel)	4.17E+08

KPSS Test Equation

Dependent Variable: P

Method: Least Squares

Date: 05/23/19 Time: 15:49

Sample: 12/01/2014 3/22/2019

Included observations: 1539

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3129.252	93.76518	33.37329	0.0000

R-squared	0.000000	Mean dependent var	3129.252
Adjusted R-squared	0.000000	S.D. dependent var	3678.417
S.E. of regression	3678.417	Akaike info criterion	19.25900
Sum squared resid	2.08E+10	Schwarz criterion	19.26247
Log likelihood	-14818.80	Hannan-Quinn criter.	19.26029
Durbin-Watson stat	0.005129		

Level Trend and Intercept

Null Hypothesis: P is stationary

Exogenous: Constant, Linear Trend

Bandwidth: 31 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.359395
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	6878802.
HAC corrected variance (Bartlett kernel)	2.04E+08

KPSS Test Equation

Dependent Variable: P

Method: Least Squares

Date: 05/23/19 Time: 15:51

Sample: 12/01/2014 3/22/2019

Included observations: 1539

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1332.091	133.7328	-9.960842	0.0000
@TREND("12/01/2014")	5.801487	0.150581	38.52723	0.0000

R-squared	0.491287	Mean dependent var	3129.252
Adjusted R-squared	0.490956	S.D. dependent var	3678.417

S.E. of regression	2624.453	Akaike info criterion	18.58443
Sum squared resid	1.06E+10	Schwarz criterion	18.59137
Log likelihood	-14298.72	Hannan-Quinn criter.	18.58701
F-statistic	1484.347	Durbin-Watson stat	0.010083
Prob(F-statistic)	0.000000		

1st Difference Intercept

Null Hypothesis: D(P) is stationary

Exogenous: Constant

Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.088061
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	69393.43
HAC corrected variance (Bartlett kernel)	74899.22

KPSS Test Equation

Dependent Variable: D(P)

Method: Least Squares

Date: 05/23/19 Time: 15:51

Sample (adjusted): 12/02/2014 3/22/2019

Included observations: 1538 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.349662	6.719272	0.349690	0.7266

R-squared	0.000000	Mean dependent var	2.349662
Adjusted R-squared	0.000000	S.D. dependent var	263.5120
S.E. of regression	263.5120	Akaike info criterion	13.98672
Sum squared resid	1.07E+08	Schwarz criterion	13.99020
Log likelihood	-10754.79	Hannan-Quinn criter.	13.98802
Durbin-Watson stat	1.864852		

1^{st} Difference Trend and Intercept

Null Hypothesis: D(P) is stationary

Exogenous: Constant, Linear Trend

Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.081698
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	69388.82
HAC corrected variance (Bartlett kernel)	74880.90

KPSS Test Equation

Dependent Variable: D(P)

Method: Least Squares

Date: 05/23/19 Time: 15:52

Sample (adjusted): 12/02/2014 3/22/2019

Included observations: 1538 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.069824	13.44903	0.451321	0.6518
@TREND("12/01/2014")	-0.004835	0.015139	-0.319352	0.7495

R-squared	0.000066	Mean dependent var	2.349662
Adjusted R-squared	-0.000585	S.D. dependent var	263.5120
S.E. of regression	263.5890	Akaike info criterion	13.98796
Sum squared resid	1.07E+08	Schwarz criterion	13.99490
Log likelihood	-10754.74	Hannan-Quinn criter.	13.99054
F-statistic	0.101986	Durbin-Watson stat	1.864976
Prob(F-statistic)	0.749503		

KPSS RAND/USD

Level Intercept

Null Hypothesis: P is stationary

Exogenous: Constant

Bandwidth: 25 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.447686
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	1.329187
HAC corrected variance (Bartlett kernel)	31.84031

KPSS Test Equation

Dependent Variable: P

Method: Least Squares

Date: 05/22/19 Time: 12:54

Sample: 12/01/2014 3/22/2019

Included observations: 1125

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.48560	0.034388	392.1574	0.0000

R-squared	0.000000	Mean dependent var	13.48560
Adjusted R-squared	0.000000	S.D. dependent var	1.153416
S.E. of regression	1.153416	Akaike info criterion	3.124222
Sum squared resid	1495.335	Schwarz criterion	3.128689
Log likelihood	-1756.375	Hannan-Quinn criter.	3.125910
Durbin-Watson stat	0.016533		

Level Trend and Intercept

Null Hypothesis: P is stationary

Exogenous: Constant, Linear Trend

Bandwidth: 25 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.452984
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	1.295955
HAC corrected variance (Bartlett kernel)	31.14605

KPSS Test Equation
Dependent Variable: P
Method: Least Squares
Date: 05/22/19 Time: 12:54
Sample: 12/01/2014 3/22/2019
Included observations: 1125

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.17014	0.067896	193.9745	0.0000
@TREND("12/01/2014")	0.000561	0.000105	5.366266	0.0000

