Title: **Bitcoin Market Penetration Vensim Dynamic Model Prediction**

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Introductory Note:

This document presents an approach on the modeling of the Bitcoin market penetration. It uses Vensim to model the system dynamics and uses as a base model the one presented in [1].

1. Abstract

Bitcoin is a growing cryptocurrency, but its growth is marked by volatile rises and falls. Some attempts have been made to predict it's growth [1], but they aren't able to represent the volatile rises and falls. In this paper we try to make this volatile rises and falls appear in the predictions by adding a random factor to the adoption and quit rate.

In the end the model was able to represent with some accuracy the real world logic of the bitcoin adoption, being able to represent to some extent the volatile rises and falls of bitcoin.

2. Bitcoin

In this chapter a brief explanation about cryptocurrencies, bitcoin and its inner works is given.

2.1 Cryptocurrency

A cryptocurrency is a type of digital currency, this means that [it's a digital representation of value, issued by private developers and denominated in their own unit of account available only in digital format. [2]] -> fazer sitação

What makes a cryptocurrency differ from a digital currency is the fact that it uses cryptography to secure and verify transactions and control the creation of new units. Besides that cryptocurrency requires the use of a immutable distributed digital ledger of transactions [2].

2.2 Bitcoin

Bitcoin is one of the many implementations of cryptocurrencies, having a market share of 57.1% [3]. It was the first cryptocurrency and followed the white paper of Satochi Nakamoto [4], which defines Bitcoin and the concept of blockchain, which is the immutable distributed digital ledger of transactions used in Bitcoin.

2.3 Bitcoin Functioning

Due to the functioning behind the Bitcoin being very complex we will only give a brief description.

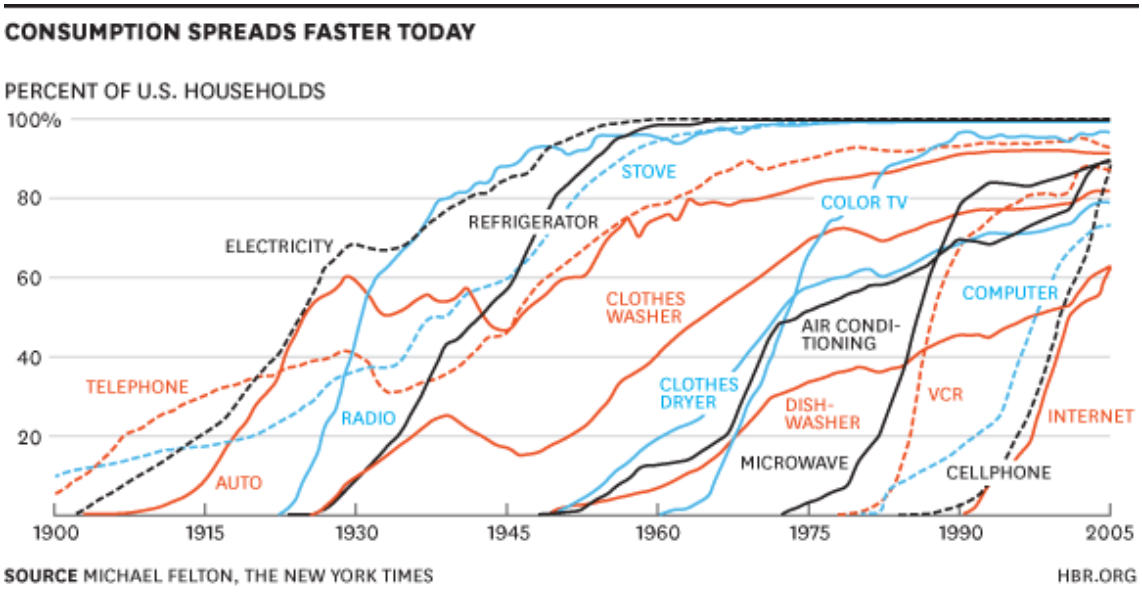
Since Bitcoin is a decentralized digital currency and the money exists only virtually, there's a need for a system to keep track of who is the legitimate owner of the currency and avoid the spent of the same money twice. Satochi Nakamoto [4] explained that this could be done by using a chain o signatures to sign every transaction and allow the users to verify the transactions by verifying the signatures. Since there is no central authority the only way to verify one transaction is by having the access to the complete history of the transactions. To achieve this, all transactions are publicly available together in a chain, the so called blockchain. This means that if one of the blocks is valid, all the blocks before this one are also valid. The introduction of the currency in the system is done by "miners" this are users that use their computers to sign the block of transactions and send it to the Bitcoin network. After a successfully signed block, the miner is rewarded with a bitcoin.

3. Bitcoin market penetration

Before we discuss the bitcoin market penetration there are a few concepts that need to be understood such as logistic growth, fractal exponentials and gartner hype cycles.

