Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Economics

Diploma Thesis

Economic Analysis of Bitcoin as an Investment Vehicle

Author: Evan Conner Clayton

Supervisor: Petr Procházka, MSc, Ph. D.

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

Bc. Evan Conner Clayton

Economics and Management

Thesis title

Economic Analysis of Bitcoin as an Investment Vehicle

Objectives of thesis

The aim of this thesis is to introduce the idea of Bitcoin to the author and to give relevant information about its existence to then lead the reader into the analytical section where they will go in depth into an analysis to answer the questions below, and to evaluate its value as a modern-day investment choice.

The following questions will be answered:
What role does Bitcoin play in an investor's portfolio?
Will Bitcoin increase in value or decrease in value within a short time period (30 days), and 1 year?
Is there a relationship between increasing difficulty of mining Bitcoins and the price of Bitcoin?

Methodology

The first part will be done by analyzing relevant available information in the form of literature both digitally and physically. With Bitcoins popularity rising, there have been significant amounts of literature produced about the topic. The second part (Analytical section) will be achieved by evaluating the digital currency with other modern currencies/commodities. Regression analysis, moving averages, and econometrical models will be used to achieve the goal of determining if Bitcoin is a truly potential investment choice.

More specifically,

"What role does Bitcoin play in an investor's portfolio?" will be answered by means of describing the different types of roles investments play (less risky, medium risky, risky, very risky), and then in the analytical section this will be determined by calculation of standard deviation.

Will Bitcoin increase in value or decrease in value within a short time period (30 days), and 1 year?" Will be determined by collecting historical pricing data and then creating a forecast in Gretl by means of ARIMA.

"Is there a relationship between increasing difficulty of mining Bitcoins and the price of Bitcoin?" Will be answered by collecting data of the difficulty of mining Bitcoin with the prices and then doing a regression analysis in either Excel or Gretl.

The proposed extent of the thesis

60 pages

Keywords

Bitcoin, Investment, Cryptocurrency, Blockchain, Regression, Correlation, ARIMA, Mining

---

Recommended information sources

Antonopoulos, A. (2017). Mastering bitcoin. Sebastopol, CA: O'Reilly. ISBN 978-1491954386

Investing.com. (2017). Investing.com – Stock Market Quotes & Financial News. [online] Available at: https://www.investing.com [Accessed 11 Nov. 2017].

Narayanan, A., Bonneau, J., Felten, E., Miller, A. and Goldfeder, S. (2016). Bitcoin and cryptocurrency technologies. ISBN 978-0-691-17169-2

Szmigielski, A. (2016). Bitcoin Essentials. Birmingham: Packt Publishing, Limited. ISBN 978-1785281976

Expected date of thesis defence

2017/18 SS – FEM

The Diploma Thesis Supervisor

Ing. Petr Procházka, Ph.D., MSc

Supervising department

Department of Economics

Electronic approval: 5. 3. 2018

prof. Ing. Miroslav Svatoš, CSc.

Head of department

Electronic approval: 6. 3. 2018

Ing. Martin Pelikán, Ph.D.

Dean

Prague on 09. 03. 2018

Declaration

I declare that the Diploma thesis titled “Economic Analysis of Bitcoin as an investment vehicle” has been generated by myself as the result of my own original research. Only sources I used are listed in the references. As the author of the diploma thesis, I declare that the thesis does not break copyrights of any other person.

In Prague on _____

Evan Clayton

Acknowledgement

I would like to thank my thesis supervisor, Mr. Prochazka for his guidance throughout the entire thesis process as well as my friend Frantisek Demko for his role in motivating me to study in Europe. Also, and most importantly I would like to thank my parents, Robert and Michele for their never-ending love and support throughout my studies because without them none of my past few years in Prague and at CZU would be possible.

Economic Analysis of Bitcoin as an Investment Vehicle

Abstract

This Diploma thesis was written to discuss and analyze Bitcoin as an investment vehicle.

The Diploma thesis is split into two main sections, the theoretical section where background information is given about Bitcoin and its functions to help the reader gain a decent level of understanding of Bitcoin and the second section is the analytical section where data and information was used to answer the following questions:

- What role does Bitcoin play in an investor's portfolio?
- Based on a time series analysis, where is the price of Bitcoin likely to go?
- What effect do the amount of Transactions per Block, Costs per Transaction, and amount of Transactions have on the price of Bitcoin?

Keywords: Bitcoin, Investment, Crypto-Currency, Portfolio, Risk, Value, Money, Volatility, Appreciate, Exchange

Ekonomická Analýza Bitcoin jako Investiční nástroj

Abstraktní

Tato Diplomová práce byla napsána, aby diskutovat a analyzovat Bitcoin jako investiční nástroj.

Diplomová práce je rozdělena do dvou hlavních částí, teoretické sekci, kde informace o Bitcoin a jeho funkce tak, aby čtenář mohl získat slušnou úroveň pochopení Bitcoin a druhá část je analytická část, kde jsou údaje a informace byly použity pro odpověď na následující otázky:

• Jakou roli má Bitcoin hrát v portfoliu investora?

• Na základě analýzy časových řad, kde je cena z Bitcoin pravděpodobné, že jít?

• Jaký je dopad na množství Transakcí za Blok, Náklady na Transakci a částku Transakce na cenu Bitcoinu?

Klíčová Slova: Bitcoin, Investice, Crypto-Měny, Portfolio, Riziko, Hodnota, Peníze, Volatilita, Ocenit, Výměna

Table of Figures

Table of Tables

List of Abbreviations

ACF	Autocorrelation Function
ADF	Augmented Dickey Fuller
ARIMA	Autoregressive Integrated Moving Average
ASIC	Application Specific Integrated Circuit
BTC	Bitcoin
CEO	Chief Executive Officer
CPU	Central Processing Unit
etc.	*et cetera*, and so on
GPU	Graphics Processing Unit
HTML	Hypertext Markup Language
IRS	Internal Revenue Service
OLSM	Ordinary Least Squares Method
PACF	Partial Autocorrelation Function
SPV	Simplified Payment Verification
UK	United Kingdom
US	United States
USA	United States of America
USB	Universal Serial Bus
USD	United States Dollar
WIF	Wallet Import Format

Table of Contents

1. Introduction

In the modern-day economy, it has become inevitable that technology will begin its overtake on the attainment of wealth and more specifically wealth attained through investments. While in the past, investors had a narrow range of physical commodities that would often take significant amounts of time to exchange, modern day investments are more instantaneous due to technology such as the internet. With investors having many traditional choices of investments to choose from, the economy with the help of technology and the internet has begun to develop so much as to have modern day "digital" commodities. At the forefront of these digital commodities is "Bitcoin". With the rise of digital commodities comes with new challenges as well as new benefits. Security, anonymity, governance, are all concerns with digital currencies such as Bitcoin. Fortunately for investors that are willing to consider Bitcoin, there are many benefits. The lack of a central exchange keeps the currency in the power of the people that hold them, and not in the power of a central entity. User to user transactions keep out unwanted influence on the currency and its exchanges.

Bitcoin was first presented in 2007 and has slowly gained respectability and interest within the past decade since its first presence. With a small investment at the beginning only ten years ago, to becoming worth thousands of percentages more now, it's not a surprise that Bitcoin has many investors attention.

2. Objectives and Methodology

2.1 Objectives

The main objective of this diploma thesis is to determine Bitcoins position as an investment vehicle. With its significant media attention in recent years, the underlying economic factors of Bitcoin have been very interesting and therefore this thesis is to bring to light some of these factors. The primary questions to be answered are the following.

- What role does Bitcoin play in an investor's portfolio?
- Based on a time series analysis, where is the price of Bitcoin likely to go?
- What effect do the amount of Transactions per Block, Costs per Transaction, and amount of Transactions have on the price of Bitcoin?

2.2 Methodology

The first part will be done by analyzing relevant available information in the form of literature both digitally and physically. With Bitcoins popularity rising, there have been significant amounts of literature produced about the topic. The second part (Analytical section) will be achieved by regression analysis such as forecasting, moving averages, and econometrical models will be used to achieve the goal of determining Bitcoins place as an investment vehicle.

3. Theoretical Section

3.1 Defining Bitcoin

Bitcoin is a form of a digital money, that is created by the Bitcoin digital ecosystem. These Bitcoins are transferred and stored among end users within the Bitcoin network. These end users, use the internet as a way of transfer and communicating with one another. Simple Bitcoin software that can be easily obtained from the internet can do this for a person allowing for simple devices such as laptops and phones to have access to Bitcoin. (Antonopoulos, A. 2015).

Besides the fact that Bitcoin is anonymous and has no centralization, conceptually it is not significantly different from other internet exchange places on the internet such as PayPal, where people are able to send and receive money. (Antonopoulos, A. 2015).

While the name implies that the currency is a coin, it is not physical in any way. The coins are simple implied transactions with a certain value that is transferred between the users. This is a difficult concept to explain to most people that have not heard of Bitcoin because most currencies and commodities have something backing it up. For example, people that use gold as currency can at any time use the gold its self because its physical, however that is not the case with Bitcoin. (Antonopoulos, A. 2015).

3.2 Brief Historical Timeline of Bitcoin (2008-2014)

October 2008: A publishers outlines a user to user electronic currency system known as “Bitcoin”. The idea is to use a software code (blockchain) to authenticate and protect transactions without a central authority. (JM Bullion. 2018)

May 2010: A person becomes the first person to use Bitcoin to purchase something. They bought a pizza at the cost of 10,000 Bitcoins, which at today’s current price would be worth around $57,000,000. (JM Bullion. 2018)

July 2011: Bitcoin accounts become victims of hacking and theft, leading many to become nervous about the currency and its safety as well as legal fears. (JM Bullion. 2018)

July 2012: The use of Bitcoin grows significantly in illegal markets causing negative press for the currency. Despite this many organizations and pioneers try to legitimize the currency by providing education information to the public. (JM Bullion. 2018)

March 2013: European authorities seize some banking assets leading to a rise in the price of Bitcoin due to its inability to be seized by government agencies. (JM Bullion. 2018)

April 2013: Price surges in the value of Bitcoin cause it to nearly reach $1,000,000,000. (JM Bullion. 2018)

May 2013: The largest exchange Mt. Gox is investigated by the department of homeland security for operation as a monetary transmitter without licenses. (JM Bullion. 2018)

July 2013: A man from Texas, USA is accused of a Ponzi scheme trying to collect bitcoins from investors and uses them on his own expenses. Chase Bank, Citibank, Wells Fargo, and US bank stop allowing accounts for small businesses that deal with Bitcoin. (JM Bullion. 2018)

August 2013: Chase bank applies for a patent to create an alternative to Bitcoin that they can regulate. The committee on Homeland Security and Government affairs then requested a hearing on Bitcoin. (JM Bullion. 2018)

October 2013: An underground marketplace famous for dealing with shading dealings such as drugs and illegal items, Silk road, is believed to be responsible for half of all Bitcoin transactions. This is due to the anonymity of it and the inability to track the currency. As well, China announces the company Baidu will accept the currency. (JM Bullion. 2018)

November 2013: The value of Bitcoin rises to around $800, which leads to the total value of Bitcoins to be worth more than $7 Billion. As well, a hearing held by the Department of Justice concludes that Bitcoin can be a legal means of exchange. Also in November, the first university in the world accepts bitcoin (Cyprus University). (JM Bullion. 2018)

December 2013: Chase banks patent for a similar technology to Bitcoin dubbed the "bitcoin killer" its published. (JM Bullion. 2018)

January 2014: Famed video game designer "Zygna", the online retailer Overstock.com, as well as the Sacramento Kings basketball team all being accepting Bitcoin as a means of currency. Wells Fargo considers offering services in Bitcoin. (JM Bullion. 2018)

February 2014: Russia declares Bitcoin illegal. The massive Bitcoin exchange Mt. Gox has difficulties and as a result suspends trading. Apple pulls the blockchain app from the App store. (JM Bullion. 2018)

March 2014: The IRS publishes an article on how cryptocurrencies such as Bitcoin, should be handed by Americans for tax purposes. (JM Bullion. 2018)

April 2014: eBay adds a virtual currency category to its listing. (JM Bullion. 2018)

May 2014: Democratic U.S. Representative Jared Polis accepts Bitcoin for his campaign funding. (JM Bullion. 2018)

3.3 How Bitcoin is Acquired

3.3.1 Mining

Bitcoin is acquired through a process known as Mining. This mining is just running Bitcoin software that is looking at solving complex algorithms. When a problem is solved, the miner or miners are rewarded with Bitcoin. This is done by using a computers processing power to continuously solve these complex problems. Bitcoin mining decentralizes the acquisition of currency because it is not acquired through an organization. It is simple mined and is then owned in the same way that a traditional miner, mines and receives something such as coal and then keeps it. This is a simple transaction between two people directly without the need of a third party such as a government. This mining creates global competition because of its ease of mining. (Antonopoulos, A. 2015).

