# CRYPTOCURRENCY BITCOIN: FUNDAMENTAL DRIVERS EXPLAINED

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DECLARATION

We hereby declare that:

(1) This undergraduate research project is the end result of our own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

(2) No portion of this research project has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) Equal contribution has been made by each group member in completing the research project.

(4) The word count of this research report is about _21,384_ words.

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The largest credit of our appreciation goes to Dr. Eng Yoke Kee, who acts as the supervisor in our Final Year Project and did a perfect job in this role. She educates and provides us with tons of useful information and data regarding the topic of Bitcoin which can ultimately lighten our burden in conducting the study. Not only these, she had also put a lot of heart and time on us with the purpose of guiding us in our works and overcoming any problem facing throughout the research. It is our great pleasure to have such a kind and carrying man as our supervisor.

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## DEDICATION

We would like to dedicate this dissertation to our family and friends who have given us their best support and encouragement during the preparation of this thesis.

Moreover, this thesis is also dedicated to our supervisor, Dr. Eng Yoke Kee for her advice and guidance to assist us in completing this thesis.

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| | |
|---|---|
| ACF | Autocorrelation Function |
| ADF | Augmented Dickey Fuller |
| AIC | Akaike Information Criterion |
| ARCH | Autoregressive Conditional Heteroscedasticity |
| ARDL | Auto Regression Distributed Lag |
| ARMA | Autoregressive Moving Average |
| ATM | Automated Teller Machine |
| BNM | Bank Negara Malaysia |
| BP | Bitcoin's Price |
| BTC | Bitcoins |
| CBOE | Chicago Board Options Exchange |
| CME | Chicago Mercantile Exchange |
| CNY | Chinese Yuan |
| CPU | Central Processing Unit |
| CNLRM | Classical Normal Linear Regression Model |
| CS | Bitcoins in Circulation |
| CUSUM | Cumulative Sum of Recursive Residuals |
| CUSUMQ | Cumulative Sum of Recursive Residuals of Squares |
| CT | Average Confirmed Transactions Per Day |
| ECM | Error Correction Model |
| FTSE | Financial Times Stock Exchange |
| GARCH | Generalized Autoregressive Conditional Heteroskedasticity |
| GI | Google Interest |
| GP | Gold Price |
| ICO | Initial Coin Offering |
| JB | Jarque-Bera |

| | |
|---|---|
| KPSS | Kwiatkowski-Philips-Schmidt-Shin |
| LM | Lagrange Multiple |
| MD | Mining Difficulty |
| PC | Personal Computer |
| PP | Phillips Perron |
| UK | United Kingdom |
| USD | United States Dollar |

## PREFACE

This research project is submitted as partly to fulfill the requirement of the course of Bachelor of Finance (HONS) having Dr. Eng Yoke Kee as the project supervisor. The topic chosen was “Cryptocurrency Bitcoin: Fundamental Drivers Explained”. This project was written solely by the authors with supporting facts from research by others which are quoted with reference.

There are many researches on the factors affecting Bitcoin’s price yet minimal in depth research on economics and technology factors and Bitcoin. This topic was chosen was due to the fact that so little research has been done on the topic and significance has yet to be proved. Hence, the purpose of this options was to bring the specific research another step closer to a clear result.

This research was considered a success and it was all because this research could help and contribute to future studies on this topic. New knowledge about economics and technology factors could very much allow researchers to better understand how they affect Bitcoin’s price in USD. Our main goal is to identify the relevant factors that are significant in explaining the Bitcoin’s price. This study is done in hope that it can be beneficial to various parties.

## ABSTRACT

This research seeks to investigate the long run and short run relationship between the Bitcoin's price and its economics and technology factors from November 2012 to December 2017. The fluctuation of Bitcoin's price in the near future has been a worldwide concern which is the main driver that urge us to involve ourselves in this subject field. The study continues with the inclusion of technology and economics factors to examine its effect on the Bitcoin's price. In other words, our purpose is to investigate whether the technology and economics can play an important part in addressing the Bitcoin's price the global is facing with. Methodologies like Unit Root Test are applied before the use of Autoregressive Distributed Lag (ARDL) approach. ARDL is used to study the long run effect between Bitcoin's price and related factors. As a result, the employment of ARDL approach reveals stable long run relationship between Google interest and Bitcoin's price, gold price and Bitcoin's price and also mining difficulty and Bitcoin's price. The Google interest, gold price and mining difficulty are found to have transferred a portion of their effect on economic growth. This finding implies that these factors are essential to stimulate the Bitcoin's price. Besides, the average confirmed transaction per day and Bitcoins in circulation show insignificant relationship against Bitcoin's price.

# CHAPTER 1: RESEARCH OVERVIEW

## 1.0 Introduction

This chapter will give an overview of the study and serve as an outline for this research project. This chapter consists of thirteen sections. Section 1.1 discusses about the research background. Section 1.2 and Section 1.3 mention about the Bitcoin's history and features. Section 1.4, 1.5 and 1.6 mention about the highlights, Malaysia Bitcoin's market and the challenges of using Bitcoin respectively. Section 1.7 discusses about the problem statement followed by Section 1.8 and Section 1.9 stated our research objective and research question. In Section 1.10, the hypotheses of this study are discussed and Section 1.11 tells the significance of our study. At last, this chapter will end with the chapter layout and conclusion in Section 1.12 and Section 1.13.

## 1.1 Research Background

Bitcoin is the pioneer of cryptocurrency and being the most popular one in the world (Nakamoto, 2008)[1]. Cryptocurrency is a type of digital payment and monetary systems that are decentralised. By decentralising, it means there is no any authorities or unit controlling the supply of Bitcoin, it cannot be controlled by monetary policies of any government. The cryptocurrency network employs a digital ledger technology known as blockchain with secure encryption.

Transaction occurs in Bitcoin network through peer-to-peer network without a central administrator. New Bitcoins are created to reward the mining activities ran by

[1] Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. This is the first journal introduce of Bitcoin and the technology of Blockchain.

miners. Miners offer their computing powers in the mining process thus verifying and recording of payment into the public ledger of users.

Specialized hardware such as mining machines and home computers which has a certain amount of computation power is used for mining, it is measured by hashes per second. Hashes can be viewed as the CPU microchip's processing power. Mining is very competitive as any individual mining with more computation power or higher efficiency has a better chance of getting the newly created Bitcoin as a compensation of effort.

Apart from mining, users can obtain Bitcoin in exchange for national currencies. Bitcoin can be sent and received electronically using freely available wallet software on a web application, mobile device, or a personal computer.

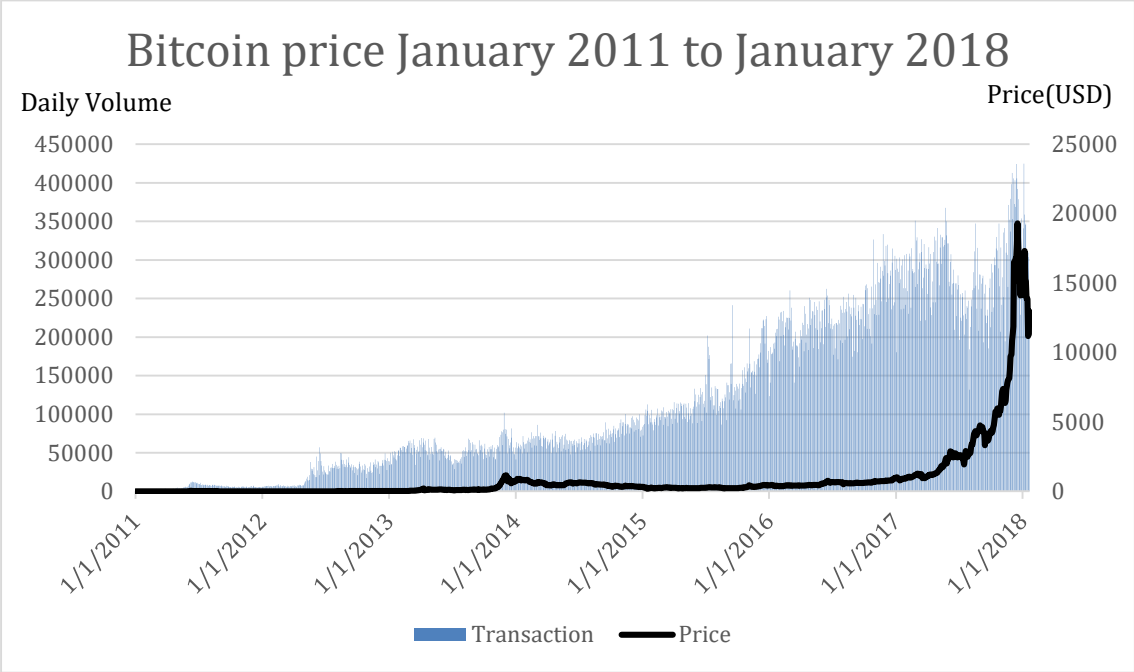
## 1.2 History of Bitcoin

Bitcoin's concept was introduced at 2009 by Satoshi Nakamoto (Barber, Boyen, Shi & Uzun, 2012). A whitepaper of Bitcoin was published by Nakamoto through metzdowd.com. Nakamoto then informed a group of people formed by cryptographers about his idea and eventually started up a forum to discuss and promote Bitcoin. It is generally believed that Nakamoto is a pseudonym. Today, Nakamoto was known no longer communicates and participates in Bitcoin under this name. The development of Bitcoin was proceeded in as open source projected by a number of volunteer programmers (Bonneau, Miller, Clark, Narayanan, Kroll & Felten, 2015; Bayern, 2013). Bitcoin was first mined in January 2009 and the first transaction of Bitcoin was also done in January 2009.

Figure 1.1 shows the statistic of Bitcoin's daily price from July 2010 to July 2017. It can be observed that since the establishment of Bitcoin, its price first increased in an astonishing speed with price fluctuating between 0.3 USD and 1000 USD. However, the Bitcoin's price climbed to a next height since January 2017. The highest daily transactions volume along the period is 425008 Bitcoins (BTC) and the average daily transactions is 114206 BTC. Along the period, the highest price of Bitcoin is

19289 USD on 17 December 2017 while the lowest is 0.3USD on 1 January 2011, the price has increased approximately 63296 times in these seven years. The transactions volume had increased around 12 times, the average transactions volume in 2011 is 23023 BTC while in 2017 is 286501 BTC. This shows that Bitcoin was getting more and more popular along the years.

Figure 1.1: Bitcoin's price from July 2011 to January 2018




Note: BTC refer to unit measurement of Bitcoin, % refer to the percentage of total value of Bitcoin traded

Source: blockchain.info

## 1.3 Features of Bitcoin

**Decentralized control of Bitcoin**

Bitcoin is a decentralized digital currency network, its transaction is verified and processed by a peer to peer system. Bitcoin does not depend on a third party intermediary to process the payments, it uses cryptographic proof in a computer software to process and verify its legitimacy and spread the work among the network (Nakamoto, 2008). The source code of the Bitcoin is fully disclosed in an open source, the disclosure of Bitcoin allows any programmer to examine the protocol. Besides,

Bitcoin is designed for operating under full consensus of all users, thus a programmer who modifies the source code of Bitcoin into their own version cannot change the original protocol without the breaking of compatibility with the rest of the network. The full agreement of Bitcoin developers and users are required for the changing of Bitcoin protocol (Lam & Lee, 2015).

**Trading and storing Bitcoin**

For the first time, payments can be made through internet without the need of control and cost of a third party as a trusted intermediary to verify transactions with the invention of Bitcoin. Bitcoin is said to be currency because it satisfies the economic definition of money, store of value, unit of account, and medium of exchange (Lam & Lee, 2015).

People can obtain Bitcoin through the mining process, buying it at a Bitcoin exchange, through Bitcoin ATM, or receiving it as a payment of goods and services provided. Bitcoin can be sent and received through a computer software, service provider and mobile app that provides cryptocurrency wallet service. An address similar to a bank account number was generated by the wallet. New Bitcoins are created to reward the miners by providing mining activities, verifying and recording payment into the public ledger by users who offer their computing power (Luther, 2013).

Bitcoin is stored in a digital wallet, users need to have digital wallet in order to sell and buy Bitcoin. There are different types of Bitcoin wallets included desktops, webs, mobiles, and hardware wallets. It is not the Bitcoin itself which is store in a wallet but the private keys and the wallet is actually a software which has the functionality of creating Bitcoin address to receive and send Bitcoin and to keep the private key of the address. Although the users could maintain the ownership of their wallet in desktop or any smart devices, such wallets are like computer files, which are vulnerable to malicious software or users. For online wallet, the private keys are stored by the service provider, the risk is that the provider may absconding with the Bitcoin (Hurlburt & Bojanova, 2014).

**How Bitcoin works?**

The revolutionary of Bitcoin is solving the double spending problem without needing a third party. Double spending is a potential flaw for which the same digital token can be spent in more than one transaction. The digital token is just like a computer file, sending the computer file is sending the copy of the file but the original file is not deleted from the computer. When one sent a money file to others, he or she still remain the original file and may send the same money file which has been spent to others in the absence of a trusted third party to verify the transactions (Barber et al., 2012).

Bitcoin solves the problem by maintaining a ledger of balance, but Bitcoin decentralizes the responsibilities to the entire network instead of manage the ledger by only one party. Blockchain is a public ledger used to keep track of Bitcoin balances in the Bitcoin network, it is a definitive record of all transactions handled ever and it is publicly accessible which allows users to verify the validity of a transactions by using the Bitcoin software. The transactions of Bitcoin are broadcasted to the entire network and added into the blockchain once verified. The double spending problem is solved by checking against the blockchain for every new transactions to make sure that the Bitcoin has not been spent (Barber et al., 2012; Lam & Lee, 2015).

**Mining and Difficulty**

Bitcoin has a total supply limit of 21 million Bitcoins and it is expected to reach the limit by year 2040. Mining is the only way to create new Bitcoin. It is a validating process of Bitcoin transactions among users and the new Bitcoin created is the incentive to miners for their computational power provided during the validation. The validation process is to check against double spending and ensure there are no illegitimate transactions recorded into the blockchain.

The Bitcoin generating process is designed to follow a mechanism. Bitcoin is generating with the unit block and a block of Bitcoin is generated approximately every

ten minutes, initially each block of Bitcoin contains 50 units of Bitcoin and it will be decreased by half for every 210,000 blocks mined. In order to control the block generation speed, the mining difficulty which is measured by hash rate will be adjusted for every 2016 blocks mined. A higher mining difficulty means more computational power is required to mine a Bitcoin. Initially, the mining yield of Bitcoin started at approximately 7200 blocks per day and decreases by one half for roughly every four years (Li & Wang, 2017). Eventually there will be no new Bitcoin awarded to the miner once the limit of Bitcoin reached and the transaction fees will be the only incentive for the miners.

It is difficult to alter the previous transactions in previous block once a new block is added into the blockchain successfully. It will be harder and harder to alter a block when more blocks are added into the blockchain because changing a block on the blockchain require revalidating and rerecord all transactions subsequent to the changed block, thus making the cost of alteration of previous block to be much higher than the benefits get from the alteration (Lam & Lee, 2015).

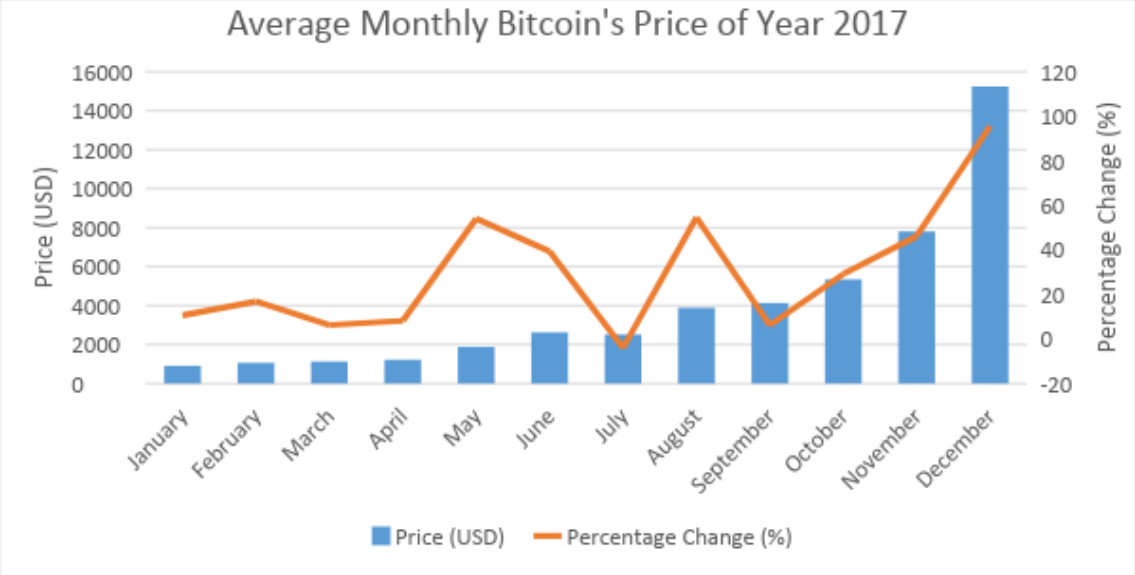
## 1.4 Highlights of Bitcoin

**Boom of Bitcoin**

Year 2017 was an astonishing year for Bitcoin, this was a year when everyone talked about Bitcoin and Bitcoin got a huge support worldwide. In this year, the Bitcoin's price reached a new high of approximately 20000 USD in December 2017 while it only costed less than 1000 USD in January 2017. Before the end of 2017, the Bitcoin's price was hovering around 15000 USD.

Figure 1.2 shows the average monthly Bitcoin's price and the percentage change of the price in the year 2017. It can be observed that the price started to increase vigorously since May and the price increased by almost 100% within one month on December.