3.1 Logistic Growth

It is the growth seen in most 20th century technologies such as internet, telecommunications and even electronic supplies. The name comes from the adoption curve that is similar to a logistic curve. [Figure 1]

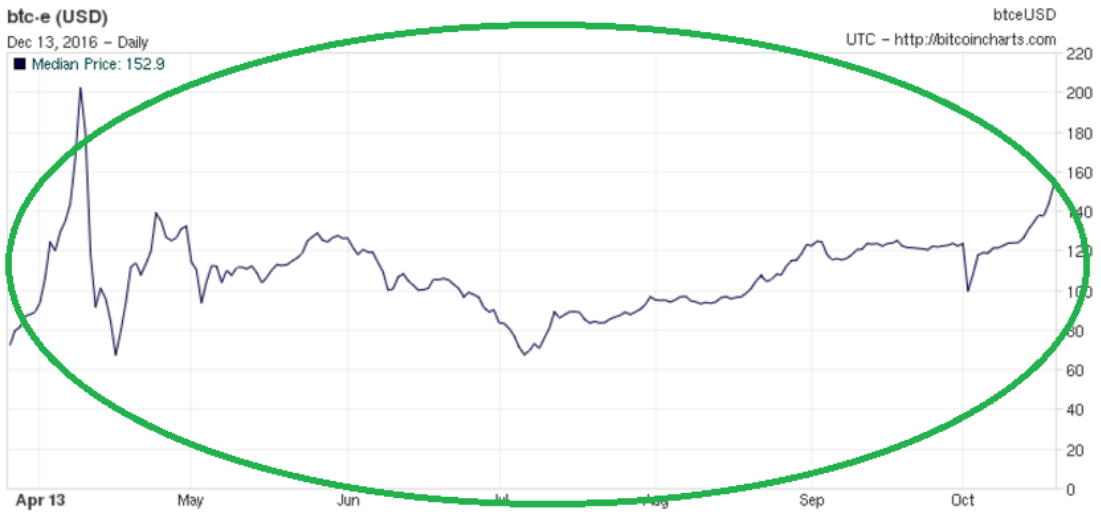


[Figure 1: Technology adoption curve in the 20th century]

(https://medium.com/@mcasey0827/speculative-bitcoin-adoption-price-theory-2eed48ecf7da)

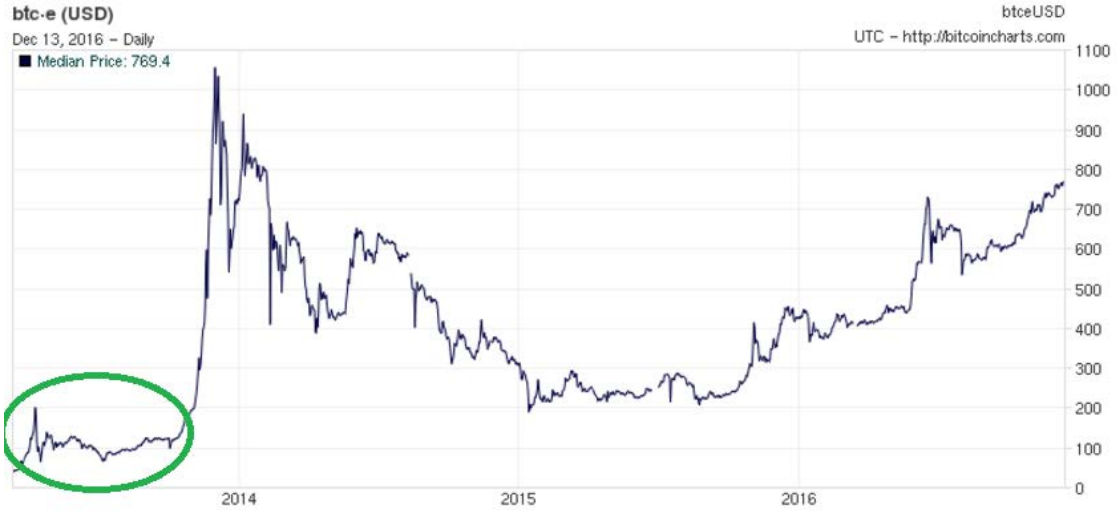
3.2 Fractal Exponentials

A fractal is a recurring pattern that gets increasingly bigger each time it repeats it self. In this case it's seen in the bitcoin market penetration and since the pattern exhibited is a exponential, the name for this fractal is a fractal exponential.[See figures 2 and 3]



[Figure 2: First bitcoin bubble]

(https://medium.com/@mcasey0827/speculative-bitcoin-adoption-price-theory-2eed48ecf7da)



[Figure 3: Second bitcoin bubble]

(https://medium.com/@mcasey0827/speculative-bitcoin-adoption-price-theory-2eed48ecf7da)

3.3 Gartner Hype Cycles

A gartner hype cycle is an hypothesis to explain the adoption of a new technology. It is divided in 5 steps [see figure 4]: technology trigger, peak of inflated expectations, through of disillusionment, slope of enlightenment and plateau of productivity. This cycles are important since they help us understand the growth of bitcoin and the fluctuation of its price.

