Economics of Competing Crypto Currencies: Monetary Policy, Miner Reward and Historical Evolution

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Content

Abstract

Since bitcoin came to the world in 2009, numerous cryptocurrencies have been created. Some thrive and enjoy their glorious moment but many more digital coins have faded into darkness. Still, cryptocurrency has been treated as a great technological breakthrough, and many papers have been published either to study and improve the algorithms behind it or to discuss the fundamental flaw in its design.

However, not much research has been conducted from economic point of view on cryptocurrency. This paper aims to cover this gap and to study cryptocurrency using macroeconomic tools.

In this thesis, we reviewed historic evolution of bitcoin, litecoin, dogecoin and reddcoin and reasons have been proposed to justify their market price fluctuation. We outlined the relationship between miners reward and market price, and also studied the monetary policy for each of these four cryptocurrencies. Future coin growth rates and projected total number of coins in circulation are also calculated to help understand the monetary policy for them.

Chapter 1 Introduction

1.1 Cryptocurrency Review

1.1.1 Bitcoin review

Milton Friedman, a Nobel laureate, is an advocate of decentralised financial regulation system[1], and he once famously claimed in the last century that he preferred "abolishing the Federal Reserve and replacing it with a computer"[2].

It seemed that the foundation stone of his "ideal world" had been finally laid in 2009, neither by any central banks nor by any well-known economists. In fact, it still remains mysterious who "made the dream comes true". The foundation stone mentioned earlier is bitcoin, and as the oldest member in cryptocurrency bitcoin made the world stage debut in 2009[3]. It was tagged as the worlds "first decentralised digital currency" by many media and academics.[1]

Bitcoins were only circulated within the enthusiasts' community in the early days. But on 18th May 2010, user Laszlo posted that he would like to "pay 10,000 bitcoins for a couple of pizzas" on bitcointalk.org[9]. Later evidence suggested that he successfully bought pizza with bitcoins. This is the first recorded real-world transaction and it is the first time for bitcoin to fulfil its function as medium of exchange like conventional money. Bitcoin price experienced a slow but steady growth in 2012, but since early 2013, bitcoin saw a dramatically rise in its price against US dollar, and the rally reached its peak on 29 Nov 2013 at $1120.40 per bitcoin.

Since Cypriot Financial Crisis in 2013, the value of bitcoin has soared and it reached all-time high on 29th (Figure 1.1). The Cyprus crisis may not be the sole trigger of this, but it acted like a detonate device that led to a spike in distrust of the government-backed currency. On 25th March 2013, a €10 billion international bailout deal was struck to save Cyprus from a disastrous national bankruptcy, and bitcoin price was increased radically since then. On 10th Apr bitcoin hit $266 before plunging to $105, but the virtual currency was eventually bouncing back to $130 on that day. The volatility did not put off traders and speculators, as the bitcoin price still experienced a tenfold increase since the beginning of the year.

Figure 1.1 Bitcoin Price Between Dec 2012 And Dec 2013[*]
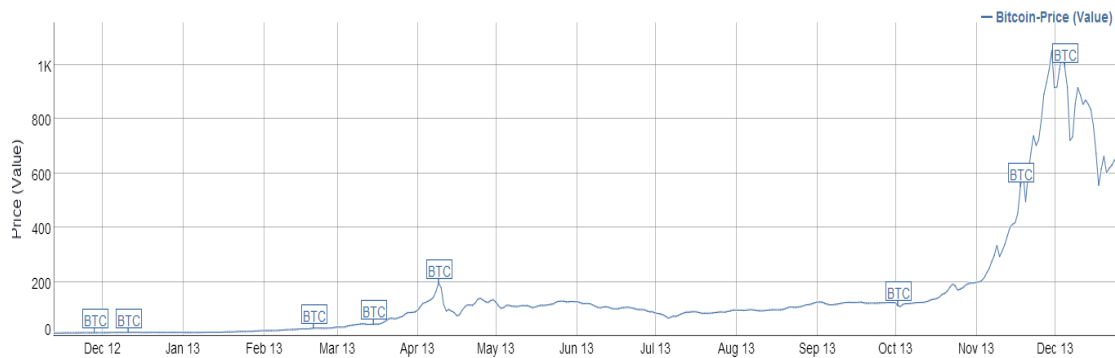
Although the value of bitcoin fell from May 2013 due to its relation with crime activities and some attacks on small exchanges, the price recovered and growing gradually after July 2013 and a sharp increase was observed since Oct 2013. Demands from China are thought being the main driving force behind this spike. News about bitcoin market was on China's State-run news agency CCTV. Baidu, China's largest search engine, announced plans to accept bitcoin as payment for some services. These helped bitcoin gain popularity in China and also fuelled optimistic feeling about virtual currency's potential growth. In United States, US government agency described bitcoin as a legal means of exchange at a Senate committee hearing in Late November 2013. FBI also recognised that the virtual currency offered legitimated financial services. Although these are not an official seal of approval, they certainly led some to believe that bitcoin will gain more mainstream acceptance in the future.

2014 has not been a good year for Bitcoin so far. Once dubbed as "the future of money", bitcoin has suffered several serious blows recently from bitcoin exchange bankruptcy[5, 6], bitcoin bank theft[7] to uncertainty of future China policy regarding the bitcoin trading[8].

Mt. Gox was the world second-largest japan-based bitcoin exchange when it filed for bankruptcy protection in Tokyo on 28th February 2014. By the end of 2013, it was handling nearly 70% of all bitcoin trading. Although it has suffered several attacks, glitches and government investigations throughout its brief life, Mr. Gox was still seen as an icon in bitcoin community. It has provided a central platform for bitcoin trading and played an important role in the continuation of bitcoin development. Market quickly reacted to the news of Mt Gox bankruptcy. Bitcoin's value was already battered due to earlier rumours about Mt Gox, and the price fell 34% to $421.27 from $564.47 on the day (Figure 1.2).

Investors feared Mt Gox might be another Lehman Brothers, and its bankruptcy could start a great cryptocurrency crisis, like 2008 financial crisis.

Figure 1.2 Market Reactions to Mt Gox Bankruptcy

* Resource: http://www.coindesk.com/price/

Surprisingly, markets recovered quickly from this chaotic event and the price gradually increased to $663.6 on 4th March. It seemed that bold traders saw it as an opportunity to expand their portfolio. Optimists from bitcoin community believe the fall of Mt Gox would calm the over-heated market and also remind investors that more mature and developed exchanges are required to cope with the fast-growth digital currencies. The re-bounce might also indicate that bitcoin has the ability to deal with unpleasant news or emergency, and the volatility is one of the major concerns that push bitcoin away from the mainstream.

Bitcoin took another hit on 10th Apri 2014, and the price dropped nearly 10% (Figure 1.3). China-based exchanges announced they had received official notice from their banks that their business account would be frozen on 15th April. No official statement was released, but many believed these sanction decisions came from People's Bank of China (PBOC), the nation's central bank. Rumours was spread that PBOC had barred all China-based financial institutions from handling Bitcoin transactions to curb risks including crime and money laundering. On the same day, National Australia Bank, one of the four largest financial institutions in Australia, also confirmed that they would close business account dealing with Bitcoin and altcoins on 2nd May due to 'unacceptable level of risk to NAB's business and reputation.

Figure 1.3 Market Reactions to China Ban Rumours
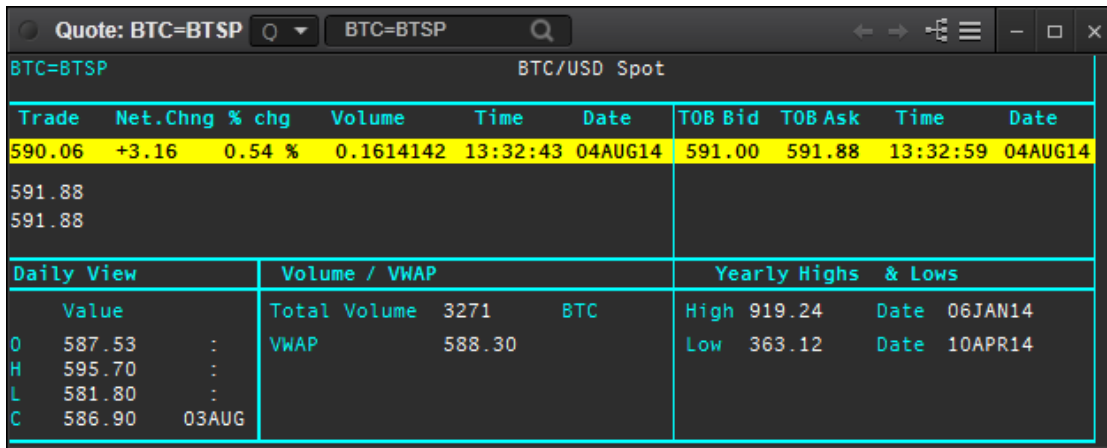
Again, market quickly stabilised a day after the news. One possible explanation is that the move made by banks is well expected, and market has had months to absorb the news.

Market capitalisation continues growing steadily after a dreadful first four months, and more attentions have been paid from market players and regulators. Dell, the world third largest PC vendor, has announced on 18th July that they are now accepting bitcoin payment. A Dell IT team has worked closely with California-based Bitcoin exchange Coinbase to incorporate Bitcoin into its existing payment system[15]. On 4th Aug, Thomson Reuters added Bitcoin pricing information (in US Dollar) into its trading software Thomson Reuters Eikon (Figure 1.4) which is used by many City and Wall Street professionals[16]. According to Thomson Reuters, this is done in response to strong customer demand. This is a very important move for bitcoin, because now elite professional traders in medium and large financial institutions are able to use the same trading software for other financial assets to analyse and trade bitcoin.

Chancellor George Osborn also sees Bitcoin or Cryptocurrency as an opportunity to make UK the global centre of finance innovation. UK Treasury has worked on a programme to exam the potential risks and benefits of cryptocurrency to UK economy, and the review would be published in next few months[17]. The results might result in a new regulatory framework for cryptocurrency in UK which would boost public and business confidence on bitcoin and other altcoins.

Figure 1.4 Eikon Trading Window for Bitcoin/USD

1.1.2 Altcoin

The long term success of Bitcoin is still far from certainty, people are still wondering if it is a modern tulip mania or a technology breakthrough like internet. But the consensus is that at least one day some sort of cryptocurrency will establish itself in the financial world[4]. Bitcoin enjoyed a solo show in the early stage, but since 2011, many bitcoin alternatives have entered public sight.

Bitcoin alternatives, known as altcoin, are all other cryptocurrency coins apart from Bitcoin. No altcoin is strong enough to challenge the leader position of bitcoin yet, but these coins have added diversity to the cryptocurrency world and offer more options to investors and speculators.

Most of altcoins claim that they solved many bitcoin's problems and therefore better than bitcoin, but some of them are Ponzi scheme or too uncompetitive and eventually fade into history. However, investments and the number of transactions of altcoins are on the rise, and there are several reasons for investors or speculators to diversify and expend their portfolio.

The first reason is the return on investment potential. For those not be able to board on the bitcoin boat in the early days, the price of Bitcoin and the cost of mining Bitcoin is too high now, and it seems impossible to buy "cheap" bitcoin and unwise to hoard large amount of

bitcoin for speculation. The profit potential has been outweighed by high price and cost. Altcoins, having much lower price compared with Bitcoin (Table 1.1), are good alternative investment or means to hedge risk although it should be considered as high risk investment itself.

Table 1.1 Top 10 Cryptocurrencies' Price Based On Market Capitalisation

Name	Market Cap[*]	Price on 2nd Sep 2014[*]
Bitcoin	6,317,345,350	477.93
Litecoin	149,541,360	4.72
Ripple	135,558,962	0.004676
BitSharesX	56,254,590	0.028127
Nxt	27,112,221	0.027112
Peercoin	16,229,070	0.748419
Dogecoin	11,902,667	0.000131
Darkcoin	10,538,154	2.28
Namecoin	9,938,972	1.03
MaidSafeCoin	8,413,583	0.018591

* Market cap and price are in US dollar.