Figure 1.2: Average Monthly Bitcoin's Price of Year 2017




Source: blockchain.info

**Increasing Bitcoin ATMs around the world**

With the growing price and demand of Bitcoin, many Bitcoin ATMs have started appearing around the world. These ATMs provide people with the freedom of purchasing and selling their Bitcoin as many as they would like without any personal information required while many websites require tiresome setups and scrutinize procedures and even with daily or weekly limits, these ATMs has provided convenient to Bitcoin user, increasing liquidity and accessibility within the world of cryptocurrencies. According to Coinatmradar.com, the number of Bitcoin ATM has grown from 953 to 2025 during the year 2017.

**Banning of crypto by China Government**

In September 2017, the China Government ban the initial coin offering (ICO) from occurring in China. People's Bank of China said on its website that the investigations on ICOs was completed and it will strictly punish offerings in the future. The regulator asked all related activities to be halted immediately and the money that

have already raised must be refunds. Following the ban of ICO, the domestic Bitcoin exchanges were instructed to voluntarily shut down their trading platforms. The world's oldest Bitcoin exchange, Shanghai-based BTCC Chinese Yuan (CNY) Exchange closed down in compliance with China policy.

**First Bitcoin futures landed**

The first Bitcoin futures was launched by Chicago Board Options Exchange (CBOE) Futures Exchange on 10th December 2017. Chicago Mercantile Exchange (CME), the world's largest futures exchange launches its own Bitcoin futures a week after CBOE launched its Bitcoin futures. The launches of the Bitcoin futures leading to the raise of Bitcoin's price as many see the launch of Bitcoin Futures as a step toward the legitimation of Bitcoin.

**Steam no longer support Bitcoin as payment method**

The most popular PC gaming platform, Steam operated by Valve Corporation announced that they were ceasing all the payments using the Bitcoin since 7 December 2017, it was first adopted as a payment method on 27 April 2016 (Nelson, 2017; Rick, 2017). In a statement of their official website[2], they claimed that with the current volatility in price, it was difficult to use the world's best performing cryptocurrency in a business sense. On the perspective of Valve Corporation, the Bitcoin's value has been volatile, but the degree of volatility has become more extreme during May to December. This would become the issue for customers who using the Bitcoin to buy the games in Steam platform. The value of Bitcoin is only guaranteed for certain period of time, so if the transaction does not complete within the certain time, then the amount of Bitcoin would be needed to use to cover the transactions. Besides, Valve stated another reason for their revoking of revoking Bitcoin services too, that is the transaction between customers and Steam would involve the very high cost. Valve explained that the transaction fees of Bitcoin have increased around USD 20 per transaction compared to around USD 0.20 when Bitcoin payment was first initiated. It is difficult to get someone

[2] Steam official website
http://steamcommunity.com/games/593110/announcements/detail/1464096684955433613

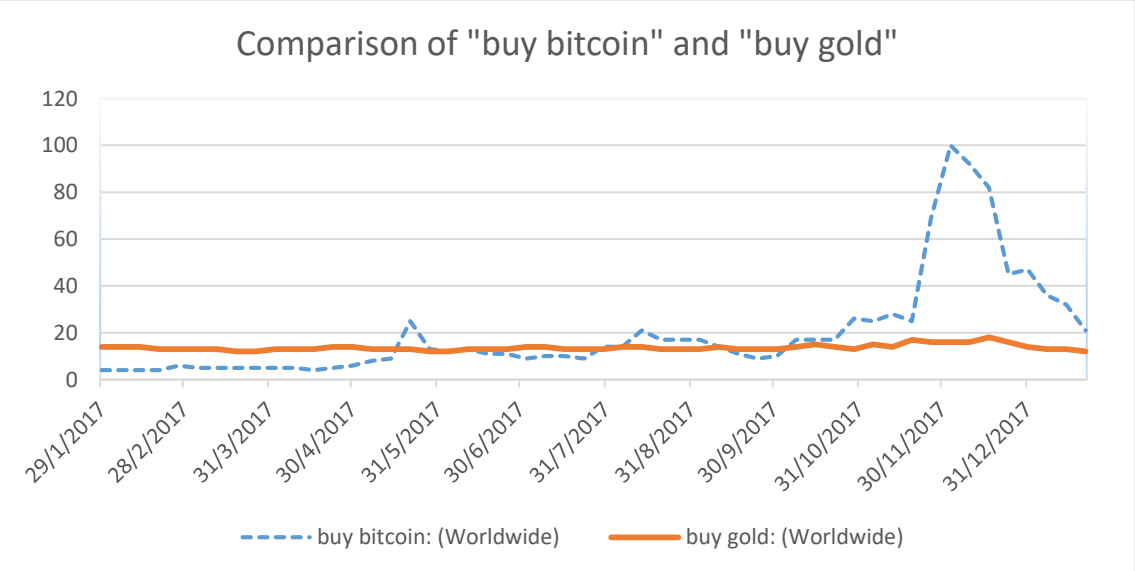
to voluntarily send a payment if large percentage of the payment need to be included as a fee. The increase in interest in Bitcoin causes the users are forced to up their fees to get the network to recognise and process their transactions. Besides, when the value of Bitcoin increased, Steam has to refund gamers the difference and the transaction cost of refund is bear by gamers too.

**Bitcoin surpasses gold in popularity**

People has treated gold as a medium of exchange and mighty store of value for centuries. The precious metal offers sense of security as a long-term investment and to be used to hedge against market volatility of stock market. Besides, gold is widely utilised in decoration especially jewellery in view of its shiny appearance (Pulgar, 2017). However, the invention of Bitcoin might diminish the luster of the gold. Simply put, the popularity of Bitcoin is higher than gold. As a matter of fact, many believe in Bitcoin's superiority over the gold. For example, Steve Wozniak, the co-founder of Apple made a statement that Bitcoin is better than gold.

The Telegraph shows "The search term 'buy Bitcoin' first surpassed 'buy gold' as a Google search term in May this 2017.

Figure 1.3: Comparison of "buy Bitcoin" and "buy gold




Source: http://bitcoinist.com/bitcoin-shining-brighter-gold/

On 3 March 2017, The Bitcoin' price outpaced the price of one ounce of gold. The Bitcoin's price reached USD 1,268 that time, while the gold was USD 1,233 per ounce. Since then, the difference in price between Bitcoin and gold has increased exponentially. As at date, Bitcoin's price is around USD 14,000, and the gold price is USD 1,302 per ounce as at 1 January 2018.

**Bitcoin will hit USD 25,000 at the end of year 2018**

According to (Zuckerman, 2018), the co-founder and Fundstat strategist Tom Lee predicted that the Bitcoin will beat USD 25,000 on 2018 during the interview. Previously, he had forecasted the Bitcoin would only reach this mark by 2022. His prediction comes after the very volatile week in the crypto market with Bitcoin hitting below USD 10,000, dipping lower than it during 22 December 2017. Tom Lee take into account the money supply growth in valuing the Bitcoin. This strategist expects the increased of institutional investors' interest on Bitcoin, the growth of user account and usage will spur Bitcoin's gains. While in technical perspective, Fundstrat report stated USD 10,000 is a support of Bitcoin's price and the next support are around USD 7,500 followed by USD 5,500.

**Major bank ban Bitcoin buying with credit card**

Since February 2018, the major credit card issuers and banks in United States and United Kingdom start to ban their customers to buy Bitcoin with credit cards one after another. This move is for reducing both legal and financial risk. The top five major credit card issuers of United State have taken this action. First, Capital One and Discover enacted the bans, then followed by Bank of America, JP Morgan, and Citigroup (Morris, 2018). Two British banks, Virgin Money and Lloyds Banking Group followed the US banks in the banning action. However, the ban do not apply to the debit cards (Farmbrough, 2018).

In the banks' point of view, using credit to finance such speculative investment like cryptocurrency is a high risk strategy, and the customer may end up with debts they

unable to pay back (Farmbrough, 2018). The moves is to protect the issuers themselves, the mania of cryptocurrency in 2017 have motivated people to use credit cards as leveraging tools and buy more cryptocurrency than they could afford. When Bitcoin price drop by more than 50 % from the peak price in December, many investors are most probably incurring loss now and may be unable to pay their credit loan (Morris, 2018).

## 1.5 Recent Bitcoin Market in Malaysia

According to Bank Negara Malaysia (BNM), there are average of RM75 millions of Bitcoin and other cryptocurrencies transactions every month in Malaysia. The deputy governor of BNM, Abdul Rasheed Ghaffour pointed out that there are currently four crypto exchangers operating in Malaysia, which are Luno, Coinhako, XBit Asia, and Pink Exchange. Table 1.1 shows the fees charged by each of the exchange for transactions of Bitcoin. The charges for LUNO and Pink Exchange are charged based on 30 days of trading volume.

Table 1.1 Transaction fees charged by particular Bitcoin's exchange in Malaysia

| Exchange | Charges to Taker | Charges to Maker |
|---|---|---|
| **Coinhako** | 1% of Bitcoin traded | 1% of Bitcoin traded |
| **XBit Asia** | 0.8% of Bitcoin traded | 0.8% of Bitcoin traded |
| **LUNO** | 1.00% (below 10 BTC)<br>0.75% (below 100 BTC)<br>0.50% (above 100 BTC) | No charges for seller |
| **Pink Exchange** | 0.15% (below 0.6 BTC)<br>0.14% (below 1.2 BTC)<br>0.12% (below 2.4 BTC) | 0.25% (below 0.6 BTC)<br>0.24% (below 1.2 BTC)<br>0.22% (below 2.4 BTC) |

| | | |
|---|---|---|
| | 0.10% (below 6 BTC) | 0.20% (below 6 BTC) |
| | 0.08% (below 12 BTC) | 0.16% (below 12 BTC) |
| | 0.05% (below 18 BTC) | 0.14% (below 18 BTC) |
| | 0.02% (below 24 BTC) | 0.12% (below 24 BTC) |
| | 0.00% (above 24 BTC) | 0.10% (below 60 BTC) |
| | | 0.05% (above 60 BTC) |

Note: BTC refer to unit measurement of Bitcoin, % refer to the percentage of total value of Bitcoin traded

Source: LUNO[3], Coinhako[4], XBit Asia[5], Pink Exchange[6]

BNM stated that Bitcoin is not a legal tender in Malaysia however BNM is not stopping the trading of Bitcoin but the cryptocurrencies exchangers are required to report their activities to BNM. The exchangers are categorised as reporting institutions under the Anti-Money Laundering, Anti-Terrorism Financing and Proceeds of Unlawful Activities Act 2001(AMLA). BNM said in a statement that reporting obligation is the first step for the activities in cryptocurrency business be more transparent in Malaysia.

In January 2018, a sale of a piece of land in Sabah's east coast Libaran Island was signed and sealed by a businessman in Sabah using Bitcoin. The 1.219 hectare of land was worth half a Bitcoin, at the time the deal was signed, a Bitcoin was valued at RM77, 665. This deal was done between one of Sabah's top tourism entrepreneurs Alexander Yee and Polycarp Chin (Vanar, 2018). Based on the information from Luno, there are over 20 places, online and offline accept Bitcoin payment in Malaysia. Table 1.2 is the list of retailer that accept Bitcoin payment in Malaysia.

Table 1.2 Offline and Online shop accepting Bitcoin payment in Malaysia

| **Name** | **Description** |
|---|---|
| **BolehVPN** | VPN services provider. |
| **Codashop** | Online platform for buying game credits. |

[3][3] Luno https://www.luno.com/en/countries

[4]Coinhako https://support.coinhako.com/hc/en-us/articles/115002062992-Cryptocurrency-Fees

[5]XBit Asia https://www.xbitasia.com/index.php/countries-fees

[6]Pink Exchange https://www.pinkexc.com/en/fees

| | |
|---|---|
| **Cygnus IT Solutions** | IT Consultancy Company that provides services to home and office. |
| **Dae Jang Geum** | Korean cuisine's restaurant. |
| **ExpressVPN** | VPN services provider. |
| **Footsteps** | Outdoor gear retailer. |
| **GeekZen** | An online retailer of technology accessories and gadgets. |
| **HostPro2U** | Websites hosting services provider. |
| **Ipmart** | An online store selling gadgets, tech items and home appliances. |
| **Jeq in the House, PJ** | A stylish coffee shop. |
| **L&W Car Rental** | Car rental service provider. |
| **Nook Bangsar** | An anti-office coworking space in Bangsar. |
| **One Edu Smart Resources** | An education institution providing short course, multiple education programs and education consultation. |
| **OverStock** | An online store selling overstocked items with affordable price. |
| **PDABase** | A smart devices dealer. |
| **RuzNor Corner** | A restaurant serving Malay, Thai and western cuisine. |
| **Seishinkan Aikido in Kuching** | Japanese martial art dojo |
| **Shell Petrol station at Jalan Raja Chulan, Kuala Lumpur** | A petrol station |
| **Spyking** | Surveillance and Automation Systems provider. |
| **Vape Club International** | An online vape juice and e-liquid retailer. |

| | |
|---|---|
| **Viv's Boutique Cafe & Restaurant** | A restaurant and cafe serving Japanese, Italian and Asian food. |
| **Wongkok@Mytown** | Hong Kong style cuisine restaurant. |

Source: https://www.luno.com/blog/en/post/spend-bitcoin-in-malaysia

## 1.6 Challenges of using Bitcoin as a method of payment

**Trust in service providers.**

Consumers must trust on the service providers that the exchange will not run and their Bitcoins in their wallet will not get stole or lost. There are some Bitcoin exchanges encounter security breaches in which Bitcoin in the exchange were stolen and the exchange collapsed, caused the individual suffering from losses. These exchange included Mt. Gox in Tokyo, BitInstant in New York City, and Flexcoin in Alberta. This was not due to the defective of Bitcoin protocol but a service issue. There are some evildoers in the real as well as in the Bitcoin ecosystem. Cyber-attacks can be occurring in online banking, and stolen of credit card details. Some customers scare of identity theft and do not trust on the authentication options and mobile login from bank.

**Price stability**

The value of currencies fluctuated in a wide range will negatively affect the customers. The value of Bitcoin has been varied significantly. In January 2014, Bitcoin reach a high of around USD 1,000 while in September its price was under USD 400. This is the reason that most of the businesses which accepting Bitcoin immediately convert it back to fiat money or the payments processor will automatically convert it to fiat money once the customers pay in Bitcoin. This is also the reason that Bitcoin is not suitable for international remittances currently.

**Technology performance**

The cryptocurrencies must be supported by technology that are suitable in order to handle millions of transactions. While artificially established and probably not a long-term sticking point, seven transactions per second of Bitcoin's current performance is

worse than other existing alternatives. Also the Bitcoin service providers performing poor in term of reliability, availability or customer support compare to traditional payment systems management companies. In Bitcoin's broadcast, distributed verification and central record approach, an interesting concept for building consensus is very resource intensive and may be less confidential, and less efficient than point-to-point transfers.

**Clear regulation**

The service providers of Bitcoin have to comply with applicable regulation though the Bitcoin itself cannot be regulated. This action is to protect the Bitcoin's user and to strengthen the confidence of users toward Bitcoin. The primary concern of regulators is the potential use of Bitcoin by criminals and the risks posed to users. The regulatory frameworks of Bitcoin today are evolving rapidly and divergent.

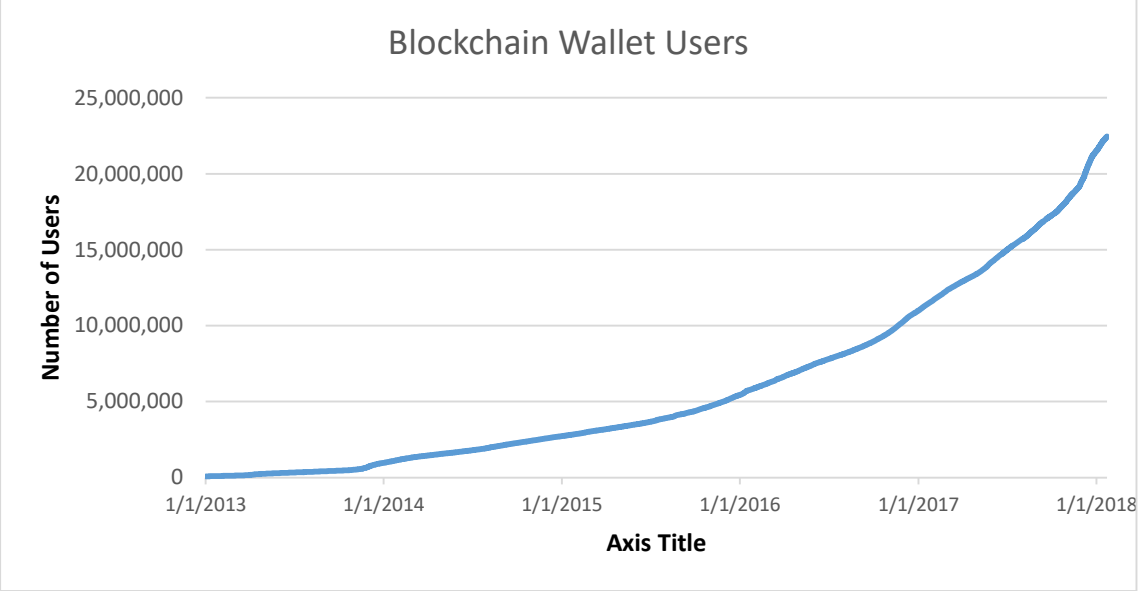
**Compelling benefits**

If the trend is for consumers to give up their old habit and switch to new alternative, Bitcoin must reinforce its proposition of cheaper, faster, and more convenient. The speed of Bitcoin's transaction is depend on situation, it could be faster or slower than current alternatives. Regardless how cheaper it is, it is not free, the conversion of regular currency into or out of cryptocurrency would not be more convenient than using regular currency itself. The experience and expectation of users can be variable and depend on the context.

