

Research Topic : How Cryptocurrency Impacts the Environment
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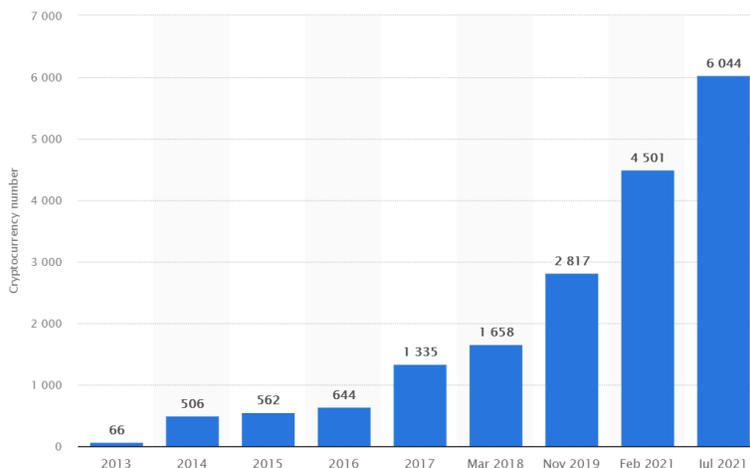


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1.0 Introduction and Problem Statement

The cryptocurrency scene has taken the world by storm. Started in 2009, the first ever cryptocurrency was created by Satoshi Nakamoto called the Bitcoin. According to the Bitcoin white paper, the purpose of this digital currency is to create a decentralised transaction system that relies on a peer-to-peer operation; in other words, it relies on the users within the network itself to validate transactions. Given the idea of decentralisation, Bitcoin has gained popularity. Following that of Bitcoin, many other cryptocurrencies have also slowly emerged from the water.

Figure 1.1: Number of crypto coins from 2013-July 2021



Source: <https://www.statista.com/statistics/863917/number-crypto-coins-tokens/>

As we can tell from the bar chart attached (Figure 1.1), the number of crypto coins started at an unimpressive number of 66 cryptocurrencies during the year 2013, then the numbers have grown immensely and ended up at 6044 cryptocurrencies during July 2021.

As the margins of the cryptocurrency prices are rising along with the number of cryptocurrencies, many see it as a new revolutionary exchange method or even a potential replacement for traditional cash and coins. But what many fail to realise is that, although virtual currencies are equipped with many advantages, it has also caused many irreversible impacts to the environment. With that include the immense usage of electricity and energy that are comparable to countries.

As tweeted by Elon Musk “We believe that it (cryptocurrencies) has a promising future, but this cannot come at a great cost to the environment.” With that, this research aims to present and bring awareness to readers that the cost of cryptocurrency transactions is not merely monetary, but externalities will also be involved. Hence, this paper breaks down the technology behind cryptocurrencies and how the impact on the environment might be adverse. Moreover, the paper projects the future expectation of cryptocurrency and suggests alternative coins for a greener and more sustainable environment. After all, the path of cryptocurrency will join us to a new technological revolution in the future, nevertheless.

2.0 Limitation of Study

There may be some possible limitations in this study. First and foremost, most of our data are obtained from the internet, thus it would be **difficult to identify the reliability of each data**. Since the cryptocurrency only became a hot topic in recent years, there is not much relevant journals and previous research available from the internet.

Besides, online survey forms regarding perception on cryptocurrency are distributed among student groups and posted on social media such as Instagram and Facebook. Therefore, the result will only represent the opinion of groups who are mostly students in the age group between 18 to 29 as they are the ones who are familiar with online platforms and are active on social media.

Answering an online survey form is also based on self-voluntary, thus **people might not be willing to take the survey** because it is not their obligation to do so, and they have the right to refuse it. Geographically, it also does not represent the opinion of citizens from all countries in the world as all respondents of the online survey are Malaysians. As a result, this survey will not intend to generalize the public opinion.

Moreover, **the sample size of the survey is not sufficiently large** to generate supportive statistical evidence and valid research results. Within 2 weeks, we are able to collect 110 responses on the online survey which only provide a brief idea on the public opinion but are not able to significantly represent the whole population. The larger the sample size, the more precise our conclusions would be.

3.0 Methodology

The method used for this research is a **mixed research method**, which is a combination of both qualitative and quantitative research methods. It is used to grasp a complete understanding of the research problem by converging quantitative and qualitative data. A convergent mixed methods design will be used where qualitative and quantitative data are collected in parallel, analysed separately and then merged.

As a detail, the **Qualitative Research Method** with primary data is applied in this research. Primary data is the kind of data that is collected directly from the data source without going through any existing sources. ^[29] In this study, the online survey is known as the primary data as it is specific to the needs of our research topic at the moment of data collection. It will be used to know the public opinion and perception on cryptocurrency and its negative impact on the environment as well as its future expectation.

For the data collection of primary data, the research applies questionnaires that will be sent to the respondents and the sample size of respondents is targeted as 100. The actual results from the feedback of respondents will be compiled and analysed. By using descriptive analysis, we are able to summarise the data collected in significant form and make an ultimate conclusion based on its result.

Besides, secondary data is the data that has been collected in the past by someone else but made available for others to use. It is usually easy to be accessed by researchers and individuals because they are mostly shared publicly. ^[29] Examples of secondary data used in this research are journals, statistical data and definitions which are properly referenced and cited.

The **Quantitative Research Method** with secondary data will also be applied to conduct the research on the negative impact of cryptocurrency to the environment. The statistical data obtained from the internet is used in this research to express the quantitative descriptions regarding the level of Cryptocurrency's impact on the environment. This could be shown through the statistics such

as annual electrical energy consumption of cryptocurrency over the years, power consumption, and the carbon intensity for different mining facilities in different locations.

In addition, the Qualitative Research Method with secondary data would also be used in this research. We use information from other research papers, journals, articles, and documents which are available online to construct an introduction on our main topic, Cryptocurrency. We would explore it in terms of background history, types of cryptocurrencies, blockchain technology behind it, as well as its alternatives and future expectations.

3.1 Survey

On 6 July 2021, we sent out an online survey including questions regarding perception on cryptocurrency and its impact on the environment to students, friends, family and relatives. We received 110 respondents as of 20 July 2021. 99 percent of the respondents are in their 20s or 30s, whereas only one respondent is below 18 years old. 97 respondents are still students or unemployed whereas only 13 are employed. Further breakdown of questionnaires will be explained in the content.

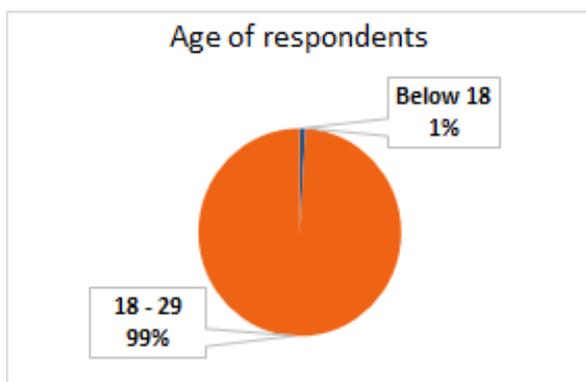


Figure 3.1.1: Age of respondents

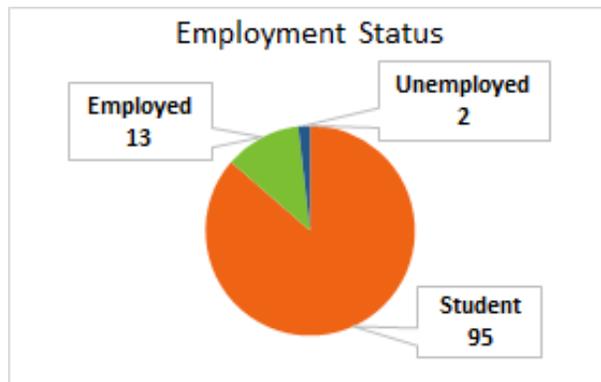


Figure 3.1.2: Employment status

To start off the questionnaires, we studied the knowledge of respondents regarding the cryptocurrency and blockchain technology so that we would be able interpret their answers accordingly. Only 20 percent of the respondents have experience in cryptocurrency trading, whereas 53 percent of the respondents rate their knowledge on blockchain technology at a low score.



Figure 3.1.3: Experience in cryptocurrency trading

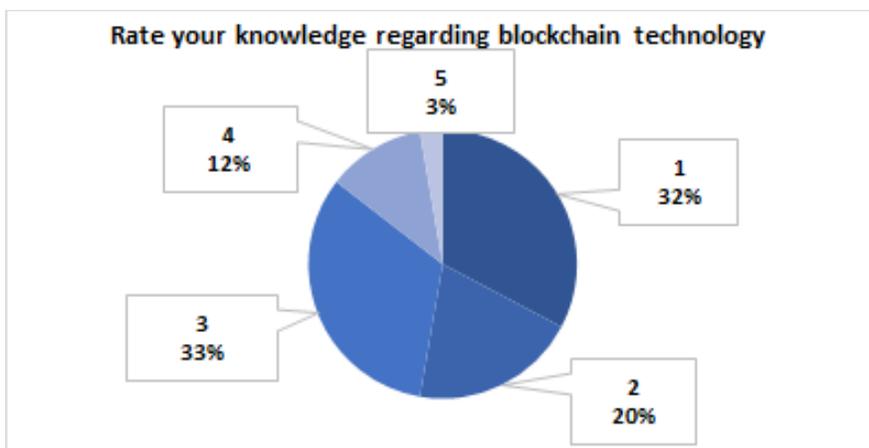


Figure 3.1.4: Rating on the respondents' knowledge regarding blockchain technology

Besides, we also look into the respondents' investing preferences, future expectation on cryptocurrency, and their willingness to switch to more sustainable types of crypto assets. From the collected responses, most of the respondents prefer to invest in stocks or equities, fixed deposit and physical assets, whereas only 30 percent of them choose cryptocurrency as their investing preference. 92 percent of the respondents think that cryptocurrency will continue to become more popular in the future while 52 percent of them think that cryptocurrency can replace money in the future due to its decentralised nature. From those who trade in crypto assets, 63 percent of them will consider trading in more sustainable types of crypto assets even though they are less profitable.