Litecoin is the second largest cryptocurrency by market capitalisation only behind bitcoin, and according to the website CoinMarketCap, Litecoin's market cap is only 2.5% of Bitcoin's on 31st August 2014. Like bitcoin, litecoin market is also incredibly volatile. The price of litecoin dropped to a 30-day low at $3.83 or 0.0079BTC on 18th Aug 2014, but it quickly recovered from the crash and rallied back to $5.82 or 0.011BTC on 21st August, which was an increase of 69% of litecoin value in US dollar (Figure 1.5). There will be more discussion on litecoin in chapter 4.

Figure 1.5 Litecoin Price Recovery From Crash on 21st August 2014

* Resource: http://bitinfocharts.com/comparison/price-ltc.html
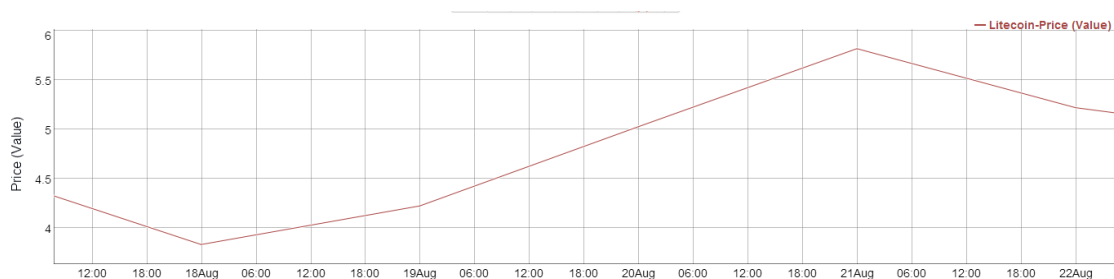
Other major altcoins listing on big cryptocurrency exchanges are Peercoin, Darkcoin, Dogecoin, Namecoin and Blackcoin. Unlike bitcoin, these altcoins do not receive much mainstream media and public attention. The reason behind this contraction is not clearly known, but it might not be coincidence that Bitcoin is the oldest cryptocurrency and it entered the market two years before any of other altcoins.

1.2 Motivation

This project aims to study a selection of altcoins and use data-driven analysis to explain the reasons behind the success and failure of different altcoins. Altcoins differ from bitcoin by applying different hashing algorithms and mining mechanisms, starting with different number of coins and adopting contrasting monetary policies, and it is the last factor that this paper will discuss. Most of the published papers on cryptocurrency focus on the technical background, while some discuss the future of the cryptocurrency but they are based on current market trend and community confidence. This paper jumps out of the circle and discuss the macroeconomics side of cryptocurrency, and the discussion will put monetary policies, more specifically money supply for bitcoin and altcoins, at central point.

Money supply is an important instrument in any country's economy, because the level of money supply has impacts on inflation rate, price level and business cycle. Although cryptocurrency economy is not constraint in a single nation, merchants, miners and spenders form a huge community which could be considered as an 'unconventional' decentralised country. Banking panic, speculative bubble or currency crisis that lead to financial crisis in real world would definitely affect cryptocurrency world – perhaps they would pose larger threats due to unregulated and decentralised nature of cryptocurrency.

Technological advances may solve some of the limitations that cryptocurrencies currently face – such as attack on the coin network or double spending problem. However, to become part of the main financial system, all digital currencies have to reduce volatility and provide reasonable and flexible money supply.

Until now, not a single altcoin can challenge the leader position of Bitcoin due to its reputation and supports from strong network of miners and investors community. However, as described above, bitcoin is not flawless, and some of these problems might eventually destroy bitcoin one day. This provides a chance for altcoins to squeeze into the spotlight. As problems arising and profits dropping, inevitably people start looking at and trading altcoins and speculating of which they think will be the next bitcoin.

There are currently around 800 known altcoins and it is likely that there are still many more unaware of[10]. It is still far from certain that how to define a successful cryptocurrency, because there are too many factors needed to be considered and the database is not large and accurate enough to be interpreted.

Here we investigate several popular or interesting altcoins and compare these different coins. Reward per block and block mining rate is used to estimate future total accumulative number of coins in circulation, assuming the average block mining rate is constant for each altcoin. Initial studies focus on 24-year time span of each altcoin from their respective starting year. Future research will combine these with other data like network hash rate and miners' revenue to find out what impacts monetary policies could have on altcoins.

Chapter 2 Technical Backgrounds

2.1 Bitcoin Introduction

Bitcoin is a peer-to-peer virtual currency and an electronic payment system based on proof-of-work. It is also known as crypto currency, because unlike some existing virtual currencies bitcoin requires cryptographic software protocol to produce and maintain the currency. Bitcoin was first proposed in a 2008 white paper[3] based on some previous crypto currency and hashcash mechanism ideas[13, 14]. Bitcoin is considered as decentralised virtual currency, because there is no central repository and no central administrative body backing it. All transaction history is stored in the block chain which acts as a public ledger. The electronic payment system based on cryptographic proof rather than trust, and this allows transfer of money conduct directly between two participating party without a trusted third party. This section will briefly discuss some important parts of the Bitcoin system.

2.1.1 Transaction

A transaction in bitcoin system is a transfer of value between electronic Bitcoins wallets, and the transaction is digitally signed for security. All the transactions are stored in bitcoin's block chains, which are bitcoin transaction database, and this information is available to anyone anonymously. During transaction, a specified amount of bitcoin is transferred from its input to its output.

An input identifies a previous transaction record which is saved as a hash of the previous transaction output and an index (recipient's public key)[3,18]. An output holds information for sending bitcoins and it specifies an amount for the transfer. The value of each output will be always fully claimed. Although each output from one transaction can only be referenced once by the input of the subsequent transaction, there could be multiple outputs that share the combined value of the input. Therefore, if one wants to send half of 100 bitcoins that he receives from previous transaction, Bitcoin will split this into two outputs and each worth 50 bitcoins. One output will be sent to the recipient account and the other output will be sent to another address, which it created for sender to hold his "change". The amount of input bitcoins not claimed in an output is considered as a transaction fee and the miner who generates the block will get it. Transaction fees provide incentives for miners to process transactions and maintain the network. Currently, miners benefit more from the mining reward, but in the future transaction fee could play an important role due to dropped profits

from mining process. Transaction with higher transaction fees could be confirmed faster, as more computing power could be used to accept and process the transaction due to higher profits.

One of the huge advantages of bitcoin is its transaction irreversibility[3]. After a transaction is confirmed and added to the block in the longest chain, the transaction practically becomes irreversible. This feature could prevent merchant or vendors from risks including credit-card fraud or charge-backs, and small or medium sized enterprises could confidently extend their business to areas where those problems exist.

2.1.2 Mining

Mining is the process of confirming and adding transaction records to bitcoin's block chain which is the public ledger of all transaction history, and currently the confirmation time for bitcoin is about 10 minutes[18].

There are two types of mining forms: solo mining and pooled mining[18]. The process of a miner attempting to generate new block on his own is called solo mining. All block reward and any transaction fee associated with transactions in that block go to the miner himself. In pooled mining, miners are grouped together and computing hashing power is combined to solve blocks together. Block rewards are divided to the pool members in correlation to the amount of power they each contributed. Pooled mining method offer more regular but smaller amount payments (rewards) to miners than solo mining, because rewards are shared by the entire mining pool.

Mining hardware evolves over time to maximum profits through mining process. In the early days, bitcoin client allowed users to use CPU to mine, but this feature was removed from client's interface later because the appearance of GPU mining made CPU mining economically impractical. More efficient GPU mining dramatically increased the hash rate of the network, and it made the value of the amount of coins mined by CPU lower than the electricity cost paid by CPU miners. Field-Programmable Gate Array (FPGA) mining method is a more cost effective way to mine blocks than GPU mining. It consumes very small amount of energy but offers higher hashing power than GPU method. The latest mining technology is Application-Specific Integrated Circuit (ASIC) mining method, and it outperforms all previous methods. ASIC mining lifts the network hash rate to another level and makes GPU mining financially unwise in some areas.

2.1.3 Block Chain

Block chain has been mentioned many times in previous section, and according to bitcoin official documentation, block chain provides "a time-stamped record of all confirmed transactions".[18] Under current system, a transaction (in a block) is confirmed once six further blocks have been processed, and it roughly takes one hour to do so. This system plays a vital role in preventing bitcoin network from double spending and malicious modification of previous transaction records.[3]

One or more transactions are grouped together and hashed, and the hashed information is stored in a block. The same block also has information about previous transaction block, so they are chained together. Newly created block is always added to the end of the block chain, and this means to modify a block in the middle of the block chain, one has to modify every single block after that target block which requires huge amount of computing power to do so. Each block generates certain number of bitcoins and miner who solves this block first is entitled to this reward, and the reward is halved every 210,000 blocks (roughly four years). The reward now is 25 coins per block after the first halving day on 29th November. The finite money supply through bitcoin generation algorithm has significant impacts on the economics side of Bitcoin and other altcoins, and this paper will discuss these points in chapter 3 and chapter 4.

Bitcoin block chain is considered as a major technology innovation, but the information buried behind it has not been deeply investigated. Blockchain website provides many useful and real-time data, and by capturing, analysing and exploring this huge database, more decisive information could be extracted. Business trends could be discovered, warning signals might be spotted and even Bitcoin related crime activities could be stopped.

2.2 Altcoin Introduction

Altcoins are bitcoin alternatives, and based on hashing algorithms difference, altcoins are categorised into three groups: SHA-256 alternate cryptocurrencies, Scrypt alternate cryptocurrencies and others. Technical details of these hashing algorithms will not be covered in this paper, but some major features will be introduced. More details about each altcoins will be discussed in chapter 4.

SHA-256 and scrypt is two most popular hashing algorithms in cryptography, and they are the two most popular algorithm systems implemented by cryptocurrencies to hash and authenticate the crypto coin blocks of transaction data, public and private keys. SHA-256 is one of the strongest cryptographic hash functions available and it is designed by the U.S. National Security Agency (NSA) in 2001.[19] The scrypt algorithm is originally designed to prevent computing system from attacks and large amount of memory is required to penetrate scrypt algorithm and perform attacks.

Bitcoin and most of other Bitcoin-clone coins use SHA-256 blocking hashing algorithm. Cryptocurrencies derived from litecoin are using scrypt algorithm. And there are other protocols used by other coins. For example darkcoin adopts a special X11 algorithm which using multiple rounds of 11 different hashes.

Chapter 3 Monetary policy and Cryptocurrencies

3.1 Monetary policy and money supply

This paper investigates how monetary policy could affect growth potential and future success of cryptocurrency. This part of the paper will first look at monetary policy on traditional fiat money. Since the oldest cryptocurrency bitcoin has only been out for 5 years, projected data of bitcoin and selected altcoins are calculated and combined with historic data.

In this section, I will compare the difference between fiat money and cryptocurrency, and I will also discuss the roles that money plays in an economy. The second part of this section will focus on monetary policy of fiat money and bitcoin. Case studies on other altcoin will be shown in chapter 4.

3.1.1 Fiat Money vs. Commodity Money

Bitcoin is a decentralised and borderless digital currency, and bitcoin users form a community regardless where they are. This community could be seen as a "unified" and unconventional country, and bitcoin is the currency used in this country as a medium of exchange. The same idea could be applied to other cryptocurrencies such as litecoin, dogecoin or reddcoin.

Traditional fiat money has its value and legal status derived from supply/demand relationship and government's regulation, and public faith also contributes to the value of the currency.[21] Unlike traditional fiat money, cryptocurrency is decentralised and trustless peer-to-peer transaction system and it is operated and governed purely by cryptographic protocols. Fiat money loss its value once it loses backing from the government that issues it, but cryptocurrency maintains its value without government support. It seems in bitcoin's case, public faith on performance of bitcoin determines the price and this trust is not from government support but from bitcoin, the great technological innovation, itself. Imagining a scenario that British pound's price is not determined by British government credibility, economic performance, GDP or unemployment rate but only based on paper notes itself, this is like today's bitcoin and other altcoins market.