On average miners solve these complex problems once every 10 minutes. Unfortunately for miners Bitcoins protocol halves at the rate at which new coins are created (every 4 years). This creates a limit for the total amount of Bitcoins that are able to be mined, leading to a total number of 21 Million coins. This is predicted to be reached by the year 2140. Unlike other currencies, Bitcoin cannot be inflated by creating or printing new money and therefore the Bitcoins that are in circulation will not influenced due to new coins after the 2140 date. (Antonopoulos, A. 2015).

Below is an example of what a Bitcoin mine looks like. It is made of a simple wood platform with railing to hold the graphics cards (the hanging rectangle objects). The graphics cards use is to do the majority of the calculations to mine the Bitcoin. Then on the wood plank towards the bottom is a motherboard which tells the graphics cards and other components what to do. Then on the end of the plank (both left and right) are square shaped objects, which are the power supplies, which as the name implies, is what powers the system. The power supply is powered by a simple plugin into a wall outlet. (Antonopoulos, A. 2015).

Figure 1 - Bitcoin Mining Rig

Source: Us.v-cdn.net (2018)

3.3.2 Costs Associate with Acquiring Bitcoin

3.3.2.1 Fixed Costs (Hardware)

The fixed costs of Bitcoin mining which are the hardware, have and are rapidly changing. In the beginning of Bitcoin, mining was able to be done with a typical computers Central Processing Unit (CPU) which is in all modern computers. Over the years though Bitcoin has become more and more intensive to mine, leading to a transition from using a generic CPU to a GPU (Graphics Processing Unit), which is generally in most modern computers. However, not all GPU's are alike. A typical computer user that doesn't use graphically intense programs or play video games doesn't need a high end GPU (a powerful and expensive GPU). They generally will have a lower end one made for simple tasks. At first these GPU's were able to be used to mine Bitcoin but overtime only high end expensive GPU's were able to mine. Further down the line, even these expensive high end GPU's weren't able to keep up with mining Bitcoin in a profitable way so the community transitioned into what is known as "Application Specific Integrated Circuits" (ASIC's).

Table 1 – Selected Bitcoin Miners

Miner	Capacity (Gh/s)	Efficiency (W/Gh)	Price
AntMiner S1	180	2	$299.00
AntMiner S2	1000	1.1	$2,259.00
AntMiner S3	441	0.77	$382.00
AntMiner S4	2000	0.7	$1,400.00
AntMiner S5	1155	0.51	$370.00
AntMiner S5+	7722	0.44	$2,307.00
AntMiner S7	4.73	0.25	$479.95
AntMiner S9	13.5	0.098	$1,987.95
AntMiner U1	2	1.25	$29.00
AntMiner U2	2	1	$49.66
AntMiner U3	63	1	$38.00

ASICMiner BE Blade	11	7.72	$350.00
ASICMiner BE Cube	30	6.67	$550.00
ASICMiner BE Tube	800	1.13	$320.00
ASICMiner BE Prisma	1400	0.79	$600.00
Avalon Batch 1	66	9.35	$1,299.00
Avalon Batch 2	82	8.54	$1,499.00
Avalon 6	3.5	0.29	$499.95
Bi*fury	5	0.85	$209.00
BFL SC 5 Gh/s	5	6	$274.00
BFL SC 25 Gh/s	25	6	$1,249.00
BFL Single 'SC'	60	4	$1,299.00
BFL 500 Gh/s Mini Rig SC	500	5.4	$22,484.00
BFL Monarch 700Gh/s	700	0.7	$1,379.00
Bitmine.ch Avalon Clone	85	7.65	$6,489.00
Black Arrow Prospero X-1	100	1	$370.00
Black Arrow Prospero X-3	2000	1	$6,000.00
Blue Fury	3	1	$140.00

Source: Own table based on Buybitcoinworldwide (2018)

As shown in the table above is a list of selected Bitcoin mining machines that can be purchased. The data given for the miners that helps a miner choose which one is best suited to their needs are the capacity which allows for more Bitcoin to be mined at once, while the efficiency is the amount of electricity the miner is using. This can be used to the miner's advantage based on where they are located. For example, a mine located in a place with cheap electricity such as Venezuela could use a miner with less efficiency but more capacity, such as the AntMiner S5+. A miner located in a country with more expensive electricity could use a miner that is the most efficient electric wise so for example the AntMiner S9, but at the expense of not being able to mine as much Bitcoin at a time. The purchase price must also be taken into account because of its potentially high investment price.

3.3.2.2 Variable Costs (Electricity)

The most important cost of mining Bitcoins is the costs related to electricity. This is important because mining Bitcoin uses extremely large amounts of energy. This gives some countries advantages of mining Bitcoin compared to others, especially those that have extremely low electricity costs such as Venezuela.

Table 2 - Bitcoin Electricity Cost per 1 Bitcoin in Countries Around the World

Country	Cost	Country	Cost	Country	Cost
Albania	$3,894	Ireland	$11,103	Rwanda	$8,922
American Samoa	$10,706	Israel	$6,087	Saudi Arabia	$3,172
Argentina	$4,560	Italy	$10,310	Serbia	$3,133
Australia	$9,913	Jamaica	$7,867	Singapore	$5,936
Bahrain	**$16,773**	Japan	$8,723	Slovakia	$4,746
Bangladesh	$2,379	Jordan	$9,913	Slovenia	$7,645
Belarus	$2,177	Kazakhstan	$2,835	Solomon Islands	$16,209
Belgium	$13,482	Kiribati	$12,966	South Africa	$5,948
Bosnia and Herzegovina	$4,084	Kosovo	$3,133	**South Korea**	**$26,170**
Brazil	$6,741	Kuwait	$1,983	Spain	$11,103
Brunei	$4,758	Laos	$4,845	Sri Lanka	$11,630
Bulgaria	$4,362	Latvia	$7,122	Surinam	$2,956
Cambodia	$8,327	Liechtenstein	$8,164	Sweden	$4,746
Canada	$3,965	Lithuania	$5,155	Switzerland	$7,494
Chile	$9,120	Luxembourg	$7,693	Tahiti	$11,103
China	**$3,172**	Macedonia	$3,914	Taiwan	$3,774
Colombia	$7,157	Malaysia	$5,147	Thailand	$4,943
Cook Islands	$15,861	Malta	$6,079	Tonga	$14,671
Croatia	$5,551	Marshall Islands	$13,751	**Trinidad and Tobago**	**$1,190**
Curacao	$11,896	Mexico	$7,645	Turkey	$4,984
Cyprus	$8,723	Moldova	$4,651	Turks and Caicos	$14,033
Denmark	$14,275	Montenegro	$6,384	Tuvalu	$14,493
Egypt	$3,172	Myanmar	$1,983	Uganda	$7,637
Estonia	$5,551	Nepal	$3,569	Ukraine	$1,852
Ethiopia	$2,855	Netherlands	$9,449	United Arab Emirates	$3,569
Fiji	$5,155	New Zealand	$7,593	United Kingdom	$8,402
Finland	$7,122	Nicaragua	$8,613	**United States**	**$4,758**
France	$7,930	Nigeria	$5,321	Uruguay	$8,723
Georgia	**$3,316**	**Niue**	**$17,566**	**Uzbekistan**	**$1,788**
Germany	$14,275	Norway	$7,784	Vanuatu	$13,085
Gibraltar	$5,710	Pakistan	$7,137	**Venezuela**	**$531**

Greece	$9,120	Palau	$9,053	Vietnam	$4,717
Guyana	$10,627	Papua New Guinea	$9,913	Western Samoa	$12,689
Hong Kong	$7,930	Paraguay	$3,140	Zambia	$3,569
Hungary	$5,365	Peru	$4,410		
Iceland	$4,746	Philippines	$7,137		
India	$3,274	Poland	$6,931		
Indonesia	$4,329	Portugal	$10,825		
Iran	$3,217	Romania	$5,698		
Iraq	$6,543	Russia	$4,675		

Source: Own table based on Elite Fixtures (2018)

In the above table, the countries South Korea, Bahrain, and Niue are the most expensive countries based on electricity costs to mine Bitcoin. South Korea at number 1 with an electricity cost of $26,170, Niue in second at $17,566 and in third Bahrain at $16,773. The least expensive countries are as follows: Venezuela by far as the cheapest at $531, Trinidad and Tobago in second at $1,190 and Uzbekistan in third at $1,788. Other notable countries are boldened which are the top three mining countries in the world. China due to it being the largest miner of Bitcoin at a relatively low rate of $3,172 as well as Georgia at $3,316 and then the United States at $4,758. ((IQOption.com. 2018))

3.4 How is it Stored

Bitcoin is stored in so called “Wallets”. Wallets are containers for storage “keys”. Keys are how coins are stored however it should not be confused that coins are keys because they are not. These keys are a sequence of other keys that leads to showing who exactly is the owner of the transaction outputs (Bitcoins). A simple way to think of it is it you have a master key, that unlocks a door that leads to another key that opens another door that leads to another key. This eventually leads a key to a vault that identifies the owner of the Bitcoin. (Antonopoulos, A. 2015).

While most wallets are digital, it is possible to create physical paper wallets. This is done by including the corresponding bitcoin address on the paper. This is primarily done to create a backup or offline bitcoin storage. This can also be called “Cold storage” because it is not stored on a computer or internet connected device. If they keys are generated offline and never stored

on a computer, it becomes much more secure from potential hackers that would otherwise have the potential to reach it. (Antonopoulos, A. 2015).

A simple paper wallet could be the following printed onto a paper:

Public Address: 1409496082903049sxkdgjwo40t9

Private Key (WIF): 590dkgk3nkod0c8fSdodoF5kdOdeg04kdJoFPfkelllespfiDj

Figure 2- Bitcoin Physical Wallet

Source: Antonopoulos, A. (2015)

Continuing from the paper wallets, it is as well possible to store this information on a different type of external storage unit, such as a simple USB flash stick. The user simply needs to save the HTML page onto the drive and then disconnect from the internet and open the file in a browser.

3.5 How are Bitcoin Transactions Conducted

A Bitcoin transaction is essentially telling the Bitcoin network that one end user has authorized the transfer of a specific number of coins to another end user. Bitcoin transactions are similar to accounting in the way that it uses a double-entry ledger. Each transaction has inputs and outputs. The inputs are against the account that is transferring the money and the

outputs are for the receiving user. This transaction results in a small fee generally by comparing the input and output, with the slight difference being the fee. (Antonopoulos, A. 2015).

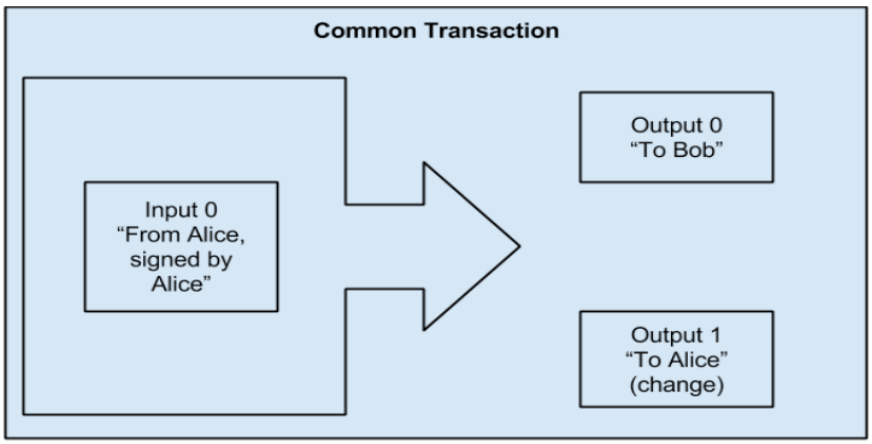
Table 3- Example of the Double Entry Ledger

Inputs	Value	Outputs	Value
Input 1	0.10 BTC	Output 1	0.10 BTC
Input 2	0.20 BTC	Output 2	0.20 BTC
Input 3	0.10 BTC	Output 3	0.20 BTC
Input 4	0.15 BTC		
Total Inputs	0.55 BTC		0.50 BTC
Inputs: 0.55 BTC			
Outputs: 0.50 BTC			
Fee/Difference: 0.05 BTC			

Source: Own table based on Antonopoulos, A. (2015)

The most common type of transaction is simply from one user to another. As seen in the picture below, Input 0 from Alice is being transacted to Bob who receives it as Output 0. Output 1 is received by Alice (the processing fee). (Antonopoulos, A. 2015).

