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Bitcoin and Stock Market Indexes Causality

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Sincerely,

Efe Akinci and Jing Li

Abstract

This paper studies Granger Causality relations between Bitcoin and 5 stock market indexes which are Japan, Russia, South Korea, Sweden and the United States. The time-period examined is from 2013 to 2017 and all the tests are conducted based on daily data. We analyze this in three different periods, last 5 years (2013-2017), in 2017 and last 3 months of 2017.

To estimate the relationship, we use unit root test and Augmented Dickey-Fuller, Lagrange Multiplier, Johansen Cointegration Test and finally Granger Causality Test. After the tests, countries have a same integrated order that exhibits a long-run relationship. In causality, except for Russia, each country has affected the Bitcoin prices and being affected in a different period, especially in the last 3 months of 2017, the impact and popularity of Bitcoin affect too much the stock market in the short-run.

As a result, the causation between Bitcoin and stock market indexes shows impact statistically significant in the 2017 year. The importance of cryptocurrency and popularity not as much as hype like late 2017 in 2018, but we think that cryptocurrencies are one of the major currencies that affect economical world very deeply.

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1. Introduction

1.1. Background

Bitcoin is a digital worldwide payment system that has decentralized, partially anonymous currency functions and there is no any support from government or institutions. (Grinberg, 2011) founded by Satoshi Nakamoto (Nakamoto, 2008). This technological innovation increased the potential of digital currencies and become mainstream for consumers and customers. After 2013, authorities and banks look the development of the cryptocurrencies and digital currencies that these will make a huge impact in country's economies and financial markets in a large-scale (Engert and Fung, 2017).

However, the rise of cryptocurrencies could have a significant impact on monetary systems of countries as they are privately issued currencies, thus not regulated by central banks. As of Bitcoin is in the news and going into a global trend, governments are curious about what will the future of finance world that it creates some plans about to adapt cryptocurrencies in their economies (Chen, 2017). Many people have digital currencies or use it in transactions mostly in bitcoins. Kamada (2017) mentioned that in many transactions individuals choose digital currency rather than paper currency and there is a shifting trend preference to use digital currency. Moreover, the usage of digital currencies getting stronger in many countries such as Japan, USA, and South Korea. Digital currencies are not a big threat to financial stability at that moment, but improvements do not disclaim, and it is conceivable in near future that these free-floating digital currencies have a potential to be an asset price that takes attention in financial stability (Ali, Barrdear, Clews, and Southgate 2014).

An economic and financial consultancy company Datatrek's analysts divided into three holding periods which they are 10 days, 30 days, and 90 days for looking the relationship of bitcoin and S&P 500 since January 2016. In the analysis, there is a strong connection between two variables. For 10 days the percentage is 79%. It is gradually decreasing in 30 and 90-day period and the correlation ratios are 52% and 33% respectively. According to the analysts, the financers and brokers are responsible for the rising popularity of bitcoin to extend its trend for the correlation. Analysts mention that "Since investors have only one brain to process risk, they will make similar decisions about cryptocurrencies and stocks when they see price volatility in the latter," they wrote (Sharma, 2018).

ECB (2012) mentions that one of the virtual currencies function is pretending like a medium of exchange and a unit of account in virtual currency world. Investors are looking the rise of bitcoin prices and willing to trade exchange currencies more than in previous days. However, the thing is that there are lots of misleading information about the price of Bitcoin and this conflict creates a panic in the financial world and make bubbles in many times. In contrast, Winklevoss twins earned over a $1 billion on bitcoin since 2011 and became the first billionaire of this currency (Morris, 2017). Some people do not believe of the reality of Bitcoin in early stages, but one thing is clear that if a person put money on Bitcoin just say $100 dollars, it is not a waste investment for sure.

The maturity of this new virtual currency brings gain more than most trustable stocks, even many people do not believe about this idea. The macroeconomic variables are affected by the maturity of bitcoin and the connection is getting stronger (Baek and Elbeck, 2014). The logical explanation for this situation is maturity engaging in the economic performance of S&P 500 and Bitcoin may reflect in some macro levels to shape the economy of United States.

There are many links between bitcoins and stock exchange indexes. A stock exchange index is a measure of the dynamics of the value of the stock exchange in its whole or of a specific industrial or services sector (Alexandru, 2012). In finance system, Peter Fortune who the Director of Research at Boston FED mentioned that there is a comparison between stock market indices and bitcoin. He examines the correlations between the returns on each of the stock price indices. In related to Fortune (1998), there are findings suggest that many indices have similar relations with bitcoin. On the other hand, there is a different segment of the market that not related to each other. Investors have looked up stock exchange indices that provided by lots of high standards and concentrated interaction flows during the day. By monitoring the evolution of the value of a stock exchange index, it is possible to identify the overall tendency of a stock exchange or of one of its sectors for bitcoin, represented by the direction of the general movement of the prices of securities, usually shares, in the respective market or in the analyzed sector (Alexandru, 2012).

Granger causality is used for determining whether one-time series is useful in forecasting another to see a relation (Granger, 1969). One of them is in Akben-Selcuk (2016) paper, most of the researchers conducted in the field of stock markets analysis has focused on the increased integration, international dependencies, and efficiency of the markets. The These assets have been extensively analyzed by Granger causality testing. We think that it is the best way to relate stock markets indexes with bitcoin by using this method.

The remainder of this paper is constructed as follows. Section 2 reviews literature study in two different subjects that cryptocurrencies - bitcoin and stock exchanges. Section 3 describes data and methodology that we applied in this research which they are Augmented Dickey-Fuller, Lagrange Multiplier, Johansen Cointegration and Granger Causality. Section 4 mentions about empirical results of our methodology showing Augmented Dickey-Fuller stationaries, Lagrange multiplier which we can see if there is an autocorrelation or not in between stock exchanges and bitcoin, cointegration tests of stock market indexes, the Granger causality between stock market indexes and bitcoin. Section 5 gives conclusion and suggestion for upcoming papers.

1.2. Problem and Purpose

At the end of 2017, cryptocurrencies have never been more popular, and people want to demand it for their own. The transferring of money and purchasing exchange currencies have some costs and fees. In many cases, using exchange currencies for buying and selling of cryptocurrencies are not profitable and inefficient in investing. On the other hand, there is no any involvement of government or intermediary institutions of the third party that costs of bitcoin transactions are lower than exchange currencies transactions.

The transaction speed between parties is so quick in cryptocurrencies because there is no any third party to regulate all the operations and eliminate classical transaction procedure by banks and intermediaries. For this reason, lots of investors attract the bitcoin investment because it gains an incredibly high benefit returns to their portfolios. One of the causes is that not so much correlations with financial assets. (Brière, Oosterlinck and Szafarz 2015).

Bitcoins are generally used in regularly payment system with cards and this option triggers the existing payment system by selling Bitcoins. Like with many online payment systems, if an investor wants to pay with Bitcoin, s/he has just needed an internet connection. Withdraw2Card is one of them. If customers want to sell their Bitcoins on one of the major exchange platforms on the internet sites and they will receive a redeemable coupon. In other words, purchasers do not need to go a bank or any exchange office to buy or sell of any bitcoin. Another advantage is that for these transactions those internet sites do not want any personal information, this gives a huge interest in bitcoin transactions and these coins involve more in stock markets by investors.

As a result, the purpose of this paper is to analyze bitcoin's causality relationship with stock market indexes, to see countries stock market of applying or researching methods to implement in their economy and how was the connection between these variables starting from releasing of bitcoin.

1.3. Research Question

Q.1: Does Bitcoin have any causality relationship with 5 stock market indexes (Japan, Russia, South Korea, Sweden, and the USA) in the last 5 years, 1 year and 3 months respectively?

2. Literature Study

This chapter provides a review of bitcoin. Bitcoin is a very fresh word in finance word and in each day and we are getting more information about it, for this reason, there are restricted literature studies in the academical articles and there are many financial websites examination about Bitcoin's situation in the financial world. Moreover, this chapter will analyze on theoretical subjects which these academical papers and financial sites based on, defining cryptocurrencies and looking relation with other assets, defining bitcoin and analyzing relationship with stock markets and looking stock market indices and its movements according to bitcoin volatility changes.

2.1. Cryptocurrencies and Bitcoin

In Grinberg's article (2011), he mentions that there are many reasons for many people think about bitcoin is a deception. One of them is unexpected changes in the inflation rate can be imposed by software developers that can change the prices for their own will. This will cause a crisis in many government economies and exchange of currencies can be useless. Moreover, there are technical problems like the anonymity of the system is compromised, if money is lost or stolen, or if hackers or governments can prevent any new transactions from settling. As of many reasons, Bitcoin can be understood so well that if one-day bitcoin is used in the transactions, bitcoin will give confidence about these problems will not happen in the future. There is no doubt that bitcoin has a huge potential to be an important asset in the payment system in the world market. In addition, it is also an alternative currency for gold to hold the currencies in the bank accounts.

However, one currency named called Iraqi Swiss Dinar has the same features with bitcoin by not-backed government supporting. Saddam Hussein's government did not manage to use their old currency in the war years which was 1990 Gulf War and created a new currency. This new currency used in the north of the Iraqi region and used in trading as well. The government printed in large quantities of this new currency that cause a hyperinflation in Iraq. After the U.S. invasion of Iraq in 2003, U.S. authority intervenes in the economy and change their hyperinflated currency to a newly Iraqi new Dinars. If we make a conclusion for this situation, if a government gives direction to its currency by printing more, it causes a big damage to the country and another conclusion is that without any government backed or institutional center, the Iraqi Swiss Dinar can sustain in economy world.

In Dwyer's paper (2015), with the developing of technology, people reach their accounts by their smartphones instead of going to the bank and make transaction easily in each day. In these devices, there is no dramatic difference between dollar or bitcoin. If counting one difference, bitcoin is not controlled or regulated by a bank or another institution such as intermediaries or banks. This advantage gives bitcoin to use more in using transactions more and some people choose to invest bitcoin instead of stocks in economic markets. So, the demand of bitcoin provides an entrance financial system that can affect and cause the relationship with stock market indexes. The author suggests that bitcoin and these similar digital currencies are in under control of government's ability for influencing the change of inflation. In these days, Bitcoin may not have an impact on the economic transaction, but in a couple of years, the relation with bitcoin and economic variables have related each other such as inflation, stocks, stock market indexes. When we looked all these information's, the author warns the countries for the effects of bitcoin and similar digital currencies in their economic stability.

Brière, Oosterlinck, and Szafarz (2015) analyze bitcoin investment from the perspective of a U.S. investor with a diversified portfolio including both traditional assets which they are worldwide stocks, bonds, currencies and alternative investments that these are commodities, hedge funds, real estate using weekly data between 2010 and 2013. Over this period under the circumstances, bitcoin brings a high return and volatility due to the prominent features of its algorithm. On the other hand, bitcoin has low correlation with other assets such as gold, oil, and hedge funds. When looking from an investor's frame, Bitcoins have decisive tools that make it a matchless asset against another economical asset such as gold. In a short run, Bitcoin affects the risk-return trade-off of well-diversified portfolio dramatically and a small change in bitcoin price is enough to improve these portfolios. There is no indication of tests that it is applicable in the medium or long-run. At the end of the paper, authors emphasize that virtual currencies which in online banking transactions are beneficial for countries economy. People are already using bitcoin in transactions and trade on online sites and this new currency has impacted the exchange currency system very strongly day by day. In conclusion, authors message is these internet-based currencies must be taken very seriously by finance world especially by investors and see its behaviors very carefully against tangible assets.

This paper presented by Bores and Hlaciuc (2016) shows the background of newly decentralized digital currency Bitcoin in other words development of cryptocurrencies. One of the function is the payment system that may be in a couple of years, Bitcoin serves as another alternative to the traditional using mechanism. However, many investors called bitcoin is an experiment for transaction functions and it has not enough ability to achieve these payment challenges. In a short term, it is useful, but it might be not a solution for long-term in currency payment. At the end of the paper, authors think that decentralized currencies are important in the next years. These currencies have no threat the financial market for now. On the other hand, cryptocurrencies especially bitcoin behaves like gold in different circumstances and this similarity to act for buying this newly currency asset. Investors want to buy bitcoin for their investment to save against instability actions in economic changes such as inflation and with this movement bitcoin enter the world market by purchasers.