[Figure 4: Gartner Hype Cycle]

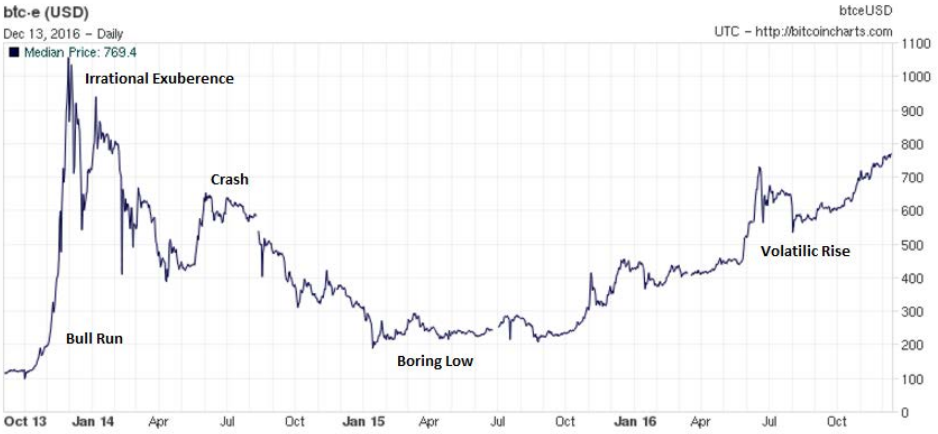
(https://medium.com/@mcasey0827/speculative-bitcoin-adoption-price-theory-2eed48ecf7da)

3.4 Market Penetration

The growth of Bitcoin is similar to the growth of most 20th century technologies, a logistic growth, although when compared the adoption rate of Bitcoin is much higher. Many believe that the reason behind it is the fact of internet being established and widely available, making the spread of information much faster.

Despite the fast growth, bitcoin adoption is marked by big spikes of adoption, called bitcoin bubbles, associated with this spikes of adoption are spikes of the value of the coin itself. When those bubbles explodes the number of adopters drastically falls, as well as the coin value. This bubbles happened several times and they are even compared to the gartner hype cycle since there's a big similarity as we can see in [figure 5]. Since every time this bubbles happen they have a exponentially bigger scale they are also seen as fractally repeating exponentially increasing bubbles.

By gathering all this characteristics we conclude that the bitcoin market penetration is marked by fractally repeating exponentially increasing gartner hype cycles. [see figure 3]



[Figure 5: Gartner Hype Cycle in Bitcoin Market Penetration]

(https://medium.com/@mcasey0827/speculative-bitcoin-adoption-price-theory-2eed48ecf7da)

4. Stakeholders

Having in mind the highly variable growth of bitcoin, for us to be able to model a dynamic system we need to understand who are the stakeholders and what influences their adoption of bitcoin.

4.1 Consumers

The consumers are an important stakeholder since they are the ones that usually choose the payment method during a transaction. The most important factors for them are the low transaction cost and the fast worldwide transactions.

4.2 Businesses

Since the consumers might want to use Bitcoin as the payment method, businesses have an important role by allowing that payment method. The biggest advantage of using Bitcoin would be the low transaction cost.

4.3 Governments

The government as well as other regulating bodies are also stakeholders, because they are the ones that keep track of payments done by consumers and businesses for taxing purposes. The pseudo anonymity makes the government role crucial since they are the ones making sure that no unlawful business happens and the taxes are paid. One clear advantage for the regulating bodies is the fact that all transactions are visible in the blockchain, making audits easier.

4.4 Banks

Banks are stakeholders because Bitcoin might be the replacement for the fiat currency. Since Bitcoin is decentralized, it would undermine the banks position as the central party for sending and receiving money. But, there's a clear role for banks in that world, they would host a secure wallet service and continue to make loans.

4.5 Investors

Investors are a clear stakeholders since they are the majority of the Bitcoin users. The investors are responsible for the bubbles and the fractal growth that we talked about in [3.4]. They don't use Bitcoin as a currency but as an appreciating asset. The price volatility hurts the trust of the average consumer in Bitcoin, making investors slow the adoption of bitcoin as a currency.

5. Advantages and Disadvantages

After analyzing the stakeholders we can determine the adoption factors of bitcoin, but before we do it we should also understand the advantages and disadvantages of bitcoin so we can give values to the adoption factors.

5.1 Advantages

As we mentioned in [chapter 4.1] for the consumer the fast transactions and their low cost are the two of the advantages of bitcoin, they represent a competitive advantage against the current model, where transactions between banks usually take one or more days and with bigger costs. To help with the bitcoin adoption the low barrier to entry is seen as an advantage, as there are no real costs and restrictions associated with the initiation of use, the only thing a costumer needs is an internet connection. For the users that are concerned with their privacy bitcoin is also seen as a better solution than the current digital payment system since it's partially anonymous.

