Bitcoin's Potential for use as a Hedge Against Adverse Market Conditions in South Africa

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By

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ABSTRACT

Bitcoin is defined as a virtual cryptocurrency that solely exists in electronic form. Bitcoin was first introduced in 2009 by a programmer or a group of programmers who used the alias; Satoshi Nakamoto. Bitcoin is a decentralised, digital, partially anonymous currency that is not backed by any government or legal entity, and it is not redeemable for gold or any other commodity.

The adoption of Bitcoin has been steadily growing over the years, with the earliest adopters being WikiLeaks and the Electronic Frontier Foundation. Ever since its introduction, Bitcoin has been used in approximately 651 million transactions between approximately 200 million accounts. As of June 2021, Bitcoin's daily transaction volume was around 250 589 bitcoins - roughly 346 million US dollars at current market exchange rates - and the total market value of all Bitcoin in circulation was 653 billion US dollars.

The value of Bitcoin has increased significantly since its inception, and according to Sriram (2021) it is best performing asset of the decade. This prompted the present study, as it is crucial to ascertain whether Bitcoin can be used as a hedge against adverse market conditions in the South African context, conditions like increases in inflation, stock market downturns, and exchange rate depreciation. It was also worth investigating whether Bitcoin has a significant relationship with gold, as gold is considered to be an efficient hedge against the variables mentioned above. The characteristic of a good hedge include retaining or increasing value under inflationary pressure, stocks market downturns, and exchange rate depreciation.

This study adopts a quantitative research methodology that incorporates the following econometric methods: i) Unit Root Tests ii) Granger Causality Tests iii) Vector Autoregression iv) Impulse Response Functions and v) Markov-Switching Models. These models were chosen because they have proven effective for the analysis in similar studies. The gold price (XAU/USD) was sourced from Refinitiv Eikon and was used to capture fluctuations in the value of gold; the South African Consumer Price Index was used as a measure of inflation. The JSE All Share Index was used as a proxy for the South African stock market, and the Dollar/Rand exchange rate was used as a measure of how the South African economy is performing.

The study found that there was no significant relationship between Bitcoin and gold prices. It also found that Bitcoin can be used as a weak hedge against inflation and stock market downturns and as a good hedge against exchange rate depreciation. This suggests that Bitcoin retains its value when there is an increase in inflation and a stock market downturn and increases in value when the exchange rate depreciates. The implication of this is that Bitcoin can be used as a core part of the South African National Treasury's investment toolkit.

ISISHWANKATHELO

IBitcoin ichazwa njengemali yakumnathazwe (cryptocurrency) esebenza kumaqonga omnathazwe kuphela. IBitcoin iqale ukwaziswa ngo-2009 ngumdwelisi-nkqubo wekhomptyutha (programmer) okanye iqela labadwelisi-nkqubo bekhompyutha ababe sebenzisa igama lobuxoki; Satoshi Nakamoto. IBitcoin ayilawulwa liqumrhu okanye umntu omnye (decentralized), ikumnathazwe, yimali enokufihlakala engaxhaswanga nangowuphi na urhulumente okanye inalo lomthetho, kwaye ayikwazi ukuhlawulela igolide kunye nayiphina imveliso.

Ukwamkelwa kweBitcoin kuthe chu ngcembe kuleminyaka idlula apha, isamkelwa okokuqala yiWikiLeaks kunye nayiElectronic Frontier Foundation. Ukusukela oko ingenisiwe, iBitcoin isetyenziswe ngokuqikelelwa kwizigidi ezingama-651 kwintengiselwano phakathi kwezigidi ezingama-200 ze-akhawunti uqikelelo. Ukususela kweyoMga ku-2021, umthamo kwintengiselwano kusuku kwiBitcoin ungama-250 589 bitcoins- malunga nezigidi zedola ezingama-346 kumaxabiso orhwebo angoku- kwaye ixabiso lemalike lilonke leBitcoin esetyenziswayo layizi bhiliyoni ezingama 653 US dollars.

Ixabiso leBitcoin linyuke kakhulu ukusukela ekuqaleni kwayo, kwaye ngokuka Sriram (2021) ngeyona asethi iqhuba kakuhle kweli shumi leminyaka. Oku kungentla kukhokhelele kolu phando, ukuqinisekisa ukuba iBitcoin ingasetyenziswa njengothango (hedge) olubinzayo kwiimeko zamahla-ndenyuka zemalike eMzantsi Afrika, iimeko ezifana nonyuko-maxabiso, ukwehla kwemalike yesitokwe, nokwehla kwexabiso lwemali yorhwebo. Bekukwabaluleka ukuphanda ukuba iBitcoin inalo na ulwalamano negolide, njengokuba igolide ibonwa njengothango olunamandla olubinzayo kwezimeko zikhankanyiweyo ngentla. Iimpawu zothango olomeleleyo ziquka ukugcina

okanye ukunyusa ixabiso phantsi koxinzelelo lokunyuka kwamaxabiso, amahla-ndenyuka emalike yezitokhwe, nokuhla kwamaxabiso orhwebo.

Olu phando lusebenzisa iqualitative research methodology edibanisa ezindlela zophando loqoqosho i) Unit Root Tests ii) Granger Causality Tests iii) Vector Autoregression iv) Impulse Response Functions and v) Markov-Switching Models. Le mizekelo ikhethwe ngenxa yokuba ibonakalise ukusebenza kuhlalutyo lolunye uphando olufana nolu. Ixabiso legolide (XAU/USD) lifunyenwe kuRefinitiv Eikon futhi lisetyenziswe ukufaka uguqu-guquko kwixabiso legolide; iSouth African Consumer Price Index isetyenziswe njengomlinganiselo wokunyuka kwamaxabiso. I-JSE All Share Index isetyenziswe njengommeli (proxy) wemalike yesitokwe yaseMzantsi Afrika kwaye urhwebo lweDollar/Rand lusetyenziswe njengomlinganiselo wenkqubo yoqoqosho lwaseMzantsi Afrika.

Olu phando lufumanise ukuba akukho lwalamano lukhulu phakathi kweBitcoin kunye namaxabiso egolide. Lukwafumanise ukuba iBitcoin ingasetyenziswa njengothango olubuthathaka (weak hedge) ukubinzela ukunyuka kwamaxabiso kunye namahla-ndenyuka emalike yesitokwe, nanjengothango olomeleleyo ukubinza amaxabiso ahlayo emali yezorhwebo. Lento ithi ukuba iBitcoin igcina ixabiso layo xa kukho ukwanda kunyuko lwamaxabiso naxa kukho amahla-ndenyuka kwimalike yesitokhwe kwaye linyanyuka ixabiso layo xa urhwebo lwemali lusihla.

DECLARATION OF ORIGINAL WORK

This page declares that the work produced in this thesis is my own and was conducted whilst completing the degree of Master of Commerce in Financial Markets whilst at Rhodes University. Any work that is not my own has been credited accordingly. I, Yonela Faba, certify that this thesis has not been submitted for a degree at any other university, technikon nor college.

Signed: Y.Faba

Date: 13/07/22

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PREFACE

ACKNOWLEDGEMENTS

In instances like this it is often tempting to be humble, but I would first like to thank myself, for never giving up, and for keeping on even when other people did not understand, this more than anything is for myself more than anyone else. This project would never exist without my supervisors Mr. R.L. Hancocks and Prof. Rogan, I give my sincerest thanks for their guidance, kindness, and patience during this time.

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CHAPTER 1: INTRODUCTION

1.1. RESEARCH CONTEXT

Cryptocurrencies are a relatively new phenomenon of the 21st century clouded by an element of uncertainty as to whether they have the capability to evolve into full-fledged currencies accepted worldwide or if they will remain a means of speculation as an asset class. There are more than 4000 cryptocurrencies in existence as of January 2021. However, the five major ones by market capitalization are Bitcoin, Ethereum, Binance Coin, Tether, and Cardano (Forex Ratings, 2021). Most of the literature focuses on Bitcoin as it is the oldest, most widely established, and most valuable at current pricing. However, conclusions drawn about Bitcoin also apply to most of the other cryptocurrencies as they share the same fundamental characteristics – they are all based on blockchain technology (Bobs Guide, 2018). This study will also focus on Bitcoin as it is the most highly capitalised cryptocurrency as it reaches above 921 billion US Dollars (Moneycontrol, 2021). It is also the most widely adopted by institutions and countries alike, and it bears most of the brunt when there is a demand shock to the cryptocurrency market (Castilo, 2020).

Baur et al. (2017) defines Bitcoin as a digital currency with a decentralized peer-to-peer payment network; this means that it allows payments to be sent from one party to the next without the intervention of a third party. Furthermore, Bitcoin can be defined as a hybrid between a fiat currency and a commodity currency without an intrinsic value and independent of any government or monetary authority. Although Bitcoin can be used as a currency, it has various properties that also allow for it to be used as an asset. Whilst a currency is characterised primarily as a medium of exchange, a unit of account, and a store of value. An asset is anything that can be utilised to produce value and that is held by an economic entity and has the potential to increase in economic value. Bitcoin is considered a hybrid as it possesses both the features of a currency and an asset.

The appeal of virtual currencies as a medium of exchange is that they have low transaction costs, their peer-to-peer, global, and government-free design, and the possibility of purchasing unique goods (e.g., illegal drugs and firearms) for which the seller may prefer the use of a virtual currency. The downside to virtual currencies is that potential users may be discouraged to make use of them if the currency or the confidence in the system, or the price of the virtual currency is low, and this depends on how the currency is viewed. Suppose the virtual currency is also viewed as a speculative investment. In that case, the demand for the asset may contribute

to the currency's price volatility and thus dissuade users who would have used it as a currency. Both aspects -speculative investment or currency- are heavily influenced by the level and nature of the virtual currency's market volatility. As Baur and Dimpfl (2017) suggest, excess volatility (as compared to mature foreign exchange markets) would classify Bitcoin as a speculative investment more than a currency.

Volatility, with respect to financial markets, can be defined as a statistical measure of the dispersion of return for a given security or market index, and in this case, Bitcoin. In most cases, the higher the volatility, the riskier the security. Volatility is measured using either the standard deviation or variance between returns from that same security or market index (Denizer, 2000). Volatility is often used when referring to the amount of uncertainty or risk attached to a security's value. High volatility means that the value of a security has the potential to be spread out over a more extensive range of values. This means that the price of a security changes drastically over a short period of time in either direction. A lower volatility means that a security's value does not fluctuate drastically and tends to be more stable (Müller et al., 1990). Various empirical studies have investigated the volatility of Bitcoin, and most of them came with fascinating conclusions – these are elaborated upon below.

In a study performed by Baur and Dimpfl (2017), in which they used volatility analysis and regressions on daily price movements between January 2014 and December 2016 to determine realised volatility. It was found that Bitcoin has a high level of volatility, and this makes reliable exchange impossible and adversely affects the store of value and unit of account characteristics of the currency. Furthermore, the fact that Bitcoin is not an official currency in any country and the full faith of any government does not back it implies that the high level of volatility affects every Bitcoin transaction within and across countries. Historically, if an official currency was that volatile, it was either replaced by barter trading or by another foreign currency. The conclusion drawn here is that Bitcoin is less suited to be an official currency, and it is better as a speculative investment.

Chu *et al*. (2017) used GARCH analysis to measure cryptocurrency volatility for the period starting in 22 June 2014 ending on 17 May 2017. Their results show that cryptocurrencies such as Bitcoin, Ethereum, Litecoin, and many others exhibit extreme volatility, especially when they looked at their inter-daily prices. Several other studies also seem to suggest that cryptocurrencies are more volatile and thus less suited to be used as currencies. As volatile as cryptocurrencies may be, it remains unclear as to whether this volatility is intrinsic to the virtual

currency or is a reaction to external factors. There are papers that have tried to explain this phenomenon.

One such study is a paper by Guizani and Nafti (2019); in this paper, the authors attempt to understand the reasons for Bitcoin price volatility. They also attempt to analyse and estimate their influence using daily data for the period starting on 19 December 2011 ending 06 February 2018. They found that their estimated results suggest that, according to the Autoregressive Distributed Lag model, demand has a significant impact on the short-term Bitcoin price volatility as well as the long term. However, the effect of the supply coefficients is not significant in short and long terms. This is because Bitcoin supply is limited since its introduction in 2008, it is impossible to create new bitcoins.

Another study that sought to explain the reasons behind Bitcoin volatility is a paper by Bystrom and Krygier (2018) which covered monthly data between 2011 and 2017. They looked at the link between the volatility in the Bitcoin market and the volatility in other related traditional markets, i.e., the gold, currency, and stock market. They also tried to answer if the volatility in the Bitcoin market can be explained by retail investor-driven internet search volumes or by the general level of risk in the financial system. Based on correlations, OLS-regressions, and VAR-analysis, their main finding is a strong positive link between Bitcoin volatility and search pressures on Bitcoin-related words on Google, particularly for the search word "bitcoin". Other than that, the only somewhat significant driver of Bitcoin volatility is the volatility in the US dollar currency market.

Finally, a paper by Conrad *et al*. (2018) attempted to identify the driving forces behind Bitcoin market movements by establishing what drives the long-term volatility of Bitcoin using a GRACH-MIDAS analysis on Bitcoin daily price data from the period starting in 2013 and ending in 2017. They found that the S and P 500 realised volatility has a negative and highly significant effect on long-term Bitcoin volatility. Furthermore, the S and P 500 volatility risk premium was reported to have a significantly positive effect on long-term Bitcoin volatility. The paper, however, did not explain why this was the case; this is a potential area of research, which will not be covered in this study. Additional observations were a strong positive association between the Baltic dry index and long-term Bitcoin volatility and a significantly negative effect on Bitcoin trading volume.

Studies have not been limited to just determining how market indices affect Bitcoin price; some studies have also looked to understand how macroeconomic fundamentals affect Bitcoin prices. A study that attempts to do this is a paper by Walther *et al*. (2019) in which they apply the GARCH-MIDAS framework to forecast the daily, weekly, and monthly volatility of Bitcoin, Etherium, Litecoin, Ripple, and Stellar as well as the cryptocurrency index, CRIX, to determine the most important exogenous drivers of volatility in cryptocurrency markets. The analysis was conducted on daily price series data ending on 31 July 2019 but varying in their starting point. The study found that Global Real economic activity outperforms its peers – which include the Global Economic Policy Uncertainty (GEPU) & Chinese Economic Policy Uncertainty (CEPU) indices as well as the trade-weighted USD index - as a positive predictor of cryptocurrency volatility. This is interesting as it means that the volatility of cryptocurrencies appears to be driven by the global economic activity which is driven by the developed world rather than country-specific economic or financial variables for developing countries. It also shows that the large trading activity and market share in emerging markets do not have a steady effect on the volatility of cryptocurrency markets. Finally, unforeseen policy changes - as given by the GEPU and the CEPU - have a short-lived but significant impact.

The above has several implications; because Bitcoin is not related to any emerging country-specific market fundamentals, then it might be possible to use it as a hedge against adverse market conditions in South Africa. Also, despite its volatility, Bitcoin has been on an upward trend since its creation; this further solidifies the idea of Bitcoin being an integral part of a country's investment toolkit to hedge against market fundamentals like inflation as the Bitcoin has experienced above inflation returns throughout its lifetime. Some literature suggests that Bitcoin might be suited for hedging against adverse market conditions; the characteristics of a good hedge include maintaining value when major currencies erode, being resilient in the face of inflation, being a good defense against deflation, and maintaining its value in times of geopolitical and policy uncertainty (FX Street, 2019). As much as several studies exist that cover this very topic there are none that have been done in the South African context, and this is what this study will address.

1.2. GOALS OF THE RESEARCH

In this project, the proposal was to examine whether Bitcoin has either a positive or no relationship with gold, inflation as given by the consumer price index, the JSE All Share Index, and the USD/ZAR exchange rates. A negative relationship indicates that Bitcoin is a good

hedge against these variables and no relationship indicates that Bitcoin is a weak hedge against these variables. A quantitative approach was used along with secondary data with the objective of determining whether Bitcoin can be used as a hedge against the above variables within the South African context. This was done to determine the suitability of Bitcoin as a mainstream volatility hedge in long horizon investment solutions as an offset to such adverse market conditions as inflation, stock market downturns, and exchange rate depreciation. Because of this, the plausibility for substitution of a portion of assets with cryptocurrency as a viable option for treasury is explored. This research is important as it addresses the potential for the addition of Bitcoin into South Africa's National Treasury's investment toolkit as it might be as suited as gold as a hedge.

- Primary goal(s):

    - To explore whether Bitcoin should be used as a core part of the South African National Treasury's investment toolkit given how it performs against other assets and its potential for use as a hedge against as inflation, stock market downturns, and exchange rate depreciation. This is relevant because an additional hedge may assist the treasury in creating an optimal portfolio that will still allow the government to meet debt and other fiscal obligations even during times of high inflation, market downturns and exchange rate depreciation. This will be done by investigating whether Bitcoin shares some characteristics with another popular hedge – gold – if they share most features, then it is highly plausible that Bitcoin will be as efficient at hedging as gold while still maintaining its own unique characteristics and not becoming a synthetic substitute.

Primary research question: Is Bitcoin suited to be a hedge against adverse market conditions in South Africa?

Secondary goal(s):

- Studying the volatility of Bitcoin prices and their correlation with various South African fundamentals. These include the South African stocks, inflation, and the dollar/rand exchange rate. These were chosen because they are diagnostic of the health of the South African economy, this is because high stock prices indicate significant economic activity, inflation gives an indication of the

currency's buying power and the exchange rate can be used as a proxy for how well an economy is performing. This will be done to determine the direction of correlation or if there is any correlation at all, this will assist in answering the question of whether Bitcoin can be used as a hedge against the above fundamentals.

