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An Investigation into the Diversification Effects of Bitcoin for Caribbean Market Investors

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Abstract

Over the last decade, cryptocurrencies have been growing rapidly in popularity. Most investors attempt to acquire a well-diversified and lucrative portfolio by investing in a multitude of assets. In preceding years, significant losses were experienced in the cryptocurrency industry caused by its volatile nature which further stimulated risk-averse decisions among investors. However, in recent months it has been regaining its value and generating returns for some investors. This study aims to determine the diversification effect through risk and return by using a counterfactual approach and to examine the volatility of Bitcoin in comparison to four Caribbean stock exchanges (Barbados Stock Exchange, Eastern Caribbean Stock Exchange, Jamaica Stock Exchange and Trinidad and Tobago Stock Exchange. The results indicate that Bitcoin does not significantly impact the return incurred by an investor. However, portfolio diversification can be increased by investing in Bitcoin. Overall, Bitcoin has a notably higher volatility in comparison to emerging market stocks.

JEL Classification: C58, G11, G13

Keywords: Bitcoin, Caribbean Stock Exchanges, Cryptocurrency, Diversification, Portfolio, Volatility

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1. Introduction

The financial system of an economy plays a pivotal role in creating an environment where individuals are comfortable and willing to engage in saving, borrowing and investing. This promotes the transferring of resources from savers to investors which results in the financing of real economic activity within the economy (Kuper & Kuper, 2004). Bonds and stocks are indispensable components of financial markets and are critical in stimulating greater economic efficiency within an economy. The highlight of any financial market lies in the movement of surplus funds of individuals to other individuals that are experiencing a shortage of available funds (Mishkin & Eakins, 2014).

Stock exchanges allow investors to purchase and sell securities. In the Caribbean, stock exchanges facilitate trading by investors. Unfortunately, Caribbean stock exchanges such as the Barbados Stock Exchange (BSE), Eastern Caribbean Stock Exchange (ECSE), Jamaica Stock Exchange (JSE) and Trinidad and Tobago Stock Exchange (TTSE) cannot be compared to that of international stock exchanges such as the New York Stock Exchange (NYSE), Toronto Stock Exchange (TSX) or London Stock Exchange (LSE). According to Cozier (2010), stock exchanges in the Caribbean have enjoyed relatively short life spans compared to the period of those in developed countries. In comparison to international stock exchanges, Caribbean stock exchanges experience exceedingly small amounts of trading activity. This can act as a possible deterrent to investors as the act of selling out a stock becomes rather complex (Bernstein, 1987).

According to the World Bank (WB), world market capitalisation stood at approximately United States dollars (USD) 78.826 trillion in 2019 and USD 93.686 trillion in 2020. Two of the top five stock exchanges globally were the National Association of Securities Dealers Automated Quotations (NASDAQ) and Shanghai Stock Exchange (SSE) which have been in existence since 1971 and 1990, respectively. In contrast, the Caribbean based stock exchanges (BSE, ECSE, JSE and TTSE) were only established in 1987, 2001, 1968 and 1981, in that order.

Table 1 below shows the market capitalisation and number of companies listed for the above-mentioned stock exchanges for 2019. Of the Caribbean stock exchanges[5], JSE trades the largest number of stocks. However, this was merely 7% and 4% of the number of stocks traded respectively, on the SSE and NASDAQ in 2019. TTSE held the largest level of market capitalisation for the Caribbean stock exchanges which accounted for 0.03% of the world's market capitalisation whilst SSE and NASDAQ accounted for 6.5% and 16.5%, correspondingly for 2019. Cumulatively, stock holdings amongst BSE, ECSE, JSE and TTSE comprised of 0.05% of the world's market capitalisation in 2019.

[5] For the purposes of this study, Caribbean Stock Exchanges specifically refers to the four major Caribbean based stock exchanges focused on in this paper, that is, Barbados Stock Exchange (BSE), Eastern Caribbean Stock Exchange (ECSE), Jamaica Stock Exchange (JSE) and the Trinidad and Tobago Stock Exchange (TTSE).

Table 1: Comparison between the market capitalisation and number of stocks listed on Caribbean Stock Exchanges and two major International Stock Exchanges[6]

Stock Exchange	Market Capitalisation (USD)	Number of Stocks
BSE	2.78 billion	18
ECSE	0.67 billion	16
JSE	13.41 billion	112
TTSE	21.98 billion	36
NASDAQ	13 trillion	3,140
SSE	5.1 trillion	1572

Sources: BSE Annual Report 2020, ECSE Annual Report 2020, JSE Annual Report 2020, TTSE Annual Report 2020, SSE Annual Report 2020, and NASDAQ Annual Report 2019

The aim of the typical investor is to hold a diversified portfolio of assets that would facilitate the maximum return probable (Avadhani, 2016). Table 2 shows the level of expected return and risk for the Caribbean Stock Exchanges and NASDAQ. It is evident that although the NASDAQ experiences the largest risk, it also bears highest returns. The level of expected risk amongst the majority of Caribbean Stock Exchanges is generally zero which perfectly exemplifies the concept of home bias. There are three known types of investors that exist: risk-loving, risk-neutral and risk-averse investors (Suer & Minibas-Poussard, 2015). Most investors are risk-averse, that is, their aim is geared toward maximising returns at the minimum risk possible (Cohn, et al. 1975). Due to the presence of asymmetric information that may exist in financial markets, investors may express unwillingness to diversify their portfolios in fear of incurring large losses (Hatchondo, 2008) and lack of knowledge of the benefits associated with portfolio diversification. As a result, most investors, especially Caribbean investors, are more likely to invest most of their portfolios in local stocks due to fear of losses and lack of knowledge of the benefits associated with diversifying their portfolios with non-local commodities.

[6] The following exchange rates were used to convert all other currencies in this table to USD (BDS$1= USD$0.5, ECD$1=USD$0.37/ JMD$1=USD$0.044/ TTD$1=USD$6.84/ RMD$1=$USD0.14)

Table 2: Comparison between the risk and return experienced on Caribbean Stock Exchanges and NASDAQ[7] for the first half of 2019.

2019	BSE	ECSE	JSE	TTSE	NASDAQ
Portfolio Expected Return	-0.01%	-0.02%	1.71%	0.01%	0.03%
Portfolio Expected Risk	0%	0%	1.31%	0%	2.4%

Source**:** Authors' Calculations

In financial markets, volatility of returns can act as a major deterrent for investments especially in small developing economies such as those existing in the Caribbean. Volatility refers to the unexpected return due to unanticipated market events that unfortunately result in huge price movements with non-constant variance (Ghufran, et al. 2016). Cryptocurrencies have a known negative connotation with volatility. Due to this, adding cryptocurrencies to a portfolio introduces the apprehension of higher volatility levels for the investor. However, this is not always the outcome as cryptocurrencies can decrease the risk to return ratio of a portfolio also known as the Sharpe Ratio (Lee, Guo & Wang, 2018). According to a HSBC Report, cryptocurrencies perform as extremely risky assets (HSBC, 2021). Therefore, small allocations can improve the Sharpe Ratio under the condition that their correlation with traditional assets stays low.

The volatility of financial instruments such as stocks or cryptocurrencies are of much concern to investors. This plays an important role in financial applications such as tracking the future movements of stock price changes calculating the value-at-risk and allowing for valuation of derivative products (Islam, 2014). It should be noted that a portfolio's risk is made up of systematic and unsystematic risks. However, well-diversified portfolios mitigate unsystematic risks that may have been present. On the other hand, systematic risks cannot be diversified away due to their association with factors such as economic growth and interest rates.

In the Caribbean, published papers relating to cryptocurrencies are few. Moore & Stephen (2016) investigated whether cryptocurrencies should be included in the portfolio of international reserves held by the Central Bank of Barbados (CBB). In the literature, there are multiple papers examining Bitcoin (BTC) and its volatility. Despite this, there has been no investigation examining the volatility of Bitcoin in comparison to the volatility of stocks on the various Caribbean stock markets. This study makes three main contributions to the literature. First, it examines the impact of Bitcoin on portfolios created using Caribbean stocks. Secondly, it utilises heterogeneous panel model techniques to determine the volatility of each stock on the various stock exchanges and compares these to that of the selected cryptocurrency, Bitcoin. Finally, the volatility of Bitcoin is examined to help further assess the diversification benefits of Bitcoin to the investor.

[7] The NASDAQ Composite Index was employed as a proxy for the NASDAQ Stock Exchange.

This paper establishes that in the context of a Caribbean investor, their nature is indeed crucial in determining whether Bitcoin would be added to the portfolio due to its high volatility. In most cases adding Bitcoin increased both the risk and return of the considered portfolios. For each of the four selected stock exchanges, the volatility of stocks was individually econometrically modelled, allowing an examination of its volatility from the inception of Bitcoin to mid-year 2019. The remainder of the paper is structured as follows: Section 2 examines some of the past literature surrounding this study. Section 3 provides an outline of the methodological framework used in this study. Section 4 reports the results and discusses the findings of the study. Section 5 provides the conclusion.

2. Brief Review of the Literature

2.1. Money and its Development into the Present Era of Digital Currencies

A cryptocurrency is a virtual coinage system that functions much like a standard currency, enabling users to provide virtual payment for goods and services free of a central trusted authority (Farell, 2015). Cryptocurrencies are a ground-breaking network of digital money. Digital currencies help conduct online transactions directly without financial institutions and intermediaries (Iurina, 2017). The idea of an electronic currency can be dated back to the late 1980s. In 2009, the first successful decentralised cryptocurrency called Bitcoin was launched by pseudonymous developer Satoshi Nakamoto (Gantori, et al. 2017). This was followed by Litecoin and Ripple which were launched in 2011 and 2013, respectively.