In the perspective of a business there are some advantages too, since the adoption of the bitcoin as a payment method usually brings media attention, which means free publicity. The fact that all payments are irreversible gives businesses the security of the received payments not bouncing back. For businesses the no single point of failure of bitcoin, assured by its decentralized nature, is an advantage since they can always conduct transactions, as the network doesn't stop. Besides that, the fact that all transactions are publicly available allows a good audit trail for governments and regulation bodies, the only thing that is needed is the address of the wallet that's going to be audited.

5.2 Disadvantages

Although there are many advantages in the use of bitcoin there are some disadvantages. For the consumer one of the big disadvantages is the complicated method of usage, as it can be frustrating to use and one error in the address for a transaction can lead to a permanent lost of the coins. Besides that, the price volatility and security risks are big discouraging factors as the consumer can't trust the coins value or wallet. Looking in another perspective the partial anonymity mentioned in the advantages [chapter 5.1] can also be a disadvantage as it facilitates

the use of bitcoin by criminals and without addresses can make it harder to do audits, a topic extensively covered by media.

5.3 Barriers

The main barriers to the proliferation of bitcoin are the fact that there is not yet a consensus over the acceptance or not of cryptocurrencies by the governments, which leads to uncertainty in the legal implications for businesses. The possible conflicts between governments (regulators) and the decentralized nature of bitcoin, the complicated usage and integration in businesses process and its governance by mining companies, which could defeat the complete purpose of its decentralized nature.

6. Adoption Factors

After defining the stakeholders and the advantages/disadvantages of bitcoin we can define which adoption factors are relevant to introduce in the dynamic model that we will build and their values.

6.1 Media

The media are an important factor in the adoption of bitcoin. The coverage of bitcoin done by the media can make the population more or less susceptible to adoption, depending on the point of view they opt. There is a focus on the negative side of bitcoin in the most articles and they tend to give the idea that the bitcoin is an asset not a currency. But if the coverage shifts and it starts focusing on the good side of bitcoin it can rise the adoption rate.

6.2 Government Policy

Depending on the government position on cryptocurrencies, there might be an incentive to adopt cryptocurrencies such as bitcoin, or, if severe regulation is imposed, might discourage the adoption and use of them. Since no regulation as been imposed on the moment, some say that companies are waiting for it before making move, others defend that the lack of regulation makes it easier for startups to build their business around bitcoin.

6.3 Governance of Bitcoin

The governance of bitcoin is an important factor because the there are problems that haven't been solved, and if a good governance of bitcoin is applied, those problems can be solved smoothly and consumers will fill confident in adoption the new currency.

6.4 Price Stability

The price stability is the factor that will make bitcoin stop being seen as an asset to be seen as, its objective in the first place, a currency. The fluctuations of price of bitcoin is one of the biggest disadvantages it has, as the fluctuations are frequent and make it harder for consumers to gain trust in the system.

6.5 User Friendliness

As we discussed in the before [chapter 5.2] bitcoin is very hard to use for a new user, even thought that there are no barriers of entry to start using it. This is one of the biggest factors in adoption as the average user doesn't want to spend much time learning the system. If the system is easy to use, more consumers will be willing to try it, making the adoption rate rise.

6.6 Exchange Collapsing

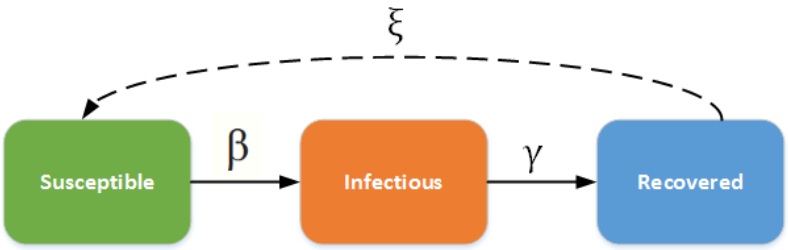
An exchange collapse consists in the lost of an exchange, all the coins involved in it disappeared and the owner can't get them back. If the rate of exchanges collapsing increases, the adopters might fill discouraged to continue using the system falling back to the previous currency.

7. Vensim Model

This chapter gives an explanation about the vensim model used to model the growth of bitcoin.

7.1 SIRS Model

Before we analyse the adopted model we need to understand the *susceptible, infected, recovered, susceptible* (SIRS) model [figure 6]. This model is usually used to model the spread of diseases and assumes that during the spread of the disease there are three states where a person can be. The first is susceptible, where the person can become infected, the second is infected, where the person already contracted the disease and its recovering, the third is recovered, where the person is no longer infected and is loosing the immunity to the disease. If the person loses the immunity it goes back to the susceptible state. The transitions probability between each state are given by γ , ξ and β wand their influence in each state can be seen in the formulas on in [figure 7].