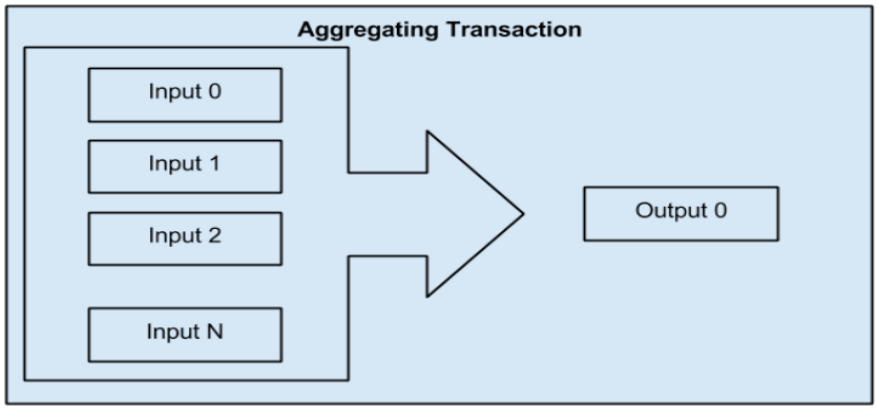
Figure 3 - Common Transaction



Source: Antonopoulos, A. (2015)

Another type of common transaction is a type that combines several inputs into one larger input. This is similar to changing smaller coins for a larger bill. As seen in the representation below, Input 0, Input 1, Input 2, and Input N are being transacted to become Output 0.

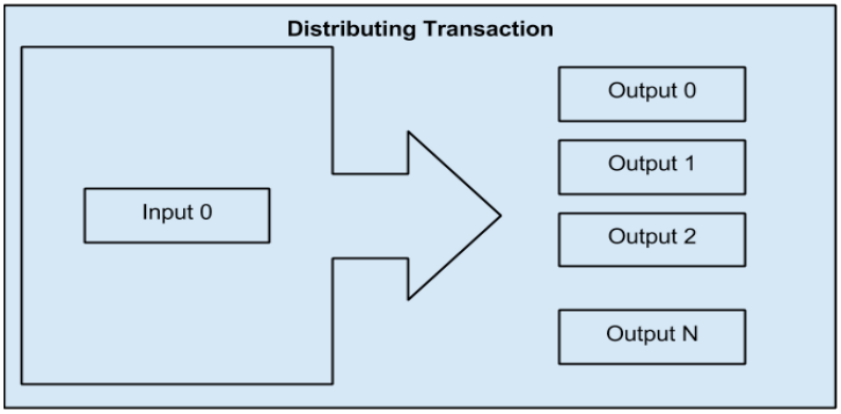
Figure 4 - Aggregating Transaction



Source: Antonopoulos, A. (2015)

Finally, the last simple type of transaction is similar to the previous one but reversed. It distributes one input to many smaller Outputs. This could be for example, if a company was paying its employees with Bitcoin.

Figure 5 - Distributing Transaction



Source: Antonopoulos, A. (2015)

3.6 How can Bitcoin be Exchanged for Other Currencies (USD, EURO, etc.)

Most people that first learn about Bitcoin are interested in how a completely digital currency can be exchanged for more traditional currencies. This is where the concept of Bitcoin exchanges come into play. Bitcoin exchanges are an extremely important part of the Bitcoin world because they allow for the currency to be exchanged for traditional currencies. Because there are so many exchanges, a select few of the major ones are going to be discussed. These are the following:

- Bitstamp
- Bitfinex
- Coinbase
- BTC-e
- Bitcoin Source

(Prableen Bajpai, C. 2018)

Bitstamp

Bistamp is a Bitcoin exchanged based in Slovenia with two main founders Nejc Kodric and Damian Merlak. It is currently one of the main exchanges based on trading volume. It allows for instant buy and sell orders for USD/BTC with withdrawals and deposits available in other currencies. Bitstamp allows for predetermined prices to be set for the buy and sell orders. Bitstamp works by creating an account with Bitstamp and then transferring money to the account. Bitstamp then earns a trading fee on successful trades based on a 30 day trading history. The minimum fee can be as low as 0.5% generally for those accounts that have a small volume. (Prableen Bajpai, C. 2018).

Bitfinex

Bitfinex is a Bitcoin exchange providing more advanced trading tools such as margin trading, short selling, liquity swaps, as well as the ability to exchange not only Bitcoin but also

Litecoins and Darkcoins. Launched in 2013, Bitfinex has grown to be one of the largest exchanges based on trading volume in USD. The people behind Bitfinex are very paranoid about security concerns so they store 99.5% of the assets in a cold storage and only keep 0.5% in wallets (which are used for deposits and withdrawals). One time per day there is a backup of the entire database of the exchange which is then encrypted. To further prevent hackers from getting to the exchange the backup is sent to different locations. The servers are tested often to prevent intruders from getting to the exchange. (Prableen Bajpai, C. 2018)

Coinbase

Coinbase has become one of the most popular exchanges based on its "one stop for all" approach to Bitcoin. Its not only an exchange but also a wallet for storing, spending, and accepting Bitcoins. It also is a tool for merchants to use Bitcoin. Coinbase is based in San Francisco, California and was primarily used in the U.S. but has since expanded to Europe, providing services to 18 countries. Coinbase differs from other exchanges in that it requests the client to link a bank account to their Coinbase account. Bitcoins that are exchanged are only released once the is credited to the bank account which generally takes 3-5 working days which might be a downside for some clients. This leads to Coinbase not being used as a day trading exchange. Generally, Coinbase users are beginners who are learning how to trade and store Bitcoin. The fee for each transfer to dollars is charged at 1% along with a 15-cent bank fee. (Prableen Bajpai, C. 2018).

BTC-e

BTC-e emerged after the trouble that Mt. Gox had. BTC-e is based in Bulgaria and came into existence in 2011 and offers many currencies such as Bitcoin, Litcoin, Peercoin, Feathercoin, Terrarcoin, Novacoin to be exchanged with US dollars, Russian Rubles, British Pounds, Euros, and Chinese Yuan. The exchange fee for transactions is 0.2% per transaction. The exchange is in both English and Russian, leading to speculation that it is not based in Bulgaria, but instead in Russia. (Prableen Bajpai, C. 2018).

Bitcoin Source

Bitcoin Source was launched in 2014 and is based in Belize. It is currently owned and managed by the DCE24 Group. One major appeal of Bitcoin source is the ability to accept deposits in a wide variety of forms, including credit cards. Bitcoin source only has trading options in USD or EUROs which can be a downside for some buyers. However, a major benefit is the security measures Bitcoin source takes in protecting itself. 98% of the funds are stored in cold wallets or offline bank accounts. Unlike BTC-e, Bitcoin source has very fast transactions, so it could be possible to used for day trading. The fee per transaction is 1% which is pretty standard for exchanges. (Prableen Bajpai, C. 2018).

3.7 The Bitcoin Network

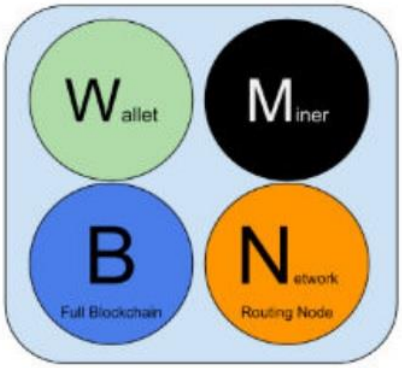
Structure

The Bitcoin network is structured in a peer to peer system that means all the participants in the network are equal and there are no special participants. All participants in the network share the responsibility of providing the networks services. There is no main server or any central oversight of the system which its main appeal is. This allows for decentralization of transactions and means the system is fair for both parties involved. While the internet in the present day of 2018 is structured rather differently, there were times in the past that it was much similar to Bitcoin in the way that the original internet was a peer to peer system as well. All other participants on the original internet were equal. (Antonopoulos, A. 2015).

Nodes

The participants in the Bitcoin network as known officially as “Nodes”. These nodes are equal as explained before but may conduct different roles in the network. These roles may be, routing, mining, conducting wallet transactions, as well as maintaining the blockchain database. (Antonopoulos, A. 2015).

Figure 6 - Bitcoin Nodes



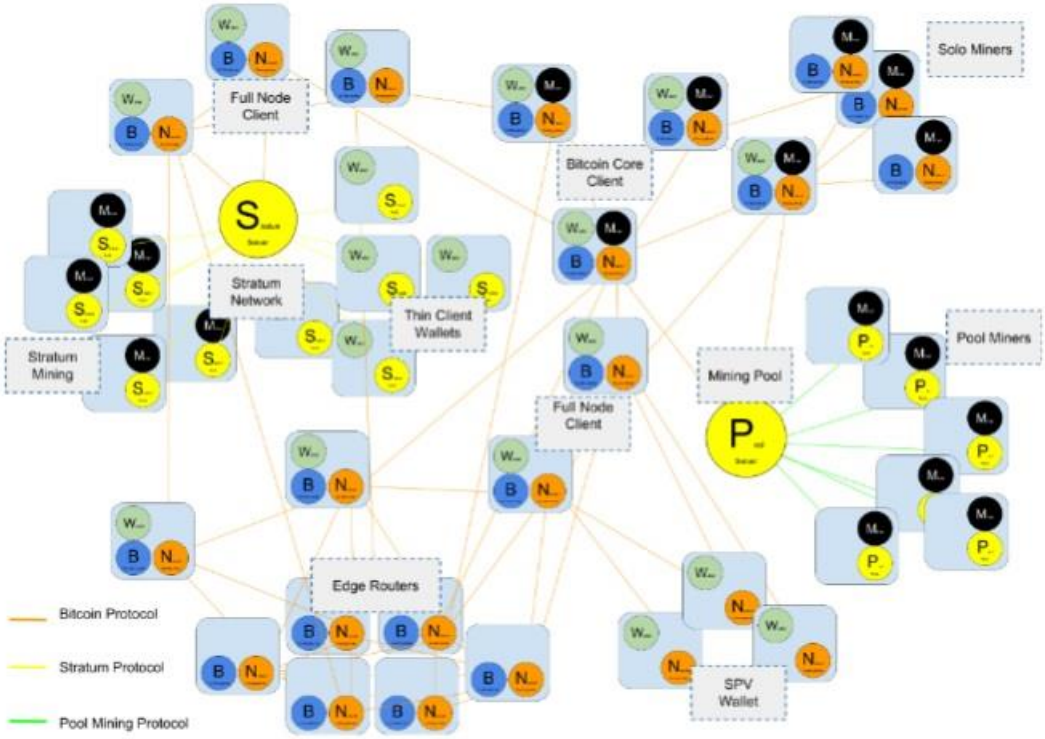
Source: Antonopoulos, A. (2015)

Some nodes are known as “full nodes” which job is to maintain the blockchain database. Full nodes have the power to verify any transaction without any external reference. Other nodes are only able to verify transactions using a method known as “Simplified Payment Verification”. They are often referred to as SPV or Lightweight nodes”. Mining nodes compete amongst themselves to create new blocks by solving complex algorithms which is how Bitcoins are mined. Some of these mining nodes are full nodes while others are lightweight nodes, the different being that full nodes can mine by themselves while a lightweight node participates in a mining pool. In the above picture, the full mining node is shown as the block circle labeled “Miner”. (Antonopoulos, A. 2015).

As stated before, wallets also may be part of a full node. Typically, wallets that are full nodes are based on a computer while SPV nodes are used on lighter devices such as cell phones or USB drives. (Antonopoulos, A. 2015).

While the main types of nodes are on the Bitcoin protocol, there are also servers and nodes running other protocols. Some of these are special mining pool protocols or lightweight client access protocols. (Antonopoulos, A. 2015)

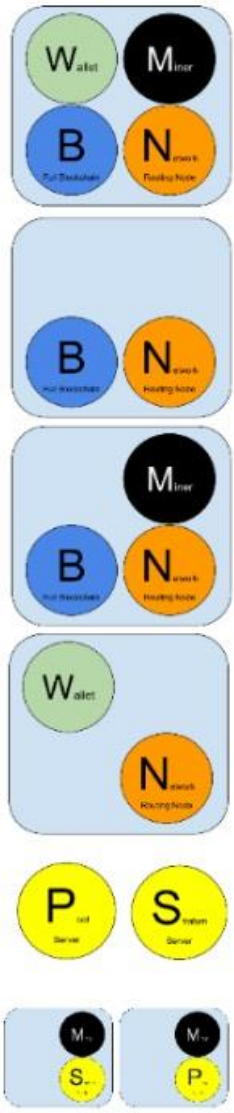
Figure 7 - Bitcoin Extended Network



Source: Antonopoulos, A. (2015)

Above is an example of how the Bitcoin network (extended network), may look with a large amount of types of nodes, routers, gateway servers and protocols.

Figure 8 - Bitcoin node types



Reference Client

This contains all everything; a full blockchain database, network routing, a wallet and a miner.