Some consider cryptocurrency as commodity currency (or pure commodity) rather than currency due to its feature, daily trading pattern and lack of price-stability, but commodity currency's value comes from objects that have value in themselves. Cryptocurrency's value

is unrelated to the value of any physical product. This makes cryptocurrency intrinsically useless, and intrinsically valueless is an important feature of fiat money.

3.1.2 Cryptocurrency and Money Functions

It seems that it is ambiguous to define cryptocurrency as either fiat money or commodity money, but it is certain that it is originally designed to be used as a medium of exchange (at least this is true for bitcoin) and money is most widely accepted as a medium of exchange. To differentiate cryptocurrency from traditional fiat money, bitcoin is classified as digital currency in this paper.

Money or currency is an integral part of any modern economy, and it serves multiple functions in these economies. Three most important functions that money played are medium of exchange, unit of account and store of value.[20]

With bitcoin's popularity growing fast, increasingly more merchants are now accepts bitcoin payment. These businesses come from a wide range of industries including online shopping, education, food, travel and many others. This year has seen a big rise in the number of retailers that accept Bitcoin payment, and some big names are decided to open its door to this new payment method. Expedia, the parent company of many notable online travel brands including hotels.com and expedia.com, has announced in July 2014 that bitcoin is accepted for hotel booking on its website. Dell, the world third largest PC seller, even took a further step and offered 10% discount on Alienware PCs with bitcoin payment. Clearly, bitcoin, the leader of cryptocurrency, has been accepted as medium of exchange, at least to some extent. Other digital currencies may not be as successful as bitcoin, but from pure economic point of view, they have the potential to become next bitcoin.

The second function that money serves to an economy is unit of account. Unit of account is a basic measure of economic value. Expressing economic values of products and assets in a common unit of account enables easy comparisons and allows useful interpretation of costs and profits.[20,21] For example, United Kingdom use the pound sterling as their national currency, and prices – including the prices of financial assets and industrial products and the price of labour (wages) – are expressed in pounds. An economy would benefit from a stable unit of account, because if the price for a currency changes rapidly and frequently, it would be hard for business owners to carry out daily operation. As discussed in chapter 1, bitcoin is a failure in terms of being a stable unit of account. The volatility of bitcoin prevents public

from adopting bitcoin in their daily use, and hinders the long-term growth of the currency as a major alternative to the fiat money. Interestingly, Germen minister of finance has recognised bitcoin as a "unit of account" in August 2013 and even allowed commercial transaction of bitcoin under supervision.

The last of the three generally accepted functions that money has is store of value[20,21]. A store of value is the function of an asset that serves as a means of holding wealth. A good asset that has store of value function should be able to saved, retrieved and exchanged at any time, and the asset should still have good value when retrieved. Gold and fiat money are most common store of value in modern times partly due to their stable price and the backing from governments respectively. Bitcoin can be deposited and used for some goods or services, and it proves that bitcoin possesses store of value function. Bitcoin's price fluctuates against fiat currencies all time and it probably would not be considered as a stable store of value, but with the rising public confidence and more adoption of bitcoin, the store of value function could play more important role in the future and drive the success of Bitcoin or other altcoins.

3.1.3 Macroeconomics and Monetary Policy

In the late 1920s, a huge financial crisis caused a dramatic economic slowdown in all large industrial countries such as United States, United Kingdom, Germany and France. One hypothesis is that stock market crash as a result of financial speculation caused the Great Depression. However, a similar stock markets' crash around the world in October 1987, known as Black Monday, did not slow the economy significantly, and the United States market recovered within two years[20]. It is more reasonable to conclude that the depression and poor economic decision making before 1929 caused the stock market crash, rather than the other way round.[23,24]

The great depression led to the development of a new sub-field within economics, called macroeconomics.[23] Today's economists use macroeconomic tools to understand and improve the performance of national economies and governments use them to try to tackle the problems and boot the economy.

Cryptocurrency is a brand new topic and it is decentralised without regulation or support from governments and central banks. Since cryptocurrencies do not belong to any countries, at first glance it seems obvious that their performance will not affect economic growth,

unemployment rate, business activities or productivities (or the effect to the financial market is not large enough to be concerned). The easy conclusion is that macroeconomic tools are not useful to the study of cryptocurrencies, because all of these topics are studied by macroeconomists. However, I have mentioned before that cryptocurrency, especially bitcoin has a huge and rapidly growing community which consists of merchants, miners, traders and more importantly users, and this fact makes the community more like an unconventional country. The performance of cryptocurrency will have a huge impact on the community's business growth, employment rate and inflation. This is where macroeconomic tools could be used to study the existing economic problems that cryptocurrency faces today.

There are three main types of macroeconomic policies: monetary policy, fiscal policy and structural policy.[24] Fiscal policy and structural policy involves governments' decisions regarding national budget and changing the underlying structure of the economy, and because cryptocurrency is decentralised, these two policies would not be concerned here. Although traditional monetary policy is also made by central bank or government, cryptocurrencies have implanted this feature through its programming. All cryptocurrencies are either having fixed amount of coins or certain amount of coins supplied annually. The impacts of fixed monetary supply and deflationary monetary policies are discussed in chapter 3.2, and case studies on different coins are shown in chapter 4.

3.2 Cryptocurrencies: Fixed Monetary Supply and Deflationary Monetary Policies

3.2.1 Modern Monetary Policy

Monetary policy refers to the decisions made by special government institutions to determine the size and the growth rate of national money supply (For example, Federal Reserve in the United States, Bank of England in United Kingdom, European Central Bank in Euro-zone and People's Bank of China in China).[20, 22] It is often used by these institutions to control the national economy. Changes in the monetary supply have impacts on important macroeconomic variables including interest rates, inflation and exchange rates.[21] It is worth to study and investigate monetary policy of cryptocurrency, because by learning from lessons of monetary policy on fiat money, we may be able to develop a monetary policy tool to specifically target at cryptocurrency and tackle the severe problems including inflation, price instability and market confidence. Before further discussion on monetary policy, it is very important to understand the definition of "money supply". The money supply is defined as the sum of currency held by public and bank deposits. It should not be interpreted as the amount of money that supplied by central banks every year.

By altering the supply of money or other forms of reserves held by commercial banks, central banks or other government body can control the money supply indirectly.[20] There are two major types of monetary policy: expansionary and contractionary. Expansionary policy expands the money supply faster than usual to boost economy and lower unemployment rate during recessions. Contractionary policy increases the supply of money in the economy more slowly or even shrinks it to slow down and calm the market to avoid economic bubble or huge inflation.

In real financial world, the primary monetary policy tool to change the money reserve is open market operation. Open market operation is a method that central banks controls supply of money through buying or selling government bonds on the open market. Suppose that a central bank aims to increase money supply. To accomplish this goal, the central bank, using newly printed money, buys government bonds that they issued earlier from commercial banks and the public. With more money reserves, commercial bank could further distribute money to the market through the process of lending and mortgage. This operation indirectly

increases money supply and the quantity of money in circulation. Opposite goal could be achieved by selling the financial assets to the public.

Another unconventional monetary policy that used regularly after 2008 financial crisis is quantitative easing (QE). QE is a type of expansionary policy, and it is used when traditional expansionary policy loses its effectiveness. Quantitative easing quickly increase money base and the amount of cash in circulation, and it could stimulate economy by direct cash injection.

3.2.2 Cryptocurrency Monetary Policy

Unlike monetary policy for fiat money, all cryptocurrencies have rather inflexible monetary policies. Central banks or government bodies could adjust their monetary policies over time to cope with different situation faced by their economies, but cryptocurrencies are born with a fixed monetary policy (In theory it could be changed, but it is complicated and often causes troubles). It is implemented through the coding and it is part of their DNA.

All cryptocurrencies could be generally classified into two categories based on the difference of monetary policy: deflationary coins and growth coins.[12] The term "monetary policy" for cryptocurrency should not be confused with the same name for fiat money. Since all digital coins increase their money supply at certain rate per unit time (i.e. they cannot shrink the size of the money supply or money in circulation on purpose, but coin loss due to loss of private key or wallet could lead to a size decrease.), cryptocurrencies are all adopting an expansionary policy. However, cryptocurrencies should be further differentiated based on how they distributing coins.

Deflationary coins are those digital currencies in which the total number of coins in existence is fixed. Bitcoin is the most famous example of this kind, and at most 21 million bitcoins will be mined out eventually as a result of block processing algorithm and halving reward. Other deflationary coins include litecoin, namecoin, vertcoin and darkcoin.

The only way for bitcoin and other deflationary coins to distribute new coins are through block reward during block mining process. The rates of block generation time for different digital currencies are different, but the number of coins generated per block is programmed to decrease geometrically. Bitcoin has a 50% reduction rate per 21,000 blocks which takes

roughly four years. It is said that the rate is set because Bitcoin tries to mimic the gold mining rate.

The other type of cryptocurrency is growth currency. There is no limit number of coins in existence for growth coins, and instead the number of coins in circulation grows steadily with a fixed coin supply rate. Famous growth coins include Dogecoin and Reddcoin.

Chapter 4 Case Study

This chapter will review bitcoin and some interesting altcoins. Historical evolutions for each coin will be first discussed and money supply policies will also be reviewed and studied individually.

4.1 Bitcoin

Bitcoin historical evolution has been reviewed and discussed extensively in previous chapters, and in this part I will focus on bitcoin case study which is used to explain general methodology. Same method is used to calculate and predict future coin production rate for other altcoins which I will discuss later, and projected total coin number in circulation in the future is calculated based on the coin growth rate. Some altcoins have special initial coin production scheme, and these are considered and combined with my study to produce database and graph.

The number of blocks processed every year is calculated as follows:

Number of Blocks Processed Annually = (60/Block Processing Time) * 24 * 365;[*]

* I assume that there are 365 days in each year and 24 hours in each day.

60/Block Processing Time calculates how many blocks could be mined out in one hour in the ideal situation. The number of coins produced every hour times 24 to get the number of blocks produced every day. The whole number then multiplied by 365 to calculate the total number of block solved each year.

The number of blocks processed overall is calculated as follows:

Number of Blocks Processed Annually = (60/Block Processing Time) * 24 * 365 + Number of Blocks Mined in Previous Years;

The number of coins mined every year is calculated as follows:

Number of Coins Produced Annually = (60/Block Processing Time) * 24 * 365 * Reward per Block;

The number of blocks processed each year multiplied by reward per block to obtain the number of coins mined every year.

Figure 4.1 Total Number of Bitcoin in Circulation
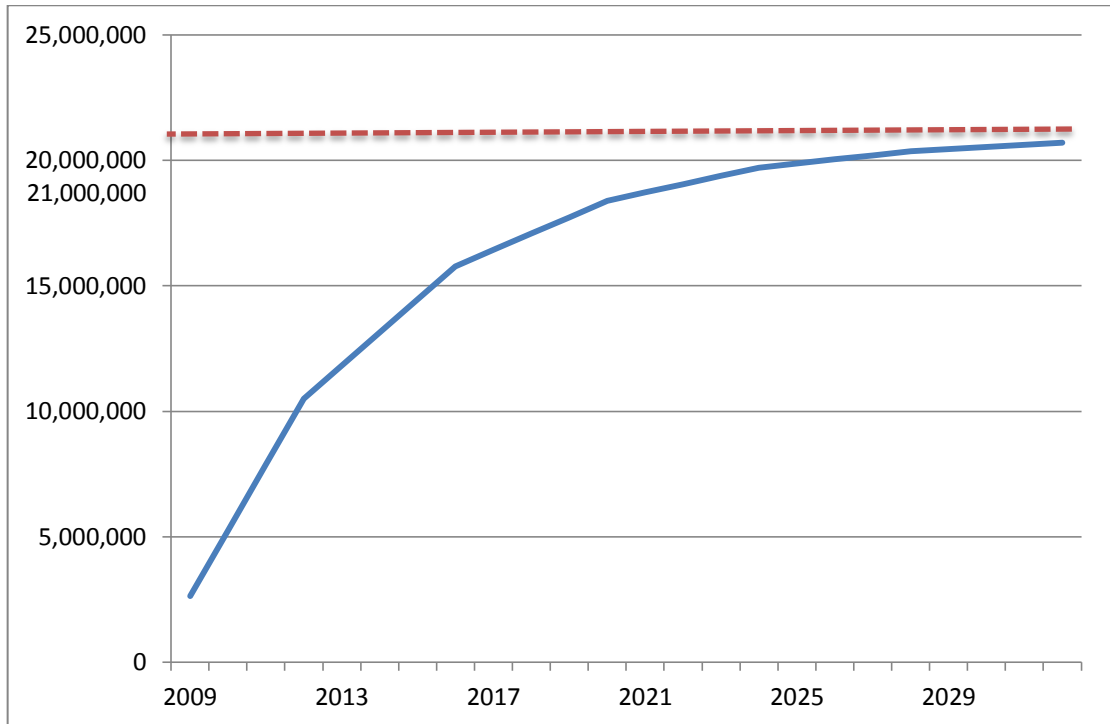
This graph shows the cumulative number of bitcoin in circulation each year from 2009 to 2033. A rapid growth rate is observed initially and it is gradually reduced every four years after the block reward halving day. Table 4.1 shows the coin growth rate (or annual inflation rate) in each year.