[Figure 6: SIRS Model]

(https://institutefordiseasemodeling.github.io/Documentation/malaria/model-sir.html)

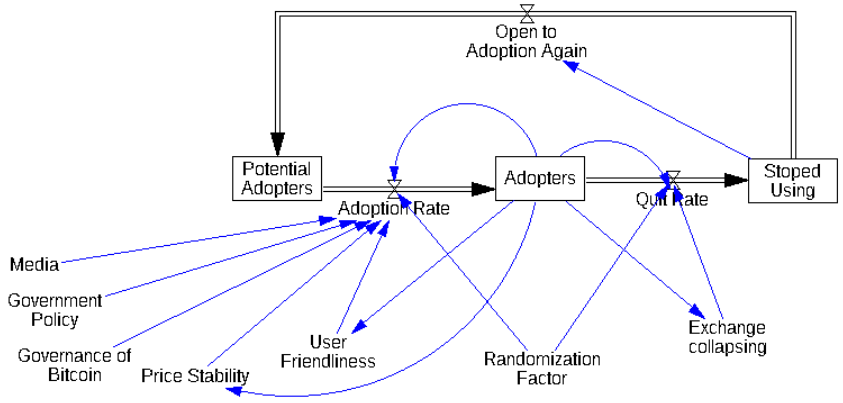
$$\frac{dS}{dt} = -\frac{\beta SI}{N} + \xi R$$
$$\frac{dI}{dt} = \frac{\beta SI}{N} - \gamma I$$
$$\frac{dR}{dt} = \gamma I - \xi R$$

[Figure 7: Derivative functions of the three possible states]

(https://institutefordiseasemodeling.github.io/Documentation/malaria/model-sir.html)

7.2 Adopted Model

The model used for adoption [figure 8] as we can see has a lot of similarities with the SIRS model [chapter 7.1], the main difference being the Adoption Rate ($-\frac{\beta SI}{N}$) where the total population (N) and the Potential Adopters (Susceptible S) are not held into account [see Table 1].



[Figure8:Vensim Model]

The Adoption Rate, or infectious rate in the SIRS model, is a combination of the different adoption factors addressed in [chapter 6], a random factor and the adoption rate seen from 2013 to 2014. The Quit Rate, or recovery rate in the SIRS model, is a combination of the base quit rate, the influence that exchange collapses have and the same random factor that influences the adoption rate. The Open to Adoption Rate, or immutability lost rate in the SIRS model, is given by the base open to adoption rate only.

The Media, Government Policy, Governance of Bitcoin, User Friendliness and Price Stability are adoption factors that can have values between -1 and 1. Also User Friendliness and the Price Stability are directly related to the number of adopters having because of that a feedback loop, the user friendliness increases 0.1 for each million of adopters and the Price Stability increases 0.01 for each million of adopters. Exchange collapsing its a value equal or bigger than 0 and represents the number of exchanges that are dropped, this exchanges are reduced as the number of adopters grows dropping 0.1 per million of adopters.

The random factor is a random number between 0.6 and 1.2 with the objective of reflecting the spikes of adoption that we analyse in [chapter 3]. It is generated using the vensim random uniform with a random seed.

Open to Adoption Rate	$= 0.001 * Stopped\ Using$
Adoption Rate	$= \mathrm{RF} * 0.159 * \frac{Governace\ of\ Bitcoin + Government\ Policy + Media + Price\ Stability + User\ Friendliness}{5} * \mathrm{Adopters}$
Quit Rate	$= Adopters * (0.001 + 0.005 * Exchange\ Collapsing) * (1 - RF/1.2)$
Potential Adopters	$INTEG(Open\ to\ Adoption\ Rate\ - Adoption\ Rate)$
Adopters	$INTEG(Adoption\ Rate - Quit\ Rate)$
Stopped Using	$INTEG(Quit\ Rate - Open\ to\ Adoption\ Rate)$
Media	=0.75
Government Policy	=0
Governance of Bitcoin	=0.5
User Friendliness	$= MAX(1, MIN(-1, \frac{Adopters}{10^6} * 0.1 - 0.1))$
Price Stability	$= MAX(1, MIN(-1, \frac{Adopters}{10^6} * 0.01 - 0.5))$
Randomization Factor (RF)	=Random Uniform (0.6, 1.2, 5)
Exchange Collapsing	$= MAX(0, 2 - \frac{Adopters}{10^7})$