Danezis and Meiklejohn (2016) state that despite their success, existing cryptocurrencies suffer from several limitations. The most important problem is the scalability which is the capability of a system, network, or process to handle a growing amount of work, or its potential to be enlarged to accommodate that growth (Bondi, 2000). Exclusively Bitcoin has at most 7 transactions in a second and struggle with significant challenges that increasing this number. While PayPal makes 100 transactions and Visa handles around 5,000 transactions per second. They notice the second problem which is not controlling the monetary system very well that it is hard to keep macroeconomic policy functions in stable economical standards and cause a volatility in the currencies between countries.

Dyhrberg (2016) investigates the capability of hedging the bitcoin against two stocks. These are Financial Times Stock Exchange Index (FTSE) on the London Stock Exchange in Great Britain and the American dollar. In general, bitcoin can be used as a hedging capability against FTSE index. With another economic asset gold, bitcoin reduce and even eliminate the main market risks. On the other hand, when compared with the American dollar, it is unclear that correlation is not exactly found and there are low correlation values towards to bitcoin values. In the short-run dollar has positive signs in hedging capability against bitcoin. Moreover, the use of bitcoin trading too much that enable appropriate conditions for hedging. However, there are no experiments for hedging capability in the medium and the long run.

In the end, Dyhrberg (2016) seems bitcoin can find a place in portfolio analysis and risk management and as indicated, Bitcoin can be used as a hedge against the FTSE Index and the American dollar. By author, bitcoin can be added to the list of instruments alongside gold and other assets to minimize risks. When we looked to other assets, Bitcoin has an advantage in a transaction that no third party involved which makes it more attractive and with this advantage, Bitcoin is one of the prominent tools to use in hedging by investors and analysts.

At the below graph, Rhoads (2017) mentioned that there is a volatility calculation for both bitcoin and VIX from the period January 2nd to 8th November 2017. When we talked about the volatility, one of the indexes is VIX that measures of the stock market's expectation of volatility implied by S&P 500 index options, calculated and published by the Chicago Board Options Exchange (CBOE). As seen, their moves are a counterpart, when bitcoin volatility is increased, VIX's volatility is decreased and same for we changed the variables.

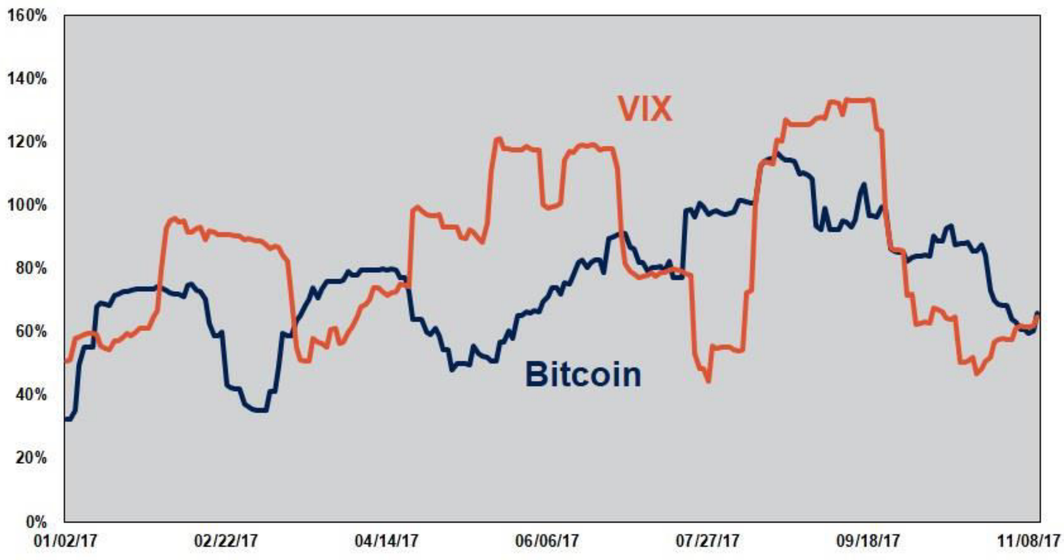


Figure 1: VIX-Bitcoin relationship

Schut (2017) studied from an investor's view how the increased maturity of Bitcoin as an asset can affect the characteristics of an investment tool. When looking market uncertainty and Bitcoin trade volume, there is a relationship between the increased maturity of Bitcoin. This result leads to S&P 500 has a significant relationship with Bitcoin prices. It is seen by forming a regression the relationship between Bitcoin prices and macroeconomic variables. Furthermore, the results with macroeconomic variables show that the S&P500 price has a positive effect on Bitcoin prices. Lastly, the efficient frontier clears that when we want to create an investment portfolio, Bitcoin has useful to add this portfolio for making high returns for different diversified portfolios. Investors know Bitcoin very well that this digital currency uses in an asset and gains high returns more than expected. In near future, Bitcoin can develop and can be a serious alternative to invest in different portfolios.

Sovbetov (2018) examines factors that there are many influences on stock prices in today's world economy and cryptocurrency are one of them. He analyzes the most common cryptocurrency Bitcoin over 2010-2018 using weekly data. Using Autoregressive Distributed Lag (ARDL) technique, there are some dynamics to determine both cryptocurrency prices and stock prices in short and long run. These long and short run ARDL model analyze to find statistically significant impact running from crypto market factors such as total trading volume, volatility, attractiveness and stock market index on Bitcoin in long and short run respectively. Trading volume has an important relationship with Bitcoin in the long-run in %1 significance level in the long-run. A unit increase in weekly trading volume causes 0.14 raises in Bitcoin in long-run. On the other hand, also volatility of cryptocurrency in Bitcoin has statistically significant determinant both in long- and short-runs for Bitcoin. The attractiveness of cryptocurrencies also important statistically significant.

When looking for long-run, there is a significant coefficient for Bitcoin at 1% significance level. In other words, 1 unit increase in attractiveness of Bitcoin, leads 1.27 units increases in their long-run prices respectively. In contrast, for short-run, the estimation is at 10 % significance level that attractiveness is not much strong compared to long-run. As a result, Bitcoin needs to be time for recognition itself and it brings more known in the log period span. When looking from S&P500 index, it has not a strong significant relationship with Bitcoin. Only 10% significant level with Bitcoin. In the short-run Bitcoin is not an important factor to affect S&P 500. However, in the long-run, it has a significant relationship in a positive way. This result shows that USD index has a stronger relationship in near future that it makes more valuable than other fiat currencies.

As shown in below graph, Cheng (2018) writes corner post about Bitcoin. According to Nick Colas, co-founder of DataTrek Research. When analyzing in the last 1-year, the correlation between daily percentage returns and S&P 500 is 33 percent, this is the highest number since cryptocurrency has a media attention at the beginning of 2016.

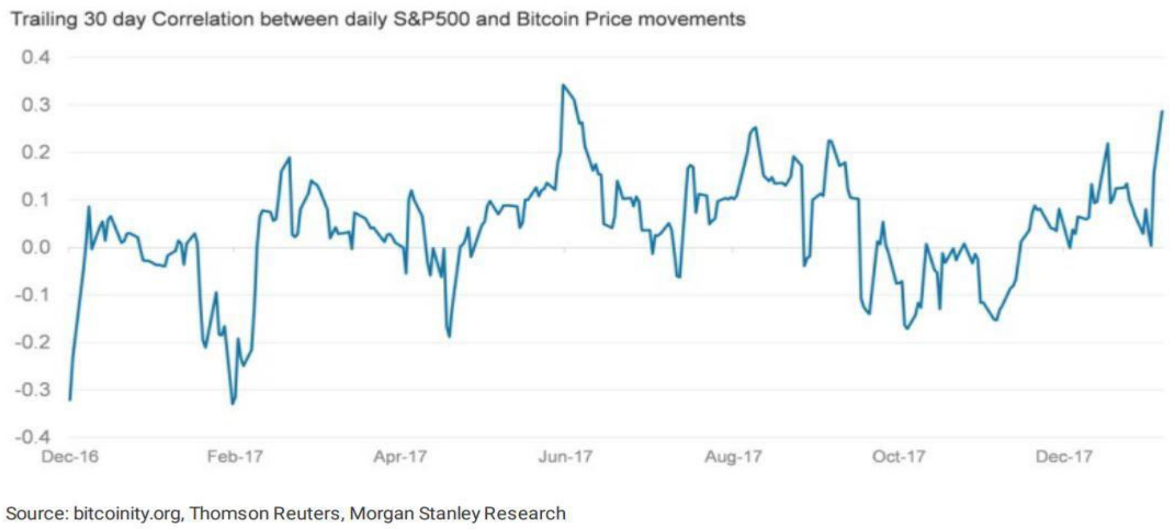


Figure 2: Correlation between S&P 500 and Bitcoin Prices

Zuckerman (2018) searches the number of 'Bitcoin' written in google search machine. Google Trends indicates that when Bitcoin reaches 20k$ in mid-December. There is a huge rising in searching the word 'Bitcoin'. As shown in the below graph, left graph shows the google trend of 'Bitcoin' and the right graph shows the price of Bitcoin. In the same-period year in 2017, the tendencies of lines very resemble each other. We can't conclude about searching the word 'Bitcoin' in Google cause the price of Bitcoin. However, Google searching is one of the factors that might be affecting the price of Bitcoin.

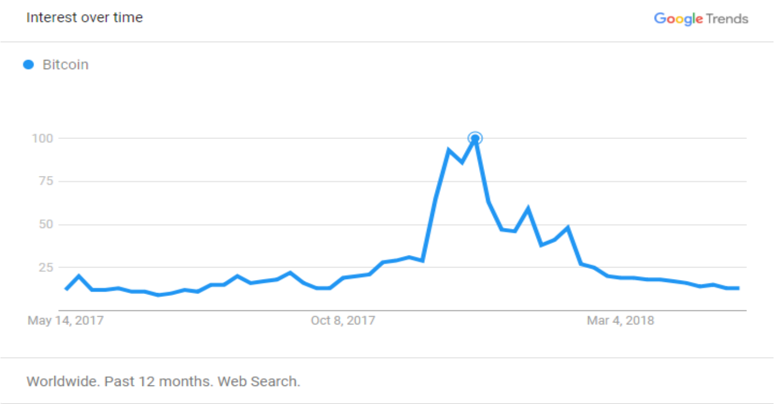


Figure 3: Google Trending when writing the word "Bitcoin"

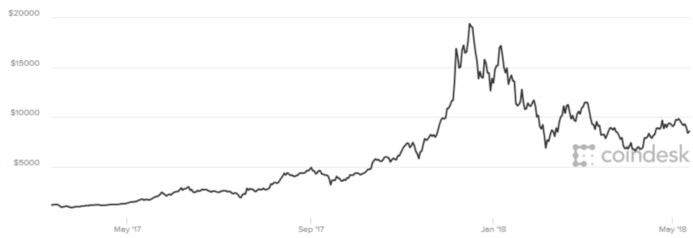


Figure 4: Bitcoin Prices in 2017 (Coindesk,2018)

2.2. Stock Exchanges

In this section, we see 5 countries which they are Japan, Russia, South Korea, Sweden, and the USA. We choose these countries because each country talks about implementing cryptocurrency in their economy or change their current system to cryptocurrency especially in bitcoin. There are some press releases about mention digital currency that some countries explanation can affect the cryptocurrency market and these countries people tend to buy digital currency. This will lead to causation of these economies and cryptocurrency market. We analyze their stock market and economies relation with cryptocurrency and bitcoin. This bitcoin is a new topic that with the beginning of 2017 many people try to understand these digital currency and bitcoin is one of the pioneers. Unfortunately, we can only find articles about this relationship in the economical websites and there is not a much academical article about this new topic. We look their actions about cryptocurrency and bitcoin in this part.

2.2.1. Japan

Kharpal (2017) investigates Japan's perspective for bitcoin. Japanese banks are looking forward to launching their own digital currency called the J-Coin to decrease the usage of cash. Mizuho Financial Group is the pioneer of this new cryptocurrency movement. At the beginning of 2017, with the popularity of Bitcoin Mizuho tested a trade finance transaction via a blockchain and it is successful.