Table 4.1 Bitcoin Number of Coins Added per Year Percentage Change

Year	Inflation Rate	Year	Inflation Rate
2009	N/A	2022	1.75%
2010	100.00%	2023	1.72%
2011	50.00%	2024	1.69%
2012	33.33%	2025	0.83%
2013	12.50%	2026	0.83%
2014	11.11%	2027	0.82%
2015	10.00%	2028	0.81%
2016	9.09%	2029	0.40%
2017	4.17%	2030	0.40%
2018	4.00%	2031	0.40%
2019	3.85%	2032	0.40%
2020	3.70%	2033	0.20%
2021	1.79%	2034	0.20%

4.2 Litecoin Case Study and Historical Evolution

Litecoin was introduced in late 2011 and is currently the second largest cryptocurrency based on Market capitalisation according to CoinMarketCap website. Many people view litecoin "the silver" to bitcoin's gold. Litecoin is based on the bitcoin protocol, but unlike bitcoin, litecoin adopts scrypt algorithm to authenticate blocks of transaction data but it uses the same Proof-Of-Work system as Bitcoin. Scrypt hashing prevents GPU, FPGA, ASIC mining of litecoin in the early days, and it helps litecoin distribute to a bigger population rather than few miners with larger computing power. The average block process time for litecoin is approximately 2.5 minutes and it is three times faster than bitcoin. To limit the total number of coins in circulation and mimic the generation trajectory of bitcoin, litecoin generation will be halved every 840,000 coins and this makes the total number of litecoin around 84 million coins. It makes litecoin more abundant than bitcoin. Litecoin development team claims that litecoin provides faster transaction confirmation time, and this could benefit users and smaller merchants and encourage more people adopting litecoin.[11] Litecoin founder Charlie Lee said in an interview that litecoin is not designed to replace bitcoin; instead it should serve as a complimentary to bitcoin. In fact it is unwise to make an opposite claim, as bitcoin, which entered market two years earlier than litecoin, has already established leader position in the cryptocurrency market. However, litecoin, with appropriate monetary policies and market positioning, could thrive in the future.

Figure 4.2 Litecoin One Year Price Chart

* Resource: http://bitinfocharts.com/comparison/price-ltc.html#log&1y

Litecoin became popular among investors and speculators after Bitcoin's boom in late 2013. After the success of Bitcoin, people are fishing in the market to look for next bitcoin that has

higher return on investment. Litecoin price rocketed to $40.61 on 28th Nov 2013 from $2.08 a month earlier, and it was a dramatic 1852% increase. The huge increase in litecoin price brought its market capitalisation to over one billion in US dollar for the first time, and the only time. It is not the first time litecoin price made such big jump though. After one and half year steady growth, litecoin price soared to $4.56 on 9th April 2013 from $0.22 on 9th March. Both spikes are related to the bitcoin's price rise. Some argues that investors who have missed early opportunities to invest on bitcoin rushed to litecoin as a result of high investment cost on bitcoin and promising future of litecoin. Others think late reaction from cryptocurrency market lead to low exchange rates between bitcoin and litecoin, and bitcoin holders who have benefited from the high return on investment of bitcoin were using their bitcoin to buy litecoin, and hoping for another wealth booster.

The bubble did not stay long, and the price of litecoin quickly shrank to $15.58, one third of its peak price less than a month earlier. Although its value quickly recovered, litecoin price continuously decreased after that short recovery. The decline is not due to any flaw in litecoin design, but because of the similar troubles suffered by bitcoin that we discussed in chapter 1.

Figure 4.3 Logarithmic Price of Bitcoin and Litecoin

* Resource: http://bitinfocharts.com/comparison/price-btc-ltc.html
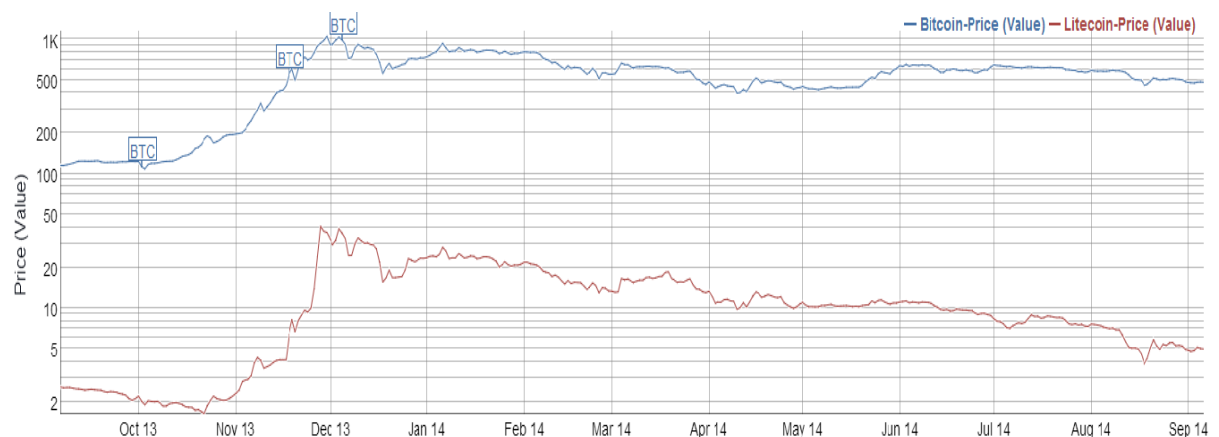
The price trend of litecoin is highly associated with bitcoin's. It probably because Bitcoin has a strong currency strength, and investors view bitcoin price as a secondary investment environment indicator. Whenever bitcoin price reacts to uncertainty, instability or promising news, litecoin market quickly follow suit (Figure 4.3). Figure 4.3 shows the logarithmic price of bitcoin and litecoin, and similar price pattern is observed. Prices in the graph are not

equidistantly displayed, because it is clearer to indicate percentage change by using logarithmic scale (Same percentage change in price are plotted as equal distance on the scale)

Figure 4.4 Total Number of Litecoin in Circulation
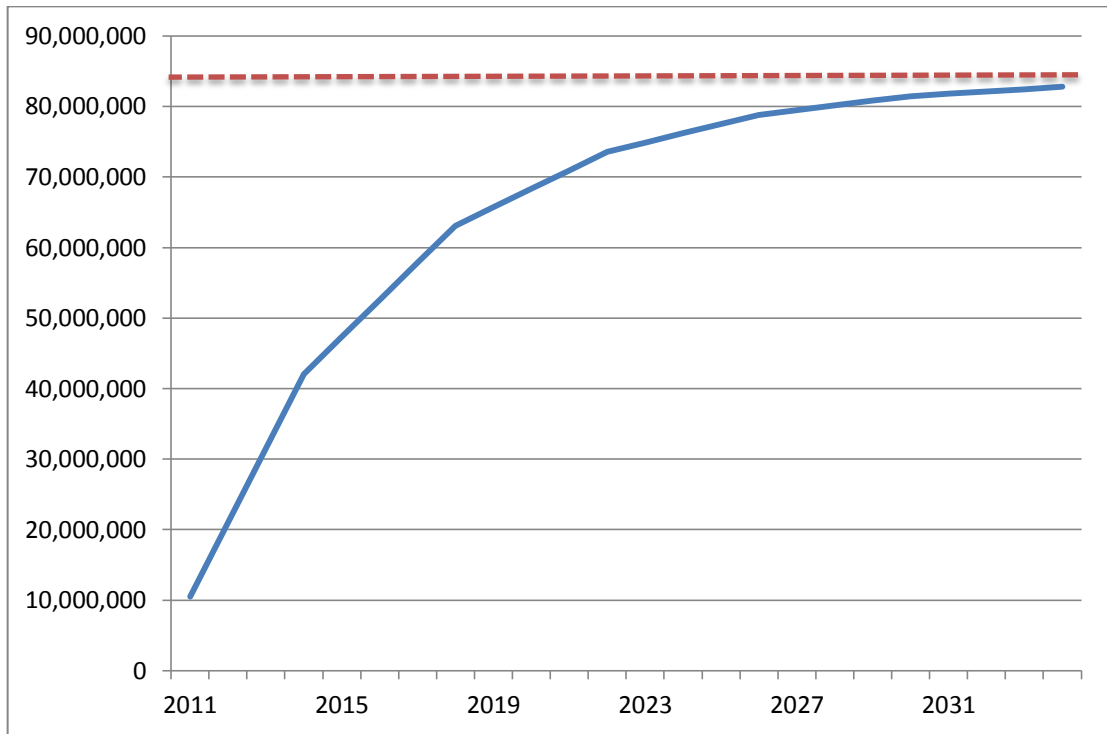
This graph shows the cumulative number of circulated litecoin each year from 2011 to 2031. In theory, a total number of 84 million currency units will be produced. Reward per block generation halves every 840,000 blocks and similar to bitcoin it takes roughly four years. Although it will take more than a century to generate all litecoins, the number of total litecoins in circulation will be close to its limit in 2031 which accounts for 99.14% of all litecoins. After this, the number of coins produced per year would be negligible compared with litecoin coin base.

Table 4.2 takes a closer look at growth rate of litecoins per year from 2011 to 2018. 2011 was the launch year for litecoin, so the growth rate is not applicable. Block reward halves every four years, and consequently number of coins produced through block generation reduced 50% every four years. From 2011 to 2014, 50 coins are generated per block and 10,512,000 litecoins are mined every year. From 2015 to 2018, 25 coins are awarded to the miner who successfully mined the block, and 5,256,000 coins are injected to the coin base per year. Growth rate or percentage change of coin addition compared with previous year

gradually drops every year, and it will only take five years (from 2012 to 2017) for growth rate to decline from 100% increase rate to 10%.

Table 4.2 Litecoin Number of Coins Added per Year Percentage Change

Year	Reward per Block	Number of Coins Added per Year	Percentage Change of Coin Addition
2011	50	10,512,000	N/A
2012	50	10,512,000	100%
2013	50	10,512,000	50%
2014	50	10,512,000	33.33%
2015	25	5,256,000	12.50%
2016	25	5,256,000	11.11%
2017	25	5,256,000	10.00%
2018	25	5,256,000	9.09%

4.3 Dogecoin Case Study and Historical Evolution

Dogecoin was launched on 8th December 2013, and it use scrypt technology in its proof-of-work algorithm as opposed to SHA-256 which is used by bitcoin. Although the sophisticated FPGA and ASIC devices which are used to mine bitcoin in large scale are complicated to create for scrypt-based coins, the first generation of scrypt ASIC machine has entered the market several months ago. Dogecoin is essentially based on litecoin, but there are several differences between them. Dogecoin has a 1 minute block generation time compared with Litecoin's 2.5 minutes. Block rewards for the first 145,000 blocks are random distributed, but this was changed later to a static reward per block. From block 145,001 to block 200,000, the reward per block was set to 250,000 coins. After block 200,000, reward per block halves every 100,000 blocks until block 600,000. The next block reward halving date is estimated on 30th September.