- To look at the relationship between the prices of Gold and Bitcoin prices and see whether there is any correlation. This is mainly because it has been established that gold is a good hedge against an increase in global risk aggregates. If Bitcoin does share a significant number of characteristics, then Bitcoin could be added to the South African National Treasury's portfolio as a means to hedge against inflation, stocks, and the depreciation of the Rand.

Secondary research questions: Is there correlation between Bitcoin and South African fundamentals: inflation, the JSE All Share Index, and the Dollar/Rand exchange rate? Is there correlation between Bitcoin and Gold and gold prices?

1.3. METHODS AND ETHICAL CONSIDERATION

At present, the most popular hedge against market risk is gold, this holds true for both mainstream investors and treasuries. In the case of treasuries, the allure of gold is the fact that it lacks credit or default risks. Gold prices go up when interest rates go down – because lower interest rates make alternative assets like stocks, government bonds less appealing, driving investors towards gold, and increasing demand and the price accordingly. Interest rates are directly proportional to the strength of the economy as result gold can be considered as a hedge against a falling economy (Relli, 2021). However, the question is whether Bitcoin is a better alternative or whether it can be used in conjunction with gold in the South African National Treasury's investment toolkit. As it stands gold is widely viewed as a hedge against market downturns which could be given by a decrease in interest rates, rises in inflation, a decrease in the price of stocks, currency depreciation, etc., for instance, during the 2008 financial crisis, central banks around the world implemented quantitative easing, effectively lowering interest rates to near zero. At the same time, gold prices rose to highs of 1,900 US dollars per ounce (Nath, 2020). The implication of this is that gold performs well in economic downturns. Studies like the one by Kyriazis (2020) suggest that Bitcoin shares a lot of characteristics with gold, these include rarity, liquidity, and transparency. This was the primary focus of this paper, to investigate whether Bitcoin would be a good addition to South Africa's investment toolkit as a

means to hedge against adverse market conditions. Bitcoin was chosen out of all the cryptocurrencies because it is both the oldest, most valuable, it is the most widely adopted and has the highest volumes currently in circulation. The way the methodology, procedures and techniques were applied is given in parts A and B below.

Part A

- Monthly historical Bitcoin price data and JSE All Share Index (ALSI) data for the years 2008 to 2018 were sourced from Refinitiv Eikon, monthly historical data for the inflation rate, and the dollar/rand exchange rate were sourced from the South African Reserve bank website. These data then underwent the Dickey-Fuller test for stationarity; this helped ensure that the Dynamic Markov Switching Model regression results were not spurious.
- After this, the Bitcoin data were graphed onto line graphs against the explanatory variables, which in this case were the ALSI, inflation, and the dollar/rand exchange rate. The aim of this was to determine whether there is a visible relationship between Bitcoin prices and the various South African fundamentals.
- A Vector Autoregressive model (VAR) was estimated to see how these variables are related. This was done to demonstrate whether there is some evidence of a relationship between bitcoin and the specific fundamentals.

Part B

- The next step entailed the use of a Dynamic Markov Switching model to identify whether there is a latent state (defined by explanatory variables) that is poorly correlated with the prices of Bitcoin. The Dynamic Markov Switching model was used because it has been established that the explanatory variables exist in two distinct states related to the condition of the local economy; this model was, therefore, suitable for describing correlated data that show distinct dynamic patterns during different time periods.
- Hypotheses tests were carried out using probability values. This was done to see whether there is a statistically significant and state-dependent relationship between the explanatory variables and dependent variable (Bitcoin prices).

Doing all the above steps assisted in determining whether there is potential for Bitcoin to be adopted as a hedge within South Africa's investment toolkit. Since bitcoin responds to global

markets and not local market fundamentals, then we would expect the switching model to have very little explanatory power- i.e., very few significant coefficients or a poorly fitting model. If this is the case, then Bitcoin can be successfully employed as a treasury hedge. No ethics application form was submitted using the ethical review application system (ERAS) as this is low-risk desktop research.

1.4. ORGANISATION OF THE THESIS

This organisation of the thesis is as follows. Chapter 2 discusses the current knowledge relevant to Bitcoin and blockchain technology in the form of a literature review. Chapter 3 outlines the data, methodology and techniques that were employed to conduct the study. Chapter 4 presents and discusses the results of the research conducted and compares the findings to previous literature. Chapter 5 concludes with a summary of the thesis and provides recommendations for future research.

CHAPTER 2: LITERATURE REVIEW

2.1. INTRODUCTION

Within the realm of economics, money can be described as anything generally accepted as a means of payment for goods, services, and debt repayment. In short, money is a medium of exchange, and real-world currencies are the best examples of money. Before the advent of money, people exchanged goods and services in what is called the bartering system. Throughout history, many types of money have been used but none have been as innovative as Bitcoin. Many would argue that Bitcoin is not real money, however, according to the theory of money by Pedro Franco – "money is durable, divisible, fungible, easy to transport and impossible to counterfeit" – Bitcoin embodies all of these characteristics (Malik, 2016).

October 31st, 2008 will forever be known as the day Satoshi Nakamoto introduced a new version of electronic cash. He described it as a peer-to-peer unit of account that would allow payments to be sent directly from one party to another without the need to go through a financial institution. Not so long after that, on January 03rd 2009, Nakamoto mined the first blockchain – which has come to be known as the "genesis block" – this event marked the birth of Bitcoin, which is the world's first decentralised cryptocurrency (Wang *et al.*, 2019). Bitcoin is a currency just like the Rand, except that it does not exist in physical form, and it is not backed by any government treasury, precious metal, or commodity (Wiseman, 2016). This new system would see traditional elements of trust, accountability, and oversight, that had characterised commerce and exchange through time be replaced by a system that would, on a fundamental level, have no need for transacting agents to know each other (Chohan, 2017).

2.2. A BRIEF HISTORY

Authors going by the pseudonymous person(s) or entity(-ies) known as Satoshi Nakamoto managed to build and create Bitcoin. Hal Finney and Wei Dai - who are the earliest adopters of Bitcoin - were suspected to be the people behind the Satoshi Nakamoto moniker, but they issued a set of statements in which they denied all involvement (Chohan, 2017).

After the Nakamoto (2008) paper was disseminated, the first platform for Bitcoin transactions was created - it was called Bitcoind, and it was the brainchild of Satoshi Nakamoto - through which the first bitcoins were issued. It is around this time that Nakamoto mined the genesis block for a reward of 50 bitcoins. Hal Finney then downloaded the Bitcoin-client and was the first person to receive 10 bitcoins from Nakamoto; this represented the first-ever Bitcoin

transaction in all known history. Nakamoto mined approximately 1 million bitcoins before disappearing and ceasing involvement with the Bitcoin movement. After this, Gavin Andresen became the lead developer at the Bitcoin Foundation and shortly after became the public face of Bitcoin (Chohan, 2017).

The initial monetary value of bitcoin was arrived at through a proto-market bargaining process, an example of which would be when 10 000 bitcoins were used to purchase two pizzas from Papa John's indirectly. This period allowed for a significant vulnerability in the system to be discovered, a vulnerability that led to the exploited overproduction of 180 billion bitcoins. Those coins have since been removed from the blockchain, and an updated security protocol was introduced to ensure that such never happens again (Chohan, 2017).

The earliest adopters of Bitcoin for the purpose of transacting include WikiLeaks and the Electronic Frontier Foundation (a non-profit group); for which the primary use was accepting donations (Greenberg, 2011). However, the Electronic Frontier Foundation stopped accepting Bitcoin in June 2011 because of the concerns it had about a lack of legal precedent about the new currency system; it then reversed its decision on May 17th, 2013 (eff.org, 2016).

In 2013 a huge incident occurred, which led to Bitcoin catching the attention of regulatory authorities. The Bitcoin transaction log, otherwise known as the blockchain, split into two independent chains, each with its own rules on how transactions were accepted. These two Bitcoin networks operated at the same time for six hours, with each having its own version of transaction history. This led to the core developers calling for a temporary halt to all Bitcoin transactions; this sparked a massive sell-off. The error was a bug in the 0.8 version of the software - normal operation was eventually restored when most of the network was downgraded to the 0.7 version of the Bitcoin software (Lee, 2013). Mt. Gox - which was a Bitcoin exchange based in Shibuya, Tokyo, Japan – briefly halted all Bitcoin deposits, and the price dropped by 23% to 37 US dollars as a result. However, the price recovered back to about 48 US dollars in the hours following the event. This led to the Financial Crimes Enforcement Network (FinCen) of the United States establishing regulatory guidelines for all decentralised virtual currencies. FinCen classified all American bitcoin miners who sell bitcoin as Money Service Businesses; this meant they were subject to registration and other legal obligations (FinExtra, 2013).

Also, in 2013, the Peoples Bank of China prohibited Chinese financial institutions from using Bitcoin (Leo, 2013). However, this was only the beginning as, in September 2017, China took

the first steps towards banning trading in Bitcoin. On February 01st 2018, this became a complete ban; this led to Bitcoin prices falling from 9 052 to 6 914 US dollars. The percentage of Bitcoin traded in the Chinese renminbi fell from just above 90% in September 2017 to below 1% in June 2018 (Xinhua, 2018).

There have been several incidents that brought the security of Bitcoin into question. In 2018, the price of Bitcoin was adversely affected as several hacks led to thefts from several cryptocurrency exchanges. This includes Coincheck in January, followed by Bithumb in June, and Bancor in July. More than 761 million US dollars' worth of cryptocurrencies were reported stolen just in the first six months of 2018. Bitcoin bore most of the adverse effects, as its prices dropped, even though other cryptocurrencies were also stolen (Daniel, 2018).

In August of 2020, MicroStrategy - a publicly traded business intelligence firm purchased 21 454 bitcoins; the company poured 250 million US dollars' worth of its inflation-hedging funds into the virtual currency. According to Chief Executive Officer Michael J. Saylor, "Bitcoin is a dependable store of value and an attractive investment asset with more long-term appreciation potential than holding cash" (Nelson, 2020). In January 2021, Elon Musk, founder and CEO of Tesla, added #Bitcoin to his Twitter bio and sent out a cryptic tweet that read, "In retrospect, it was inevitable." - this led to the price of Bitcoin spiking by over 20% (Browne, 2021). Shortly after, MicroStrategy announced that it had increased its position by continuing to buy Bitcoin, and as of January 25th, 2021, it had holdings of about 2.38 billion US dollars' worth of bitcoin (Microstrategy.com, 2021). Significant institutional adoption continued as on February 08th 2021; Tesla announced that they had just purchased 1.5 billion US dollars' worth of Bitcoin and that the company planned to start accepting Bitcoin as payment for vehicles (Li, 2021).

Since its inception, Bitcoin has been used in approximately 651 million transactions that have occurred between approximately 200 million accounts. As of June 2021, the daily transaction volume was around 250 589 bitcoins - this is about 346 million US dollars at current market exchange rates - and the total market value of all Bitcoin in circulation was 653 billion US dollars (Blockchain.info 2021).

2.3. PRINCIPLES AND DESIGN

2.3.1. Fundamental Characteristics

Although Bitcoin now occupies a central position within the realm of digital cash instruments, some vehicles did exist before it. Bitcoin does have a set of unique propositions; however, there were other digital monetary systems in circulation in the online sphere that had similar traits to Bitcoin, such as proof of work or digital scarcity (Chohan, 2017).

Proof of work (PoW) can be described as a means through which one party (the prover) proves to others (the verifiers) that a certain amount of computational effort has been expended (Houben and Snyers, 2018). Proof of work has several uses; however, it is widely used in cryptocurrency mining, mainly for the validation of transactions and the mining of new tokens (Frankenfield, 2021). Digital scarcity, on the other hand, refers to the control over the abundance of digital assets; this is the opposite of digital abundance, which allows Internet users to enjoy access to almost unlimited content. This is important when it comes to assigning value to a digital item such as a cryptocurrency; for instance, Bitcoin is limited to 21 million bitcoins, and that number cannot be hacked, cheated, or tampered with (Thomas, 2019). As it stands an estimated 900 new bitcoins are mined per day, this means that on average, 144 blocks are mined daily with each containing 6.25 Bitcoins (Kraterou, 2021). The addition of new bitcoins through mining does not have a significant impact on the price as the rate at which new coins are introduced is designed to slow over time. As an example, the rate at which new coins are introduced slowed from 6.9% in 2016, 4.4% in 2017 and eventually 4.0% in 2018. This creates a situation in which the demand for bitcoins increases faster relative to supply increases, this leads to an increase in the price (Bloomenthal, 2021).

The underlying principle behind most currencies is scarcity; it is a prerequisite for assigning value to any form of money. From a microeconomic perspective, scarcity protects against counterfeiting, and from a macroeconomic standpoint, it creates a predictable growth path for the monetary base and facilitates price stability. In modern economies, most money is held in electronic forms, and legal rules maintain scarcity; this ensures the correctness of book-keeping records. This means that electronic money involves a financial system in which a transaction automatically triggers a credit for one account and a corresponding debit to another account. In this type of system, the central banks hold the power to adjust the amount of money in circulation (Böhme *et al.*, 2015).

Given this, Bitcoin can easily be understood as the first widely adopted mechanism that can provide absolute scarcity of money supply. Bitcoin was designed in such a way that it lacks a centralised authority which would distribute or track who holds which coins. As a result of this, the process underlying the issuing and the verification of transactions is relatively difficult when compared to more classic book-keeping systems. Bitcoin does this by issuing currency to private parties at a controlled pace as a means to incentivise those parties into maintaining its book-keeping system and verifying the validity of transactions (Böhme *et al.*, 2015).

2.3.2 Transactions

Other reasons for the creation of Bitcoin were inherent weaknesses in the trust-based model of transacting. As much as this system works well enough for most transactions, the reliance on third parties in order to process electronic payments has a lot of flaws that can be avoided with blockchain technology (Nakamoto, 2008). Unlike traditional ways in which banking and payment systems work, the Bitcoin system is based on decentralised trust. Unlike the system that initially existed, there is no central trusted authority; trust is achieved through the interactions of different participants within the Bitcoin system (Antonopoulos, 2014). This can manifest itself in cases where one would need to make a non-reversible transaction over an electronic platform.

When it comes to electronic methods of payment that predated Bitcoin, completely non-reversible transactions are not possible, and this is primarily because financial institutions cannot avoid mediating disputes. This cost of mediation leads to an increase in transaction cost, leading to a limit in the minimum possible transaction size, and this eventually closes off the possibility of small casual transactions. This in turn results in a social burden, as a broader cost comes with the inability to make non-reversible payments for non-reversible services. The existence of transaction reversibility leads to an increased need for trust between buyers and sellers. This can manifest itself in situations wherein a merchant might hassle a buyer for more information than they would otherwise need (Nakamoto, 2008).

In these instances, a certain percentage of fraud is accepted as unavoidable. Prior to Bitcoin, these cost and payment uncertainties could only be avoided with the use of physical currencies, but there was no mechanism in existence that allowed payments to be made over a communications channel without the involvement of a trusted party. What was needed was a fully electronic payment system based on cryptographic proof instead of trust. This would then allow any two willing parties to transact directly with each other without the call for a trusted

third party. This has several implications, transactions that are computationally impractical to reverse would help protect sellers from fraud, and the implementation of routine escrow mechanisms could be used to protect buyers easily. In his 2008 paper, Nakomoto proposed a set of solutions to pre-existing electronic cash systems, this includes a solution to the double-spending problem – which is the risk that a digital currency can be spent twice – by using a server that distributes timestamps in order to generate computational proof of the order in which transactions occurred (Nakamoto, 2008).

A set of complex algorithms allow Bitcoin transactions to occur; a transaction sends a signal to the network that tells it that an owner of a certain number of bitcoins has authorised the transfer of bitcoins to another party. The new owner can now spend these bitcoins by going through the same process and authorising transfer to another party, this goes on and on in a chain of ownership (Antonopoulos, 2014).

Bitcoin transactions can be viewed as lines in a double-entry ledger. One could look at each transaction as containing one or more inputs, which are debits against a Bitcoin account. The other side of the transaction would show outputs which are credits added to another Bitcoin account. These inputs and outputs (credits and debits) do not add up to an equivalent amount as there are transaction fees which are small amounts collected by miners who include the transaction in the ledger (Antonopoulos, 2014). A Bitcoin miner is a person who partakes in the process through which new bitcoins are entered into circulation. This process is also a critical component of the maintenance and development of the blockchain ledger. It is performed through very sophisticated computers that solve highly complex computational math problems (Mansa, 2021).

These transactions also contain proof of ownership for each number of bitcoins that are transferred; this takes on the form of a digital signature from the owner, which can be independently validated by anyone. In the case of Bitcoin, "spending" is simply signing a transaction that transfers value from a prior transaction over to a new owner that is identified by a Bitcoin address (Antonopoulos, 2014).

There are three main types of transactions that can occur on the Bitcoin network, and they tie into how Bitcoin can be used. The most common type of transaction is a transfer of funds from one party to another; it can sometimes include "change" that is sent back to the original owner. This transaction consists of one input and two outputs. The second most common type of transaction is one that bundles up several inputs into a single output. This is equivalent to

exchanging a pile of coins for a single and larger note. These transactions are generated mainly by wallet applications as a means to clean up small amounts that were generated as change for payments. Lastly, the third most common transaction is one that distributes one input to multiple outputs, which represent multiple recipients. This type of transaction is used mainly by firms in order to distribute funds, an example of which would be processing payroll payments to employees (Antonopoulos, 2014).

2.3.3. Bitcoin Liquidity

Liquidity is a very important aspect of modern financial markets. It encompasses how easily, quickly, and inexpensively one can trade - that is, the level of difficulty involved in converting to cash or an asset without impacting its market price. It is very relevant for market participants, exchanges, and regulators alike. However, when it comes to new and developing markets for cryptocurrencies like Bitcoin; relatively little is known about how their liquidity is developed and its determinants (Scharnowski, 2021).

