Haaga-Helia
ammattikorkeakoulu Oy

# Arbitraging the KimChi premium with Bitcoin

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# Abstract

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The almost meteoric rise of Bitcoin has brought with it an investment boom in cryptocurrencies. The cryptocurrency markets however, are not functioning entirely as one would expect. Markets seem to have mispriced assets on a scale that would not happen in the stock market. Perhaps the most notable of these phenomena is the KimChi Premium or the relative overvaluing of bitcoins in Korea when compared to international markets

The aim of the study will be to establish whether or not the KimChi premium exists, what is the scale of the premium and give some clues to why the premium has come about.

The first chapter is an introduction to the subject, where the subject is outlined.

Then chapters 2-4 will explain the key ideas and concepts to understand the phenomena being examined as well as giving a backdrop against which the KimChi premium can be assessed. The chapters 2,3 and 4 seek to explain the price setting mechanisms, foreign exchange policy and Bitcoin as a larger phenomenon respectively.

Chapters 5-6 are the research and conclusion chapters where the data collected is assessed and analyzed and conclusions are drawn.

**Keywords**
Bitcoin, Arbitrage, KimChi premium, currency controls

# Abstract

Haaga-Helia ammattikorkeakoulu Oy

**Tekijä**
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**Sivut**
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Bitcoinin arvo on noussut räjähdysmäisesti sijoitusvillityksen mukana. Kryptovaluuttamarkkinat eivät kuitenkaan näytä toimivan täydellisesti. Kryptovaluuttojen hinnoittelussa ilmenee poikkeuksellisen suuria hinnoitteluvirheitä eri markkinapaikkojen kesken. Viime vuosina merkittävin näistä on KimChi preemio, joka kuvaa Koreassa maksettua ylihintaa kryptovaluutoille.

Tutkimuksen tavoitteena on kerätä perustietoa KimChi preemiosta: onko preemio todella olemassa, kuinka merkittävä se on ja kuinka se on syntynyt.

Ensimmäisessä kappaleessa esitellään aihe.

Kappaleissa 2-4 käydään läpi aiheen teoreettista viitekehystä ensin sijoitusten hinnoittelun, sitten vaihtokurssien ja lopulta Bitcoinin näkökulmista

Lopussa kappaleessa 5 käydään läpi kerätty data ja kappaleessa 6 analysoidaan kerätty data sekä tehdään lopulliset päätelmät.

**Avainsanat**
Bitcoin, Arbitraasi, KimChi preemio, valuuttasääntely

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# Key Terms

**Altcoins** refer to cryptocurrencies that are not Bitcoin. The word comes from alternative coin.

**Bitcoin**s are an electronic form of currency or an asset that can be traded peer-to-peer

**Bitcoin network** used to refer to the larger network of bitcoin users, essentially covering not only bitcoin holders but also entities that use bitcoins intermittently.

**Blockchain** refers to the distributed ledger underlying cryptocurrency transactions.

**Capital flight** is a phenomena where individuals try to secure their assets by taking them out of the country, with obvious negative effects to the national economy.

**Classical arbitrage** Is done when there is a divergence in prices between two locations and a trader buys where it is cheaper and sell where it is more expensive

**Currency controls** are a range of methods to control international flows of money

**Fintech** is technology for the financial sector, mostly focusing on software solutions.

**FOMO** or the Fear Of Missing Out, a psychological effect where the one is constantly afraid of missing a great event or opportunity. In the investment world this can lead to questionable investment decisions.

**Foreign exchange or FX** refers to transfers of money internationally

**Hodling** (Hold On for Dear Life) is term coined to refer to an investment strategy in the cryptocurrency community, where the investor should just hold on to his investment and never sell.

**KimChi Premium** refers to the positive price difference paid in South Korea for bitcoins when compared to international markets.

**Law of one price** is a rule in economics where all assets that are the same should cost the same amount.

**Hedging** means making investments that reduce the risk of an investment

**Pegging** in this context refers to a currency having a set exchange rate making it unable to change.

**Portfolio** in this context is a portfolio of assets. The purpose of portfolios is generally to diversify investments usually to reduce risk

**Risk-free rate** Is a theoretical return from a risk-free asset, setting a baseline interest rate above which a premium is paid on riskier investments.