Bitcoin continues to hold the largest market capital amongst the existing cryptocurrencies (Agnihotri, 2018) and has emerged as the most widely used digital currency, with proponents lauding its usefulness as an alternative currency (Wu & Pandey, 2014). While cryptocurrencies are not likely to replace traditional fiat currency, they possess the characteristics to change the way internet-connected global markets interact with each other, while clearing barriers surrounding normative national currencies and exchange rates (DeVires, 2016). There has been a rising interest of academics, investors, speculators and portfolio managers concerning the dominant coin in the cryptocurrency market (Hassani, Xu & Silva, 2018).

It is stated that Bitcoin and by extension, cryptocurrencies, provide a distinct advantage to populations living in underdeveloped and struggling economies since it solves problems of hyperinflation, exchange, counterfeiting and inaccessibility (Darlington, 2014). Cryptocurrencies have been on the rise in the Caribbean and Latin America which are beleaguered by slow economic growth and high levels of debt. The government of Puerto Rico and members of the Eastern Caribbean Currency Union (ECCU) have expressed their willingness to learn about cryptocurrencies and blockchain technology and how it might be able to help their economies (Kwok & Koh, 2019). During the last few years, two regional central banks would have ventured into pilot projects as well as launching their own digital currencies. On October 20, 2020, the Central Bank of Bahamas launched the world's first Central Bank Digital Currency (CBDC), 'Sand Dollar' (Bharathan, 2020). This was the end result of a pilot project by the bank, 'Project Sand Dollar', aimed at issuing a digital currency and improving the digital payment system. In February of 2019, the Eastern Caribbean Central Bank (ECCB) signed a contract with the Barbados-based Financial Technology (FinTech) company, Bitt Inc. to conduct a CBDC pilot project, utilising blockchain technology (Berkmen, et al., 2019). The aim of the project was to enhance the risk profile of territories in the ECCU region, while focusing on developing a secure and robust digital payment system. However,

in March 2021, ECCB was able to issue the Caribbean's second CBDC, 'DCash' (ECCB, 2021). Also, the country of Venezuela issued a sovereign cryptocurrency which was done to aid its collapsing economy. Chohan (2018) stated that the creation of the Venezuelan Petro (PTR) resulted due to the severe economic crises that crippled the economic growth of Venezuela. There are many applications of cryptocurrency and its foundational blockchain technology (Miraz & Ali, 2018).

The level of adoption of cryptocurrency in Africa has grown over the last few years. As of 2021, the continent has become the global leader in adoption of cryptocurrencies, where the overall market value has ballooned by over 1,200% between June 2020 and June 2021 (Adeyanju, 2021). Three African countries rank in the top ten globally in terms of ownership of cryptocurrency: Kenya, South Africa and Nigeria. Around 8.5%, 8.3% and 6.3% of the respective populations of Kenya, South Africa and Nigeria own crypto assets (Triple A, 2021). One of the main reasons for the expansion is the youth on the continent, who are well equipped with mobile devices and smart technology (Nault, 2021). The combination of blockchain technology and greater adoption of cryptocurrency has contributed to a further advancement in financial inclusion throughout Africa. Africans are using cryptocurrency in two ways: cross border transactions in terms of remittances and as a store of value. Remittances are considered stable private inflows which not only help to foster financial development but also reduce poverty (Gupta, Pattillo & Wagh 2007). Transferring money can be quite expensive in Africa when utilizing traditional channels such as banks and money transfer companies such as Western Union and MoneyGram. The average global fee to send USD 200 to any country within Africa was around 8.2% in 2021, which is one of the highest transactional costs globally (World Bank, 2021). However, using cryptocurrency alternatives tend to be cheaper, where the cost drops by around 90% (Bitcoin.com, 2019).

Cryptocurrency is now being seen as a store of value, especially Bitcoin which is referred to as "Gold 2.0" or "digital gold" (Lasebikan, 2020). With continuous pressure being experienced within the world's economies, persons are being driven towards possibly taking up cryptocurrencies. This has contributed to a growing lack of trust of Central Banks and the ever-present risks to the financial system (IMF, 2021). In the past, some of the currencies of the nations within the African continent have faced inflationary pressures, thereby resulting in adverse impacts on economies like Zimbabwe and Sudan and further causing devaluation of their currencies. Zimbabwe's and Sudan's inflation rates would have reached 557.2% and 194.6%, respectively by the end of 2020 (Statista.com, 2021). This contributed to a significant increase in the cost of goods and services and the overall standard of living. However, countries within Africa started to turn even more to crypto assets to alleviate the impacts from inflation on the economies in the region. In comparison to traditional fiat currencies, cryptocurrencies are not subjected to changes in the inflation rate within a country. The value of some of the cryptocurrencies like Bitcoin surged over the last year, while a couple of the currencies within the African continent such as Nigeria's declined (Allafrica.com, 2021). This in turn has made cryptocurrencies a viable option as a store of value. Considering that the total supply of cryptocurrency is estimated to be 21 million in total, it could be seen as a scarce asset similar to gold. Due to its scarcity, it could be deemed as another tool in helping individuals build wealth.

The use of cryptocurrencies can be beneficial to both developing and emerging economies. Nakamoto (2008) proposes that one benefit is that it increases the access to financial services for a population. It is estimated that the share of persons without access to a bank account within Africa and parts of the

Middle East is higher than 50% (BIS, 2020). As a result, a lot of the population does not have access to many financial services, including cross-border transactions. Service fees and other costs implemented by financial institutions are quite high when it comes to settling such international transactions. Therefore, using cryptocurrencies and blockchain provides a greater level of financial inclusion for citizens who might have been previously omitted. In order to circumvent the regulations by central banks on the African continent, Africans have been using peer-to-peer (P2P) platforms, which uses blockchain technology, to transfer funds including remittances between countries, and trade bitcoin and altcoin (Goddard, 2021). One example is the company BitPesa, a remittance company in Kenya where bitcoin is used for international transactions (Mules, 2020). Through the adoption of cryptocurrencies and financial technology (FinTech), there has been a move to the upgrading of existing payment infrastructures which enable both 24/7 and near-time settlement of payments globally. In addition, some emerging economies started witnessing an explosion in mobile phone penetration rates over the years. Countries like South Africa, India and China have registered mobile penetration rates of 90%, 84.6% and 76%, respectively. This has empowered these economies to move towards a lesser dependence on cash. Nigeria has also been increasing the settlement of payments using mobile phones or mobile wallets, which has been driving greater usage between customers and retailers (PricewaterhouseCoopers, 2016).

2.2 Diversification Effects on an Investor's Portfolio

Cryptocurrencies may be a useful investment option since research shows that they are normally uncorrelated with traditional assets. Ketelaars (2018) proposed that cryptocurrencies are interesting to investors for three reasons. Firstly, cryptocurrencies can serve as a vehicle currency in the traditional money market (White, 2014). Secondly, cryptocurrencies can shape future markets with their advanced blockchain technology (Fanning and Centers, 2016). Lastly, both Bodie, Kane & Marcus (2017) and Trimborn, Li & Hardle (2020) found that cryptocurrencies appear to be uncorrelated with traditional assets and even with each other. Therefore, cryptocurrencies can be efficiently used by investors for diversification purposes. Efficient portfolio diversification can be achieved by investing in a broad spectrum of weakly correlated and uncorrelated assets.

Even greater diversification opportunities can be derived from investing in a variety of cryptocurrencies. Andrianto & Diptura (2018) explored the effects of cryptocurrencies on well-performing portfolios and revealed that a portfolio with cryptocurrencies increases the effectiveness of a portfolio by minimising the standard deviation and creating more allocation options for investors to choose from. Liu (2019) stated that the ability to invest was determined along with the role of diversification in the cryptocurrency market. It was concluded that diversification across different cryptocurrencies can significantly improve investment results.

There has been some literature supporting the addition of cryptocurrencies to investment portfolios. Ketelaars (2018) explored the effects of investing in cryptocurrencies and found that after adding Bitcoin to a well-diversified portfolio, that the investor would gain greater returns. An investigation into the degree to which cryptocurrencies provided diversification benefits to an investor, showed an expanded investment universe with cryptocurrencies dominating the traditional portfolio which consisted mainly of stocks, bonds, and cash (Anyfantaki, Arvanitis & Topaloglou, 2018) since it yielded potential diversification benefits and provided better investment opportunities for some risk averse investors. Similarly, Briere, Oosterlinck and Szafarz (2015) noted that since the correlation of

cryptocurrencies with other assets was extremely low, even a small proportion of Bitcoin may considerably improve the risk-return trade-off in well diversified portfolios. Wu and Pandey (2014) as well as Bjordal & Opdahl (2017) also found the same results, while Guesmi et al. (2019) reported that a short position in the Bitcoin market allowed hedging of investments for various financial assets as well as hedging strategies involving gold, oil and equities.

3. Methodology

This section provides a description of the approaches utilised. The paper focused on the Caribbean region and concentration was positioned on the four main stock exchanges: (i) Barbados Stock Exchange (BSE), (ii) Eastern Caribbean Securities Exchange (ECSE), (iii) Jamaica Stock Exchange (JSE) and (iv) Trinidad and Tobago Stock Exchange (TTSE). This section is divided into two subsections: Section 3.1 explores the counterfactual approach used in determining whether the benefit of portfolio diversification exists by investing in Bitcoin, and Section 3.2 describes the econometric approach used to assess the volatility of the stocks in each stock exchange relative to Bitcoin.

3.1. Counterfactual Approach

A counterfactual approach was applied to determine whether an investor should include cryptocurrencies whilst diversifying their portfolio. Closely following the theoretical underpinnings of (Ketelaars, 2018), four standardised portfolios were created to aid in this analysis. The approach and execution are discussed in further detail within this section.