Adelstein (2018) wrote Japan's new cryptocurrency called Monacoin and add his impressions about it. Monacoin is become a serious asset in recent years but is it worth to invest? This new Japanese cryptocurrency created in December 2013 from Japanese textbook called "2channel". It resembles with bitcoin that also it's creator has a nickname called "Mr.Watanabe". Mr. Watanabe introduced his new currency as using much more in the video game called "Final Fantasy". Mr. Watanabe states that his intention is not to create a new cryptocurrency, presents it as a virtual currency. After the dissolution of world's largest bitcoin exchange site Mt. Gox in 2014 in that time, Monacoin got involved much more in exchange trading especially in cryptocurrency market and changed its strategic plan as “safest currency that made in Japan.” At that time there are other four major exchange currency exchanges in Japan and Monacoin want to find a place in this exchange market. Monacoin got traded in ZAIF which is the local currency exchange site in Japan and many ATMs has also accepted exchange with this cryptocurrency. There is a huge demand for buying Monacoin because of its first cryptocurrency in Japan. There is an announcement that people are purchasing real estates as using Monacoin on 23 March 2017. JIT Holdings company is the first company to offer its Japanese citizens to buy a house, also there are hoping to extend their offers to abroad. Monacoin is mostly used in Japan and it is not an international cryptocurrency to trade in other countries too much. Most importantly for Japan, an investor can easily to get Monacoin in Japan and use in purchasing a house or in exchange currency.

2.2.2. Russia

Suberg (2018) mentions in his article that Russia’s President Vladimir Putin has signed a document on cryptocurrency mining starting by July 2018. Russian bank VTB stated that “has not seen a lot of interest in Bitcoin” from the country’s consumers. The bank’s CEO Andrey Kostin disagrees with the Putin’s idea of Bitcoin. He mentions that instead of popularity in Bitcoin, actual usage of Bitcoin is low, and at some point, cryptocurrencies damage the economy. It is hard to regulate and can be dangerous.

Chang (2018) mentions in his article that the Russian Ministry of Finance opposes Putin’s cryptocurrency idea. The Ministry plans to introduce a law that if anyone uses any cryptocurrency, s/he will be punished for using that. Elvira Nabiullina, head of the Bank of Russia, said she and the Russian Finance Ministry oppose the use of virtual currencies and her idea about cryptocurrency is "as private money and money surrogates”. Moreover, she adds that Russia’s currency is ruble and the only ruble can be used to pay for goods and services." The Ministry of Finance aims to protect its national currency ruble from any other digital cryptocurrencies for losing value. Also, Nabiullina states that "This is necessary to protect the ruble as the single legal payment in Russia".

2.2.3. South Korea

Guez (2018) speaks about the interest of Bitcoin in South Korea. South Korean authorities plan to preserve in cryptocurrency trading for preparing their economy for Bitcoin. On the other hand, the bitcoin price went down with the beginning of 2018 and South Korea Finance Minister Kim Dong-Yeon said “Shutting down digital currency exchanges was still an option for the government". South Korea is the third biggest market for Bitcoin trades, behind from Japan and US respectively and has a couple of exchange cryptocurrencies sites. South Korea use transaction in cryptocurrency trading very actively even though Bitcoin price is too volatile. One of the analytics firms in South Korea WiseApp made a survey that every 1/20 people in South Korea use cryptocurrency trading at least once and there is a huge increase in using these cryptocurrencies up to 2 million users. Government is hesitant about using cryptocurrency in daily life and implementing in their economy. Moreover, investors are careful and think about that it is just a short-term highly return on the investment. They think that people don't fall in too much in this digital cryptocurrency market that government bring some legislation about trading exchanges and to avoid people from the tax evasion.

Reiff (2018) mentions that South Korean government think this volatility of Bitcoin can damage the economy and people are exaggerating the Bitcoin situation too much. Because of that, the government has thought about to act of threatening all cryptocurrencies used banning in South Korea and shut down some exchanges which ones related with cryptocurrencies. On the other hand, cryptocurrency gains so much reputation that the number of cryptocurrency exchanges app users increases 14 times in three months. In recent years, South Korea economy trend is not so well that there is an increasing number of the rate of unemployment causing a slowing down in the economy. People tend to invest in new assets which cryptocurrency especially Bitcoin is one of them. South Korean investors seem this high intensity on cryptocurrency may affect for allowing the government to take a step that can regulate some obligations of buying cryptocurrency. As a result, if there is a decreasing number of South Korean investment happen, Bitcoin prices can affect, and even other digital currencies prices can change in a negative way.

2.2.4. Sweden

Roden (2018) mentions about Sweden Central Bank, which was the name called Riksbank, published in November 2016 that there is a possibility to Sweden launch its own digital currency name called "e-krona" and Sweden may be the first country to do it. HSBC global economist James Pomeroy guesses can present it the next couple of the years. Sweden has to potential to take a further step for creating its cryptocurrency. One of them is, people do not use cash in daily life when they buy goods and products instead of their choice is always to use credit cards even in financial transactions. "Sweden is one of the pioneer countries that getting used the credit cards more than cash usage that Sweden is ahead of the UK, Europe, and the USA in this area. Because of how technologically developed it is, you see a lot of new interesting things in economics quite a while before you see it elsewhere," Roden (2018). Pomeroy also told The Local that " Sweden's cash usage is decreasing dramatically more than other EU countries. In payments, the usage of cash is at around 40 percent in 2010, in a 6-year period, this usage went to 15 percent in 2016. If this trend continues, The Riksbank will publish more interesting information about using cash and credit cards analysis that there will be no cash usage more than 10 percent in 2020." Roden (2018). With the beginning of 2017, there is a huge interest in cryptocurrencies especially in Bitcoin that makes it valuable because of the non-cash transaction between individuals or parties. Sweden can regulate its economic system very quickly because of Swedish people do not need any cash to transfer to their money.

In near future, Sweden will need a new type of currency to replace cash. However, it can lead to an economic crisis if there are no cash accepted places such as by intermediaries and banks. In this case, Riksbank takes step by slowly for the transition to a cashless economy and creating a new cryptocurrency may be good for Sweden. Lastly, James Pomeroy mentions "It's telling how many places in Sweden have stopped accepting cash – that's where the central bank has to step in. The Riksbank states that if that usage of cash in a stop in near future, the function of the central bank in Sweden provides another solution that people accept to pay in another payment style. If cash is no longer an accepted means of payment, the central bank has the task of providing an alternative." Roden (2018).

2.2.5. USA

Cox (2017) mentions in his article that as the price of the cryptocurrency popularity continues to increase, the Federal Reserve has an idea of creating a new cryptocurrency that just likes same coding system with Bitcoin. In New York, William Dudley, who is the CEO of Federal Reserve Bank (FED) William Dudley said that "The Fed is exploring the idea of its own digital currency, according to reports from Dow Jones. It would be very premature to estimate when the Fed would come up with its own offering." Cox (2017).

Acheson (2018) searches for which companies use Bitcoins. Accepting Bitcoin in stores increase from the beginning of 2017. However, many stores did not look so well in using Bitcoin because of price volatility and many internet sites got transactions fees. Despite these incidents, you can still buy a wide range of goods and services with Bitcoin. One example is flight and hotel agencies which are Expedia, CheapAir and Surf Air. One of the multinational technology company Microsoft accepts bitcoin in its app stores that you can download music, movies, games. Some musicians (Bjork, Imogen Heep) will let you download their music in exchange for the cryptocurrency.

3. Data and Methodology

3.1. Data Collection

For our analysis we use Augmented-Dickey Fuller, Johansen Cointegration, Lagrange Multiplier (Autocorrelation) and Granger Causal relationships, the daily closing prices for the following indices: In Japan, we choose Nikkei Index (Nikkei 225) which is a stock index for the Tokyo Stock Exchange and the currency in Japanese Yen (JPY). The biggest exchange group in Russia is Moscow Exchange, the currency in Russian Ruble (RUB). The Korea Composite Stock Price Index (KOSPI) is a very typical stock market index in South Korea. It is including all common shares on the Korea Stock Exchange and the currency in South Korea Won (KRW). The OMX Stockholm 30 (OMXS 30) stock market index for Stockholm Stock Exchange is selected to represent Sweden. The last one we choose Standard & Poor´s 500 Index (S&P 500) for the United States and the currency in U.S. dollar.

Countries	Stock Market Indices	Currencies
Japan	NIKKEI 225	JPY
Russia	MOSCOW EXCHANGE	RUB
South Korea	KOSPI	KRW
Sweden	OMXS 30	SEK
USA	S&P 500	USD

Table 1: Stock Market Indices in 5 Different Countries

The analyze time-period cover 5 years from 1^{st} January 2013 to 31^{st} December 2017. The study examines 1304 observations in daily data for all variables which are collected from DataStream. Since the price of bitcoin is U.S. dollar, we change different local currencies with the exchange rate to U.S. dollar for the empirical procedure. In order to reduce the potential effects of heteroscedasticity, we convert data into logarithm form. All the empirical procedure is applying by using Eviews 8.

	BITCOIN	NIKKEI 225	MOSCOW EXCHANGE	KOSPI	OMXS 30	S&P 500
Mean	1093.540	155.7583	2.629654	1.843799	184.8012	2035.172
Median	440.1500	151.9472	2.699625	1.815182	187.4524	2050.875
Maximum	18934.00	203.5414	3.685890	2.343665	214.9894	2690.160
Minimum	0.000000	117.5785	1.388460	1.520530	145.6167	1426.190
Std. Dev.	2276.048	16.40981	0.498068	0.160569	14.98090	276.1846
Skewness	4.706364	0.525510	-0.334524	0.793392	-0.240351	0.112390
Kurtosis	28.50931	3.558843	2.189133	3.569062	2.127962	2.643832
Jarque-Bera	40169.94	76.98755	60.04543	154.3999	53.87283	9.637738
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.008076
Sum	1425976.	203108.8	3429.069	2404.314	240980.7	2653865.
Sum Sq. Dev.	6.75E+09	350874.4	323.2371	33.59452	292429.0	99390115
Observations	1304	1304	1304	1304	1304	1304

Table 2: Descriptive Statistics

At the above graph, there is a summary of descriptive statistics for the selected variables. 1304 daily observations of all the variables have been examined to estimate the following statistics. The mean describes the average value in the series and Std. Deviation measures the dispersion or spread of the series. The maximum and minimum statistics measures upper and lower bounds of the variables under study during our chosen time span.

	BITCOIN	NIKKEI 225	MOSCOW EXCHANGE	KOSPI	OMXS 30	S&P 500
BITCOIN	1.000000	0.689224	0.351988	0.672318	0.160584	0.617101
NIKKEI_225	0.689224	1.000000	0.350171	0.612759	0.024949	0.931165
KOSPI	0.672318	0.612759	0.500337	1.000000	0.575774	0.542687
MOSCOW	0.351988	0.350171	1.000000	0.500337	0.105504	0.267584
OMXS30	0.160584	0.024949	0.105504	0.575774	1.000000	-0.067368
S_P_500	0.617101	0.931165	0.267584	0.542687	-0.067368	1.000000

Table 3: Correlation of Stocks and Bitcoin

In order to avoid spurious regression, we need to make sure variables are stationary during the procedure. Four main econometric models are conducted in this study: Augmented Dickey-Fuller to determine whether a unit root, a feature that can cause issues in statistical inference, is present in an autoregressive model. Secondly, Lagrange Multiplier (LM) test checking autocorrelation. Thirdly, Johansen Cointegration test whether the procedure exists cointegrating vector or not. The last step, Granger Causality test to examine the relationship between individual stock market indices variables and bitcoin.

3.2. Augmented Dickey-Fuller Test

It is important to detect series stationary status when we analyze the relationship between bitcoin and stock market indices. Clearly, non-stationary will have an effect on the process and will result in spurious regression results. When there is an indication of a non-stationary or unit root test, it is necessary to conduct a formal unit root significance test which is an Augmented Dickey-Fuller test. We will perform Augmented Dickey-Fuller test (1979) in the first step for testing unit roots.