**Remittances** are money flows from immigrants back to their families in their countries of origin.

**Triangular arbitrage** can be done when there is a discrepancy in the exchange rates offered on currencies, where through 3 transactions over 3 currencies a profit can be made.

# 1 Introduction

Bitcoin and blockchain technologies have been the hot new thing in fintech that has been assumed to disrupt everything from the monetary system to the politics and society. Early adopters imagined a world completely reshaped by this groundbreaking discovery.
Since its implementation in 2008 Bitcoin has changed its face many times, going from obscurity to drug money to a savior or the harbinger of doom, depending on who you ask. Bitcoin prices have skyrocketed, and the question of what this actually means become relevant.

State actors have acted very differently from each other, showing that not even the top brass of our financial world can fully agree on what to do. Central banks in Europe have mostly only talked of regulation, China and a few others have either banned or brought severe restrictions to trade while Japan has opened up to cryptocurrencies and is in the midst of a cryptocurrency boom.

My personal interest comes from the perspective of a Finance student who has thought that bitcoin was a bubble that was going to burst since 2014 when I first came aware of the currency, this was due to my impression that Bitcoin is not backed by anything and the expectations shoved upon it seemed unrealistic.

I was curious and kept developing my knowledge whenever I would happen upon articles and slowly became aware of Chinese traders and how they were circumventing capital controls by trading Bitcoin. It took me some months to realize that there should, as a result, be a price difference between the price of Bitcoin in Chinese Yuan and Dollars as it turns out there is. The KimChi premium turned out to be a more interesting research subject however, as China banned cryptocurrency exchanges and the KimChi premium became famous overnight with allegedly huge 50% arbitrage opportunities.

The questions I will be asking are:
1. Are there arbitrage opportunities available in exchanging Euros to Korean Won through the use of Bitcoin.
    1.1 How large are the margins of this?
    1.2 Why does the opportunity exist?
    1.3 Why is the law of one price not applicable?

# 2 Arbitrage

## 2.1 Supply and Demand

Supply and demand is a cornerstone of economic thinking and it is based on the supply and demand curves. (Matti Pohjola 2015, 50-54)
The supply curve shows at what price producers or holders are willing to sell for example apples. So, if the price of apples go up, one would assume that apple producers will be incentivized to produce more. If the price goes down they might wish to produce something else that gets them more money. (Matti Pohjola 2015, 50-54)

The demand curve is much like the supply curve but opposite. If prices of apples go down people will be happier to buy more, while if prices go up people will seek to reduce their consumption. (Matti Pohjola 2015, 50-54)

When you combine the two you get an equilibrium, where the right amount of apples are available at the right price. (Matti Pohjola 2015, 50-54)

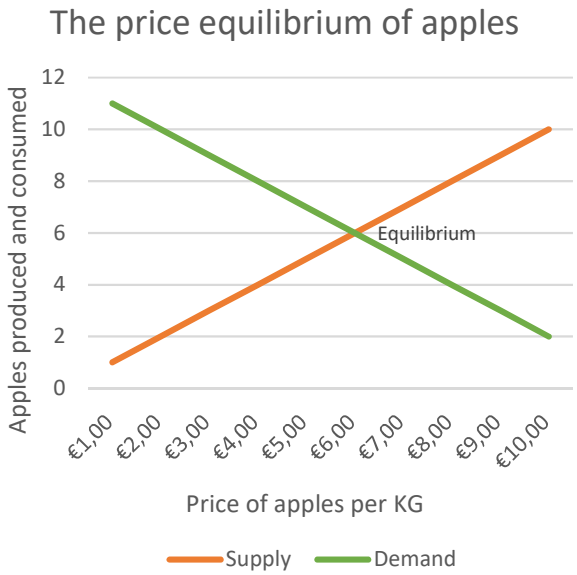



Figure 1 Supply and demand

## 2.2 Markets

For perfect market to exist, Matti Pohjola in his book Taloustieteen oppikirja sets the following parameters.