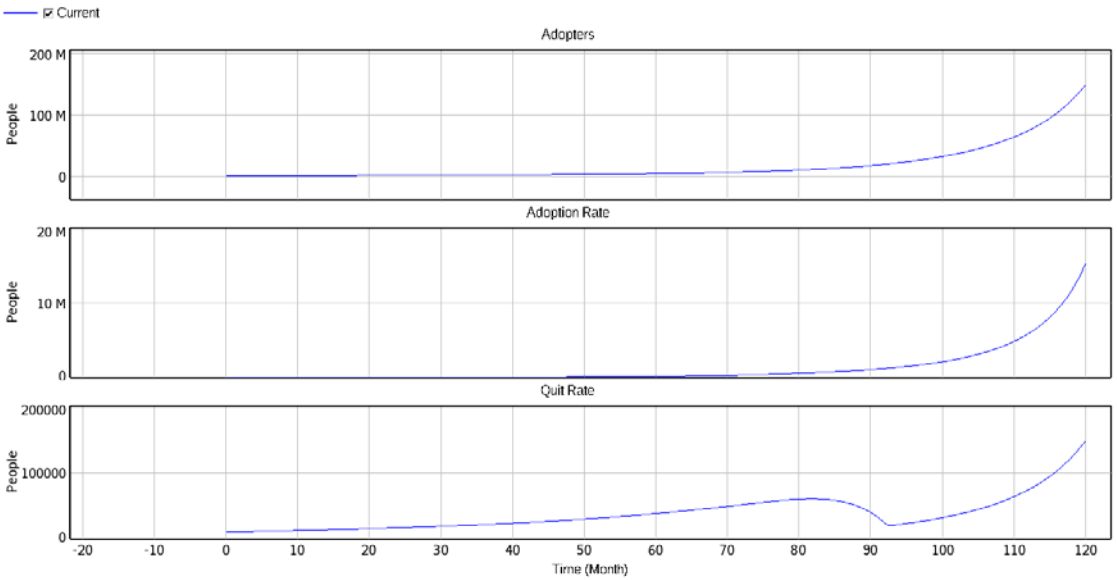
[Table 1: Model Equations]

8. Results

This chapter presents the obtained results using the model explained in [chapter7].

8.1 Model Without Randomization

To understand the effects of the randomization factor we need to have a base prediction without it. The results obtained using Vensim [Figure 9] shows us that the number of adopters starts slowly increasing until it hits around 150 million, the adoption rate gets near 15 million of people, which means that per month bitcoin was receiving 15 million new adopters.

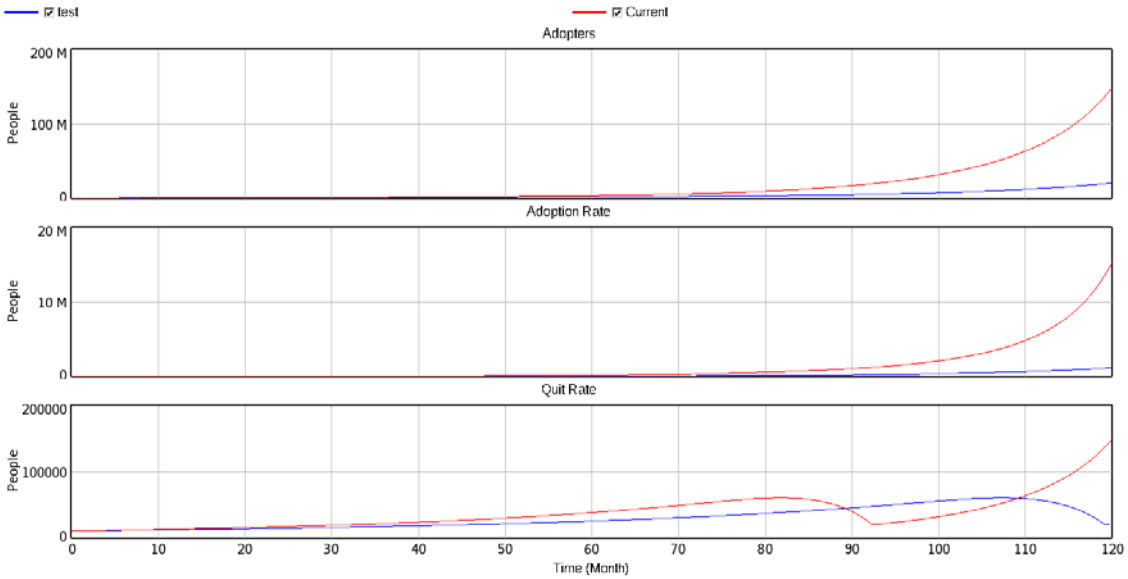


[Figure9: Results of the base run]