H0: δ =0, non-stationary process

H1: δ <0, stationary process

$$\Delta Y_t = \propto + \lambda t + \delta Y_{t-1} + \sum_{j=1}^{P} \varphi \Delta Y_{t-j} + \varepsilon t$$

$Here: \Delta = First\ difference\ operater;\ \alpha = Intercept\ constant\ term; p = lag\ number;\ \varepsilon t = Error\ term; Yt = variables(bitcoin\ and\ stock\ indices);\ \delta = coefficent.$

The null hypothesis implies there exist unit roots and series are non-stationary. However, the alternative hypothesis is no unit roots and series are stationary. If δ is equal to zero, then we cannot reject the null hypothesis, we conclude there has a unit root and it is a non-stationary process. This implies to do the Johansen test for the next step. If the coefficient δ is less than zero, then the null hypothesis that y contains a unit root is rejected. Rejection of the null hypothesis denotes stationarity in the series.

3.3. Lagrange Multiplier-Autocorrelation Test

For checking autocorrelation, we use Lagrange Multiplier (LM) test. This test results can be used to check whether the residuals are autocorrelation or not. The null hypothesis is no autocorrelation up to the specified lag, but the alternative hypothesis is existing autocorrelation up to the specified lag. According to Evans and Patterson (1985), based on the requirements, if the p-values of t-statistic are higher than 5 percent critical p-value, we cannot reject the null hypothesis. Hence, there is no autocorrelation between variables.

H0: $\rho = 0$, there is no autocorrelation

H1: $\rho \neq 0$, there is autocorrelation

$$Y_t = \beta_0 + \beta_1 X_{1t} + \cdots + \beta_p X_{pt} + \mu_t$$

$$with\, \mu_t = \rho_1 \mu_{t-1} + \rho_2 \mu_{t-2} + \cdots + \rho_p \mu_{t-p} + \epsilon_t$$

$$then, Y_t = \beta_1 + \beta_2 X_{2t} + \cdots + \beta_p X_{pt} + \rho_p \mu_{t-p} + \epsilon_t\ ;$$

$$\widehat{\mu_t} = Y_t - \widehat{\beta_0} - \widehat{\beta_1} X_{1t} - \cdots - \widehat{\beta_p} X_{pt}$$

Here: Y_t= time series vector at time t; ε_t=error term; β=estimated coefficients.

3.4. Johansen Cointegration Test

We can't perform non-stationary data in the regression model because it will cause spurious regression. Whether the variables are stationary or not, this does not imply they are cointegration or not. In the beginning, Engle and Granger (1987) mentioned two-step procedure for the testing cointegrated relationship between variables, Johansen and Juselius (2009) pointed out eigenvalue statistics and trace test later. The VAR model with order: P

$$Y_t = \mu + \emptyset_1 Y_{t-1} + \emptyset_2 Y_{t-2} + \cdots + \emptyset_p Y_{t-p} + \varepsilon_t$$

Here: Y_t= time series vector at time t; μ=vector-valued mean of series; P=lag number; $\emptyset_i$= coefficient matrices for each lag; $\varepsilon_t = noise\ term\ with\ mean\ zero$.

The equation can be written in this form:

$$\Delta Y_t = \mu + +\Gamma_1 \Delta Y_{t-1} + \cdots + \Gamma_p \Delta Y_{t-p} + \Pi Y_{t-1} + \varepsilon_t$$

Here:. $\Delta Y_t = Y_t - Y_{t-1}\ is\ the\ differencing\ operator$; Π=the matrices of parameters; $\Gamma_i = \emptyset_1 \emptyset_2 \ldots \emptyset_{p.}$ $\Pi Y_{t-1} = error\ correlation\ terms$.

The Johansen Cointegration test is to estimate the rank of Π which is the maximum number of independent vectors. Here are three following conditions.

1, if rank (Π)=0, there is no cointegration

2, if rank (Π)=n (full rank), there are all the variables are stationary.

3, if 0< rank (Π) $= r < n$(less than full rank), there are r independent cointegration relationship.

Therefore, the hypothesizes are assumed to be as follow:

H0: there is no cointegrating vector

H1: there is a cointegrating vector

The null hypothesis is no cointegrating relationship among variables. If the statistic value of Maximum Eigenvalue test and Trace Test is higher than the critical value (at 5 percent), then we can reject the null hypothesis of no cointegration. This implies we can find cointegration relationship and exhibit a long-run relationship between variables. However, If the statistic value of Maximum Eigenvalue test and Trace Test is less than the critical value (at 5 percent), we cannot reject the null hypothesis. During the empirical procedure, cointegration test should be performed by using level data instead of using first difference data. Moreover, if variables have same integrated of order, we will perform Johansen test for examining the cointegrating relationship between variables. If the series are cointegrated, there exhibit a long-run relationship.

3.5. Granger Causality Test

After performing Johansen Cointegration test, the Granger causality test can be used to determining whether one-time series is significant in forecasting another or not (Granger, 1969). Basically, it seeks to question that how variable or variables for example (x1) is determined another variable or variables (x2). If x1 does not cause x1, then x2 does not help to determine x1. Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term. The application of Granger causality assumes that the analyzed signals are covariance stationary. Non-stationary data can be treated by using a windowing technique (Hesse et al. 2003) if sufficiently short windows of a non-stationary signal are locally stationary.

We apply Toda and Yamamoto (1995) procedure for Granger Causality Test. Since the method of Toda and Yamamoto Model is works regardless data are cointegrated or not. This means even if variables do not have same integrated of order which is not cointegrated, we can still perform Toda and Yamamoto (1995) method.

The process of applying Toda Yamamoto model is shown in the following steps. To begin with, we need to decide the order of integration for each time series with ADF test. Then, we are required to choose the maximum order of integration for each group, we set up this order as *m*. In the third step, we need to establish VAR model by using level data instead of using first difference data. Fourthly, the appropriate maximum lag length for the variables need to be determined in the VAR model. To deal with this problem, we followed the information criteria AIS, SIC and HQ to choose the lag length. After that, if we need to test variables are autocorrelation or not, we can use LM test. Moreover, if time series have the same order of integration, we use Johansen methodology to test if variables are cointegrated. After finishing all above steps, with the help of AR root graphs we can test for dynamic stability by checking if all inverse roots are within the unit circle. Later, we re-estimate the level of VAR by adding extra 1 lag in the equations for each variable. In the end, we need to test Granger Causality for variables.

H_0: $\gamma_1 = \gamma_2 = \cdots = \gamma_i = 0$ or $\emptyset_1 = \emptyset_2 = \cdots = \emptyset_i = 0$, there is no causality

H_1: $\gamma_1 = \gamma_2 = \cdots = \gamma_i \neq 0$ or $\emptyset_1 = \emptyset_2 = \cdots = \emptyset_i \neq 0$, there is causality

EViews runs bivariate regressions of the form:

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i Y_{t-i} + \sum_{i=1}^{k} \gamma_i X_{t-i} + \varepsilon_t$$

$$X_t = \beta_0 + \sum_{i=1}^{k} \beta_i X_{t-i} + \sum_{i=1}^{k} \emptyset_i Y_{t-i} + u_t$$

$Here: Y_t, X_t = staionary\ time\ series;\ \varepsilon_t, u_t = residuals;\ \alpha_0, \beta_0 = constant\ term.$

Here we can set Y_t is the log of bitcoin price, and X_t is logs of stock market indices including OMX Stockholm 30 index (LOMXS30), Nikkei 225 index (LNIKKEI225), Moscow Exchange index (LMOSCOW), Standard & Poor´s 500 indexes (LS_P500), Korea Composite Stock Price index (LKOSPI). The null hypothesis for the first equation is bitcoin price does not Granger-Cause stock market indices. Moreover, the null hypothesis for the second equation is stock market indices does not Granger-Cause bitcoin price.

4. Empirical Results

LBIT	Logarithm function of Bitcoin
LNIKKEI225	Logarithm function of Nikkei 225 Index
LMOSCOW	Logarithm function of Moscow Exchange Index
LKOSPI	Logarithm function of Korea Composite Stock Index
LOMXS30	Logarithm function of Stockholm 30 Index
LS_P500	Logarithm function of Standard & Poor's Index

Table 4: Abbreviations

4.1. Unit Root Test Results

Variables	Null Hypothesis	P-Value	Choice (5% significant level)	Results
Bitcoin	LBIT contains at least one-unit root (not stationary)	0.8200	Do not Reject	**LBIT is not stationary**
Japan	LNIKKEI 225 contains at least one-unit root (not stationary)	0.0781	Do not Reject	**LNIKKEI 225 is not stationary**
Russia	LMOSCOW contains at least one-unit root (not stationary)	0.3810	Do not Reject	**LMOSCOW is not stationary**
South Korea	LKOSPI contains at least one-unit root (not stationary)	0.5939	Do not Reject	**LKOSPI is not stationary**
Sweden	LOMXS30 contains at least one-unit root (not stationary)	0.1918	Do not Reject	**LOMXS30 is not stationary**
United States	LS_P500 contains at least one-unit root (not stationary)	0.0688	Do not Reject	**LS_P500 is not stationary**

Table 5: Unit Root Test Results at level

We perform all ADF tests at level by using 5 years data. Here, LBIT, LOMXS30, LNIKKEI225, LMOSCOW, LS_P500, LKOSPI are the logs of bitcoin and OMX Stockholm 30 index, Nikkei 225 index, Moscow Exchange index, Standard & Poor´s 500 indexes and Korea Composite Stock Price index respectively. According to the Augmented Dickey-Fuller test (1979) for testing unit roots, we know that the null hypothesis is existing unit roots in series and the alternative hypothesis is no unit roots in series. By looking at the results, it appears that the p-values for all the included variables in our research are greater than the critical value (5%). So, we cannot reject the null hypothesis and we must, therefore, conclude that all six variables which are growing are non-stationary, meaning that those variables follow a random walk with drift and no time trend. This implies that we need to take the first difference of those variables before they can be run in the regression model.

Variables	Null Hypothesis	P-Value	Choice (5% significant level)	Results
Bitcoin	LBIT contains at least one-unit root (not stationary)	0.0000	Reject	**LBIT is stationary**
Japan	LNIKKEI 225 contains at least one-unit root (not stationary)	0.0001	Reject	**LNIKKEI 225 is stationary**
Russia	LMOSCOW contains at least one-unit root (not stationary)	0.0000	Reject	**LMOSCOW is stationary**
Sweden	LOMXS30 contains at least one-unit root (not stationary)	0.0000	Reject	**LOMXS30 is stationary**
South Korea	LKOSPI contains at least one-unit root (not stationary)	0.0000	Reject	**LKOSPI is stationary**
United States	LS_P500 contains at least one-unit root (not stationary)	0.0000	Reject	**LS_P500 is stationary**

Table 6: Unit Root Test Results at 1st Difference

We perform all ADF tests at first difference by using 5 years data. As we can see from the results, all the p-values are smaller than the critical value (5%), we can reject the null hypothesis which is there exist unit roots and series are non-stationary. Therefore, the results of ADF test at first difference implies that all variables are stationary. Since stationary properties are proved by ADF test, Johansen cointegration test can be performed to test if the variables exhibit long-run relationships in their first differences.

4.2. Serial Correlation LM Test Result

Countries	**Variable**	**Null Hypothesis**		**P-Value**	**Choice (5% significant level)**	**Results of autocorrelation**
Japan	LNIKKEI225, LBIT	No autocorrelation up to the specified lag		0.3159	Do not Reject	**No**
Sweden	LOMXS30, LBIT	No autocorrelation up to the specified lag		0.2423	Do not Reject	**No**
Russia	LMOSCOW, LBIT	No autocorrelation up to the specified lag		0.3501	Do not Reject	**No**
United States	LS_P500, LBIT	No autocorrelation up to the specified lag		0.6900	Do not Reject	**No**
South Korea	LKOSPI, LBIT	No autocorrelation up to the specified lag		0.1530	Do not Reject	**No**

Table 7: Results of LM-Autocorrelation Test

We perform all LM tests by using 5 years data. We use Serial Correlation LM test for diagnostic checking autocorrelation. The null hypothesis is no autocorrelation up to the specified lag for variables, the alternative hypothesis is autocorrelation up to the specified lag for variables. From this results table, all the p-values are higher than the critical value (5%). Based on this situation, we cannot reject the null hypothesis. Therefore, there is no autocorrelation between variables. According to this test results, there is no serial correlation in the error term, we can perform the Johansen cointegration test for the next step.