Full Blockchain Node

This contains a full blockchain database and a network routing node.

Solo Miner

This contains a full copy of the blockchain database, a network routing node and a mining function.

Lightweight (SPV) wallet

This contains a network routing node, and a wallet function.

Pool Protocol Servers

These are gateway routers allowing nodes and other protocols to run such as pool mining.

Mining nodes

These contain a mining function without a blockchain database.

Source: Antonopoulos, A. (2015)

3.8 Bitcoin Security

Securing Bitcoin is a significant challenge to the digital currency. Its anonymity means that anyone that has the key to a wallet can do as they wish with it and as with real like currency such as cash, once it's gone its gone. Bitcoins de-centralization is a major appeal even though it causes a majority of the security issues. The responsibility is completely up to the end users and its there jobs to maintain and monitor there coins and mining. Bitcoin authorizes transactions only based on a specific value (the key) and therefore has no information on the identity or whereabouts of the parties. This is so secure that Bitcoin transactions can be exchanged even over unsecured internet without a risk of interruption. (Antonopoulos, A. 2015).

Although Bitcoin is quite secure, in the early days some Bitcoin exchanges tried to concentrate coins into major wallets (what essentially would be a traditional bank) which would remove the control from the users and would defeat the "decentralization" of Bitcoin that allows it to work fluently. Many of these modified systems were hacked and stolen from. Another risk that reduces the security of Bitcoin is trying to reduce transaction fees by using an "off blockchain" structure that only connects with the Bitcoin blockchain when needed. This as with the early concentration attempts centralizes Bitcoins, therefore leading to unsecure coins. (Antonopoulos, A. 2015).

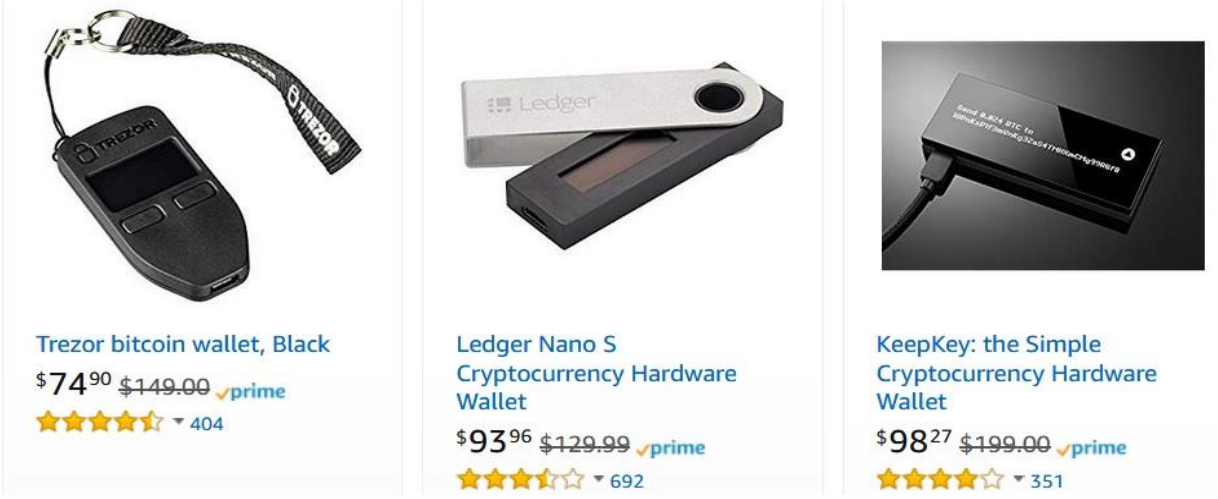
Best Practices for Security

For thousands of years humans have had ways of protecting physical assets, but protection of digital assets has only been around for the past 50-60 years. With the ever growing internet, it allows more and more users to become potential victims of fraud, theft and abuse. It is especially difficult to protect digital media assets such as movies, music and video games. Whenever a source of this content is taken down another 10 pop up, causing it to be a never ending game of "cat and mouse" for the owners of this content. With major investments in both security and alternative solutions, there has been a stable amount of digital theft but not nearly as large as it was in the early to mid-2000's. (Antonopoulos, A. 2015).

Bitcoin is especially interesting for thieves and hackers due to its intrinsic value that allow it to be stolen and diverted to the thieves instantly and without the ability to revoke the transaction. Until technological assets such as Bitcoin, hackers had to change identifiable information related to the stolen asset such as credit cards, bank information into something of value for them. With Bitcoin, however this is not the case because once it is accessed and transferred it is not possible for the victim to have it returned as it would be in the case of a stolen credit card. (Antonopoulos, A. 2015).

Fortunately for decentralized currencies such as Bitcoin there are also incentives to help increase and improve the quality of computer security. When a user holds Bitcoin on a computer that has the potential to be hacked they now have to know all the ways to protect their computer (and Bitcoin). Because of Bitcoin, in the past 2-3 years, there have been significant increases in the form of hardware and software encryption, digital escrow and Bitcoin external wallets. (Antonopoulos, A. 2015).

Figure 9 - Physical Bitcoin Wallets



Source: Amazon (2018)

Figure 9 examples of a few of the many available encrypted Bitcoin hardware storage devices.

3.9 Bitcoin Skepticism

While there are many supporters of Bitcoin, there are skeptics as well. These critics believe Bitcoin is overhyped, not safe, allows for money laundering and terrorism and doesn't make sense to the public. (Antonopoulos, A. 2015).

Safety

The first problem critics speak of regarding Bitcoin is the safety of it. With largescale internet based attacks such as ransomware devastating the U.S., the U.K. and many other countries in recent years there is a genuine concern by Bitcoins skeptics. Ransomware hackers generally use Bitcoin as the ransom for recovering data stolen from victims, because of its anonymity. Without this anonymity then the hackers will likely have a paper trail leading to significantly less ransomware attacks. As well, in 2014 the largest Bitcoin exchange, Mt. Gox was been breached and had to file for bankruptcy as a result. Later in 2016, Hackers stole $69 million worth of Bitcoin from Bitcoin exchange Bitfinix. (Antonopoulos, A. 2015).

Scaling

Over the past few years the Bitcoin community has had a significant problem deciding how to upgrade its blockchain. Many businesses have been unable or have had significant trouble using Bitcoin as a currency due to the amount of time and fees that are involved with verifying transactions. (Antonopoulos, A. 2015).

Rival Digital Currencies

While Bitcoin is likely the most well-known digital currency, it is not alone. This creates a diversified market of digital currencies. A few digital currencies similar to Bitcoin include, Ethereum, Litecoin, Monero, Zcash. With an estimated 700 rivals to Bitcoin its quite a

significant number of competitors. Bitcoin has slowly been losing its market share to the rise of Ethereum.

Not Recognized by Governments

A major drawback regarding Bitcoin is that the public for the most part doesn't understand it. This leads to the problem of government agencies and more specifically regulators not understanding it as well and therefore it is hard to regulate and trust the currency. In 2015 New York tried to implement "licenses" for cryptocurrency companies but only three companies applied for it. The reasoning was the major costs of applying, leading to many smaller startups to not be able to afford the license. Later in 2017, Bitcoin dropped significantly in value when the famed Winklevoss twins were denied a proposal for creating a publicly traded fund based on Bitcoin. (Antonopoulos, A. 2015).

3.10 Other Digital Currencies

While Bitcoin is certainly the most popular digital currency, it is most definitely not the only digital currency. Besides Bitcoin there are four other major digital currencies, currently. These are Litecoin, Ethereum, Zcash, and Dash (originally known as Darkcoin). Each of these digital currencies have slightly different histories and backgrounds, therefore they will be each explained in detail to better understand their differences. (Antonopoulos, A. 2015).

Monetary Parameter Alternative CryptoCurrencies

There are some main parameters that Bitcoin has that give it a unique characteristic of being a decentralized fixed issuance currency. It is slowly becoming more difficult to mine with only 21 Million Bitcoins being allowed for issuance. Many Alternative "ALT" Coins have made slight changes to these characteristics of Bitcoin to create all new Crypto Currencies. Some of the most notable are Litecoin, Dogecoin, Freicoin. (Antonopoulos, A. 2015).

Lite Coin

Lite Coin was one of the first major alt coins, being release in 2011. It was the second most successful cryptocurrency after Bitcoin. The primary innovation that set it apart was the use of a "scrypt" for the "Proof of Work algorithm". (Antonopoulos, A. 2015).

Block Generation time: 2.5 minutes

Total Currency: 84 Million by 2140

Consensus Algorithm: Scrypt Proof to Work

Market Capitalization: $160 Million in 2014

Dogecoin

Dogecoin was released in the year 2013, being based on a part of Litecoin. While it starting out being a sort of internet joke, it turned into a real life popular crypto currency. It has a difference between Bitcoin and Litecoin because it has a high currency capitalization and because its monetary policy allows for a rapid issuance of coins. (Antonopoulos, A. 2015).

Block Generation Time: 60 Seconds

Total Currency: (100,000,000,000) by 2015

Consensus Algorithm: Scrypt Proof to Work

Market Capitalization: $12 Million by 2014

Freicoin

Freicoin was introduced in the year 2012 and is a "demurrage currency" meaning it has a negative interest rate for any stored value. Value in Freicoin is a 4.5% APR fee and is to encourage consumption rather than storage. Its difference between other Crypto currencies is that it is implementing a monetary policy which is the complete opposite of Bitcoin's approach. (Antonopoulos, A. 2015).

Block Generation Time: 10 Minutes

Total Currency: 100 million coins by 2140

Consensus Algorithm: SHA256

Market Capitalization: $130,000 by 2014

Consensus Innovative Alt Coins

The consensus structure of Bitcoin is based on "Proof to Work" using the SHA 256 Algorithm. The first alt-coins used a scrypt that was based on a modified version of this "Proof to Work" algorithm to create a more CPU-friendly mining. Since this first modification of the Proof to Work algorithm, many more alt coins have adopted similar algorithms. These include Scrypt-N, Skein, Groestl, SHA3, Blake and many others. Some Alt Coins combined many of these algorithms together. (Antonopoulos, A. 2015).

In 2013, there was a development of the Proof to Work algorithm to a modified version called "Proof of stake" which is the form from which many of the modern Alt Coins are based on. Proof of stake is where existing owners can "Stake" a currency as interest receiving collateral. This is some-what like a "Certificate of Deposit", where the holder can reserve a part of their holdings while earning interest in the form of new currency from interest payments as well as transaction fees. (Antonopoulos, A. 2015).

Peercoin

Peercoin was introduced in 2012 and was the first Alt Coin to use a mix of the Proof to Work and Proof of Stake algorithm. (Antonopoulos, A. 2015).

Block Generation: 10 Minutes

Total Currency: No limit

Consensus Algorithm: Mixed: Proof of Stake with Proof of Work

Market Capitalization: $14 Million by 2014

Myriad

Myriad was first introduced in 2014 and is notable because it has five different Proof of Work algorithms. It uses SHA256d, Qubit, Scrypt, and Myriad Groestle or Skein. These are used simultaneously and differ based on the miner's participation. The point of Myriad is to make itself resistant to centralization as well as consensus attacks because all of these algorithms would have to be attacked at the same time reducing the likelihood of that event. (Antonopoulos, A. 2015).

Block Generation: 30 Second Average (2.5 Minutes per mining algorithm)

Total Currency: 2 Billion by 2024

Consensus Algorithm: Multi-Algorithim based on Proof of Work

Market Capitalization: $120,000 by 2014

Blackcoin

First introduced in 2014, Blackcoin uses a Proof of Stake algorithm and was notable for introducing "multi-pools". Multi-pools are a type of mining that allows for switching between different types of alt coins at one time, allowing for the ability to change profitability. (Antonopoulos,A.2015).

Block Generation: 1 Minute

Total Currency: No limit

Consensus Algorithm: Proof of Stake

Market Capitalization: $3.7 Million by 2014

Vericoin

First launched in 2014, Vericoin uses a Proof of Stake algorithm with a variable interest rate that changes based on supply and demand. It also is notable for being the first alt coin featuring "auto exchange" allowing Bitcoin to be paid directly from the wallet. (Antonopoulos, A. 2015).

Block Generation: 1 Minute

Total Currency: No limit

Consensus Algorithm: Proof of Stake

Market Capitalization: $1.1 Million by 2014

NXT

Pronounced “Next”, NXT is a “pure” Proof of Stake alt coin. This means it does not use Proof of Work mining. NXT is an alt coin from scratch meaning its not related to the structure of Bitcoin or other alt coins. NXT has many advanced characteristics such as name registry, secure messaging, and stake delegation. NXT is considered the 2.0 cryptocurrency. (Antonopoulos, A. 2015).