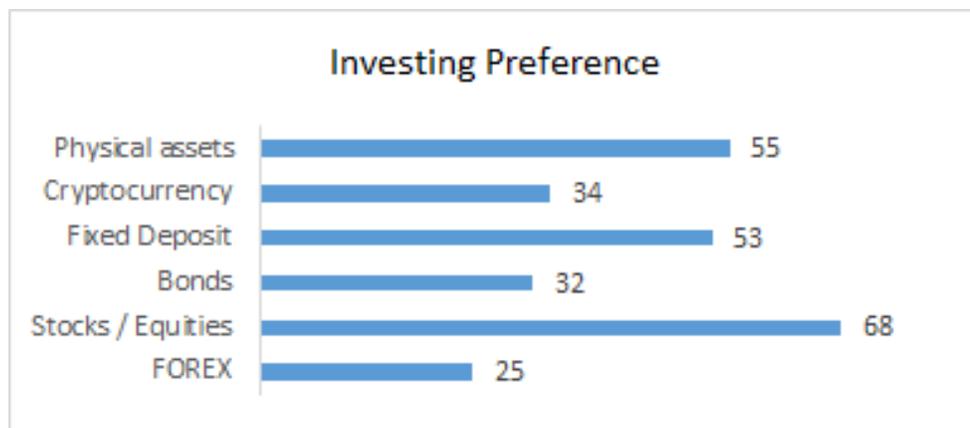


Figure 3.1.5: Investing preference of the respondents

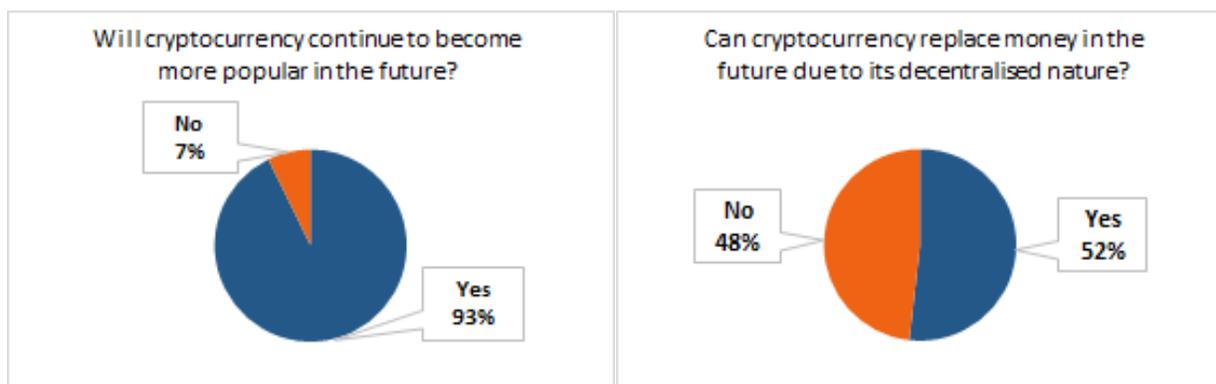


Figure 3.1.6: Future expectation on cryptocurrency

4.0 Literature Review

1. **(Liana Badea, 2017)** ^[51] discusses the controversies of Bitcoin, by conducting a SWOT analysis for Bitcoin and its effects for the economy and the environment. This research paper also discusses the sustainability of Bitcoin and the possibility of Bitcoin replacing fiat currency in the near future. It compares Bitcoin's energy consumption and CO₂ emissions in terms of mining compared to other transactional assets such as VISA and gold. Furthermore, it also discusses possible solutions to reduce the negative effects of Bitcoin mining on the environment. Their study shows that Bitcoin will still continue to grow in popularity, regardless of its very high energy consumption and its negative effects on the environment.

2. **(Hass McCook, 2018)** ^[38] investigates the costs incurred by Bitcoin and its sustainability in the economy. As quoted, "Cryptocurrency is the "Life" of money, of which Bitcoin was "first-life" - literally converting energy into money." The average cost to mine one Bitcoin is estimated to be around USD 6,450 (MYR 27,199.65 as of 5 August 2021) - ranging between USD 5,400 to USD 7,500 (MYR 22,771.80 to MYR 31,627.50) under the assumptions made. Furthermore, the study also shows that the Bitcoin network releases 63 million tonnes of CO₂ annually. To put this into context, it is about 0.12% of global greenhouse gas emissions. The energy used by the Bitcoin network is 105 TWh annually, out of 160,000 TWh globally.

3. **(Andrew L. Goodkind, 2020)** ^[37] studies the per coin economic damages of cryptocurrency in terms of air pollution emissions, human mortality and climate impact, focusing on countries such as the US and China. Their study finds that for every USD 1 of Bitcoin, the climate and health damages in monetary terms is USD 0.49 in the US and USD 0.37 in China.

4. **(Olga Martynov, 2020)** ^[53] discusses the true profitability of cryptocurrencies by considering its social costs and social benefits. These are assessed by considering its environmental impact through different models and frameworks. Based on the study, cryptocurrencies are forecasted to cause a growth in carbon emissions to match the carbon emitted by the United States in 2018, which is 5,269 MMmt. The study also shows that the electricity used in mining these

cryptocurrencies would lead to a cost ranging from USD 23 billion to USD 57 billion annually with its carbon emissions of 53 MtCO₂ to 64 MtCO₂.

5. (Ahmad Abdullah Aljabr, 2019) ^[4] investigates the mining process of Bitcoin, known as Blockchain, including some strategies and reward mechanisms that can be adopted. The complex computational puzzle in the context of Blockchain is known as Proof of Work (POW). Furthermore, to solve this, miners would need a Bitcoin software called node, which uses a lot of energy and memory space.

5.0 Introduction to cryptocurrency

5.1 What is Cryptocurrency?

According to Investopedia ^[32], “cryptocurrency is a digital or virtual currency that is secured by cryptography, which makes it impossible to counterfeit or double-spend.” In the world of cryptocurrencies, crypto investors will exchange real money for cryptocurrencies which investors can use to buy and sell things online, in many parts of the globe. In other words, cryptocurrency is a form of payment that can be exchanged for goods and services.

Unlike regular money, which has a central issuing authority and regulatory body, cryptocurrencies are standalone currencies that are not attached to any state or government; hence, making them free from government controls and limitations. With that, one might ask, “If cryptocurrencies are digital currencies, and there is no centralized authority governing the money, what are the risks of counterfeits?”. Although that might be concerning, cryptocurrency is not simply a set of data that can be duplicated, except it is an entry in a global ledger called the blockchain (Section 6.1). Many blockchain-based cryptocurrencies are kept safe by an encryption method called cryptography; hence the word “crypto-” in cryptocurrency.

As Richards, K. (2020) ^[64] states, cryptography is a method of protecting information and communications through the use of codes. In the language of cryptocurrency, the definition is almost identical, where cryptocurrencies are primarily safe due to “keys”, which is a set of mathematical guarantees that encodes and decodes data. When an account, also known as a wallet, is set up in a cryptocurrency network, it is linked with two keys. The first key is a private key that is used to encode and sign a message when a transaction is being made. When the message is encoded and signed, the second key, or the public key, is used to send out the message and blockchain keepers can use the public key to verify the authenticity of the message. Keys are very important components of cryptography. As unlike a written signature, it cannot be forged.

Most see cryptocurrencies as the new revolutionary vessel of transaction, but there are some potential problems that might occur with cryptocurrencies. As the biggest attraction of cryptocurrency is the decentralisation, one might face the problem of forgetting the password to the wallet or physically losing the hard drive that contains the cryptocurrency wallet. With that,

without a centralised authority, there is no aid of retrieving the lost cryptocurrency. Other than that, as most cryptocurrencies rely on a peer-to-peer system, the value of each currency is determined by the interest of the users, much like stocks and shares. With that, if people on the cryptocurrency network have simultaneously decided to detach from the currency, the value will plunge indefinitely. Without the help of a centralised government, the cryptocurrency will likely be banished and isolated forever, and cash and assets invested will be sunken. Although these potential issues may be frightening, it still does not take away from the fact that cryptocurrency is the first step to a revolutionary future.

5.2 The History of Cryptocurrency

In 2008, following the financial recession, a person or a group by the name Satoshi Nakamoto released the Bitcoin whitepaper, a guideline to the first ever decentralized cryptocurrency that relies on a peer-to-peer operating network. The document explains the basic principles of blockchain technology and cryptography. With that, came the birth of the first cryptocurrency - Bitcoin. Although Bitcoin was founded in 2008, the first blockchain entry was not made until January 3rd, 2009.

At first when cryptocurrency was introduced, the traction and impact on the general public was not significant, as people still yet to understand the digital currency. Mining (Section 6.1) back then was as simple as using personal computers (PC) and laptops.

In May of 2010, the first real world transaction of Bitcoins for goods and services happened, where a man named Laszlo Hanic, bought two Papa John's pizzas for the price of 10 thousand Bitcoins. During the time of the transaction, 10 thousand Bitcoins was not a lot, but comparing it today's value, it would have equated to more than 300 million USD. After this dumbfounded historical event, Hanic and Papa John's courier, Jeremy Sturdiant, made the world realise a greater possibility of cryptocurrencies. Shortly after that, Bitcoin and cryptocurrency started to gain popularity, causing many companies and individuals to start their own project of creating their own cryptocurrencies. With that, many familiar names have come to existence, some of which are Ethereum, Litecoin, Ripple, and Dogecoin.

As cryptocurrency is gaining popularity, 2017 is the year of cryptocurrency build-up, where the market for cryptocurrencies is rising rapidly.

Figure 5.2.1: Bitcoin (BTC) Price Index



Source: <https://www.coindesk.com/price/bitcoin>

According to the BTC price index (Figure 5.2.1), from an initial flat curve from 2014 to 2016, it started to rise in April of 2017, and it has been growing ever since. As of 2020, there are an approximate total of 5392 cryptocurrencies in the world that are publicly traded every day; and undoubtedly, this number will continue to grow.

5.3 The types of Cryptocurrencies

Cryptocurrency is an electronic money created with technology controlling its creation and protecting transactions, while hiding the identities of its users (Decryptionary, 2017) ^[21]. It is an alternative form of payment to cash, credit cards and checks. There are three main types of cryptocurrency which will be discussed further in the below section.

5.3.1 Bitcoin

Bitcoin is a digital currency that was created in January 2009, which follows the ideas set out in a whitepaper by the mysterious and pseudonymous Satoshi Nakamoto (Jake Frankenfield, 2021) ^[31]. It is the world's largest cryptocurrency by market capitalization. It aims to eliminate the need for a trusted third party, democratise money and ensure that transactions are anonymous ^[40].

Bitcoin is not issued or regulated by any banks or governments. There are no physical bitcoins, only balances kept on a public ledger that everyone has transparent access to. With the existence of blockchain technology of Bitcoin, each transaction can happen directly between users without using a third party, which is known as a peer-to-peer network.

5.3.2 Altcoins

Bitcoin has triggered the launch of hundreds of other cryptocurrencies, collectively referred to as altcoins. According to CoinMarketCap^[30], altcoins accounted for over 40% of the total cryptocurrency market, with more than 9,000 cryptocurrencies and counting, as of March 2021.

Altcoins share the same characteristics with Bitcoin but are also different from them in other ways. Altcoins improve upon Bitcoin's perceived limitations to establish a competitive advantage. For instance, some altcoins use the Proof-of-Stake (PoS) consensus method to minimize energy consumption and the time required to create blocks and validate new transactions, instead of using the Proof-of-Work (PoW).