R-squared	0.025002	Mean dependent var	13.48560
Adjusted R-squared	0.024133	S.D. dependent var	1.153416
S.E. of regression	1.139413	Akaike info criterion	3.100681
Sum squared resid	1457.949	Schwarz criterion	3.109615
Log likelihood	-1742.133	Hannan-Quinn criter.	3.104057
F-statistic	28.79682	Durbin-Watson stat	0.016955
Prob(F-statistic)	0.000000		

1st Difference Intercept

Null Hypothesis: D(P) is stationary
Exogenous: Constant
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.112975
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000

	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.021986
HAC corrected variance (Bartlett kernel)	0.019985

KPSS Test Equation
Dependent Variable: D(P)
Method: Least Squares
Date: 05/22/19 Time: 12:55
Sample (adjusted): 12/02/2014 3/22/2019
Included observations: 1124 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.003106	0.004425	0.701941	0.4829

R-squared	0.000000	Mean dependent var	0.003106
Adjusted R-squared	0.000000	S.D. dependent var	0.148343
S.E. of regression	0.148343	Akaike info criterion	-0.977694
Sum squared resid	24.71224	Schwarz criterion	-0.973223
Log likelihood	550.4639	Hannan-Quinn criter.	-0.976004
Durbin-Watson stat	1.926603		

1st Difference Trend and Intercept

Null Hypothesis: D(P) is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 11 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.083346
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.021981
HAC corrected variance (Bartlett kernel)	0.019931

KPSS Test Equation
Dependent Variable: D(P)
Method: Least Squares
Date: 05/22/19 Time: 12:55
Sample (adjusted): 12/02/2014 3/22/2019
Included observations: 1124 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007096	0.008858	0.801036	0.4233
@TREND("12/01/2014")	-7.09E-06	1.36E-05	-0.519977	0.6032

R-squared	0.000241	Mean dependent var	0.003106
Adjusted R-squared	-0.000650	S.D. dependent var	0.148343
S.E. of regression	0.148391	Akaike info criterion	-0.976155
Sum squared resid	24.70629	Schwarz criterion	-0.967215
Log likelihood	550.5993	Hannan-Quinn criter.	-0.972777
F-statistic	0.270376	Durbin-Watson stat	1.927068
Prob(F-statistic)	0.603182		

Appendix B: ARCH Effect Results

BITCOIN/USD

Lag 1

Heteroskedasticity Test: ARCH

F-statistic	299.4725	Prob. F(1,1536)	0.0000
Obs*R-squared	250.9374	Prob. Chi-Square(1)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 11/12/19 Time: 13:18
Sample (adjusted): 12/02/2014 3/22/2019
Included observations: 1538 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	41094.20	9457.414	4.345184	0.0000
RESID^2(-1)	0.403932	0.023342	17.30527	0.0000

R-squared	0.163158	Mean dependent var	68957.66

Adjusted R-squared	0.162613	S.D. dependent var	399393.2
S.E. of regression	365480.0	Akaike info criterion	28.45711
Sum squared resid	2.05E+14	Schwarz criterion	28.46405
Log likelihood	-21881.52	Hannan-Quinn criter.	28.45969
F-statistic	299.4725	Durbin-Watson stat	2.026336
Prob(F-statistic)	0.000000		

Lag 2

Heteroskedasticity Test: ARCH

F-statistic	150.5130	Prob. F(2,1534)	0.0000
Obs*R-squared	252.1365	Prob. Chi-Square(2)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 11/12/19 Time: 13:20
Sample (adjusted): 12/03/2014 3/22/2019
Included observations: 1537 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	39788.85	9519.647	4.179656	0.0000
RESID^2(-1)	0.390752	0.025518	15.31251	0.0000
RESID^2(-2)	0.032610	0.025519	1.277904	0.2015

R-squared	0.164045	Mean dependent var	69002.53
Adjusted R-squared	0.162955	S.D. dependent var	399519.3
S.E. of regression	365520.9	Akaike info criterion	28.45798
Sum squared resid	2.05E+14	Schwarz criterion	28.46840
Log likelihood	-21866.96	Hannan-Quinn criter.	28.46186
F-statistic	150.5130	Durbin-Watson stat	2.009744
Prob(F-statistic)	0.000000		

Lag 3

Heteroskedasticity Test: ARCH

F-statistic	114.1328	Prob. F(3,1532)	0.0000
Obs*R-squared	280.5829	Prob. Chi-Square(3)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 11/12/19 Time: 13:20
Sample (adjusted): 12/04/2014 3/22/2019
Included observations: 1536 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	33868.14	9475.769	3.574184	0.0004
RESID^2(-1)	0.385873	0.025262	15.27460	0.0000
RESID^2(-2)	-0.025731	0.027110	-0.949127	0.3427
RESID^2(-3)	0.149308	0.025263	5.910271	0.0000