4.3. Johansen Cointegration Test Results

Countries	**Series**	**Test**	**Hypothesized No. of CE (s)**	**Trace statistic/ Max-Eigen Statistic**	**5% critical value**	**Prob.****	**Cointegration**
Japan	LBIT LNIKKEI225	Maximum Eigenvalue	None	13.78054	11.22480	0.0174	**YES**
			At most 1	0.227701	4.129906	0.6910	
		Trace test	None	14.00824	12.32090	0.0258	**YES**
			At most 1	0.227701	4.129906	0.6910	

Table 8: Johansen Cointegration Test of Japan

The time span last 5 years is from 1st January 2013 to 31st December 2017. The second time period last 1 year is in 2017 and the last three months is from 1st October 2017 to 31st

December 2017. If the p-values are higher than 0.05 (critical value), the null hypothesis cannot be rejected. Therefore, one variable does not Granger causality another variable need to be accepted.

After checking for autocorrelation, we perform all Johansen Cointegration tests by using 5 years data. The null hypothesis is no cointegration between variables and the alternative hypothesis is existing cointegration between variables. The results are shown on the above table, we can see that the statistic value of both Trace test (14.00) and Maximum eigenvalue test (13.78) are greater than 12.32 and 11.22 (5 percent critical value). We can reject the null hypothesis based on the requirements, so there is existing cointegration between bitcoin and Nikkei 225 index in Japan. This indicates a long-run relationship between these two variables. In addition, Toda Yamamoto model works no matter variables are cointegrated or not, it will not affect the next step.

Countries	**Series**	**Test**	**Hypothesized No. of CE (s)**	**Trace statistic/ Max-Eigen Statistic**	**5% critical value**	**Prob.****	**Cointegration**
Russia	LMOSCOW, LBIT	Maximum Eigenvalue	None	28.19391	11.22480	0.0000	**YES**
			At most 1	0.831072	4.129906	0.4176	
		Trace test	None	29.02498	12.32090	0.0000	**YES**
			At most 1	0.831072	4.129906	0.4176	

Table 9: Johansen Cointegration Test of Russia

In Russia, we find the statistic value of Maximum Eigenvalue test is 28.19 which is higher than 11.22 (5 percent critical value). Moreover, the statistic value of the Trace test is 29.02 that higher than 12.32(5 percent critical value) as well. The null hypothesis of no cointegration can be rejected, there is existing cointegration between bitcoin and Moscow Exchange in Russia. It is worth to mention that Toda Yamamoto model works no matter variables are cointegrated or not. Hence, this will not affect our analysis.

Countries	**Series**	**Test**	**Hypothesized No. of CE (s)**	**Trace statistic/ Max-Eigen Statistic**	**5% critical value**	**Prob.****	**Cointegration**
South Korea	LBIT, LKOSPI	Maximum Eigenvalue	None	27.27386	19.38704	0.0029	**YES**
			At most 1	1.553887	12.51798	0.9893	
		Trace test	None	28.82775	25.87211	0.0208	**YES**
			At most 1	1.553887	12.51798	0.9893	

Table 10: Johansen Cointegration Test of South Korea

In this case, all the statistic values of Trace test (28.83) and Maximum Eigenvalue test (27.27) are higher than 25.87 and 19.39 (5 percent critical value) respectively. Hence, we can reject the null hypothesis of no cointegration between variables. We can conclude that there is cointegration between bitcoin price and KOSPI stock index in South Korea. This implies a long-run relationship for bitcoin and KOSPI stock index. As we mentioned before, Toda Yamamoto model works regardless of variables are cointegrated or not.

Countries	**Series**	**Test**	**Hypothesized No. of CE (s)**	**Trace statistic/ Max-Eigen Statistic**	**5% critical value**	**Prob.****	**Cointegration**
Sweden	LOMXS30, LBIT	Maximum Eigenvalue	None	12.27762	11.22480	0.0325	**YES**
			At most 1	0.003567	4.129906	0.9602	
		Trace test	None	12.28118	12.12090	0.0498	**YES**
			At most 1	0.003567	4.129906	0.9602	

Table 11: Johansen Cointegration Test of Sweden

Based on the results, we find that statistic value of Maximum Eigenvalue test (12.27) is greater than 11.22 (5 percent the critical value), and the statistic value of Trace test (12.28) is higher than 12.12(5 percent the critical value). So, the null hypothesis can be rejected in the case of Sweden, we can find cointegration between bitcoin and OMXS 30 stock index This implies a long-run relationship for bitcoin and OMXS 30 stock index.

Countries	**Series**	**Test**	**Hypothesized No. of CE (s)**	**Trace statistic/ Max-Eigen Statistic**	**5% critical value**	**Prob.****	**Cointegration**
United States	LBIT, LS_P500	Maximum Eigenvalue	None	14.26838	19.38704	0.2367	**NO**
			At most 1	2.629420	12.51798	0.9174	
		Trace test	None	16.89780	25.87211	0.4226	**NO**
			At most 1	2.629420	12.51798	0.9174	

Table 12: Johansen Cointegration Test of United States

The cointegration results of United States imply that no cointegration can be found between bitcoin price and S&P 500 stock index. Due to both statistic values of Maximum Eigenvalue test (14.27) and Trace test (16.90) is less than 25.87 and 19.39 (5 percent the critical value) respectively. We are failing to reject the null hypothesis of no cointegration, so there is no cointegration between these two variables.

4.4. Granger Causality Results

Time	Null hypothesis(H0)	Prob.	Choice (5% significant level)	Results	Direction of Causality
Last 5 years	LNIKKEI225 does not Granger Cause LBIT	0.8080	Accept H0	LNIKKEI225 does not Granger Cause LBIT	**No Granger Causality**
	LBIT does not Granger Cause LNIKKEI225	0.1153	Accept H0	LBIT does not Granger Cause LNIKKEI225	
Last 1 Year	LNIKKEI225 does not Granger Cause LBIT	0.7917	Accept H0	LNIKKEI225 does not Granger Cause LBIT	**LBIT ⟶ LNIKKEI225**
	LBIT does not Granger Cause LNIKKEI225	0.0361	Reject H0	LBIT does Granger Cause LNIKKEI225	
Last 3 Months	LNIKKEI225 does not Granger Cause LBIT	0.8286	Accept H0	LNIKKEI225 does not Granger Cause LBIT	**No Granger Causality**
	LBIT does not Granger Cause LNIKKEI225	0.0587	Accept H0	LBIT does not Granger Cause LNIKKEI225	

Table 13: Granger-Causality Result of Japan

⟶ *Denotes the unidirectional causality.*

According to the requirements, we find that no Granger causality between NIKKEI 225 stock index and bitcoin price for last 5 years and for last 3 months. The reason is p-values are higher than 0.05, we cannot reject the null hypothesis. We find no Granger Causality relationship between these two variables. However, a unidirectional Granger Causality which is bitcoin price Granger-cause NIKKEI 225 stock index but not vice versa for last 1 year.

Time	Null hypothesis(H0)	Prob.	Choice (5% significant level)	Results	Direction of Causality
Last 5 years	LMOSCOW does not Granger Cause LBIT	0.0781	Accept H0	LMOSCOW does not Granger Cause LBIT	**No Granger Causality**
	LBIT does not Granger Cause LMOSCOW	0.7532	Accept H0	LBIT does not Granger Cause LMOSCOW	
Last 1 Year	LMOSCOW does not Granger Cause LBIT	0.1187	Accept H0	LMOSCOW does not Granger Cause LBIT	**No Granger Causality**
	LBIT does not Granger Cause LMOSCOW	0.8883	Accept H0	LBIT does not Granger Cause LMOSCOW	
Last 3 Months	LMOSCOW does not Granger Cause LBIT	0.3837	Accept H0	LMOSCOW does not Granger Cause LBIT	**No Granger Causality**
	LBIT does not Granger Cause LMOSCOW	0.6148	Accept H0	LBIT does not Granger Cause LMOSCOW	

Table 14: Granger-Causality Result of Russia

→ *Denotes the unidirectional causality.*

As is shown above, the empirical results find all statistic p-values are higher than 5% (critical value). Therefore, we cannot reject the null hypothesis of no granger causality. We get the conclusion of no Granger Causality between Moscow stock index and bitcoin price for last 5 years, last 1 year and last 3 months in Russia.

Time	**Null hypothesis(H0)**	**Prob.**	**Choice (5% significant level)**	**Results**	**Direction of Causality**
Last 5 years	LKOSPI does not Granger Cause LBIT	0.4800	Accept H0	LKOSPI does not Granger Cause LBIT	**No Granger Causality**
	LBIT does not Granger Cause LKOSPI	0.1283	Accept H0	LBIT does not Granger Cause LKOSPI	
Last 1 Year	LKOSPI does not Granger Cause LBIT	0.5047	Accept H0	LKOSPI does not Granger Cause LBIT	**No Granger Causality**
	LBIT does not Granger Cause LKOSPI	0.3769	Accept H0	LBIT does not Granger Cause LKOSPI	
Last 3 Months	LKOSPI does not Granger Cause LBIT	0.4354	Accept H0	LKOSPI does not Granger Cause LBIT	**LBIT** → LKOSPI
	LBIT does not Granger Cause LKOSPI	0.0435	Reject H0	LBIT does Granger Cause LKOSPI	

Table 15: Granger-Causality Result of South Korea

→ *Denotes the unidirectional causality.*

South Korea: The empirical results find no Granger causality between KOSPI stock index and bitcoin price for last 5 years and last 1 year. Nevertheless, the results find unidirectional Granger Causality between two of these variables. That is bitcoin price does Granger Cause

Time	**Null hypothesis(H0)**	**Prob.**	**Choice (5% significant level)**	**Results**	**Direction of Causality**
Last 5 years	LBIT does not Granger Cause LOMXS30	0.7368	Accept H0	LBIT does not Granger Cause LOMXS30	**No Granger Causality**
	LOMXS30 does not Granger Cause LBIT	0.5087	Accept H0	LOMXS30 does not Granger Cause LBIT	
Last 1 Year	LBIT does not Granger Cause LOMXS30	0.4998	Accept H0	LBIT does not Granger Cause LOMXS30	**No Granger Causality**
	LOMXS30 does not Granger Cause LBIT	0.1692	Accept H0	LOMXS30 does not Granger Cause LBIT	
Last 3 Months	LBIT does not Granger Cause LOMXS30	0.1438	Accept H0	LBIT does not Granger Cause LOMXS30	**LOMXS30** → **LBIT**
	LOMXS30 does not Granger Cause LBIT	0.0099	Reject H0	LOMXS30 does Granger Cause LBIT	

KOSPI stock index but not vice versa for last 3 months in 2017.

Table 16: Granger-Causality Result of Sweden

→ *Denotes the unidirectional causality.*

In the case of Sweden, the empirical results find no Granger causality between OMXS 30 stock index and bitcoin price for last 5 years and for last 1 year. However, the results find a unidirectional Granger causality which is OMXS 30 stock index granger cause bitcoin price but not vice versa for last 3 months.

Time	**Null hypothesis(H0)**	**Prob.**	**Choice (5% significant level)**	**Results**	**Direction of Causality**
Last 5 years	LS_P500 does not Granger Cause LBIT	0.2762	Accept H0	LS_P500 does not Granger Cause LBIT	**LBIT → LS_P500**
	LBIT does not Granger Cause LS_P500	0.0295	Reject H0	LBIT does Granger Cause LS_P500	
Last 1 Year	LS_P500 does not Granger Cause LBIT	0.5300	Accept H0	LS_P500 does not Granger Cause LBIT	**LBIT → LS_P500**
	LBIT does not Granger Cause LS_P500	0.0102	Reject H0	LBIT does Granger Cause LS_P500	
Last 3 Months	LS_P500 does not Granger Cause LBIT	0.7522	Accept H0	LS_P500 does not Granger Cause LBIT	**LBIT → LS_P500**
	LBIT does not Granger Cause LS_P500	0.0043	Reject H0	LBIT does Granger Cause LS_P500	

Table 17: Granger-Causality Result of United States

→ *Denotes the unidirectional causality.*

USA: The empirical results find unidirectional Granger Cause for these two variables. The causality direction is bitcoin price Granger Cause S&P 500 stock index but not vice versa for last 5 years, last 1 year and last 3 months. It means that bitcoin price is leading S&P 500 stock index in the United States for the analysis time-period.