Loi (2018) studied the liquidity of Bitcoin using time-series daily data over the period 01 January 2014 to 31 December 2015. Five Bitcoin exchanges were chosen (Bitstamp, Bitfinex, BTC-e, HitBTC, and itBit) to were compared with the liquidities of different sizes of stocks measured using indexes. Five liquidity measures were chosen for the study, this includes Amibud's Proxy for Illiquidity, Relative Change in Volume, Roll, and Roll. Three indexes were used to measure stock liquidity: the iShare S&P Small Cap 600 Value Index Fund, iShare S&P Mid Cap 400 Value Index Fund, and iShare S&P 100 Index Fund. The results suggest that the liquidity of Bitcoin depends on the choice of Bitcoin exchange. For example, two people who buy or sell Bitcoin in different Bitcoin exchanges will face different liquidity of their bitcoin. The study also compared the liquidity of stocks with that of Bitcoin; the results indicate that stocks are more liquid than Bitcoin no matter the sizes of stocks

Scharnowski (2021) also attempted to shed light on this by using bid-ask spreads, quoted depth, trading volume, the number of trades, and trade price volatility from various exchanges in order to determine Bitcoin liquidity through regression analysis. The author used daily, weekly, and monthly trading data from Bitstamp, BTCe, Bitfinex, OKcoin, and Coinbase for the period starting 01 July 2013 ending in September 2019. The author found that the driving factors behind liquidity and trading activity changes come mostly from within the Bitcoin network. At the same time, the state of the US economy only weakly influences Bitcoin liquidity.

2.4. BLOCKCHAIN TECHNOLOGY

A major component of Bitcoin is what is referred to as the blockchain; this simply refers to a ledger in which all Bitcoin transactions are securely recorded. However, this is not a completely new idea as it can be traced back to a series of publications by Haber and Stornetta dating back as early as 1991. Haber and Stornetta (1991) proposed a method for the secure timestamping of documents; this would become a key feature in blockchain technology. The primary function of timestamping would be to give an approximate idea of when a document was created; the most important element would be how timestamping gives the correct order of when these documents were created. If one document was created before another document, then the timestamps would reflect that. To ensure security, these timestamps need to have an additional feature which is the inability to change a document's timestamp after one has been assigned (Narayanan *et al.*, 2016).

In the Haber and Stornetta (1991) scheme exists a timestamping service to which a client would send a document to timestamp. The server would receive the document and sign it with the current time and a link to a document that preceded it, and it would then issue a "certificate" that contained this information. What this achieves is that each document's certificate ensures the integrity of the previous document; this means that each certificate fixes the entire history of documents and certificates before it. This ensures that the ordering of the documents is preserved (Narayanan *et al.*, 2016).

Haber and Stornetta refined this model in 1993; where instead of having documents linked individually, it was made possible to collect these documents into a block and connect them in a chain. The documents would be linked together within each block, but this would be a tree structure, and these documents would not be linked linearly. This in turn eliminates the need to check whether a document appears before another in the history of the system. This data structure is what forms the skeleton of Bitcoin's blockchain; however, Bitcoin subtly refined this idea. Bitcoin introduced a protocol similar to Hashcash - which is a proof-of-work system used to limit email spam and denial-of-service attacks - the primary function of this protocol is to delay the rate at which new blocks are added to the chain. This modification has significantly favourable consequences for the Bitcoin model as there is no need for trusted servers; instead, events are recorded on untrusted nodes (a server) called "miners". In order to become a miner, one has to employ computers with strong computing power to solve complex mathematical puzzles that allow the creation of new blocks. Essentially, Bitcoin uses a combination of

mathematical puzzles to regulate the creation of new coins and timestamping to record a ledger of transactions to prevent double-spending (Narayanan *et al.*, 2016). The result is an open and distributed ledger that can record transactions between a number of parties in an efficient, verifiable, and permanent way (Ianciti and Lakhani, 2017). Blockchain technology is quite innovative and has many practical applications; these include revolutionising counterfeit detection, contracts, financial services, and healthcare, just to name a few.

The trade in counterfeit goods is growing, and it is affecting the profits of many companies. In this instance, blockchain technology can be used by associating unique identifiers to products, documents, and shipments and storing records of the transactions related to those items in a registry which cannot be forged or altered. Manufacturers can store the relevant information about product sales on the blockchain, which is accessible to everyone. The total number of products sold by the seller and the total products left will be transparent. The user of this technology – in this case, the customer – will be able to immediately use the system to perform vendor-side verification, which will allow them to ascertain whether their procured product is a counterfeit or not (Ma *et al.*, 2020).

Traditional contracts need to be fully executed and enforced by a third party; however, blockchain technology has allowed for smart contracts which do not need an intermediary between the contracting entities. In a smart contract, clauses are written in a computer program, and they will only be executed once a set of predefined conditions are met. Smart contracts have several advantages over traditional contracts. These include decreased risks because of the immutability of blockchains; this means that smart contracts cannot be altered once they have been issued. Additionally, all transactions in the blockchain are traceable and auditable; this can help in mitigating cases of fraud. Another advantage of smart contracts is the cutting down of administration and legal costs primarily because the contracts are created automatically. These advantages compound and improve the overall efficiency of business processes, mainly due to the elimination of intermediaries (Zheng *et al.*, 2020). Smart contracts are a new phenomenon, because of this smart contract developers are in short supply. This can make it difficult for small to medium enterprises to add them to their business processes as a simple smart contract with no complex business logic costs around 7000 US dollars. More advanced contracts cost up to 45 000 US dollars, it quite common for large organisations with specialised knowledge to ask up to 100 000 US dollars (Medium, 2018).

Since 2016 blockchain technology has been receiving the attention of financial firms, a large majority of these firms see blockchains as a potential driver of considerable savings in infrastructure and back-office processes. In traditional banking, information verification, credit scoring, loaning processing, and the distribution of funds can take between thirty to ninety days for an individual to secure a loan. Blockchain technology has the potential to streamline this whole process, thereby reducing counterparty risk and decreasing issuance and settlement times (Cermeno, 2016).

Healthcare is one of the industries in which blockchain is expected to have a significant impact. In late 2019, the world was devastated by the COVID-19 pandemic; Blockchain technology found its use as a means to connect healthcare providers in need of medical equipment with global suppliers which they would otherwise be unable to find on their own. This is just in the management of the COVID-19 pandemic; other uses include the management of electronic medical records, pharmaceutical supply chains, biomedical research and education, remote patient monitoring, health insurance claims, and health data analytics (Agbo *et al.*, 2019).

2.5. RISKS, TAXES, AND LEGALITY

2.5.1. Risks

2.5.1.1. The Trade in Illicit Goods

The advent of cryptocurrencies has transformed the trade in illegal goods, especially drugs; primarily due to the anonymisation tools attached to most cryptocurrency clients. Most of these transactions occur in dark markets, sites on the dark web where people can buy or sell illicit goods and services online. There has been increasing intervention by authorities; however, this has done nothing to quell this scourge as the number of illegal goods on offer has been growing significantly (Stroukal and Nedvedova, 2016). Bitcoin has a long history of being used in illicit transactions.

In 2013, through the Federal Bureau of Investigation (FBI), Drug Enforcement Administration (DEA), The Internal Revenue Service (IRS), and other law enforcement agencies, the United States government arrested Robert Ulbricht, the founder of Silk Road, an online black market, and it was best known for selling illegal drugs. Although it was not the biggest centre of drug trade, it was a significant milestone for cybercrime as it only allowed the sale of goods and other services through Bitcoin. It used a similar format to popular auction sites such as eBay. Users would have anonymous nicknames, and they would be able to offer and buy products in

both legal and illegal categories. The buyers would receive their goods through the postal service; however, they would not be delivered directly to their place of residence as a means to protect their identity (Barrat and Aldridge, 2016).

In order to hide, Silk Road existed on what is known as the TOR network or The Onion Router, which is a network that allows anyone anonymous web browsing – this is especially true for sites that contain the -.onion suffix on which dark marketplaces like Silk Road are placed. TOR is a network that consists of thousands of volunteer computers that are connected; the users connect to this network in such a way that makes their movements almost untraceable. Meaning that these sites and marketplaces operate outside the bounds and supervision of standard browsers and search engines; this is why it eventually became collectively known as the deep web, which is different from the dark web – this is the illegal part of the deep web (Stroukal and Nedvedova, 2016).

In 2015 alone, a total of 85 dark markets were established, and only 6 of them were closed by authorities (Gwern 2015). All dark markets facilitate their transactions through cryptocurrencies, especially using Bitcoin. Other than dark markets, dark web users can find a variety of specialised sites that offer a single product. However, most of these sites sell drugs, but one can find sites through which they can buy weapons, a fake identity, hire a hacker, or even an assassin (Weimann, 2016).

As much as dark markets are primarily used for the sale of drugs, there is the possibility of selling goods that are available in the real world at marked-down prices. This means that the difference between the price at dark markets and the prices in the real world will increase significantly. This can have an implication on economic policy as goods can be sold cheaper on these sites, and this is something policymakers will need to take into account as these sites can render policy useless (Stroukal and Nedvedova, 2016).

The Bitcoin market has periods of high liquidity and moderate liquidity, and recently value of the digital tokens has seen steady decrease. Bitcoin trading on cryptocurrency exchanges has slowed and using Bitcoin to buy legal items has also dropped. However, the trade in illicit good using Bitcoin is still going strong as the amount of cryptocurrency spent on dark markets, rose 60 percent to reach a new high of $601 million in the last three months of 2019. This suggests that Bitcoin liquidity does not have a significant effect on the trade in illicit goods (Popper, 2020).

2.5.1.2. Financing Terrorism

Bitcoin's unique properties, such as its peer-to-peer nature and pseudo-anonymity, serve as an advantage to terrorists as it is a means through which they can finance their activities. This illicit funding is important to the survival of these terrorist groups, without which these organisations would be unable to maintain their daily administrative tasks, offer support to their members, or carry out attacks. Because traditional money has the centrality feature, most terrorist groups procure funding from various legal and illegal methods, including state sponsors, petty theft, illicit trade, extortion, charitable donations, and personal wealth. However, since September 11th terrorist attacks, law enforcement agencies have taken significant strides in establishing efficient counter-terrorist finance methods. These methods have been effective in thwarting the movement of fiat currencies – or government-issued currencies – to terrorist groups. However, there are arguments that the success of these counter-terrorist finance measures may encourage these terrorist groups to seek alternative ways through which they can finance their activities, alternatives such as the growing cryptocurrency market (Fletcher *et al.*, 2021). Bitcoin, which serves as the most popular alternative wealth transfer mechanism, has the ability to allow criminals and terrorist organisations to bypass governments, financial institutions, and financial markets regulators' efforts to reduce the international financing of illegal activities through the traditional financial system (Amiram *et al.*, 2020).

2.5.1.3. Money Laundering

Money laundering refers to the process of taking money that has been made from illegal activities, i.e., "dirty money", and making it appear legal. There are three main steps in which criminals accomplish money laundering; the first is placement, where criminals inject dirty money into the financial system. The second step is layering, which involves the transfer of dirty money to dissociate it from its illegal source, and finally, integration, where the funds re-enter the financial system in a seemingly legitimate state. Cryptocurrencies, therefore, add another layer of complexity to money laundering because, unlike traditional currencies, there are no physical materials to observe or even intercept to prove the occurrence of illegal activities (Bryans, 2014).

Because of the inability to tie an identifiable user to a single Bitcoin address, tracking the injection, layering, and re-entry of laundered funds proves to be extremely difficult for law enforcement agencies. Bitcoin allows any user, legitimate or criminal, the ability to transfer

money at lightning-fast speeds at little to no cost, with relatively low barriers to entry, while remaining virtually anonymous without a paper trail. The ability of users to exchange bitcoins directly for other currencies, transfer bitcoins through several Bitcoin addresses, and trade with other users for physical goods has led to the frustration of Anti-Money Laundering efforts. Simply put; Bitcoin and other virtual currencies have the potential to enable money launderers to move illicit funds cheaper, discretely, and faster than ever before (Bryans, 2014).

2.5.2. Taxes

2.5.2.1. Tax Status

For five years after its creation, Bitcoin did not have any tax status; on March 26th, 2014, the Internal Revenue Service (IRS) issued a press release that stated that all cryptocurrencies do not have legal tender status in the United States and as a result, they will be treated as property for federal tax purposes. The decision meant that holders of cryptocurrencies were subject to the same general tax principles that apply to property transactions analogous to real property, stocks, and bonds. The decision to classify Bitcoin has the potential to lead to difficulties with reporting taxes for many users. The IRS' decision came under fire from many cryptocurrency supporters, stating that it will be harder for virtual currencies to now function as a means to purchase everyday items. The average consumer would bear most of the brunt of this decision (Wiseman, 2016).

On May 07th 2014, Steve Stockman introduced the Virtual Currency Tax Reform Act of the United States of America, which proposed to change the tax status of virtual currencies from property to foreign currency. Stockman was a representative of the Republican Party and a known supporter of Bitcoin and other virtual currencies. He claimed the need for the proposed legislation, and in a press release, he stated, "cryptocurrency is the future. We need to encourage it, not discourage it". The act was based on congressional findings that when virtual currencies are classified as property users are subjected to a capital gains tax on any transaction involving the currency - mainly based on any gain or loss relative to the change in the virtual currency's value from the time of purchase. This would then place an immense burden on everyday users as they would have to perform difficult tax calculations every time a Bitcoin transaction took place. With the large volume of transactions taking place on a daily basis, calculating tax for each transaction was not only impractical but also impossible. The main effect of the act's reclassification would be allowing the users of virtual currencies to forego the hassle attached to filling out a yearly IRS form and instead report income taxes normally

and pay a sales tax whenever the virtual currency is used. However, this act failed to pick up traction, and it never got passed in Congress (Wiseman, 2016).

In South Africa, the use of bitcoins as a medium of exchange is not as widespread as it is in the United States. However, there is an increasing trend of South African retailers accepting Bitcoin as a means of payment for goods and services, an example of which would be Takealot. However, as it stands, the South African Revenue Service (SARS) has not provided guidance as to the tax treatment of virtual currency transactions. It seems that virtual currencies fall under the Eighth Schedule of the Income Tax Act, as Section 24I references both the terms "assets" and "currency". When the meaning of the term "asset" is considered, appears to be wide enough to include Bitcoin as a form of property. On the other hand, South African authorities may want to classify Bitcoin as a foreign currency as it is used as a medium of exchange (Wicht, 2016).

2.5.2.2. Tax Evasion

In years following the creation of Bitcoin, no authority thought about the taxation of virtual currencies, mainly due to a lack of knowledge and the low prices. However, in 2017 the matter became urgent as the price of cryptocurrencies soared significantly. Although there has been significant strides in taxing Bitcoin capital gains and transactions, it is still easy to get away with not doing so. Because of this feature, many have considered virtual currencies to be tax havens mainly due to the ease with which investors are able conceal earnings from tax authorities in the investors' home jurisdictions. Particularly because cryptocurrencies possess many traditional features of tax havens: earnings cannot be easily traced and are thus not subject to taxation, and the anonymity of taxpayers is maintained (Jalal and Sargiacomo, 2020)

According to the IRS Tax Crimes Handbook, there exists two definitions of tax evasion: evasion of assessment and evasion of payment. Evasion of assessment is the most common of the two and occurs when a person intentionally omits income from taxes, underreports income, or exaggerates deductions. According to the Cyber Digital Task Force report – which is a report compiled by the United States Department of Justice on how to deal with the illicit use of cryptocurrencies –, "not reporting capital gains from the sale or other disposition of the cryptocurrency, not reporting business income received in cryptocurrency, not reporting wages paid in cryptocurrency, or using cryptocurrency to facilitate false invoice schemes designed to fraudulently reduce business income are examples of evasion of assessments". The report further states that these are frequently seen evasion of assessments in the world of

cryptocurrencies. On the other hand, evasion of payment occurs after the tax assessment has been done, and the taxpayer conceals assets or funds that can be utilised to pay off the tax liability (Chandrasekera, 2020).

Because of the increasing popularity of cryptocurrencies, global regulators are now starting to pay a significant amount of attention to the cryptocurrency world. This is notably different from previous years, where regulators had a primary focus on security and fraud concerns that are related to Initial Coin Offerings (ICOs). In 2020 the Government Accountability Office of the United States issued a report that suggested that the IRS must improve its efforts to enforce cryptocurrency tax. This was followed by a statement from the Organisation for Economic Co-operation and Development (OECD), which recommended that tax authorities all over the world form a uniform tax policy for cryptocurrencies (Chandrasekera, 2020).

There exists a growing trend among users of cryptocurrencies to partake in tax evasion, mainly due to the nature of cryptocurrencies themselves. Cryptocurrencies were created to operate outside the sphere of banks and governments, and it is this very feature that attracts tax avoiders. This is exacerbated by the fact that the core of the technology itself is libertarian and gives more rights to the individual to control their own money. The more profound ideology here sees the state as a parasitic and unnecessary institution. As cryptocurrencies gain legitimacy, the decentralisation attached to these virtual currencies could make the state an illegitimate and obsolete depository of power. The advancement of privacy coin technology has made avoiding taxation easier than ever (Smith, 2021).

The Biden administration has made it clear that it will crack down on tax cheats, and cryptocurrencies seem to be an area of interest, as they offer investors a way to shield income from tax authorities. According to the administration's tax agenda, virtual currencies would be treated as cash, requiring all businesses to report when they receive more than 10 000 US dollars' worth of virtual currency. Digital asset exchanges, custodians, financial institutions, and payment settlement entities would be required to report transactions over a certain amount (Iacurci, 2021).