By distinguishing themselves from Bitcoin, altcoins have created a market for themselves as the investors are able to see the potential in them as alternatives to Bitcoin, which are able to garner more traction and users as well as appreciate in price. Examples of popular altcoins are Ethereum (ETH), Ripple (XRP), Bitcoin Cash (BCH) and Litecoin (LTC).

5.3.3 Tokens

Unlike Bitcoin and Altcoins, tokens do not have their own underlying distributed ledger technology (DLT) or blockchain. They are built on top of existing cryptocurrency's blockchain. Therefore, they are not able to operate independently and will need to depend on the network of another cryptocurrency. Examples of popular tokens are Tether, UNUS SED LEO, Chainlink, Huobi Token and Maker ^[11].

Tokens can be used for investment purposes, to store value as well as to make purchases on the decentralized applications (dApps). Since dApps are built on other blockchains such as Ethereum, a token transaction is still verified by the nodes on that blockchain, thus the transaction fee is paid with Ether, and not with the token itself. As a result, the investor will need to hold some altcoins which the dApp is built on in order to pay for the transaction fees ^[49].

5.4 How does cryptocurrency differ from traditional currency?

Fiat money is government-issued currency that is not backed by a physical commodity, such as gold or silver, but rather by the government that issued it. The value of fiat money is derived from the relationship between supply and demand and the stability of the issuing government, rather than the worth of a commodity backing it as is the case for commodity money (James Chen, 2021)^[12]. The types of fiat currency would be paper currency, banknotes, coins and bills. It has a store of value and is used as a means of trade to purchase goods and services.

Comparison	Fiat currency	Cryptocurrency
Issued by	Issued by the central bank	Operate independently
Intermediaries	Required to make transfer, except when two parties trade in cash	Not required
Unit	Dollar, Rupee, Euro and etc	Bitcoin, Ethereum, Litecoin and etc
Legal	Legal in all countries	Illegal in some countries
Represented by	Coins, Notes and Bills	Private and Public pieces of code
Storage	Can be stored in bank accounts and digital wallet	Can be stored in digital wallets
Supply	Unlimited and controlled by central banks	Limited
Tangibility	Have tangible appearance in the form of coins and notes	Cannot be touched

Reference from: (Sneha Kulkarni, 2021)^[48]

5.5 Comparison of cryptocurrency and other types of investment

There are various types of investments to be used as tools which help investors to achieve their financial goals. Cryptocurrency is a fairly new investment option compared to Foreign Exchange (forex), stocks, bonds, fixed deposits and physical assets such as gold. When people decide to invest in a cryptocurrency, they usually buy it for the long term as they believe the price will go up, regardless of other factors which act in the opposite way. The investors will also be able to buy or sell cryptocurrency at any time as the crypto market operates 24/7 globally. However, cryptocurrencies often have wild fluctuations, making them a very risky investment.

Asymmetric information, also known as “information failure”, occurs when one party in a transaction is in possession of more information than the other. In certain transactions, sellers can take advantage of buyers because asymmetric information exists whereby the seller has more knowledge of the goods being sold than the buyer^[8]. One of the major advantages of cryptocurrencies is anonymity, which may help to prevent this from happening.

Crypto vs Forex

Foreign exchange is a process of changing one currency into another currency for a variety of reasons, usually for commerce, trading or tourism^[13]. The foreign exchange market is larger, well-established and more regulated compared to the crypto market. Both investments involve trading of currencies and have high volatility. There will be significant changes in price in a short amount of time due to various factors affecting their respective market.

Crypto vs Stocks

A stock represents equity in a company. When the investors buy a share of a company’s stock, they are buying a tiny fraction of the company’s operations and assets^[50]. As compared, most cryptocurrencies do not give any legal entitlements to its holders, unlike stock which entitles owners to dividend as a share of the company profit. In term of ownership and possession, cryptocurrencies are much simpler to own than stock

Crypto vs Fixed Deposit

A fixed deposit is a type of bank account that promises the investor a fixed rate of interest. In return, the investor agrees not to withdraw or access their funds for a fixed period of time^[43]. The interest earned at the end of any fixed deposit investment can be calculated easily due to its certainty. Therefore, fixed deposits provide certainty while buying cryptocurrency is quite risky.

5.6 How are cryptocurrencies being traded?

Cryptocurrency trading is the act of speculating on cryptocurrency price movements via a Contract for Differences (CFD) trading account, or buying and selling the underlying coins via an exchange^[41].

The trader would be able to speculate on cryptocurrency price movements without taking ownership of the underlying coins through CFD trading. CDF is a leveraged derivative product; therefore, the trader could open a position for just a fraction of the full value of the trade. He should go long on the derivative if he thinks a cryptocurrency will rise in value and short the derivative if he thinks it will fall.

Besides, the trader could choose to buy and sell cryptocurrencies via an exchange. He will need to create an exchange account, put up the full value of the asset to open a position, and store the cryptocurrency tokens in his own wallet until he is ready to sell. Many exchanges have limits on how much a person can deposit and accounts can be very expensive to maintain.

The cryptocurrency market is usually available to trade 24 hours a day and seven days a week due to its nature of decentralised governance of the market. It is also considered illiquid as the transactions are dispersed across multiple exchanges and comparatively small trades can have a huge impact on market prices. As a result, the cryptocurrency market is volatile.

6.0 Mining Process of Crypto

6.1 Introduction to blockchain mining

Blockchain is a revolutionary technology which is mainly used for enforcing decentralization, providing credibility to the list of records stored inside the blocks and spreading the encrypted data across multiple networks. The concept of Blockchain^[35] states that every block that contains data is connected cryptographically to the next block in a public distributed ledger. This technology ensures that no computer can monopolize the whole cryptocurrency market as it relies on overall consensus on each node during the day-to-day operation of the blockchain.

Cryptocurrency is a decentralised digital currency in which every transaction is made without intermediaries. Traditional cryptocurrencies such as Bitcoin use a decentralized blockchain ledger to share the data. There is a validation process required to verify each transaction and do the transaction documentation. The process is known as blockchain mining. Mining process is also a development of the blockchain ledger. The person who is involved in the mining is called a miner who mainly focuses on legitimizing and monitoring transactions. A miner could be anyone who has sophisticated computing power and Internet access. Not only that, miners need a GPU (graphics processing unit) or an application-specific integrated circuit (ASIC)^[26] to set up a more efficient mining rig. In order to enable computers to communicate securely among miners, blockchain miners are required to install and run a special Blockchain mining software. Once a computer installs the software, joins the network and begins mining cryptocurrency, it will form a communication point which is called a ‘node’^[60]. Each node stores a complete copy of the distributed ledger, and the miner can run a full node and access the full blockchain history.

Once the transaction process is being performed by a user, the transactions have to be authenticated by the cryptographic keys^[27] which are a string of data that identifies the user and give access to their “account” or “wallet” of value on the system. After a secure digital identity is created via digital signatures, the transaction is being added to a pool of unconfirmed transactions. Miners will

pick up the transaction from the pools and bundle all the outstanding transactions together as an unconfirmed block. However, selection (e.g., checking sustainability) is needed to be done before appending the block to the public ledger. The transaction will be treated as eligible to be added to blockchain only if the wallet of the sender has sufficient funds balance according to blockchain history.

After the election, the transactions are being combined in a new block and the new block needs the signature which is known as ‘Proof of Work (PoW)’ before adding it to the blockchain. The transaction blocks will be sent to every node and the miners will validate the transactions by solving a mathematical puzzle using cryptographic hash algorithm. It is not as easy as we think. The unique feature of the SHA-256^[58] which is the hashing algorithm used in blockchain will prevent any unauthorized access to ensure that the blocks are kept secure. SHA-256 takes an input string of any size and returns a fixed 256-bit output, and it is a one-way function which cannot derive the reverse of the input reverse fully from the output. What the miners do to solve the complex equation is to make guesses on a target hash by generating as many nonces as possible until the hash value is less than the target. It is a time-consuming process. Plus, each block has different problems to be solved due to different hash input. Therefore, substantial computational work is required to decrypt the data encoded and find the perfect hash output that matches the hash input.

The first miner who gets the qualified output will introduce his block and its signature to other miners. The other miners will validate the signature launched and match the hash out. Once the consensus is reached among the miners, the block which contains the transaction is now ready to be added on and chained to all the previous blockchain ledger as well as spread across all other nodes on the network. At the point of time, the data is saved, and no one can modify the first official record. Miners will continue to work on another block for other transactions made. The next block in the public ledger will contain the hash-codes in the previous block and only the block that can match the previous hash code will be linked together which proves that the record is immutable. When there is a data block change due to hacking, the hash value will also change

which results in the corruption of the chain and blocks in the ledger will be delinked. However, the possibility of altering and modifying the data is very low and could be said to be merely impossible as it is open in a public ledger and the transactions are recorded in a chronological order. Therefore, it is known that every subsequent block which is added after that block is considered as a “confirmation” for that particular block.

Since there are lots of miners being attracted to mining for bitcoin nowadays, the miners are competing among themselves to solve the hash problem and the miner who solves the mathematical problems are rewarded with the bitcoins as an incentive. Satoshi Nakamoto, the creator of Bitcoin, designed the Bitcoin network to allow for a block to be mined every 10 minutes. The difficulty of mining Bitcoin will change over time as more and more computers join in and more cryptocurrency such as bitcoin are being mined. The level of difficulty also changes depending on the time it takes to mine a block.

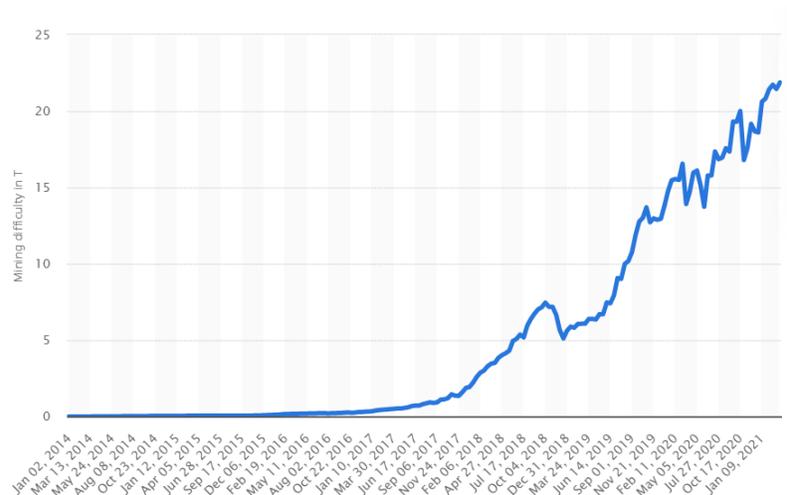


Figure 6.1.1: Average mining difficulty of Bitcoin from January 2014 to March 19, 2021

From the figure 6.1.1, it shows how many times on average miners should calculate the function to find a cryptocurrency block. In 2021, the mining difficulty reached an all-time high of nearly 22 trillion in which the difficulty increased to 21.87 times in March 2021. The computing power needed to solve the complex problem is larger which results in higher consumption of energy. The further details in the energy consumption will be discussed in the next section (Section 7.0).