## 1.7 Problem Statement

Bitcoin mania of cryptocurrency is getting higher and higher throughout the years along with increasing of its price. It can be observed from Figure 1.4, blockchain wallet user had increase vigorously recently, from less than 100 hundred thousand at year 2013 to date around 22.5 million users as at 23 January 2018.

Figure 1.4: Blockchain wallet users from 2013 to 2018




Source: blockchain.info

With the increased popularity of Bitcoin, some believe that the so called Bitcoin mania will burst once the mania end. Joseph Borg, director of the Alabama Securities Commission and also the president of the North American Securities Administrators Association, raised concerned in an interview with Consumer News and Business Channel (CNBC) that if people used credit cards, equity lines and even mortgages to buy Bitcoin, that would lead to the next financial crisis such as the subprime crisis where people not able to repay their borrowing[7].

From the academic side, Nobel prize-winning economist Robert Shiller hailed Bitcoin as "an interesting experiment" but will not be a "permanent feature" of the financial world[8]. Dr. Garrick Hileman, an economic historian at the University of Cambridge and the London School of Economics raised concern that cryptocurrencies could threaten stability and even exacerbate next crisis in an interview with Business Insider. He said the crucial problem is lack of the reliable information about the value of cryptocurrencies and the traders artificially inflate price at investors' expense. He said this is caused by the fact that valuation models are still being developed (Hodgson,

[7] https://www.cnbc.com/2017/12/11/people-are-taking-out-mortgages-to-buy-bitcoin-says-joseph-borg.html
[8] https://www.weforum.org/agenda/2018/01/robert-shiller-bitcoin-is-just-an-interesting-experiment/

2017). Moreover, Yermack (2013) claims that Bitcoin does not have any intrinsic value. So, if Bitcoin does have no intrinsic value, what could be the fundamental that drives the Bitcoin price?

It has been argued in the literature that the value of Bitcoin price is driven by fundamental demand and supply forces (Luther & White, 2014; Shcherbak, 2014; Hayes, 2015). Factor for instance, the mining difficulty, i.e., the blockchain technology, affects the production of Bitcoin that impact the supply side of Bitcoin in term of cost of production (Li & Wang, 2017; Hayes, 2016). However, the demand is not merely depending on the fundamental demand factor but also market expectation about the future price that might be reflected in public collective sentiment. Therefore, besides demand and supply, this raise the need to measure public sentiment.

A currency to be took as a currency because of its government and public recognition. Such as the fiat money, it can be anything that the government has ordered or declared to be money. Bitcoin is recognised by many people as a currency because it contains the characteristics of money, medium of exchange, standard of value, and store of value (Van Alstyne, 2014). The public recognition allows Bitcoin to act as a medium of exchange, the merchants accept Bitcoin as payment because they recognized Bitcoin as a type of currency. There is a curiosity that is the recognition of the public toward Bitcoin grant it the value and forming its price. Polasik, Piotrowska, Wisniewski, Kotkowski and Lightfoot (2015) stated that the popularity and the transactional need is the primary factor of the price formation of Bitcoin. It need to be find out how popularity and the public recognition of Bitcoin affect its price.

Gold has been the safest hedging and store of value tools in the past decade. But this trend seems to be waned when the cryptocurrencies start to bloom in the market. According to Eddie Van Der Walt, a Bloomberg journalist, the surge of Bitcoin is attracting investor interest toward cryptocurrency and away from metal, this was showed on Google trend. According to Google trend, the global search on “buy Bitcoin” have overtaken “buy gold” since October 2017. Eddie Van Der Walt said the amount of gold changing hands during October on Bullion Vault’s online platform was drop by 1/3 from the 12-month average. Adrian Ash, the director of research at Bullion Vault said in

a report that some of gold investors were distracted by Bitcoin and other cryptocurrencies, this had weakened the interest from new gold investors (Ash, 2017). In earlier December 2017, Larry McDonald, the head of US macro strategy at ACG Analytics claimed in an CNBC interview that investors were switching from gold to Bitcoin during November and December 2017 (Partz, 2018).

Many took Bitcoin as "digital gold" due to some common features with gold, its limited amount. There is only 21 million of Bitcoin can be mined, once the Bitcoin is totally mined, the supply of Bitcoin will stop, that is why people compare Bitcoin to gold. Besides, Bitcoin also contain the characteristic of store of value as its not perishable feature. After all, can Bitcoin compare with gold and will gold affect Bitcoin's price? We can see that the original gold buyer switches to buy Bitcoin. An inestimable consequence could be happening to the buyer if an unexpected incident happened. At last, there is doubt about Bitcoin may substitute the gold in the market eventually.

After all, the market of Bitcoin still full of doubt waiting for an answer. Therefore, this research aims to study the interaction of demand and supply fundamental, as well as public sentiment and traditional conventional safe heaven asset with Bitcoin's price. Bitcoins in circulation and mining difficulty are included as the supply side drivers, while average confirmed transactions per day as demand side driver. To measure public sentiment, we use the searching frequency of bitcoin in Google and lastly the gold price is included.

## 1.8 Research Objectives

### 1.8.1 General Objective

The general purpose of this study is to study the fundamental drivers that can explain Bitcoin's price.

### 1.8.2 Specific Objectives

The general research objective can be narrowed down to

i. to investigate the demand and supply fundamentals determinants of Bitcoin's price.
ii. to measure the public mood/ sentiment and its impact on the evolution of Bitcoin's price.
iii. to investigate is Bitcoin a substitution commodity of gold.

## 1.9 Research Question

i. What are the key demand and supply determinants of Bitcoin's price?
ii. Is public sentiment on Bitcoin affect its price?
iii. Is Bitcoin a new 'safe' haven' asset compared to gold?

## 1.10 Hypotheses of the Study

### 1.10.1 Average confirmed transactions per day

$H_0$: Average confirmed transactions per day has no significant relationship with Bitcoin's price.

$H_1$: Average confirmed transactions per day has a significant relationship with Bitcoin's price.

### 1.10.2 Google interest

$H_0$: Google interest has no significant relationship with Bitcoin's price
$H_1$: Google interest has a significant relationship with Bitcoin's price

### 1.10.3 Gold Price

$H_0$: Gold price has no significant relationship with Bitcoin's price
$H_1$: Gold price has a significant relationship with Bitcoin's price

### 1.10.4 Bitcoins in circulation

$H_0$: Bitcoins in circulation has no significant relationship with Bitcoin's price
$H_1$: Bitcoins in circulation has a significant relationship with Bitcoin's price

### 1.10.5 Mining difficulty

$H_0$: Mining difficulty has no significant relationship with Bitcoin's price
$H_1$: Mining difficulty has a significant relationship with Bitcoin's price

## 1.11 Significance of the Study

This research is aim to investigate the relationship between the endogenous variable (Bitcoin's price) and exogenous variables (Google interest, transaction per day, gold price, Bitcoins in circulation, and Mining difficulty) with the monthly time series data from November 2012 to December 2017. By using a more recent data, this research can let the users know what significantly affect the Bitcoin's price.

The Bitcoin's price had increase vigorously throughout the years. The highly volatile of its price had bring danger to the users and investor. This research is able to benefit the users or investor of Bitcoin by telling the users what is significantly affect the Bitcoin's price.

## 1.12 Chapter Layout

Chapter 1 is an overview of the research background followed by problem statement, research objectives, research question, hypothesis and significance of the study. At last, a conclusion will end the chapter.

Chapter 2 provide the literature review of the research. We studied the relevant theoretical models and conceptual framework and hypotheses development from the past research to strengthen our position. A conclusion will lead to the end of the chapter.

Chapter 3 will focus research methodology. This include research design, data collection methods, sampling design, research instrument, data processing and data analysis. Lastly, a conclusion will be made for the chapter.

Chapter 4 is data analysis. The data collected in Chapter 3 will be analysed. The analysis method use would be descriptive analysis, and inferential analysis. Lastly, there will be a conclusion to summarise the chapter.

Chapter 5 is the last chapter of this research. This chapter provide a summary for the analysis done in previous chapter, followed by a discussion on the major finding, provide the implication and limitation of the research. After that, we will make a recommendation for the future research. A conclusion will be made to end the chapter and the whole research.

## 1.13 Conclusion

In conclusion, this chapter has briefly introduced the background of Bitcoin and cryptocurrency. We believed that it is important to let the users know the effect of their demand toward the Bitcoin's price and significant of gold price toward Bitcoin's price. Moreover, the research objectives and the research questions have been discussed in this chapter. Lastly, the hypotheses and significance of the research were addressed, followed by the layout of the whole research. The following chapter will review the past research to provide a deeper understanding about the research.

# CHAPTER 2: LITERATURE REVIEW

## 2.0 Review of the relevant literature

### 2.0.1 Bitcoin: an asset for store of value?

Bitcoin as the pioneer of cryptocurrency has been receiving ceaseless media coverage lately for its soaring price. There are plenty of viewpoint from the public towards Bitcoin. Some look it as an asset for store of value while some look it as a speculative tool. It is important to learn what are the major determinants at the back that drives the upwards spree of Bitcoin's price. After understanding the determinants, one may have a brief insight whether to get a Bitcoin in the meantime or not. However, it is rare to find researches on determinants of Bitcoin's price. By paying attention to this, investors are able to have a better planning in the future about investment on Bitcoin. Hence, this study will explore the impacts of Bitcoin average confirmed transactions per day, search interest on Google platform, gold price, Bitcoins in circulation and mining difficulty on Bitcoin's price denominated in US dollar from 2011 to 2017.

Nakamoto first illustrated the concept of Bitcoin in his paper in 2008 and it went public in 2009. It is the biggest cryptocurrency in market capitalization that has been gaining much spotlight on. The incrementing popularity emanates from its innovative features to be decentralized and transparency. The price of Bitcoin has sky-rocketed time to time since its inception. Most investors look into Bitcoin as investment tool or currency. Selgin (2015) argues that Bitcoin works more like a speculative commodity rather than a currency.

### 2.0.2 Challenges faced in using Bitcoin in long run

Hanley (2013) suggests that Bitcoin is solely a manufactured currency where its value floats against other fiat currencies with no fundamental value to support it. Bitcoin is hypothesized to be not credible and is advocated by proponents that intend to profit from the illusory asset. Yermack (2013) studies Bitcoin's viability as a currency and further protest intrinsic value says in cryptocurrencies. Bitcoin is intangible and the effort needed to mine for them is computational instead of human labor, hence that kind of value in Bitcoin cannot be compared to tangible intrinsic value like gold has. To be frank, it is undeniable that Bitcoin and other cryptocurrencies still have milestones to go to become 'money'. Yermack (2013) pointed out a solid issue about the fluctuating Bitcoin's price that denominated in dollars and the various dollar price that being quoted among different cryptocurrency exchanges. The effort to analyze price data is troublesome to users.

Yermack (2013) in another research has claimed that there are few barriers to turn Bitcoin into a meaningful unit of account. In comparison with fiat currencies, Bitcoin's extreme volatility makes it changes value in a wide range every day. In such case, if merchandisers accept Bitcoin as a method of payment, they have to recalculate prices very frequently. The fluctuating market value of one bitcoin has been a dilemma for those who seeks to signify a solid point for determining consumer prices. This practice would be costing a lot to the merchant and cause confusion to both sides of buyer and seller. In theory, this issue diminished in an economy where its principal currency is Bitcoin.

### 2.0.3 What happens when Bitcoin violates the Law of One Price?

Another problem arises from the variation of "current market prices" that one gets Bitcoin on any occasion. There are many exchanges that serve the cryptocurrency market. However, the price of Bitcoin can have a large disparity

among the exchanges. This phenomenon clearly violated the classical law of one price and may be unhealthy towards the growing currency market owing to the ease of arbitrage. In consequence, many sites tend to rely on the cumbersome price aggregations by taking the average Bitcoin's price over several exchanges. No matter how, these aggregates will not bring the actual cost of obtaining or selling a Bitcoin at the moment to the consumers.

Pieters and Vivanco (2017) found that Bitcoin are traded at different prices across exchanges as not all of them are abiding to the law of one price, an economic theory indicating that identical goods should be sold at same prices after taking costs into consideration. Anti-money-laundering and know-your-customer (KYC) policies are two regulatory policies already in broad use across the global financial system. The exchanges that consistently fail law of one price are found to be not require customer identification to register an account, which means do not fully implement the policies. This suggests that standard financial regulations can affect Bitcoin's prices across a group of distinct global exchanges. Besides, Bitcoin-pricing data should be collected in a deliberate approach as there are distinction across platforms.

### 2.0.4 What volatility of Bitcoin's price tells us?

However, there are studies that are positive towards Bitcoin's value. Woo, Gordan and Iaralov (2013) proposes that Bitcoin could started the next era of online business payment which appear to be a strong contender to traditional money-transfer providers. Thus, Bitcoin's money-like feature as a medium of exchange may offer its existence certain fair value. Nevertheless, the rampant speculative activities in cryptocurrency market have created high volatility in Bitcoin which hinders it to be accepted as a payment method for online commerce at this moment.

Public valuation towards Bitcoin gradually progress to a "grown-up" status, which is similar to other financial instruments and associates with

economic theories in the long term (Li & Wang, 2017). According to Gandal and Halaburda (2014), the value of a bitcoin is determined by competition among cryptocurrencies in its early establishment stage. This phenomenon engenders volatility in its initial price. However, cryptocurrencies later change into pricing behavior similar to a financial instrument.

In a nutshell, there are both positive and negative views towards the value of Bitcoin in the future. In this research, we will look into few factors that we believe to be affecting the Bitcoin's price. Throughout the research, we will denominate the price of Bitcoin in US Dollar.

### 2.0.5 What is blockchain?

Bitcoin and alternative digital coins are generally referred to as cryptocurrencies as the underlying arithmetic and security are intimately connected to digital cryptographic arithmetic. A public accessible database records all trade of currency. Every Bitcoin is related with an address and the trade of Bitcoin is the transaction from one address to another. This database is known as the "blockchain". That is not final for a transaction in Bitcoin, unless it is involved in the block chains obtainable from numerous sources. No Bitcoin are held independently or exist of the blockchain. The chain of records of Bitcoin produced and transaction are called blockchain. Miners add to the blockchain by resolve computational issue and including new transactions (Dwyer, 2015).

### 2.0.6 Does Bitcoin's price being driven by the supply and demand?

Indeed, the Bitcoin's price is largely relied upon the supply and demand. This denotes that low supply ad high demand frequently leads to an expansion in the price. Note that, there are controlled supply of Bitcoin whereby the aggregate

number of Bitcoins in circulation should never exceed 21 million. Due to the restricted supply, there are speculations that the price of Bitcoin will keep on rising with time.

The quantity of transactions is difficult to be controlled as the action doing it includes a gigantic cost. The quantity of transactions also shows an expansion in use of the Bitcoin network. It is one of the finest ways to measure whether Bitcoin utilization is stays stable, growing or diminish.

### 2.0.7 Does the supply of Bitcoin being monitored?

The supply of Bitcoin is severely limited and the amount of the Bitcoin only have 21 million. Besides, the codes used to control the issuance of the Bitcoin is decentralized to the thousands and ten thousand of nodes used to operate the software Bitcoin. The value of moneys is being preserved as each of people have interest to maintain the monetary policy, it is not likely to observe any modification in monetary policy. In addition, the technical modifications such as changing the block size are seen as impossible to make the Bitcoin. The Bitcoin is very much similar to the gold. In fact, it is possible to supply the copy of Bitcoin but not changing the Bitcoin. Some of users are intended to stick to the inflation schedule. None of the change is made if the monetary policy of Bitcoin is undeniable, and no one can control it as the supply of the Bitcoin is very limited.

Ciaian, Rajcaniova, & Kancs (2018) found that the supply of a currency is the key factor of its price. When everything else hold constant, the higher the growth rate of currency in circulation, the more the currency faces inflationary pressure. Therefore, most currency including standard currency and virtual curency will be regulated by monitoring both of its growth rate and stock in circulation. However, Bitcoin does not have both of its stock circulation and growth rate to be controlled by any government or centralized financial authority, but just by a software algorithm.

### 2.0.8 Will Bitcoin's supply affects its price?

There is some empirical research also found the similar outcome which shows the relationship between the supply of Bitcoin and its price. Hayes (2015) stated that the market force of demand and supply is the main driver of Bitcoin's price. However, Ciaian, Rajcaniova, & Kancs's recent study in 2018 disagree with this statement, stating that Bitcoin supply can only affect its price in short run. They also proved that demand is a better factor compared to supply.

Ciaian et al. (2018) have stated the fact that the currency price formation will be varies when the currency adopt a different supply mechanism from those standard currencies. Bitcoin is adopting fast due to its fixed coin supply, as it gives incentives to users and miners to collect more coins after its release, forecasting a possible future price rise. They also mentioned this statement in another study in 2016 that Bitcoin imply different price formation because some features in its supply and demand are different from a standard currency. For example, Bitcoin supply is subject to its production techology and returns.

### 2.0.9 Is Bitcoin's price being affected by the scarcity of its supply?

The study of Li and Wang (2017) revealed that Bitcoin's supply follows a fixed schedule thus is subject to natural deflation. Since the total amount of Bitcoin circulating is capped, its current supply may reveal the relative scarcity of future supply, leading to currency price appreciation. Dyhrberg (2016) also agreed that the value of Bitcoin is mainly derived from its shortage of supply as it is not monitored by any authorities other than independent miners. The similar statement is found in the study of Hayes in 2015 which stated that when more Bitcoin is mined, the amount of remaining Bitcoin to be mined decrease, its scarcity increase, the value will rise.

Lam & Lee (2015) has highlight the threat that Bitcoin will died if it deplete its coin supply too quick and early. When Bitcoin reach its full supply of 21 million in one day, most of the miners will drop out when the benefit is only the transaction fees. However, if the transaction fees drive too high, the traders are the one who will drop out.