2.5.3. Legality

2.5.3.1. Legal Status

Cryptocurrencies cannot be pinned down to one universal legal essence in the world today. As a result, the legal status of cryptocurrencies differs from country to country – although the legal

definitions in South Africa and the United States do overlap (Kirilova *et al.*, 2018). As it stands, bitcoins are considered a form of intangible private property. They are not a contractual obligation or debt owed by one party to another; they are assets and valuable property of their current owner, who can transfer them anytime they please. Bitcoins can be compared to other forms of intangible private property; this includes copyright and trademarks, brands, digital music, domain names, frequent flier points, goodwill, and shares. However, unlike copyrights and trademarks, they are not protected by domestic legislation or international treaties. This, however, does not undermine their status as a transferrable and valuable form of private property. To expand, unlike digital music, frequent flier points, or trademarks, bitcoins have no other use other than being a store of value, i.e., they do not have any additional value other than as a currency. However, they have a set of unique characteristics that are missing from other intangible private property – bitcoins are divisible, easily stored, finite, and scarce (Bollen, 2013).

2.5.3.2. Regulatory Landscape

When looked at from a global perspective, the regulatory landscape of Bitcoin is not only mixed but inconsistent. Countries like China have outright bans on digital currency; other countries have degrees of regulation or no regulation at all. Many countries – including Algeria, Bolivia, Ecuador, Nepal, Nigeria, and Turkey have imposed outright bans on virtual currencies. Russia and Vietnam have partially banned cryptocurrencies; they bar the use of the coins as a means of payment; they have, however, not prohibited their citizens from trading and investing in virtual currencies. In 2013, China banned all registered financial institutions from partaking in cryptocurrency transactions or providing clearing, custodian, and payment services to users of cryptocurrencies.

On the other hand, the European Central Bank classifies Bitcoin as a decentralised virtual currency, but not currency or money from a legal standpoint. It advised European financial institutions with exposure to crypto assets to use appropriate risk management frameworks. Japan allows cryptocurrencies to be used as a legally accepted means of payment; however, authorities have not designated Bitcoin legal tender – the first country to do so was El Salvador. The Japan Financial Services Agency recognises and regulates Bitcoin exchange operators. In the United States, things are not as clear-cut as various agencies have their definitions and these definitions affect how they view regulation (Tran, 2021).

The United States Treasury believes that Bitcoin is a virtual decentralised currency; like Japan it does not recognise the currency as legal tender. Entities that either process or help process Bitcoin transactions are viewed as money transmitters. They are subject to the supervision of FinCen; this includes being required to report any suspicious activity. The IRS, however, views Bitcoin as property that is subject to a capital gains tax. The Commodity Futures Trading Commission sees Bitcoin as a commodity that can be traded using derivative contracts, any and all activity involving Bitcoin derivative contracts falls under its scope. The Securities and Exchange Commission (SEC) has determined that while Bitcoin does not qualify to be considered a security, assets or tokens attached to Bitcoin can be defined as such and thus subject to its supervisory authority. Like the agencies, the states and municipalities in the United States take varying regulatory approaches (Tran, 2021).

States can range from being friendly to cryptocurrency businesses by, for example, issuing a state banking charter for banks that deal in digital assets - as is the case in Wyoming. To pushing for the registration of exchanges and other companies servicing Bitcoin transactions as money-service companies or money transmitters, or even banning cryptocurrency mining. States like Arizona, New York, and Rhode Island have developed reputations as unfriendly to cryptocurrency activities mostly because of their attempts to regulate them. At the same time, several states have created environments in which cryptography - the practice and study of techniques for secure communication - businesses are exempt from regulatory oversight during initial development (Tran, 2021).

South Africa, on the other hand, has officially started pushing for the regulation of cryptocurrencies in the wake of cryptocurrency scams. In June 2021, a regulatory timeline was established, which foresaw the finalising of a regulatory framework in three to six months. Cryptocurrency service providers have been operating without any regulatory oversight, even as the popularity of the asset class has soared. The most significant event that prompted the regulation of cryptocurrencies in South Africa was the collapse of Johannesburg-based Mirror Trading International (MTI). Which at one stage claimed to have over 100 000 members and may have taken billions of rands in investments – this was considered the biggest crypto-related scam in the world. As it stands, South Africa is still waiting for the release of the regulatory framework from its banking regulator known as The Prudential Authority (Businesstech, 2021).

2.6. VOLATILITY

2.6.1. Bitcoin Volatility

There is consensus among experts that Bitcoin is highly volatile, which has been shown in studies such as the one by Pichl and Kaizoji (2017). They used several methodologies in order to study the volatility of Bitcoin prices; these range from the stylised features of logarithmic return distribution, transaction volume distribution at multiple time scales, arbitrage opportunities on the 1-hour trading scale for the currency pairs of EUR/USD and USD-CNY, econometric analysis of the time-series of realised volatility, and classical machine learning prediction of logarithmic returns for BTC/USD on daily time scale employing the artificial neural network. Their results show that the price of Bitcoin is highly volatile, and any real fundamentals do not support it; that is, there is no real economy behind cryptocurrencies. Bitcoin prices may have random walk properties, which seem to be quite popular in financial time-series. Their main finding is that time-series of Bitcoin prices are significantly more volatile than those of EUR/USD exchange rates, for the sake of comparison, with market bubbles and crashes relatively abundant.

Cermak (2017) found that Bitcoin's volatility is the most susceptible to movements in the Chinese yuan. At the moment, macroeconomic shocks from China, the US, and the EU have a disproportionately more significant impact on Bitcoin than shocks from other countries. Bitcoin must grow less reliant on larger countries to truly become a global alternative to fiat currencies. However, volatility levels have traditionally been heading downward. The author predicted that if Bitcoin continued to trend in the same direction as it has between 2016 and 2017, it will reach the volatility levels of fiat currencies in 2019-2020 - this is, however, not the case as of yet.

Chaim and Laurimi (2018) start with a standard log-normal stochastic volatility model and then explore two formulations that incorporate discontinuous jumps to volatility and returns on daily data starting on 01 April 2018 through 31 May 2018. They found that Bitcoin displays patterns of varying average volatility and discontinuous return jumps that traditional models of conditional volatility do not properly capture. This particular study is of potential relevance for portfolio, and risk-management procedures since the presence of these jumps can substantially impact the structure of losses and gains related to Bitcoin. Volatility is not exclusive to Bitcoin as a financial instrument; it is also evident in the various markets in which Bitcoin is traded.

Lahmiri *et al.* (2018) attempted to capture the underlying nonlinear patterns of the time-varying volatility for seven major Bitcoin markets. Daily Bitcoin price datasets for seven markets were extracted from various source. The seven Bitcoin markets and their respective time periods are the following: BITX (15 November 2016 to 9 November 2017), CEX.IO (24 August 2015 to 9 November 2017), COINBASE (13 January 2015 to 9 November 2017), EXMO (6 October 2015 to 9 November 2017), GEMINI (8 October 2015 to 9 November 2017), HITBTC (27 December 2013 to 9 November 2017), and KRAKEN (14 February 2014 to 9 November 2017). They used a FIGARCH-based modelling approach to gauge the long-range memory structure of the examined series. They found that every other Bitcoin market's order of integration is higher than BITX's, especially the order of integration for COINBASE. COINBASE has the largest long-range dependence, whereas BITX has the lowest. As a result, predicting volatility in the BITX market is more complicated than predicting volatility in other Bitcoin markets and indeed more difficult than predicting volatility in COINBASE. The implication is that some Bitcoin markets are more volatile than others, which may point towards market depth and the liquidity of Bitcoin in these markets.

2.6.2. Determinants of Bitcoin Volatility

As the world's most successful cryptocurrency, Bitcoin has gained a lot of attention, most of which has been positive. However, the main problem that hinders the public from fully accepting Bitcoin is its high volatility, unpredictability, and the lack of government backing. Because the exact causes of Bitcoin volatility are relatively unknown, find below components that would change its demand from a theoretical perspective.

There is no formal regulation for the exchange of Bitcoin; the faith of investors in the cryptocurrency tends to be shifted by market conditions and current events. This results in the value changing sporadically when public opinion changes. The price is mainly determined by market sentiment, which investors believe will happen to the currency in the near future. Bitcoin volatility could then, in theory, be caused by the perceived value of Bitcoin rapidly increasing or decreasing (Brandvold et al., 2015).

Furthermore, the price changes are also correlated with the number of buyers who enter the market at any given point in time (Ciaian et al., 2016). This is mainly because an increase in demand allows sellers to trade Bitcoin at higher prices. The main incentive that would drive sellers to behave this way is the pursuit of capital gains (Ingram et al., 2015). Because of this, it is safe to conclude that anything that causes people to enter the market would thus cause

Bitcoin prices to increase. Conversely, when many buyers leave the market, sellers are then forced to lower their prices if they are to convert their bitcoins to currency (Mc Warther, 2018).

News also has a significant impact on Bitcoin volatility as news persuades the public to enter or leave the market mainly through the manipulation of public opinion. This change in public opinion leads to changes in the demand and the perceived value of Bitcoin (Stenquist and Lonno, 2017). When the price changes in the market it reinforces the news announcement's effect on public opinion and more changes in demand and perceived value, this eventually leads to a snowball effect. This snowball effect can be further explained as the concept in which the original news announcement had an initially small impact on the market. However, the small impact manipulates more of the public's opinion which eventually generates a greater impact on the market and so forth. This is mainly because buyers in the market would be basing their investment decisions on both projected changes and observable changes in the price of Bitcoin (Mc Warther, 2018). The snowball effect can continue until a new news announcement changes the public's opinion again. There is evidence of this happening as from May 01st, 2021, a series of negative news announcements correlated with an extended period of falling prices (Bitcoinity 2021).

Other factors contribute to Bitcoin price volatility; for instance, large holders of Bitcoin can shift the prices when they make huge transactions, and this is mainly due to the limited nature of Bitcoin. This means that wealthy investors can drive up prices when they purchase a large amount at once, thus leading to an increase in demand and then selling for a quick profit and creating a small bubble. Investors can also buy a large amount of Bitcoin and then advertise the currency on social media as a means to deliberately increase demand then sell the cryptocurrency once the demand has caused higher prices (Barker, 2018)

Government regulation and tax treatment of Bitcoin also has the capability of creating a significant amount of volatility. Investors tend to view regulation and tax treatment as an incentive to enter or leave the market. The government's regulation and taxation of Bitcoin suggests that the cryptocurrency is gaining legitimacy in the eyes of world leaders. Because of this view, investors gain faith in Bitcoin's ability to maintain its value and longevity. However, the downside to this is that the regulation and taxation strips aways some of the intrinsic value that Bitcoin has over fiat currency – this eventually strips away at some of the uses that attracted investors to the Bitcoin market in the first place. Governments are driven to stop the use of cryptocurrencies to purchase illegal goods, which would mean removing their ability to make

completely anonymous transactions. Moreover, governments want to increase their tax base, so they are also driven to impose new tax laws that would take advantage of Bitcoin capital gains. Lastly, governments also have an incentive to make Bitcoin transfers more expensive this would be done in order to make their own currencies a cheaper alternative for money transfers. The government would like to prevent Bitcoin from replacing the use of their national currencies in order to protect pre-existing monetary systems (Barker, 2018).

2.7. BITCOIN AND EXCHANGE RATES

Cryptocurrencies differ in design; some are designed to complement pre-existing fiat currencies. However, cryptocurrencies like Bitcoin are more ambitious in that they were designed to act as substitutes for all fiat currencies. Because of this, it is not surprising that there could possibly be a relationship between cryptocurrencies and exchange rates.

A paper by Corelli (2018) analysed the relationship between the most popular cryptocurrencies and a range of selected fiat currencies using multivariate regressions, all the datasets fell within the 28 April 2013 to 7 March 2018 range. The cryptocurrencies in the study were, Bitcoin, Etherium, Ripple, Litecoin, Monero, and Dash. The fiat currencies in the study included the Euro, Australian Dollar, Indian Rupee, Swiss Franc, Malaysian Ringit, Thai Baht, Taiwan Dollar, South African Rand, New Zealand Dollar, Chinese Yuan, and Japanese Yen. The study found that three Asian fiat currencies (Thai Baht, Taiwan Dollar, and Chinese Yuan) have a strong granger causal relationship with the six major cryptocurrencies available to investors at the time. The study also shows that the relationship is bidirectional as cryptocurrencies seem to granger cause the three Asian fiat currencies.

2.8. ECONOMIC CONSIDERATIONS

Digital currencies have found themselves gaining more popularity against the backdrop of recent events triggered by economic uncertainty. While digital currencies are being given more and more attention, some of the prices of the digital currencies are free-floating. They are subject to high volatility, mainly due to a lack of fundamental valuation methods. The high volatility of Bitcoin is a serious concern. It mainly stems from the small number of bitcoins in circulation and the small number of merchants that accept virtual currency. This limit in liquidity has several implications, the most significant of which is that a small event or trade can significantly affect the value of Bitcoin. For instance, in 2013, the value of Bitcoin dropped 50% from 1 155 to 576 US Dollars. When recorded, Bitcoin's volatility was 142% compared

to the traditional currency volatility of 10% and the stock volatility of 25%. Unlike gold, the value of a bitcoin is not tied to any resource, and as a result, it cannot be recovered. Because of this, there have been several concerns over why Bitcoin cannot be used as a currency (Swartz, 2014).

According to Sigalos (2021), volatility is the price Bitcoin pays for being decentralised and having a limited supply – ironically; these are the features that proponents say give it its value. What makes Bitcoin so valuable is the fact that it has digital scarcity as a fundamental part of its design. As it stands, there are currently 18.7 million bitcoins in circulation, which is slowly approaching its maximum threshold of 21 million. New bitcoins are created as a means to reward miners who use their computing power to verify transactions over the decentralised network. Because of this, the supply of Bitcoin is perfectly inelastic, i.e., "A rise in demand cannot result in the increase in the supply of bitcoin or increase the speed at which bitcoin is issued" (Bhutoria, 2020).

The primary response to these criticisms is that Bitcoin is not backed by cash flows, decree, or industrial utility. The main things that serve as a backing to Bitcoin are the code and the consensus among its key stakeholders. Bitcoin stakeholders have made the explicit decision to use and support the network after they realised Bitcoin's key attributes, i.e., perfect scarcity, transaction irreversibility, etc. With each new member, Bitcoin's network effect - which is a phenomenon whereby increased numbers of people or participants improve the value of a good or service – makes it more reliable and further solidifies its properties, thus attracting more users to the asset so on and so forth. The rules that govern Bitcoin are presented by the code underlying the digital currency; however, the execution of an agreement on the rules by stakeholders gives rise to what is an open, secure, and global value storage and transfer system that exists today. Also, Bitcoin volatility is the trade-off for perfect supply inelasticity and the inability to intervene in its market. However, as more institutions and users adopt Bitcoin and develop its derivatives and investment products, the result will be the continued decrease of Bitcoin volatility as observed historically (Bhutoria, 2020).

2.9. CRYPTOCURRENCIES AS A SAFE-HAVEN

According to Baur and Lucey (2010), a safe-haven asset is one that is uncorrelated with stocks during a market downturn. Therefore, one would consider gold a safe-haven as it does relatively well during market crashes. Sandoval and Franca (2012) expand on this and say that assets that are uncorrelated with stocks can be safe havens. This characteristic is important because, during financial crises, assets correlated with each other tend to be why the crises spread to other financial markets. An asset tends to be a weak hedge if it is uncorrelated with another asset, and it is a strong hedge if it is negatively correlated with another asset. The same applies to the case of safe havens, an asset is a weak safe-haven if it is uncorrelated with another asset during times of distress, and it is a strong safe-haven if it is negatively correlated with another asset during times of distress (Mariana *et al.*, 2021).

When the question of whether Bitcoin can be used as a safe-haven or hedge for stocks was posed, Smales (2019) argued that Bitcoin was unsuited to this purpose mainly because of its high volatility, illiquidity, and transaction cost. Conlon and McGee (2020) further argue that because Bitcoin is highly correlated with the S and P 500, it cannot be a safe haven, especially during the COVID-19 market downturn. Corbet *et al.* (2020) expanded on this further by saying, Bitcoin does not even qualify to be a diversifier but an amplifier of contagion.

However, Dyhrberg (2016) argues that it is quite possible to use Bitcoin as a hedging instrument. Bitcoin can possibly be a safe haven; however, this depends on several factors, including stock market types, investment horizons, and time horizons (Bouri *et al*., 2017). According to Bouri *et al*. (2020), cryptocurrencies are unlike any other traditional economic and financial assets. As a result, investors should add them into their portfolios as they serve as good diversifiers. Furthermore, the safe-haven properties that Bitcoin possesses are even better than commodities like gold. There are a few studies that exist that studied Bitcoin's safe-haven characteristics during the COVID-19 pandemic, some of which are discussed below.

A Mariana et al. (2021) study shows that Bitcoin and Ethereum, as the two largest cryptocurrencies by market capitalisation, show significant short-term safe haven characteristics for stocks. Furthermore, they discover that Ethereum might be better suited at being a safe haven than Bitcoin during short extreme stock market downturns, but Ethereum shows significantly higher return volatility than Bitcoin. The above falls in line with what Gil-Alana *et al*. (2020) found.

According to Gil-Alana *et al*. (2020), there are low-level bilateral linkages between cryptocurrency markets and stock indices. This affects the choice of asset class that an investor may invest in mainly due to price independence. When viewed from a portfolio perspective; since traditional assets classes have no direct influence on cryptocurrency markets, investors might be willing to invest in cryptocurrencies due to their diversifying benefits- this is similar to what Stensas *et al*. (2019) found.