1. There are sufficient market participants with small enough shares of the market
2. All products are homogenous, and buyers pay no interest on who they buy from
3. All actors in the market have perfect information
4. Actors are free to enter and leave markets and there are no limitations on the ability to produce

As we can see the limitations on a market being perfect are very stringent and are unlikely to occur, so much so that coming up with an example of such conditions is exceedingly hard. (Matti Pohjola 2015, 38)

As we have seen the conditions for markets to always function perfectly are strenuous so to understand what is happening in the markets is often up to understanding the imperfections of the market. (Matti Pohjola 2015, 112)

Imperfect competition tends to arise when there is a lack of competition. This may be due to Monopolies or Oligopolies that push prices up in order to maximize their own profits and end up reducing the utility that society gets from their business. (Matti Pohjola 2015, 113)

Natural monopolies are businesses like that are unlikely to be competed for. An example would be electricity distribution, where a competitor would have to rebuild the entire electricity network in order to be able to compete. Simply the cost of entering such a market is so high that market will always tend towards a single owner. (Matti Pohjola 2015, 113)

The expenses of the government will always in the end have to be covered by tax income. In the markets taxation is pushed in to the pricing of products, no matter if the tax comes at the start or the end of the production cycle. (Matti Pohjola 2015, 113-114)
The effects of taxation are then dependent on the price elasticity of the product. Price elasticity can be understood by asking a question like: If oil prices double, how much less gas will I consume? The more elastic the pricing is the greater the effect will be on consumption. Gasoline is indeed a good example of inelastic consumption for example in Finland over 50% of the price of gasoline is made up of taxes. This has still not brought an end to driving cars in Finland. (Matti Pohjola 2015, 113-114; Polttoaineveroprosentti-laskuri)

Externalities in this context is taken to mean the secondary effects of some actions. Education is a good example, as education in itself does not produce any tradeable products, but is rather done for the possible future benefits an education can bring. From the perspective of a state it is worth educating people as they might pay more taxes in the future. There are also negative externalities, like for example child labor that reduces the ability of the children to develop in to adults who could have become more productive. (Matti Pohjola 2015, 115-119)

Negative externalities can be controlled in a variety of ways. One is to use force like for example requiring children to go to school. Emissions trading is in vogue for reducing greenhouse emissions. And taxation of things like alcohol to reduce consumption and to acquire funds for treating externalities. Taxes to reduce negative externalities are called Pigou taxes, after A.C.Pigou (1877-1959) who was able to show that negative externalities could be controlled through taxation. (Matti Pohjola 2015, 115-119)

Asymmetric information refers to market participants not knowing the same amount, and as such the one with more information will be able to make better financial solutions. A fruit peddler might well be aware that his fruit are rotten on the inside, but still sell them at full price to the unsuspecting customers. (Matti Pohjola 2015, 121-122)

In the modern world there are institutions and laws aimed at stopping people from taking advantage of consumer or investor trust. In Finland Finanssivalvonta is tasked with overseeing the financial markets and has a far-reaching mandate to supervise and punish, if necessary, rogue actors. (Matti Pohjola 2015, 121-122)

When it becomes apparent that counterparties have been playing foul, trust will erode, and trade as a whole might be stymied. This is what happened during the 2008 financial crisis, counterparties could no longer be sure of the liquidity of the banks they had dealt with and authorities had to step in to restore trust. (Matti Pohjola 2015, 121-122)

Transaction costs can refer to several different types of costs when they do transactions or enter markets. Transaction costs are not merely the out-of-pocket costs incurred when doing a transaction, but also the opportunity cost of the time spent and the mental cost of managing transactions. (Zak Slayback 2016)

Even as markets are generally considered a good way to organize economic activity, we can see that they don't always work as they should. Therefore, governments and institutions can improve the functioning of the market. Free markets also bring about inequality which can be addressed with taxation and remittances. (Matti Pohjola 2015, 110)

The way governments act in a society is through institutions, and even as not all institutions are run by the government, the government has the power to enforce the rule of the institutions they find necessary. Well working institutions work to bring about stability and trust in the society and enable markets to function better. (Matti Pohjola 2015, 110)

Governments can also go a long way in suppressing the creation of Monopolies and Oligopolies, as well as control the pricing of natural monopolies. (Matti Pohjola 2015, 110)