Hayes (2017) also revealed the limitation of Bitcoin to adjust its supply to accommodate the fluctuation in demand as its supply is fixed at a steady rate to maintain a linear rate of production. Even though the cost of production hold constant, Bitcoin's price will still rise if the miner cannot provide enough supply to meet the increase in new demand.

### 2.0.10 How does mining of Bitcoin takes place?

The mining of Bitcoin employs computational power measure in gigahashes per second (GH/s). To be successful in mining Bitcoin, it is not only depending on computational power but the algorithm difficulty level also needed to be taken into consideration during the mining period. The difficulty of mining describes how arduous to mine a Bitcoin. With the same mining rate, more computational power is required for mining Bitcoin at higher difficulty than in lower difficulty (Hayes, 2015; Hayes 2016). Whereas, the computational power cost in mining depend on the advancement of technology used (Li & Wang, 2017).

Unlike the traditional commodity production which has a regular difficulty for production overtime, every ten minutes will only have one Bitcoin be mined on average regardless of the total mining power. In Bitcoin mining, the supply cannot be change to accommodate fluctuation in demand. The difficulty level is adjusted up and down automatically so that on average, only a block of Bitcoin is found every ten minutes (Hayes, 2015). To control the block generation speed, the mining difficulty is adjusted every 2016 blocks mined. The Bitcoin mining yield is reducing by one half every 4 years (Li & Wang, 2017).

As more miner are participating in the mining, mean more computational power are put in the mining, the difficulty will increase as to maintain the set ten minutes interval.

### 2.0.11 What does mining difficulty imply?

Mining difficulties serves as a good proxy of the average mining cost of miners (Li & Wang, 2017; Hayes, 2016). The adjustment of difficulty is like a mechanism for stabilizing and increasing the production cost. When more aggregate computational power is on the mining, the difficulty of mining move up. For instance, on average if with current difficulty, a mining rig can mine 1 BTC/day, when the difficulty increases 10% or 20%, less Bitcoin was expected to be mined with the same rag every day. If new coins mined are not enough to meet new demand influx, the cost of production remains could largely the same while the market price increases. The miners would be induced to increase their efforts on mining which leading to the increase of difficulty and thus increase the production cost until it reached a new breakeven level (Hayes, 2015).

It also has a variable, or ongoing cost which is the direct expense of electricity consumption. Each unit of hashing power consumes a specific amount of electricity based on its efficiency, which has a real-world cost for the miner. Because miners cannot generally pay for their electricity cost in bitcoin, they must refer to the currency price of a bitcoin to measure profitability given a monetary cost of electricity (Hayes, 2015).

### 2.0.12 Will mining difficulty of Bitcoin affects its price?

(Garcia, Tessone, Mavrodiev & Perony, 2014) argue that the Bitcoin price should not be less than the cost of production through mining, and creating a lower bound for the Bitcoin's fundamental value depend on the energy cost used in mining. It seems that the value formation of Bitcoin is related to the marginal cost of its production.

According to (Kristoufek, 2015), there are two opposing effects between the mining difficulty and the Bitcoin price. The investor obtained the Bitcoin by investing in the hardware and mine for it rather than buying bitcoins directly. This could cause two possible effects. The Bitcoin price increased arouse market participants to invest start mining by investing in mining machine, which lead to increase of hash rate and thus higher difficulty. Another way, the demand for better mining machine and electricity increased due to the increase of hash rate and the difficulty resulting in more miners leave the mining industry. These miners can become bitcoin purchasers if they take Bitcoin mining as an alternative to direct purchase from the market and thus increase bitcoins demand and also the price (Kristoufek, 2015).

According to (Kristoufek, 2015), the mining difficulty is strongly affect the price in positive direction. The result of (Kristoufek, 2015) stated the Bitcoin's price is the factor of difficulty although this effect diminished over time. The relationship is dominated by the effect of appearing of new miners due to the increase in price. The relationship diminished as the time pass can be due to the stabilizing or decreasing in price of bitcoins recently, which no longer offsets the cost of production required for mining. In the short run, this overturn is very distinct at the end of (Kristoufek, 2015) analyzed period where as the correlation of Bitcoin price and both hash rate and difficulty turn negative, which is illustrated by the westward pointing phase arrows. This finding highlight that there is strong competition among miners but the Bitcoin market participants including miners and purchaser are also adapting quickly (Kristoufek, 2015). Besides, as mining technology becomes more efficient, the

long term impact of mining difficulty toward Bitcoin price diminishes over time (Li & Wang, 2017).

According to (Hayes, 2016), the relative production rates for a given mining effort level are tremendous. For a given level of hashpower, less units will be yielded when the difficulty increased, and thus the relative production cost. In other way, fewer units will be yielded if the block reward was reduced or a more stringent mining algorithm was employed. This suggest that value formation of cryptocurrencies was driven by the differences in the relative production cost on the margin.

### 2.0.13 What makes people choose to use Bitcoin?

Why would everyone use cryptocurrencies? Similarly, the most distinct reason for people to use physical money is the low cost of exchange from individual to individual. People can use digital deposits in numerous transactions and will definitely use it in even more situations later on when the technology develops into a more advance level. Still, without the technology intervention, we cannot transfer digital deposits between banks or perhaps other financial institution. However, the paying bank and the receiving bank must both accept the digital deposit transfer. On the other hand, the transaction of digital deposits does not support offline as well as the Bitcoin's transaction.

An attractive feature of currency transaction is the element of incognito. Transaction of physical currency are incognito which indicate that no party has kept a central database recording every physical currency transaction. Although no organization has kept the central record of every bank deposits transaction, but the total record could be collected by accumulating information from different banks. Even so, during transactions of physical currency, a middle man receiving currency from at least one banks is adequate to transferring of purchasing power.

### 2.0.14 Will Bitcoin be misused for transactions of illegal activities?

Meiklejohn, Pomarole, Jordan, Levchenko, McCoy, Voelker and Savage (2013) try to aggregate entities and characterize transactions through 13 April 2013. They created accounts to place purchases order in order to get addresses then supplemented it by self-identified addresses obtainable from Bitcoin forums. They examine Bitcoin transactions, to define whether Bitcoin helps to facilitate illegal activity. They figure out that Bitcoin does not support illegal utilizes in high value, for example, drugs or laundering. They discover tendency of quick spending in small transactions which come from a web-based gambling website: Satoshi Dice. Sales through legitimate sellers could accomplish expanding importance in the end of 2012 and the beginning of 2013, in spite of the fact that Satoshi Dice is a big user.

Nevertheless, Bitcoin utilizes certification in peer-to-peer basic which is different from central certification proposed by Chaum, Fiat and Naor (1990) in order to settle the double-spending issue. Different websites preserve copies of the blockchain and modeling copies of other network nodes to update their copies. Transaction can happen in a couple of seconds, despite the double spending hazard does not lessened to a minimal level for at least ten minutes involving in a block chain. Therefore, the double spending hazard cannot be removed in quick transaction (Karame, Androulaki & Capkun, 2012).

In short, we are confident that Bitcoin may become the currency of next era. The increasing rate of utilization of Bitcoin indicates growing demand towards Bitcoin. Therefore, we may see Bitcoin’s price growing together with the surge in number of transactions per day.

### 2.0.15 What effects do technology developments bring to the business society?

A beta edition of Google Insights (http://www.google.com/insights/search/) was introduced to the world by Google in the midst of 2008. Search queries towards certain keywords can be compared across nations in customizable time frames from 2004 onwards via this service. The results are subsequently tailored according to the input of keywords (up to 5), region and time frame selected (Askitas & Zimmermann, 2009). The extensive acceptance of search engines and information technologies that are relevant have brought the world to a new level of technological era.

An individual's preferences and thoughts to do a monetary transaction are precious data that are reviews every time the consumer survey for a product through the Internet (Moe & Fader, 2004). In other words, demand and supply can be estimated by assessing the information of these intentions. Such development in information technology is still ongoing and it foreshadows an associated enhancement in human's ability as in doing business predictions precisely and transformation in business decision-making. This new evolution of information technology is not a minimal distinction in degree, yet a fundamental reconstruction of how people behave against handling information.

### 2.0.16 Does Google Trend reflects the market interest?

Search intention does forego buying decisions and definitely a more "honest signal" of actual preferences as there is no negotiation involved (Pentland & Heibeck, 2008). Therefore, consumers' searching history can be collected to uncover the summed-up idea of genuine concealed economic intentions. Hence, precise forecasts about potential customers can be drawn by utilizing aggregation of query data gathered from the Internet.

Google Trend data have been utilized by various economic market such as labor and housing for market prediction (Askitas & Zimmermann, 2009; Judge & Hand, 2010; Wu & Brynjolfsson, 2009). D'Amuri and Marcucci (2010) proved how US unemployment rate is predicted through the help of Google Trends. Some healthcare authority and organization also use it to discover and monitor health pattern such as influenza outbreak (Carneiro and Mylonakis, 2009). Health relevant data has been surfed by millions of people worldwide every day. This phenomenon has made Internet search queries a priceless information source of common health patterns. Google launched an experimental tool lately for almost on the spot diagnosis of influenza outbreaks by inspecting and keeping health care searching action under surveillance in the form of queries to its online search engine. It is being named Google Flu Trends, a revolutionary Web-based tool used to detect regional influenza outbreaks in the United States. The Centers for Disease Control and Prevention (CDC) has made it looks promising after tests in the United States.

### 2.0.17 Does public recognition affect Bitcoin's price?

Li and Wang (2017) take accounts of search intensity and social media mention as two technology means to identify popularity. Public recognition is revealed by both means but they do have subtle dissimilarity. Search intensity refers to recognition driven by information retrieval. It indicates the expressed intention to learn about Bitcoin. Meanwhile, social media mention focuses on information sharing and provision. It speaks one's desire to acquire knowledge about Bitcoin. Daily Google search queries on the keyword "Bitcoin" have been collected from Google Trends. Besides, the number of Twitter posts mentioning Bitcoin in daily basic have been collected as a proxy of social media mention from Bitcoinpulse.com. Topsy which stores all tweets under a contract with Twitter has been utilized by Bitcoinpulse.com to counts all tweets but does not include retweets that contain the keyword "Bitcoin".

Kristoufek (2013) claims a coexisting relationship between Bitcoin market price and search queries on Wikipedia and Google Trends. In other words, it potentially reveals a speculative bubble driven by curiosity. Polasik et al. (2015) finds that Bitcoin's price is formed solely on the transactional demands of its users and its popularity. They also applied Google search queries as a variable to investigate and found it to be particularly significant.

In contrast, Hayes (2015) proclaims that Google search queries cannot served as an accurate measurement as the test results may be invalid. During the time the studies took place, Bitcoin's price shoots up drastically. The extensive price growth has attracted large media coverage and word-of-mouth reaches Bitcoin to new people who eventually searched to gain knowledge on it through the internet. The Bitcoin miners or users who actively participate in Bitcoin market do not necessarily have to search the word "Bitcoin" in Google again and again in his suspect. The Google search queries would rather comprise people searching it for the first time or to explore it to a deeper dimension.

### 2.0.18 Is Bitcoin similar to gold?

According to Woo (2013), the Bitcoin and Gold have 3 common attributes such as both of them do not required to pay the interest, the supply of gold is limited as well as the Bitcoin, and the financial assets are more difficult to be traced with using them.

As mentioned by Baur and Lucey (2010), the Bitcoin has the same hedging capabilities with gold in the United Kingdom market. As long as Bitcoin is not correlated with London Stock Exchange's hundred largest companies while the gold's return is oppositely related to the return of stock and bond in UK market, the UK investors can use the Bitcoin as well as gold to offset the market risk.

Furthermore, the Bitcoin could be utilized to hedge against the FTSE Index in overall and also can play an important role together with gold to minimize and even eliminate the specific market risk. When using very small values to find the correlation, the conclusion will become more unclear. In short term, the Bitcoin have the capabilities to hedge against the dollar which means that the trading of Bitcoin in high frequency can create the appropriate conditions in order to conduct the hedging.

Most of the aspects between Bitcoin and gold are almost the same as they are reacted to similar variables in GARCH model. Not only that, both of Bitcoin and gold can be used to hedge against the risk and they could react to favorable and unfavorable news symmetrically. As the trading of Bitcoin is getting faster and also react quickly to the market sentiment, the frequency of Bitcoin might be higher.

### 2.0.19 Can Bitcoin be treated as a currency?

As stated by Dyhrberg (2016), there is similar hedging capabilities among the Bitcoin, gold and dollar, and they will be useful on risk management. The characteristics of the exchange medium are distinct while Bitcoin is reacted notably to the federal fund rate indicating that Bitcoin is functioning like a currency. Yet, the Bitcoin would not act accurately like the currency on market nowadays since the Bitcoin is decentralized and not regulated. The whole outcome suggested that the Bitcoin is something middle in between the commodity and currency because of its nature of decentralization and its limited market size. It does not indicate that the Bitcoin is less functional when compared to current commodity in the market.

In contrast, the portfolio managers and market analyst are suggested to obtain the comprehensive information of the market which include the Bitcoin in order to make more sophisticated decision and earn other instrument during hedging. In addition, the risk averse investors could use the Bitcoin to anticipate

the bad situation. The position of the Bitcoin would be among the gold and dollar at which one extreme will get the benefits of store of the value, and other extreme will get advantages of exchange medium. As a result, the Bitcoin are suggested to combine together with commodities and currencies to get the advantages in financial markets and it would be useful in risk analysis, market sentiment analysis and portfolio management.

Through this research, we want to find out whether Bitcoin suits the argument to be digital gold. Bitcoin is a remarkably significant invention, as it has a lot of great features that gold does not possess. It is extremely easy to transfer it around the world in a very short period, and it is more difficult to seize compared to gold. Thus, it brings exciting possibilities for parties who have faith in the significance of sound money for society.

## 2.1 Review of Relevant Theoretical Model

### 2.1.1 Law of Supply and Demand (Marshall, 1890)

Economy is at equilibrium when the supply is equal to the demand, leading to the most efficient distribution of goods as the amount of goods demanded could be fulfilled by the amount of goods supplied. When a market achieves equilibrium, shifts in either demand or supply will affect prices based on the nature of the change. The key factor of Bitcoin's price is its market force of demand and supply (Hayes, 2017). Ciaian, Rajcaniova, & Kancs (2016) revealed that the supply of Bitcoin, measured by Bitcoins in circulation has affected its market price and this relationship tend to increase over time.

(Balcilar, Bouri, Gupta & Roubaud, 2017) also state that the demand of Bitcoin which is measured by average confirmed transactions per day has more impact on the Bitcoin's price than the supply of Bitcoin. The more users are

using the system, the more valuable the system becomes to each of the users (Li & Wang, 2017). As a result, the increasing utility of holding the Bitcoin and the usefulness of Bitcoin in business dealing will lead to an increase in the price of Bitcoin in long term (Kristoufek, 2015).

### 2.1.2 Theory of Value (Smith, 1776)

This model advocates that mining difficulty increase will leads to the increase of cost of production, the cost of production is a main factor of the valuation of the Bitcoin's price. When the demand for Bitcoin is not met by the new Bitcoin mined, the cost of production would remain the same while the Bitcoin's price increase. The increase of the Bitcoin's price induces the miners to increase their mining effort and thus increase the difficulty of mining. This lead to the raising of the cost of production until it reaches a new level of breakeven (Hayes, 2015). The increasing hash rate and difficulty expel more miners to leave the mining pool because of the rising cost of electricity and hardware. These miners could become the Bitcoin purchase and thus increase the demand for Bitcoin and its price if they mine the Bitcoin as an alternative to invest in Bitcoin (Kristoufek, 2015).

The difficulty of mining is a key factor in cost of production of Bitcoin. As the mining difficulty increase, the hashing rate needed to find one Bitcoin increase and thus increase the computational power need. The increase of computational power would either attain by a higher efficiency mining hardware or consume more electricity, thus it will increase the cost for mining (Kristoufek, 2015). The cost of production should not be higher than the fundamental value of Bitcoin, thus form a lower bound to the Bitcoin's price (Garcia et al., 2014). As so, the increase of production cost would increase the Bitcoin's price

### 2.1.3 Technology Acceptance Model (Davis, 1989)

This model suggests that a person's perception of the technology would model their intention to adopt it, which depends on external environment conditions, such as information provision and social norms. The overall public recognition thus would affect the overall value of the Bitcoin system and the exchange rate of Bitcoin (Li & Wang, 2017). Besides, as with any network product and peer-to-peer system, its value exhibits network externality. It is expected that the value of Bitcoin depends on transaction capability resulting from public recognition and adoption (Li & Wang, 2017). Ciaian et al. (2016) also stated that the attractiveness of Bitcoin for its investors is the key factor of its price. As a result, we use Google interest index to represent the attractiveness and the public recognition of Bitcoin.

### 2.1.4 Substitution Effect – Consumer Theory (Green, 1971)

The substitution effect is one of the economic theory stating that when prices increase, consumers will shift more costly items with less expensive alternatives. Generally, economists have done comparison between gold and Bitcoin due to their similarities (Dyhrberg, 2016). Bitcoin's excess returns and volatility rather resemble a highly speculative asset than gold or the US dollar (Baur, Dimpfl, & Kuck, 2017). Moreover, the Bitcoin's return is not influenced by variation in the stock market, creating an additional option for investors to do hedging on the market risk, which means that gold and Bitcoin have likely hedging ability in the UK market (Dyhrberg, 2016). This result indicates that Bitcoin have incorporate some of the advantages from both currencies and commodities in the financial markets and thus become an effective tool for, risk analysis, market sentiment analysis and portfolio management. Therefore, we have enough evidence to suggest that Bitcoin could be a substitute to gold.