5. Conclusion and Discussion

In our thesis, we analyze the causality relationship between bitcoin and 5 different stock market indexes which are Japan, Russia, South Korea, Sweden and the United States. We apply four tests to see any causality. With the Granger Causality test, we can conclude results and you can see the next paragraph.

From last 5 years, the empirical results find no Granger causality between stock index and bitcoin price in Japan, Sweden, Russia and South Korea, except the United States. For last 1 year, the empirical results find no Granger causality between stock index and bitcoin price in Sweden, Russia and South Korea. Moreover, the results show that unidirectional Granger Cause between two variables in Japan and United States. First causality direction is bitcoin price Granger Cause stock price but not vice versa in Japan. However, the second causality direction is stock index Granger Cause bitcoin price but not vice versa in the United States. For last 3 months, the empirical results find no Granger causality between stock index and bitcoin price in Japan and Russia. In addition, the results exhibit unidirectional Granger Cause between two variables in Sweden, South Korea, and the United States. One causality direction is bitcoin price Granger Cause stock index but not vice versa in South Korea and the United States. Another causality direction is stock index Granger Cause bitcoin price but not vice versa in Sweden.

From these results, the most reasonable interpretation is that there is no any causality in the long-term except the United States. Bitcoin is on the currency market in 2009, but we start to hear its name at the beginning of 2017 and become popular instantaneously. Bitcoin has not an original currency like dollar or euro, but the transactions are made by dollar currency this will cause the bitcoin prices have a cause on S&P 500 index. In medium-run, when we looked for the year of 2017, Japan and USA are affected by bitcoin prices for their indexes NIKKEI 225 and S&P 500. With the development of cryptocurrencies, Japan one of the three big markets for trading Bitcoins and there are some speculations about decreasing the usage of cash and starting the using of new cryptocurrencies called J-Coin and Monacoin. These events cause the change of stock market index movement of Japan and actively being affected. In USA stock market continued to be caused by bitcoin volatility prices. Lastly, in the last 3 months of 2017, in the short run, except for Russia each stock market indexes affected the Bitcoin price or being affected. Sweden is the only example that its stock market index affected the Bitcoin prices. Sweden is one of the countries that decreasing its cash usage and want to implement a cashless economy in the country.

Riksbank, Swedish central bank, present the project “e-krona” in its website that Swedish government wants to use this new digital currency in the economy. The impacts of this currency may create a movement of the economy to cause Bitcoin. prices. Japan also continued to be affected but Japanese government makes some actions against cryptocurrencies usage. They are afraid so dependent on cryptocurrency market that Japanese stock market responds this action negatively. However, they are also affected by bitcoin prices but not statistically significant to its last 1-year index prices. Like Japan, South Korea is also frightened by the popularity of cryptocurrencies especially Bitcoin. Bitcoin prices have a causality on the stock market index of South Korea which is the same situation applies to their economy like the USA. When we talk about the USA, for analyzing each time-period, the effects of Bitcoin are not different. It is always statistically significant for affecting S&P 500 index.

For investment, starting from January 2013, January 2017 and October 2017, investors should consider the last 1-year period. Two big cryptocurrencies trading countries Japan's and United States' stock market indexes have significantly strong causality within Bitcoin. This leads to in which countries investors construct their investment strategies and possible outcomes of gaining Bitcoin in related to looking movement in these countries economy. Moreover, in the last 3 months except for Russia, investors should be careful about stocks in Japan, South Korea, Sweden and United States. Bitcoin remains a risky investment, but investors can gain with high returns compared to the other asset classes except for Sweden.

For further studies, Bitcoin is a new topic and it takes part actively in the economy since 2017. There are not many written articles about the function of Bitcoin that affects the country's economy or causes any relation or correlation with it. We think that our article is one of the pioneer articles that assist future articles about writing the relationship between Bitcoin and finance world in different subjects. Such as macroeconomic variables, which are the interest rate, unemployment, GDP, are also related and they cause and effect relationship in almost 1 year. We believe that the cryptocurrency subject is important in next years. The importance of cryptocurrency and popularity not as much as hype like late 2017 in 2018, but we think that cryptocurrencies are one of the major currencies that affect economical world very deeply. We suggest that we can't underestimate the power of cashless transactions which are digital currencies, may be very important macroeconomic variable to give the decision of country's economy in future.

6. References

Acheson, N. (2018). *What can you buy with bitcoins?* Retrieved January 20, 2018. from https://www.coindesk.com/information/what-can-you-buy-with-bitcoins/

Adelstein, J. (2018). *Monacoin: Japan's First Native Cryptocurrency – Next Big Thing or Next Beta-Max?* Retrieved April 19, 2018. from https://www.forbes.com/sites/adelsteinjake/2018/04/19/monacoin-japans-first-native-cryptocurrency-next-big-thing-or-next-beta-max/#7aa4e8ab3495

Akben-Selcuk, E. (2016). Granger Causality Between Stock Prices and Trading Volume: Evidence from Turkey. *Proceedings of the 22nd International Academic Conference.*

Alexandru, C. A., (2008). Indicators for the analysis of the evolution of the stock exchange, MPRA Paper 12981, University Library of Munich, Germany.

Ali, R., Barrdear, J., Clews, R. & Southgate, J. (2014). Innovations in payment technologies and the emergence of digital currencies, *Bank of England Quarterly Bulletin*, 54(3), 262–86.

Baek, C., & Elbeck, M. (2014). Bitcoins as an investment or speculative vehicle? A first look. *Applied Economics Letters, 22*(1), 30-34.

Bondi, A. B. (2000). Characteristics of scalability and their impact on performance. *Proceedings of the second international workshop on Software and performance* - WOSP'00.

Bores, R., & Hlaciuc, A. M. (2016). Digital Currency in the Current Cyber Security Environment. *Contemporary Economy Journal, 1*(3), 70-79.

Brière, M., Oosterlinck, K., & Szafarz, A. (2015). Virtual currency, tangible return: Portfolio diversification with bitcoin. *Journal of Asset Management*, *16*(6), 365-373.

Chang, S. (2018). *Russia to Criminalize Bitcoin Use as Money Substitute: Putin to Roll OutLaws.* Retrieved March 7, 2018. from https://www.investopedia.com/news/russia-criminalize-bitcoin-use-money-substitute-putin-roll-out-laws/

Chen, Qin. (2017). *Next Stop in the cryptocurrency craze: A government-backed coin.* Retrieved November 30, 2017. from https://www.cnbc.com/2017/11/30/cryptocurrency-craze-springboards-government-backed-coin.html

Cheng, E. (2018). *Bitcoin becomes just like everything else on Wall Street as correlation with stocks jumps to 2-year high.* Retrieved February 8, 2018. from https://www.cnbc.com/2018/02/08/bitcoins-correlation-with-stocks-jumps-to-2-year-high.html

Coindesk (2018). *Bitcoin Price Index – Real-time Bitcoin Price Charts.* Retrieved March 11, 2018, from https://www.coindesk.com/price/

Cox, J. (2017) *Federal Reserve starting to think about its own digital currency Dudley says.* Retrieved November 29, 2017. from https://www.cnbc.com/2017/11/29/federal-reserve-starting-to-think-about-its-own-digital-currency-dudley-says.html

Danezis, G., & Meiklejohn S. (2016). Centrally Banked Cryptocurrencies. *Proceedings 2016 Network and Distributed System Security Symposium*.

Dickey, D. A., Fuller, W. A., (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of American Statistical Association*, 74(366), 427.

Dyhrberg, A. H. (2016). Hedging capabilities of bitcoin. Is it the virtual Gold? *Finance Research Letters*, *16*, 139-144.

Dwyer, G.P. (2015). The economics of Bitcoin and similar private digital currencies. *Journal of Financial Stability*, *17,* 81-91.

Engert, W., & Fung, S.C. (2017). Central Bank Digital Currency: Motivations and Implications. *Bank of Canada Staff Discussion Paper*

Engle, R. F. & Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*. *55*(2), 251–276.

European Central Bank (ECB) (2012) *Virtual Currency Schemes*. retrieved October 2012. From http://www.ecb.int/pub/pdf/other/virtualcurrencyschemes201210en.pdf

Evans, G. & Patterson, K. (1985). The Lagrange Multiplier test for autocorrelation in the presence of linear restrictions. *Economic Letters, 17*(3), 237-241.

Fortune, P. (1998). A primer on U.S. stock price indices. *New England Economic Review*, *Federal Reserve Bank of Boston*, 25-40.

Granger, C. W. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica*. *37*(3),424–438

Grinberg, R. (2011). Bitcoin: An Innovative Alternative Currency. *Hastings Science & Technology Law Journal,* 160-216.

Guez, J. (2018). *Why Does South Korea matter so much to Bitcoin?* Retrieved January 18, 2018. from http://www.theweek.co.uk/91029/why-does-south-korea-matter-so-much-to-bitcoin

Hesse, W., Möller, E., Arnold, M. & Schack, B. (2003). The use of time-variant EEG Granger causality for inspecting directed interdependencies of neural assemblies. *Journal of Neuroscience Methods 124*(1), 27-44.

Johansen, S. & Juselius, K. (2009). Maximum Likelihood Estimation and Inference on Cointegration – With Applications to the Demand for Money. *Oxford Bulletin of Economics and Statistics 52*(2), 169-210.

Kamada, K. (2017). The Transactions Demand for Paper and Digital Currencies. *Discussion Paper* no.2017-E-6.

Kharpal, A. (2017). *Japanese banks thinking of making their own cryptocurrency called the J-Coin.* Retrieved September 27, 2017. from https://www.cnbc.com/2017/09/27/japanese-banks-cryptocurrency-j-coin.html

Morris, C. (2017). *Bitcoin Regrets: How Much $100 Would Be Worth Today if You Invested Earlier.* Retrieved December 12, 2017. from http://fortune.com/2017/12/12/bitcoin-historical-investment-values/

Nakamoto, S. (2008), Bitcoin: A Peer-to-Peer Electronic Cash System, *Working Paper*, Retrieved October 31, 2008. from http://bitcoin.org/bitcoin.pdf.

Quantstart (2016). Johansen Test for Cointegrating Time Series Analysis in R. Retrieved June 20, 2016. from https://www.quantstart.com/articles/Johansen-Test-for-Cointegrating-Time-Series-Analysis-in-R

Reiff, N. (2018*). Why is South Korea so Important to Bitcoin Prices?* Retrieved February 20, 2018. from https://www.investopedia.com/news/why-south-korea-so-important-bitcoin-prices/

Rhoads, R. (2017). *Bitcoin vs. VIX – What Has Been More Volatile in 2017?* Retrieved November 14, 2017. from http://www.cboe.com/blogs/options-hub/2017/11/14/bitcoin-vs.-vix---what-has-been-more-volatile-in-2017

Roden, L. (2018). *Sweden predicted to become the first country with own cryptocurrency*. Retrieved January 15, 2018. from https://www.thelocal.se/20180115/sweden-predicted-to-become-first-country-with-own-cryptocurrency

Sharma, R. (2018). *Are Bitcoin Price and Equity Markets Returns Correlated?* Retrieved February 23, 2018. from https://www.investopedia.com/news/are-bitcoin-price-and-equity-markets-returns-correlated/

Schut, M. (2017). Bitcoin analysis from an investor's perspective: insight into market relations and diversification possibilities. *Erasmus School of Economics*.

Sovbetov, Y. (2018). Factors Influencing Cryptocurrency Prices: Evidence from Bitcoin, Ethereum, Dash, Litcoin, and Monero. *Journal of Economics and Financial Analysis*, *2*(2), 1-27.

Suberg, W. (2018*). Putin Confirms Russia Will Regulate ICOs, Mining July 2018*. Retrieved October 24, 2017. from https://cointelegraph.com/news/putin-confirms-russia-will-regulate-icos-mining-by-july-2018

Toda, H.Y. & Yamamoto, T. (1995) Statistical Inference in Vector Autoregressions with Possibly Integrated Processes. *Journal of Econometrics*, *66*, 225-250.