R-squared	0.182671	Mean dependent var	69047.41
Adjusted R-squared	0.181071	S.D. dependent var	399645.5
S.E. of regression	361658.1	Akaike info criterion	28.43739
Sum squared resid	2.00E+14	Schwarz criterion	28.45129
Log likelihood	-21835.91	Hannan-Quinn criter.	28.44256
F-statistic	114.1328	Durbin-Watson stat	2.057985
Prob(F-statistic)	0.000000		

RAND/USD

Lag 1

Heteroskedasticity Test: ARCH

F-statistic	17.55513	Prob. F(1,1122)	0.0000
Obs*R-squared	17.31550	Prob. Chi-Square(1)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 11/12/19 Time: 13:21
Sample (adjusted): 12/02/2014 3/22/2019
Included observations: 1124 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.019133	0.001660	11.52739	0.0000
RESID^2(-1)	0.124099	0.029619	4.189885	0.0000

R-squared	0.015405	Mean dependent var	0.021845
Adjusted R-squared	0.014528	S.D. dependent var	0.051618
S.E. of regression	0.051242	Akaike info criterion	-3.102744
Sum squared resid	2.946062	Schwarz criterion	-3.093803
Log likelihood	1745.742	Hannan-Quinn criter.	-3.099365
F-statistic	17.55513	Durbin-Watson stat	2.030927
Prob(F-statistic)	0.000030		

Lag 2

Heteroskedasticity Test: ARCH

F-statistic	18.65711	Prob. F(2,1120)	0.0000
Obs*R-squared	36.20785	Prob. Chi-Square(2)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 11/12/19 Time: 13:22
Sample (adjusted): 12/03/2014 3/22/2019
Included observations: 1123 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.016642	0.001742	9.553097	0.0000
RESID^2(-1)	0.108182	0.029635	3.650490	0.0003
RESID^2(-2)	0.130512	0.029620	4.406233	0.0000

R-squared	0.032242	Mean dependent var	0.021854
Adjusted R-squared	0.030514	S.D. dependent var	0.051640
S.E. of regression	0.050846	Akaike info criterion	-3.117349
Sum squared resid	2.895594	Schwarz criterion	-3.103928
Log likelihood	1753.391	Hannan-Quinn criter.	-3.112277
F-statistic	18.65711	Durbin-Watson stat	2.014151
Prob(F-statistic)	0.000000		

Lag 3

Heteroskedasticity Test: ARCH

F-statistic	13.70559	Prob. F(3,1118)	0.0000
Obs*R-squared	39.80016	Prob. Chi-Square(3)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 11/12/19 Time: 13:22
Sample (adjusted): 12/04/2014 3/22/2019
Included observations: 1122 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.015701	0.001811	8.671660	0.0000
RESID^2(-1)	0.100590	0.029870	3.367662	0.0008
RESID^2(-2)	0.124708	0.029787	4.186617	0.0000
RESID^2(-3)	0.057158	0.029855	1.914559	0.0558

R-squared	0.035473	Mean dependent var	0.021865
Adjusted R-squared	0.032884	S.D. dependent var	0.051662
S.E. of regression	0.050805	Akaike info criterion	-3.118070
Sum squared resid	2.885769	Schwarz criterion	-3.100163
Log likelihood	1753.237	Hannan-Quinn criter.	-3.111302
F-statistic	13.70559	Durbin-Watson stat	2.003563
Prob(F-statistic)	0.000000		

Appendix C: AR(1) – GARCH(1,1) Test Results

AR(1)-GARCH Bitcoin/USD results

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	469.3170	121903.1	0.003850	0.9969
AR(1)	0.999999	1.85E-06	540658.8	0.0000
		Variance Equation		
C	1.079198	0.180193	5.989119	0.0000
RESID(-1)^2	0.172438	0.008025	21.48773	0.0000
GARCH(-1)	0.875359	0.004133	211.7889	0.0000

R-squared	0.994871	Mean dependent var	3129.252
Adjusted R-squared	0.994868	S.D. dependent var	3678.417
S.E. of regression	263.5223	Akaike info criterion	10.63752
Sum squared resid	1.07E+08	Schwarz criterion	10.65487
Log likelihood	-8180.572	Hannan-Quinn criter.	10.64397
Durbin-Watson stat	1.864704		
Inverted AR Roots	1.00		

AR(1)-GARCH Rand/USD Results

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	13.07508	686.7186	0.019040	0.9848
AR(1)	0.999998	3.14E-06	318124.4	0.0000
		Variance Equation		
C	0.000293	0.000109	2.689973	0.0071
RESID(-1)^2	0.050364	0.008552	5.888785	0.0000
GARCH(-1)	0.937625	0.010818	86.67035	0.0000

R-squared	0.983467	Mean dependent var	13.48560
Adjusted R-squared	0.983452	S.D. dependent var	1.153416
S.E. of regression	0.148375	Akaike info criterion	-1.072458
Sum squared resid	24.72304	Schwarz criterion	-1.050122
Log likelihood	608.2575	Hannan-Quinn criter.	-1.064017
Durbin-Watson stat	1.926457		
Inverted AR Roots	1.00		