Block Generation: 1 Minute

Total Currency: No limit

Consensus Algorithm: Proof of Stake

Market capitalization: $30 Million by 2014

3.10.1 Evaluating these “Alt coins”

There is a large selection of so called “Alt coins” to choose from, with only a small fraction of the largest in the above list. With many choices comes many factors to determine what is best for a particular investor. Security also plays a factor because some of them are created for the sole purpose of creating a “Get rich quick” scheme. (Antonopoulos, A. 2015).

Some questions a potential might consider are the following:

- How is this altcoin different from other altcoins?
- Is this altcoin providing significant innovation?
- Does the altcoin have a niche market or application?

- Can the altcoin prevent against consensus attacks?
- What is the total market capitalization of the alt coin?
- How many users does the alt coin have?
- How many merchants accept the altcoin?
- How much volume is transaction based on the alt coin?

(Antonopoulos, A. 2015).

4 Analytical Section

In this section Bitcoin is going to be analyzed by both fundamental and technical analysis. Fundamental analysis is important to use to get an idea of the situation of Bitcoin that is NOT related to its price but rather other influential factors. Technical analysis is related to analyzing based on data (in this case the value of Bitcoin). As stated at the beginning of this thesis the goal of the analytical section is to help answer the following questions:

- What role does Bitcoin play in an investor's portfolio?
- Based on a time series analysis, where is the price of Bitcoin likely to go?
- What effect do the amount of Transactions per Block, Costs per Transaction, and amount of Transactions have on the price of Bitcoin?

4.1 Fundamental analysis

Because Bitcoin is not centrally controlled, and therefore has nothing backing it, it is completely based on Intrinsic Value. This leads to the analysis of the fundamental values of Bitcoin. These are:

- The amount of companies accepting Bitcoin
- The trading volume of Bitcoin
- Market Penetration

4.1.1 Amount of Companies Accepting Bitcoin

First Quarter of 2017

January 3rd: 8207 Businesses accept Bitcoin

March 28th: 8665 Businesses accept Bitcoin

Percentage change: +5.58%

Second Quarter of 2017

April 4th: 8682 Businesses accept Bitcoin

June 27th: 9143 Businesses accept Bitcoin

Percentage Change +5.30%

Third Quarter of 2017

July 4th: 9176 Businesses accept Bitcoin

September 26th: 9972 Businesses accept Bitcoin

Percentage Change: +8.67%

Fourth Quarter of 2017

October 3rd: 10,040 Businesses accept Bitcoin

December 19th: 11,291 Businesses accept Bitcoin

Percentage Change +12.46%

(Cointelegraph. 2018)

Some of the large companies that accept Bitcoin are:

- KFC Canada
- Overstock.com
- Subway

- Microsoft
- Virgin Galatic
- Alza
- Wikipedia
- NewEgg.com
- The Pirate Bay
- Zygna
- Whole Foods
- Bloomberg.com
- Gap, Gamestop, JC Penny
- Lionsgate Films
- LOT Polish Airlines
- RE/MAX London
- T-Mobile Poland

(Chokun, J. 2018).

Why are the amount of companies and types of companies that accept Bitcoin important?

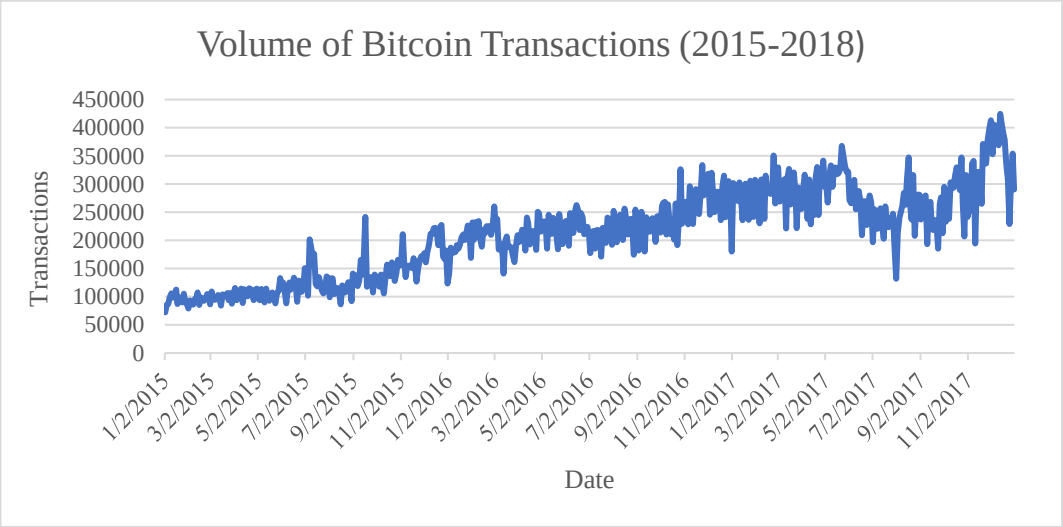
The amount of companies and types of companies that accept Bitcoin is an important indicator of Bitcoin as an investment option because if a large amount of reputable companies are willing to accept it, it shows they believe in the value of Bitcoin and therefore gives Bitcoin some "legitimacy". This also helps with the value of Bitcoin because it shows potential investors in Bitcoin that were hesitant at first, now they might be less hesitant to invest therefore driving the value of Bitcoin up due to the increasing amount of people investing in Bitcoin.

4.1.3 Volume of Bitcoin Transactions

The volume is an important fundamental factor because it helps give a viewpoint much Bitcoin is being transacted. If Bitcoin has significantly low amounts of transactions or a significant decrease in transactions this can be a sign that there is a loss interest. Another reason volume is important is because it is used with prices to help determine whether there is

significant change. For example if there is a large increase in the volume and large increase in price its likely its going to continue on an upward trend.

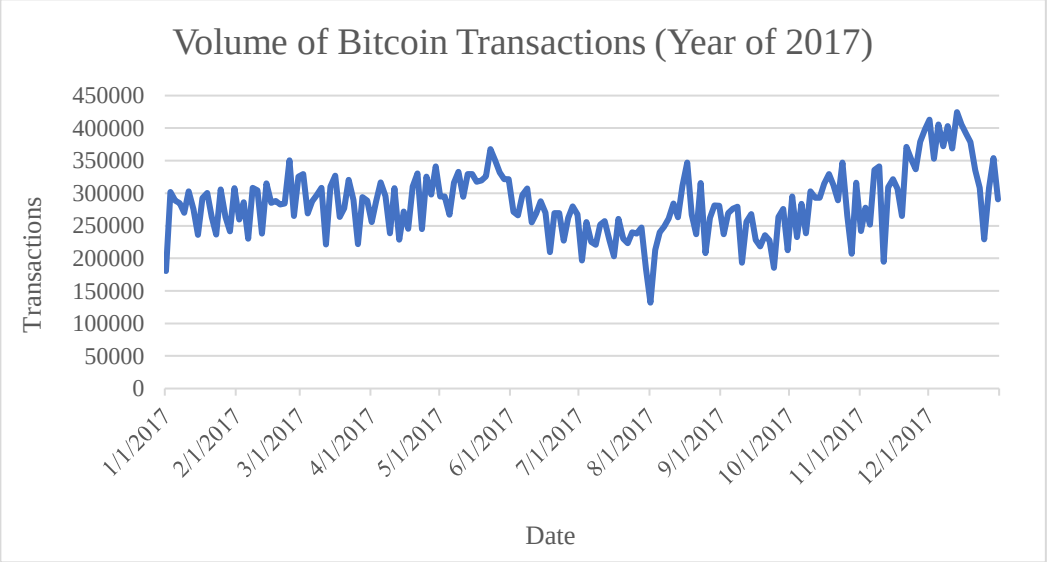
Figure 10 - Volume of Bitcoin Transactions: year 2015 - 2018



Source: Blockchain (2018)

In the chart above, it can be seen that the amount of volume has been increasing over time at a stable rate. There have been periods of significant increases and decreases and it would be extremely likely that these would correlate to the price of Bitcoin.

Figure 11 - Volume of Bitcoin Transactions: year 2017



Source: Blockchain (2018)

In the figure above the volume over the course of the year of 2017 was shown to have ups and downs but relatively stayed the same. This could be a sign of the interest in Bitcoin leveling out and therefore could be a sign of an upcoming decreasing in volume and potentially price.

4.1.4 Bitcoin News

In this section, current news related to Bitcoin and cryptocurrencies in general will be discussed. This news is current as of the time of this thesis being written (Autumn of 2017).

Russia's own cryptocurrency

The first major current news is that Russia is finally going to have its own cryptocurrency called the "Crypto-Ruble". This was a surprise to many because Russia has stated that it will ban all other cryptocurrencies such as Bitcoin. Vladimir Putin gave his approval for the new cryptocurrency and Russian communications Minister Nikolay Nikiforov has stated that the government will regulate the currency. This defeats the main benefits of cryptocurrencies because it removes the anonymity of them. The minister also stated that the "Crypto-Ruble" will

be taxed at a rate of 13% based on the value that it has appreciated at. Russia's President, Vladimir Putin has been extremely opposed to anonymous cryptocurrencies such as Bitcoin based on it being able to be used for tax evasion, money laundering, and funding of terrorism. Putin has also called for more regulation of cryptocurrencies which ironically sent the price of Bitcoin soaring. (Robinson, B. 2018)

Bitcoin Price Predictions

The second major current news around Bitcoin is that according to a recent survey (as on October 20th, 2017) a large majority of respondents believe that Bitcoin is heading towards $10,000. Currently at a price around $5700, it's a significant jump. According to CNBC's survey, nearly half of the respondents believe Bitcoin is heading towards a price of $10,000. A third are skeptical still of Bitcoin and agree with the CEO of JPMorgan Chase who said, "you'll pay the price" for investing in Bitcoin (meaning it's not a good investment and is likely just a "bubble"). Of the 23,118 surveyed, 16% said they believe Bitcoin will increase to anywhere between $6000 and $8000. Just this year alone Bitcoin has risen over 470% with an all-time high of $5856 earlier this month. (Kharpal, A. 2018).

4.2 Technical Analysis

4.2.1 The role that Bitcoin plays in an investor's portfolio

Every investor that has a portfolio tends to have a combination of the following types of investments, less risky, medium risky, highly risky. Generally, the more the risk, the greater the possibility of the return. The role of Bitcoin as an investment is going to be analyzed in this section to determine which role it plays in an investor's portfolio.

Due to the USD's relative strength, it can be used as a good index for an understandable currency to compare Bitcoin with. So BTC/USD (Bitcoin compared to US Dollar) historical data was used to calculate a statistical analysis resulting in the standard deviation. Standard deviation is important to use in this determination because it is the quantity expressing how much the data members vary from the group mean value. In short it shows the amount that the numbers differ from the average.

Then the standard deviation will be calculated and shown for the exchange rate of EURO/USD. The exchange rate EUR/USD was selected due to it being a relatively stable exchange rate, which will allow for a comparison of BTC/USD which is more likely to be not as stable.

Descriptive Statistics Short Term (BTC/USD)	
Mean	2520.000977
Standard Error	88.25702991
Median	2252
Mode	1056.2
Standard Deviation	1546.388089
Sample Variance	2391316.122
Kurtosis	-0.193774934
Skewness	0.861274618
Range	6516.4
Minimum	778.6
Maximum	7295
Sum	773640.3
Count	307
Confidence Level(95.0%)	173.6674827

Source: Investing (2018)

As shown in the figure above the standard deviation is extremely high. In simple terms this means that the price varies from the mean value significantly meaning that this is an extremely volatile and therefore risky investment. The range can also be seen to be very high and the minimum and maximum are quite far from each other, potentially meaning high volatility.

Descriptive Statistics Short Term (EUR/USD)	
Mean	1.120557466
Standard Error	0.003398488
Median	1.1194
Mode	1.0644
Standard Deviation	0.050522154
Sample Variance	0.002552488
Kurtosis	-1.556452243
Skewness	0.108718206
Range	0.1629
Minimum	1.0406
Maximum	1.2035
Sum	247.6432
Count	221
Confidence Level(95.0%)	0.006697759

Source: Investing (2018)

As shown in the figure above the standard deviation is not very high and therefore not volatile due to the price not varying greatly from the mean price. The minimum and maximum also appear to be extremely close, meaning that its likely to be a very stable rate.

Descriptive Statistics Long Term (BTC/USD)	
Mean	638.2354436
Standard Error	22.08535168
Median	369
Mode	5.1
Standard Deviation	1008.456916
Sample Variance	1016985.352
Kurtosis	11.71773691
Skewness	3.272282929
Range	7295
Minimum	0
Maximum	7295
Sum	1330720.9
Count	2085
Confidence Level(95.0%)	43.31164856

Source: Investing (2018)

As shown in the figure above the standard deviation is extremely high. In simple terms this means that the price varies from the mean value significantly meaning that this is an extremely volatile and therefore risky investment. As was in the short term, there is a large range and the minimum and maximum are extremely far away from each other. This potentially means large amounts of volatility.