There are different types of mining

1. Individual mining

User who registers itself as a miner is considered as an individual mining. However, participants with a small percentage of the mining power stand a very small chance of discovering the next block on their own.^[26]

2. Pool mining

In order to create economies of scale, multiple nodes can share their resources to mine a block. Mining pool offers miners the chance to share the computational workload and split the reward among all participating miners evenly based on the amount of processing power they have invested.^[25]

3. Cloud Mining^[60]

There is cloud mining service providers eg. Genesis Mining and HashFlare are provided to allow users to rent processing or hashing power to mine bitcoins remotely. The miner does not need to purchase mining hardware, but 2 percent of the total earnings will be charged with the cloud mining service providers.

7.0 Impact on environment

As mentioned from the previous section about mining, maintaining and developing the blockchain requires a huge amount of computational power which in turn requires energy and electricity to run. An important point to make here is that this large amount of energy comes from the mining on the blockchain by providing a Proof-of-Work, not directly from the transaction activities of cryptocurrencies. However, when crypto trading becomes more popular and in demand, the number of miners would increase. As a result, there would be more energy used for this activity. Here, we will be discussing the current impact on the environment due to these large amounts of energy used for mining. For simplicity, we will be looking at the 2 biggest cryptocurrencies at date, Bitcoin (BTC) and Ethereum (ETH) which are developed based on the Proof-of-Work system. However, Ethereum has plans to replace Proof-of-Work for Proof-of-Stake, a more sustainable and energy-efficient system. ^[59]

Section 6.0 explains in detail the process of mining. To recap, the mining of BTC and ETH are done by the Proof-of-Work mechanism where miners would need to verify their transactions on the blockchain using large computational power. When they successfully do so, miners are rewarded with newly minted units of cryptocurrency. To power their computers, they need electricity which is generated by several types of sources such as coal, solar, wind and so on.

Cambridge Bitcoin Electricity Consumption Index (CBECI)

To start off, we would discuss the electricity usage by Bitcoin, arguably one of the most popular cryptocurrencies. For an estimate on the total electricity used, we will be using the Cambridge Bitcoin Electricity Consumption Index (CBECI) which provides both a lower and upper bound, together with a best-guess estimate calculated from the floor and ceiling values. The lower bound is based on the absolute minimum total electricity used where miners would use the most energy-efficient equipment. On the other hand, the upper bound is estimated based on the maximum total electricity used where miners use the least energy-efficient items, considering that it is the most profitable in electricity terms. The best-guess estimate is based on the fact that miners would be using a mix of equipment which is profitable at the same time for them.^[10]

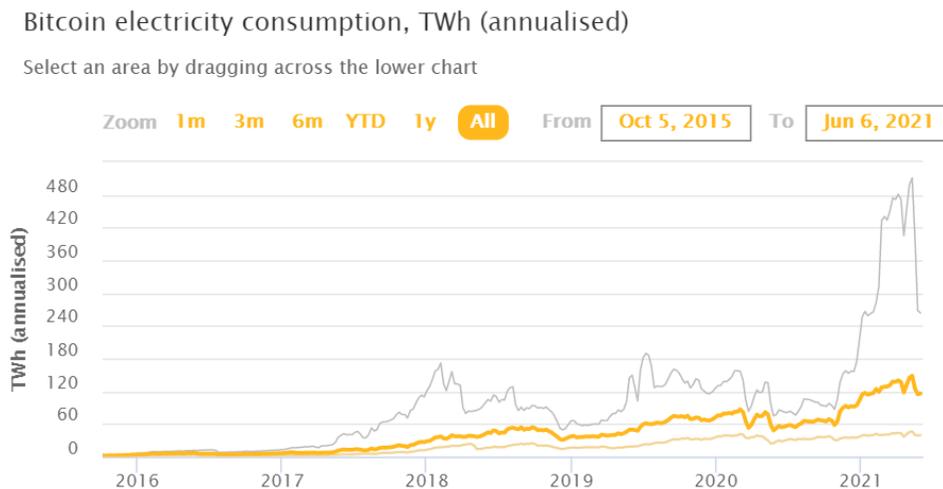


Figure 7.0.1: Annualised Bitcoin electricity consumption (TWh) from 5 October 2015 to 6 June 2021 - CBECI

As seen in Figure 7.0.1, the grey line represents the estimated upper bound, the yellow line represents the estimated lower bound while the orange bolded line represents the best-guess estimate for the annualised Bitcoin electricity consumption in TWh. As of 6 June 2021, the best-guess estimate is 116.24 TWh, the upper bound estimate is 264.15 TWh and the lower bound estimate is 39.42 TWh. There is an increasing trend in the electricity consumption as shown which is worrying, especially when there is a clear intention of miners who will use the cheapest available electricity for profitability reasons. They would carry out their activities in locations which depend primarily on coal, leading to a huge carbon footprint.

The estimates made above are based on the assumptions which are:

1. Global electricity price is constant and equal to 0.05 USD/kWh.
2. When there is no profitable mining equipment for a certain time period, the model uses the last known equipment which is profitable.
3. In estimating the lower bound, miners always use the most energy-efficient equipment available, and all mining facilities have a Power Usage Effectiveness (PUE) of 1.01.
4. In obtaining the upper bound estimate, all miners are assumed to use the least energy-efficient equipment, as long as it is a profitable choice and mining locations have a PUE of 1.20.
5. The best estimate is obtained by making the assumption that miners use a mix of profitable (in electricity terms) equipment equally weighted and that mining places have a PUE of 1.10.

With these assumptions come limitations to the model used above. Some limitations discussed include cost estimations. This model assumes that global electricity price is fixed which is a very big assumption since costs can differ a lot based on different regions due to the varying sources and factors. Furthermore, costs involved in maintenance of mining equipment are not factored into the degree of profitability of the equipment used, which is used to determine the estimates for the upper, lower bounds and the best estimate.

In summary^[42], to put into context these values obtained from the index, we will be comparing it in different situations. The electricity usage of BTC accounts for 0.46% of total electricity production and 0.53% of total electricity consumption. Out of the total electricity produced by renewable sources, the electricity consumed by BTC accounts for 2.78% of energy produced by Hydro, 20% of energy produced by biofuels and waste, 8.33% of energy produced by solar, wind and other sources.^[75] Annually, BTC uses more electricity than countries like Netherlands (110.68 TWh) and Philippines (93.35 TWh). If the BTC network was a country, it would be ranked number 33 as a country which consumes the most electricity.

Digiconomist Bitcoin & Ethereum Energy Consumption Index

Other sources state that as of November 2018, BTC consumes electricity of 45.8 TWh annually. CBECI estimates BTC electricity consumption to be 43.7 TWh, an average obtained from the best estimate for the month November 2018. [22] Digiconomist estimates BTC electricity consumption to be 67.3 TWh, with a minimum electrical energy consumption of 52.4 TWh. All estimates relate to November 2018 for consistency. Furthermore, they also found out that the energy used by the BTC network could power 39.1% of the total energy consumed by United Kingdom. As of June 2021, the BTC network is estimated to consume 102.04 TWh of electricity annually (CBECI) while Digiconomist estimates it to be 127.55 TWh, which is almost similar to power consumed by the United Arab Emirates. Moreover, according to Figure 8.0.2, there is an increasing trend in the energy consumed by the BTC network annually.

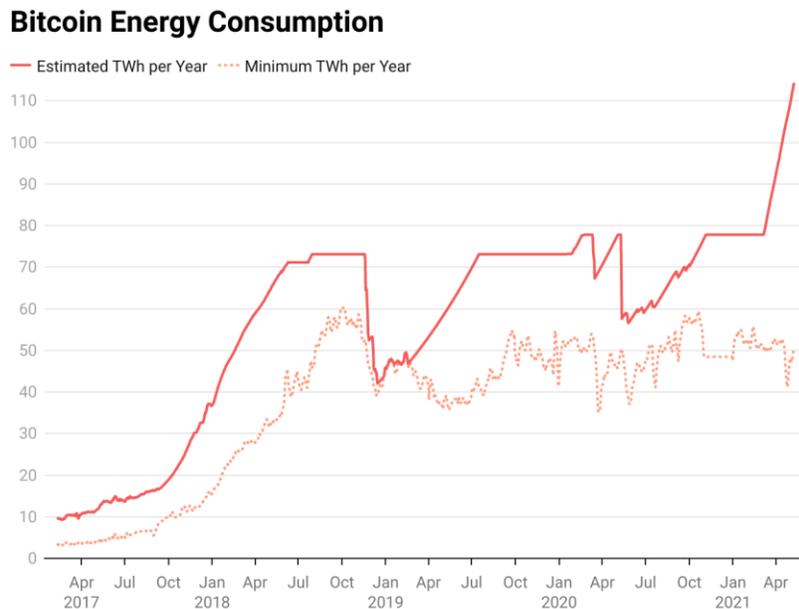


Figure 8.0.2: Annual Bitcoin Energy Consumption from 2017 to June 2021 (TWh) - Digiconomist

The estimates above relate to the electricity consumption by BTC. For another popular cryptocurrency, known as Ethereum (ETH), sources such as Digiconomist estimate the annual electricity consumption to be 15.4 TWh, with a minimum of 6.7 TWh for data spanning over the month November 2018. Referring to the graph on Figure 8.0.2, Digiconomist estimates a steep increase in the energy consumed by Ethereum from 2020 to 2021. Furthermore, as of June 2021,

Digiconomist estimates a figure of 50.28 TWh to be the electrical energy consumed by the ETH network, similar to the energy consumed by Peru. One ETH transaction contributes to an electrical energy usage of 108.63 kWh.