Firstly, a portfolio of assets was created for each stock exchange using daily data. The daily data was obtained from each of the respective stock exchange websites, that is, BSE, ECSE, JSE and TTSE. The period was not identical across the stock exchanges as their datasets contained missing information and all stocks did not start trading at the same point in time. For BSE, ECSE, JSE and TTSE the following time periods were considered: 12/07/2018 – 30/06/2019, 12/04/2017 – 30/06/2019, 10/04/2015 – 30/06/2019 and 19/09/2017 – 30/06/2019, respectively. Presently, the cryptocurrency with the largest market capital is Bitcoin (Bouri, Shahzad & Roubaud, 2019). Daily data for Bitcoin was recorded from bitcoinprices.org. The accessible Bitcoin downloadable data was pegged to the United States Dollar. However, the stock exchanges under consideration used its defaulted currencies: Barbados Dollar (BBD), Eastern Caribbean Dollar (ECD), Jamaica Dollar (JMD) and Trinidad and Tobago Dollar (TTD), respectively. This data was not available for download and therefore, had to be recorded manually using the graphs available on bitcoinprices.org. Bitcoin prices were recorded for the aforementioned time periods depending on the respective stock exchange. The main applications utilised in the manipulation and analysis of the portfolios and its datasets were Microsoft Excel and EViews.

A simple mathematical calculation was performed to compute the daily returns of each stock on each of the respective stock exchanges using the formula below:

$$R_t = log\left(\frac{P_t}{P_{t-1}}\right)$$

Where,

R_t represents today's return, that is, the return at time t

P_t represents today's price, that is, the price at time t

P_{t-1} represents yesterday's price, that is, the price at time t-1

Next, the statistical properties of each of the stocks and portfolios were calculated. These statistical properties included: mean, variance, standard deviation, skewness and kurtosis. Subsequently, the variance-covariance matrix was created.

The four standardised portfolios were chosen to provide simulations of constraints influenced by different characteristics. These portfolios were created to test the robustness of the results obtained if a change occurred. In each of the four portfolios, the summation of investments equals 100%. However, Portfolio 2 and Portfolio 3 fosters accommodation for short sale constraints. For each portfolio, the expected return, standard deviation, and Sharpe Ratio are calculated as described below.

Portfolio 1: This portfolio assumes that the stocks are equally weighted. Simply, a weight of 100 divided by the number of assets that exists in the portfolio was assigned to each asset. Next, the expected return, standard deviation and Sharpe ratio was calculated with and without Bitcoin, and then compared to determine whether investing in Bitcoin offered any benefits to the investor. The following formulae were used:

- Expected Return: $\overline{R_p} = \sum_{j=1}^{m} W_j R_j$ where $\bar{R}$ is the expected return of a portfolio, *W* is the proportion or weights of total funds invested in security j, R_j is the expected return for security j and m is the total number of different securities in the portfolio
- Standard Deviation: $\sigma_p = \sqrt{\sum_{i=1}^{n} w_i^2 \sigma_i^2 + \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j Cov_{ij}}$ where σ_p is the standard deviation of the portfolio, w_i is the weights of the individual assets in the portfolio, σ_i^2 is the variance of rates of return for asset i and Cov_{ij} is the covariance between the rates of return for assets i and j where $Cov_{ij} = r_{ij}\sigma_i\sigma_j$
- Sharpe Ratio: $S_p = \frac{R_{p-R_f}}{\sigma_p}$ where S_p is the Sharpe Ratio (risk/return ratio) of the portfolio, R_p is the return of the portfolio, R_f is the risk-free rate and σ_p is the standard deviation of the portfolio's excess return. In this study, the risk-free rate is assumed to be 0%.

Portfolio 2: Cryptocurrencies are known to involve high risk due to their volatility. This portfolio seeks to provide control of the diversification effect which is constrained by the standard deviation of the asset which holds the lowest value in the basic portfolio. Using the basic portfolio created for Portfolio 1, weekly rolling standard deviations are calculated for each individual stock and Bitcoin. The stock with the minimum rolling standard deviation on the stock exchange is selected. Then a constraint is set up to determine the lowest standard deviation portfolio. If the weekly rolling standard deviation of Bitcoin is less than the stock with the minimum weekly rolling standard deviations on that stock exchange, then

the lowest standard deviation portfolio would be the basic portfolio with Bitcoin. If the opposite is true, then the lower standard deviation portfolio would be the basic portfolio without Bitcoin.

Portfolio 3: This portfolio tries to create a least variance portfolio and is controlled by the asset with the highest weekly return. It is expected that the addition of cryptocurrencies will lead to a lower standard deviation. The aim is to further decrease the standard deviation and understand if we can maintain the same return as the single highest stock in the portfolio. Using the basic portfolio created for Portfolio 1, weekly rolling returns are calculated for each individual stock and Bitcoin. The stock with the maximum rolling returns on the stock exchange is selected. Then a constraint is set up to determine the least variance portfolio. If the weekly rolling returns of Bitcoin is greater than the stock with the maximum weekly rolling returns on that stock exchange, then the least variance portfolio would be the basic portfolio without Bitcoin. If the opposite is true, then the least variance portfolio would be the basic portfolio with Bitcoin.

Portfolio 4: This portfolio aims to maximise the risk-to-return ratio by use of the Sharpe Ratio formula. The Sharpe Ratio is a common measure used in the evaluation of portfolio performance (Goetzmann et al., 2002). It is important to note that no weight constraint has been applied. This should yield the highest risk to return ratio of all portfolios. Using the basic portfolio created for Portfolio 1, the average return is calculated without Bitcoin after which this is divided by the standard deviation of that portfolio. The same process is repeated with Bitcoin. The risk to return ratios are compared. If the portfolio including Bitcoin has a smaller risk to return ratio, then this is not the desired portfolio. If not, the opposite is true.

3.2 Econometric Approach

An investigation was carried out to ascertain the appropriateness of the GARCH model to accurately model the characteristics of Caribbean Stock Exchange data and to assess the volatility of its stock returns in comparison to that of the selected top cryptocurrency contender, Bitcoin. This analysis also considered stock returns.

Firstly, the price information for each stock was obtained from the websites of the respective stock exchanges. The returns were calculated using the same formula presented in the previous section. Next, each stock return was subjected to the Augmented Dickey Fuller (ADF) test to determine its stationarity. In most cases, financial time series use returns instead of prices of assets. According to Campbell, Lo & MacKinlay (2012), this occurs for two reasons: (i) returns are a scale-free summary of investment and (ii) returns series are easier to handle than prices because the previous has more attractive properties than the latter.

For each stock of the various stock exchanges, the following iteration was utilised: stock returns, constant, trend and an autoregression of order one (AR (1)). An AR model of order one was determined to be the optimal and most appropriate lag length using the Akaike Information Criterion (AIC). The statistical properties, that is, mean, median, maximum, minimum, standard deviation, skewness, kurtosis, Jarque-Bera and probability were recorded for each stock. The skewness and kurtosis were meticulously examined to determine the normality of the distribution.

To apply generalised autoregressive conditional heteroskedasticity (GARCH) modelling to a financial time series, there must be the presence of an autoregressive conditional heteroskedasticity (ARCH) effect (Ekong & Onye, 2017). This is determined by testing the significance of the coefficient. The heteroskedasticity ARCH LM test allows the testing of each stock to establish whether there is an ARCH effect present (Engle, 1982).

The hypotheses are as follows:

H_0: ARCH effect is not present ($\alpha_i = 0$)

H_1: ARCH effect is present ($\alpha \neq 0$)

Significance level: 5%

Decision Rule: If probability < 0.05, Then Reject H_0

No ARCH effect suggests that a GARCH model cannot be applied and would not sufficiently represent the time series data. This usually occurs when a stock or cryptocurrency exhibits low variability in prices and by extension returns. Furthermore, this suggests that the stock or cryptocurrency is not extremely responsive or sensitive to shocks or fluctuations in the market. Once an ARCH effect was present, the following three types of the GARCH models were applied to each stock: ARCH (1), GARCH (1, 1) and TGARCH (1,1,1).

The GARCH (1,1) is the most used volatility model (Ekong & Onye, 2017). The GARCH (1,1) model is shown below:

$$\sigma_t^2 = \omega + \alpha x_{t-1}^2 + \beta \sigma_{t-1}^2 \text{ where } \omega, \alpha, \beta \geq 0 \text{ and } \alpha + \beta < 1$$

In this model, alpha measures the extent to which volatility shocks today feeds through into next period's volatility. The value of beta is interpreted as an impact of the past value of volatility on today's volatility. To satisfy the condition of stationarity, the summation of alpha and beta should be less than one. The summation is occasionally referred to as the volatility persistence and measures the rate at which the effect dies out over time. Persistence of volatility occurs when the summation of alpha and beta equals to one, thus implying that the long run variance will tend towards infinity, suggesting that the shocks die out slowly (Bollerslev, 1986). This indicates that the process is not stationary in nature and should be possibly modelled using an integrated generalised autoregressive conditional heteroskedasticity (IGARCH) model. In this case, the unconditional variance becomes infinite. The value that is achieved when running the threshold generalised autoregressive conditional heteroskedasticity (TGARCH) model represents the fatness of the distribution tail and is documented as gamma.

According to Ahmed and Suliman (2011), a non-zero value of gamma indicates that the returns are asymmetric in nature. However, the standard symmetric GARCH model is achieved when gamma is equal to zero and a leverage effect exists when gamma is positive. The TGARCH (1,1) model is shown below:

$$\sigma_t^2 = \omega + \alpha x_{t-1}^2 + \delta D_t x_{t-1}^2 + \beta \sigma_{t-1}^2 \text{ where } D_{t-1} = \begin{cases} 1, & x_{t-1} < 0 \\ 0, & x_{t-1} \geq 0 \end{cases}$$

An analysis of the coefficients between the stock exchanges is performed. The stationarity of the GARCH and TGARCH models is also investigated to determine whether the models satisfy the stationary condition.

4. Results

This section comprises of two sub-sections. The results of the counterfactual approach are illustrated followed by the results of the econometric approach.