## 2.2 Proposed Theoretical Framework

Figure 2.1 Proposed theoretical framework

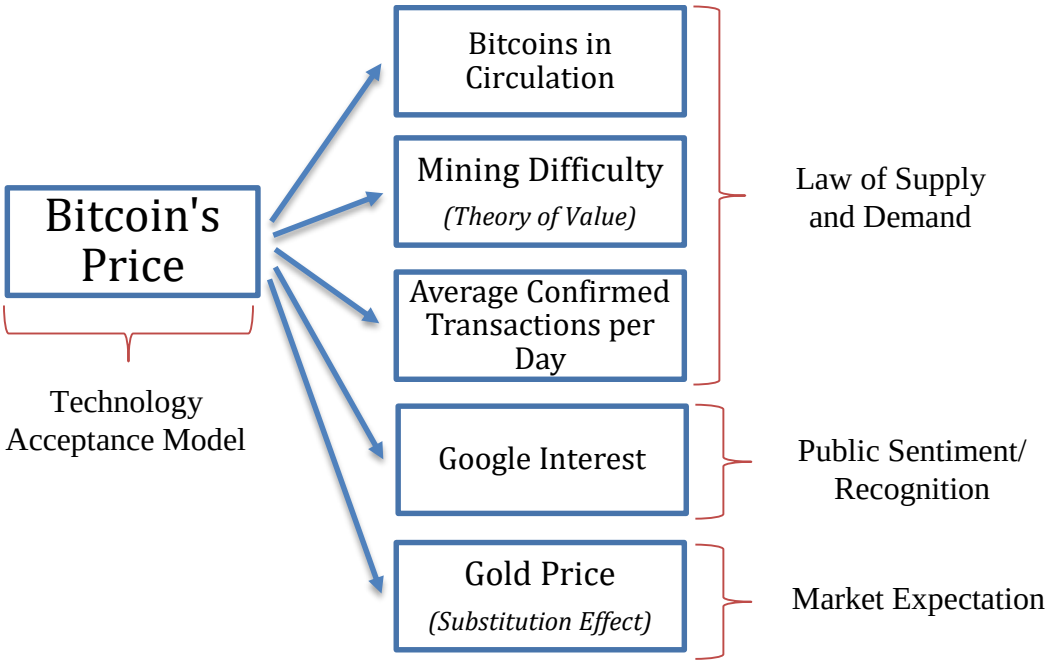



Figure 2.1 shows our proposed theoretical framework model that execute to serve in this research. This framework is a research in measuring the effect of five independent variables on Bitcoin's Price. The five independent variables refer to Bitcoins in circulation, mining difficulty, average confirmed transactions per day, google interest and gold price. The dependent variable, Bitcoin's price is explained by Technology Acceptance Model. Bitcoins in circulation, mining difficulty and average confirmed transactions per day represent the supply and demand side, where mining difficulty is explained by Theory of Value. Google interest represent the public sentiment and recognition whereas gold price represents the market expectation which is explained by substitution effect.

## 2.3 Hypothesis Development

**Bitcoins in circulation influenced the Bitcoin's price**

According to the Law of Supply and Demand, there is a negative relationship between the supply of a good and its price. As an indicator of the supply of Bitcoin, we expect that an increase in Bitcoins in circulation will reduce the Bitcoin's price.

$H_1$: Bitcoins in circulation has negative significant relationship with Bitcoin's price

**Mining difficulty influenced the Bitcoin's price**

The previous study done by Hayes in 2017 had found a positive relationship between mining difficulty and Bitcoin's price. Therefore, we expect the mining difficulty, which act as the cost of production will have positive relationship with the Bitcoin's price.

$H_2$: Mining difficulty has positive significant relationship with Bitcoin's price.

**Average confirmed transactions per day influenced the Bitcoin's price**

According to the Law of Supply and Demand, the demand of a good will have positive impact on its price. As an indicator of the demand of Bitcoin, the average confirmed transactions per day is expected to have positive relationship with Bitcoin's price.

$H_3$: Average confirmed transactions per day has positive significant relationship with Bitcoin's price

**Google Interest influenced the Bitcoin's price**

According to the previous research of Li and Wang (2017), there is a positive significant between Google interest and Bitcoin's price. Therefore, we expect that the Google interest has positive relationship with the Bitcoin's price.

$H_4$: Google Interest has positive significant relationship with Bitcoin's price

**Gold price influenced the Bitcoin's price**

The Substitution Effect imply that when the price of a good increase, the price of substitute good will increase. Since Bitcoin was widely being considered as the substitute of gold, an increase in gold price will result an increase in Bitcoin's price.

$H_5$: Gold price has positive significant relationship with Bitcoin's price

## 2.4 Conclusion

Former researchers come out with functional information and guideline on several variables such as Google interest, average confirmed transactions per day, gold price, Bitcoins in circulation and mining difficulty which done on the research topic of Bitcoin's price. Therefore, the relationship of the independent variables toward the Bitcoin's price was stated. Meanwhile, the relevant theory of those factors was explained in the third part of this chapter. Lastly, the proposed framework was prepared. The next chapter will carry out the research methodology with the collected data to determine the independent and dependent variables.

# CHAPTER 3: METHODOLOGY

## 3.0 INTRODUCTION

In this chapter, this research discuss the empirical strategy to investigate the key determinants of Bitcoin using time series data start from November 2012 to December 2017, using Autoregressive Distributed Lag (ARDL) modelling approach. This study aim to investigate the key determinants of Bitcoin's prices.

## 3.1 Sources of data

The data used to conduct this study are secondary, time series, and quantitative. The data is a monthly data from November 2012 to December 2017. The data Bitcoin price denominated in United States Dollar (USD) obtained from blockchain, Google interest obtained from Google Trends, Bitcoin average confirmed transactions per day obtained from blockchain, gold price obtained from Quandl, Bitcoins in circulation obtained from blockchain, and mining difficulty also obtained from blockchain (See Table 3.1).

Table 3.1: Data description

| Variables | Description | Sources |
|---|---|---|
| **Bitcoin's price (BP)** | Average market price of main exchanges of Bitcoin denoted in USD | Blockchain https://blockchain.info/charts/market-price |
| **Google interest (GI)** | Interest over time: Numbers that stand for the highest point relative to the search interest on the chart for the given time and region. The specific term is half as popular if the value is 50. The specific term is the highest popularity if the value is 100. In addition, the specific term is lower than 1% of the highest popularity if the value is 0. | Google Trends https://trends.google.com/trends/explore?q=bitcoin |
| **Average confirmed transactions per day (CT)** | The number of daily confirmed Bitcoin transactions. | Blockchain https://blockchain.info/charts/n-transactions |
| **Gold price (GP)** | International standard price of gold set by London Gold Fixing Companies in AM. | Quandl https://www.quandl.com/data/LBMA/GOLD-Gold-Price-London-Fixing |
| **Bitcoins in circulation (CS)** | The sum of the number of Bitcoins that already been mined; is also can be considered as the supply of Bitcoins on the network. | Blockchain https://blockchain.info/charts/total-bitcoins |
| **Mining difficulty (MD)** | The relative measurement of difficulties to find a new block. Periodically arrange the difficulty as a function of how many hashing power already deployed by the miners' network. | Blockchain https://blockchain.info/charts/difficulty |

## 3.2 The model

To investigate the key determinants of Bitcoin's price, this research express the long run relationship between the variables can be expressed as:

$$BP = f(GI, CT, GP, CS, MD) \quad (1)$$

Where BP is the average market price of main exchanges of Bitcoin denoted in USD; GI denotes interest over time: Numbers that stand for the highest point related to the search interest on the chart for the given time and region. The specific term is half as popular if the value is 50. The specific term is the highest popularity id the value is 100. In addition, the specific term is lower than 1% as popular as the highest if the value is 0.; CT denotes The number of daily confirmed Bitcoin transactions; GP denotes international standard price of gold set by London Gold Fixing Companies in AM; CS The sum of the number that Bitcoins already been mined; is also can be said that it is the supply of Bitcoins on the network.; MD denotes The measurement of difficulties to find a new block. Periodically arrange the difficulty as a function of how many hashing power already deployed by the miners' network.

According to Li and Wang (2017) Google interest will causing the Bitcoin price to increase or decrease. This research do adopted Google search queries as one of our independent variable. Digital currencies are the new instrument of economic. Probably the most vital one of them is the way that they no fundamental resource, they are not issued by any national bank or government and they bring no dividends or interest. One of the digital currency namely Bitcoin have pulled the public attention because of the exceptional price surges with conceivable profits of hundred percent in only a little while or months. People can only search Bitcoin through online as it is not issued by any national bank or government. Thus, the search queries will affect the prices of Bitcoin (Puri, 2016).

This study adopted gold price as one of the independent variables, this is because there are some same hedging abilities on gold are same with Bitcoin (Zhu, Dickinson & Li, 2017). It can be said that something in between American dollar and gold on a scale from simple medium of exchange benefits to simple keeping of value

benefits. Investor always contrast Bitcoin with gold as they both have limited amount and can utilized as a purchase method.

The third independent variable from our research is Bitcoin transactions per day. The volume of transactions of Bitcoin is namely the demand for the Bitcoin. Some of the study find that the demand for Bitcoin have a significant impact on its price. Specifically, the request side drivers, for example, speed of Bitcoin circulation and the size of the Bitcoin economy, have the most grounded effect on the price of Bitcoin. Thus, given that supply of Bitcoin is exogenous, the request side drivers' improvement will be among the key factors of Bitcoin cost additionally later on (Ciaian et al., 2016).

The Bitcoins in circulation is the amount of Bitcoins issued (Kristoufek, 2015). The supply of Bitcoin indicates the amount of units in circulation. Due to the conscious regulations the supply of Bitcoin is unchangeable, causing the limited supply of Bitcoin. Hence people will tend to pay more to get what they think have value such as Bitcoin. There are two contradicting impacts among the Bitcoin cost and hash rate and also the difficulties of mining. Mining may be viewed as a kind of investment in Bitcoins. Instead of directly purchasing the Bitcoins, speculator can invests and spend in the hardware and acquires the cryptocurrencies by implication via mining. This strategy prompts two conceivable impacts. The market participants have been motivated by the expanding of Bitcoin's price to begin their investing in hardware as well as begin mining, which prompts the hash rate to expand and, as a result, towards the higher level of difficulty. Then again, the trouble associated with the expanding cost demand for hardware and the hash rate cause more diggers out of the mining pool. If the diggers in the past mined the cryptocurrencies as a purposed to investment, they can progress toward becoming Bitcoin buyers and subsequently expand demand for Bitcoins, thus the cost will be increased (Kristoufek, 2015).

The long run relationship between Bitcoin's price and its determinants can be expressed as the following functional form:

$$log(BP_t) = \beta_0 + \beta_1 log(GI) + \beta_2 log(CT) + \beta_3 log(GP) + \beta_4 log(CS) + \beta_5 log(MD) + u_t \quad (2)$$

Where log denotes the logarithm transformation of the series.

This study have use Autoregressive Distributed Lag (ARDL) as an approach to investigate or determine the long run relationship between Bitcoin's price and its determined factors. Besides, Gujarati and Porter (2009) mentioned that the standard assumptions are violated against asymptotic analysis which could cause t-ratios and p-values become more invalid as in fact it does not exact follow the t-distribution. However, it could lead the estimated parameter standard error become more inefficient and biased probably, which result in misleading conclusion.

To estimate the long run parameters, this research use ARDL approach. The ARDL approach presume that only a single reduce form equation relationship exist between the independent and dependent variables. The dynamic short run relationship between variables can be written in an ARDL-in-level form as below:

$$\log(BP)_t = \alpha + \sum_{i=1}^{p} \alpha_{1i} \log(BP)_{t-i} + \sum_{i=0}^{q1} \alpha_{2i} \log(GI)_{t-i} + \sum_{i=0}^{q2} \alpha_{3i} \log(CT)_{t-i} + \sum_{i=0}^{q3} \alpha_{4i} \log(GP)_{t-i} + \sum_{i=0}^{q4} \alpha_{5i} \log(CS)_{t-i} + \sum_{i=0}^{q5} \alpha_{6i} \log(MD)_{t-i} + e_t \quad (3)$$

Given that there are six variables involved in the model, the ARDL. Through a simple linear transformation from ARDL model in (3), one can obtain an Error Correction Model (ECM), which incorporated short run alterations with long run equilibrium without forfeit long run information. Adequate number of lags have been took by the related ECM model to catch the data creating procedure in general to particular modelling frameworks.

The unconditional ECM model can be shown as follow:

$$\Delta\log(BP)_t = \sigma_0 + \sum_{i=1}^{p-1} \sigma_{1i} \Delta\log(BP)_{t-i} + \sum_{i=0}^{q_1-1} \sigma_{1i} \Delta\log(BP)_{t-i} + \sum_{i=0}^{q_2-1} \sigma_{2i} \Delta\log(GI)_{t-1} + \sum_{i=0}^{q_3-1} \sigma_{3i} \Delta\log(CT)_{t-1} + \sum_{i=0}^{q_4-1} \sigma_{4i} \Delta\log(GP)_{t-1} + \sum_{i=0}^{q_5-1} \sigma_{5i} \Delta\log(CS)_{t-1} + \sum_{i=0}^{q_6-1} \sigma_{6i} \Delta\log(MP)_{t-1} + \delta_0 \log(BP)_{t-1} + \delta_1 \log(GI)_{t-1} + \delta_2 \log(CT)_{t-1} + \delta_3 \log(GP)_{t-1} + \delta_4 \log(CS)_{t-1} + \delta_5 \log(MP)_{t-1} + \varepsilon_t \quad (4)$$

Where Δ denotes the changes in the variables.

To test whether there is long run relationship exist between Bitcoin's price with its determinants, this research can perform bound test of cointegration. The null hypothesis no cointegration among the variables:

$H_0: \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$

i.e., there is no cointegration among the variables.

$H_1: \delta_0 \neq \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$

i.e., there is cointegration among the variables.

The long run parameter, $\beta$'s can be calculate as

$$\beta_1 = -\left(\frac{\delta_1}{\delta_0}\right),\ \beta_2 = -\left(\frac{\delta_2}{\delta_0}\right),\ \beta_3 = -\left(\frac{\delta_3}{\delta_0}\right),\ \beta_4 = -\left(\frac{\delta_4}{\delta_0}\right),\ \beta_5 = -\left(\frac{\delta_5}{\delta_0}\right),\ \beta_6 = -(\frac{\delta_6}{\delta_0})$$

(5)

The long run and short run relationship can be depicted in conditional ECM model as follow:

$$\Delta\log(BP)_t = \sigma_0 + \sum_{i=1}^{p-1} \sigma_{1i}\Delta\log(BP)_{t-i} + \sum_{i=0}^{q_1-1} \sigma_{1i}\Delta\log(BP)_{t-i} + \sum_{i=0}^{q_2-1} \sigma_{2i}\Delta\log(GI)_{t-1} + \sum_{i=0}^{q_3-1} \sigma_{3i}\Delta\log(CT)_{t-1} + \sum_{i=0}^{q_4-1} \sigma_{4i}\Delta\log(GP)_{t-1} + \sum_{i=0}^{q_5-1} \sigma_{5i}\Delta\log(CS)_{t-1} + \sum_{i=0}^{q_6-1} \sigma_{6i}\Delta\log(MP)_{t-1} + \delta_1\log(GI)_{t-1} + \delta_2\log(CT)_{t-1} + \delta_3\log(GP)_{t-1} + \delta_4\log(CS)_{t-1} + \delta_5\log(MP)_{t-1} + \gamma u_{t-1} + e_t$$

(6)

## 3.3 Preliminary Test

ARDL is a model that developed by Pesaran, Shin and Smith (2001) to study the long run relationship between the variables. This model can be estimated using the bound testing cointegration procedure. The ARDL is chosen on this study as the procedure of bound testing is simple and easy. In made comparison to the model that developed by Johansen and Juselius (1990) and Engle and Granger (1987), the ARDL bound test allows us to estimate the cointegration relationship by using the OLS method as long as the lag order of the model is identified. On ARDL model, the variables are unnecessary as requirement to be integrated in the same order, however, it is very useful when the variables are fractionally integrated or integrated as I~(1), I~(0). Besides,

ARDL bound test can be used to examine small and finite sample data sizes and it will become more efficient. As mentioned by Nkoro and Uko (2016), the unbiased estimates of the long run model can be acquired with apply ARDL Bound test. Furthermore, the ARDL model has included both of the lags of the endogenous and exogenous variables that utilized to examine the short run relationship directly and the long run relationship indirectly (Royfaizal, 2009). Whereas the OLS can be utilized to obtain the long run and short run parameters with appropriate lag length, nevertheless whether the independent variable is exogenous.

Before the research conduct the ARDL procedure, the stationarity of time series data of each independent variable must be checked carefully. According to Shrestha (2017), if non-stationary time series data are used to conduct regression analysis, definitely it could result in spurious regression problem which means the hypothesis testing and regression analysis cannot be trusted. Hence, this research will conduct the unit root test that is Augmented Dickey Fuller (ADF) test, Phillips-Perron (PP) test and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test to perform in this study for stationary checking purpose.

**Augmented Dickey- Fuller (ADF)**

Augmented Dickey-Fuller (ADF) is a type of unit root test that further improved by Dicker and Fuller (1981). This test is able to find out whether the time series data is associated with the unit root problem and determine whether the data is second or first difference. Other than that, the outliers in the data also can be determined by ADF, which is very critical to find out data's non-stationary movement. A stationary movement refers to the covariance, mean are constant and variance over the time series data. If there is a non-stationary movement, the unit root test will become more unreliable. There are two types of models in ADF tests are "without trend and with constant" and "with trend and constant". Other than that, the lag length observed by unit root test is determined according to the minimum Schwarz Information Criterion (SIC) and Akaike's Information Criterion (AIC) to ensure that there is no autocorrelation issue in the econometric model.