Table 4.3 Dogecoin Reward per Block for first 600,000 blocks

Block Number	Reward per Block	Time
145,001	250,000	17 March 2014
200,001	125,000	28 April 2014
300,001	62,500	02 July 2014
400,001	31,250	30 September 2014
500,001	15,625	18 November 2014
600,001	10,000	26 January 2015

This special designed reward scheme gives dogecoin a fast initial production rate. Around 100 million coins are expected to be mined out by the end of 2014. Since block reward is fixed at 10,000 after block 60,000, there will be roughly 5.2 million coins added to money base in circulation every year. It initially gives Dogecoin roughly 5% inflation rate after 2015, but this will be dropped gradually every year because the year production rate is fixed while the money base is increased year on year (Table 4.4).

Table 4.4 Dogecoin Yearly Coin Addition Rate (Inflation Rate)

Time	Number of Coins Added per Year	Number of Blocks at the Beginning of the Year	Coin Addition Rate
26 January 2015	5,200,000,000	103,637,000,000	**107.27%**
26 January 2016	5,200,000,000	108,837,000,000	**5.02%**
26 January 2017	5,200,000,000	114,037,000,000	**4.78%**
26 January 2018	5,200,000,000	119,237,000,000	**4.56%**

Based on my calculation, the inflation rate will be dropped to 4.56% at the beginning of 2018 regardless of dogecoin performance and big economic environment.

Figure 4.5 Total Number of Dogecoin in Circulation from 2013 to 2025
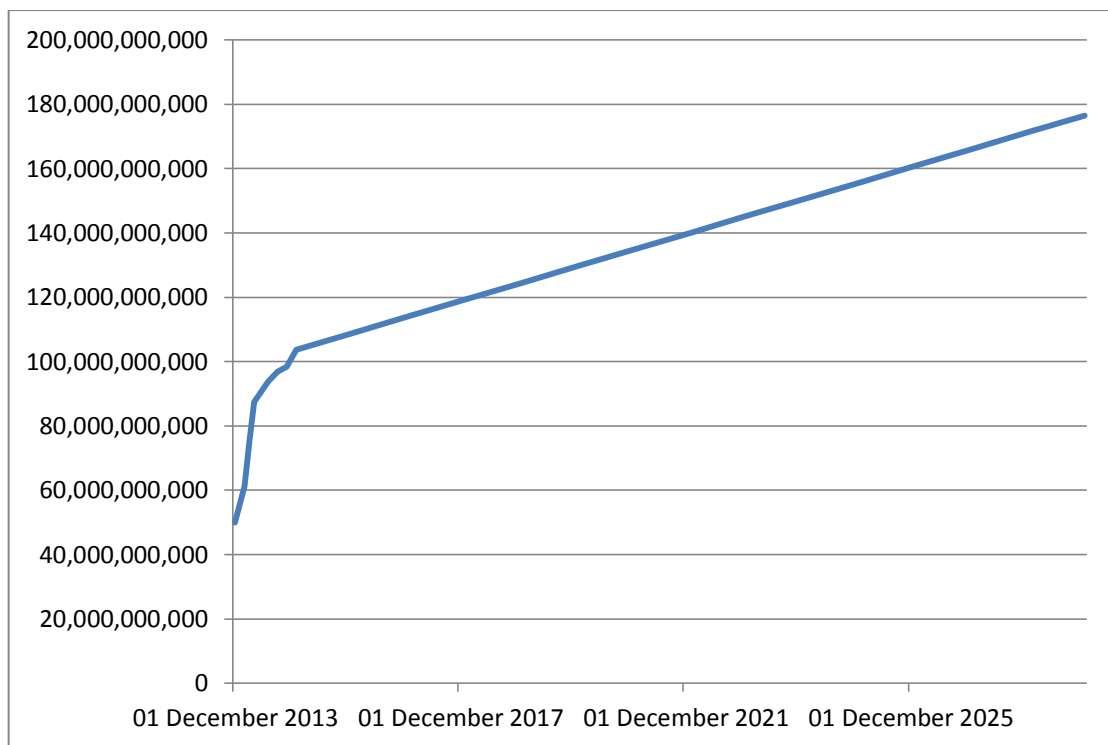
Graph 4.5 shows the total number of dogecoin in circulation each year from 2013 to 2025. The number of coins quickly reaches 100 million by the end of 2014 and remains a steady growth after that.

Figure 4.6 Total Number of Dogecoin in Circulation from 2013 to 2015
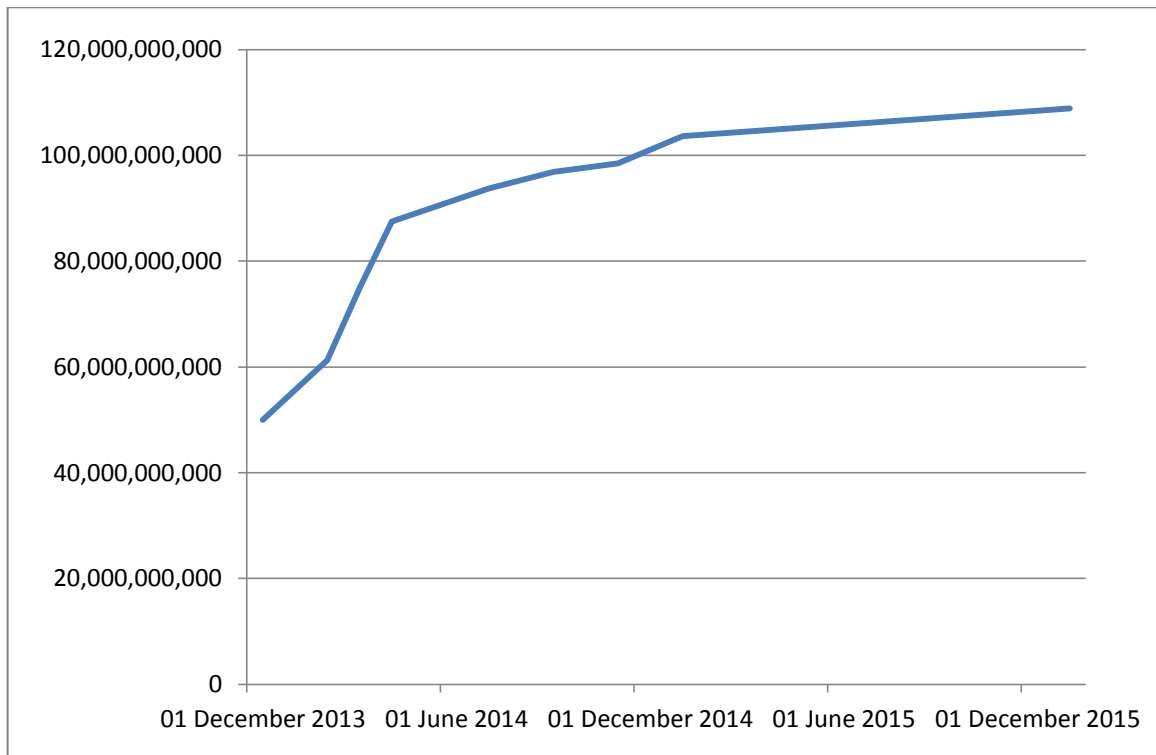
Figure 4.6 narrows the time span from 12 years to 3 years, and this clearly shows how the number of coins grows for the first two years since its introduction.

Although as a business payment option dogecoin is not as widely accepted as bitcoin and litecoin, it has performed well in fund raising activities and online internet tipping system. Twitch, a fast growing online streaming website and recently acquired by Amazon, started to accept dogecoin tipping in May 2014. Facebook, having more than 1 billion active users, approved Dogecoin Tipping app in June 2014. Other social networks like reddit and twitter are also having their own version of dogecoin tipping system. Tipping itself might not be considered as a commercial application, but it helps to distribute dogecoin to a much wider user base (In theory, billions of users could get their first dogecoin through tipping system). Wider distribution could promote more adoption of dogecoin and ensure a promising future. Fundraising activities have received huge support from the Dogecoin community and foundation. One of the most notable events is the fundraising campaign for Jamaican Bobsled Team. They have qualified for the 2014 Sochi Olympics, but did not have enough funding to attend. The Dogecoin community quickly set up a fundraising page and raised three quarters of the $40,000 required within two days.

Dogecoin had its moments in the first several months since its release, but like other cryptocurrencies, it could not maintain its momentum and suffer from problems like hash rate decline, network security, diminished rewards and uncertain future.

Figure 4.7 Dogecoin Overall Price Chart

Like litecoin, dogecoin price trend is also closely related to bitcoin, and it is also viewed by many investors as a risk hedge. On 18th December 2013, bitcoin price dropped 37.5% to $554.52 within a week, and on 19th same month the value of dogecoin soared 300% in three days, from $0.00026 to $0.00095. However, the market crashed by dropping nearly 80% in value days later as a result of rumours from China and inappropriate mining by large mining pools. Into the first three weeks to year 2014, when values of both bitcoin and litecoin continuously decreased, dogecoin reached all-time high on 21st at $0.00185. After that it suffered from the same problem as other cryptocurrencies due to the bankruptcy of Mt Gox.

Price trend became very interesting from the beginning of March. As mentioned earlier, dogecoin scheduled several block reward halving date within a year. The first four "DOGE" flags in Figure 4.7 signifies all four halving date (As expected, the hash rate drops significantly due to reduced reward, but this paper focus on economic side of cryptocurrency, so I will leave this observation along.). Without exception, a jump in dogecoin price is observed shortly before all four block reward halving days. Red circles indicate these sudden increases in price.

Supply-demand theory might be useful to explain these findings. Let's first look at how supply-demand relationship affects oil price (Figure 4.8). Oil price soared whenever there was a crisis which could cause a shortage in oil production and supply. The demand for oil

decreased during financial crisis and 9/11 terror attack, so the price of oil also dropped (Note in 1986, there is a demand for cleaner and more efficient energy, so the oil price crashed).

Figure 4.8 Crude Oil Prices between 1970-2008

CRUDE OIL PRICES 1970-2008
US$ per barrel

Click on LINKS to find out more

$139 BARREL

$100 BARREL - JAN 2008

LEBANON CONFLICT

IRAN-IRAQ WAR

ASIAN FINANCIAL CRISIS

IRANIAN REVOLUTION

GULF WAR

IRAQ WAR

OIL PRICE CRASH

ARAB-ISRAELI WAR

9/11

June 2008

Figures are not inflation adjusted

SOURCE: BP/Bloomberg

* Resource: http://news.bbc.co.uk/1/hi/business/7431805.stm
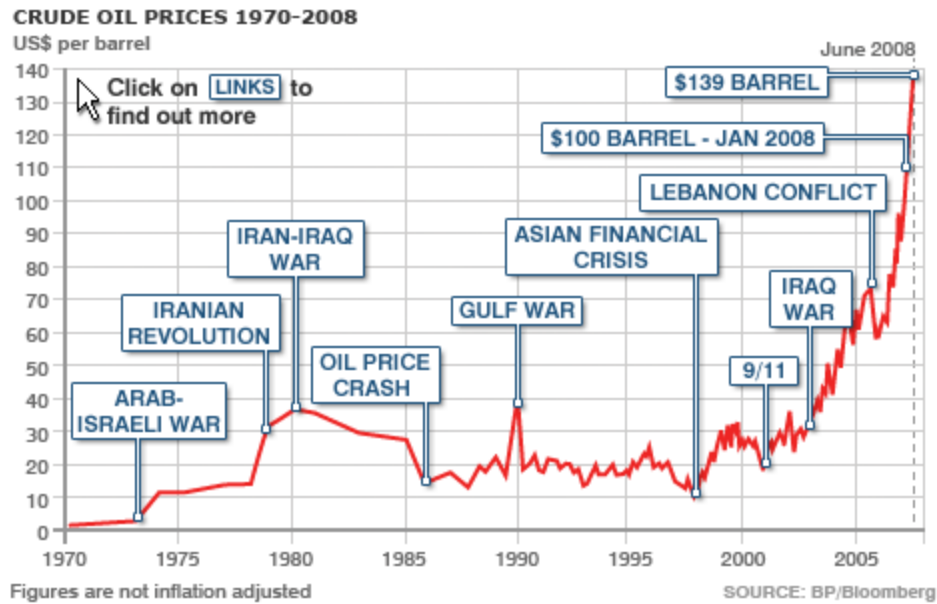
The same theory could be applied to dogecoin. Assuming demand for dogecoin either remaining same or rising, the price of dogecoin will inevitably increase due to foreseeable supply shortage caused by reward halving. However, while oil is crucial to the world's energy supply, dogecoin is not considered as much important as oil. The fear of dogecoin supply shortage quickly turned to the fear of falling demand, and the price consequently dropped.