Stensas *et al.* (2019) discovered evidence of a difference between developed and developing countries regarding Bitcoin's ability to serve as a hedge. Bitcoin acts as a strong hedge in most developing markets; however, it only acts as an effective diversifier in the developed markets. They also found that Bitcoin is a strong hedge for only a few national and regional equity indices and commodities. The significant finding of their study was that Bitcoin might be highly suitable as a safe-haven asset in specific periods of high uncertainty. Quite different from Bouri *et al*. (2020) – who found that the interaction between cryptocurrencies and equities is multifaceted and generally mixed.

2.10. CONCLUSION

Cryptocurrencies represent the newest chapter in the human race's forms of money – these virtual currencies and their underlying technology seem to have a lot of potential; this includes application in various sectors and the potential to become full-fledged currencies. Cryptocurrencies, like all money, are not an end but a means to several ends, and as a result, they can be used either positively or negatively. As time progresses and blockchain technology improves, we can hopefully see cryptocurrencies move past their infancy and be adopted by more institutions allowing them to reach their full potential.

At present the most popular hedge against inflation, stock market downturns, and exchange rate depreciation is gold. However, Bitcoin and gold do share a significant number of characteristics, this suggests that Bitcoin can be as good a hedge as gold. This study used Granger Causality Tests, Vector Autoregression, Impulse Response Functions, and Markov-Switching Models to ascertain whether Bitcoin can be used as a hedge against inflation, stock market downturns and exchange rate depreciation in emerging markets. This study is of particular importance as it focuses on emerging markets, there is a gap in the existing literature as similar studies have focused on developed markets. This study sought to fill that gap by investigating whether Bitcoin can be used as a hedge against inflation, stock market downturns, and exchange rate depreciation in South Africa.

CHAPTER 3: DATA, METHODOLOGY AND TECHNIQUES

3.1. INTRODUCTION

Chapter 3 provides a description of the data used in the analysis, the data period, their source, as well as rationalisations for why the specific variables were chosen, it also describes the methodology employed in order to answer the research question. These data and techniques were used in an attempt to answer the question of whether Bitcoin can be used as a hedge against adverse market conditions in South Africa. This is followed by an overview of the preliminary assessments and econometric models applied in Chapter 4.

3.2. DATA DESCRIPTION

Secondary data sources were utilised in this study to attain monthly time-series data; the two time periods under investigation are from August 2010 to December 2019 and January 2017 to December 2019. The rationale for the two separate times periods was that using the August 2010 to December 2019 dataset the Markov-Switching model would have led to the model picking up the pre-2017 period as the 'low' value regime when, in fact, there were no changes over the period - mainly because Bitcoin was too new. The Bitcoin prices dataset is more dynamic from January 2017 this makes this period more suited for the Markov-Switching model.

To analyse Bitcoin's potential as a hedge against adverse market conditions in South Africa, the present study considered South Africa's stock market as given by the JSE All Share Index (ALSI), the gold market, the country's inflation, and exchange rate. These are compared to Bitcoin prices to see if there are any significant relationships. The ALSI, gold, and historical Bitcoin prices were sourced from the Refinitiv Eikon database, while CPI and the exchange rate were sourced from the Reserve Bank website.

The ALSI represents 99% of the full market capital value, that is, before applying any investability weightings of all ordinary securities listed on the main board of the Johannesburg Stock Exchange, subject to minimum free float and liquidity criteria. The index, although mainly used as a performance benchmark, can also be used to create index-tracking funds and derivatives (Russel, 2017). The ALSI can also be used to measure how well the South African economy is performing, if South Africa is experiencing a downturn, it will be reflected in this index as the stock price of most companies might be down due to a decrease in profits. It was important to use this measure as it is an indication of how well the South African market is

doing. A good hedge would be an asset that moves in the opposite direction as the ALSI, and a weak hedge would be an asset that is not correlated with the ALSI[1]

XAU is the ISO 4217 standard code for one troy ounce of gold, considered as a currency was chosen in this study. Gold prices like Bitcoin prices are moved by a combination of supply, demand, and investor behaviour. This is not the only similarity that Bitcoin shares with gold; both are stores of value. Both are scarce goods that humans cannot produce; they can only be extracted. They both have positive price elasticity with respect to demand, meaning the value increases along with demand (Emspak, 2021). There are studies that suggest that gold is price inelastic, studies such as the one by Batchelor and Gulley (1995). However, for this analysis we the former explanation was chosen as it aligns with the present studies' school of thought. This study sought to find out whether Bitcoin and gold share another essential characteristic: the ability to hedge against market downturns. Gold has little or no correlation with other asset classes like currencies and stock indices. Gold is treated as a hedge because historically, when stock markets experience, downturns gold will likewise retain its value or rise, resulting in either profits or reducing losses in a portfolio. This is why it was essential to include historical gold prices, as correlation could imply that Bitcoin could be as suited as gold at hedging against adverse market conditions (Forex live, 2020).

As given by CPI, inflation is the decrease of a currency's purchasing power over time; alternatively, it can be defined as a general rise in prices. This rise in the general price level is often expressed as a percentage; this means that a unit of currency now effectively buys less than it did in prior periods. An inflation hedge is an investment that one makes for the sole purpose of protecting the investor against the decreasing purchasing power of money due to the rise in the prices of goods and services. The ideal investments used for hedging against inflation tend to be investments that either maintain their value during inflation or increase value over a specified period of time. Traditional portfolios often include assets such as gold and real estate as their hedges against inflation – however, if Bitcoin is either positively correlated or not correlated to inflation at all, it could be considered as a good hedge against inflation (Corporate Finance Institute, 2021).

[1] An asset tends to be a weak hedge if it is uncorrelated with another asset, and it is a strong hedge if it is negatively correlated with another asset. The same applies to the case of safe havens, an asset is a weak safe-haven if it is uncorrelated with another asset during times of distress, and it is a strong safe-haven if it is negatively correlated with another asset during times of distress (Mariana *et al.*, 2021)

The USD/ZAR exchange rate is the rate at which one Dollar will be exchanged for Rands; this variable was chosen because it is an indicator of a country's economic strength and can act as a proxy for the South African market as a whole (Levinson, 2014). This exchange rate measure was chosen over other exchange rate measures because it is one of the important factors that influence overall economic activity. Exchange rate and foreign currency exchange reserves are highly correlated have a huge influence on a country's economic activity (Pramanik, 2021). This variable is similar to the ALSI as a negative, or a lack of correlation between the USD/ZAR and Bitcoin could imply that Bitcoin is a good hedge against market downturns in South Africa.

3.3. METHODOLOGY

3.3.1. Econometric Methodology

3.3.1.1. Stationarity

The first step was to test the ALSI, Bitcoin prices, gold prices, inflation, and dollar/rand exchange rate for stationarity. There are differences in opinion when it comes to estimating a Vector Autoregression (VAR) using non-stationary variables; this study agrees with the view of some proponents of the VAR approach that differencing non-stationary variables to attain stationarity will throw away the rich dynamics the data may have (Herrera and Pesavento, 2013). However, to test the sensitivity of the estimations in level form, a VAR with differenced variables was estimated and attached in the appendices.

3.3.1.2. Unit Root Tests

In the Dickey-Fuller test one considers the below equations:

Y_t is a random walk: $\Delta Y_t = \delta Y_{t-1} + u_t$ (1)

Y_t is a random walk with drift: $\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t$ (2)

Y_t is a random walk with drift around a stochastic trend: $\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + u_t$ (3)

It is assumed that the error term u_t is uncorrelated. But in case the u_t are correlated, Dickey and Fuller developed a test, known as the augmented Dickey–Fuller (ADF) test. This test is conducted by augmenting the preceding three equations by adding the lagged values of the

dependent variable Y_t. To be specific, suppose one uses (3). The ADF test here consists of estimating the following regression:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + \varepsilon_t \quad (4)$$

where ε_t is a pure white noise error term and where $\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$, $\Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$, etc. The number of lagged difference terms to include is often determined empirically, the idea is to include enough terms so that the error term in (4) is serially uncorrelated. In the ADF test, one still tests whether $\delta = 0$ and the ADF test follows the same asymptotic distribution as the DF statistic, this means that the same critical values can be used (Gujarati *et al*., 2012). The unit root tests were performed in this case because it was important to determine if the results would lead to a spurious regression and whether they could be used for forecasting in future studies.

3.3.1.2. Granger Causality

The Granger causality test, first proposed by Clive Granger in 1969, is a statistical hypothesis test to determine whether one time-series shows evidence of a causal relationship with another. Regressions tend to reflect correlations merely, but Granger argued that causality could be tested in economics by measuring the ability to predict the future values of a time-series using prior values of another time-series. For example, time-series X is said to Granger-cause time-series Y if it can be shown - and this is done through a series of t-tests and F-tests on lagged values of X - that those X values provide statistically significant information about future values of time-series Y. If a time-series is a stationary process, the test is performed using the level values of two (or more) variables. If the variables are non-stationary, then the test is done using first differences or higher. A Granger-causality analysis can be carried out in order to assess whether there is any potential predictability power of one variable on another (Granger, 1969). The study sought to test the relationship between Bitcoin and the USD/ZAR exchange rate as preliminary analyses only showed the potential of a bidirectional between only these two variables. The Granger causality test is important as it is a preliminary test before building the model, it gives one an idea of the direction of causality, however, the test should not be considered in isolation. That is why it was important to also estimate a Vector Autoregression to see whether the results agree with each other.

3.3.1.3. Vector Autoregression

The Vector Autoregression model tends to be considered if there is true simultaneity among a set of variables, as a result, the variables should all be treated on an equal footing; there should not be any *a priori* distinction between endogenous and exogenous variables. The term autoregressive is due to the appearance of the lagged value of the dependent variable on the right-hand side, and the term vector is due to the fact that one is dealing with a vector of two (or more) variables. This model is suited when one assumes that there may be multi-directional relationship between variables. In the case of a VAR, one can estimate each equation using Ordinary Least Squares (OLS) u's are the stochastic error terms, called impulses or innovations or shocks in the language of VAR (Gujarati *et al*., 2012).

Impulse response functions trace the dynamic impact to a system of a shock or change to an input. Their primary purpose is to describe the evolution of a model's variables in reaction to a shock in one or more variables. This feature allows one to trace the transmission of a single shock within an otherwise noisy system of equations and, thus, makes them very useful tools in the assessment of economic policies (Enders, 2010).

One must decide on the maximum lag length, k. This tends to be an empirical question. If one has 50 observations in all, the inclusion of too many lagged terms will consume degrees of freedom, not to mention introducing the possibility of multicollinearity. Including too few lags will lead to specification errors. One way of deciding this question is to use a criterion like the Akaike or Schwarz and choose the model that gives these criteria the lowest values. There is no question that some trial and error is inevitable. Because of the use of several lags of the same variables, each estimated coefficient will not be statistically significant, possibly because of multicollinearity. But collectively, they may be significant on the basis of the standard F test. A VAR model may be used for both hypothesis testing and forecasting; when it comes to hypothesis testing, one may use non-stationary variables to make the variables stationary by differencing or detrending, which may result in a loss of information. However, for forecasting, it is important to make the variables stationary (Enders, 2010). The VAR model was used in this study to estimate the relationship between Bitcoin and gold, inflation, the ALSI, and the USD/ZAR exchange rate. It was important to do this as the study seeks to see whether the time series influence each other, that is, knowing whether one can predict Bitcoin with each variable series along with past values of Bitcoin.

3.3.1.4. Markov-Switching Models

The prevailing assumption that most economic processes are linear can provide useful approximations to the actual time paths of economic variables. However, policy makers could make a grave error if they ignore the empirical evidence that, for example, the unemployment rate increases more sharply than it decreases. Because of this, it is helpful to consider non-linear models, which are a form of regression analysis in which observational data are modelled by a function which is a nonlinear combination of the model parameters and depends on one or more independent variables. An example of such a non-linear model is the Markov-Switching Model (Enders, 2010).

A Markov-Switching Model is a regime-switching model and a variation of the Threshold Autoregressive Model (TAR). A regime-switching model allows the behaviour of y_t to depend on the state of the system. The autoregressive coefficient is a1 in regime 1 and a2 in regime 2. For example, a correlation study of Bitcoin in the American context by Foelber (2021) suggests that Bitcoin behaves differently in a recession that during an expansion this suggests that Bitcoin prices behave differently based on the state of the economy. As such, the dynamic adjustment equation for Bitcoin prices depends on whether the economy is in an expansionary state (or regime) or in a recession. When the economy changes from an expansionary regime to a contractionary regime, the dynamic adjustment of Bitcoin prices is likely to change. In other circumstances, regime switches might be due to the magnitude of the variable of interest, the result of an election that changes the behaviour of policymakers, or may be completely unobservable (Enders, 2010).

One can separate the observations according to whether y_{t-1} is above or below the threshold. In this case the adjustment process depends on the current state of the system. In contrast, the Markov switching model developed by Hamilton (1989), posits that regime switches are exogenous. To take a simple example, suppose there are two regimes (or states of the world) and that the autoregressive process for y_t is regime dependent. Let:

$$yt = a10 + a1yt-1 + \varepsilon 1t \text{ if the system is in regime 1}$$

$$yt = a20 + a2yt-1 + \varepsilon 2t \text{ if the system is in regime 2}$$

There are fixed probabilities of a regime change. If p_{11} denotes the probability that the system remains in regime one, $(1 - p_{11})$ denotes the probability that the system switches from regime one to regime two. Similarly, if p_{22} denotes the probability that the system remains in regime

two, $(1 - p_{22})$ is the system's probability of switching from regime two to regime one. Thus, the switching process is a first-order Markov process. No attempt is made to explain the reason that regime changes occur, and no attempt is made to explain the timing of such changes. There are several essential features of the Markov switching model:

1. Since the transition probabilities (i.e., p_{11} and p_{22}) are unknown, they need to be estimated along with the coefficients of the two autoregressive processes. If one of the regimes rarely occurs, the coefficients for that regime will be poorly estimated.

2. The overall degree of persistence depends on the autoregressive parameters and the transition probabilities. For example, if $a_1 > a_2$ and p_{11} are large, the process will remain in the regime with substantial autoregressive persistence. Moreover, if p_{22} is small, the system will tend to switch into regime one from regime two.

3. The probabilities p_{11}, $(1 - p_{11})$, p_{22} and $(1 - p_{22})$ are all conditional probabilities. For example, if the system is in regime two, $(1 - p_{22})$ is the system's conditional probability to switch into regime one (Enders, 2010).

A Markov switching model was chosen for this study mainly because it has been established that the gold, inflation, the ALSI, and the USD/ZAR exchange rate behave differently during downturns of the South African economy. This has to be modelled and estimated as it will give an indication of whether Bitcoin can be successfully used as a hedge against inflation, stock market downturns, and exchange rate depreciation within the South African context or not.

3.4. CONCLUSION

This chapter discussed the data and variables used in the analysis and detailed the different methods employed to obtain the results presented in Chapter 4. The sample period and data source were discussed in section 3.2. Section 3.4 put forward the Augmented Dickey-Fuller test, Granger Causality, Vector Autoregression, and the Markov Switching Model. After reviewing the relevant literature set out in Chapter 3, the methods put forth in this chapter were believed to be the most suitable for the study's objectives. Chapter 4 presents the empirical findings obtained using the methods and procedures outlined in Chapter 3.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. INTRODUCTION

This chapter puts forward and discusses the empirical results obtained using the methods and tests discussed in the previous chapter. Section 4.2 sets out the preliminary assessments in graphs, Section 4.3 presents the Augmented Dickey-Fuller unit root tests, Section 4.4 sets out the Granger Causality tests results. Section 4.5 shows the Vector Autoregression models, hypothesis test results, and Impulse Response Functions. Section 4.6 sets out the results of the Markov Switching Models. Then Section 4.7 presents a discussion of the results, and Section 4.8 concludes the chapter.

4.2. GRAPHED RESULTS

Line graphs were drawn to give a preliminary assessment of the relationship between the various variables. The graphed results are shown in Figures 1 to 4.

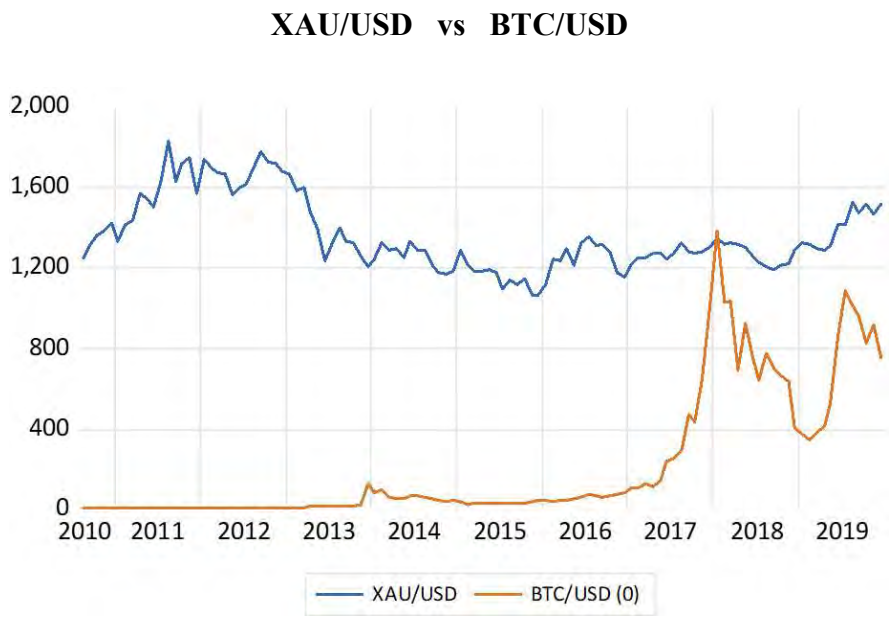

Figure 1. *A graph of historical Gold Prices against historical Bitcoin Prices*

Figure 1 shows historical gold prices against historical Bitcoin prices from August 2010 to December 2019. The blue line represents historical gold prices, and the orange line represents historical Bitcoin prices. The visual relationship does not conform to *a priori* expectations as it does not show a significant relationship between historical gold prices and historical Bitcoin prices.