Descriptive Statistics Long Term (EUR/USD)	
Mean	1.214334944
Standard Error	0.002806609
Median	1.2157
Mode	1.1155
Standard Deviation	0.10909733
Sample Variance	0.011902227
Kurtosis	-1.565342379
Skewness	0.065739961
Range	0.3547
Minimum	1.0387
Maximum	1.3934
Sum	1834.8601
Count	1511
Confidence Level(95.0%)	0.005505265

Source: Investing (2018)

As shown in the figure above the standard deviation is not very high and therefore not volatile due to the price not varying greatly from the mean price. Similarly to the short term exchange rate, the range is small and the minimum and maximum are close to each other, meaning the rate is involatile.

4.2.2 Real Life Simulation

In the authors personal opinion he believes that Bitcoin will increase in value over the short term and to prove (or disprove this belief) the author created a real-life scenario where $10,000 was invested into Bitcoin at the beginning of November 2017.

November 1st $10,000 purchased 1.48648046021 Bitcoins. Over the course of the month the increase and decrease in value of these hypothetical Bitcoins were analyzed to determine if at the end of the month the value will exceed the purchase price or not.

Table 4 - Bitcoin Investment Simulation

	Amount of Bitcoins owned	USD value per BTC	Current Value of Investment (USD)	Increase/Decrease
November 1st	1.48648046021	6727.3	**10,000**	0
November 2nd	1.48648046021	7019.9	10434.94418	434.9441827
November 3rd	1.48648046021	7278.4	10819.19938	384.255199
November 4th	1.48648046021	7369	10953.87451	134.6751297
November 5th	1.48648046021	7382	10973.19876	19.32424598
November 6th	1.48648046021	6995	10397.93082	-575.2679381
November 7th	1.48648046021	7103.3	10558.91665	160.9858338
November 8th	1.48648046021	7442.4	11062.98218	504.0655241
November 9th	1.48648046021	7126.2	10592.95706	-470.0251215
November 10th	1.48648046021	6542.2	9724.852467	-868.1045888
November 11th	1.48648046021	6300.7	9365.867436	-358.9850311
November 12th	1.48648046021	5822.1	8654.437887	-711.4295483
November 13th	1.48648046021	6474.6	9624.366388	969.9285003
November 14th	1.48648046021	6394.9	9505.893895	-118.4724927
November 15th	1.48648046021	7278.3	10819.05073	1313.156839
November 16th	1.48648046021	7864.2	11689.97964	870.9289016
November 17th	1.48648046021	7677.9	11413.04833	-276.9313097
November 18th	1.48648046021	7773.3	11554.85856	141.8102359
November 19th	1.48648046021	8054.2	11972.41092	417.5523613
November 20th	1.48648046021	8245.1	12256.18004	283.7691199
November 21st	1.48648046021	8097.3	12036.47823	-219.701812
November 22nd	1.48648046021	8230.1	12233.88284	197.4046051
November 23rd	1.48648046021	7977.1	11857.80328	-376.0795564
November 24th	1.48648046021	8191.6	12176.65334	318.8500587

November 25th	1.48648046021	8766.2	13030.78501	854.1316724
November 26th	1.48648046021	9316	13848.05197	817.266957
November 27th	1.48648046021	9728.8	14461.6711	613.619134
November 28th	1.48648046021	9893.6	14706.64308	244.9719798
November 29th	1.48648046021	9749.4	14492.2926	-214.3504824
November 30th	1.48648046021	9907	**14,726.56192**	234.2693205
Profit	**$4,726.56192**			

Source: Own table based on data from Investing (2018)

4.2.3 Time Series Forecasting using ARIMA in Gretl

Autoregressive integrated moving average (ARIMA) is a good choice of time series forecasting because they help fit time series data to better understand the data and to predict future points in the series (known as forecasting).

The first step in the ARIMA process is determining value “d”. To determine d, a time series plot must be generated from the data. The time series plot shows the variance and mean. Then depending on this, a test will be conducted to find the value needed for ARIMA. This is based on the ADF Unit Root Test.

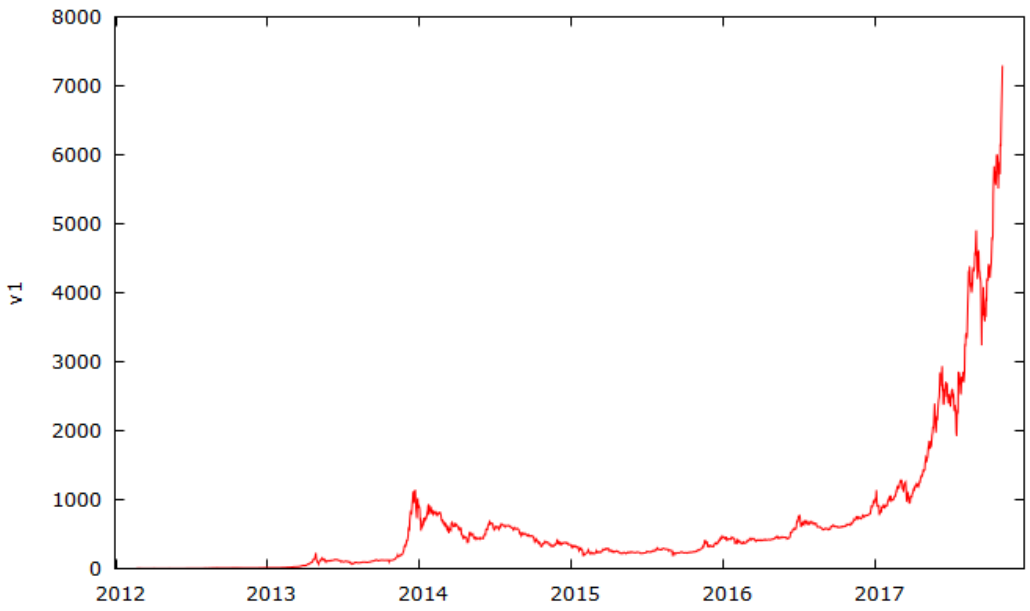
The ADF Unit Root test has the following hypothesis’s

H0: Unit Root

HA: No Unit Root

The null hypothesis is that there is a unit root in the data set, and the alternative hypothesis is that there is no unit root in the data set. If the data is around a stationary constant, it can be assumed that the null hypothesis will be rejected, and the alternative hypothesis will be accepted. If their data is not considered to be around a stationary constant, it can be assumed that the null hypothesis will be accepted.

Figure 12 - Trend of Bitcoin Price in Gretl



Source: Gretl computation

As shown in the time series plot, the data appears to not be around the mean and appears to have significant variance. This leads to the conclusion that the null hypothesis will be accepted, and therefore we can assume there is a Unit Root.

The next step in the calculation is to test this using the Augmented Dickey Fuller test. This test also known as the "ADF" test and is used to test the null hypothesis that a unit root is present in a time series.

Figure 13 - Augmented Dickey Fuller Test in Gretl

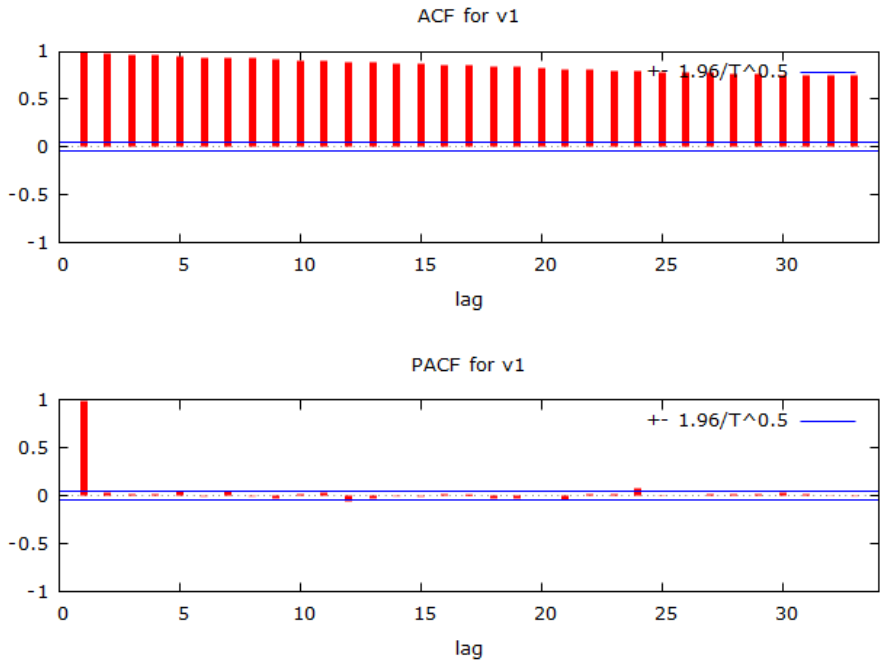
```
Augmented Dickey-Fuller test for v1
testing down from 13 lags, criterion t-statistic
sample size 2071
unit-root null hypothesis: a = 1

  test with constant
  including 13 lags of (1-L)v1
  model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
  estimated value of (a - 1): 0.00967664
  test statistic: tau_c(1) = 6.74015
  asymptotic p-value 1
  1st-order autocorrelation coeff. for e: -0.001
  lagged differences: F(13, 2056) = 4.578 [0.0000]

  with constant and trend
  including 13 lags of (1-L)v1
  model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
  estimated value of (a - 1): 0.0106513
  test statistic: tau_ct(1) = 5.90192
  asymptotic p-value 1
  1st-order autocorrelation coeff. for e: -0.002
  lagged differences: F(13, 2055) = 4.595 [0.0000]
```

Source: Gretl computation

As shown in the test, when the p value is compared with 0.005, it is greater and therefore we will accept the null hypothesis as predicted. This means the data needs to be made differenced, which means that “d” in the ARIMA p d q model is equal to 1.

The next values that need to be determined in the ARIMA p d q model are the “p” and “q”. These are determined using a correlogram. The correlogram is used for determining a correlation. It helps to determine the numbers of both “p” and “q”. If there appears to be no correlation (such as not determinable patterns in the correlograms then it can be concluded that the values to be used will be 0. If there appears to be a pattern, then their values are equal to 1.

Figure 14 - ACF and PACF in Gretl



Source: Gretl computation

As shown in the above correlogram, both the ACF and PACF appear to be steadily decreasing. This is a sign that "p" and "q" are both equal to 1. What this leads to is the conclusion of the model. "d" in the ARIMA model was found to be 1 earlier in this analysis, and now with "p" and "q" being equal to 1, it means the model is considered a "1-1-1" model.

Figure 15 - Time Series Model in Gretl

	coefficient	std. error	z	p-value	
const	3.49524	1.16961	2.988	0.0028	***
phi_1	-0.432549	0.413983	-1.045	0.2961	
theta_1	0.392661	0.422424	0.9295	0.3526	

Mean dependent var	3.497553	S.D. dependent var	54.98918
Mean of innovations	-0.000022	S.D. of innovations	54.92246
Log-likelihood	-11305.41	Akaike criterion	22618.82
Schwarz criterion	22641.39	Hannan-Quinn	22627.09

Source: Gretl computation

In the above figure, the coefficients will be determined whether or not there is statistical significance. This is done by comparing the value of the coefficient with the p value. If the p value is smaller than 0.05 than there is statistical significance.