4.4 Reddcoin

Reddcoin was officially launched on 2nd February 2014, and it was derived from litecoin. Reddcoin has branded itself as "social currency" and it primarily targets at wider circulation among social media users.

It used scrypt Proof-of-Work algorithm initially, but on 29th April, Reddcoin team announced Proof-of-Stake Velocity (PoSV) algorithm will be used to replace POW system. On 2nd August 2014, Reddcoin successfully switched to PoSV algorithm, two weeks after third and final block reward halving day. PoSV is a variant version of Proof-of-Stake algorithm which has gained popularity among new altcoins. It emphasises the ownership of Reddcoin (Stake) and activity (velocity) rather than computing (hashing) power. Holding larger amount of reddcoin would help miner finding a valid block and therefore receiving the block reward. It is a growth coin, meaning there is no limit on the total amount of reddcoins. It has an average of 60 seconds block processing time same as dogecoin and shorter than litecoin. By the end of PoW era (2nd Auguest), there are nearly 27 million coins circulated in the market.

Table 4.5 Reddcoin Block Reward Releasing Schedule (Inflation Rate)

Event	Date	Blocks	Reward per Block
Genesis Block		0	10 000
IPCO Pre-Mine		1 - 10	545 000 000
Bonus Reward 1	02 February 2014	11 - 9 999	300 000
Bonus Reward 2	09 February 2014	10 000 - 19 999	200 000
Bonus Reward 3	16 February 2014	20 000 - 29 999	150 000
Regular Reward	23 February 2014	30 000 - 139 999	100 000
1st Halving	10 May 2014	140 000 - 189 999	50 000
2nd Halving	14 June 2014	190 000 - 239 999	25 000
3rd Halving	19 July 2014	240 000 - 260 799	12 500
Switch to PoSV	02 August 2014	260 800 - indefinite	5% annual interest

* Resource: http://www.reddit.com/r/reddCoin/wiki/faq

There are several stages have been scheduled in the first stage of Reddcoin project (Table 4.5). After genesis block, which is the first block in the block chain (although it is assigned to block number 0), Reddcoin had an Initial Public Coin Offering (IPCO) prior its official launching date. IPCO raised money for what is necessary to expend Reddcoin's network and infrastructure.

Reddcoin set a relative high reward per block to promote itself and attract more users. In February, Reddcoin's reward per block reduced three times and it dropped 66.7% to 100, 000 coins per block from 300,000. Three more halving dates were scheduled from May to July, and eventually the annual inflation rate is fixed at 5% after switching to PoSV.

Table 4.6 Reddcoin Coin Growth Rate

Date	Blocks	Coin Growth Rate	Percentage of Coins in Circulation to PoW era Total Coins (~27 million)
Genesis Block	0	N/A	0.00%
IPCO Pre-Mine	1 - 10	N/A	20.22%
02 February 2014	11 - 9 999	54.99%	31.33%
09 February 2014	10 000 - 19 999	23.68%	38.75%
16 February 2014	20 000 - 29 999	14.36%	44.32%
23 February 2014	30 000 - 139 999	92.07%	85.12%
10 May 2014	140 000 - 189 999	10.89%	94.40%
14 June 2014	190 000 - 239 999	4.91%	99.04%
19 July 2014	240 000 - 260 799	0.97%	100.00%
02 August 2014	260 800 - indefinite	5.00%	N/A

Table 4.6 shows reddcoin growth rate at each stage and percentage of produced coins in each stage to the total number of coins mined in PoW era. Like dogecoin, reddcoin used a quickly initial coin generation scheme, and 85.12% out of 27 million coins has been in circulation by 10th May 2014. Note that Table 4.6 indicates the reddcoin growth rate of each stage compared with previous stage and this is not based on unit of time because each stage consists of different number of days. For example, regular reward stage (also see Table 4.5) started from 23rd February to 10th May and it consists of 77 days, while first halving stage started from 10th May to 14th June with only 36 days.

Figure 4.9 has a better presentation of coin growth on a weekly basis from the reddcoin official launching date on 2nd February to 2nd September, a month after switching to PoSV algorithm. The blue line shows the total number of reddcoin in circulation and the vertical y axis on the left hand side is the scale for it. The y axis on the right hand side is for red line which indicates the number of coins produced per week. As expected, the growth rate (or the inflation rate) is gradually decreased over time and eventually fixed at a 5% annual rate. The number of coins produced per week is dropped significantly after 23rd February due to reduced reward.

Figure 4.9 Reddcoin Total Number of Coins in Circulation and Number of Coins Produced On a Weekly Basis
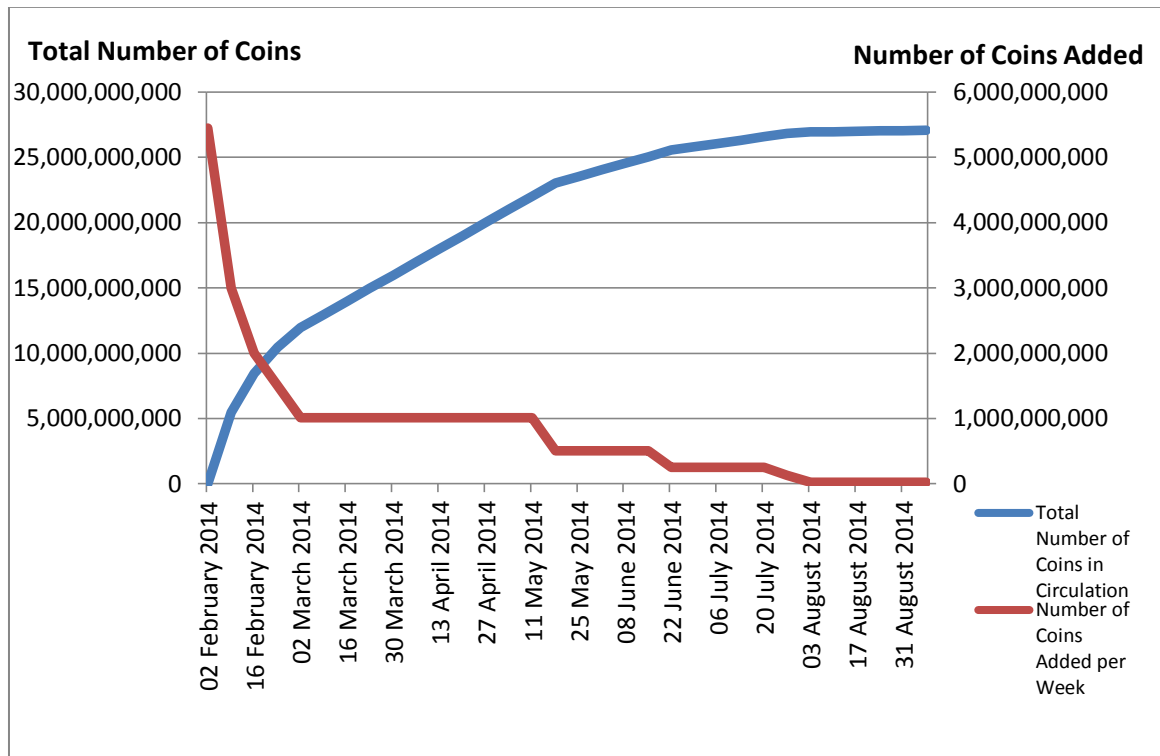
Reddcoin successfully raised fund in its Initial Public Coin Offering (IPCO), and it claimed that 386 investors pledged around 168 bitcoins investment (bitcoin lowest price in January was $770.72 on 28th January), it did not push reddcoin price up until late March. The price soared to $0.0000254 from less than $0.0000001 on 29th March according to bitinforcharts.com. I could not find any evidence to support this jump in value, so I tried to find other sources to confirm this data. However, no other websites contain historical reddcoin price against US dollar, so I could not verify this data.

Figure 4.10 Reddcoin Overall Price Chart

* Resource: http://bitinfocharts.com/comparison/price-btc-ltc.html

Reddcoin achieved a new high in value on 30th April and the price was $0.00003770. This increase in value is caused by the Proof of Stake Velocity (PoSV) announcement made by Reddcoin team a day earlier. Market had reacted positively to the news, but the price quickly dropped to $0.0000241 which was still higher than the price before the announcement.

Reddcoin price experienced three sudden increases on 9th May, 10th June and 18th July respectively (Figure 4.11). These three dates are all shortly before reddcoin reward halving day.

Figure 4.11 Reddcoin Price Jump Before Halving Day
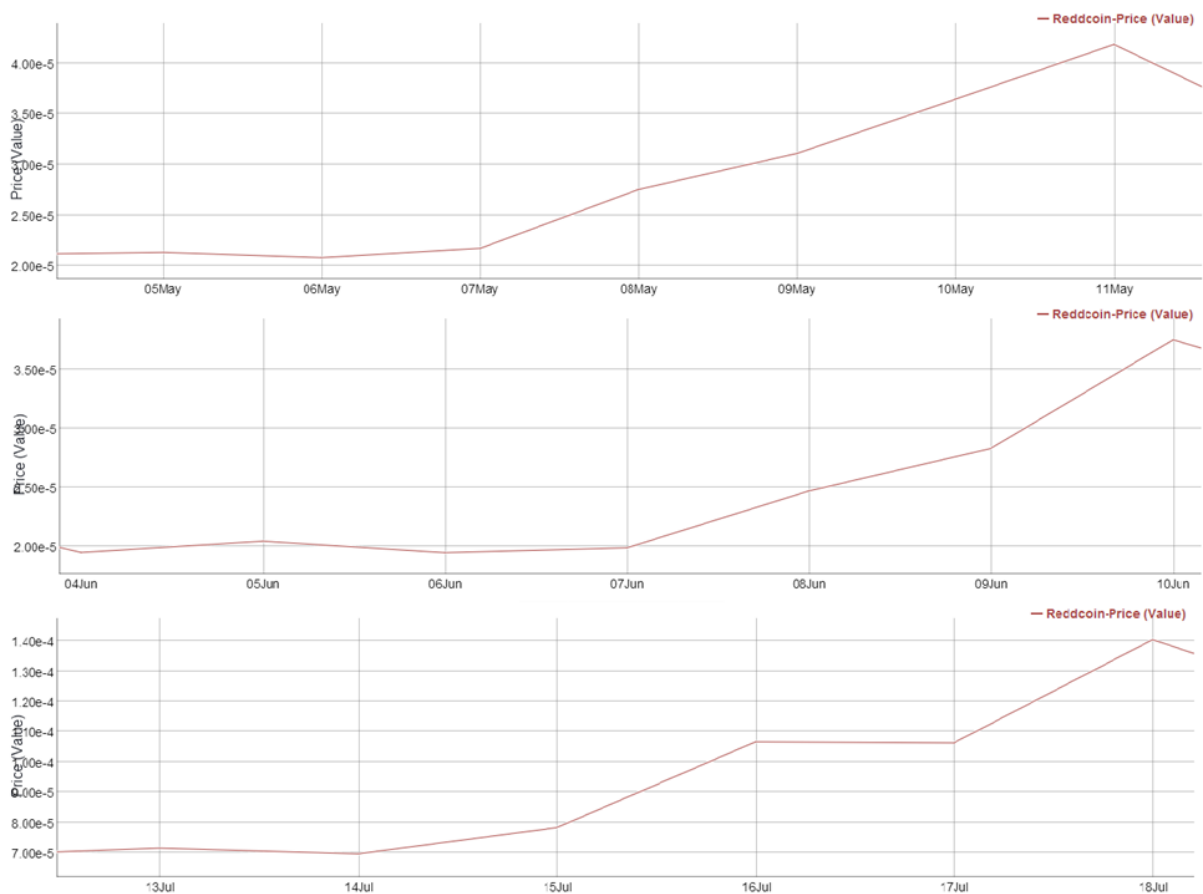
Recall that I used supply-demand theory to explain similar observation for dogecoin. The same theory could probably explain this coincidence for reddcoin. However, as reddcoin was not as popular as dogecoin and there was an over-supply problem for reddcoin, it is not very convincible in this case. It is more likely that some people deliberately put sell order at higher prices for their own agenda.