4.1. Counterfactual Approach

Portfolio 1 considered the change in expected return when Bitcoin was added to the portfolio. Equal weighting was applied. Excluding the BSE, all the other stock exchanges experienced a fall in expected returns indicating that larger losses are being incurred. A more diversified portfolio was achieved but this was at the expense of holding a portfolio with higher risk. For the BSE, there was no recorded change in expected returns. In all portfolios an increase in volatility was experienced.

Portfolio 2 aimed to constrain the portfolio by using the lowest standard deviation and by extension the lowest variance. The weights assigned to the portfolio assets were calculated using weights generated by the Solver function in Excel. Across the stock exchanges the same result was observed. The addition of Bitcoin decreased the returns and increased the volatility of the portfolios immensely. Therefore, it can be concluded that an investor would not invest in Bitcoin if the goal were to minimise the riskiness of their portfolio.

Portfolio 3 intended to constrain the portfolio by using the asset with the highest return in the basic portfolio. It was anticipated that the addition of cryptocurrencies would lead to a lower standard deviation. Using an IF function, it was determined that Bitcoin had the highest return amongst the stocks of the selected stock exchanges. Therefore, an investor could choose to allocate resources toward Bitcoin once the maximum return was achieved.

Portfolio 4 used Excel Solver to determine the optimal portfolio of weights for each portfolio. It can be concluded that an investor holding BSE stocks can further diversify their portfolio by investing 2% of their portfolio into Bitcoin while still maximising their risk-to-return ratio. For the TTSE, the optimal portfolio includes approximately 8% of shares in Bitcoin. Alarmingly, out of the 113 active stocks on the JSE, the optimal portfolio only consists of three stocks including Bitcoin. Unfortunately, for ECSE an optimal portfolio was not attained as the Excel solver was unable to allocate a percentage toward any stock or Bitcoin.

4.2 Barbados Stock Exchange (BSE)

The first portfolio was created using equal weights. There are currently 18 active stocks trading in the BSE. Therefore, each asset is assigned a weight of (1/18) = 0.06. For an investor holding a portfolio of stocks, the average return can be scaled to zero. The portfolio's standard deviation is approximately 8%,

which is particularly low. This reflects that the returns incurred by the investor of this portfolio has a high probability of being within close range of the average return of the portfolio. Recalling that the average return was negative, this further emphasises that the resulting Sharpe Ratio will also yield the same outlook. This can be interpreted as the returns of the portfolio not exceeding the risks. With the addition of Bitcoin, the expected return of the portfolio is still representative of zero returns. The portfolio's standard deviation however decreases to 1.43%. The risk-to-return ratio decreased by roughly 3 percentage points.

The second portfolio aims to constrain the portfolio by using the lowest standard deviation and by extension the lowest variance. The weights assigned to the portfolio assets were calculated using weights generated from the Solver function in Excel. In the BSE, there are 18 stocks which were pooled together to create this portfolio. This portfolio results in a positive return of .0081% associated with a 2.9% rate of volatility. This reflects that the data is not highly dispersed. As an investor this lack of dispersion is preferred since returns are more likely to be found in a narrower range. This minimises the probability of loss incurred as an investor. Adding Bitcoin to this portfolio, an investor would incur a negative expected return of 0.001016% accompanied by volatility of 0.94%.

The third portfolio aims to constrain the portfolio by the asset with the highest return in the basic portfolio. It is anticipated that the addition of cryptocurrencies will lead to a lower standard deviation. Using an IF function, it has been determined that Bitcoin has the highest return amongst the stocks in the BSE. Therefore, an investor would choose to allocate resources toward Bitcoin.

The fourth portfolio aims to maximise the Sharpe ratio. Essentially, this refers to the maximisation of the risk-return ratio. It is expected that this portfolio should yield the highest risk to return ratio of all the portfolios. Both cases, that is, with and without the inclusion of Bitcoin, result in the same percentage of expected returns. There has been a 0.02% decrease in the standard deviation of the portfolio after Bitcoin has been included. This indicates that the portfolio become less volatile. However, the Sharpe ratio increases which implies that the risk to return ratio of this portfolio has increased. The table below shows the comparison between the weights assigned to each stock both with and without Bitcoin. Therefore, it can be concluded that an investor holding BSE stocks can further diversify their portfolio by investing 2% of the portfolio into Bitcoin while still maximising the risk-to-return ratio.

4.3 Eastern Caribbean Stock Exchange (ECSE)

In the case of Portfolio 1 and Bitcoin, the investor may not invest in Bitcoin since an increase in return is accompanied by an increase in volatility. As there is a gain, the portfolio becomes riskier. This was also the result when compared to Portfolio 2 and 3. For Portfolio 4, unfortunately Excel Solver was unable to allocate a percentage toward any stock on this portfolio. It is important to note that even with the inclusion of Bitcoin only a few stocks were chosen, and Bitcoin was not significant in this optimal portfolio.

4.4 Jamaica Stock Exchange (JSE)

The Jamaica Stock Exchange (JSE) currently lists 112 active stocks. For the first portfolio, each asset was equally weighted and thus assigned a weight of (1/112). This portfolio yields an average return of 4.9% while adding Bitcoin decreases returns by 0.1%. Both portfolios experienced positive skewness and high kurtosis suggesting that the dataset does not resemble a normal distribution. The volatility remains

constant. Therefore, it can be concluded that adding Bitcoin to a portfolio where an investor is only concerned about the average return would not affect the level of risk. Portfolio 4 aims to maximise the risk-return ratio using the Sharpe ratio. Excel Solver was used to determine the optimal portfolio weights. Out of the 112 active stocks on the JSE, the optimal portfolio only included one stock without including Bitcoin and three stocks with the inclusion of Bitcoin involved.

4.5 Trinidad and Tobago Stock Exchange (TTSE)

The first portfolio of the Trinidad and Tobago Stock Exchange (TTSE) listed 36 active stocks. Each asset was equally assigned with a weight of 0.03 (1/36). This portfolio results in a negative return of 0.0016%. For an investor, this portfolio does not yield any returns. However, it is associated with a volatility of 26.24%. Therefore, the risk return ratio is also suggesting that an investor may be speculative of investing in such a portfolio due to negative returns. This portfolio can be diversified by adding Bitcoin. Although, the portfolio may become more diversified this is at the expense of the investor as they would now incur larger losses. This loss can be superseded since the volatility of the portfolio significantly plummets to 3.8% as compared to 26.24% excluding Bitcoin.

In the case of Portfolio 1, an investor might be willing to invest in Bitcoin as the returns appear to be closely indicative of a normal distribution. The level of return also increases but is accompanied by an increase in volatility as well. The data suggests that the portfolio with the investment in Bitcoin is more positive than the investment without Bitcoin. This again reflects that the investment without Bitcoin is further similar to that of a normal distribution. The positive skewness indicates that an investor may expect small losses and few gains from investing in this portfolio. However, this is more desirable as there is a degree of probability present that the investor can gain large profits which can cover all the frequent small losses. Although the risk is greater, the investor that is risk-loving or risk-neutral might still invest in Bitcoin due to the aforementioned reasons. Both portfolios with and without Bitcoin possess excess kurtosis and therefore, follow a leptokurtic distribution. This suggests that Portfolio 1 is riskier without the inclusion of Bitcoin.

The second portfolio aims to constrain the portfolio by using the lowest standard deviation and by extension the lowest variance. Weights assigned to the portfolio assets were calculated using weights generated from the Solver function in Excel. In the TTSE, there are 36 stocks which have been pooled together to create this portfolio. With the inclusion of Bitcoin, this portfolio results in a negative return of 30.54% associated with a negative 6462.78% rate of volatility. This reflects that the portfolio becomes extremely volatile when Bitcoin is included. All weighting was assigned to the UCL (Unilever Company Limited) share. This result is not necessarily preferred unless the investor is risk-loving in nature.

The third portfolio was analysed using an IF function, and it was determined that Bitcoin had the highest return amongst the stocks in the TTSE. Therefore, an investor could choose to invest in Bitcoin.

The fourth portfolio aims to maximise the risk to return ratio using the Sharpe ratio. Excel Solver was used to determine the optimal portfolio weights of this portfolio. This portfolio returns 0.0051%. Similar to portfolio 1, this portfolio would not benefit the investor. The volatility of the portfolio is 0.06% which is also very low. The risk to return ratio of 8% is very low as well. However, the profit remains greater than the losses incurred. Including Bitcoin in this portfolio barely increases the expected return by percentage points. The volatility of the portfolio, however increases more rapidly than the expected

returns thus, resulting in a higher Sharpe ratio. However, it should be noted that the optimal portfolio includes approximately 8% of shares in Bitcoin.

4.6 Econometric Approach

This section delved into the coefficient values obtained from the variations of ARCH modelling performed and primarily focused on the stocks that exhibited ARCH effects with Bitcoin (See Table 3). The coefficients of each stock were compared to their respective Bitcoin coefficient value. For example, the BSE ARCH model alpha coefficient for Bitcoin was compared to the BSE ARCH model alpha coefficient for each individual BSE stock. The ECSE was excluded from the analysis due to the low volatility among its listed stocks, which resulted in the absence of ARCH effects that were needed to employ the GARCH modeling and its iterations.

Table 3: Bitcoin's Coefficient Values for Each Respective Model and Stock Exchange.