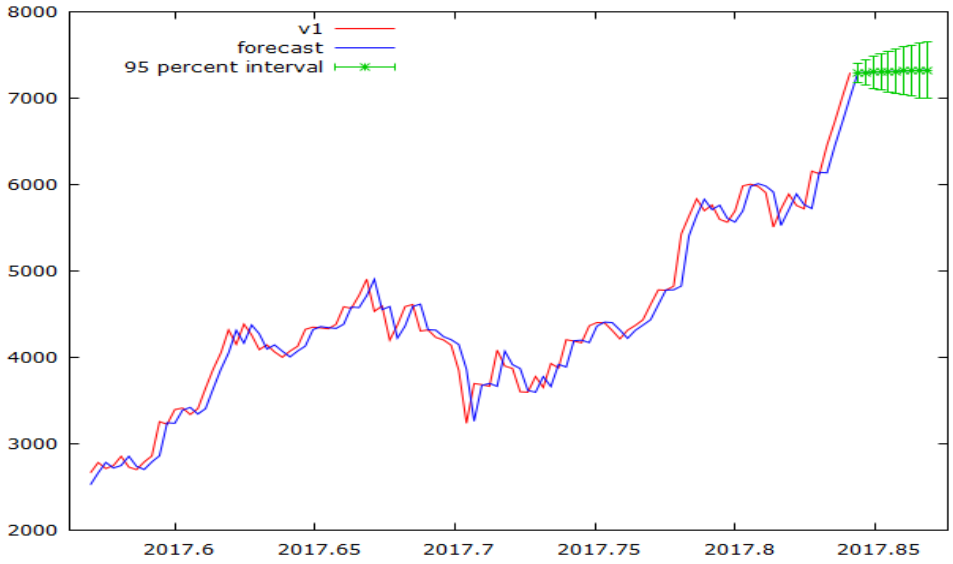
Table 5 - Determining Statistical Significance

value	3.49524	-0.432549	0.392661
p-value	0.0028	0.2961	0.3526
SS / NS *	**SS**	**NS**	**NS**

Source: Own table based on Gretl computation

* SS - parameter statistically significant, NS - parameter statistically not significant

Figure 16 - Times Series Predictions in Gretl

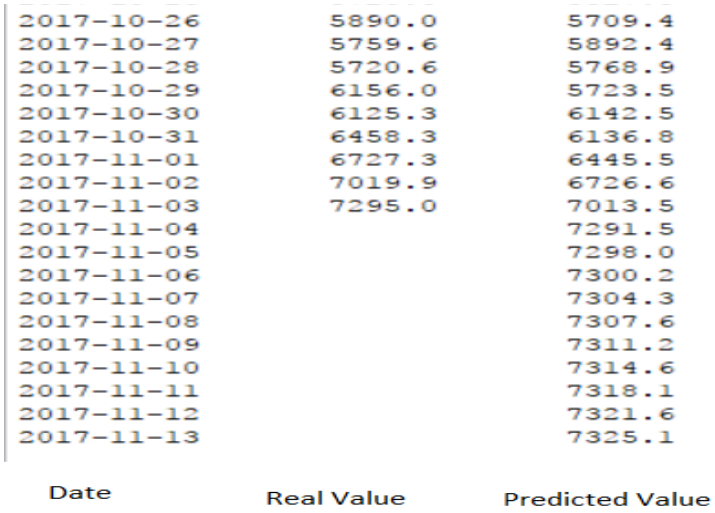


Source: Gretl computation

As shown in the graph above, the trend was pointing towards an increase over the next 10 points in time based on a 95 percent interval. We can assume with high confidence that based

on the historical pricing data of Bitcoin that the next few numbers are highly likely to be within that range (as shown by the green sticks).

Figure 17 - Comparison of Times Series Predicted Values with Real Values



Source: Gretl computation

Shown above is the comparison of the real values of data compared with the predicted value. While it is not exact, it is relatively close.

4.2.4 Economic and Econometric Models

Economic model:

$y_{1t} = f(x_1, x_2, x_3, x_4)$

Econometric model:

$\beta_{11} y_{1t} = \gamma_{11} x_{1t} + \gamma_{12} x_{2t} + \gamma_{13} x_{3t} + \gamma_{14} x_{4t} + u_{1t}$

Declaration of variables + units:

Independent Variable:

$\mathbf{y_{1t}}$ … Price of Bitcoin

Dependent Variables:

$\mathbf{x_1}$ … Unit Vector (Constant)

$\mathbf{x_2}$ … Transactions per Block

$\mathbf{x_3}$ … Costs per Transactions

$\mathbf{x_4}$ … Transactions per Day

Stochastic Variable:

$\mathbf{u_{1t}}$ … Error Term

Assumptions

1. The higher the amount of Transactions per Block, the higher the price of Bitcoin.
2. The higher the Costs per Transaction, the higher the price of Bitcoin.
3. The higher the amount of Transactions per day, the higher the price of Bitcoin.

Figure 18 - Descriptive Statistics

	Mean	Median	S.D.	Min	Max
Price	4028	2587	4062	785.2	19499
Constant	1.000	1.000	0.0000	1.000	1.000
TransPerBlock	1871	1910	305.5	885.1	2723
CostsPerTrans	31.20	23.14	30.82	5.244	161.7
TransPerDay	2.847e+005	2.828e+005	50635	1.319e+005	4.906e+005

Source: Gretl computation

In the picture above, the Mean, Median, Standard Deviation, Minimum and Maximum are shown for the data set.

Figure 19 - Correlation Matrix

Correlation Coefficients, using the observations 2017-01-01 - 2018-01-01
5% critical value (two-tailed) = 0.1025 for n = 366

Price	TransPerBlock	CostsPerTrans	TransPerDay	
1.0000	0.3698	0.9729	0.4254	Price
	1.0000	0.2286	0.7257	TransPerBlock
		1.0000	0.2947	CostsPerTrans
			1.0000	TransPerDay

Source: Gretl computation

In the picture above, a Correlation Matrix is shown to show the relationships between the variables. Fortunately, there is no Multicollinearity. Multicollinearity causes problems because the variables are supposed to be independent from each other and if there is multicollinearity then the data is likely to be inaccurate when calculating the economic and econometric model.

Parameters Estimation using OLSM in Gretl

Ordinary Least Squares Movement (OLSM) is a method of regression analysis for estimating the unknown parameters in a linear regression model. The necessity of finding the unknown parameters is important because they are the restrictions of the values.

Matrix X = Constant, Transactions per Block, Costs per Transaction, and Transactions per Day.

Matrix Y = Price of Bitcoin

Figure 20 - Descriptive Statistics Output in Gretl

```
Model 1: OLS, using observations 2017-01-01:2018-01-01 (T = 366)
Dependent variable: Price

                 coefficient     std. error   t-ratio   p-value
  ------------------------------------------------------------
  const          -4091.23        230.252      -17.77    3.11e-051 ***
  TransPerBlock      1.33183       0.169122     7.875   4.01e-014 ***
  CostsPerTrans    122.091         1.20659    101.2     1.48e-267 ***
  TransPerDay        0.00638854    0.00103937   6.147   2.09e-09  ***

Mean dependent var   4027.969   S.D. dependent var   4061.816
Sum squared resid    1.67e+08   S.E. of regression   678.8290
R-squared            0.972299   Adjusted R-squared   0.972069
F(3, 362)            4235.368   P-value(F)           1.9e-281
Log-likelihood      -2903.776   Akaike criterion     5815.551
Schwarz criterion    5831.162   Hannan-Quinn         5821.755
rho                  0.829195   Durbin-Watson        0.361596
```

Source: Gretl computation

Parameters in the equation

$y_{1t} = -4091.23 + 1.133183x_{2t} + 122.091x_{3t} + 0.00638854\ x_{4t} + u_{1t}$

Economic Verification

1. If the amount of Transactions per block increases by 1% then the price of Bitcoin increases by 1.133183%. This is the same as the assumption.
2. If the costs per transaction increase by 1% then the price of Bitcoin will increase by 122.091%. This is the same as the assumption.
3. If the amount of transactions per day increase by 1% then the price of Bitcoin will increase by 0.00638854%. This is the same as the assumption.

From this economic verification and from the p values, we can determine that this regression is most likely a spurious regression. This means that while it shows there is a relationship, it is likely that the relationship is not related on the variables but is instead an error and just so happens to appear to be related.

Table 6 - Testing for Statistical Significance with T- Table Values

t-value	-4091.23	1.133183	122.091	0.00638854
t-tab. (α = 0.1)	1.7959	1.7959	1.7959	1.7959
SS / NS *	**NS**	**SS**	**SS**	**NS**

Source: Own table

* SS - parameter statistically significant, NS - parameter statistically not significant

At an alpha level of 1% the t-tab. is equal to 1.7959. In this case parameters x_2 and x_3 are statistically significant. This means that parameters x_1 and x_4 are NOT statistically significant.

Figure 21 – R^2 Interpretation of Outputs from Gretl

R-squared 0.972299 Adjusted R-squared 0.972069

Source: Gretl computation

The variables in the model, Constant, amount of transactions per block, costs per transaction, and amount of transactions per day, describe the price of Bitcoin by 97.2299%

Testing for autocorrelation using Durbin Watson Test.

T (Number of Observations) = 366 (Number of observations used)

K (Number of Parameters) = 4

D_1 (Value found from Durbin Watson Table) = 1.81029

D_h (Value found from Durbin Watson Table) = 1.84389

During Watson test value (from GRETL output) = 0.361596

Figure 22 - Autocorrelation Intervals from Gretl

a. Interval $<0; d_l>$ means positive autocorrelation
b. In the interval $<d_l; d_h>$ is not significantly possible to make the decision about statistical significantly of autocorrelation, it is a grey zone
c. Interval $<d_h; 2>$ means statistically not significant positive autocorrelation
d. Interval $<2; 4-d_h>$ means statistically not significant negative autocorrelation
e. In the interval $< 4-d_h; 4-d_d>$ is also not significantly possible to make the decision about statistical significantly of autocorrelation, it is a grey zone
f. Interval $<4-d_d; 4>$ means statistically significant negative autocorrelation

Source: Gretl

Based on the criteria above, the Durbin Watson test value (0.361596) is only correct on letter (a), it means there is positive autocorrelation. This means that there appears to be a delayed copy of itself meaning the data is having an influence on itself later down in the model.

Testing for cointegration with Engler Granger test

Step 1: testing for a unit root in v1

Augmented Dickey-Fuller test for v1
including 7 lags of (1-L)v1
sample size 358
unit-root null hypothesis: a = 1

test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): 0.0010924
test statistic: tau_c(1) = 0.226579

asymptotic p-value 0.9743
1st-order autocorrelation coeff. for e: 0.007
lagged differences: F(7, 349) = 6.044 [0.0000]

Step 2: testing for a unit root in v3

Augmented Dickey-Fuller test for v3
including 7 lags of (1-L)v3
sample size 358
unit-root null hypothesis: a = 1

test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0.0991262
test statistic: tau_c(1) = -2.30588
asymptotic p-value 0.1701
1st-order autocorrelation coeff. for e: -0.008
lagged differences: F(7, 349) = 12.942 [0.0000]

Step 3: testing for a unit root in v4

Augmented Dickey-Fuller test for v4
including 7 lags of (1-L)v4
sample size 358
unit-root null hypothesis: a = 1

test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): 0.0261257
test statistic: tau_c(1) = 2.59351
asymptotic p-value 1
1st-order autocorrelation coeff. for e: 0.001
lagged differences: F(7, 349) = 8.111 [0.0000]

Step 4: testing for a unit root in v5

Augmented Dickey-Fuller test for v5
including 7 lags of (1-L)v5
sample size 358
unit-root null hypothesis: a = 1

test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0.0889403

test statistic: tau_c(1) = -2.00991
asymptotic p-value 0.2827
1st-order autocorrelation coeff. for e: 0.003
lagged differences: F(7, 349) = 14.639 [0.0000]

Step 5: cointegrating regression

Cointegrating regression -
OLS, using observations 2017-01-01:2018-01-01 (T = 366)
Dependent variable: v1

	coefficient	std. error	t-ratio	p-value
const	−4091.23	230.252	−17.77	3.11e-051 ***
v3	1.33183	0.169122	7.875	4.01e-014 ***
v4	122.091	1.20659	101.2	1.48e-267 ***
v5	0.00638854	0.00103937	6.147	2.09e-09 ***

Mean dependent var 4027.969 S.D. dependent var 4061.816
Sum squared resid 1.67e+08 S.E. of regression 678.8290
R-squared 0.972299 Adjusted R-squared 0.972069
Log-likelihood −2903.776 Akaike criterion 5815.551
Schwarz criterion 5831.162 Hannan-Quinn 5821.755
rho 0.829195 Durbin-Watson 0.361596

Step 6: testing for a unit root in uhat

Augmented Dickey-Fuller test for uhat
including 7 lags of (1-L)uhat
sample size 358
unit-root null hypothesis: a = 1

model: (1-L)y = (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0.13009
test statistic: tau_c(4) = -3.28772
asymptotic p-value 0.2733
1st-order autocorrelation coeff. for e: -0.006
lagged differences: F(7, 350) = 3.533 [0.0011]

There is evidence for a cointegrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables, and
(b) the unit-root hypothesis is rejected for the residuals (uhat) from the cointegrating regression.

What was found in the Engler Granger cointegration test?

In the results above, when all of the asymptotic p values are compared with the critical values (listed in the appendixes) it can be concluded that none of these factors selected can determine the growth of Bitcoin and none are significant in influencing it. There appears to be no long run relationship among the variables and therefore we can conclude the factors are not significant.