The reddcoin price continuously increased since 22nd July and reached all-time high at $0.000199 on 26th July, and this happened one week before reddcoin transition to PoSV. It is

possible that investors and speculators wanted to catch the last boat to extend their portfolio before the last block reward reduction day. The value of reddcoin had a steep and rapid fall after its transition to PoSV, and the price dropped 68% to $0.0000637. Its market price is highly volatile and this is not good for a serious and ambitious coin like reddcoin.

Chapter 5 Conclusions and Further Research

5.1 Conclusions

In this paper, we first reviewed historic evolution of bitcoin from economic point of view and concluded that bitcoin has been seen as a market indicator for any other cryptocurrencies. The performance of bitcoin will have a huge impact on overall cryptocurrency market, and both investors and speculators are using other digital coins as a risk hedge.

Based on discussion and analysis on major governments' policy towards bitcoin, we believe bitcoin will be considered as an alternative to traditional fiat money in the future (In this thesis, we assumed that technology flaw can be fixed before the destruction of a given cryptocurrency). Cryptocurrency will become more mature and stable when the majority of the public starts to realise its importance in daily use rather than simply appreciate its innovative ideas.

Chapter 3 discussed the difference between fiat money and commodity money and provided evidence to explain why cryptocurrency should not be considered as a commodity. Cryptocurrency has no intrinsic value and its value is not related to any physical product. Therefore, it could be seen as a financial instrument but not a commodity.

Macroeconomic theory was briefly introduced here and explanation on how and why macroeconomic tools could be applied to analyse cryptocurrency was given. We proposed that bitcoin community could be seen as an unconventional country, and macroeconomic policy, or more precisely monetary policy, should be used to ensure the continuous growth of the country.

Case study on bitcoin, litecoin, dogecoin and reddcoin is provided. We found litecoin market price was highly related to bitcoin, and we believe it is unwise for litecoin to compete with bitcoin directly. We made an interesting discovery on dogecoin price. We found that there was a small price jump before each of the dogecoin halving date so far without any exception. Supply and demand theory could be used to explain it, although it might also be caused by speculating activities. It indicates that the market has be ability to anticipate the reward halving events in time due to fear of supply shortage in the near future. Similar finding is observed for reddcoin, but due to smaller user base and reddcoin over-supply issues, we

think there is a big possibility that its price was deliberately increased by putting many high price selling orders in a short time.

5.2 Future Research

Cryptocurrency is a very new field and it is very hard to gather accurate data to conduct research. Finding reliable data source for analysis should be a primary target.

Future study should consider the possibility of imposing a certain degree of regulation on cryptocurrency. The regulation may help cryptocurrency defend itself from market violation. The fall of the market of invisible hand could also be studied and be compared with decentralised cryptocurrency and unregulated market.

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Appendix

These tables provide raw data that is required to produce various tables and graphs in our thesis.

All tables here are edited in Excel 2010.

A. Bitcoin Table

Block	Reward Era	Reward per Block	Year	Bitcoin at the Beginning of the year
0	1	50.000	2009	0
52,560	1	50.000	2010	2,628,000
105,120	1	50.000	2011	5,256,000
157,680	1	50.000	2012	7,884,000
210,240	2	25.000	2013	10,512,000
262,800	2	25.000	2014	11,826,000
315,360	2	25.000	2015	13,140,000
367,920	2	25.000	2016	14,454,000
420,480	3	12.500	2017	15,768,000
473,040	3	12.500	2018	16,425,000
525,600	3	12.500	2019	17,082,000
578,160	3	12.500	2020	17,739,000
630,720	4	6.250	2021	18,396,000
683,280	4	6.250	2022	18,724,500
735,840	4	6.250	2023	19,053,000
788,400	4	6.250	2024	19,381,500
840,960	5	3.125	2025	19,710,000
893,520	5	3.125	2026	19,874,250
946,080	5	3.125	2027	20,038,500
998,640	5	3.125	2028	20,202,750
1,051,200	6	1.563	2029	20,367,000
1,103,760	6	1.563	2030	20,449,125
1,156,320	6	1.563	2031	20,531,250
1,208,880	6	1.563	2032	20,613,375
1,261,440	7	0.781	2033	20,695,500
1,314,000	7	0.781	2034	20,736,563
1,366,560	7	0.781	2035	20,777,625
1,419,120	7	0.781	2036	20,818,688
1,471,680	8	0.391	2037	20,859,750

Year	Number of Bitcoin Added Each Year	Number of Bitcoin At the End of the Year	Inflation Rate	Percentage of Bitcoin numbers to the Total Number
2009	2,628,000	2,628,000	infinite	12.51%
2010	2,628,000	5,256,000	100.00%	25.03%
2011	2,628,000	7,884,000	50.00%	37.54%
2012	2,628,000	10,512,000	33.33%	50.06%
2013	1,314,000	11,826,000	12.50%	56.31%
2014	1,314,000	13,140,000	11.11%	62.57%
2015	1,314,000	14,454,000	10.00%	68.83%
2016	1,314,000	15,768,000	9.09%	75.09%
2017	657,000	16,425,000	4.17%	78.21%
2018	657,000	17,082,000	4.00%	81.34%
2019	657,000	17,739,000	3.85%	84.47%
2020	657,000	18,396,000	3.70%	87.60%
2021	328,500	18,724,500	1.79%	89.16%
2022	328,500	19,053,000	1.75%	90.73%
2023	328,500	19,381,500	1.72%	92.29%
2024	328,500	19,710,000	1.69%	93.86%
2025	164,250	19,874,250	0.83%	94.64%
2026	164,250	20,038,500	0.83%	95.42%
2027	164,250	20,202,750	0.82%	96.20%
2028	164,250	20,367,000	0.81%	96.99%
2029	82,125	20,449,125	0.40%	97.38%
2030	82,125	20,531,250	0.40%	97.77%
2031	82,125	20,613,375	0.40%	98.16%
2032	82,125	20,695,500	0.40%	98.55%
2033	41,063	20,736,563	0.20%	98.75%
2034	41,063	20,777,625	0.20%	98.94%
2035	41,063	20,818,688	0.20%	99.14%
2036	41,063	20,859,750	0.20%	99.33%
2037	20,531	20,880,281	0.10%	99.43%

B. Litecoin

Block	Reward Era	Reward per Block	Year	Litecoin at the Beginning of the year
0	1	50.000	2,011	0
210,240	1	50.000	2,012	10,512,000
420,480	1	50.000	2,013	21,024,000
630,720	1	50.000	2,014	31,536,000
840,960	2	25.000	2,015	42,048,000
1,051,200	2	25.000	2,016	47,304,000
1,261,440	2	25.000	2,017	52,560,000
1,471,680	2	25.000	2,018	57,816,000
1,681,920	3	12.500	2,019	63,072,000
1,892,160	3	12.500	2,020	65,700,000
2,102,400	3	12.500	2,021	68,328,000
2,312,640	3	12.500	2,022	70,956,000
2,522,880	4	6.250	2,023	73,584,000
2,733,120	4	6.250	2,024	74,898,000
2,943,360	4	6.250	2,025	76,212,000
3,153,600	4	6.250	2,026	77,526,000
3,363,840	5	3.125	2,027	78,840,000
3,574,080	5	3.125	2,028	79,497,000
3,784,320	5	3.125	2,029	80,154,000
3,994,560	5	3.125	2,030	80,811,000
4,204,800	6	1.563	2,031	81,468,000
4,415,040	6	1.563	2,032	81,796,500
4,625,280	6	1.563	2,033	82,125,000
4,835,520	6	1.563	2,034	82,453,500
5,045,760	7	0.781	2,035	82,782,000
5,256,000	7	0.781	2,036	82,946,250
5,466,240	7	0.781	2,037	83,110,500

Year	Number of Litecoin Added Each Year	Number of Litecoin At the End of the Year	Inflation Rate	Percentage of Litecoin numbers to the Total Number
2,011	10,512,000	10,512,000	infinite	12.51%
2,012	10,512,000	21,024,000	100.00%	25.03%
2,013	10,512,000	31,536,000	50.00%	37.54%
2,014	10,512,000	42,048,000	33.33%	50.06%
2,015	5,256,000	47,304,000	12.50%	56.31%
2,016	5,256,000	52,560,000	11.11%	62.57%
2,017	5,256,000	57,816,000	10.00%	68.83%
2,018	5,256,000	63,072,000	9.09%	75.09%
2,019	2,628,000	65,700,000	4.17%	78.21%
2,020	2,628,000	68,328,000	4.00%	81.34%
2,021	2,628,000	70,956,000	3.85%	84.47%
2,022	2,628,000	73,584,000	3.70%	87.60%
2,023	1,314,000	74,898,000	1.79%	89.16%
2,024	1,314,000	76,212,000	1.75%	90.73%
2,025	1,314,000	77,526,000	1.72%	92.29%
2,026	1,314,000	78,840,000	1.69%	93.86%
2,027	657,000	79,497,000	0.83%	94.64%
2,028	657,000	80,154,000	0.83%	95.42%
2,029	657,000	80,811,000	0.82%	96.20%
2,030	657,000	81,468,000	0.81%	96.99%
2,031	328,500	81,796,500	0.40%	97.38%
2,032	328,500	82,125,000	0.40%	97.77%
2,033	328,500	82,453,500	0.40%	98.16%
2,034	328,500	82,782,000	0.40%	98.55%
2,035	164,250	82,946,250	0.20%	98.75%
2,036	164,250	83,110,500	0.20%	98.94%
2,037	164,250	83,274,750	0.20%	99.14%

C. Vertcoin

Block	Reward Era	Reward per Block	Year	Vertcoin at the Beginning of the year
0	1	50	2014	0
210,240	1	50	2015	10,512,000
420,480	1	50	2016	21,024,000
630,720	1	50	2017	31,536,000
840,960	2	25	2018	42,048,000
1,051,200	2	25	2019	47,304,000
1,261,440	2	25	2020	52,560,000
1,471,680	2	25	2021	57,816,000
1,681,920	3	13	2022	63,072,000
1,892,160	3	13	2023	65,700,000
2,102,400	3	13	2024	68,328,000
2,312,640	3	13	2025	70,956,000
2,522,880	4	6	2026	73,584,000
2,733,120	4	6	2027	74,898,000
2,943,360	4	6	2028	76,212,000
3,153,600	4	6	2029	77,526,000
3,363,840	5	3	2030	78,840,000
3,574,080	5	3	2031	79,497,000
3,784,320	5	3	2032	80,154,000
3,994,560	5	3	2033	80,811,000
4,204,800	6	2	2034	81,468,000
4,415,040	6	2	2035	81,796,500
4,625,280	6	2	2036	82,125,000
4,835,520	6	2	2037	82,453,500