BITCOIN	ARCH	GARCH		TGARCH		
	Alpha α	Alpha α	Beta β	Alpha α	Beta β	Gamma γ
BSE	0.086755	0.082920	0.822297	0.097858	0.821104	-0.024367
JSE	8.716361	1.315858	-0.002254	-0.003354	0.002805	1.297146
TTSE	0.129087	0.040599	0.881980	0.038842	0.878453	0.006235

Source**:** Authors' Calculations

In this analysis, the alpha coefficients for the stock returns and Bitcoin are assessed using an ARCH (1) model. The alpha value of Bitcoin for BSE and TTSE is approximately 0.1 suggesting that the squared errors contain weak positive serial correlation revealing that if Bitcoin experienced a small shock in returns in the preceding period, the volatility of its returns in the present period is expected to be little. It is observed that all BSE stocks and the majority of TTSE stocks possess alpha values which are greater than the alpha value of Bitcoin, indicating that the returns of the previous period are likely to have a significant impact on the returns of the present period. The alpha value of JSE for Bitcoin exceeds one, implying that the variance of the error term is explosive and will recurrently increase over periods. There are very few stocks on both TTSE and JSE for which the opposite is true, the alpha value exceeds one generally. The ARCH effect is also known to measure the risk of the asset. This further reiterates that an investor allocating a portion of their portfolio into Bitcoin is more likely to experience positive rather than negative returns due to the low level of risk that is being transmitted to the present period. An investor would experience lower risk and a higher probability of profit in this investment.

Next, the GARCH (1,1) is employed. The results of the GARCH (1,1) alpha coefficients mirror those of the ARCH (1) model discussed above. The beta coefficient of Bitcoin for JSE is negative, suggesting that the past has no significant impact on the present-day volatility. The beta coefficients of Bitcoin for BSE and

TTSE highlight that the past volatility of Bitcoin has a highly significant impact on its volatility today. The inclusion of the trend and AR (1) components would increase the beta coefficient of Bitcoin. Individual inspection of the beta values of the stocks implies that most TTSE and all JSE stocks experience high influences from past volatility on today's volatility. All BSE stocks fall below the beta value for Bitcoin. Bitcoin only satisfies the stationarity condition for BSE and TTSE which infers that volatility is persistent. It was observed that there are few stocks on the TTSE and JSE that do not satisfy the stationarity condition and implies that the model would be explosive in nature and unstable. The BSE stocks, however, have an extremely low stationarity suggesting that there is a rapid decay of the effect as mean reversion occurs.

Lastly, the TGARCH model was utilised to accommodate and appropriately consider negative and positive news that might have occurred. Good news impacts the conditional variance through alpha and bad news by means of the summation of alpha and gamma. Bitcoin's alpha coefficients for both BSE and TTSE were less than 0.1, indicating that there is an exceptionally low and insignificant effect of good news today upon the next period's volatility. For JSE, Bitcoin's alpha is negative, indicating that positive news might trigger an overall negative impact. Across the stock exchanges, gamma is not equal to zero and consequently, all bad news would create an asymmetric impact. In the case of JSE and TTSE, Bitcoin's gamma value exceeds one implying that bad news increases its volatility. Few stocks on the TTSE and JSE have high alpha values, representing that good news in the present-day would have a significant impact on the next period's volatility. Among the stock exchanges, it is evident that the stocks satisfy the stationarity condition. However, there are a few outliers in both the TTSE and JSE which suggests that the distributions are normally dispersed.

5. Discussion

This paper attempted to provide Caribbean investors with plausible scenarios and an econometric assessment involving the local and major regional stock exchanges and Bitcoin. Bitcoin was used in relation to the BBD, ECD, JMD and TTD. All exchange rates experienced an average of zero returns suggesting that Bitcoin does not have an apparent effect on rates of return. However, Bitcoin/ Jamaican Dollar (BTC/JMD) had the highest volatility. According to Kotze (2005), this indicates that there is a large variation and suggests that JMD is most responsive to market fluctuations (Thompson, 2020) whilst the BBD has the lowest observable volatility (Worrell, Craigwell and Mitchell, 2006). All exchange rates displayed positive kurtosis, but JMD had the highest most positive kurtosis. Nearly all investors are risk-averse implying that they prefer a distribution with low kurtosis (Ivanovski, Stojanovski and Narasanov, 2015).

BSE, JSE, TTSE and ECSE have eighteen (18), one hundred and thirteen (113), thirty-six (36) and sixteen (16) active stocks, respectively. Across the stock exchanges, the volatility and kurtosis indicate that a normal distribution is not followed. BSE stocks are not highly responsive to fluctuations in the market and ABV Investments Incorporated (ABV) has the highest volatility of 7%. For JSE, very few stocks have high volatilities implying elevated risks. Both the volatility and variance levels are quite high on a few stocks for TTSE, but these do not exceed 1%. The volatility of the stocks fluctuates even though positive returns are experienced on ECSE.

It was expected that the average return and Sharpe Ratio would have increased when Bitcoin was added to Portfolio 1 (Rantanen, 2015). However, only JSE followed this expectation. BSE and TTSE experienced

a reduction in risk which decreased the volatility of the portfolio to an investor when adding Bitcoin to the portfolio. Consequently, an investor holding Jamaican stocks should be cautious when investing in Bitcoin since the increase in returns would be accompanied by increased risk. Investors with portfolios of either BSE, ECSE or TTSE stocks should consider investing in Bitcoin since there are double benefits: further diversification which is complemented by a reduction in volatility and increased returns (Yonghyeon, 2017). Consistent with Sharpe (1964), it was expected that Portfolio 1 without Bitcoin would have held the lower standard deviation. Across the stock exchanges it was evident that the portfolio without Bitcoin was less volatile. Risk averse investors prefer the less volatile investment option (Concina, 2014). Therefore, the results suggest that when holding a portfolio of Caribbean stocks and seeking to maintain a low level of volatility, an investment should not be made into Bitcoin.

Wu and Pandey (2014) suggested that investors should only allocate small portions and remain overly cautious of the risks that exist in Bitcoin. Briere, Oosterlinck & Szafarz (2015) concluded that Bitcoin investments exhibit remarkably high volatility and exceedingly high returns and a small proportion of Bitcoin in a well-diversified portfolio may dramatically improve risk-return characteristics. Portfolio 4 results support this for TTSE and BSE. However, investors seeking to maximise their Sharpe ratio holding JSE stocks, should not allocate any proportion towards Bitcoin. Similarly, our results suggest that investors holding portfolios of Caribbean stocks could invest in Bitcoin, excluding stocks of the JSE.

The econometric approach aimed to investigate the volatility of the stocks on each of the selected stock exchanges using the standard ARCH, GARCH and TGARCH models. It was expected that this type of modelling would have been applicable to these four stock exchanges. The ARCH LM test indicated that few stocks possessed significant ARCH effects. ECSE was eliminated from the analysis, which was not alarming since the ECSE consisted of extremely limited and missing amounts of data. For BSE, JSE and TTSE only 11%, 27% and 42% of stocks held significant ARCH effects, respectively.

The Caribbean does not possess an extremely volatile stock market environment. Trades do not occur as frequently as foreign or digital stock exchanges that foster Bitcoin trading and other cryptocurrencies. As an investor, this develops the idea of illiquidity among Caribbean stock exchanges (Arjoon and Greenidge, 2007) which is a possible deterrent. When an investment into an asset is made, an investor would prefer an asset that can be liquidated with minor complications. Investors may be subjected to lengthy waiting periods to buy or sell their stocks. However, Amihud (2002) argues that illiquidity that is anticipated in a market would positively affect the ex-ante excess stock return and can be visualised as an illiquidity premium.

The ARCH model concludes that Bitcoin is riskier than most stocks on JSE and TTSE based on the alpha values. This can be linked to Bitcoin's highly volatile and uncertain nature. All three models reiterate that a market occurrence today in either of the stock exchanges is less likely to affect the future of the stock's volatility as compared to Bitcoin. Rabemananjara & Zakoian (1993), Glosten, Jagannathan & Runkle (1993) and Engle & Ng (1993) are the paramount contributors of the T-GARCH model. The beta values of the GARCH and TGARCH models suggest that both BSE stocks Emera Deposit Receipt (EMABDR) and Sagicor Financial Corporation (SFC) have no significant impact on the present-day volatility. In the GARCH model, the past volatility of Bitcoin does not have a highly significant impact on its volatility today. The gamma value is relatively low, suggesting that the distribution is normal as there

are minimal outliers present in the dataset. In terms of stationarity, very few stocks do not satisfy the stationarity condition and are explosive in nature.

Portfolio diversification scenarios using Caribbean stocks and Bitcoin might be beneficial to those already invested or considering Bitcoin investments. This paper shows that investing in Bitcoin increases portfolio diversification but not all stock exchanges benefit from increased returns or reduced Sharpe ratios. Digital currencies have a significant role despite its unacceptability as a replacement for fiat money. These are unaffected by inflation and have high transaction speeds which are attractive to investors desiring a liquid-based asset portfolio. Within BSE, ECSE, JSE and TTSE the viability of cryptocurrencies is dependent on the nature of the investor and the type of portfolio.

For the Caribbean Stock exchanges, it was discovered that Bitcoin investments can impact on average return, volatility and standard deviation. Cryptocurrencies attain high transaction speeds, but this benefit is not utilised within the Caribbean Stock Exchanges as highlighted by econometric analysis. Specifically, ARCH, GARCH and TGARCH indicated that this market does not have volatile stocks implying that illiquidity is present. Within the Caribbean market, data was neither easily accessible nor complete. Despite these constraints this study can inform potential investors within the Caribbean about the diversification benefits of Bitcoin holdings.

6. Conclusion

Cryptocurrencies are a new asset class and are extremely sensitive to bad news which triggers Bitcoin's high volatility. In summary, investors holding stocks from TTSE, BSE, ECSE should invest in Bitcoin, the exception being investors holding JSE stocks. Kajtazi & Moro (2019) agreed that Bitcoin plays a vital role in portfolio diversification and there is a visible link between the increase in returns and the marginal role in the associated decreasing volatility. This study also concludes that Bitcoin improves the Sharpe ratio of a portfolio, implying that for the Caribbean investor with stocks from either BSE, ECSE or TTSE, adding Bitcoin will increase the risk to return ratio.