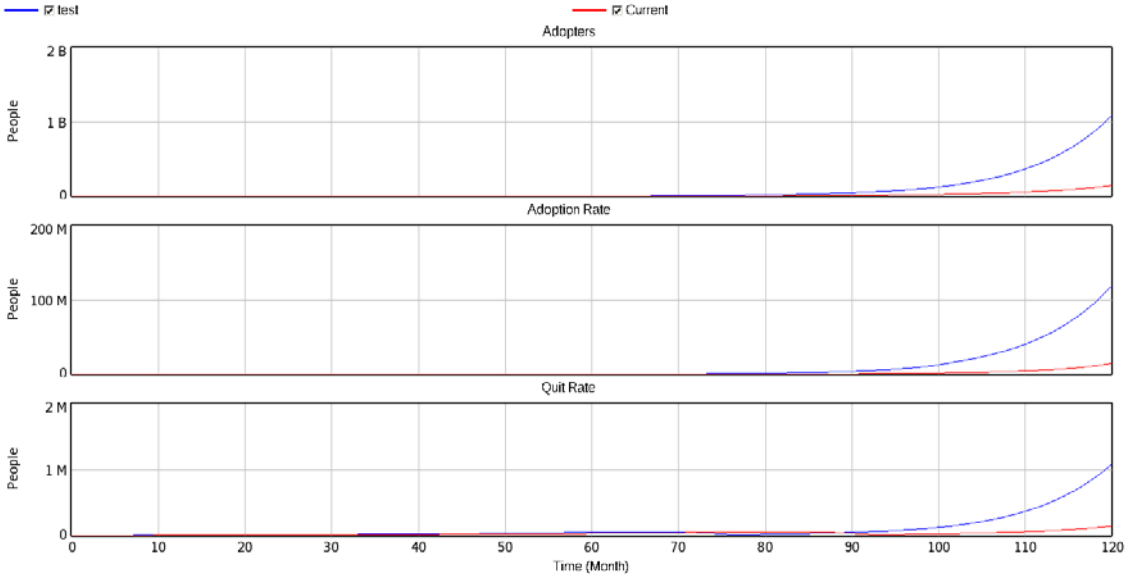
8.2 Model with Adoption Factor Changes

To verify the correctness of the model, we should evaluate the changes in the model prediction when changing adoption factors. To do this we decided to change some values and run separate simulations to each one of them so we could verify some changes. We ran 3 tests, one were government policy is negative, one were government policy is positive and one were government policy is negative and media is neutral.

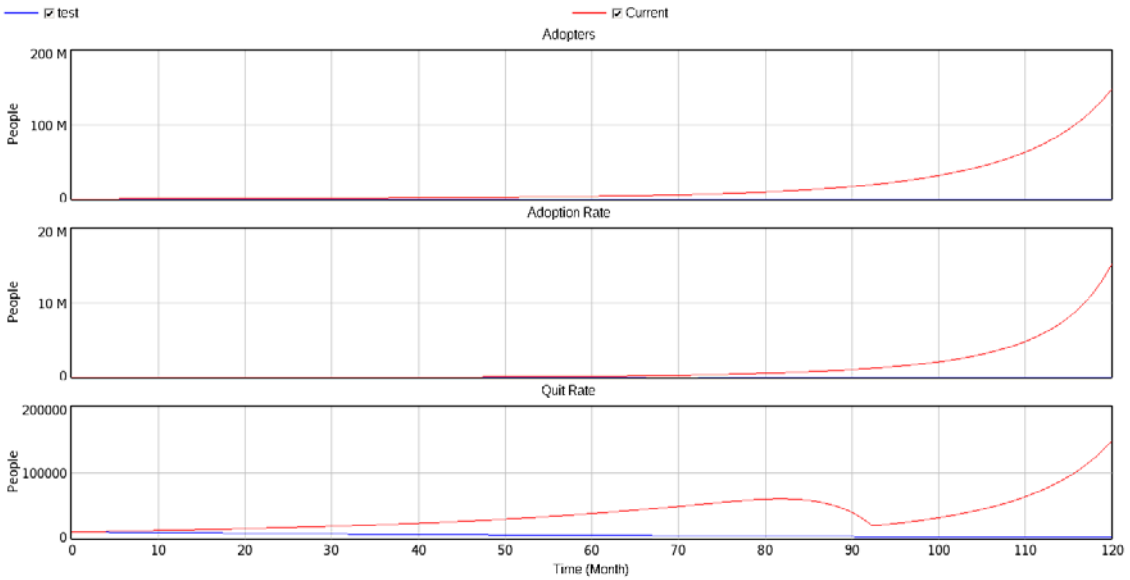
As expected, with a negative government policy (-0.2) the growth of bitcoin almost stagnated [figure10] when compared to the base run. With a positive government policy (0.2) the growth in adoption rate and consequently in adopters is clearly faster [figure 11]. If the media turns neutral and a negative government policy is applied (-0.2) the system collapses [figure 12].



[Figure 10: Results of the negative government policy run]