Model with constant and with trend:

$$\Delta y_t = \mu + \beta trend + \delta y_{t-1} + \sum_{i=1}^{k} \Delta y_{t-i} + \varepsilon_i \quad (6)$$

$y_t$ refers to the variables used in this study, namely, BP denotes Bitcoin's price; GI denotes Google interest; CT denotes average confirmed transactions per day; GP denotes gold price; CS denotes Bitcoins in circulation; and MD denotes mining difficulty.

Model with constant without trend:

$$\Delta y_t = \mu + \delta y_{t-1} + \sum_{i=1}^{k} \Delta y_{t-1} + \varepsilon_i \quad (7)$$

The null of unit root can be tested with

$\delta \geq 0 \ (y = BP, GI, CT, GP, CS, MD)$

$\delta < 0 \ (y = BP, GI, CT, GP, CS, MD)$

The test statistic can be calculated by:

Test Statistic = $\frac{\delta - \delta}{SE(\delta)}$

A rejection of null of unit root indicated that the series is stationary. If the null cannot be rejected, the research should perform the unit root test on the first different of the series. The testing procedure will be stop if the series achieve stationary.

**Phillips-Perron Test (PP)**

PP is type of unit root test that developed by Phillips and Perron (1988). It is a non-parametric test that utilized to determine whether the time series data is unit root or not. Besides, it can resolve the both heteroscedasticity and serial correlation problem by changing the Dickey-Fuller test statistic. The objective of using PP test is to determine the non-ADF test and modifying the Dickey-Fuller statistic and therefore the test statistic's asymptotic distribution would not influence by serial correlation. The specific lag length is unnecessary to become requirement for the regression model when using PP test.

**Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Stationarity Test**

This test developed by Kwiatkowski, Phillips, Schmidt, Shin (1992). According to Hobjin, Franses and Ooms (2004), it is aimed to enhance the unit root test. This test is used as a stationary test to ensure the stationary of a series and it can offer more robust result.

Model of KPSS test:

$$y_t = \alpha + \beta_t + d\sum_{i=1}^{t}\mu_i + \varepsilon_t$$

$y_t$ refers to the variables used in this study, namely, BP denotes Bitcoin's price; GI denotes Google interest; CT denotes average confirmed transactions per day; GP denotes gold price; CS denotes Bitcoins in circulation; and MD denotes mining difficulty.

Under the KPSS test, it consider the alternative hypothesis for the test is that the data is not stationary, while the null hypothesis for the series is stationary.

## 3.4 Diagnostic Checking

Since the ARDL used in the study employ OLS estimates, it is crucial for use to checking to ensure that Classical Normal Linear Regression Model (CNLRM) assumptions of multiple linear regressions can be satisfied before performing further inference. According to Ullah, Wan and Chaturvedi (2002), the inferential procedures might be invalid which could result in misleading conclusions if any basic assumptions are violated. This is due to the results would be considered as inconsistent, inefficient, and biased if econometrics problems such as heteroscedasticity, model misspecification, autocorrelation and non-normality of error terms arise in the model. As a result, diagnostic checking is significant to make sure that the conclusion would become reliable on this study.

**Jarque-Bera Normality Test**

The Jarque-Bera (JB) test carry out to examine the normality of the data. It is one of the consistent presumption for many statistical tests. The F test and t test are the best example for that. Test procedure that carried on according to the normal distribution is the main reason that the normality presumption must be satisfied before carrying out those statistics tests. If there is violation to the assumption, inaccurate inferences would take place and even lead to fallacious results. The kurtosis and skewness measurements are applied in Jarque-Bera test to study that the data has match a normal distribution. Kurtosis is measuring whether the data are heavy-tailed or light-tailed in making comparison to a normal distribution whereas the skewness refers to the degree of asymmetry of a distribution. In order to let the distribution to be normal, the kurtosis coefficient of 3 and skewness coefficient of 0 must be satisfied. Jarque-Bera statistics go with chi-square distribution with two degrees of freedom for large sample,

Consider testing the null hypothesis:

$H_0$: The error term is normally distributed

$H_1$: The error term is not normally distributed

The formula for the Jarque-Bera test statistic is:

**JB = n [(Skewness) 2/ 6 + (Kurtosis – 3)2/ 24]**, where n is the sample size

The critical values can be found from the chi-square distribution's table as:

| **Significance Level, $\alpha$** | **Critical Value** |
|---|---|
| 0.10 | 4.61 |
| 0.05 | 5.99 |
| 0.01 | 9.21 |

Decision rule: Reject the null hypothesis if JB test statistic is more than $X^2_{(\alpha,2)}$ and it will conclude that the data is not normally distributed.

**Breusch-Godfrey Serial Correlation Lagrange Multiple Test**

According to Arellano (2002), the principle of Lagrange Multiple (LM) testing can applied in many econometrics issue. It is one of the part of diagnostic checking by examining whether there is autocorrelation among the error term. LM test could inspect the ARMA error at higher odder and can be applied regardless there are lagged regressand variables. Other than that, the influence on the first order condition for a maximum likelihood of imposing the hypothesis can be tested by using the LM test. Whereas according to Breusch and Pagan (1980), in their research the restricted models that are necessary to be estimated and sample size, the LM test still can perform efficiently and effectively. Furthermore, the researcher mentioned that the benefits of using the LM test whereby least square residual are required, which simply to be computed. However, according to Greene and McKenzie (2012), it shows that there is other advantages where LM test was satisfied standard distributional properties when the parameter are being tested lie on the boundary of the parameter space under the null hypothesis.

**Autoregressive Conditional Heteroscedasticity (ARCH) Test**

Heteroscedasticity is a problem that occurs when the error terms are different across the observations, which means that the variances of the error terms are not constant. When the heteroscedasticity was existing, OLS model is still consistent but not efficient. The weighted least squares method can be used to estimate the model again and again if there is heteroscedasticity problem and a new set of estimates parameters is produced.

The ARCH test is carried out to detect the Heteroscedasticity problem. This test is only available to time series data models and is carried out based on the independent variable. The estimated model and auxiliary model of the ARCH test are as followed:

Estimated Model

$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + u_i$

Auxiliary Model

$\varepsilon,t = p_0 + p_{11,t-1} + \ldots + pp\ p,t-p + vt$

Hypothesis statement:

$H_0$: There is no heteroscedasticity problem in the model.

$H_1$: There is heteroscedasticity problem in the model.

Decision rule: Reject $H_0$ if the p-value is less than 0.01, otherwise do not reject $H_0$.

**CUSUM and CUSUM Square**

As mentioned by Harish and Mallikarjunappa (2015), the cumulative sum of recursive residuals (CUSUM) is a well-known technique to utilize the stability of the series. To investigate the sequential changes in the variables' beta, CUSUM test can carried out the sequential analysis perform the investigation. The systematic movement can be determined by CUSUM test, as long as the values of coefficient display that there is a possible instability in the structure. Besides, CUSUM Square test realized that there is the random movement. Both of the CUSUM and CUSUM Square are conducting in the identical procedure with using the cumulative sum of recursive residual. Besides that, the recursive residual can be observed from the first set of observations. There are two scenarios the CUSUM statistic will be plotted. There are plotted out of the significance level of 5% or within the significance level of 5%.

This explanation may be made where the forecasted coefficient is either unstable or stable respective toward the statistic plotted position. The recursive residuals used is the only difference between CUSUM Square and CUSUM. As mentioned by Farhani (2012), employing the square recursive residual when carry out the CUSUM Square test. The stable relationship will be established between the independent and dependent variable. Nevertheless, the error-correction term is taking place together with the short run dynamic. It is designed by the long-run coefficient stability. At the same time, a short run dynamic inadequate modelling with the changes from long run relationship would result in an instability issue. According to Irpan, Saad, Nor, Noor, and Ibrahim (2016), it is necessary to apply the CUSUM and CUSUM Square test to encompass the short run dynamic to corporate with the long run parameter.

**Correlogram**

As mentioned by Stephanie (2016), the correlogram is the technique to show us the serial correlation in time series data that can change over the period. This method is also called as Autocorrelation Function (ACF) or Autocorrelation plot. Besides, the serial correlation refers to the error in one point in time move to subsequent point in time. In this study, the correlogram can be used to examine whether the pairs of data have showed the autocorrelation problem or not but they cannot be utilized to measure the size of autocorrelation.

Given a time series data such as stock market data, the successive values in the time series are always correlated with each other (Mathuranathan, 2014). The term of "correlation" was referred to "autocorrelation", "inertia" or "persistence", besides, it will increase the power in lower frequencies of frequency spectrum. The degrees of freedom in time series model such as Moving Average (MA), Autoregressive Moving Average (ARMA) and Autoregressive (AR) models can be reduced by using the series correlation. However, when testing statistical significance, it need to be taken into account as it confuses test by decreasing the number of independent observations.

Furthermore, the correlation of a time series with its future and past values is referred to "series correlation or lagged" and Autocorrelation. The specific form of "persistence" is the sign of positive autocorrelation, the tendency of a system is remaining in the similar situation from one observation to the next one. According to Mathuranathan (2014), the future values of the samples would depend on both of the current and past samples if a time series has showed there is correlation. Hence, the presence of autocorrelation can be utilized in forecast as well as modelling time series. Autocorrelation can be examined with using the tools such as Autocorrelation function (ACF), lagged scatterplot and time series plot.

# CHAPTER 4: DATA ANALYSIS

## 4.0 Introduction

The content in this chapter will concentrate on interpreting and analyzing the empirical results using the methodology in previous chapter. To determine the relationship between Bitcoin's price and two technological factors which are mining difficulty and Google interest and three economics variables which are gold price, average confirmed transaction per day and Bitcoin in circulation is the main objective of this study. The mentioned technological and economics variables here are inclusive of Bitcoins in circulation, mining difficulty, average confirmed transactions per day, Google interest and gold price. The time period covered by the time series data is from November 2012 until December 2017 in monthly basis. In order to conduct analysis accurately, the obtained data are inputted into EViews software to generate interpretable results. By using EViews 10, the data sets have gone through several tests such as Unit Root Test (ADF, PP), Stationarity test (KPSS), Autoregressive Distributed Lag (ARDL) Cointegration Bound Test, and Long Run ARDL model. Diagnostic checking applied includes Breusch-Godfrey serial correlation LM test, Jarque-Bera Normality test, Heteroskedasticity ARCH test, and followed by CUSUM test, CUSUM-squared test and Bound test.

## 4.1 Descriptive Analysis

**Table 4.1: Descriptive Statistic, Nov 2012 – Dec 2017**

| | Mean | Median | Maximum | Minimum | Std. Dev. | Jarque-Bera |
|---|---|---|---|---|---|---|
| **In level** | | | | | | |
| **BP** | 1069.182 | 439.7743 | 15251.93 | 11.5861 | 2264.618 | 1735.882*** |
| **GI** | 7.3065 | 3.0000 | 100.0000 | 1.0000 | 13.8394 | 2858.728*** |
| **CT** | 148113.4 | 109676.4 | 358831.1 | 31939.20 | 94459.82 | 6.2144** |
| **GP** | 1282.847 | 1263.475 | 1724.352 | 1068.317 | 136.5507 | 46.9919*** |
| **CS** | 14029641 | 14221843 | 16745105 | 10403677 | 1952973 | 4.6462* |
| **MD** [1] | 213.6649 | 48.6218 | 1668.6328 | 0.003 | 358.9418 | 126.6806*** |
| **In Log** | | | | | | |
| **Log (BP)** | 6.0312 | 6.0862 | 9.6325 | 2.4498 | 1.3739 | 3.7270 |
| **Log (GI)** | 1.4305 | 1.0986 | 4.6052 | 0.0000 | 0.8844 | 25.2591*** |
| **Log (CT)** | 11.6810 | 11.6049 | 12.7906 | 10.3716 | 0.6969 | 5.3500* |
| **Log (GP)** | 7.1517 | 7.1416 | 7.4526 | 6.9738 | 0.0996 | 26.6213*** |
| **Log (CS)** | 16.4467 | 16.4703 | 16.6336 | 16.1577 | 0.1440 | 4.9318* |
| **Log (MD)** | 23.4285 | 24.6073 | 28.1430 | 14.9596 | 3.9129 | 11.0448*** |

Note: ***, ** and * indicate that null hypothesis are rejected at significance level of 1%, 5% and 10% respectively. BP denotes Bitcoin price (USD), GI denotes Google interest (relative measure), CT denotes average confirmed transaction per days (number of transactions), GP denotes gold price (USD), CS denotes Bitcoins in circulation (number of Bitcoins), MD denotes mining difficulty (relative measure).

Table 4.1 shows a statistical summary of the dependent and independent variables for sixty-two months from November 2012 to December 2017. From the table above, the mean shows the average of the data values; the median refers to the middle data value; the standard deviation measures the average difference among the mean and a single observation; the minimum tells the smallest data value while the maximum tells the biggest data value and lastly the Jarque-Bera result indicate whether the variables follow the normal distribution.

For Bitcoin's price, it indicates a mean of USD 1, 069.18 in the 62 months period. It also shows a median of USD 439.77. The maximum Bitcoin's price is USD15, 251.93 while a minimum of USD 11.59. As mentioned in Chapter 1, there are tremendous fluctuations in Bitcoin's price in recent year, and it is proven here by the

high standard deviation of USD 2, 264.62 and the spread of USD 15, 240.64 between the maximum and minimum value.

The other variable that was used in the analysis is Google interest, which indicates the search intensity index of the topic of Bitcoin by Google search engine, for the range of 1 to 100. Results show a mean value of 7.31; the median index of 3 and the standard deviation of 13.84, which is very low when compared to the range of 100. This shows that the search intensity of Bitcoin in Google spikes in certain period. as mentioned previously in Chapter 1, the search term of "buy Bitcoin" has surpassed "buy gold". However, most of the time, there is only little search intensity on this topic.

Average confirmed transactions per day is another variable that is taken into account. It represents the average number of confirmed Bitcoin transactions in a month. This analysis shows an average mean of 148,113 transactions, while recording median transactions of 109,676. Maximum transactions is 358,831 while the minimum is 31,939. It recorded a high standard deviation of 94,460 transactions, indicating that the number of transactions are fluctuating and are averagely far from the mean. This could be explained by the findings in Chapter 2 that there are more transactions occurred in later time due to technology development.

Other than that, gold price is also an independent variable that was tested and recorded an average of USD1, 282.85. The results show a median price of USD1, 263.48 as well as a standard deviation of USD 136.55. The maximum gold price resulted at USD1, 724.35, while minimum price is 1,068.32. These figures reflected that the gold price is very stable and this is why people favor and have faith in gold as an asset and investment.

In addition, Bitcoins in circulation is a variable taken to explain the number of Bitcoins circulating in market. In this research, test results show an average number of 14,029,641, which is the mean, and a median number of 14,221,843. The maximum number of Bitcoins circulating are 16,745,105, while the minimum is 10,403,677. The result shows a standard deviation of 1,952,973, this low figure is due to the fact that the number of Bitcoins mined in a period is limited, which was discussed in Chapter 2.

For mining difficulty, the mean value, which is the average value for the mining difficulty is around 214 billions. 49 billions is the median value obtained from the test. The analysis shows 1669billions as the maximum mining difficulty, which means in some period, it is very difficult to mine Bitcoin. While on the other hand, the minimum mining difficulty is 3 millions, which means in certain period, people face very little difficulty in mining Bitcoins. This is explained by the findings in Chapter 2 that when more miners enter the market in later time, the mining difficulty will increase. The fluctuation is high as we observed the high standard deviation of 359billions.

Lastly, one thing that this research concern about is the normality of data. The result shows that data of every variables had passed the Jarque-Bera normality test at least 10% significant level. Some variables even passed the test at 1% significance level. Due to the high range between the volatile data, the data are being converted into log form in order to perform a smoother and more explainable test.

## 4.2 Unit Root Test

**Table 4.2: Result of Unit Root Test (ADF and PP) and Stationarity Test (KPSS)**

| | ADF | | PP | | KPSS | |
|---|---|---|---|---|---|---|
| **Level** | **Constant without trend** | **Constant with trend** | **Constant without trend** | **Constant with trend** | **Constant without trend** | **Constant with trend** |
| BP | -0.944(1) | -1.960(1) | -1.023(2) | -1.744(2) | 0.750(6) | 0.136(5)*** |
| GI | -0.057(0) | -0.850(0) | -0.004(4) | -1.001(3) | 0.604(5)*** | 0.180(5)*** |
| CT | -0.870(1) | -3.099(0) | -1.027(3) | -3.260(4)* | 0.984(6) | 0.119(5)*** |
| GP | -3.279(1)** | -2.853(1) | -3.325(7)** | -2.522(8) | 0.506(5)*** | 0.230(5) |
| CS | -2.666(1)* | 0.850(1) | -10.114(5)*** | 0.340(5) | 0.975(6) | 0.252(6) |
| MD | -3.266(1)** | -3.286(1)* | -2.660(5)* | -1.341(5) | 0.869(6) | 0.216(6)*** |

| First Difference | Constant without trend | Constant with trend | Constant without trend | Constant with trend | Constant without trend | Constant with trend |
|---|---|---|---|---|---|---|
| BP | -4.478(0)*** | -4.418(0)*** | -4.440(3)*** | -4.374(3)*** | 0.222(2)*** | 0.222(2) |
| GI | -5.943(0)*** | -6.417(1)*** | -5.691(5)*** | -5.709(6)*** | 0.237(4)*** | 0.155(5)*** |
| CT | -9.471(0)*** | -9.398(0)*** | -9.544(2)*** | -9.464(2)*** | 0.059(3)*** | 0.044(3)*** |
| GP | -5.800(0)*** | -6.036(0)*** | -5.629(9)*** | -5.988(14)*** | 0.370(3)*** | 0.0800(8)*** |
| CS | -1.988(0) | -4.006(0)** | -1.990(3) | -4.386(3)*** | 0.926(6) | 0.062(5)*** |
| MD | -2.056(1) | -3.096(1) | -2.003(1) | -2.736(1) | 0.406(6)*** | 0.109(5)*** |

Note: ***, ** and * indicated that null hypothesis are rejected at significance level of 1%, 5% and 10% respectively. BP denotes Bitcoin price (USD), GI denotes Google interest (relative measure), CT denotes average confirmed transactions per days (number of transactions), GP denotes Gold price (USD), CS denotes Bitcoins in circulation (number of Bitcoins), MD denotes mining difficulty (relative measure). All variables are logarithm transformed.