Zuckerman, M.J. (2018) *Google Searches for 'Bitcoin' Slump in Synchronicity with Bitcoin's Price.* Retrieved March 11, 2018. from https://cointelegraph.com/news/google-searches-for-bitcoin-slump-in-synchronicity-with-bitcoins-price

7. Appendix

Appendix 1: Unit Root Results (ADF Test)

Bitcoin

Level:

Null Hypothesis: LBIT has a unit root			
Exogenous: Constant, Linear Trend			
Lag Length: 0 (Automatic - based on SIC, maxlag=22)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.527407	0.8200
Test critical values:	1% level	-3.965181	
	5% level	-3.413301	
	10% level	-3.128678	
*MacKinnon (1996) one-sided p-values.			

First difference:

Null Hypothesis: D(LBIT) has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=22)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-34.71384	0.0000
Test critical values:	1% level	-3.435223	
	5% level	-2.863580	
	10% level	-2.567905	
*MacKinnon (1996) one-sided p-values.			

Japan

Level:

Null Hypothesis: LNIKKEI225 has a unit root			
Exogenous: Constant, Linear Trend			
Lag Length: 1 (Automatic - based on SIC, maxlag=22)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.234541	0.0781
Test critical values:	1% level	-3.965109	
	5% level	-3.413266	
	10% level	-3.128657	
*MacKinnon (1996) one-sided p-values.			

First difference:

Null Hypothesis: D(LNIKKEI225) has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=22)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-47.90702	0.0001
Test critical values:	1% level	-3.435161	
	5% level	-2.863552	
	10% level	-2.567891	
*MacKinnon (1996) one-sided p-values.			

Russia

Level:

Null Hypothesis: LMOSCOW has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=22)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.311904	0.4266
1% level	-3.965104	
5% level	-3.413264	
10% level	-3.128656	

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

First difference:

Null Hypothesis: D(LMOSCOW) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-35.95363	0.0000
Test critical values:	1% level	-3.435161	
	5% level	-2.863552	
	10% level	-2.567891	

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

South Korea

Level:

Null Hypothesis: LKOSPI has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 1 (Automatic - based on SIC, maxlag=22)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.932579	0.6367
Test critical values:	1% level	-3.965109	
	5% level	-3.413266	
	10% level	-3.128657	

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

First difference:

Null Hypothesis: D(LKOSPI) has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=22)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-32.74054	0.0000
Test critical values:	1% level	-3.435161	
	5% level	-2.863552	
	10% level	-2.567891	
*MacKinnon (1996) one-sided p-values.			

Sweden

Level:

Null Hypothesis: LOMXS30 has a unit root			
Exogenous: Constant, Linear Trend			
Lag Length: 0 (Automatic - based on SIC, maxlag=22)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.815594	0.1918
Test critical values:	1% level	-3.965104	
	5% level	-3.413264	
	10% level	-3.128656	
*MacKinnon (1996) one-sided p-values.			

First difference:

Null Hypothesis: D(LOMXS30) has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=22)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-38.47533	0.0000
Test critical values:	1% level	-3.435161	

	5% level	-2.863552
	10% level	-2.567891

United States

Level:

Null Hypothesis: LS_P500 has a unit root			
Exogenous: Constant, Linear Trend			
Lag Length: 0 (Automatic - based on SIC, maxlag=22)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.287107	0.0688
Test critical values:	1% level	-3.965104	
	5% level	-3.413264	
	10% level	-3.128656	
*MacKinnon (1996) one-sided p-values.			

First difference:

Null Hypothesis: D(LS_P500) has a unit root			
Exogenous: Constant			
Lag Length: 0 (Automatic - based on SIC, maxlag=22)			
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-37.16596	0.0000
Test critical values:	1% level	-3.435161	
	5% level	-2.863552	
	10% level	-2.567891	
*MacKinnon (1996) one-sided p-values.			

Appendix 2: Determination of the optimal lag length

Bitcoin Japan

VAR Lag Order Selection Criteria
Endogenous variables: LBIT LNIKKEI225

Exogenous variables: C

Sample: 1/01/2013 12/29/2017

Included observations: 1274

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-188.9154	NA	0.004626	0.299710	0.307795	0.302747
1	5622.574	11595.61	5.08e-07	-8.817228	-8.792974	-8.808119
2	**5669.091**	**92.66794***	**4.75e-07***	**-8.883973***	**-8.843550***	**-8.868791***
3	5672.377	6.536831	4.76e-07	-8.882853	-8.826261	-8.861598
4	5675.785	6.765999	4.76e-07	-8.881922	-8.809161	-8.854595
5	5680.418	9.187544	4.76e-07	-8.882917	-8.793986	-8.849517
6	5681.608	2.354121	4.78e-07	-8.878505	-8.773404	-8.839031

Bitcoin Russia

VAR Lag Order Selection Criteria

Endogenous variables: LMOSCOW LBIT

Exogenous variables: C

Sample: 1/01/2013 12/29/2017

Included observations: 1274

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1730.429	NA	0.052022	2.719668	2.727753	2.722705
1	**4763.447**	**12957.17***	**1.96e-06***	**-7.468519***	**-7.444265***	**-7.459410***
2	4764.687	2.470043	1.97e-06	-7.464186	-7.423763	-7.449004
3	4766.852	4.307733	1.97e-06	-7.461307	-7.404714	-7.440052
4	4768.018	2.313883	1.98e-06	-7.456857	-7.384095	-7.429529
5	4772.089	8.071642	1.98e-06	-7.456968	-7.368037	-7.423567
6	4773.171	2.141911	1.99e-06	-7.452387	-7.347287	-7.412914

Bitcoin South Korea

VAR Lag Order Selection Criteria

Endogenous variables: LBIT LKOSPI

Exogenous variables: C

Sample: 1/01/2013 12/29/2017

Included observations: 1274

Lag	LogL	LR	FPE	AIC	SC	HQ

0	-435.9587	NA	0.006818	0.687533	0.695618	0.690570
1	5987.298	12816.26	2.86e-07	-9.389794	-9.365540*	-9.380684
2	**5997.562**	**20.44641***	**2.84e-07***	**-9.399626***	**-9.359203**	**-9.384444***
3	5999.666	4.184988	2.85e-07	-9.396650	-9.340057	-9.375395
4	6002.615	5.856258	2.85e-07	-9.395000	-9.322238	-9.367672
5	6005.821	6.356350	2.85e-07	-9.393753	-9.304822	-9.360353
6	6007.980	4.274379	2.86e-07	-9.390864	-9.285763	-9.351390

Bitcoin Sweden

VAR Lag Order Selection Criteria

Endogenous variables: LOMXS30 LBIT

Exogenous variables: C

Sample: 1/01/2013 12/29/2017

Included observations: 1280

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-669.7440	NA	0.009792	1.049600	1.057654	1.052624
1	**5777.690**	**12864.65***	**4.15e-07***	**-9.018265***	**-8.994103***	**-9.009193***
2	5780.975	6.544606	4.16e-07	-9.017148	-8.976878	-9.002027
3	5783.908	5.833675	4.17e-07	-9.015481	-8.959102	-8.994311
4	5787.211	6.559944	4.17e-07	-9.014392	-8.941905	-8.987174

Bitcoin United States

VAR Lag Order Selection Criteria

Endogenous variables: LBIT LS_P500

Exogenous variables: C

Sample: 1/01/2013 12/29/2017

Included observations: 1274

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-471.1792	NA	0.007205	0.742824	0.750909	0.745861
1	**6306.705**	**13523.85***	**1.74e-07***	**-9.891216***	**-9.866962***	**-9.882107***
2	6310.243	7.048686	1.74e-07	-9.890491	-9.850068	-9.875309
3	6311.511	2.523452	1.74e-07	-9.886203	-9.829611	-9.864948

4	6314.059	5.059808	1.75e-07	-9.883924	-9.811162	-9.856596
5	6317.969	7.751541	1.75e-07	-9.883782	-9.794851	-9.850381
6	6319.499	3.028955	1.75e-07	-9.879904	-9.774804	-9.840431

Appendix 3: Diagnostic check for residuals, Serial Correlation LM Tests

Bitcoin Japan

VAR Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Sample: 1/01/2013 12/29/2017

Included observations: 1286

Lags	LM-Stat	Prob
1	6.446219	0.1682
2	7.072488	0.1321
3	4.732352	0.3159

Bitcoin Russia

VAR Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Sample: 1/01/2013 12/29/2017

Included observations: 1289

Lags	LM-Stat	Prob
1	2.350507	0.6716
2	4.436596	0.3501

Probs from chi-square with 4 df.

Bitcoin South Korea

VAR Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Sample: 1/01/2013 12/29/2017

Included observations: 1286

Lags	LM-Stat	Prob

1	3.960941	0.4113
2	3.648014	0.4557
3	6.693737	0.1530
Probs from chi-square with 4 df.		

Bitcoin Sweden

VAR Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Sample: 1/01/2013 12/29/2017

Included observations: 1289

Lags	LM-Stat	Prob
1	6.555194	0.1613
2	5.470435	0.2423

Bitcoin United States

VAR Residual Serial Correlation LM Tests

Null Hypothesis: no serial correlation at lag order h

Sample: 1/01/2013 12/29/2017

Included observations: 1289

Lags	LM-Stat	Prob
1	7.363051	0.1179
2	2.249343	0.6900

Appendix 4: Johansen Test result

Bitcoin Japan

Sample (adjusted): 1/04/2013 12/29/2017
Included observations: 1283 after adjustments
Trend assumption: No deterministic trend
Series: LBIT LNIKKEI225
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.010683	14.00824	12.32090	**0.0258**
At most 1	0.000177	0.227701	4.129906	0.6910

Trace test indicates 1 cointegrating eqn (s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.010683	13.78054	11.22480	**0.0174**
At most 1	0.000177	0.227701	4.129906	0.6910

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Bitcoin Russia

Sample (adjusted): 1/03/2013 12/29/2017
Included observations: 1286 after adjustments
Trend assumption: No deterministic trend
Series: LBIT LMOSCOW
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.021685	29.02498	12.32090	**0.0000**
At most 1	0.000646	0.831072	4.129906	0.4176

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.021685	28.19391	11.22480	**0.0000**
At most 1	0.000646	0.831072	4.129906	0.4176

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Bitcoin South Korea

Sample (adjusted): 1/04/2013 12/29/2017

Included observations: 1283 after adjustments

Trend assumption: Linear deterministic trend (restricted)

Series: LBIT LKOSPI

Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.021034	28.82775	25.87211	**0.0208**
At most 1	0.001210	1.553887	12.51798	0.9893

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.021034	27.27386	19.38704	**0.0029**
At most 1	0.001210	1.553887	12.51798	0.9893

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Bitcoin Sweden

Sample (adjusted): 1/03/2013 12/29/2017
Included observations: 1286 after adjustments
Trend assumption: No deterministic trend
Series: LBIT LOMXS30
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.009502	12.28118	12.12090	0.0498
At most 1	2.77E-06	0.003567	4.129906	0.9602

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.009502	12.27762	11.22480	**0.0325**
At most 1	2.77E-06	0.003567	4.129906	0.9602

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Bitcoin United States

Sample (adjusted): 1/03/2013 12/29/2017

Included observations: 1286 after adjustments

Trend assumption: Linear deterministic trend (restricted)

Series: LBIT LS_P500

Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.011034	16.89780	25.87211	**0.4226**
At most 1	0.002043	2.629420	12.51798	0.9174

Trace test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.011034	14.26838	19.38704	**0.2367**
At most 1	0.002043	2.629420	12.51798	0.9174

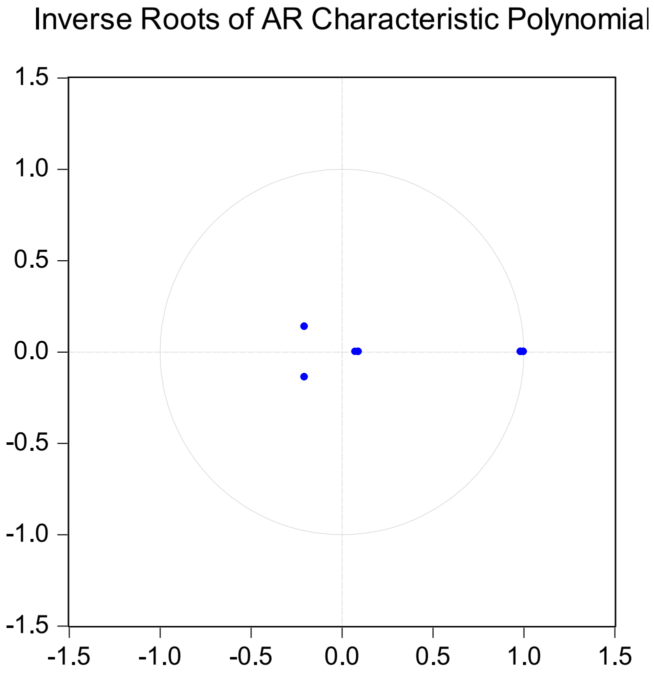
Max-eigenvalue test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