This paper aimed to bridge the gap in knowledge for Caribbean investors that are considering adding a digital currency to their portfolio. The counterfactual approach highlighted that the nature of the investor and the goal of the portfolio are very crucial factors in determining the investment strategy moving forward. While adding Bitcoin to a portfolio increases diversification, it is more probable that risk loving investors would do this rather than risk averse investors, as major losses can be incurred due to the volatile nature of Bitcoin. Specifically, in the Caribbean stock exchanges it was found that Bitcoin can impact on the average return, volatility and standard deviation of portfolio investments.

An econometric approach was employed to examine the volatility of the individual stocks on these stock markets. However, this further justified the illiquidity that exists amongst the stock markets of the Caribbean. Bitcoin experiences significantly more volatility than any of the stocks held with the Caribbean stock exchanges and is more than likely to increase the risk of any portfolio once included.

References

Adeyanju, Oluwaseun. 2021. *Bitcoin Opportunity: Africa Adoption Rate Is Highest Globally*. September 14. Accessed December 17, 2021. https://www.forbes.com/sites/oluwaseunadeyanju/2021/09/14/bitcoin-opportunity-africa-adoption-rate-is-highest-globally/?sh=321f1cad6d57.

Agnihotri, M. 2018. "Volatility, Market Capitilisation and Seasonality of Bitcoin Prices." *Journal of Research in International Business and Management* 74-80.

Ahmed, Ahmed Elsheikh M, and Suliman Zakaria Suliman. 2011. "Modelling Stock Volatility Using Garch Models Evidence From Sudan." *International Journal of Business and Social Science.*

Allafrica.com. 2021. *How Hyperinflation is Driving Cryptocurrency Adoption in Africa.* September 10. Accessed December 19, 2021. https://allafrica.com/stories/202109100733.html.

Amihud, Yakov. 2002. "Illiquidity and Stock Returns: Cross-Section and Time-Series Effects." *Journal of Financial Markets* 31-56.

Andrianto, Yanuar, and Yoda Diputra. 2018. "The Effect of Cryptocurrency on Investment Portfolio Effectiveness." *Journal of Finance and Accounting* 5 (6): 229-238.

Anyfantaki, Sofia, Stelios Arvantis, and Nikolas Topaloglou. 2018. "Diversification, Integration and Cryptocurrency Market." *Bank of Greece Working Paper.*

Arjoon, Vaalmikki, and Kevin Greenidge. 2007. "The Efficiency of Caribbean Stock Markets." *Central Bank of Barbados Working Paper.*

Avadhani, V.A. 2016. *Securicities Analysis and Portfolio Management.* 12th. Himalaya Publishing House.

Bank of International Settlements. 2020. "Annual Economic Report."

Berkmen, P, K Beaton, D Gershenson, J Arze del Granado, K Ishi, M Kim, E Kopp, and M Rousset. 2019. "Fintech in Latin America and the Caribbean: Stocktaking." *IMF Working Papers* 2019 (071): 1-54.

Bernstein, P.L. 1987. "Liquidity, Stock Markets, and Market Makers." *Financial Management* 16 (2): 54-62.

Bitcoin.com. 2019. *Crypto-Based Transfers Can Cut Remittance Costs in Africa by 90%.* April 23. Accessed December 17, 2021. https://news.bitcoin.com/crypto-based-transfers-can-cut-remittance-costs-in-africa-by-90/.

Bjordal, Andreas, and Espen Opdahl. 2017. "Portfolio Optimisation in the Cryptocurrency Market." *Norwegian School of Economics.*

Bodie, Zvi, Alex Kane, and Alan Marcus. 2017. *Investments- Standalone Book.* 11th. McGraw-Hill Education.

Bollerslev, Tim. 1986. "Generalised Autoregressive Conditional Heteroskedasticity." *Journal of Econometrics* 31 (3): 307-327.

Bouri, Elie, Jawad Hussain Shahzad, and David Roubaud. 2019. "Co-explosivity in the Cryptocurrency Market." *Finance Research Letters* 29: 178-183.

Briere, Marie, Kim Oosterlinck, and Ariane Szafarz. 2015. "Virtual Currency, Tangible Return: Portfolio Diversification With Bitcoin." *Journal of Asset Management* 16: 365-373.

Campbell, John Y, Andrew W Lo, and A Craig Mackinlay. 2012. *The Econometrics of Financial Markets.* Princeton University Press.

Chohan, Usman W. 2018. "Cryptocurrencies as Asset-Backed Instruments: The Venezuela Petro." *SSRN Electronic Journal.*

Cohn, Richard A, Wilbur G Lewellyn, Ronald Lease, and Schlabraum. Gary G. 1975. "Individual Investor Risk Aversion and Investment Portfolio Composition." *Journal of Finance* XXX (2).

Concina, Laura. 2014. *Risk Attitude & Economics.* https://www.icsi-eu.org/en/publication/viewpoint-economics.

Cozier, John G. 2010. "The Evolution of Stock Markets in the Caribbean: From 1969 and Beyond." https://sta.uwi.edu/conferences/09/salises/documents/J%20Cozier.pdf.

Darlington III, James K. 2014. "The Future of Bitcoin: Mapping the Global Adoption of World's Largest Cryptocurrency Through Benefit Analysis." *Chancellor's Honours Program Projects.* https://trace.tennessee.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=2741&context=utk_chanhonoproj.

DeVries, Peter D. 2016. "An Analysis of Cryptocurrency, Bitcoin, and the Future." *International Journal of Business Management and Commerce* 1 (2).

Eastern Caribbean Central Bank. 2021. *Bitt Partners with ECCB to Develop World's First Central Bank Digital Currency in a Currency Union.* March 21. https://www.eccb-centralbank.org/news/view/bitt-partners-with-eccb-to-develop-worldas-first-central-bank-digital-currency-in-a-currency-union.

Ekong, Christopher N, and Kenneth U Onye. 2017. "Application of Garch Models to Estimate and Predict Financial Volatility of Daily Stock Returns in Nigeria." *International Journal of Managerial Studies and Research (IJMSR)* 5 (8): 18-34.

Engle, Robert F. 1982. "Autoregressive Conditional Heteroscedasticity With Estimates of the Variance of United Kingdom Inflation." *Econometrica* 50 (4).

Engle, Robert F, and Victor K Ng. 1993. "Measuring and Testing the Impact of News on Volatility." *The Journal of Finance* 48 (5): 1749-1778.

Fanning, Kurt, and David P Centers. 2016. "Blockchain and Its Coming Impact on Financial Services." *The Journal of Corporate Accounting & Finance* 27 (5).

Farell, Ryan. 2015. "An Analysis of the Cryptocurrency Industry." *Wharton Research Scholars* 130. https://repository.upenn.edu/cgi/viewcontent.cgi?article=1133&context=wharton_research_scholars.

Gantori, Sundeep, Paul Donovan, Kiran Ganesh, Matthew DeMichiel, Kevin Dennean, Fabio Trussardi, and Michael Klien. 2017. *Cryptocurrencies: Beneath the Bubble*. UBS.

Ghufran, Bushra, Hayat A Awan, Aftab Khan Khakwani, and Muhammad Azeem. 2016. "What Causes Stock Market Volatility in Pakistan? Evidence From the Field." *Economics Research International* (Hindawi Publishing Corporation) 1-9.

Glostein, Lawrence R, Ravi Jagannathan, and David E Runkle. 1993. "On the Relation Between the Expected Value and the Volatility of the Nominal Excess Return on Shocks." *The Journal of Finance* 48 (5): 1779-1801.

Goddard, Jerry. 2021. *Africa Leading Retail-Sized Bitcoin Payments Suggests Increasing Adoption.* November 2021. https://www.nasdaq.com/articles/africa-leading-retail-sized-bitcoin-payments-suggests-increasing-adoption-2021-11-02.

Goetzmann, William, Jonathan Ingersoll, Matthew Spiegel, and Ivo Welch. 2002. "Sharpening Sharpe Ratios." *National Bureau of Economic Research.*

Guesmi, Khaled, Samir Saadi, Ilyes Abid, and Zied Ftiti. 2019. "Portfolio Diversification With Virtual Currency: Evidence From Bitcoin." *International Review of Financial Analysis* 63: 431-437.

Gupta, Sanjeev, Catherine Pattillo, and Smita Wagh. 2007. "Impact of Remittances on Poverty and Financial Development in Sub-Saharan Africa." *International Monetary Fund.*

Hassani, Hossein, Xu Huang, and Emmanuel Silva. 2018. "Big-Crypto: Big Data, Blockchain and Cryptocurrency." *Big Data and Cognitive Computing.*

Hatchondo, Juan Carlos. 2008. "Asymmetric Information and the Lack of Portfolio Diversification." *International Economic Review* 49 (4): 1297-1339.

HSBC. 2021. *What are they and why do they matter?* HSBC, 1-20. https://www.research.hsbc.com/C/1/1/320/ZgFhWNK.

International Monetary Fund. 2021. "Global Financial Stability Report- COVID-19, Crypto and Climate: Navigating the Challenging Transitions." October.

Islam, Mohd Aminul. 2014. "A Study on the Performance of Symmetric and Asymmetric GARCH Models in Estimating Stock Returns Volatility." *International Journal of Empirical Finance* (Research Academy of Social Sciences) 2 (4): 182-192.

Iurina, Alina. 2017. "Initial Coin Offering in Gibraltar-Case Study: Calidumcoin." *Karella University of Applied Sciences*. https://www.theseus.fi/handle/10024/138654.

Ivanovski, Zoran, Toni Stojanovski, and Zoran Narasanov. 2015. "Volatility and Kurtosis of Daily Returns at MSE." *UTMS Journal of Economics* 6 (2): 209-221.

Kajtazi, Anton, and Andrea Moro. 2019. "The Role of Bitcoin in Well Diversified Portfolios: A Comparative Global Study." *International Review of Financial Analysis* 61: 143-157.