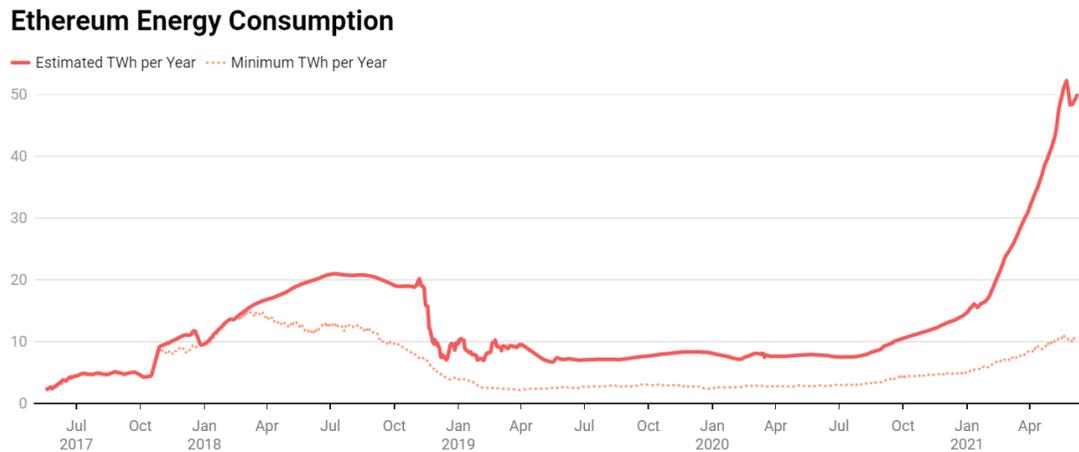


Figure 8.0.3: Annual Ethereum Electrical Energy Consumption (TWh) from July 2017 to June 2021 - Digiconomist. [23]

The impact on the environment due to the mining of these cryptocurrency coins depends greatly on the sources used to produce the electricity consumed by mining facilities. Many researchers have published estimates and guesses on the mix of types of energy sources used by these mining facilities which include coal, hydroelectricity and natural gas. This mix depends on the locations of the mining facilities and the available energy sources, taking into account the profitability of the mining of these coins. [20] A survey in 2020 shows that miners who use the Proof-of-Work system use 76% of renewable energy but the total renewable energy consumption only accounts for 39% of the total energy used. In other words, 61% of total energy consumption is sourced from non-renewables such as coal. This is due to seasonal volatility in hydroelectric energy which will be affected negatively with the threat of climate change. The survey also revealed that out of all the mining facilities, 62% used hydroelectric power, 17% used wind energy, 15% used solar energy and 8% used geothermal power.

Most studies first start with identifying the locations of mining facilities around the world, to accurately calculate the carbon emissions and carbon footprint by taking into consideration the different energy sources in different locations. A survey (Global Cryptocurrency Benchmarking

Study [39]) done by Garrick Hileman and Michel Rauchs in 2017 identified the power consumption and carbon intensity as stated in Table 8.0.1. Under this study by Hileman and Rauchs in 2017, the weighted average carbon intensity is 475 gCO₂eq/kWh.

According to Digiconomist [22], annually, BTC has a carbon footprint of 60.16 MtCO₂ (similar to carbon footprint of Morocco) with an amount of 9.55 kT of electronic waste (similar to waste produced by Luxembourg). For one BTC transaction, the carbon footprint sums up to 745.95 kgCO₂ with an amount of 118.40 g of electronic waste. These estimates are made on the hypothesis that miner income and costs are related, looking at the energy consumption from an economical perspective. Looking at Figure 8.0.4, as the months go on, the BTC network hashrate was found to originate or validated in areas which are using less greener energy sources as a proportionate to the total BTC network hashrate.

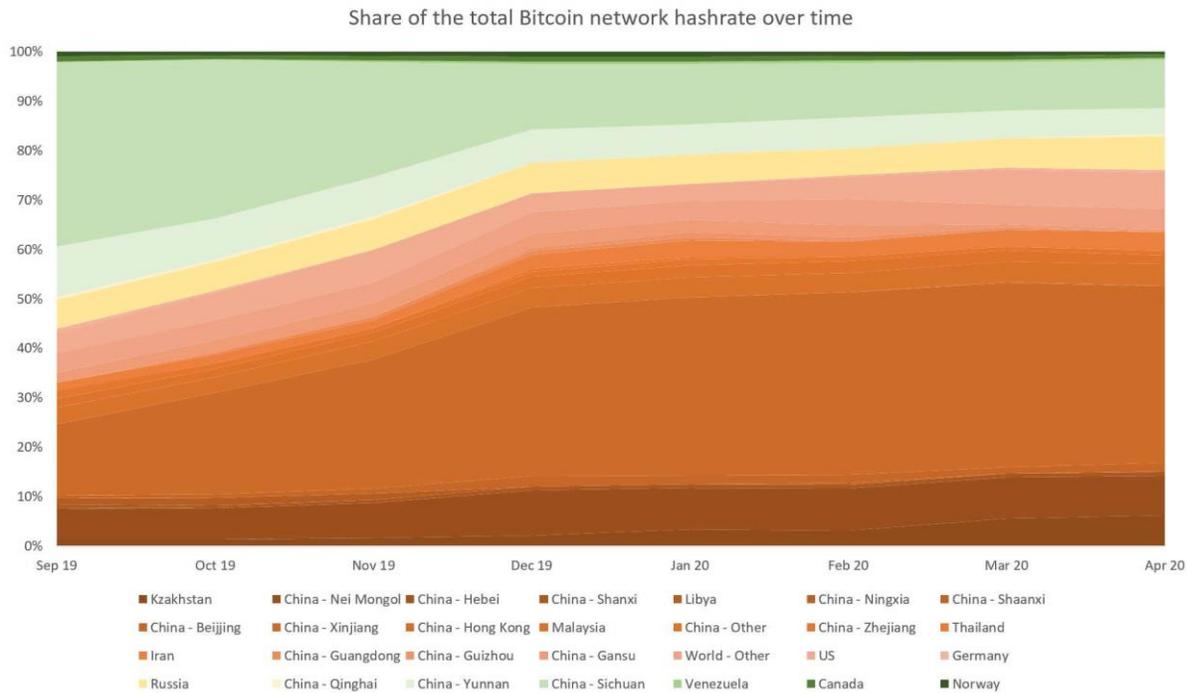


Figure 8.0.4: Share of total Bitcoin network hashrate from 2019 to 2020 (mining locations arranged according to how ‘green’ the energy used; Norway consumes energy from the ‘greenest’ sources) - Digiconomist [22]

Using the above figures, we can make comparisons to existing transactional mediums such as a non-cash payment system, VISA. According to their sustainability report ^[75], there were 138.3 billion transactions in 2019 and they have consumed 740000 GJ for all operations. For each VISA transaction, they only have a carbon footprint of 0.45 gCO₂eq. This means, for one BTC transaction, the energy consumed can be used to make 1056600 VISA transactions and the carbon footprint is equivalent to the 1659088 VISA transactions. Moreover, gold mining has a carbon footprint of 14 tonnes CO₂ while BTC mining has a carbon footprint of 179 tonnes CO₂, when comparing for an equal value (1 BTC).

Location	Power consumption (megawatts)	% of surveyed facilities	Carbon intensity (gCO₂eq/kWh)
China	111	47.60	711
Georgia	60	25.80	231
United States	27	11.60	489
Canada	18	7.70	158
Sweden	10	4.30	13
Iceland	5	2.10	0
Estonia	2	0.90	793
Total/ Weighted Average	223	100.00	475

Table 8.0.1: Power consumption (MW) and the carbon intensity (gCO₂eq/kWh) for different mining facilities in different locations.

In another study^[14] by Stoll et al in 2019, which obtained their estimates by considering the IP addresses of miners found a weighted average carbon intensity of 480-500 gCO₂eq/kWh. Also, they obtained an estimate of the power consumption of 345 MW at the end of 2016, 1637 MW for 2017 and 5232 MW in November 2018. Furthermore, the study also makes an estimate on the carbon footprint of BTC. They do so by basing their guess on average emission factors for carbon intensity of the power generation source mix and marginal emission factors for the carbon intensity for incremental load change. They found that Bitcoin emits carbon at an annual amount ranging from 22.0 to 22.9 MtCO₂ globally. If BTC was a country, the amount from before would be in

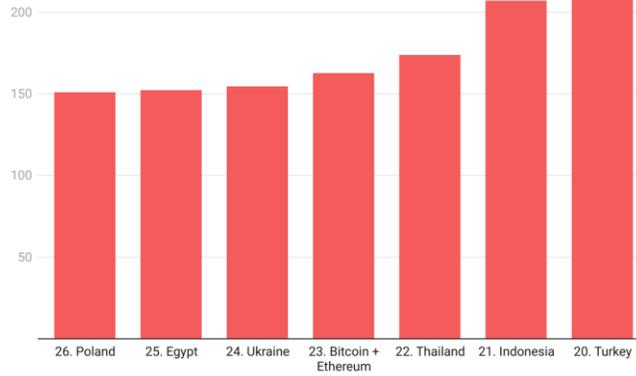
between Jordan and Sri Lanka. In China, according to the statistics^[9] of BTC.com, 58% mining facilities are located in areas that use more hydro energy while the remaining 42% are located in areas which use more coal. For context, if the estimates were based on the assumption that mining consumes energy entirely from fossil fuels, the annual carbon emitted by BTC comes to a figure of 51.0 MtCO₂.

According to a study by Hass McCook^[38], the BTC network contributed to 0.12% of the global CO₂ emissions, produces 89,250 tonnes of PO₄ equivalents and produces 312,000 tonnes of SO₂ equivalents. Another study by Goodkind, Jones and Berrens states that for one single BTC coin, the climate damages have a monetary value of USD 1849 in USA and USD 2135 in China for the year 2018.

Next, we look at the carbon footprints left by another popular cryptocurrency, ETH. According to Digiconomist's Ethereum Energy Consumption Index, the whole ETH network has a carbon footprint of 23.88 Mt CO₂ which is comparable to Sri Lanka's carbon footprint. One single ETH transaction contributes to a carbon footprint of 51.6 kgCO₂. This carbon footprint is equal to watching YouTube for 8600 hours or 114,363 VISA transactions.

Looking at Figure 8.0.5, if the whole BTC and ETH network was a country, it would rank at 23 in terms of energy consumption annually in TWh.