The overall results of unit root test are shown in Table 4.2. In this study, the results revealed that the variables we used are either I(0) or I(1). Such situation suggests us to apply ARDL model for this study. The purpose of using ADF test, PP test and KPSS test is to determine the stationarity of the variables as the stationarity of a series can strongly influence its behavior and properties. In traditional approach, if dependent variable is I(1), then the rest of the variables must be I(1). This approach do not recognize whether the combination is I(0) or I(1). If one of the variables is non-stationary, it could lead to spurious regression result. In contrast, the advantage of using ARDL approach is that ARDL recognize the mixture of I(0) and I(1) variables. This research use ARDL approach to conduct unit root test and stationarity test since it is very useful and helpful in the particular test as this study contain the combination of I(0) and I(1).

By referring to Table 4.2, the result of ADF, PP and KPSS test in level form can be obtained. The analysis tested all of the variables with trend and without trend for these 3 tests. In level form, some of the variables such as gold price, Bitcoins in circulation and mining difficulty do not have unit root in level without trend for ADF test whereas only mining difficulty do not have unit root in with trend for ADF test. Not only that, the results show the gold price and Bitcoins in circulation have no unit root in without trend for PP test, at the same time, all the variables have unit root except

average confirmed transactions per day in with trend for PP test. Besides, the results of KPSS show that the Google interest and gold price are stationary variables in without trend, however, the gold price and Bitcoins in circulation are non-stationary variables in with trend. Some of variables are non-stationary variables since the test statistics are lower than critical value. This study will continue to conduct ADF test, PP test and KPSS test with first difference as long as the main goal is to achieve stationary in result for all the variables at all significant levels.

According to the Table 4.2, the overall results of ADF, PP and KPSS in First Difference are better than results in level form. In ADF test, only Bitcoins in circulation and mining difficulty have unit root in without trend whereas all variables have no unit root except mining difficulty in with trend. Other than that, Bitcoins in circulation and mining difficulty also have unit root in without trend for PP test as well as ADF test. Also, the PP test with trend had revealed that all variables are stationary variables except mining difficulty. By referring KPSS results, only Bitcoins in circulation is non-stationary in without trend and only Bitcoin's price is non-stationary variable in with trend. Since the stationary problem is still existing, however, this study will continue to perform other tests.

## 4.3 The ARDL Modelling Approach

After investigating whether or not the variables are stationary by using Unit Root Test and Stationarity Test, this study proceeds to the ARDL models to estimate the long run determinants of the Bitcoin's Price, this study employs the ARDL modelling approach. First and foremost, the Bound test will be conducted on an estimated ARDL model, and secondly, the long run parameter can be derived from the estimated ARDL model. In ARDL, this research is able to obtain the value of AIC for maximum 12 lag lengths. ARDL suggest lag length of 3 for the dependent variable, Bitcoin's price, lag length of 5 for Google interest, lag length of 3 for average confirmed transactions per day, lag length of 4 for gold price, lag length of 3 for Bitcoins in circulation and lag length of 5 for mining difficulty. The Table 4.3 shows that the results of ARDL model

in level form. The selection of best lag length in model are depending to Akaike Information Criteria (AIC).

**Table 4.3: ARDL in Level (3,5,3,4,3,5)**

| Variable | Coefficient | Standard Error | t-Statistics |
|---|---|---|---|
| **LBP(-1)** | 0.374 | 0.149 | 2.504** |
| **LBP(-2)** | 0.177 | 0.167 | 1.062 |
| **LBP(-3)** | -0.372 | 0.121 | -3.070*** |
| **LGI** | 0.486 | 0.0621 | 7.836*** |
| **LGI(-1)** | -0.001 | 0.118 | -0.012 |
| **LGI(-2)** | -0.124 | 0.111 | -1.114 |
| **LGI(-3)** | 0.201 | 0.090 | 2.226** |
| **LGI(-4)** | 0.129 | 0.079 | 1.622 |
| **LGI(-5)** | 0.101 | 0.062 | 1.612 |
| **LCT** | 0.039 | 0.181 | 0.215 |
| **LCT(-1)** | -0.185 | 0.195 | -0.950 |
| **LCT(-2)** | -0.118 | 0.188 | -0.624 |
| **LCT(-3)** | 0.6325 | 0.196 | 3.221*** |
| **LGP** | -0.873 | 0.645 | -1.352 |
| **LGP(-1)** | 0.609 | 0.826 | 0.737 |
| **LGP(-2)** | 0.010 | 0.763 | 0.013 |
| **LGP(-3)** | 1.274 | 0.724 | 1.761* |
| **LGP(-4)** | 0.896 | 0.721 | 1.242 |
| **LCS** | 23.798 | 45.009 | 0.529 |
| **LCS(-1)** | -67.005 | 88.764 | -0.755 |
| **LCS(-2)** | 104.333 | 86.741 | 1.203 |
| **LCS(-3)** | -63.868 | 40.499 | -1.578 |
| **LMD** | 0.750 | 0.279 | 2.693** |
| **LMD(-1)** | -0.178 | 0.502 | -0.355 |
| **LMD(-2)** | 0.0605 | 0.495 | 0.122 |
| **LMD(-3)** | -0.284 | 0.412 | -0.689 |
| **LMD(-4)** | -0.450 | 0.367 | -1.225 |
| **LMD(-5)** | 0.393 | 0.184 | 2.134** |
| **C** | 23.554 | 34.234 | 0.688 |

Note: ***, ** and * indicated that null hypothesis are rejected at significance level of 1%, 5% and 10% respectively. LBP denotes log Bitcoin price, LGI denotes log Google interest, LCT denotes log average confirmed transactions per days, LGP denotes log Gold price, LCS denotes log Bitcoins in circulation, LMD denotes log mining difficulty.

Subsequently, this research uses the bounds test to detect the existence of cointegration between variables. Besides, in order to get valid and robust result, the diagnostic checking was used in this research which including Breusch-Godfrey Serial Correlation LM test, JB normality test, ARCH test, Correlogram & Correlogram Square Residual test and CUSUM & CUSUM Square test.

## 4.4 Result of Diagnostic Checking

**Table 4.4: Overall Result of Diagnostic Checking**

| **Diagnostics checking:** | |
|---|---|
| **Bound test** | **5.947*** ** |
| **BGLM test (2)** | 0.587 |
| **Jarque-Bera** | 0.491 |
| **Heteroskedasticity:** | |
| **ARCH (1)** | 0.002 |
| **ARCH (2)** | 0.388 |
| **ARCH (3)** | 1.319 |
| **ARCH (4)** | 1.716 |

Note: ***, ** and * indicated that the null hypothesis is rejected at significance level of 1%, 5% and 10% respectively.

Under the BGLM test, test statistic from lagged two (0.587) are greater than critical value of all three significance level (10%, 5% and 1%). For that reason, the alternative hypothesis of autocorrelation has not rejected, besides, it can be concluded from here that autocorrelation problem does not exist in the estimated model. In addition, all of test statistic of lagged one, lagged two, lagged three and lagged 4 are greater than the critical value of significance levels in ARCH test. Hence, the null hypothesis of homoscedasticity was accepted and this research concluded that the estimated model is free from heteroscedasticity problem. For normality checking, the p-value (0.782) is greater than all 10%, 5%, and 1% significance levels under Jarque-Bera normality test. Hence, this research do not reject the null hypothesis and concluded that the error term in model is normally distributed.

## 4.5 CUSUM and CUSUM Square

**Figure 4.1: Result for CUSUM Test**

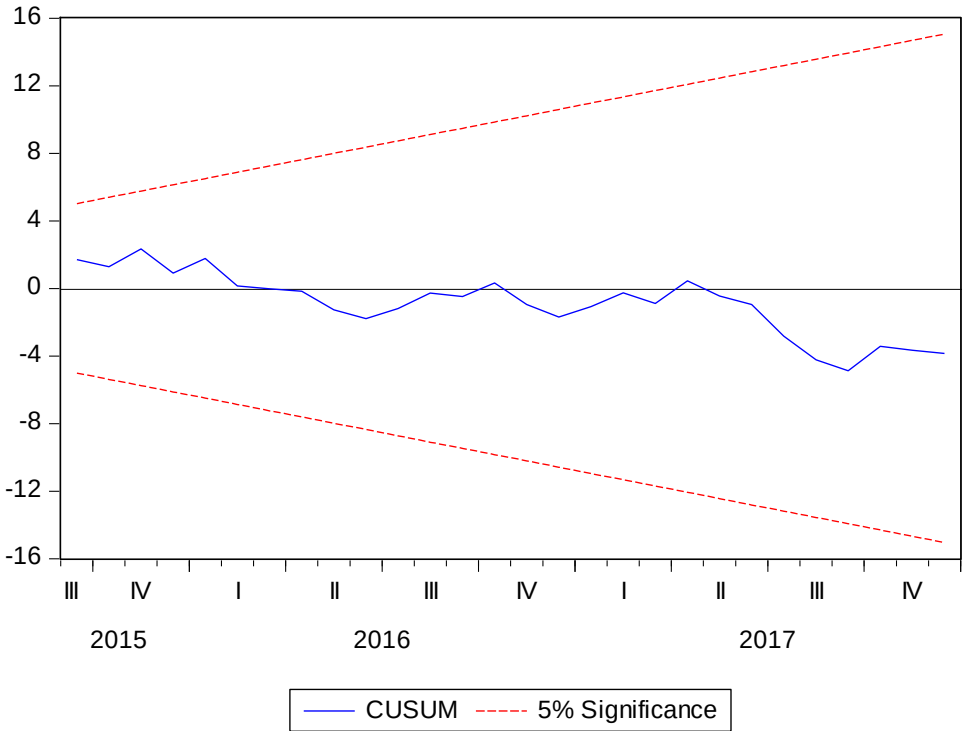
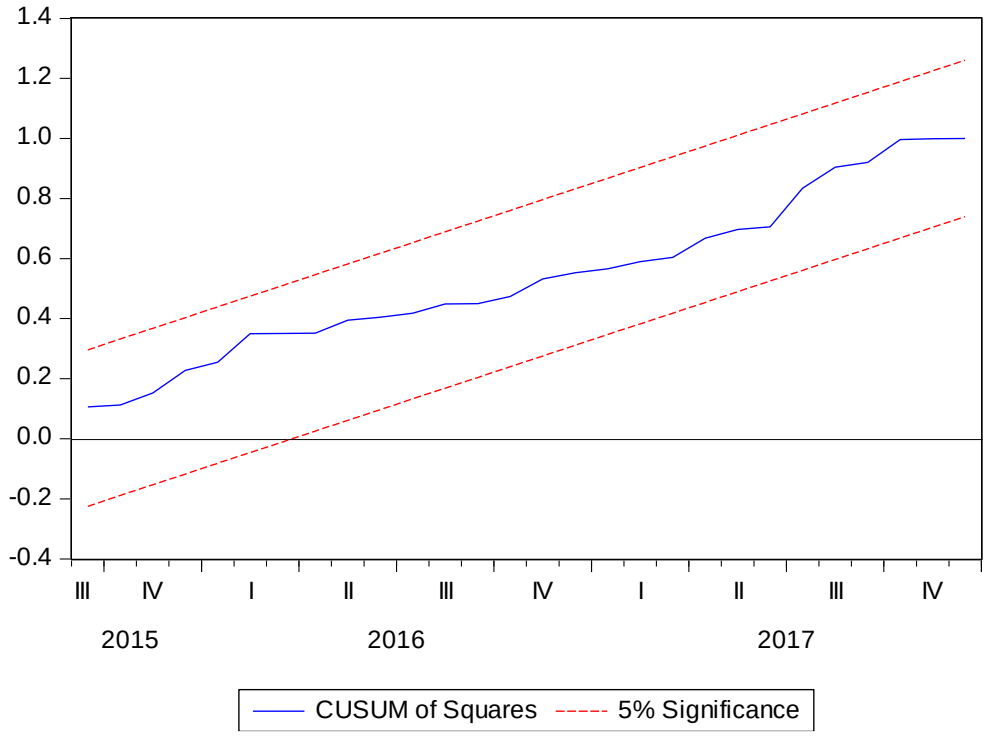



**Figure 4.2: Result for CUSUMSQ Test**



According to the result of CUSUM and CUSUMSQ as shown in the Figure 4.1 and 4.2 respectively, the problem of parameter and error variance instability is not existing in ARDL model as long as the plots of the CUSUM and CUSUMSQ statistic are moving within the critical bounds at significance level of 5%.

## 4.6 Correlogram and Correlogram Square Residual

**Table 4.5: Result of Correlogram & Correlogram Square Residual**

| | Residual | | | Square Residual | | |
|---|---|---|---|---|---|---|
| **Lag** | **ACF** | **PACF** | **Q** | **ACF** | **PACF** | **Q** |
| **1** | -0.055 | -0.055 | 0.180 | 0.006 | 0.006 | 0.002 |
| **2** | 0.007 | 0.004 | 0.183 | -0.082 | -0.082 | 0.414 |
| **3** | 0.002 | 0.002 | 0.183 | -0.122 | -0.122 | 1.343 |
| **4** | -0.142 | -0.142 | 1.465 | -0.041 | -0.048 | 1.448 |
| **5** | -0.282 | -0.305 | 6.621 | -0.149 | -0.174 | 2.888 |
| **6** | -0.043 | -0.097 | 6.745 | 0.087 | 0.064 | 3.386 |
| **7** | -0.036 | -0.055 | 6.831 | 0.185 | 0.153 | 5.676 |
| **8** | -0.069 | -0.118 | 7.159 | -0.089 | -0.123 | 6.219 |
| **9** | 0.107 | -0.008 | 7.962 | 0.171 | 0.226 | 8.262 |
| **10** | -0.053 | -0.180 | 8.160 | 0.054 | 0.063 | 8.469 |
| **11** | -0.082 | -0.205 | 8.656 | -0.035 | 0.002 | 8.558 |
| **12** | -0.001 | -0.140 | 8.656 | -0.191 | -0.094 | 11.27 |
| **13** | 0.009 | -0.111 | 8.662 | -0.012 | -0.058 | 11.28 |
| **14** | -0.246 | -0.409 | 13.40 | 0.113 | 0.153 | 12.27 |
| **15** | 0.164 | -0.175 | 15.55 | -0.082 | -0.137 | 12.82 |

Note: ***, ** and * indicated that null hypothesis was rejected at significance level of 1%, 5% and 10% respectively. In conclusion, all of the Q-statistics are not significant.

Based on Table 4.5, the results of Correlogram and Correlogram Square Residual showed that the serial correlation is not exist in residuals. The ACF and PACF at all lags are approximately getting closer to zero and there is not significant for all Q-statistics.

## 4.7 Bound Test

As the ARDL-in-level (3,5,3,4,3,5) model is free from econometric problem, the model can be re-estimated as an unconditional econometric model that was reported in Table 4.6. The table in above had showed us that the F-statistic of 5.9465 is the highest when comparing to each upper critical values at a significance level of 1%, 5%, and 10%. As a result, it shows that the rejection of null hypothesis of no cointegration at significance level of 1%, 5% and 10%. We can conclude that the long run relationship between the variables is existing in the model. According to Table 4.6, the long run effect of each variable can be evaluated on Bitcoin's Prices in this study. Since there is long run relationship for these variables, this research can proceed to long run parameter.

**Table 4.6: F-Statistic Bound Test**

| F-Bounds Test | | | Null Hypothesis: No levels relationship | |
|---|---|---|---|---|
| Test Statistic | Value | Signif. | I(0) | I(1) |
| | | Asymptotic: n=1000 | | |
| F-statistic | 5.946494 | 10% | 2.08 | 3 |
| k | 5 | 5% | 2.39 | 3.38 |
| | | 1% | 3.06 | 4.15 |
| | | Finite Sample: | | |
| Actual Sample Size | 57 | n=60 | | |
| | | 10% | 2.204 | 3.21 |
| | | 5% | 2.589 | 3.683 |
| | | 1% | 3.451 | 4.764 |
| | | Finite Sample: n=55 | | |
| | | 10% | 2.226 | 3.241 |
| | | 5% | 2.617 | 3.743 |
| | | 1% | 3.543 | 4.839 |

## 4.8 The Long Run Relation of Bitcoin's Price and its Economics and Technology Determinants

The results in Table 4.7 have showed us that Google interest, gold price and mining difficulty are significant to determine the long run relationship with Bitcoin's price at significance level of 5%, at the same time, the average confirmed transactions per day and Bitcoins in circulation are not significant to make interpretation to the Bitcoin price at significance level of 5%.

**Table 4.7: Results of Long Run Parameter**

| Variable | Coefficient | Std. Error | t-Statistic |
|---|---|---|---|
| **LGI** | 0.963 | 0.066 | 14.656*** |
| **LCT** | 0.449 | 0.333 | 1.350 |
| **LGP** | 2.332 | 0.664 | 3.510*** |
| **LCS** | -3.337 | 2.826 | -1.181 |
| **LMD** | 0.355 | 0.065 | 5.481*** |
| **C** | 28.673 | 42.916 | 0.668 |

Note: ***, ** and * indicated that null hypothesis are rejected at significance level of 1%, 5% and 10% respectively. LBP denotes log Bitcoin price, LGI denotes log Google interest, LCT denotes log average confirmed transactions per days, LGP denotes log Gold price, LCS denotes log Bitcoins in circulation, LMD denotes log mining difficulty.