Ketelaars, Tim. 2018. "Investing in the Cryptocurrency Market: Analysing the Diversification Effects of Cryptocurrencies in a Well-Diversified Portfolio." *Radbound Universiteit Nigmegen*. https://theses.ubn.ru.nl/handle/123456789/6169?locale-attribute=en.

Kotze, and A A. 2005. "Stock Price Volatility: A Primer." *Financial Chaos Theory*.

Kuper, Adam, and Jessica Kuper. 2004. *The Social Science Encyclopedia*. 3rd. Routledge.

Kwok, Andrei O J, and Sharon G. M Koh. 2019. "Is blockchain technology a watershed for tourism development?" *Current Issues in Tourism* 2447-2452.

Lasebikan, Tomiwa. 2020. *Accelerating Bitcoin trading in Nigeria*. September 25. Accessed December 2019, 2021.

Lee, David Kuo Chuen, Li Guo, and Yu Wang. 2018. "Cryptocurrency: A New Investment Opportunity." *Journal of Alternative Investments* (Research Collection Lee Kong Chian School of Business) 20 (3): 16-40.

Liu, Weiyi. 2019. "Portfolio diversification across cryptocurrencies." *Finance Research Letters* 29: 200-205.

Miraz, Mahdi H, and Maaruf Ali. 2018. "Applications of Blockchain Technology Beyond Cryptocurrency." *Annals of Emerging Technologies in Computing (AETiC)* 2 (1): 1-6.

Mishkin, Frederic S., and Stanley Eakins. 2014. *Financial Markets and Institutions*. 8th. Pearson.

Moore, Winston, and Jeremy Stephen. 2016. "Should cryptocurrencies be included in the portfolio of international reserves held by central banks?" *Cogent Economics & Finance* 4 (1).

Mules, Ineke. 2020. *Africa's quiet cryptocurrency revolution*. October 8. https://www.dw.com/en/africas-quiet-cryptocurrency-revolution/a-55199637.

Nakamoto, Satoshi. 2008. *Bitcoin: A Peer-to-Peer Electronic Cash System*.

Nault, Derrick M. 2021. "Money, Technology, and Human Rights: Cryptocurrencies and the Right to Development in Africa." *Human Rights and Foreign Policy*.

Pricewaterhousecoopers. 2016. "Emerging Market- Driving the Payments Transformation."

Rabemananjara, R, and J M Zakoian. 1993. "Threshold arch models and asymmetries in volatility." *Journal of Applied Econometrics* 8 (1): 31-49.

Rantanen, J. 2015. "Suitability of the equal-weighted diversification strategy to the cryptocurrency investment environment." *Otaniemi: School of Business.*

Sharpe, William A. 1964. "Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk." *The Journal of Finance* 19 (3): 425-442.

Statista.com. 2021. *Sudan: Inflation rate from 1986 to 2026.* Accessed December 19, 2021. https://www.statista.com/statistics/727148/inflation-rate-in-sudan/.

—. 2021. *Zimbabwe: Inflation rate from 1986 to 2026.* Accessed December 19, 2021. https://www.statista.com/statistics/455290/inflation-rate-in-zimbabwe/.

Suer, Omur, and Jale Minibas-Poussard. 2015. "Social Representations of Risk: A Comparision Between Risk-Taker and Risk-Adverse Investors." *Actual Problems of Economics.*

Sundeep, Gantori, Paul Donovan, Kiran Ganesh, Matthew DeMichiel, Kevin Dennean, Fabio Trussardi, and Michael Klien. 2017. *Cryptocurrencies- Beneath the Bubble.* Chief Investment Office, Wealth Management. https://www.scribd.com/document/361862351/Cryptocurrencies-Beneath-the-bubble.

Thompson, McPherse. 2020. "Heightened Uncertainty Around Volatility in FX Rate." *The Gleaner*, February 7. https://jamaica-gleaner.com/article/business/20200207/heightened-uncertainty-around-volatility-fx-rate.

Trimborn, Simon, Mingyang Li, and Wolfgang Karl Härdle. 2020. "Investing with Cryptocurrencies—a Liquidity Constrained Investment Approach." *Journal of Financial Econometrics* 18 (2): 280–306.

Triple A. 2021. *Cryptocurrency across the world.* Accessed December 17, 2021. https://triple-a.io/crypto-ownership.

White, Lawrence H. 2014. "The Market for Cryptocurrencies." *GMU Working Paper in Economics No.14-45*. doi:https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2538290.

World Bank . 2021. *Defying Predictions, Remittance Flows Remain Strong During COVID-19 Crisis.* May 12. Accessed December 2021, 2021. https://www.worldbank.org/en/news/press-release/2021/05/12/defying-predictions-remittance-flows-remain-strong-during-covid-19-crisis.

Worrell, Delisle, Roland Craigwell, and Travis Mitchell. 2006. "A Small Foreign Exchange Market with a Long-Term Peg: Barbados. International Monetary Fund." *International Monetary Fund Working Paper No. 06/245.*

Wu, C, and V Pandey. 2014. "The Value of Bitcoin in Enhancing the Efficiency of an Investor's Portfolio." *Journal of Financial Planning* 44-52.

Yonghyeon, Nam. 2017. "A New Opportunity of Bitcoin for Improving Portfolio Efficiency in Japan." *Ritsumeikan Asia Pacific University*. https://core.ac.uk/download/pdf/92529056.pdf.

Appendix

Statistical Properties

Table A: BSE Stock Returns Statistical Properties

BSE Stocks	Mean	Standard Deviation	Variance	Skewness	Kurtosis
ABV	0.00000	0.06587	0.00434	0.00000	176.50000
BICO LTD	0.00019	0.00334	0.00001	12.01943	198.73724
BDI DAIRY	0.00019	0.00334	0.00001	12.01943	198.73724
BFL FARM	-0.00104	0.01225	0.00015	-14.19152	218.78671
CSP	0.00015	0.00330	0.00001	6.75274	106.52778
FCI	0.00015	0.00389	0.00002	4.71394	68.12015
CPFD	0.00033	0.00683	0.00005	9.42096	133.92343
CPFV	-0.00011	0.00555	0.00003	0.18890	63.88883
GEL	-0.00160	0.03244	0.00105	-18.02500	334.62965
ICBL	0.00011	0.01106	0.00012	1.22152	142.37418
JMMBGL	0.00036	0.00607	0.00004	1.88904	45.79661
OCM	-0.00022	0.00256	0.00001	-16.82711	300.57642
SFC	0.00020	0.01217	0.00015	3.00700	104.39070
WIB	0.00025	0.00253	0.00001	6.98615	69.08678
BHL	0.00000	0.01246	0.00016	0.00000	176.50000
EMABDR	0.00029	0.00823	0.00007	-0.19335	57.77317
PBSL975	0.00000	0.00000	0.00000	0.00000	0.00000
PBSLO	0.00000	0.00312	0.00001	0.00000	176.50000

Table B: ECSE Stock Returns Statistical Properties

ECSE Stocks	Mean	Standard Deviation	Variance	Skewness	Kurtosis
BON	-0.00048	0.00818	0.00007	-13.94985	271.37894
BOSV	0.00028	0.01570	0.00025	0.80561	212.06850
CWKN	-0.00036	0.00778	0.00006	-21.86321	478.00000
ECFH	0.00025	0.00938	0.00009	2.38090	150.62052
GCBL	-0.00045	0.01679	0.00028	-8.46638	178.85141
GESL	0.00000	0.00000	0.00000	0.00000	0.00000
SKNB	0.00000	0.00000	0.00000	0.00000	0.00000
SLES	0.00000	0.00178	0.00000	0.00000	284.00000
SLH	0.00024	0.00465	0.00002	19.36492	375.00000
TDC	-0.00064	0.01629	0.00027	-10.04044	204.61485

Table C: JSE Stock Returns Statistical Properties

JSE Stocks	Mean	Standard Deviation	Variance	Skewness	Kurtosis
138SL	0.00146	0.11559	0.01336	-0.97887	33.24479
138SLVR	0.00045	0.01887	0.00036	30.36979	1095.02280
1834	-0.00067	0.06740	0.00454	-0.20504	11.89588
AFS	0.02681	1.09716	1.20375	-0.51635	14.65629
AMG	0.02952	0.48226	0.23258	0.68208	28.58438
BIL	0.04915	0.72330	0.52316	1.32762	26.77319
BRG	0.01240	0.54878	0.30116	-0.79721	11.28197
BPOW	0.04949	1.22068	1.49005	0.31375	26.42619
MUSIC	0.00143	0.02698	0.00073	6.17844	120.12912
CHL	0.08352	0.70878	0.50236	8.94500	129.31218
CCC	0.07731	1.39279	1.93986	-0.08960	5.52555
KREMI	0.00147	0.27276	0.07440	-0.66234	6.69028
CFF	0.02398	0.45451	0.20658	0.77489	22.96146
CPJ	0.00635	0.17117	0.02930	-0.24296	4.17126
CAR	0.06339	0.78589	0.61763	5.47013	90.66627
CBNY	-0.00010	0.01419	0.00020	0.32644	18.65666
PURITY	0.00100	0.10478	0.01098	0.53462	8.96524
DTL	0.02011	0.42249	0.17850	0.22160	61.51651
DCOVE	-0.00669	0.53382	0.28496	-0.05902	12.53246
EPLY	0.35162	4.98098	24.81017	15.12312	235.02403
GENAC	0.00364	0.12075	0.01458	-0.49331	6.28828
GK	0.11736	1.06984	1.14455	5.04331	64.95731