**Energy Consumption by Country inc. Bitcoin + Ethereum
(Annualized TWh)**

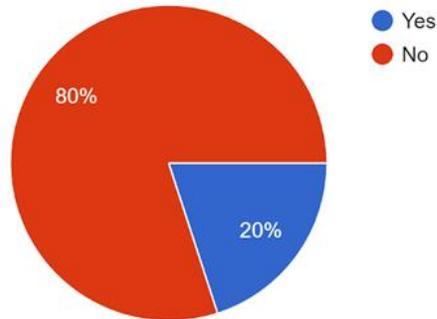


**Figure 8.0.5: Annual Energy Consumption (TWh) by BTC and ETH networks
(Ranked at 23) compared to other countries - Digiconomist^[23]**

8.0 Discussion

8.1 Perceptions on Crypto

Have you traded in cryptocurrency before?
 110 responses



Rate your knowledge regarding blockchain technology.
 110 responses

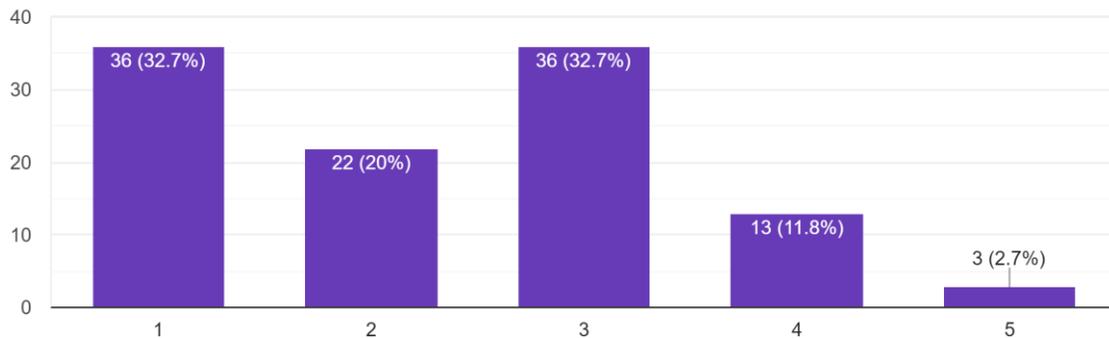


Figure 9.1.1: Respondents rate their knowledge regarding blockchain technology

A total of 110 responses are collected from a survey on cryptocurrency trading and its impact on the environment. The respondents are mainly Malaysian students who are between 18 and 29 years old. From Figure 9.1.1, we observed that 80% of them do not have cryptocurrency trading experience and approximately 52.7% of them have relatively little knowledge about the blockchain technology.

The sample size may not be sufficient in order to come out with a significant insight, but the survey result indicates there is a lack of awareness or knowledge regarding cryptocurrency trading and thus also its impact on the environment among the Malaysian students.

8.1.1 Why are miners still mining even if it's bad for the environment?

A. Bitcoin Reward System

Bitcoin offers a disrupting technology in the blockchain. The currency itself is decentralised and allows transactions to happen globally without government restrictions and delays. With the blockchain, the network is served by the entire global community of miners. Each contributes to confirming the legitimacy of each transaction. Miners are awarded for their services with a block as an incentive to contribute. As a result, miners of Bitcoin see the value in the decentralization of cryptocurrency (Corporate Finance Institute, 2021)^[18].

Besides, Bitcoin mining is attractive due to its potential as an investment. Believers of Bitcoin predict the price can shoot far past \$100,000 per coin. The price of Bitcoin is important in mining because miners receive a certain amount of Bitcoin when they validate the transaction, and the miner may want those Bitcoins to be more worthy in terms of fiat money.

B. Initial Investment Cost

The miners aim to earn rewards through validating the transactions by solving the complex mathematical problems with the highest speed among all the competing devices. To achieve this aim, miners need to own the latest hardware to compete with the increasing requirements for successful mining. However, competitive mining computers or software would be costly and can become obsolete in a matter of years. For instance, the ASIC mining rigs cost over \$1500 per computer^[18].

In order to tackle the issue of rising mining difficulty, the idea of Bitcoin mining pools rose. A group of miners pool their computing power together to mine for Bitcoin collectively and allocate

their mining rewards according to the proportion of computing power contributed. A membership fee may be charged on each miner who wishes to join the mining pool.

All these initial investment costs incurred would act as a barrier to exit the cryptocurrency mining activities. Miners will need to at least earn a return which could break even so that it will not be a loss in their investment. Therefore, they might not stop mining even if they realise that it would bring a negative impact to the environment as they could not afford the loss.

C. Lack of environmental awareness

At the beginning stages of Bitcoin in the early 2000s, mining was able to be carried out by using only personal computers. Then, its difficulty increases as the popularity of mining increases. More computer processing power was required to accommodate the growing level of difficulty. Miners may not be aware that this evolution of mining has led to increased consumption of energy and would bring negative impacts to the environment.

8.1.2 The difference in priorities of different population

A. Corporations

The main objective of a corporation is to maximise its profit. They strive to increase their sales revenue as well as reducing their operating cost. In a business' perspective, cryptocurrency provides several advantages over the traditional form of payments. It is a secure payment method and has a transaction fee lower than credit card payment. When cryptocurrency is not exchanged, it eliminates the need for bank charges such as service charge and charges on current account statements. By removing the barriers and restrictions to trade, cryptocurrency makes international trade more accessible. Ultimately, this results in easier to accept payments in different currencies for business purposes. By using cryptocurrency, the corporation could also reduce fraud as a payment made with cryptocurrency cannot be reversed after the fact. As a comparison, credit card payment can actually be reversed using chargebacks, which is a feature often exploited by fraudsters.

B. Traders

Traders of cryptocurrency would aim for immediate profit. Cryptocurrency market has significant volatility due to the huge amounts of short-term speculative interest. As a result, a range of opportunities are provided by rapid intraday price movements, to traders to go long and short in order to turn a larger profit. Besides, the cryptocurrency market is usually available to trade 24 hours a day, seven days a week which provides convenience as the traders will be able to perform transactions all over the world whenever they discover an opportunity to gain profit.

Both corporations and traders would emphasize the profit gained by using cryptocurrency rather than other assets. Therefore, most of them might actually neglect the negative impacts of blockchain technology behind the cryptocurrency towards the environment as it may conflict with their priority, profitability. They might be aware of the huge energy usage by the operation of the cryptocurrency but still could not let go of the opportunity to exploit the advantage of using it.

C. Miners

The miners aim to earn rewards through validating the transactions by solving the complex mathematical problems with the highest speed among all the competing devices. To achieve this aim, most of them actually build or buy the mining machines which use up a lot of energy to increase the computing speed in order to increase their chance of getting rewards through the mining process. In their perspective, the cost and energy spent in operating the mining machine is the input for getting an output of cryptocurrency rewards and thus they are willing to pay for that in terms of money invested, time spent as well as its environmental effect.

Compromise Between Profit, Economy and Environment on Cryptocurrency Usage

In order to maximise profits, cryptocurrency miners seek low-cost electricity and permissive policy locations, which would create environmental hazards and impact local consumers without producing any benefit for communities. They are earning a profit at the expense of our mother nature.

Cryptocurrency miners produce currency through energy intensive mining processes, which require extensive computing resources. According to the Cambridge Bitcoin Electricity Consumption Index (CBECI), Bitcoin uses 113 TWh of energy per year. Using the current global average grid figure of about 0.6 tons of carbon dioxide per kWh of electricity produced, Bitcoin mining emits 70 Mt of carbon dioxide annually (Hass McCook, 2021)^[54]. These may contribute to the greenhouse effect which leads to global warming.

If you were trading in cryptoassets, would you consider trading in more sustainable types of cryptoassets even though they are less profitable?

110 responses

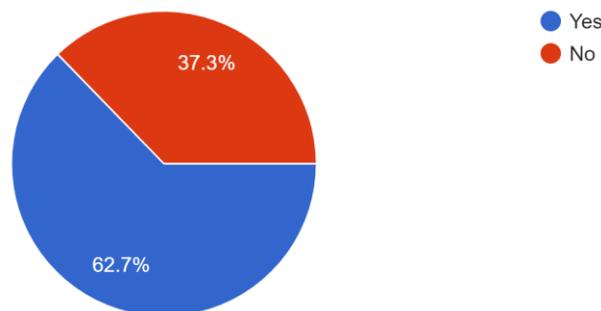


Figure 8.1.2: Respondents rate their willingness of using more sustainable types of crypto assets

However, we are able to reduce the environmental impacts by using a more sustainable type of cryptocurrency such as non-blockchains cryptocurrency. Figure 8.1.2 shows the result of a survey regarding the willingness of using more sustainable types of cryptocurrencies which will compromise their profit for the sake of the environment. Around 62.7% of the respondents vote that they would consider the less profitable but more sustainable types of crypto assets.

8.2 Future Expectations

It is no surprise that cryptocurrencies have grown larger and larger in popularity due to its accelerating value. According to Investopedia^[44], Bitcoin's price went from USD 1 in April 2011 to USD 32 in June 2011. As of 23 June 2021, 1 Bitcoin is equal to USD 34,231.50, proving its continuous increase in demand and popularity. Another popular cryptocurrency, known as Ethereum, went from USD 1.30^[15] in 2015 to USD 2,041.56 on 23 June 2021. Public figures^[7] such as Chamath Palihapitiya (Founder of Social Capital and Co-Owner of Golden State Warriors) say that 1 BTC will reach USD 1,000,000 by 2037 while Wences Casares (CEO of Xapo, Bitcoin wallet startup) predicts that it will reach the USD 1 million earlier by 2027. According to Coin Price Forecast^[16], they predict (prediction as at 24 June 2021) that by 2032, Ethereum will rise to USD 10,553, which is an increase of 416% from its value on 23 June 2021. Furthermore, Bitcoin alone has a market capitalisation of USD 624.58 billion (as a comparison, in the US stock market^[72], this figure can be compared to Tesla's) while Ethereum has a market capitalisation of USD 226.26 billion. Looking at cryptocurrencies as a whole, the total market capitalisation is higher than USD 2 trillion^[66].

8.2.1 Cryptocurrency replacing fiat currency

Many organisations^[28] such as Morgan Creek Capital Management and its analysts predict that fiat exchange would be completely replaced by cryptocurrencies in the coming future. In 2019, Deutsche Bank stated, in their 'Imagine 2030' *magazine*, that fiat exchange might be replaced by the usage of cryptocurrency by 2030. There are many reasons behind this prediction, as governments and organisations globally have been working towards adopting the usage of digital payment systems, going towards a cashless society. Furthermore, as discussed before, the market capitalisation of cryptocurrencies has been rising, proving its strong performance in the market. On top of that, El Salvador^[56] becomes the first country in the world to make Bitcoin as legal tender, which means that businesses there must accept Bitcoin as payment in exchange for their goods and services.

According to Finance Magnates^[28], compared to other payment services such as PayPal, money transfer services, traditional wire transfer, cash, etc., cryptocurrencies as a payment method are much cheaper. Moreover, crypto transactions do not require a third party like a financial institution to validate it due to its decentralised nature. Therefore, there are no transaction fees since there is no intermediary involved which makes sending money globally cheaper than existing methods.

48.2% of the respondents (mostly 18-29 years old) of our survey think that cryptocurrency can replace fiat currency in the future.

Those that agreed with this statement gave reasons such as convenience, the adoption of new technology for the future, popularity of cryptocurrency in the market, decentralised nature of cryptocurrency, efficiency, low transaction costs, the accelerating growth rate of cryptocurrency, goes in line with government policies such as the adoption of a cashless society, sustainability and privacy.

Those that think that cryptocurrency will never completely replace fiat currency in the future also gave supporting reasons to their belief. Reasons include volatility, stability, the need for regulation, environmental issues, lack of knowledge, employment issues, a high level of freedom, differences in technological advancements for different countries, the overreliance on physical money and security.