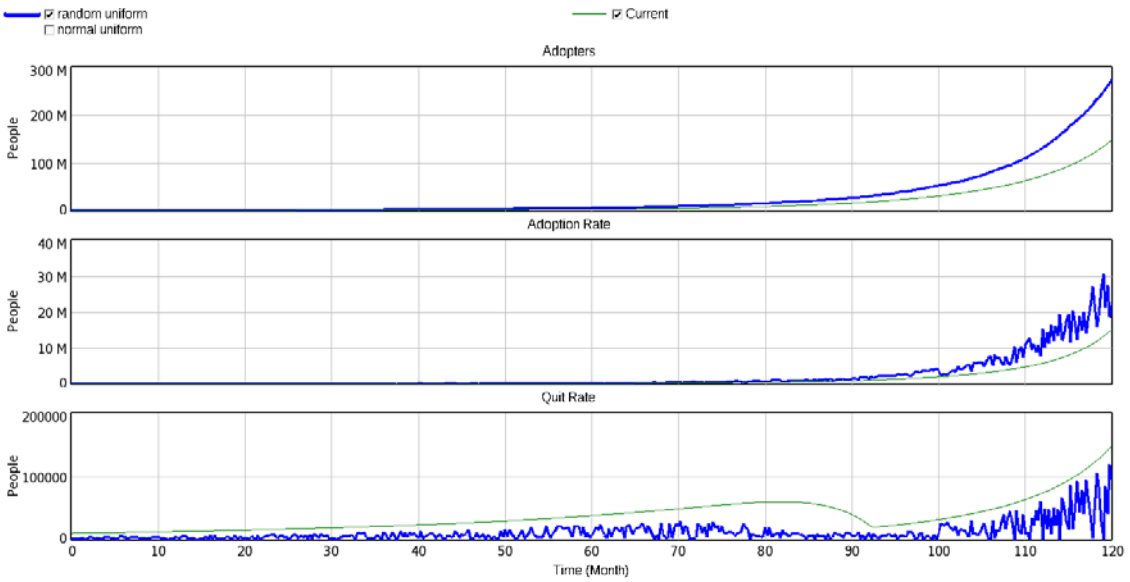
[Figure 11: Results of the positive government policy run]



[Figure 12: Results of the negative government policy and neutral media run]

8.3 Model with Uniform Randomization

After the base run we decided to add the random factor. As explained before [chapter 7] we started by using a random uniform, which means that the random numbers are evenly distributed through the space we defined. The space defined for this run was [0.6, 1.2] meaning, that we would see some aggressive growth followed by some stagnation. As we can see in the results [figure 13], this isn't able to represent the growth of bitcoin as the obtained values are too much volatile even for the bitcoin.



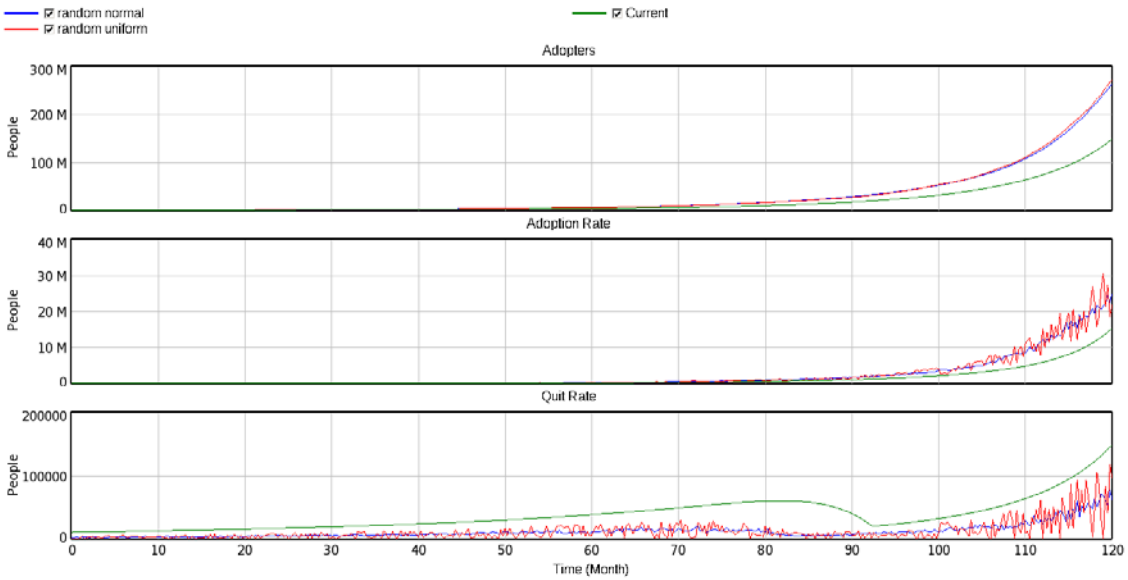
[Figure 13: Results of the random uniform run]

8.4 Model with Normal Randomization

After the results obtained with a random uniform being inadequate we decided to use another randomization factor, using another type of random, the normal random.

Random Factor = $Random\ Normal(0.6, 1.2,9,0.05, 5)$

The adoption and quit rate are now much more realistic [figure 14] without the aggressive spikes seen with a normal growth, but this isn't enough to see the fractal exponentials that we see in in the bitcoin growth.



[Figure 14: Results of the random normal run]

9. Conclusions

From the results obtained with the vensim model it can be concluded that the modulation of bitcoin growth can be done having in account the adoption factors that we chose and that changes in them are representative of what would be expected in reality. The use of the random factor allows us to create a more realistic approach by showing the rises and sudden falls of bitcoin. The random uniform gives an unrealistic adoption rate growth, that can be resolved by the use of a random normal, that gives a more smooth growth.

It still remains to do a random that could accurately represent the fractally repeating exponentially increasing gartner hype cycles.

10. References

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