The value of 0.963 implies that when the Google interest increased by 1 percent, on average, the estimated Bitcoin's price has increased by 0.963 percent in the long run, ceteris paribus. Our finding is consistent with empirical result of Li and Wang (2017) as they also explain that there is Google interest has positive relationship with Bitcoin's price.

Besides, the value of 2.332 indicated that the gold price increased by 1 percent, on average, the estimated Bitcoin's price will increase by 2.332 percent, ceteris paribus.

The empirical result done by Baur et al. (2017) found that the gold price is positive and significant toward Bitcoin's price which also consistent with our test result.

In addition, the value of 0.355 implies that when the mining difficulty increased by 1 percent, on average, the estimated Bitcoin's price will increase by 0.355 percent in the long run, holding other variables constant. The empirical result done by Hayes in 2017 found that the mining difficulty has positive relationship with Bitcoin price.

Other than that, the result of the average confirmed transactions per day and circulation supply are insignificant to Bitcoin's price when examining long run relationship. However, our result is inconsistent with the empirical result that are done by researchers. From the study of Balcilar, Bouri, Gupta, & Roubaud (2017) and Kristoufek (2015), they found that the daily confirmed transaction has positive relationship with Bitcoin's price. At the same time, Ciaian et al. (2016) found that the Bitcoins in circulation has strong negative relationship with Bitcoin's price and the relationship tends to increase over time.

## 4.9 Error Correction Model

After observing the long run equilibrium in the fundamentals of Bitcoin's price, this research also considers the short run evolution of the variables. Therefore, Error Correction Model (ECM) was applied to observe the short run relationship among the variables. This model allows this study to adjust and correct the deviation in the short-term disequilibrium relationship between the variables to achieve long run equilibrium. As a result, some of the variables are significant but some variables are insignificant when examining the short run relationship. The short run relationship is existing between the variables if the variables are significant.

## Table 4.8: Conditional ECM Estimation

| Variable | Coefficient | Std. Error | t-Statistic |
|---|---|---|---|
| **D(LBP(-1))** | 0.195 | 0.108 | 1.798* |
| **D(LBP(-2))** | 0.372 | 0.104 | 3.567*** |
| **D(LGI)** | 0.486 | 0.050 | 9.800*** |
| **D(LGI(-1))** | -0.306 | 0.105 | -2.925*** |
| **D(LGI(-2))** | -0.430 | 0.092 | -4.655*** |
| **D(LGI(-3))** | -0.229 | 0.057 | -4.039*** |
| **D(LGI(-4))** | -0.101 | 0.044 | -2.297*** |
| **D(LCT)** | 0.039 | 0.147 | 0.264 |
| **D(LCT(-1))** | -0.515 | 0.158 | -3.252*** |
| **D(LCT(-2))** | -0.632 | 0.139 | -4.563*** |
| **D(LGP)** | -0.873 | 0.459 | -1.899* |
| **D(LGP(-1))** | -2.179 | 0.534 | -4.083*** |
| **D(LGP(-2))** | -2.170 | 0.531 | -4.085*** |
| **D(LGP(-3))** | -0.896 | 0.550 | -1.628 |
| **D(LCS)** | 23.798 | 33.120 | 0.719 |
| **D(LCS(-1))** | -40.465 | 48.734 | -0.830 |
| **D(LCS(-2))** | 63.868 | 32.141 | 1.987* |
| **D(LMD)** | 0.750 | 0.191 | 3.929*** |
| **D(LMD(-1))** | 0.280 | 0.269 | 1.040 |
| **D(LMD(-2))** | 0.340 | 0.222 | 1.536 |
| **D(LMD(-3))** | 0.057 | 0.204 | 0.278 |
| **D(LMD(-4))** | -0.393 | 0.148 | -2.658** |
| **CointEq(-1)*** | -0.821 | 0.116 | -7.110*** |

Note: ***, ** and * indicated that null hypothesis are rejected at significance level of 1%, 5% and 10% respectively. BP denotes Bitcoin price (USD), GI denotes Google interest (relative measure), CT denotes average confirmed transactions per days (number of transactions), GP denotes gold price (USD), CS denotes Bitcoins in circulation (number of Bitcoins), MD denotes mining difficulty (relative measure).

The following Table 4.8 revealed that the coefficients of Bitcoin's price with lagged one and lagged two are positive and also significant in short run at significance level of 1% and 10%. Besides, the ECM coefficient of Google interest is positive and significant at 1% in the short run, at the same time, this research concluded that the coefficients of Google interest with lagged one to lagged 4 are same in negative value and significant in the short run.

Average confirmed transactions per day is also one of the variables that was taken into account which represents the average number of Bitcoin transactions in a day. The results in Table 4.8 shows that the coefficient of Average confirmed transactions per day without lag is positive but not significant, however, the Average confirmed transactions per day with lagged one and lagged two is significant in the short run at significance level of 1%.

Other than that, gold price is an independent variable that was tested in Conditional ECM model estimation. According to the results in Table 4.8, the coefficients of gold price without lagged form and with lagged form are negative, however, gold price with lagged three is insignificant in the short run. The coefficient of gold price without lagged is significant at 10% in the short run equilibrium whereas gold price with lagged one and lagged two is significant in short run equilibrium at significance level of 1%.

In addition, Bitcoins in circulation is a variable taken to explain the number of Bitcoins circulating in market. In this case, test results show that the coefficient of Bitcoins in circulation without lag is positive but insignificant, while the Bitcoins in circulation with lagged one is negative in the ECM coefficient but not significant in the short run equilibrium. Besides, the coefficient of Bitcoins in circulation with lagged two is positive and significant in the short run at significance interval of 10%.

For mining difficulty, test results show that all the coefficients of mining difficulty are positive except mining difficulty with lagged four, however, the mining difficulty without lagged and with lagged four are significant at 1% and 5% respectively in the short run equilibrium.

When the ECM was conducted, a series of diagnostic checking such as JB Normality test, BGLM test, ARCH test, CUSUM and CUSUM Square are applied in the model and the results showed on previous part. At the end of the test, the model showed valid and accurate due to no autocorrelation, no heteroskedasticity, residual is normally distributed, and no error variance instability.

# CHAPTER 5: DISCUSSION, CONCLUSION AND IMPLICATIONS

## 5.0 Introduction

Major findings in our research from Chapter 4 will be posted over this chapter by comparing the literature review and tests findings. Implications of study, limitations and recommendations will then be covered to enrich the content of this research paper.

## 5.1 Discussions

This thesis is conducted to study the fundamental drivers that will exert influence on the Bitcoin's price. From the historical charts, it is undeniable that the price of the Bitcoin is very dynamic. People nowadays are actively discussing over topics related to Bitcoin or blockchain technology behind it. Thus, this research adopted some factors to find out whether they are significant drivers of Bitcoin's price. Those factors are Google interest, average confirmed transactions per day, gold price, Bitcoins in circulation and mining difficulty. The output of this research is illustrated in Table 5.1 as below.

**Table 5.1: Summary of results**

**Long Run Estimates:**

$$log(BP_t) = \underset{}{28.673} + \underset{(0.066)^{***}}{0.963log(GI)} + \underset{(0.333)}{0.449log(CT)} + \underset{(0.664)^{***}}{2.332log(GP)} - \underset{(2.826)}{3.337log(CS)} + \underset{(0.065)^{***}}{0.355log(MD)}$$

Bound Test: 5.947***

| **Hypothesized result:** | **Actual Result:** |
|---|---|
| 1. Bitcoins in circulation has negative significant relationship with Bitcoin's price | Insignificant |
| 2. Mining difficulty has positive significant relationship with Bitcoin's price | Positive Significant |
| 3. Average confirmed transactions per day has positive significant relationship with Bitcoin's price | Insignificant |
| 4. Google Interest has positive significant relationship with Bitcoin's price | Positive Significant |
| 5. Gold price has positive significant relationship with Bitcoin's price | Positive Significant |

From the tests, Bitcoins in circulation has no significant influence on the Bitcoin's price in both short run and long run. Such result is not consistent with our hypothesis. In contrast to our result, Ciaian et al. (2018) found that the supply of Bitcoin can affect the Bitcoin's price in short run. Dyhrberg (2016) also agreed that the value of Bitcoin is mainly derived from its scarcity principle due to the limited supply. Moreover, it is not controllable by any government or institution. The similar statement is found in the study of Hayes in 2015 which stated that when more Bitcoin is mined, the amount of remaining Bitcoin to be mined decrease, its scarcity increase, the value will rise. However, in a further research by Hayes (2017), he highlighted the fact that once the ceiling of Bitcoin's supply is hit, Bitcoin's unit can be easily divided or subdivided. Ciaian et al. (2016) had reject the implication of traditional economic theory of supply and demand on Bitcoin due to the absent of several currency's feature in Bitcoin such as the issuance of currency by any government or central bank.

Besides that, the mining difficulties have positive influence on the Bitcoin's price in long run. According to Kristoufek (2015), Bitcoin's price is highly correlated with mining difficulty is a positive manner. The sky-rocketed Bitcoin's price induces market participants to start engaging in mining activities by investing in hardware. Such phenomenon causes increase in hash rate and thus higher difficulty. However, the increase of hash rate and the difficulty leads to fast-paced increasing cost demands for hardware efficiency as the hardware is frequently replaced by the ones of newer generation. This factor serves as a reason why more miners are leaving the mining pool. Anyway, the miners who previously picked mining as an indirect way of investment can turn themselves into Bitcoin purchasers which will first increase the demand, then drive the Bitcoin's price (Kristoufek, 2015).

On the other hand, average confirmed transactions per day is proved to have no effect on Bitcoin' price in long run. This means that there is no relationship between them. This finding is not consistent with our hypothesis. There is previous research finding that is similar to our hypothesis but not consistent with our test result. According to Buchholz, Delaney, Warren and Parker (2012), interaction of market forces that are demand and supply of Bitcoin is an important factor of its price. Bitcoin was introduced to the world as a new era's medium of exchange. Thus, its demand is mainly derived from the transaction needs. Development in economics and finance in the society may vitalize the utilization of Bitcoin in exchange and trade, thus creating positive impact to the Bitcoin's price. However, Ciaian et al. (2016) had said that the effect of speculation of Bitcoin had exceed the effect of macroeconomic factor on the Bitcoin's price. They stated that the dramatic rises of Bitcoin's price acts more like a speculative bubble rather than the increase demand of the users.

The test result shows that Google interest is able to exert positive impact on the Bitcoin's price in long run. Such result is consistent with the previous research carried out by Polasik et al. (2015). Their analysis told that Bitcoin's price is formed solely on the transactional demands of its users and its popularity. The Google search queries is found to be particularly significant in their research. Besides, the coexisting relationship between Bitcoin's price and search frequencies on Google Trends is supported by Kristoufek (2013). The result revealed that search intention does forego buying decision

and definitely a more “honest signal” of actual preferences as there is no negotiation involved (Pentland & Heibeck, 2008).

Apart from that, gold price is ratified to have positive long run effect on Bitcoin’s price. This result consolidates the idea from Baur and Lucey (2010) that Bitcoin has the same capabilities with gold in hedging against the United Kingdom market. If the price of gold increase, people will switch to buy Bitcoin as a substitute goods. The more people buy Bitcoin, which increases the demand will then lead to surge in Bitcoin’s price. Bitcoin is similar to gold in terms of scarcity as it has only maximum cap of 21 million units. According to Woo (2013), Bitcoin and gold have another two common attributes such as both of them do not pay interest and they are hard to tracked compared to other financial assets.

## 5.2 Implications of the Study

This research contributes to the society in several aspects. First of all, it establishes a holistic discussion on the factors of exchange rates of Bitcoin as the pioneer of cryptocurrencies. The model framework draws attention to the significance of integrating economic theories with technological factors to investigate Bitcoin which is an IT-enabled financial innovation. Besides, this research contributes to the exploration on exchange market dynamics and speculative trading field. For fund managers, this research provides an inclusive discussion about the factors they need to think of in the valuation of a cryptocurrency (Ince & Trafalis, 2006). This research does introduce the unique features of cryptocurrency systems and direct the implementation of financial decision support systems in the emerging cryptocurrency markets (Sermpinis, Dunis, Laws & Stasinakis, 2012).

In order to test the Bitcoin’s price formation hypotheses, time-series analytical mechanisms are applied to monthly data for the period 2012–2017. The empirical results show that market forces which are supply and demand of Bitcoin are not significant to influence Bitcoin’s price in long run. Such results imply that the formation of Bitcoin’s price is not able to be described in a standard economic model for

traditional commodity's price formation. As Bitcoin is not traditional commodity, merely demand and supply theory is inadequate to explain its price formation, thus public sentiments and market expectations should be added in analysis. To be particular, the variable that serves as our demand-side driver is average confirmed transactions per day and we take Bitcoins in circulation and mining difficulty as the supply-side drivers.

Second, it is found that the arrival of new information era impacts Bitcoin's price positively in both short run and long run. Ever since the establishment of Google search engine in this Internet era, it has changed the way people gather information and knowledge from books in the library to typing keywords on the search engine. Our data collected from Google Trends has showed us how people get curious at Bitcoin and Google it for some understandings especially when major news on Bitcoin been covered by the media. Such phenomenon has indirectly showed the degree of public recognition towards Bitcoin. The positive relationship between Bitcoin's price and Google interest may have resulted from the increasing trust among users as they are believed to be gaining sufficient knowledge from the Internet and become confident to invest in the cryptocurrency market. Therefore, policy makers of China are suggested to unban Google as the largest search engine provider worldwide in view of its usefulness in gathering information and knowledge.

Third, the result indicates that gold price closely tracked Bitcoin's. It answers our objective that Bitcoin exists as a substitution to gold. Thus, making Bitcoin a good instrument for hedging to be considered in portfolio management decision. Investors are suggested to consider looking into Bitcoin as another hedging heaven aside of gold. Our finding has cleared the doubt of public and solidify the thought of looking Bitcoin as a "digital gold".

Forth, our research has taken mining difficulty into consideration as we denote it as an average cost of production. In fact, the actual cost incurred to mine Bitcoin like the cost of mining machines, electricity costs, manpower allocation and et-cetera are not traceable into units. From our result, we can see that mining difficulty does impact Bitcoin's price in the long run. It implies that intrinsic value of Bitcoin could have been calculated by acquiring the relevant data.

For regulators, our research reveals that the cryptocurrency market has shown signs of maturity in recent years. As cryptocurrency keeps on gaining economic significance worldwide, it is vital to keep exchange market activities under surveillance. Concurrently, policy makers need to implement proper regulation to constrain excessive speculation and cope with the technology advancement.

Our analysis results highlight the significance of analyzing the drivers of Bitcoin's price from various aspects as the results are apparently be biased if only look at one factor at a time. A clear understanding on the Bitcoin's price formation is of utmost importance from a central banking monetary policy point of view. It is also vital in the case to examine Bitcoin's ability to serve as a medium of exchange for international economy transactions. Our findings contribute to a finer understanding on the determinants that drives Bitcoin's price to fluctuate. The huge price movements of Bitcoin could bring risks and costs to users that use it as medium of exchange in transactions as by varying the purchasing power time to time.

## 5.3 Limitation of the study

Based on our research, there are few limitations to be mentioned here. The difficulty to collect data would be one of them. Most of our data such as Bitcoin's price, average confirmed transactions per day, Bitcoins in circulation and mining difficulty were obtained from blockchain.info which serve as a Bitcoin block explorer. However, the website only provide data on two-day basic. Due to the dynamic nature of Bitcoin, data in daily frequency would be more effective in capturing the effects of independent variables on dependent variables. We did look into multiples of famous websites to search for the daily data, however, none of them had provided such variety of data about Bitcoin as blockchain.info does. Therefore, we decided to convert the data into monthly frequency.

Other than that, we have used the Google interest to represent the public interest and recognition because it is the most recognized and leading search engine in the internet (Li & Wang, 2017). However, it could not fully represent all of the public

interest in the internet because it does not include others common websites such as Wikipedia, YouTube, Yahoo and Bing. We had only found the data of Google interest and Wiki search frequency. However, both of them are calculated in different term, Google interest is measured in term of relative index while Wiki search is measured in term of number of search. Therefore, we only use Google interest in our study since it is the most common used search engine in the world.

## 5.4 Recommendations for future studies

Based on the limitations mentioned above, we would suggest the future researchers to continue this effort on Bitcoin's price formation. Bitcoin's price is extremely dynamic in its nature. Therefore, every phases might be driven by various determinants. As of this study is completed (beginning of March 2018), Bitcoin's price is quite stable, it will be good for future researchers to incorporate the findings of this research in future analysis.

To capture the public recognition and interest towards Bitcoin more holistically, future researchers are suggested to include more data from various search engines such as YouTube, Wikipedia, Yahoo and Bing. Wider range of data from various source of search engine could better capture the effect of public interest and recognition on the Bitcoin's price.

Apart from that, applying data frequency that are different from this study are advisable. This is because data frequency of different length can give us distinctive implications various terms. Yearly data should be applied to examine long term structural changes of Bitcoin. On the other hand, volatility of Bitcoin can be revealed by looking into daily data which visualize the dynamic nature of Bitcoin.

## 5.5 Conclusion

In a nutshell, this thesis is to examine the impact of the key determinants that we deem to be fundamental drivers of Bitcoin's price (Google interest, average confirmed transactions per day, gold price, Bitcoins in circulation, and mining difficulty) on Bitcoin's price throughout the period from November 2012 to December 2017 in monthly basis.

This particular chapter summarized the major finding of researches and also the implication or significance of studies for certain parties. Besides, the limitations of studies in this research paper and some critical recommendations against these problems and future studies are being discussed.

Lastly, this research analysis can contribute to any parties by clarifying the relationship between Bitcoin's price and the price drivers that we took into consideration. This can definitely assist them in making decisions to identify which factors stands more important role in determining Bitcoin's price.

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