If cryptocurrency were to replace fiat currency, this would be a huge disadvantage to developing countries and third world countries who are not equipped with the technology compared to developed countries. Moreover, unlike fiat currency, where countries adopt the fixed or mixed rate for their currency to avoid volatility in the exchange rate in order to keep their economy stable, cryptocurrency is totally decentralised.

On top of that, in order for cryptocurrency to replace fiat currency, it needs to fulfill the characteristics of money, one of them being a medium of exchange. Therefore, society needs to be confident in the value of cryptocurrency for it to be used as an exchange for goods and services.^[1] There is a need for more people to accept the use of cryptocurrencies among merchants before its

implementation as a replacement to fiat currency. However, cryptocurrency cannot be regulated by the government and there is no upper limit to the number of cryptocurrencies circulating in the market, since it entirely depends on the demand and supply forces of the market.

8.2.2 Impact on the environment

There have been several environmental groups going against cryptocurrencies such as Bitcoin due to its large usage of energy, leading to large amounts of carbon emissions which are comparable to countries. Furthermore, due to its negative effects on the climate, Tesla has suspended the usage of Bitcoin as one of their payment methods. Several other cryptocurrencies such as SolarCoin, BitGreen and Cardano have evolved to using more sustainable methods involving the verification of transactions on the blockchain. SolarCoin is created on the basis of solar technology, where 1 SolarCoin is generated for every Megawatt hour used from solar energy. BitGreen uses the Proof-of-Stake mechanism and can be earned by performing eco-friendly activities such as carpooling and volunteering.^[53] Cardano is a peer-reviewed cryptocurrency which uses the Proof-of-Stake algorithm, whereby in one second, Cardano can verify 1000 transactions as compared to Bitcoin which can only verify 7 transactions. Greener alternatives to Bitcoin will be discussed in further detail in Section 8.3.

Ethereum also has plans to move towards using the Proof-of-Stake mechanism in 2 years, replacing the energy exhausting mechanism, Proof-of-Work. As of 26 May 2021^[65], the top 10 most popular cryptocurrencies are Bitcoin, Ethereum, XRP, Tether, Cardano, Stellar, Chainlink, Uniswap, Polkadot and USD Coin. Out of these 10 cryptocurrencies, XRP, Cardano, Stellar, Chainlink and Polkadot are the more sustainable ones, which is only half of the list. However, a lot of new cryptocurrencies are starting up by using more sustainable mechanisms which do not use as much energy as previously discussed cryptocurrencies like Bitcoin or Ethereum.

Growth of cryptocurrency compared to other traded assets

Compared to other existing assets in the market such as stocks, foreign currency, bonds and physical assets such as gold and real estate, the market for cryptocurrency has shown a huge growth

in a small period of time. As of January 2021^[51], there are more than 4000 types of cryptocurrencies currently available in the market with Bitcoin being the first cryptocurrency in the world and was created back in 2009. On the other hand^[46], stocks were first offered back in 1602. According to our survey, 92.7% out of 110 respondents think that cryptocurrency will continue to become popular in the future.

Furthermore, referring to Figure 8.2.1, cryptocurrency accounts for 12.5% for the investment preferences, the 4th largest out of all. Stocks and equities are highest at 25.1% followed by physical assets at 20.3%, fixed deposit at 19.6%, cryptocurrency at 12.5%, bonds at 11.8% and lastly FOREX at 9.2%.

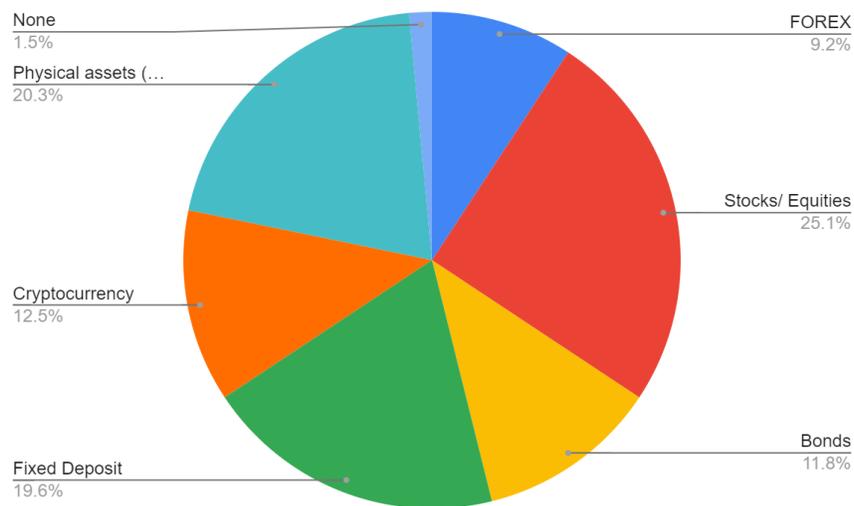


Figure 8.2.1: Investment preferences based on our survey done among people aged between 18-29 years old.

According to data from glassnode^[36], Blockchain.com users increased by 70%, from 45 million users in January 2020 to 63.5 million users in January 2021. Based on Figure 8.2.1, the number of active addresses has significantly increased, and it is continuing to grow. In January 2020, there were 712,208 addresses, which rose to 1,209,828 in January 2021.

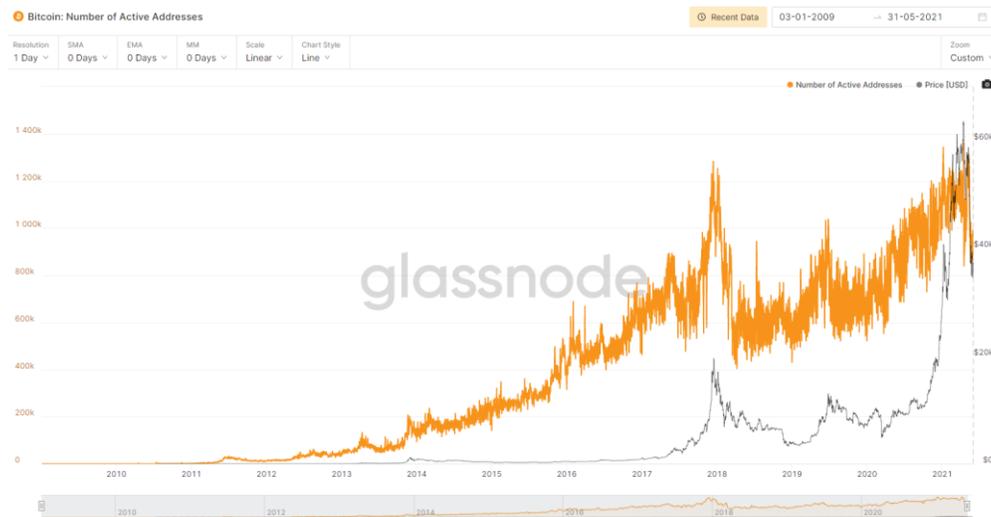


Figure 8.2.3: Number of daily active addresses for Bitcoin users from 2009 to May 2021 (orange line) - Glassnode [36]

8.2.3 Risk of Cryptocurrency

Other than the high profitability of cryptocurrency due to its growth, the majority are interested in this asset because of its decentralised nature, where transactions are verified by the peer-to-peer system. The fact that transactions are anonymous and transparent since it is traceable and permanently stored on the blockchain makes cryptocurrency an attractive investment. Since they are not controlled by any financial institutions or any government bodies, its value cannot be manipulated to make it stable, which is why the value of cryptocurrencies is so volatile. In this case, cryptocurrencies are said to be superior to fiat currencies. However, this is not always accurate because if mining locations are concentrated in a particular area, they would theoretically be able to control or get ahold of the data available.

Another point to take note is due to anonymity and cryptocurrencies' decentralised nature, fraud can be committed much more easily. It makes it easier for people to conduct illegal activities such as money laundering, smuggling and tax evasion. On top of that, the New York Department of Financial Services (DFS) [24] has reached out to 20 companies which deal with Bitcoin to ensure its legitimacy. Some companies like Mt. Gox [44] have also been accused of not complying with regulations set by the U.S financial institutions, which led to their funds being confiscated.

Cryptocurrencies are also said to have minimal transactional costs, which make it suitable for payments to be made internationally. Libra, a cryptocurrency, was introduced by Facebook for this particular reason. In a discussion with Professor Grundfest of Stanford University,^[70] he thinks that this approach is flawed, as this would affect traditional banking systems worldwide.

Conclusion

There is no doubt that cryptocurrencies have been gaining in popularity over the past few years. Many organisations have been making predictions on how cryptocurrency will flourish in the future, each contributing their expectations for cryptocurrency, particularly on the market. This includes cryptocurrency replacing traditional physical money, known as fiat exchange. Many have agreed to this possibility, giving justifications such as lower transaction costs and its popularity in the market. However, there are contrasting arguments such as the lack of regulation due to its decentralised nature and environmental issues. Furthermore, with more cryptocurrencies moving towards adopting more sustainable mechanisms to solve the existing environmental problems due to the energy extensive system in maintaining the blockchain.

8.3 Alternatives

News: On 13th May 2021, Elon Musk, the owner of companies Tesla and SpaceX, tweeted “We (Tesla team) are concerned about rapidly increasing use of fossil fuels for Bitcoin mining and transactions, especially coal, which has the worst emission of any fuel.”. Musk showing concern to the environment, officially declared that purchases of any Tesla products using Bitcoins are suspended. This news then led the market to crash in just a matter of days, from highs of 60,000 dollars to lows of 30,000 dollars. Elon also stated in the same tweet, “We are also looking at other cryptocurrencies that use <1% of Bitcoin’s energy/transaction.”. In other words, Elon is potentially considering other cryptocurrencies that are more environmentally friendly. After all the attention given to the environmental factors of Bitcoin, many investors have now started to shift to alternatives that are more **sustainable**.

8.3.1 Ripple (XRP)

Most often the names Ripple and XRP are used interchangeably, but in fact, they are two very different things. Ripple, also known as Ripple Labs, is a company founded in 2012 with its initial purpose to solve the problems of payment settlements exchange across international borders and to revolutionize global payments. Meanwhile XRP is a tool, that is the cryptocurrency token to help Ripple’s business objective. Similar to Bitcoin, XRP runs under a decentralized ledger system, but contrastingly, XRP does not use the blockchain technology, but rather a system called the consensus protocol. The consensus protocol is a peer-to-peer system that uses a voting system, where users in the ledger can vote on transactions to prove its authenticity, and a majority of 80% validation is needed before a transaction is approved. With that, the concept of proof-of-work and mining does not exist for XRP. Hence, this has brought in two significant benefits. Firstly, XRP is highly scalable with 1500 TPS (transaction per second), compared to Bitcoin with only 4.5 TPS. Other than that, the validation process is more energy efficient and eco-friendly. According to a research company, TRG Datacenter (2021)^[74], XRP is the least energy intensive among the top seven cryptocurrencies (Dogecoin, Cardano, Binance Coin, Tether, Ethereum, Bitcoin). XRP consumes 0.0079 KWh of power per transaction, whereas Bitcoin consumes 707 KWh per

ransaction. Due to its low energy consumption, XRP can be a green alternative for crypto investors. In fact, Ripple pledged to reach net-zero carbon emission by 2030.^[69]

8.3.2 IOTA (MIOTA)

IOTA was first released in 2015, by the non-profit IOTA foundation in Germany. The company focuses on be the backbone for the **internet of things (IoT)**, hoping to connect devices and machines around the world via the internet to forge a truly machine-to-machine economy. In a society where machines are able to communicate and transact with each other, a transactional pillar is needed, hence MIOTA was created.