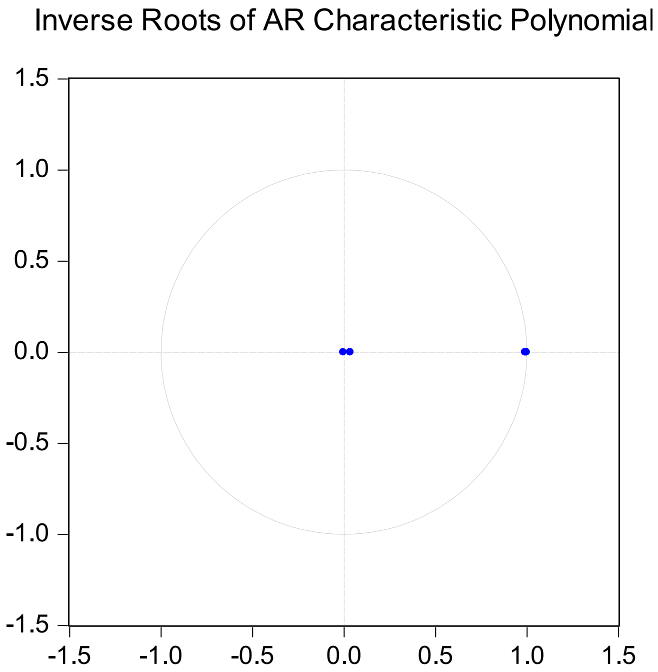
**MacKinnon-Haug-Michelis (1999) p-values

Appendix 5: AR Roots Graph

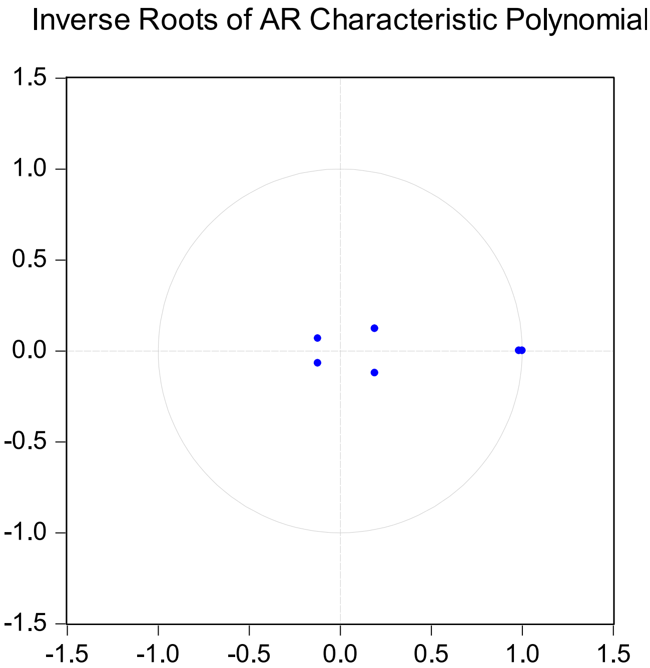
Bitcoin Japan



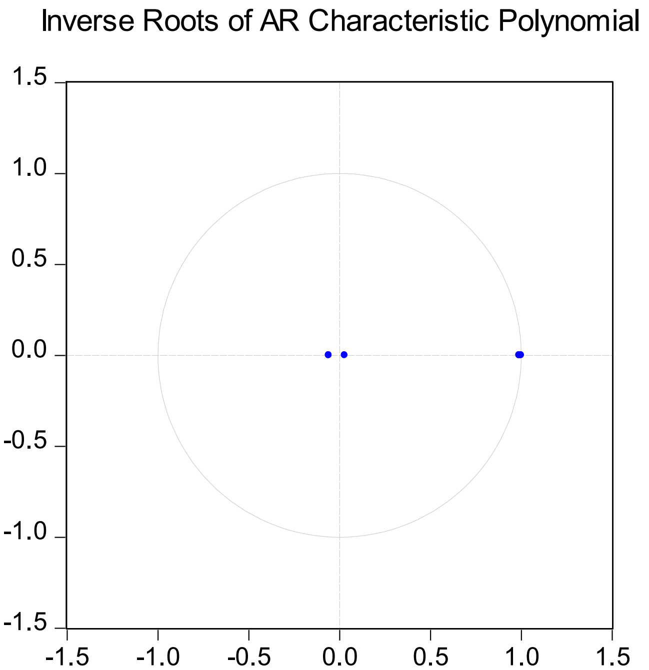
Bitcoin Russia



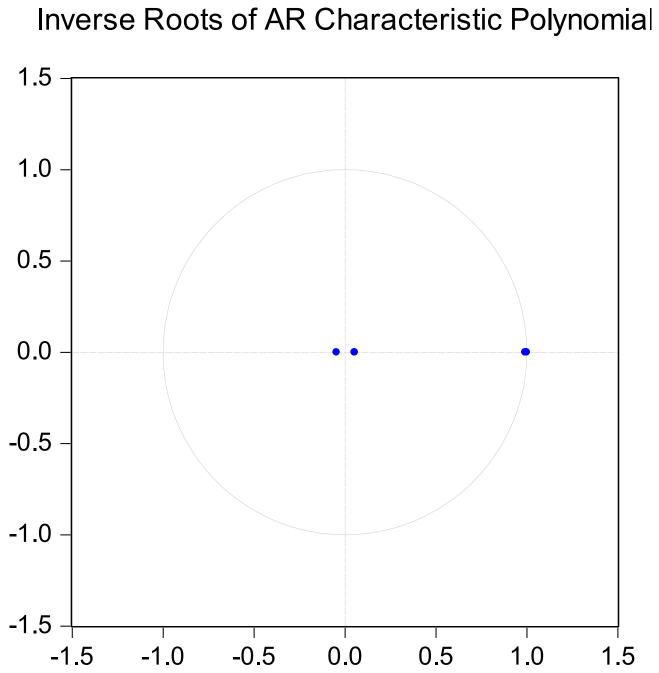
Bitcoin South Korea



Bitcoin Sweden



Bitcoin United States



Appendix 6: The result of the Granger Causality Test

Bitcoin Japan

5 years

VAR Granger Causality/Block Exogeneity Wald Tests Sample: 1/01/2013 12/29/2017 Included observations: 1283			
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LNIKKEI225	0.427429	2	**0.8076**
All	0.427429	2	0.8076
Dependent variable: LNIKKEI225			

Excluded	Chi-sq	df	Prob.
LBIT	4.320609	2	**0.1153**
All	4.320609	2	0.1153

1 year

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 1/02/2017 12/29/2017			
Included observations: 260			
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LNIKKEI225	0.467073	2	**0.7917**
All	0.467073	2	0.7917
Dependent variable: LNIKKEI225			
Excluded	Chi-sq	df	Prob.
LBIT	6.643861	2	**0.0361**
All	6.643861	2	0.0361

3 months

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 10/02/2017 12/29/2017			
Included observations: 65			
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LNIKKEI225	0.376041	2	**0.8286**

All	0.376041	2	0.8286
Dependent variable: LNIKKEI225			
Excluded	Chi-sq	df	Prob.
LBIT	5.670728	2	**0.0587**
All	5.670728	2	0.0587

Bitcoin Russia

5 years

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 1/01/2013 12/29/2017			
Included observations: 1286			
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LMOSCOW	3.103084	1	**0.0781**
All	3.103084	1	0.0781
Dependent variable: LMOSCOW			
Excluded	Chi-sq	df	Prob.
LBIT	0.098898	1	**0.7532**
All	0.098898	1	0.7532

1 year

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 1/02/2017 12/29/2017			

Included observations: 260

Dependent variable: LBIT

Excluded	Chi-sq	df	Prob.
LMOSCOW	2.434099	1	**0.1187**
All	2.434099	1	0.1187

Dependent variable: LMOSCOW

Excluded	Chi-sq	df	Prob.
LBIT	0.019738	1	**0.8883**
All	0.019738	1	0.8883

3 months

VAR Granger Causality/Block Exogeneity Wald Tests

Sample: 10/02/2017 12/29/2017

Included observations: 65

Dependent variable: LBIT

Excluded	Chi-sq	df	Prob.
LMOSCOW	0.758684	1	**0.3837**
All	0.758684	1	0.3837

Dependent variable: LMOSCOW

Excluded	Chi-sq	df	Prob.
LBIT	0.253197	1	**0.6148**
All	0.253197	1	0.6148

Bitcoin South Korea

5 years

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 1/01/2013 12/29/2017			
Included observations: 1283			
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LKOSPI	1.468018	2	**0.4800**
All	1.468018	2	0.4800
Dependent variable: LKOSPI			
Excluded	Chi-sq	df	Prob.
LBIT	4.107538	2	**0.1283**
All	4.107538	2	0.1283

1 year

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 1/02/2017 12/29/2017			
Included observations: 260			
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LKOSPI	1.367477	2	**0.5047**
All	1.367477	2	0.5047

Dependent variable: LKOSPI			
Excluded	Chi-sq	df	Prob.
LBIT	1.951581	2	**0.3769**
All	1.951581	2	0.3769

3 months

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 10/02/2017 12/29/2017			
Included observations: 65			
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LKOSPI	1.662774	2	**0.4354**
All	1.662774	2	0.4354
Dependent variable: LKOSPI			
Excluded	Chi-sq	df	Prob.
LBIT	6.269329	2	**0.0435**
All	6.269329	2	0.0435

Bitcoin Sweden

5 years

VAR Granger Causality/Block Exogeneity Wald Tests
Sample: 1/01/2013 12/29/2017
Included observations: 1286

Dependent variable: LOMXS30			
Excluded	Chi-sq	df	Prob.
LBIT	0.112968	1	**0.7368**
All	0.112968	1	0.7368
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LOMXS30	0.436777	1	**0.5087**
All	0.436777	1	0.5087

1 year

VAR Granger Causality/Block Exogeneity Wald Tests Sample: 1/02/2017 12/29/2017 Included observations: 260			
Dependent variable: LOMXS30			
Excluded	Chi-sq	df	Prob.
LBIT	0.455434	1	**0.4998**
All	0.455434	1	0.4998
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LOMXS30	1.890033	1	**0.1692**
All	1.890033	1	0.1692

3 months

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 10/02/2017 12/29/2017			
Included observations: 65			
Dependent variable: LOMXS30			
Excluded	Chi-sq	df	Prob.
LBIT	2.136970	1	**0.1438**
All	2.136970	1	0.1438
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LOMXS30	6.648251	1	**0.0099**
All	6.648251	1	0.0099

Bitcoin United States

5 years

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 1/01/2013 12/29/2017			
Included observations: 1286			
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LS_P500	1.185537	1	**0.2762**
All	1.185537	1	0.2762
Dependent variable: LS_P500			

Excluded	Chi-sq	df	Prob.
LBIT	4.735300	1	**0.0295**
All	4.735300	1	0.0295

1 year

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 1/02/2017 12/29/2017			
Included observations: 260			
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LS_P500	0.394429	1	**0.5300**
All	0.394429	1	0.5300
Dependent variable: LS_P500			
Excluded	Chi-sq	df	Prob.
LBIT	6.592712	1	**0.0102**
All	6.592712	1	0.0102

3 months

VAR Granger Causality/Block Exogeneity Wald Tests			
Sample: 10/02/2017 12/29/2017			
Included observations: 65			
Dependent variable: LBIT			
Excluded	Chi-sq	df	Prob.
LS_P500	0.099658	1	**0.7522**

All	0.099658	1	0.7522

Dependent variable: LS_P500

Excluded	Chi-sq	df	Prob.
LBIT	8.159916	1	**0.0043**
All	8.159916	1	0.0043