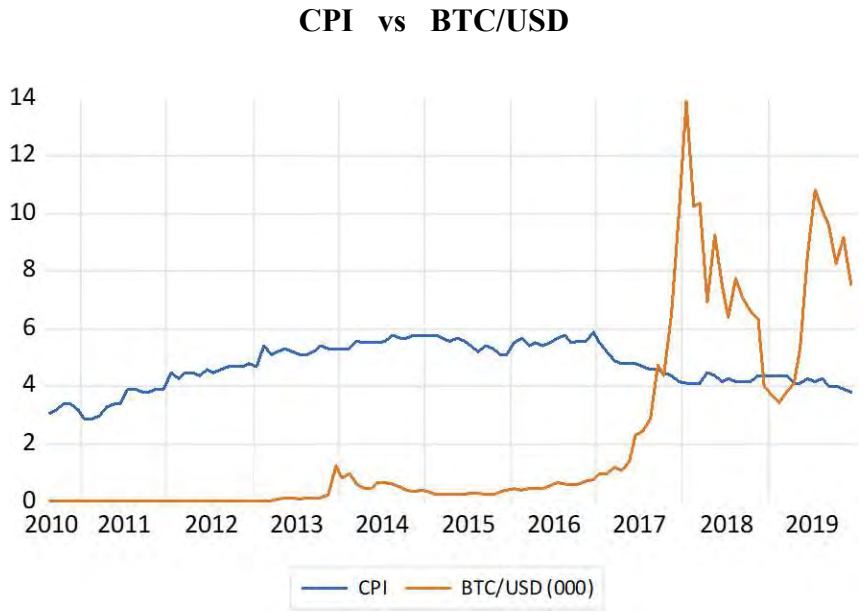

Figure 2. *A graph of the Consumer Price Index (Inflation) against historical Bitcoin Prices.*

Figure 2 shows a consumer price index (inflation) graph against historical Bitcoin prices from August 2010 to December 2019. The blue line shows the Consumer Price Index (CPI), and the orange line shows historical Bitcoin prices. The graph shows no significant visual relationship between the two variables. CPI trends upward from 2010 and started trending downwards from around 2016/2017; the Bitcoin prices became more cyclical from around this period. Despite this, there was no pronounced visible relationship between the two variables after 2017.

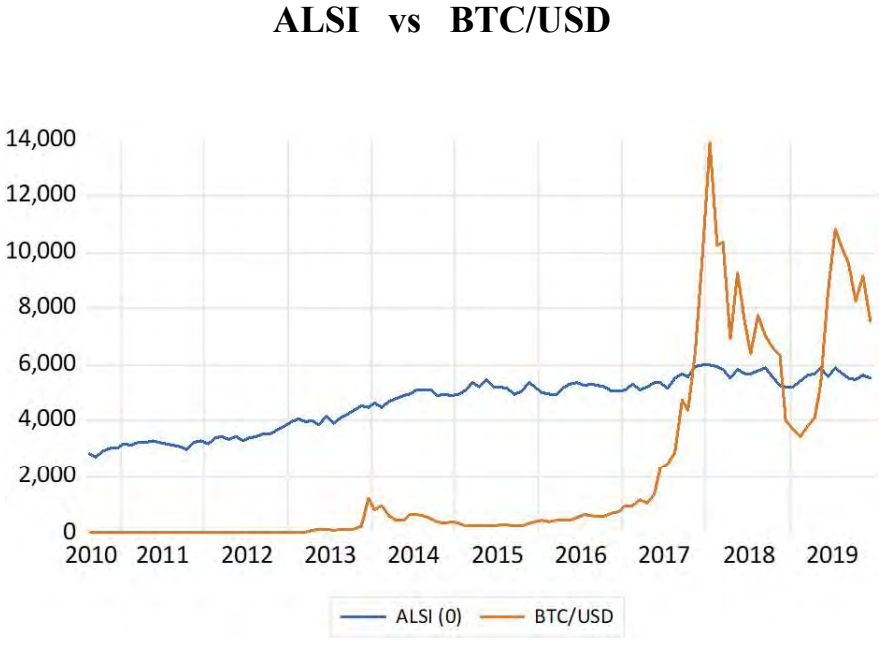

Figure 3. *A graph of the JSE All Share Index against historical Bitcoin Prices.*

Figure 3 shows a graph of the JSE All Share Index (ALSI) against historical Bitcoin prices from August 2010 till December 2019. The blue line shows the ALSI, and the orange line shows historical Bitcoin prices. Both the ALSI and historical Bitcoin prices trend upwards, suggesting that both variables have increased over time. However, there was no visible relationship between the two variables, even post 2017 when the Bitcoin time series was more dynamic.

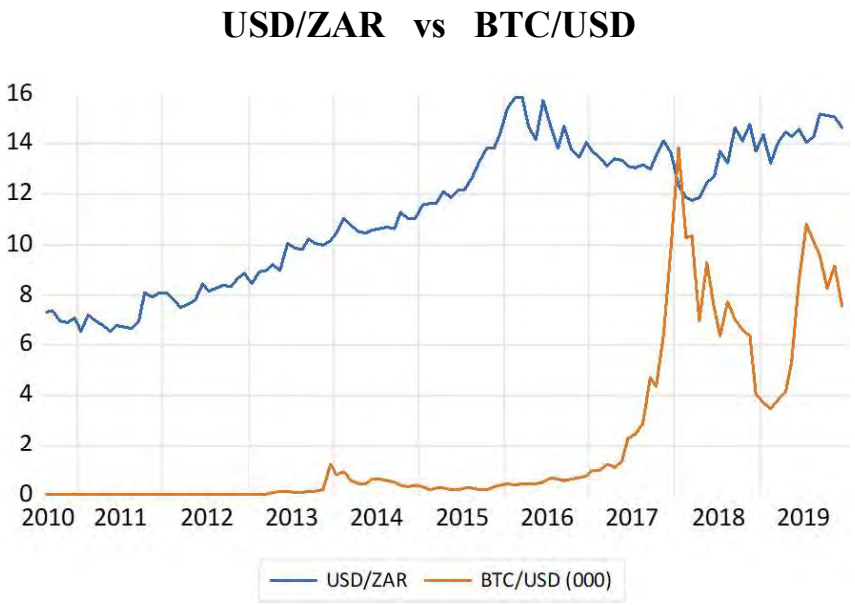

Figure 4. *A graph of the Dollar/Rand exchange rates against historical Bitcoin Prices.*

Figure 4 shows the Dollar/Rand exchange rate (USD/ZAR) against historical Bitcoin prices from August 2010 until December 2019. The blue line shows the USD/ZAR, while the orange line shows historical Bitcoin prices. Between 2010 and 2017, both variables trended upwards; however, this changed after 2017 as there appears to be a negative relationship between the variables. When the USD/ZAR declined in 2017, Bitcoin prices showed a visible increase. Similarly, when the USD/ZAR increased in 2018, Bitcoin prices visibly decreased. This suggests that Bitcoin might be a strong hedge against the USD/ZAR.

The graphical assessments first suggest that Bitcoin does not share any significant characteristics with gold. The graphs also indicate that Bitcoin can be used as a weak hedge against inflation and the South African stock market and a strong hedge against the South African exchange rate.

4.3. TESTS FOR STATIONARITY

Knowing whether the variables were stationary at either level terms or first differences was particularly important for estimating the Granger Causality test and the Markov-Switching models as the VAR model was estimated at level terms. This follows the approach outlined by Chris Brooks (2014) that differencing to induce stationarity should not be done**.** It argued that the purpose of VAR estimation is purely to examine the relationships between the variables, and that differencing will throw information on any long-run relationships between the series away

Table 1: *Augmented Dickey-Fuller test for stationarity results for historical Bitcoin and gold prices, inflation, the JSE All Share Index, and the Dollar/Rand exchange rate at level terms and first differences.*

Series	t - statistic	Lags	Probability Value	Result
BTC/USD	-1.159442	0	0.6899	Not Stationary
D(BTC/USD)	-9.970869	0	0.0000	Stationary
XAU/USD	-1.558924	1	0.5002	Not Stationary
D(XAU/USD)	-12.48019	0	0.0000	Stationary
CPI	-1.847152	0	0.3562	Not Stationary
D(CPI)	-11.52837	0	0.0000	Stationary
ALSI	-1.703863	0	0.4266	Not Stationary
D(ALSI)	-12.51286	0	0.0000	Stationary
USD/ZAR	-1.160099	0	0.6897	Not Stationary
D(USD/ZAR)	-12.93437	0	0.0000	Stationary

August 2010 to December 2019

Source: Author

The augmented Dickey-Fuller tests for the period between August 2010 till December 2019 were performed, and the results are shown in Table 1. The number of lags to include was based on the selection order criterion. The results show that historical Bitcoin and gold prices, inflation, the All-Share Index, and the Dollar/Rand exchange rate series are not stationary at level terms. The second step was to difference the series and determine whether that has an influence on stationarity or not. When the series were differenced, the results showed that series were all integrated of order 1, which means they are stationary at first differences.

Table 2: *Augmented Dickey-Fuller test for stationarity results for historical Bitcoin and gold prices, inflation, the JSE All Share Index, and the Dollar/Rand exchange rate at level terms and first differences.*

Series	t - statistic	Lags	Probability Value	Result
BTC/USD	-0.323864	0	0.5615	Not Stationary
D(BTC/USD)	-5.437896	0	0.0000	Stationary
XAU/USD	1.134576	3	0.9301	Not Stationary
D(XAU/USD)	-3.338140	3	0.0019	Stationary
CPI	-2.201341	0	0.0286	Stationary
ALSI	0.288790	0	0.7639	Not Stationary
D(ALSI)	-6.962283	0	0.0000	Stationary
USD/ZAR	0.137074	0	0.7194	Not Stationary
D(USD/ZAR)	-7.605646	0	0.0000	Stationary

January 2017 to December 2019

Source: Author

The Augmented-Dickey Fuller tests for stationarity for the period between January 2017 and December 2019 show that all the variables are stationary at first differences – integrated of order 1, except for CPI, which is stationary at level terms – integrated of order 0.

4.4. GRANGER CAUSALITY TEST

Due to the visible negative relationship between the Dollar/Rand exchange rate and historical Bitcoin prices between the latter part of 2017 and 2019, it was essential to test whether there is evidence of directional causality between the two variables.

Table 3: *Granger Causality test results the Dollar/Rand exchange against historical Bitcoin prices between August 2010 and December 2019.*

Variables	Lags	F-statistic	Result
D(USD/ZAR) vs D(BTC/USD)	1	0.74788	USD/ZAR does Granger Cause BTC/USD
D(BTC/USD) vs D(USD/ZAR)	1	5.47713**	BTC/USD does not Granger Cause USD/ZAR
D(USD/ZAR) vs D(BTC/USD)	2	2.91349***	USD/ZAR does not Granger Cause BTC/USD
D(BTC/USD) vs D(USD/ZAR)	2	2.69928***	BTC/ZAR does Granger Cause USD/ZAR

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Source: Author

When it was tested whether the Dollar/Rand exchange rate Granger Causes historical Bitcoin prices, it was found that the F-statistic was not statistically significant at 1 lag and statistically significant at the 10% at 2 lags. Therefore, the null hypothesis was not rejected at lag 1, and the conclusion drawn was that USD/ZAR does not Granger cause BTC/USD at 1 lag, but it Granger caused BTC/USD at 2 lags at the 10% level of significance.

It was also tested whether historical Bitcoin Prices Granger Cause the Dollar/Rand exchange rate. The F-statistic was significant at the 10% level at lag 1; it was also found to be statistically significant at lag 2 at the 10% level. Therefore, the null hypothesis was not rejected at lag 1 and at lag 2, and it was concluded that BTC/USD does Granger Cause USD/ZAR at lag 1 and lag at the 10% level of significance.

The above all suggests BTC/USD might be counter-cyclical to USD/ZAR. This further suggests that BTC/USD might be a good hedge against USD/ZAR.

4.5. VECTOR AUTOREGRESSION RESULTS

Bivariate Vector Autoregressive estimates are shown below, it was essential to estimate the models in this way as the aim was to isolate the relationship between Bitcoin and each variable and to see whether past values of each variable have an effect on Bitcoin prices.

Table 4: *Vector autoregression results for gold against historical Bitcoin prices between August 2010 and January 2019.*

Dependent Variable	**XAU/USD**	**BTC/USD**
XAU/USD(-1)	0.792919*	0.599242
XAU/USD(-2)	0.154379	-0.987617
BTC/USD(-1)	0.005447	1.016802*
BTC/USD(-2)	-0.004878	-0.056133
C	72.16138	670.6896

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Source: Author

Table 4 shows two equations, the gold equation, and the Bitcoin equation. In the gold equation, only the first lag of itself is significant at the 1% level. In the Bitcoin equation, the first lag of Bitcoin is significant at the 1% level, suggesting that there is no significant relationship between historical gold and bitcoin prices. The vector autoregression results show that there is

no statistically significant relationship between past gold prices and current Bitcoin prices – suggesting that Bitcoin may not be as good a hedge as gold.

Table 5: *Vector autoregression results for inflation against historical Bitcoin prices between August 2010 and January 2019.*

Dependent Variable	**CPI**	**BTC/USD**
CPI(-1)	0.831330*	8.120755
CPI(-2)	0.226679	-40.930
BTC/USD(-1)	-1.63E-05	10.2812*
BTC/USD(-2)	6.35E-05	-0.060050
C	0.274066*	297.4122

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Source: Author

Table 5 shows the inflation equation and the Bitcoin equation. Only the first lag of inflation is statistically significant at the 1% level in the inflation equation. In the Bitcoin equation, only the first lag of Bitcoin is significant at the 1% level, suggesting no significant relationship between inflation and historical Bitcoin prices. The vector autoregression shows that there is no significant relationship between past CPI values and current Bitcoin prices. This suggests that Bitcoin can be used as a weak hedge against inflation.

Table 6: *Vector autoregression results for the ALSI against historical Bitcoin prices between August 2010 and January 2019.*

Dependent Variable	**ALSI**	**BTC/USD**
ALSI(-1)	0.789804*	0.082301
ALSI(2)	0.197216**	-0.059987
BTC/USD(-1)	-0.048005	0.963564*
BTC/USD(-2)	-0.023793	-0.035505
C	1.25734	-844.2101

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Source: Author

The Vector Autoregression results in Table 6 show the ALSI equation and the Bitcoin equation. The ALSI equation clearly shows that the first lag and second lag of the ALSI are significant at the 1% and 5% levels, respectively. In the Bitcoin equation, only the first lag of Bitcoin is significant at the 1% level; this suggests that there is no significant relationship between the ALSI and historical Bitcoin prices. The vector autoregressions also show that there is no statistically significant relationship between past ALSI suggesting that Bitcoin can be used as a weak hedge against the stock market.

Table 7: *Vector autoregression results for the Dollar/Rand exchange against historical Bitcoin prices between August 2010 and January 2019.*

Dependent Variable	**USD/ZAR**	**BTC/USD**
USD/ZAR(-1)	0.757236	167.3367
USD/ZAR(-2)	0.228701*	-106.5594
BTC/USD(-1)	-0.000112*	1.005498*
BTC/USD(-2)	0.000113*	-0.065777
C	0.248495	-509.4756

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Source: Author

Table 7 shows the Dollar/Rand exchange rate equation and the Bitcoin equation. In the exchange rate equation, it is evident that the second lag of the exchange rate is significant at the 1% level. An additional observation made was that the first lag of Bitcoin prices has a small but statistically significant -1% level - negative relationship with the South African exchange rate in the current period. The second lag of Bitcoin prices also has a small but statistically significant positive relationship with the current Dollar/Rand exchange rate. In the Bitcoin equation, the first lag of Bitcoin is significant at the 1% level. These results suggest that past values of Bitcoin prices significantly affect the current Dollar/Rand exchange rate. However, there is no statistically significant relationship between past values of the South African exchange rate and current Bitcoin prices. The vector autoregression shows that there is no statistically significant relationship between past USD/ZAR prices and current Bitcoin prices. This suggests that Bitcoin can also be used as a weak hedge against the South African exchange rate.

To test the robustness of these results, the variables were differenced, and vector autoregressions were estimated. These models are attached in the appendices and are presented as Tables A-1 to A-4. These tables are presented to illustrate how the results were to look if the variables were differenced. The results obtained are the same as the undifferenced variables with the exception of the USD/ZAR, the past values of which show a positive relationship with Bitcoin.

In addition, the vector autoregressions, impulse response functions were also estimated – these are presented in Figures 5 to 8.

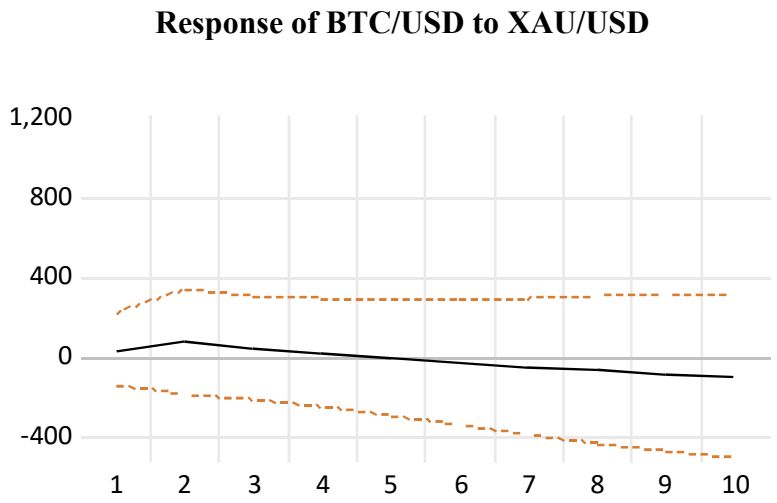

Figure 5: *Impulse Response Functions for Bitcoin prices against historical Gold prices.*

Figure 5 shows that a 1-unit positive shock the gold price would bring about an initially positive approximately 25-unit shock to Bitcoin prices at about lag 2 which gradually decreases, it becomes zero at lag 5 then becomes more and more negative as the lag length increases. This suggests that no statistically significant relationship exists between shocks in gold prices and shocks in Bitcoin prices.