MIOTA is a cryptocurrency token that is transacted in Tangle, a distributed ledger that is otherwise known as the Directed Acyclic Graph (DAG). The meaning of DAG: Directed – only points to one direction, Acyclic – Non-circular, Graph – distributed ledger, is what preventing the problem of double spending. When a transaction is updated to the IOTA’s ledger, the new transaction helps to verify two previous transactions before it, and this process repeats. With every new transaction, two other transactions are validated; hence, this makes the Tangle system highly scalable, and without the need of MIOTA miners. Unlike Bitcoin and other blockchain-based cryptocurrencies, the network slows down when there is an excessive number of transactions; in contrast, the Tangle network speeds up with every entry of new transaction due to the self-managed network of transactions. Ryan,J.(2019)^[45]. Other than that, as mentioned that without any miners, the computing power needed to update the IOTA ledger is significantly lower and lightweight, with any device from a simple smartphone to a laptop can achieve, also making IOTA eco-friendly. Ultimately, that is what IOTA is trying a achieve, to interconnect the work while being sustainable.

8.3.3 Chia (XCH)

Chia, incorporated in August 2017, but was only recently introduced for “farming” in February 2021. The new cryptocurrency created by Bram Cohen, also the founder of the BitTorrent protocol, aims to solve the bigger problem that Bitcoin could not. As mentioned by Elon Musk, Bitcoin is causing environmental concerns. Thus, Chia has a focus on the environmental implications of the energy-intensive and highly specialized “mining”, with the key difference being the “proof of

space and time” model^[3]. Unlike the “proof of work”, the system relies on excess storage power on individuals’ computer, rather than the CPU’s computing power, which causes a drastic drop in energy consumption with every transaction. In Chia, the mining process is called “farming”. To elaborate on what is the “proof of space and time” model, the process allows users to validate transactions by showing that physical storing data has been kept over a certain period of time^[17]. With that, anyone and everyone with excess storage space on their computer or hard drives can be a “farmer” in exchange for Chia coins; meanwhile also eliminating the problem of “**pool mining**” that monopolises the mining process, and ultimately reduces the number of mining farms. As open trading of Chia has been allowed on 3rd May 2021, Chia has shown an initial drop in value but has been steadily holding at 287.69 dollars at the time of this report writing. With that, it is uncertain that Chia will rise or fall in the future, but given the current state of low volatility, it is looking promising as the new “green cryptocurrency” for the revolutionary future.

8.3.4 Cardano (ADA)

Founded in 2015 and launched in 2017, Cardano is founded by the man who co-founded the Ethereum blockchain, Charles Hoskinson. The vision of Hoskinson after his resignation from Ethereum is to provide a more balanced and sustainable ecosystem^[61]. With that, Cardano aims to solve 2 major problems of cryptocurrencies: Scalability and Sustainability. Firstly, Cardano and its native token ADA uses the Ouroboros’ proof-of-stake system on the Cardano blockchain. Instead of allowing miners in the network to compete with each other to update the blockchain, the proof-of-stake system uses an election process to randomly select a validator to validate the blockchain each time a new transaction occurs. Before becoming a validator, users must deposit a certain number of tokens into the network as their stake; the greater the stake, the greater the likelihood of being elected, hence the name proof-of-stake. This also solves the problem of security, as when a fraudulent transaction is approved, validators will lose part of the deposited stake, incentivising proper validation. In addition, unlike the proof-of-work system, expensive mining equipments are unnecessary to earn tokens, thus the proof-of-stake system encourages more people to set up validation nodes, increasing the security and decentralization. With that the proof-of-stake system simultaneously increased the scalability by avoiding mining competition and electing

specified validators, and increased sustainability by utilizing less energy and computing resources to validate transactions.

8.3.5 Stellar (XLM)

According to Investopedia^[61], “Stellar is an open-source payment technology that shares several similarities with Ripple. Its founder, Jed McCaleb, also co-founded Ripple.” Much like Ripple, Stellar aims to connect the world’s financial infrastructure, including banks, businesses, and individuals, in hopes to reduce the time and cost for cross-borders transactions. With that, Stellar created a cryptocurrency, the Lumen, that serves as a universal translator between assets. For example, the current method of cross-border transfers is difficult as it requires domestic banks to have connections with foreign banks. Otherwise, international transfers will have to go through intermediaries which are slow, complicated, and expensive. With Lumens, currency transfers and conversions can be done in under five seconds with a small fee of 0.000001% of the total transaction. The fee is small enough the active users do not notice them, but high enough to disincentivise spammers.

Moreover, a unique thing about Stellar is that any assets can be converted into Stellar tokens. For example, US dollars, Euros, and Malaysian Ringgit can all be converted into tokens. Other than that, even company assets like real estate investments, and other cryptocurrencies can be turned into a token as well. Since all Stellar tokens can be traded, transferred, stored, and exchanged like regular Lumens, this makes transacting with Stellar quick, easy, and inexpensive. The proofing system of Stellar is called the Stellar consensus protocol, following the Federated Byzantine Agreement (FBA). Similar to Ripple, Stellar uses a voting system to validate transactions, but with the implemented FBA, validators in the network choose other validators which they trust, essentially creating a quorum of trusted validators. Without the need of a centralised authority to select the validator list, it creates an open membership network that is truly decentralised.

8.3.6 Third-Generation Cryptocurrency

As these are the five recommended alternatives for traditional blockchain-based cryptocurrencies to be considered as a greener and more sustainable cryptocurrency, it is unavoidable that the five mentioned cryptocurrencies do share some similarities. All five cryptocurrencies mentioned are referred to as third-generation cryptocurrencies. “What are third-generation cryptocurrencies?”. It is the latest category of cryptocurrencies that emerges with the purpose of better improving the problems we had with the previous two generations of cryptocurrencies.

With the previous two generations of cryptocurrencies represented by Bitcoin and Ethereum respectively. The third generation hopes to improve on the main problems of transaction cost, scalability, and sustainability. As we can tell, all the cryptocurrencies mentioned use unique and specially engineered proofing systems that differ from traditional blockchain validations. With that, these currencies had banished “miners” from the proofing process which cuts down on the electrical resources to validate transactions. Moreover, without the need of miners, unique implementations of protocols like Taggle and Proof-of-space-and-time have increased the transaction speed by a mile compared to Bitcoin and Ethereum. Lastly, given the higher interoperability of the third-generation cryptocurrencies, transaction fees have also reduced significantly. All in all, the mentioned cryptocurrencies have ultimately become the recommended alternative as they are purposely designed to replace the older generations. With that, the new generation is more practical in the sense of money currencies that will make an impact in the future, but not just a vessel for investing.

9.0 Conclusion

Based on what we have discussed above, the carbon footprint becomes harder to ignore as cryptocurrency such as bitcoin has become mainstream progressively. The sustainability of cryptocurrency is still in a feverish debate among people due to its market volatility and environmental impact. It is undeniable that cryptocurrency has gained its popularity among a large number of the investors but an improvement in technology is a must to support the viability of cryptocurrency in the long term.

However, a greener cryptocurrency is not easy to be promoted to existing miners as they are in an extremely competitive market in which miners don't have the luxury to care about the environment. There is absolutely no natural incentive in the system to try to make it happen as well. That's the issue that we need to raise, and the government should act against the extensive energy use of these digital currencies by getting the balance right between anti-establishment sentiment of cryptocurrencies and environmental concern. Dr Charis Savvides, a lawyer, academic and blockchain and crypto regulation expert, mentioned that "I believe that the key in changing the situation is to find ways to invest in renewable energy and how we can transform renewable energy into a more competitive way of getting energy and definitely a lot cheaper".

That's absolutely right! To make a meaningful impact, the industry needs to come up with a standard that's open and transparent to measure the use of renewables and make renewable energy accessible and cheap for miners. Furthermore, not all cryptocurrencies are as energy intensive as bitcoin. The question we should be asking ourselves is how to limit the ecological damage that they might cause. As discussed, proof-of-stake is an alternative mechanism to replace proof-of-work, an eco-friendlier peer-to-peer review. Third generation cryptocurrency e.g. IOTA, Stellar, and Carano have been designed to solve the main problems of transaction cost, scalability, and sustainability. These show a good attention towards the alarming status of power consumption as discussed in Section 7.0.

Lastly, a good topic that you may think of is how could a strong pool of miners or investors receive criticism of this technology? It is so volatile that public comments may affect its value, e.g. as impact of Elon Musk's tweet on value of Bitcoin. How can cryptocurrency and blockchain technology lead the way and become a positive as well as transformative force for the energy sector? It is a continuous and long-term project that each and every one of us including the government, experts, investors and public should work together on. Making aspirational commitments to sustainability – one step towards greener cryptocurrency.

10.0 Glossary/ Dictionary

1. **Blocks**^[19]: These are the individual sections that comprise each overall blockchain and each block contains a list of completed transactions.
2. **Hash**: This is the value obtained by passing the previous hash value, the data, and the nonce through the SHA-256 algorithm, it is the digital signature of the block
3. **Hashing power**: Miners are known as hashing powers
4. **Internet of things**^[2]: A system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.
5. **Nodes**: Communication point for each miner which enables the transmission of information from node to node within the distributed network of computers using Peer-to-peer Protocol. The role of a node is to validate a new block, store and save transaction history of a block, and keep updating the latest information among one another.^[67]
6. **Nonces**: Every block is supposed to generate a hash value, and the nonce is the parameter that is used to generate the hash value. It is the key to generate 64-bit hexadecimal numbers which are only used once in changing each hash input to get the desired hash output.
7. **Sustainable**^[55]: In the traditional way of thinking about sustainability, it is associated with long-term thinking of achieving lasting ecological, meanwhile also meeting economic, environmental, and social needs, without compromising for future generations.
8. **Pool mining**^[34]: A mining pool is a joint group of cryptocurrency miners who combine their computational resources over a network to strengthen the probability of finding a block or otherwise successfully mining for cryptocurrency.

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