Year	Number of Vertcoin Added Each Year	Number of Vertcoin At the End of the Year	Inflation Rate	Percentage of Vertcoin numbers to the Total Number
2014	10,512,000	10,512,000	infinite	12.51%
2015	10,512,000	21,024,000	100.00%	25.03%
2016	10,512,000	31,536,000	50.00%	37.54%
2017	10,512,000	42,048,000	33.33%	50.06%
2018	5,256,000	47,304,000	12.50%	56.31%
2019	5,256,000	52,560,000	11.11%	62.57%
2020	5,256,000	57,816,000	10.00%	68.83%
2021	5,256,000	63,072,000	9.09%	75.09%
2022	2,628,000	65,700,000	4.17%	78.21%
2023	2,628,000	68,328,000	4.00%	81.34%
2024	2,628,000	70,956,000	3.85%	84.47%
2025	2,628,000	73,584,000	3.70%	87.60%
2026	1,314,000	74,898,000	1.79%	89.16%
2027	1,314,000	76,212,000	1.75%	90.73%
2028	1,314,000	77,526,000	1.72%	92.29%
2029	1,314,000	78,840,000	1.69%	93.86%
2030	657,000	79,497,000	0.83%	94.64%
2031	657,000	80,154,000	0.83%	95.42%
2032	657,000	80,811,000	0.82%	96.20%
2033	657,000	81,468,000	0.81%	96.99%
2034	328,500	81,796,500	0.40%	97.38%
2035	328,500	82,125,000	0.40%	97.77%
2036	328,500	82,453,500	0.40%	98.16%
2037	328,500	82,782,000	0.40%	98.55%

D. Namecoin

Block	Reward Era	Reward per Block	Year	Namecoin at the Beginning of the year
0	1	50.000	2,011	0
52,560	1	50.000	2,012	2,628,000
105,120	1	50.000	2,013	5,256,000
157,680	1	50.000	2,014	7,884,000
210,240	2	25.000	2,015	10,512,000
262,800	2	25.000	2,016	11,826,000
315,360	2	25.000	2,017	13,140,000
367,920	2	25.000	2,018	14,454,000
420,480	3	12.500	2,019	15,768,000
473,040	3	12.500	2,020	16,425,000
525,600	3	12.500	2,021	17,082,000
578,160	3	12.500	2,022	17,739,000
630,720	4	6.250	2,023	18,396,000
683,280	4	6.250	2,024	18,724,500
735,840	4	6.250	2,025	19,053,000
788,400	4	6.250	2,026	19,381,500
840,960	5	3.125	2,027	19,710,000
893,520	5	3.125	2,028	19,874,250
946,080	5	3.125	2,029	20,038,500
998,640	5	3.125	2,030	20,202,750
1,051,200	6	1.563	2,031	20,367,000
1,103,760	6	1.563	2,032	20,449,125
1,156,320	6	1.563	2,033	20,531,250
1,208,880	6	1.563	2,034	20,613,375
1,261,440	7	0.781	2,035	20,695,500
1,314,000	7	0.781	2,036	20,736,563
1,366,560	7	0.781	2,037	20,777,625

Year	Number of Namecoin Added Each Year	Number of Namecoin At the End of the Year	Inflation Rate	Percentage of Namecoin numbers to the Total Number
2,011	2,628,000	2,628,000	infinite	12.51%
2,012	2,628,000	5,256,000	100.00%	25.03%
2,013	2,628,000	7,884,000	50.00%	37.54%
2,014	2,628,000	10,512,000	33.33%	50.06%
2,015	1,314,000	11,826,000	12.50%	56.31%
2,016	1,314,000	13,140,000	11.11%	62.57%
2,017	1,314,000	14,454,000	10.00%	68.83%
2,018	1,314,000	15,768,000	9.09%	75.09%
2,019	657,000	16,425,000	4.17%	78.21%
2,020	657,000	17,082,000	4.00%	81.34%
2,021	657,000	17,739,000	3.85%	84.47%
2,022	657,000	18,396,000	3.70%	87.60%
2,023	328,500	18,724,500	1.79%	89.16%
2,024	328,500	19,053,000	1.75%	90.73%
2,025	328,500	19,381,500	1.72%	92.29%
2,026	328,500	19,710,000	1.69%	93.86%
2,027	164,250	19,874,250	0.83%	94.64%
2,028	164,250	20,038,500	0.83%	95.42%
2,029	164,250	20,202,750	0.82%	96.20%
2,030	164,250	20,367,000	0.81%	96.99%
2,031	82,125	20,449,125	0.40%	97.38%
2,032	82,125	20,531,250	0.40%	97.77%
2,033	82,125	20,613,375	0.40%	98.16%
2,034	82,125	20,695,500	0.40%	98.55%
2,035	41,063	20,736,563	0.20%	98.75%
2,036	41,063	20,777,625	0.20%	98.94%
2,037	41,063	20,818,688	0.20%	99.14%

E. Reddcoin

Block	Reward Era	Reward per Block	Year
0	1	10,000	Genesis Block
11	2	545,000,000	Pre-Mine
10,000	3	300,000	02 February 2014
20,000	4	200,000	09 February 2014
30,000	5	150,000	16 February 2014
140,000	6	100,000	23 February 2014
190,000	7	50,000	10 May 2014
240,000	8	25,000	14 June 2014
260,800	9	12,500	19 July 2014
280,960	10	5% Annual Increase	02 August 2014
806,560	10		02 August 2015
1,332,160	10		02 August 2016
1,857,760	10		02 August 2017
2,383,360	10		02 August 2018
2,908,960	10		02 August 2019
3,434,560	10		02 August 2020
3,960,160	10		02 August 2021
4,485,760	10		02 August 2022
5,011,360	10		02 August 2023
5,536,960	10		02 August 2024
6,062,560	10		02 August 2025
6,588,160	10		02 August 2026
7,113,760	10		02 August 2027
7,639,360	10		02 August 2028
8,164,960	10		02 August 2029
8,690,560	10		02 August 2030
9,216,160	10		02 August 2031
9,741,760	10		02 August 2032
10,267,360	10		02 August 2033
10,792,960	10		02 August 2034
11,318,560	10		02 August 2035

Year	Number of Reddcoin Added Each Year	Number of Reddcoin At the End of the Year	Inflation Rate
Genesis Block	10,000	10,000	Infinite
Pre-Mine	5,450,000,000	5,450,010,000	54500000.00%
02 February 2014	2,997,000,000	8,447,010,000	54.99%
09 February 2014	2,000,200,000	10,447,210,000	23.68%
16 February 2014	1,500,150,000	11,947,360,000	14.36%
23 February 2014	11,000,100,000	22,947,460,000	92.07%
10 May 2014	2,500,050,000	25,447,510,000	10.89%
14 June 2014	1,250,025,000	26,697,535,000	4.91%
19 July 2014	260,012,500	26,957,547,500	0.97%
02 August 2014	1,347,877,375	28,305,424,875	5.00%
02 August 2015	1,415,271,244	29,720,696,119	5.00%
02 August 2016	1,486,034,806	31,206,730,925	5.00%
02 August 2017	1,560,336,546	32,767,067,471	5.00%
02 August 2018	1,638,353,374	34,405,420,844	5.00%
02 August 2019	1,720,271,042	36,125,691,887	5.00%
02 August 2020	1,806,284,594	37,931,976,481	5.00%
02 August 2021	1,896,598,824	39,828,575,305	5.00%
02 August 2022	1,991,428,765	41,820,004,070	5.00%
02 August 2023	2,091,000,204	43,911,004,274	5.00%
02 August 2024	2,195,550,214	46,106,554,488	5.00%
02 August 2025	2,305,327,724	48,411,882,212	5.00%
02 August 2026	2,420,594,111	50,832,476,323	5.00%
02 August 2027	2,541,623,816	53,374,100,139	5.00%
02 August 2028	2,668,705,007	56,042,805,146	5.00%
02 August 2029	2,802,140,257	58,844,945,403	5.00%
02 August 2030	2,942,247,270	61,787,192,673	5.00%
02 August 2031	3,089,359,634	64,876,552,307	5.00%
02 August 2032	3,243,827,615	68,120,379,922	5.00%
02 August 2033	3,406,018,996	71,526,398,918	5.00%
02 August 2034	3,576,319,946	75,102,718,864	5.00%
02 August 2035	3,755,135,943	78,857,854,807	5.00%

F. Dogecoin

Block	Reward Era	Reward per Block	Year	Dogecoin at the Beginning of the year
0	1	0-1000000 (random)	08 December 2013	0
100,001	2	0-500000 (random)	14 February 2014	50,000,000,000
145,001	3	250,000	17 March 2014	61,250,000,000
200,001	4	125,000	28 April 2014	75,000,000,000
300,001	5	62,500	02 July 2014	87,500,000,000
400,001	6	31,250	30 September 2014	93,750,000,000
500,001	7	15,625	18 November 2014	96,875,000,000
600,001	8	10,000	26 January 2015	98,437,000,000
N/A	8	N/A	26 January 2016	103,637,000,000
N/A	8	N/A	26 January 2017	108,837,000,000
N/A	8	N/A	26 January 2018	114,037,000,000
N/A	8	N/A	26 January 2019	119,237,000,000
N/A	8	N/A	26 January 2020	124,437,000,000
N/A	8	N/A	26 January 2021	129,637,000,000
N/A	8	N/A	26 January 2022	134,837,000,000
N/A	8	N/A	26 January 2023	140,037,000,000
N/A	8	N/A	26 January 2024	145,237,000,000
N/A	8	N/A	26 January 2025	150,437,000,000
N/A	8	N/A	26 January 2026	155,637,000,000
N/A	8	N/A	26 January 2027	160,837,000,000
N/A	8	N/A	26 January 2028	166,037,000,000
N/A	8	N/A	26 January 2029	171,237,000,000
N/A	8	N/A	26 January 2030	176,437,000,000
N/A	8	N/A	26 January 2031	181,637,000,000
N/A	8	N/A	26 January 2032	186,837,000,000
N/A	8	N/A	26 January 2033	192,037,000,000
N/A	8	N/A	26 January 2034	197,237,000,000
N/A	8	N/A	26 January 2035	202,437,000,000
N/A	8	N/A	26 January 2036	207,637,000,000

Year	Number of dogecoin Added Each Year	Number of dogecoin At the End of the Year	Inflation Rate
08 December 2013	50,000,000,000	50,000,000,000	Infinite
14 February 2014	11,250,000,000	61,250,000,000	22.50%
17 March 2014	13,750,000,000	75,000,000,000	22.45%
28 April 2014	12,500,000,000	87,500,000,000	16.67%
02 July 2014	6,250,000,000	93,750,000,000	7.14%
30 September 2014	3,125,000,000	96,875,000,000	3.33%
18 November 2014	1,562,000,000	98,437,000,000	1.61%
26 January 2015	5,200,000,000	103,637,000,000	5.28%
26 January 2016	5,200,000,000	108,837,000,000	5.02%
26 January 2017	5,200,000,000	114,037,000,000	4.78%
26 January 2018	5,200,000,000	119,237,000,000	4.56%
26 January 2019	5,200,000,000	124,437,000,000	4.36%
26 January 2020	5,200,000,000	129,637,000,000	4.18%
26 January 2021	5,200,000,000	134,837,000,000	4.01%
26 January 2022	5,200,000,000	140,037,000,000	3.86%
26 January 2023	5,200,000,000	145,237,000,000	3.71%
26 January 2024	5,200,000,000	150,437,000,000	3.58%
26 January 2025	5,200,000,000	155,637,000,000	3.46%
26 January 2026	5,200,000,000	160,837,000,000	3.34%
26 January 2027	5,200,000,000	166,037,000,000	3.23%
26 January 2028	5,200,000,000	171,237,000,000	3.13%
26 January 2029	5,200,000,000	176,437,000,000	3.04%
26 January 2030	5,200,000,000	181,637,000,000	2.95%
26 January 2031	5,200,000,000	186,837,000,000	2.86%
26 January 2032	5,200,000,000	192,037,000,000	2.78%
26 January 2033	5,200,000,000	197,237,000,000	2.71%
26 January 2034	5,200,000,000	202,437,000,000	2.64%
26 January 2035	5,200,000,000	207,637,000,000	2.57%
26 January 2036	5,200,000,000	212,837,000,000	2.50%