5 Results and Discussion

5.1 Results

In the first part of the analytical section (the fundamental analysis), the number of stores that accept Bitcoin was analyzed. This was done to determine whether or not there is any legitimacy outside of Bitcoin being an investment tool. This can be useful because if investors feel there is no value to Bitcoin in the real world, they are less likely to invest. It was found that over the course of 2017 there was a steady increase of the number of stores that accepted Bitcoin as a form of payment. The second factor that was analyzed in the fundamental section was the trading volume. This is an important fundamental factor because it helps give a viewpoint of how much Bitcoin is being transacted. If Bitcoin has significantly low amounts of transactions or a significant decrease in transactions this can be a sign that there is a loss interest. Another reason volume is important is because it is used with prices to help determine whether there is significant change. In the first part of the technical section, the position of Bitcoin in an investor's portfolio was evaluated and discussed. This was done by using historical Bitcoin pricing data (to the USD), and then it was compared to historical Euro (to the USD) pricing. This was done to compare a longer more stable currency to a more recent modern one. What was found was that Bitcoin/USD had a very high standard deviation in both the short term and long term. This is important because its showing how much the values would sway away from the trend. In comparison the EURO/USD exchange rate significantly lower (meaning the values were not that far from the trend line). This shows that when compared to other currencies Bitcoin can be seen as a risky investment for investors. The second section of the analytical section of this dissertation was an experiment showing what kind of return an investor would get at the

end of a month (starting at November 1st and ending November 30th). This was done by converting an initial investment of $10,000 into Bitcoin at the beginning of November. Then every day the change in value of Bitcoin was evaluated according to the amount of Bitcoin that was purchased with the initial investment of $10,000. What was found was that the difference between the ending of the investment period (November 30th) and the beginning (November 1st) was a profit of $4726.56192. Following that was a time series forecast based on historical pricing data of Bitcoin to USD. What was found was according to the trend, Bitcoins price was likely due to increase. Following the time series was a regression analysis based on the dependent variable being the price of Bitcoin/USD and the independent variables being the amount of Transactions per Block, the costs per Transaction, and the amount of Transactions per day. After running and analyzing the regression, it was believed that the regression is spurious, and therefore appears to have a relationship theoretically but practically it appears to be incorrect (Spurious) and therefore there is no genuine relationship among the variables.

5.2 Discussion

In this section, selected areas of the work of the author is going to be compared with a similar scientific article. In this case the article that is being compared with the thesis is the article "What are the main drivers of the Bitcoin Price? Evidence from Wavelet Coherence Analysis by Ladislav Kristoufek". Similarly, to this thesis, a major indicator of the price of Bitcoin that was used was the price of Bitcoin compared to the USD. In this thesis paper, a time series was conducted by forecasting to predict future values. While the scientific article that is being compared was conducted much earlier than the time of this thesis, the findings are similar. Both in the scientific article and this thesis paper it is predicted that the price of Bitcoin is likely to continually and steadily increase. (Kristoufek, L. 2015) This will be shown in the figure below.

Figure 23: Bitcoin Price Index from Scientific Article

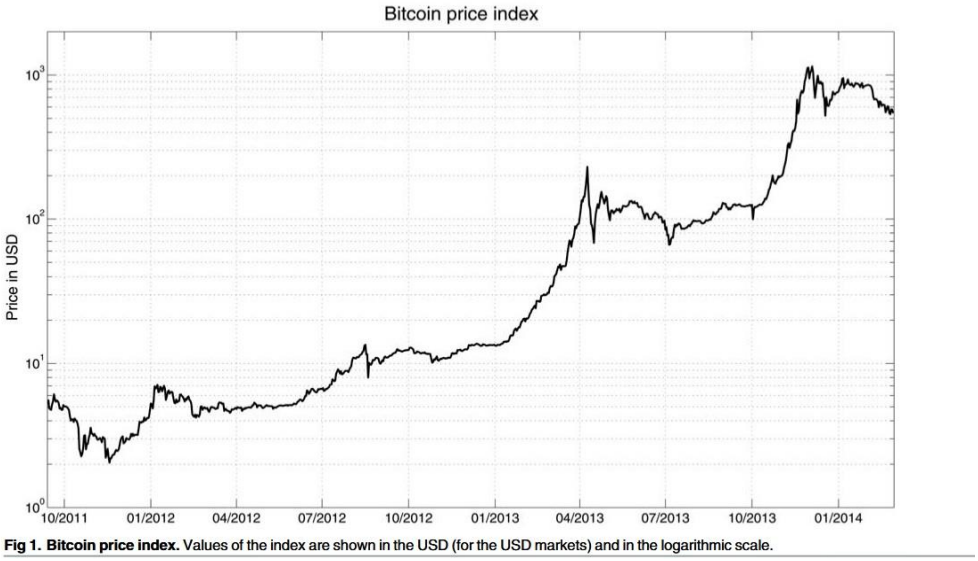


Fig 1. Bitcoin price index. Values of the index are shown in the USD (for the USD markets) and in the logarithmic scale.

Source: Kristoufek, L. (2015)

Also in the article, the author describes the importance of the volume of Bitcoin transactions as does this thesis.

Figure 24: Bitcoin and Trade Transactions from Scientific Article

Source: Kristoufek, L. (2015)

As shown in the figure the author shows that there is a positive relationship in the long term that the transactions help leads the Bitcoin price. The relationship does decrease at the beginning of 2013 and appears to become statistically insignificant though.

The second scientific article to be used to compare with this thesis is "The Economics of Bitcoin – Market Characteristics and Price Jumps" by Marc Gronwald. In the article, the author found that the key factors influencing the price were the public's interest in Bitcoin and investors attractiveness. Similarly, to this diploma thesis, the author of the article also used variables such as transaction values to help gain more knowledge behind the price of Bitcoin. The author also found a correlation between the number of Google searches related to Bitcoin and the volume of Bitcoin trading. The author states that Bitcoin prices are not only driven by speculative forces but also by fundamental factors such as usage in trade, money supply, and price level. (Gronwald, M. 2018).

6. Conclusion

To conclude this thesis, the reader should know have an in depth understanding of both the theoretical and technical investment views of Bitcoin as an investment vehicle. In the theoretical section, Bitcoin was explained simply and thoroughly, a brief history was given, how to acquire, store, transact, exchange for tangible currency were also explained. Bitcoin security, skepticism and similar cryptocurrencies were also discussed. Then in the analytical section more detailed analysis took place. This consisted of determining the role Bitcoin plays in an investor's portfolio, a "real life" simulation of investing in Bitcoin, analyzing trading volumes of Bitcoin, a times series prediction and an econometric model to determine if there was a relationship between the price of Bitcoin and transactions per block, costs per transaction and transactions per day. It appeared that the relationship among the variables was Spurious, meaning it showed a relationship but in reality its likely a coincidence.

7. References

Antonopoulos, A. (2015). *Mastering Bitcoin*. Sebastopol, CA: O'Reilly.

Amazon.com. (2018). *Amazon.com: bitcoin wallet*. [online] Available at: https://www.amazon.com/s/ref=nb_sb_noss_1?url=search-alias%3Daps&field-keywords=bitcoin+wallet&rh=i%3Aaps%2Ck%3Abitcoin+wallet [Accessed 7 Mar. 2018].

Blockchain.info. (2018). *Confirmed Transactions Per Day*. [online] Available at: https://blockchain.info/charts/n-transactions [Accessed 7 Feb. 2018].

Buybitcoinworldwide.com. (2018). *5 Best Bitcoin Mining Hardware ASICs 2018 (Comparison)*. [online] Buybitcoinworldwide.com. Available at: https://www.buybitcoinworldwide.com/mining/hardware/ [Accessed 7 Mar. 2018].

Chokun, J. (2018). *Who Accepts Bitcoins As Payment? List of Companies*. [online] 99 Bitcoins. Available at: https://99bitcoins.com/who-accepts-bitcoins-payment-companies-stores-take-bitcoins/ [Accessed 7 Feb. 2018].

Cointelegraph. (2018). *Bitcoin Adoption by Businesses in 2017*. [online] Available at: https://cointelegraph.com/news/bitcoin-adoption-by-businesses-in-2017 [Accessed 7 Feb. 2018].

EliteFixtures. (2018). *Home Lighting & Decor Discounted from EliteFixtures*. [online] Available at: https://www.elitefixtures.com/ [Accessed 7 Mar. 2018].

Gronwald, M. (2018). *The Economics of Bitcoins -- Market Characteristics and Price Jumps*. [online] Poseidon01.ssrn.com. Available at: https://poseidon01.ssrn.com/delivery.php?ID=195074122123116099123076071012015025053087027082034055099021088106113069068101093110053035120006007034111118083012106018001015126082004073093124016113098022003025031013007074069069125001066027027095123086110068006010080122064101069089090117118104092&EXT=pdf [Accessed 24 Mar. 2018].

Investing.com. (2018). *BTC USD | Bitcoin US Dollar Bitfinex - Investing.com*. [online] Available at: https://www.investing.com/currencies/btc-usd [Accessed 7 Feb. 2018].

Investing.com. (2018). *EUR USD | Euro Dollar - Investing.com*. [online] Available at: https://www.investing.com/currencies/eur-usd [Accessed 7 Feb. 2018].

IQOption.com. (2018) [online] Available at: https://blog.iqoption.com/en/three-countries-with-the-largest-number-of-bitcoin-miners/ [Accessed 7 Mar. 2018].

JM Bullion. (2018). *Bitcoin vs. Gold Infographic*. [online] Available at: https://www.jmbullion.com/bitcoin-vs-gold-infographic/# [Accessed 17 Feb. 2018].

Kharpal, A. (2018). *Bitcoin is heading to $10,000, CNBC survey says*. [online] CNBC. Available at: https://www.cnbc.com/2017/10/20/bitcoin-price-is-heading-to-10000-cnbc-survey-says.html [Accessed 17 Feb. 2018].

Kristoufek, L. (2015). What Are the Main Drivers of the Bitcoin Price? Evidence from Wavelet Coherence Analysis. *PLOS ONE*, 10(4), p.e0123923.

MacKinnon, J. (2018). [online] Qed.econ.queensu.ca. Available at: http://qed.econ.queensu.ca/working_papers/papers/qed_wp_1227.pdf [Accessed 24 Mar. 2018].

Prableen Bajpai, C. #1 (2018). *A Look At The Most Popular Bitcoin Exchanges*. [online] Investopedia. Available at: http://www.investopedia.com/articles/investing/111914/look-most-popular-bitcoin-exchanges.asp [Accessed 17 Feb. 2018].

Prableen Bajpai, C. (2018). *A Look At The Most Popular Bitcoin Exchanges*. [online] Investopedia. Available at: http://www.investopedia.com/articles/investing/111914/look-most-popular-bitcoin-exchanges.asp [Accessed 7 Mar. 2018].

Prableen Bajpai, C. #2 (2018). *What Are the 6 Most Important Cryptocurrencies Other Than Bitcoin?*. [online] Investopedia. Available at: http://www.investopedia.com/tech/6-most-important-cryptocurrencies-other-bitcoin [Accessed 7 Mar. 2018].

Robinson, B. (2018). *END OF CASH: Russia launches own cryptocurrency dubbed the Cryptoruble*. [online] Express.co.uk. Available at: http://www.express.co.uk/finance/city/867686/Vladimir-Putin-green-light-for-Russian-cryptocurrency-CryptoRuble-fight-bitcoin [Accessed 17 Feb. 2018].

Us.v-cdn.net, (2018). [image] Available at: https://us.v-cdn.net/5021640/uploads/editor/wn/2suhmu6scmwu.jpg [Accessed 17 Feb. 2018].

Appendixes

Table 3. Critical Values for Linear Trend Case (τ_{ct})

N	Level	Obs.	β_∞	(s.e.)	β_1	β_2	β_3
1	1%	15,000	−3.95877	(0.000122)	−9.0531	−28.428	−134.155
1	5%	15,000	−3.41049	(0.000066)	−4.3904	−9.036	−45.374
1	10%	15,000	−3.12705	(0.000051)	−2.5856	−3.925	−22.380
2	1%	15,000	−4.32762	(0.000099)	−15.4387	−35.679	
2	5%	15,000	−3.78057	(0.000054)	−9.5106	−12.074	
2	10%	15,000	−3.49631	(0.000053)	−7.0815	−7.538	21.892
3	1%	15,000	−4.66305	(0.000126)	−18.7688	−49.793	104.244
3	5%	15,000	−4.11890	(0.000066)	−11.8922	−19.031	77.332
3	10%	15,000	−3.83511	(0.000053)	−9.0723	−8.504	35.403
4	1%	15,000	−4.96940	(0.000125)	−22.4694	−52.599	51.314
4	5%	15,000	−4.42871	(0.000067)	−14.5876	−18.228	39.647
4	10%	15,000	−4.14633	(0.000054)	−11.2500	−9.873	54.109
5	1%	15,000	−5.25276	(0.000123)	−26.2183	−59.631	50.646
5	5%	15,000	−4.71537	(0.000068)	−17.3569	−22.660	91.359
5	10%	15,000	−4.43422	(0.000054)	−13.6078	−10.238	76.781
6	1%	15,000	−5.51727	(0.000125)	−29.9760	−75.222	202.253

Source: MacKinnon, J. (2018)