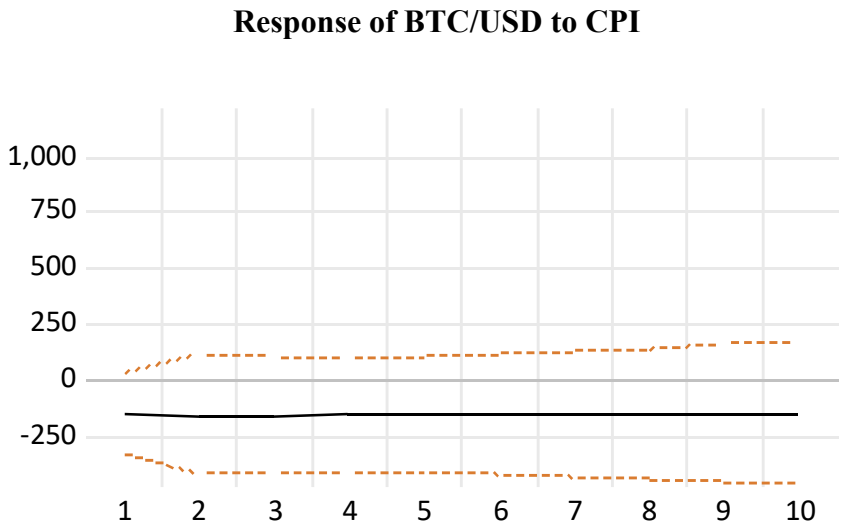

Figure 6: *Impulse Response Functions for Bitcoin prices against CPI.*

A 1-unit positive shock to CPI leads to a negative ~125-unit shock to Bitcoin prices, this response remains constant as the lag length increases. This relationship is however not statistically significant, this suggests that a shock to CPI does not have an effect on Bitcoin prices.

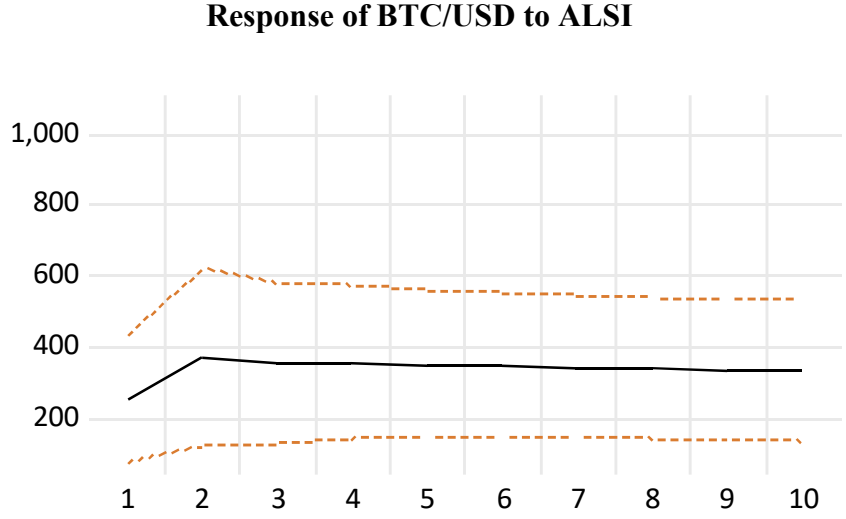

Figure 7: *Impulse Response Functions for Bitcoin prices against the ALSI.*

Figurer 7 shows that 1-unit positive shock to the ALSI will lead to a significant positive approximately 150-unit shock to Bitcoin prices. This gradually increases and peaks just below 400 at lag 2, and gradually decreases as the lag length increases.

Response of BTC/USD to USD/ZAR

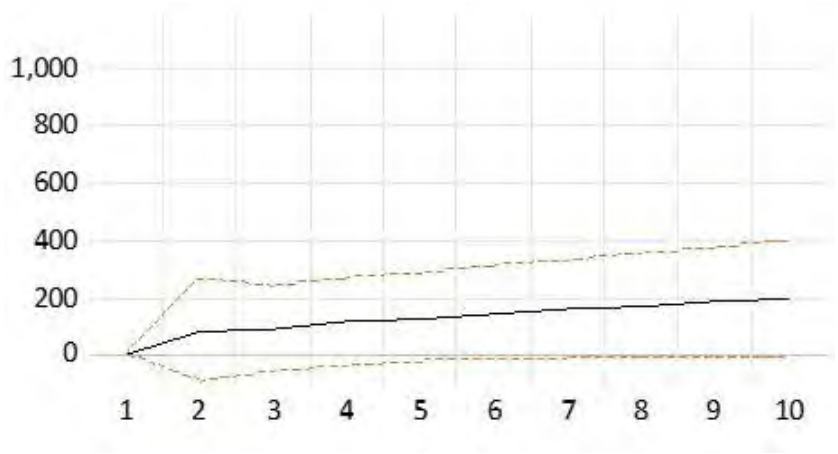

Figure 8: *Impulse Response Functions for Bitcoin prices against the USD/ZAR.*

Figure 8 shows that a positive 1-unit shock to the USD/ZAR results in a positive but minor shock to Bitcoin prices at about lag 1. The shock quickly increases as the lags increase. The shock gradually flattens out at just below 200, and this is where it remains for the rest of the lag length, the response is steady positive and insignificant.

The impulse functions suggest no statistically significant relationship between shocks to gold prices and shocks to Bitcoin prices. Suggesting that Bitcoin might not be as good a hedge as gold. In the case of shocks to inflation, it is evident that there is no statistically significant relationship between positive shocks to inflation and shocks to Bitcoin prices. A positive shock to the ALSI also shows no statistically significant relationship with shocks to Bitcoin prices. Figure 8 shows a positive relationship between shocks in the USD/ZAR and shocks in Bitcoin prices. This suggests that Bitcoin and the South African exchange rate are counter-cyclical, and that Bitcoin might be a good hedge against the South African exchange rate.

4.6. MARKOV-SWITCHING MODELS

The relationship between some variables can sometimes be non-linear as the data generating process underlying the data can vary depending on the different states of the system. In this case it was established that the data generating process underlying the gold prices, CPI, the ALSI, and the USD/ZAR is different based on the state of the South African economy, that is, whether the country is in an expansion or a recession. Because of this it was essential to estimate a Markov-Switching model in addition to the VAR as it captures this non-linearity.

Table 8: *Markov-Switching models for Bitcoin against inflation, the ALSI, and the Dollar/Rand exchange rate between January 2017 and December 2019.*

Dependent Variable:	**BTC/USD**					
	Regime 1		**Regime 2**		**Transition Probabilities**	
Independent Variable	**Coefficient**	**Constant**	**Coefficient**	**Constant**	**P11-C**	**P21-C**
D(XAU/USD(-1))	-4.459583	3363.764*	21.83742**	8533.264*	0.0024	0.0000
D(CPI(-1))	1906.605	8684.495*	5334.273	3614.918*	0.0132	0.3990
D(ALSI(-1))	0.027995	8672.139*	0.018548	3340.481*	0.0953	0.0030
D(USD/ZAR(-1))	-1243.738***	8800.044	423.8637	3381.876*	0.0198	0.0173

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Source: Author

Table 7[23] shows the Markov-Switching model results for historical Bitcoin prices against the various variables - each row in the table is a separate model, the variables were not estimated simultaneously. The first observation made is that Bitcoin exists in two distinct states: a high-growth state and a low-growth state. In the first equation, it can be deduced that Regime 1 is the high-growth state and Regime 2 is the low-growth state, this is based on the value of the means. The independent variable is the differenced first lag of gold prices in the first equation. It can be seen that gold only has a positive and statistically significant relationship with Bitcoin during Bitcoin's high growth state as the coefficient of the differenced first lag of gold prices is significant at the 5% level. The evidence suggests that Bitcoin and Gold are pro-cyclical and thus share similar movements. This suggests that Gold and Bitcoin might have similar hedging properties.

In the second equation in which CPI is the independent variable, there is no statistically significant state-dependent relationship between the two variables in either state. This is mainly because the coefficients of the differenced lag of CPI are not statistically significant in

[2] The models were estimated at first differences, mainly because when the models were estimated at level terms some of the conditional means came out negative, this was counterintuitive as all of the independent variables cannot be a negative value, because of this, the above models were deemed the most representative of the relationship between Bitcoin prices and the above-mentioned variables - the results for the models at level terms are included in the appendices.

[3] In Table 7 there are four equations listed, in all of which historical Bitcoin prices are the dependent variable, the results for the Markov-Switching models were obtained from a truncated version of the sample as Bitcoin prices became more dynamic in 2017, as a result the period that was deemed suitable for these models was between 2017 and 2019.

both Bitcoin's high-growth and low-growth states, that is Regime 2 and Regime 1, respectively. This suggests that Bitcoin can be used as a weak hedge against South African inflation.

In the case where the differenced lag of the ALSI is an independent variable, it can also be seen here that Regime 1 is the high-growth state and Regime 2 is the low growth state. The differenced lagged coefficients of the ALSI are not statistically significant in both Regime 1 and Regime 2. This suggests that there is no statistically significant state-dependent relationship between the Bitcoin prices and the ALSI. This suggests that Bitcoin can be used as a weak hedge against the South African stock market.

Finally, when the differenced lag of the South African exchange rate was used as the independent variable, it was seen that Regime 1 is the high-growth state and Regime 2 is the low-growth state. The coefficient of the differenced lag of the exchange rate was found to be negative and statistically significant at the 10% level when observed in Regime 1, while there was no evidence of a statistically significant relationship in Regime 2. This evidence suggests that Bitcoin might be a good hedge against the South African exchange rate.

The Markov-Switching models suggest a pro-cyclical relationship between gold and Bitcoin prices this suggests that Bitcoin might be as suited at hedging as gold. The results further suggest that Bitcoin can be used as a weak hedge against inflation and South African stock market downturns. The model also suggests that Bitcoin can be used to hedge against the South African exchange rate.

In the appendices, models in which the ALSI and the USD/ZAR are the dependent variables and BTC/USD is the independent variable are added. Since these are the indicators of the South African economy's health, it was important to show how Bitcoin moves relative to these variables. Table A-7 in the appendices shows that there is no significant relationship between Bitcoin and the ALSI further suggesting that Bitcoin can be used as a weak hedge against the South African stock market. Table A-8 in the appendices shows that there is a negative relationship between Bitcoin prices and the USD/ZAR, further suggesting that Bitcoin can be used as a good hedge against the South African exchange rate.

4.7. DISCUSSION OF FINDINGS

The present study aimed to investigate whether Bitcoin could be used as a hedge against adverse market conditions within the South African context. Adverse market conditions, in this case, include increases in inflation, stock-market downturns, or depreciation in the South

African exchange rate. The study first sought to investigate whether there is a significant relationship between Bitcoin prices and gold prices as gold is considered to be a good hedge against said adverse market conditions. Secondly the study investigated whether there is a significant relationship between Bitcoin, South African inflation, the JSE All Share Index (ALSI), and the South African exchange rate. A number of empirical studies have a similar focus; however, this type of study has not been done within the South African context.

In the case of Bitcoin and gold - based on a graphical assessment, which showed no visible relationship and, vector autoregression results and impulse response functions which showed no statistically significant relationship, this study found that as much as gold and Bitcoin share a set of characteristics, they are not correlated. These results are similar to what Torpey (2020) found; the author used a correlation chart and Spearman rank correlation calculations to assess whether there was a significant correlation between Bitcoin and gold prices between 2011 and 2020. In a Spearman rank correlation calculation, price correlation is measured on a scale from -1 to 1. A score of -1 indicates a perfect inverse correlation, 0 indicates no correlation, and 1 indicates a perfect level of positive correlation. The study found that the price correlation between Bitcoin and gold has hovered around 0 to 0.2 since late 2013. This would point to a very weak and insignificant level of correlation between the two assets.

This contrasts the views of a study by Zwik and Syed (2019) in which they used a two-step approach in order to test the long-term relationship between Bitcoin and gold prices. The authors used both a linear and a two-regime approach to estimate the relationship. They found that their empirical results indicate that gold is a significant predictor of Bitcoin prices. They indicate, however, that this impact is not linear over the period. A structural break occurring on the 5th of October 2017 implies that a two-regime relationship exists between Bitcoin and gold prices. This is also what the Markov-Switching model in the present study found as there is a positive relationship between gold prices and Bitcoin during Bitcoin's high-growth state.

The present study also looked at whether there is a significant relationship between Bitcoin prices, South African inflation, the ALSI, and the South African exchange rate. Four assessments used for each were: a graphical analysis, a vector autoregression (VAR), impulse response functions, and a two-regime Markov-Switching model. The results for each variable are given below.

In the case of a relationship between Bitcoin prices and inflation, the graphical assessment showed no visible relationship between the two variables. In the case of the VAR and impulse

response functions, the results clearly show that there is no statistically significant relationship between the two variables. The Markov-Switching model also showed that there is no significant relationship between Bitcoin prices and inflation. The results from these assessments all agree with each other; the graphical analysis, the VAR, impulse response functions, and the Markov-Switching model all point toward a lack of correlation. This lack of correlation is similar to what a study by Malik (2020) found. The study focused on the drivers of bitcoin prices within the Indian context. Comparing this study with the current study is of particular importance as both studies were done within the context of emerging markets. The study sought empirically analyse the determinants of Bitcoin prices in India for 156 weeks spanning from 2017 to 2019 using a vector error correction model (VECM). The study found that inflation has no significant impact on Bitcoin prices. Both the present study and the Malik (2020) study suggest that Bitcoin might be a weak hedge against inflation in emerging markets.

When the present study looked at whether there was any correlation between the ALSI and Bitcoin, the graphical analysis showed no visible relationship between the two variables. A vector autoregression and impulse response functions were estimated, the results of which align with what was seen on the graph, which is, there is no statistically significant relationship between the JSE All Share index and Bitcoin prices. The Markov-Switching model found no statistically significant relationship between the ALSI and Bitcoin prices.

These results were similar to a 2018 study by Alexander, in which the author sought to investigate the use of multiple cryptocurrencies in a diversified portfolio. This study is particularly important because it is one of a few performed within the South African context. The study used a quantitative research method, which starts by finding an area of study, then questions are asked, or hypotheses proposed. Subsequently, data is collected, and variables are quantified by employing statistical methods, providing information that can be interpreted and used to form an answer to such questions or hypotheses. One of the research questions of the study was whether South African equities are related to cryptocurrencies. The study found that the correlation of cryptocurrencies to equities is low positive over the period, suggesting that some relationship exists between these variables. However, based on fundamental factors, this positive relationship is likely not compelling. The South African market plays an insignificant part in the broader cryptocurrency market. Fiat currencies like the USD, Euro, Japanese Yen, Chinese Yuan, and South Korean Won make up close to all of the market. All of this suggests that Bitcoin might be a weak hedge against the ALSI.

The study also looked at whether there exists a significant relationship between Bitcoin prices and the South African exchange rate. The graphical analysis shows that Bitcoin and South African exchange rates have a negative relationship. Based on the graphical analysis, it was seen that post-2017 Bitcoin prices and the exchange rate exhibited a negative relationship. This prompted the use of a Granger Causality test to test whether there was evidence of one variable Granger-causing another. It was found that the lagged value of the South African exchange rate does Granger-cause of Bitcoin prices. The VAR shows no statistically significant relationship between the past values of the exchange rate and current Bitcoin prices. This does not agree with a 2019 study by Vecchio in which the author used correlation analysis to analyse the relationship between Bitcoin and emerging market currencies. It found that there was no correlation between Bitcoin and the Indian Rupee, a negative relationship with the Turkish Lira, and no relationship with the South African Rand.

The impulse response functions were plotted, and they also displayed a counter-cyclical relationship between the Rand and Bitcoin prices. Finally, the Markov-Switching model shows a negative statistically significant state-dependent relationship between the differenced lag of the exchange rate and Bitcoin prices as when the exchange rate is depreciating, Bitcoin is experiencing its highest growth. These findings are similar to those in Okonkwo et al. (2021) study. They sought to investigate the co-movement of Bitcoin and some African currencies using a wavelet analysis. The authors found a significant negative relationship between the South African Rand and Bitcoin prices.

4.8. CONCLUSION

This chapter reported empirical results of the relationship between historical gold and Bitcoin prices (primary goal) and the relationship between Bitcoin prices and three South African fundamentals, namely, inflation, the JSE All Share Index (ALSI), and the South African exchange rate (secondary goal). This chapter consisted of seven sections (excluding the conclusion). The chapter commenced with a graphical analysis of Bitcoin against gold prices, inflation, the ALSI, and the exchange rate. The results showed no visible relationship between Bitcoin and the other variables except for the exchange rate.

The chapter then proceeded to provide augmented Dickey-Fuller unit root tests for stationarity. The results found that that Bitcoin, gold, inflation, ALSI, and exchange rate data were all stationary at first differences, which meant that the variables were integrated of order one.

A Granger-Causality test was conducted for Bitcoin and exchange rate data to establish the direction of causality and long and short-run dynamics of the relationships, respectively. The study found a unidirectional causality relationship from the exchange rate to Bitcoin at lag 1.