HONBUN	0.01731	0.32513	0.10571	-1.23297	30.46390
JBG	0.02850	0.61306	0.37584	0.27020	8.01701
JP	0.05589	0.68125	0.46411	0.96350	9.48259
JPS5C	0.00001	0.00051	0.00000	39.29377	1544.00000
JPS5D	0.00002	0.00057	0.00000	31.61446	1048.44523
JPS6	0.00003	0.00080	0.00000	34.78348	1265.32273
JPS9.5	0.31412	5.23611	27.41682	12.09469	188.67291
JPS7	0.00008	0.00155	0.00000	20.02324	430.81672
JSE	0.05401	0.54421	0.29617	1.39376	12.30595
JAMT	0.01378	0.19598	0.03841	0.50783	8.30010
JMMBGL	0.05010	0.69918	0.48885	1.11173	16.30544
KLE	0.00113	0.10742	0.01154	-0.64920	14.45171
KPREIT	-0.00016	0.44016	0.19374	-12.49800	247.61422
KW	0.05631	1.07769	1.16142	0.98054	13.81498
KEX	0.07617	0.66235	0.43871	2.84302	22.88540
LASD	0.00639	0.18439	0.03400	0.08077	9.11480
LASF	0.00260	0.16640	0.02769	0.03434	7.08036
LASM	0.00621	0.14136	0.01998	0.21849	3.38418
MTL	0.00008	0.00876	0.00008	-0.58160	40.09555
MIL	0.00597	0.25600	0.06554	0.39615	4.60342
MDS	-0.00294	0.26667	0.07111	-0.78783	14.07495
PAL	1.53641	29.79481	887.73088	4.05313	142.48766
PJAM	0.13880	1.27328	1.62125	2.01092	14.38472
PTL	0.03055	0.29121	0.08480	5.66449	57.21396
PROVEN	0.00015	0.00905	0.00008	0.22120	6.91847

PULS	0.01869	0.28842	0.08319	3.36672	48.15522
RJR	0.00447	0.10487	0.01100	-1.24418	28.75374
SJ	0.05350	0.78522	0.61658	0.84433	12.33550
XFUND	0.00922	0.34330	0.11785	0.17803	8.77932
SALF	0.02443	0.61545	0.37878	1.11390	28.02664
SGJ	0.05036	1.21637	1.47956	0.01037	3.84156
SEP	0.04442	1.00539	1.01082	0.52742	13.00547
SIL	0.00798	0.39660	0.15729	0.34259	35.27329
SVL	0.03472	0.39331	0.15469	0.82758	12.85499
SRA	-0.00207	0.03547	0.00126	-6.09358	105.46716
PROVENJA	0.03676	0.52407	0.27465	2.94939	115.54686
TTECH	-0.00504	0.28317	0.08018	0.32913	5.26807
CAC	0.01162	0.36774	0.13523	2.29552	33.92615
JMMBGLUSD5.75	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
JMMBGLUSD6.00	0.00008	0.01254	0.00016	-0.46287	39.31208
JMMBGL7.25	0.00039	0.01293	0.00017	3.97306	167.74780
SILUS	-0.00003	0.00198	0.00000	1.17954	153.38026
ROC	0.00110	0.13432	0.01804	-2.15659	30.00461
JETCON	0.00601	0.40847	0.16685	-17.57251	494.94464
ISP	0.02512	0.63299	0.40067	-1.04896	40.32953
KEY	0.00249	0.15141	0.02292	0.54578	14.69881
PJX	-0.00778	0.26799	0.07182	-0.08803	11.89063
EPLY8.25	0.00142	0.04863	0.00236	5.85777	123.94638
MEEG	-0.00086	0.28848	0.08322	-0.52315	4.58946
NCBFG	0.27539	1.95929	3.83882	0.77268	9.81465

CAB11B	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
CAB11A	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
ECL	0.01279	0.30023	0.09014	-0.20789	11.96621
SOS	0.01155	0.32459	0.10536	4.82344	51.15354
PBS9.75	0.01565	0.52831	0.27911	2.11668	59.13495
PBS	0.00017	0.01171	0.00014	1.35567	46.61957
FOS	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
GWEST	0.00104	0.09964	0.00993	1.04113	8.70042
FOSRICH	0.00172	0.15682	0.02459	0.51893	4.78673
WISYNCO	0.03744	0.34359	0.11805	2.75387	17.22564
VMIL	0.00845	0.11764	0.01384	2.75572	16.97769
EPLY5.00	-0.00020	0.00253	0.00001	-9.97548	116.63187
ELITE	0.00659	0.09274	0.00860	3.70372	44.50918
EPLY8.75	-0.00020	0.01898	0.00036	-2.35669	145.58354
DTL9	-0.00169	0.04633	0.00215	1.81469	92.94604
JMMBGL5.50NC	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
JMMBGL5.75C	0.00068	0.02685	0.00072	-0.77321	42.08203
JMMBGL7.00C	-0.00024	0.01344	0.00018	-0.10343	61.92372
Date	43433.59294	122.77651	15074.07212	-0.00090	-1.19871
JMMBGL7.25C	-0.00184	0.03507	0.00123	-3.76100	74.41206
CAC9.50	0.00180	0.02407	0.00058	3.11183	36.34372
SCIUS	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
SCIJA	-0.00175	0.14548	0.02116	-6.68177	208.57567
SCIUSD	0.00022	0.00498	0.00002	0.55114	4.06045
SCIJMD	0.00725	0.40944	0.16764	0.47093	13.66266

EFRESH	0.00072	0.08274	0.00685	0.18038	2.00081
MJE	0.01621	0.32857	0.10796	0.46802	5.75849
INDIES	0.00000	0.09557	0.00913	1.81339	13.23071
SML	-0.02147	0.23160	0.05364	-0.59040	3.49797
SSLVC	0.00211	0.07240	0.00524	0.50079	6.98478
EPLY7.50	0.00000	0.01238	0.00015	-1.21609	102.50000
FTNA	0.01408	0.14214	0.02020	4.57759	39.93192
MPCCEL	-0.00655	0.09295	0.00864	-3.03835	39.15555
MPCCELUS	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
ELMIC	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
MTLJA	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
ICREATE	-0.00754	0.03704	0.00137	0.14664	6.49456
JMMBUS6.00	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
JMMB7.50	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
PTL8.75	0.00000	0.00000	0.00000	#DIV/0!	#DIV/0!
WIG	0.02400	0.05068	0.00257	1.68963	2.06410

Table D: TTSE Stock Returns Statistical Properties

TTSE Stocks	Mean	Standard Deviation	Variance	Skewness	Kurtosis
AGL	0.000100759	0.001600925	2.56296E-06	16.94266617	371.881739
AHL	3.85575E-05	0.001195121	1.42831E-06	12.53781809	251.7396344
AMBL	-5.20896E-05	0.001325174	1.75609E-06	-8.325887179	150.5814084
AMCL	-0.000117505	0.002612469	6.82499E-06	-1.853059843	51.12537935
BER	3.2206E-05	0.000821095	6.74198E-07	25.49509757	650
CALYP	-0.00026007	0.004805949	2.30972E-05	-3.811148177	44.47488326
CIF	0.00010552	0.002073461	4.29924E-06	0.071156245	11.06272197
CINE1	0	0	0	0	0
CPFV	0	0	0	0	0
FCB	0.000149092	0.001882357	3.54327E-06	3.430180551	55.6957185
FCI	2.45369E-05	0.002507247	6.28629E-06	0.314302351	35.67067292
GHL	8.92184E-05	0.003915879	1.53341E-05	1.049688778	15.6416607
GKC	7.94772E-05	0.005241731	2.74757E-05	0.831171037	29.53694407
GMLP	9.78985E-06	0.000241768	5.84518E-08	25.48173766	649.5419257
GML	-0.000242906	0.003184554	1.01414E-05	-8.797414646	143.3984552
JMMBGL	0.000317235	0.007079838	5.01241E-05	1.51845417	13.04209557
LJWA	-0.000149092	0.002714192	7.36684E-06	-18.54345722	349.2100257
LJWB	0.000157497	0.005860202	3.4342E-05	0.972833733	38.49127411
LJWP	0	0	0	#DIV/0!	#DIV/0!
MASSY	7.73009E-05	0.002581243	6.66282E-06	4.290971251	58.67594326
MOV	-0.00012598	0.002629052	6.91192E-06	-23.47678476	571.0421955

MPCCEL	0	0	0	#DIV/0!	#DIV/0!
NCBFG	0.000434345	0.005763074	3.3213E-05	1.609088735	18.30645975
NEL	-0.000302903	0.003282638	1.07757E-05	-5.579587953	92.86827518
NFM	-0.000112528	0.003824125	1.46239E-05	0.109077613	12.01727779
NGL	0.000143491	0.002663171	7.09248E-06	0.595073431	21.9963974
OCM	-0.000221021	0.003525596	1.24298E-05	-2.654483654	68.13216319
PHL	-8.08853E-05	0.004124691	1.70131E-05	-5.467471569	161.1838314
PLD	-6.85428E-05	0.001920904	3.68987E-06	-1.426242269	54.05863906
PPMF	0	0	0	#DIV/0!	#DIV/0!
RFHL	0.000114197	0.003273712	1.07172E-05	6.33790753	144.9479859
SBTT	4.72325E-05	0.00150877	2.27639E-06	4.362946159	75.58342985
SFC	0.000132594	0.006212431	3.85943E-05	3.570501828	42.94219631
TCL	-0.000333399	0.007140893	5.09924E-05	-1.614186218	41.02508339
UCL	-0.000469771	0.005541788	3.07114E-05	-3.161221055	39.45113591
WCO	-8.62276E-05	0.003409755	1.16264E-05	-4.306907629	78.23540653

Table E: Bitcoin Returns Statistical Properties

Statistical Properties				
	BTC/ECD	**BTC/TTD**	**BTC/JMD**	**BTC/BBD**
Mean	0.00	0.00	0.00	0.00
Standard Deviation	0.020188	0.020968	0.044526	0.016866
Variance	0.000408	0.00044	0.001983	0.000284
Skewness	-0.21634	1.019062	2.785122	0.271898
Kurtosis	4.865779	12.54925	400.1201	7.900457