Results from the estimated VAR and impulse response functions showed no statistically significant relationship between Bitcoin and the other variables except for the exchange rate, which showed a negative and statistically significant relationship. This prompted the plotting of impulse response functions to see how exchange rate shocks affect Bitcoin prices.

Markov-Switching models were then estimated for the Bitcoin data against gold, inflation, ALSI, and exchange data. The results showed evidence of a positive and state-dependent relationship between Bitcoin and gold and a negative state-dependent relationship between Bitcoin and the exchange rate. There was no statistically significant state-dependent relationship between Bitcoin and the rest of the variables, the rest of the variables being inflation and the ALSI. The final section of this chapter provided a discussion on the findings of the estimated models and their relation to existing literature.

CHAPTER 5: CONCLUSION

5.1. INTRODUCTION

This study's goal was to see whether Bitcoin could be used as a core part of the South African National Treasury's investment toolkit, given how it performs against other assets and gold. The study also investigated its potential for use as a hedge against inflation, stock market downturns, and exchange rate depreciation. The study found that Bitcoin can be used as a weak hedge against inflation and the stock market and a good hedge against the exchange rate. This is in line with the overall hypothesis.

Chapter 1 outlined the research context, problem statement, and contributions of the study. It also presented the research objectives and methods employed. The first research goal was to examine whether Bitcoin is correlated with gold; if this were the case, it would suggest that Bitcoin might be as good a hedge as gold. The study used a preliminary graphical analysis and a vector autoregression to investigate this relationship. The second research goal was to identify whether there is correlation between Bitcoin and three South African fundamentals, namely, inflation, the JSE All Share Index, and the South African exchange rate. This was done through graphical analysis, a Granger Causality test, vector-autoregressions, and Markov-Switching models. The main hypothesis was that if Bitcoin and the three South African fundamentals are poorly correlated, Bitcoin can be considered a weak hedge against inflation, ALSI, and the South African exchange rate.

Chapter 2 provided an overview of the existing literature and empirical findings reported both locally and internationally. Chapter 3 provided a description of the data used in the analysis and the methods and procedures employed to achieve the empirical results. Finally, the empirical results were presented in Chapter 4

5.2. SUMMARY

A literature review was presented in Chapter 2 and goes in-depth into Bitcoin and its role as an asset class. Bitcoin is a digital asset created by Satoshi Nakamoto in 2009. It uses blockchain technology, an immutable double ledger system that bestows Bitcoin with many of its defining characteristics: digital scarcity, decentralisation, and fungibility, among others (Nakamoto, 2009). Bitcoin was once valued at less than a penny; on the week of the 17th of October 2021, it reached an all-time high valuation of nearly 67 000 US Dollars which translates to over a million Rands. This has been mainly due to the increasing interest in cryptocurrencies and

blockchain technology and all the possibilities they offer (Moore *et al.*, 2021). However, an essential section of the literature review is the section on cryptocurrencies as a safe-haven.

A study by Baur and Lucey (2010) states that a safe-haven asset is uncorrelated with stocks during a market downturn. Because of this, it would be safe to consider gold a safe-haven as it does relatively well during market crashes. This characteristic is of particular importance because, during financial crises, assets correlated with each other tend to be why the crises spread to other financial markets. An asset is a weak safe-haven if it is uncorrelated with another asset during times of distress, and it is a good safe-haven if it is negatively correlated with another asset during times of distress. The same applies to the case of a hedge; an asset tends to be a weak hedge if it is uncorrelated with another asset, and it is a good hedge if it is negatively correlated with another asset (Mariana *et al*., 2021).

In Chapter 3, the methodology undertaken along with a theoretical explanation of how the study would achieve its two sub-goals were described. The chapter then provided a description of the data used in the analysis, the data period, their source, as well as rationalisations for why the specific variables were chosen. This was followed by an overview of the preliminary assessments and econometric models applied in Chapter 4. The variables chosen to be compared against Bitcoin prices were gold, inflation, the ALSI, and the South African exchange rate.

Gold prices, like Bitcoin prices, are moved by a combination of supply, demand, and investor behaviour (Emspak, 2021). Gold is treated as a hedge because historically, when stock markets experience, downturns gold will likewise retain or rise, resulting in either profits or reducing losses in a portfolio. Therefore, it was essential to include historical gold prices, as correlation could imply that Bitcoin could be as suited as gold at hedging against adverse market conditions (Forex live, 2020).

As given by CPI, inflation is the decrease of a currency's purchasing power over time; alternatively, it can be defined as a general rise in prices. An inflation hedge is an investment that one makes for the sole purpose of protecting the investor against the decreasing purchasing power of money due to the rise in the prices of goods and services. The ideal investments used for hedging against inflation tend to be investments that either maintain their value during inflation or increase value over a specified period of time (Corporate Finance Institute, 2021). Therefore, if Bitcoin is either negatively correlated or not correlated to inflation, it could be considered a good hedge against inflation.

The ALSI is mainly used as a performance benchmark and can also measure how well the South African market is performing. If South Africa as a country is experiencing a downturn, it will be reflected in this index as the stock price of most companies might be down due to a decrease in profits. It was essential to use this measure as it is an indicator of how well the South African market is doing. A good hedge would be an asset that moves in the opposite direction as the ALSI, and a weak hedge would be an asset that is not correlated with the ALSI.

The USD/ZAR exchange rate is the rate at which one Dollar will be exchanged for Rands; this variable was chosen because it is an indicator of a country's economic strength and can act as a proxy for the South African market as a whole (Levinson, 2014). This variable is similar to the ALSI as negative, or a lack of correlation between the USD/ZAR and Bitcoin could imply that Bitcoin is a good hedge against market downturns in South Africa.

In Chapter 4, the results of correlation analysis are presented, the conclusions drawn from which are presented in the next section.

5.3. CONCLUSIONS OF STUDY

Several of the studies indicated in this research reveal that Bitcoin as an asset class shares common characteristics with the commodity gold, the econometric analyses in these past studies suggest that Bitcoin exhibits low or negative correlation with gold. This is similar to the conclusion drawn in the present study, as both the graphical analysis and the vector autoregression suggested that there is no statistically significant relationship between Bitcoin and gold. However, some studies suggest that the relationship between Bitcoin prices and gold is not linear, and that could explain why it was not evident in the graphs and the VAR. When the Markov-Switching model was estimated a positive state-dependent relationship was seen between Bitcoin and gold prices. The results suggest that Bitcoin can be used similarly to gold – the results also indicate that gold is more stable regarding its safe-haven characteristics and acts more efficiently as a hedger during ordinary economic conditions. The Bitcoin market should mature by a much larger level for Bitcoin to be comparable to gold concerning its global safe-haven or hedging properties. Thereby, Bitcoin has to make significant leaps forward regarding its popularity and institutional adoption to be included in the country's national treasury portfolios as willingly as they prefer gold during stressed periods. However, Bitcoin might be better at hedging in the long-term as its growth prospects far outweigh gold. The fact that it has limited supply along and its demand has been steadily increasing should be the driving force behind its continued price increase.

It is worth mentioning that despite Bitcoin's substantial gains over the years, there have been significant crashes in its price. These have mainly been driven by negative news around the cryptocurrency; these include announcements of regulatory action or tweets by Elon Musk. However, despite these crashes Bitcoin has grown from strength to strength with the cryptocurrency having realised 38.56% in returns over the past six months (Luno, 2021). This suggests that if one is looking for a recession-resistant investment that can combat inflation, stock market downturns, and exchange rate depreciation, and has long-term growth potential, then Bitcoin is the best option. This makes sense for South Africa's National Treasury as they would want to meet their obligations in the long-term. However, it might be off interest for the treasury to profit on short-term movements in Bitcoin as crypto assets can also be used in derivative products, being referenced as underlying assets.

Bitcoin's meteoric rise over the past decade suggests that it would be a good inflation hedge, as it is considered the best-performing asset of the past decade (Young, 2021). Bitcoin has seen its price continue increasing as inflation climbs higher and higher. It appears, then, that Bitcoin might be an effective inflation hedge. The present study found that there is no significant correlation between Bitcoin and South African inflation when looking at a graphical analysis and a vector autoregression and the Markov-Switching model. Four of the study's assessments point towards a lack of correlation between Bitcoin and inflation; this suggests that Bitcoin can be used as a weak hedge against inflation in South Africa. However, Bitcoin is also extremely volatile, affecting its potential as an inflation hedge or preventing risk-averse countries from touching the asset altogether. Although Bitcoin's price is currently fluctuating around an all-time high, its use cases and adoption should only increase from this point. Its limited supply paired with steadily increasing demand should continue to drive the price higher.

The present study also investigated whether Bitcoin can be used as a hedge against the South African stock market. All three assessments of the study – the graphical analysis, the vector autoregression, and the Markov-Switching model- suggest no statistically significant relationship between the South African stock market and Bitcoin prices. Based on these outcomes, it is safe to suggest that Bitcoin can be used as a weak hedge against the ALSI and can therefore be used alongside gold to eliminate or minimize specific market risks. This is because Bitcoin has advantageous characteristics such as a high rate of return and weak correlations with other assets.

Additionally, as Bitcoin is traded at high and continuous frequencies with no days where trading is closed, like other assets, bitcoin has specific speed advantages and adds to the already rich list of hedging tools available to analysts. The only downside is that Bitcoin may introduce volatility into a portfolio, which can be minimised with the addition of other assets. However, this does not take away from the fact that Bitcoin's extreme volatility undermines its risk-hedging capabilities.

The last relationship that this study investigated was that of Bitcoin against the South African exchange rate. It is no secret that the Rand has significantly depreciated since its introduction in 1961. Factors such as political instability in the National Treasury, financial mismanagement, a loss of investor confidence, and its tie to commodity prices further introduce volatility into the currency. The Rand can additionally be used as a proxy to gauge how well the South African market is fairing. Because of this, it is prudent for the South African National Treasury to hedge against the depreciation of the Rand as depreciation would mean that it would be harder to meet fiscal targets and service any government debt. This study was critical as it sought to investigate whether Bitcoin could be added into the National Treasury's investment toolkit as a means to hedge against a depreciating Rand. Four of the study's assessments – the graphical analysis, vector autoregression, the impulse response function, and the Markov-Switching model - suggest that there is a counter-cyclical and statistically significant relationship between the Rand and Bitcoin. This indicates that Bitcoin is a good hedge against the South African exchange rate. This is evident in the current trends as more citizens are turning towards cryptocurrencies as a viable solution to Rand volatility. This trend will continue so long as the South African Rand keeps declining and does not stabilise. Because of this, it is only prudent that the South African National Treasury also adds Bitcoin into its investment toolkit as a means to hedge against the depreciation of the Rand.

5.4. POLICY IMPLICATIONS AND RECOMMENDATIONS

Based on the above conclusions, several suggestions are presented for the South African National Treasury. Bitcoin is a weak hedge against inflation and stocks and a good hedge against the Rand. This suggests that the South African National Treasury should add Bitcoin into its investment toolkit as it would be able to weakly hedge against these three economic variables. However, the National Treasury should be wary of the following when considering Bitcoin as an investment; they should be mindful of Bitcoin's speculative and uncertain nature.

While the average value of Bitcoin's return is greater than that of other assets, its volatility also is higher. That is, Bitcoin's high returns also contain a significant amount of risk.

Bitcoin is a valuable hedging asset for stocks, inflation and a good hedge for the South African rand. This means that the Treasury can benefit from Bitcoin when they encounter losses from inflation and stocks due to the lack of correlation between these and Bitcoin. In addition, adding Bitcoin to portfolios that include the Rand can assist in hedging against the depreciation of the Rand. If a portfolio contains multiple assets simultaneously, Bitcoin can play numerous roles, such as a hedging asset and a means of diversification. It is worth noting that, given the market conditions that accompany a financial crisis, it is therefore plausible that the least desirable Bitcoin characteristics may during this time manifest as Bitcoin tends to spread contagion. As a recommendation, the Treasury should add Bitcoin into its investment toolkit; however, they should be wary of the asset's risks. Hopefully, as the Bitcoin market matures and institutional adoption increases, so will Bitcoin’s volatility decrease, and it can hopefully become as good a hedge as gold.

5.5. LIMITATIONS OF STUDY AND AREAS FOR FURTHER RESEARCH

The major limitation of this study was limited data availability in the case of Bitcoin prices. Additionally, Bitcoin prices remained more or less stagnant, between 2009 and 2017, and only became a bit more dynamic post-2017. This meant that the Bitcoin data usable for the Markov-Switching model began in 2017, significantly reducing the sample size.

Further studies can use other econometric models like linear regression analysis and vector error correction models to ascertain the relationship between the variables in the present study. This can add more evidence to the literature about whether Bitcoin can indeed be used as a hedge within South Africa’s National Treasury. This study did not include a significant number of South African economic indicators; there is a considerable gap for further research on other macroeconomic variables such as GDP and crude oil prices,. The current study results were presented for the South African context. There is merit in broadening the study to account for other emerging countries.

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7. APPENDICES

Table A-1: *Vector autoregression results for gold, against Bitcoin prices, both at first differences.*

Dependent Variable	**D(XAU/USD)**	**D(BTC/USD)**
D(XAU/USD)(-1)	0.024545	0.005484
D(XAU/USD)(-2)	0.175316***	0.006389
D(BTC/USD)(-1)	0.383762	-0.200175**
D(BTC/USD)(-2)	-1.104142	-0.041236
C	55.39186	0.874482

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Table A-2: *Vector autoregression results for inflation against Bitcoin prices, both at first differences.*

Dependent Variable	**D(CPI)**	**D(BTC/USD)**
D(CPI)(-1)	-0.118359	75.8671
D(CPI)(-2)	-0.021038	-608.6511
D(BTC/USD)(-1)	-1.12E-05	0.027776
D(BTC/USD)(-2)	-1.48E-05	0.156207
C	0.006614	59.02439

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Source: Author

APPENDICES (CONTINUED)

Table A-3: *Vector autoregression results for the ALSI against Bitcoin prices, both at first differences.*

Dependent Variable	D(ALSI)	D(BTC/USD)
D(ALSI)(-1)	-0.158197	-0.039005
D(ALSI)(-2)	0.013489	0.150296
D(BTC/USD)(-1)	-0.060444	0.111582***
D(BTC/USD)(-2)	-0.002486	0.104360
C	279.8879	5.877647

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Table A-4: *Vector autoregression results for the Dollar/Rand exchange against Bitcoin prices, both at first differences.*

Dependent Variable	D(USD/ZAR)	D(BTC/USD)
D(USD/ZAR)(-1)	-0.235427*	312.8970***
D(USD/ZAR)(-2)	0.003133	377.8512**
D(BTC/USD)(-1)	-0.000117*	0.022228
D(BTC/USD)(-2)	6.81E-07	0.223448
C	0.09583	0.223448

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Source: Author

APPENDICES (CONTINUED)

Table A-5: *Vector autoregression results for Bitcoin against the ALSI, CPI, and the Dollar/Rand between August 2010 and January 2019.*

Dependent Variable	ALSI	CPI	USD/ZAR	BTC/USD
ALSI(-1)	0.755865*	-1.32E-05	1.60E-05	0.122792**
ALSI(-2)	0.164619	1.71E-05	2.52E-05	-0.036427
CPI(-1)	-168.0561	0.809176	-0.253736	49.87386
CPI(-2)	359.0625	0.141216	0.197164	-734.6612
USD/ZAR(-1)	4.647579	-0.016302	0.693295*	121.7624
USA/ZAR(-2)	168.2154	0.000379	0.190707*	-143.2544
BTC/USD(-1)	-0.019924	1.18E-05	-0.000143*	0.865096*
BTC/USD(-2)	0.009472	2.23E-07	0.000105**	0.090904
C	1182.162	0.267613*	-0.16534	-42.05016

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: ***

Source: Author

Table A-6: *Markov-Switching models for Bitcoin against inflation, the ALSI and the Dollar/Rand exchange rate where the independent variables at level terms*

Dependent Variable:	**BTC/USD**					
	Regime 1		**Regime 2**		**Transition Probabilities**	
Independent Variable	**Coefficient**	**Constant**	**Coefficient**	**Constant**	**P11-C**	**P21-C**
XAU/USD(-1)	Err	Err	Err	Err	Err	Err
CPI(-1)	-6468.946*	33549.45*	-7624.882*	42662.41*	0.4248	0.0086
ALSI(-1)	0.839855*	-451514.56*	0.436522	-15288.00	0.0203	0.3732
USD/ZAR(-1)	1383.665	-15515.94	98.91674	7427.955	0.0000	0.0025

Significant at 1% level: * Significant at 5% level: ** Significant at 10% level: *** Err: This is not the best specification for the variables.

Table A-7: *Markov-Switching models for the ALSI against Bitcoin between January 2017 and December 2019.*

Dependent Variable:	**ALSI**					
	Regime 1		**Regime 2**		**Transition Probabilities**	
Independent Variable	**Coefficient**	**Constant**	**Coefficient**	**Constant**	**P11-C**	**P21-C**
D(BTC/USD)	-0.025750	52746.13*	0.21028	57031.01*	0.0000	0.9686
Significant at 1% level: *		Significant at 5% level: **		Significant at 10% level: ***		

Source: Author

Table A-8: *Markov-Switching models for the USD/ZAR against Bitcoin between January 2017 and December 2019.*

Dependent Variable:	**USD/ZAR**					
	Regime 1		**Regime 2**		**Transition Probabilities**	
Independent Variable	**Coefficient**	**Constant**	**Coefficient**	**Constant**	**P11-C**	**P21-C**
D(BTC/USD)	-3.89e-05	14.40820*	-3.56E-06	12.97194*	0.0026	0.0895
Significant at 1% level: *		Significant at 5% level: **		Significant at 10% level: ***		

Source: Author