### 2.3 **Assets**

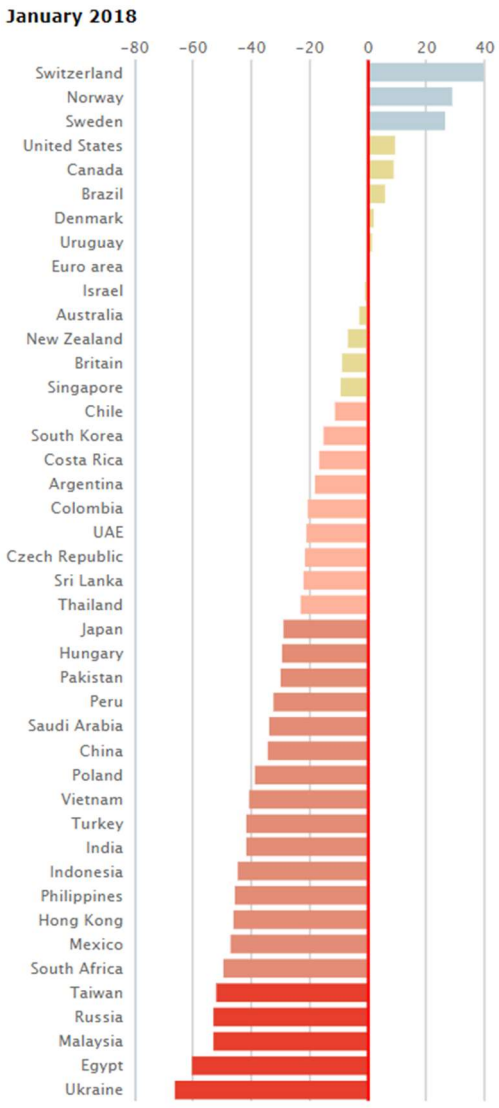
An asset is a resource held by an entity for example a person that is held with the expectation of it benefitting the holder in some way in the future. A financial way of thinking of an

asset is to think of it as something that will generate future cash flow either directly though getting money or indirectly by increasing other cash flows or reducing costs. (Investopedia (3))

In his book John C. Hull (2012, 24) notes that there can be assets of different kinds. Commodity assets require assessments of quality, these are things produced in the real world like corn that are rarely heterogenous in quality. Some commodities are traded in different quality ranges.

Financial assets however are generally well defined. For example, there is no need to define the quality of a Bitcoin compared to another Bitcoin. (John C. Hull 2012, 24-25)

Purchasing power parity to which I will from now on refer to as PPP is an example of the law of one price, containing the idea that the same goods or assets should be purchasable for the same price. How well this principle works in international markets is seen through the PPP. According to the law of supply and demand if a currency is underpriced then the products of that country should be cheaper, and demand should increase to bring the markets back to an equilibrium. (John L. Teall, 2013 185)




A well-known example is the “Big Mac index” which measures how much a Big Mac costs at MacDonald’s. The index is meant to be a somewhat light-hearted look at PPP, but is gets the point across quite well. If the law of one price holds true a Big Mac should cost the same in all countries. If a Big Mac costs less in euros than in dollars we can claim that the euro is undervalued, or the dollar is overvalued. (John L. Teall, 2013 185)

Figure 2: The Big Mac implied over and undervaluedness of currencies (The Economist (1))

To trade in assets there needs to be a mechanism in place to define its value, a widely known pricing model is the Capital Asset Pricing Model (CAPM). CAPM calculates the expected return of an asset through the risk involved.

The risk is divided in to 2 parts:

1. Systematic risk that affects the entire market and as such cannot be hedged against.
2. Nonsystematic risk that is specific to a single asset and can be hedged against by diversification.

CAPM is calculated with the following formula:

$$\text{Expected return} = R_F + \beta\,(R_M - R_F)$$

Here
- $R_F$ = The risk-free Rate
- $\beta$ = Is the systematic risk
- $R_M$ = Is the market return rate

Therefore, the β shows the sensitivity of the asset to the returns on the market. Example If the stock market yields increase by 2% then a stock with a β of 1 will also increase 2% in yield or with a β = 2 the yield of the stock will increase by 4%. So, the β tracks how well an asset follows market movements. (John C. Hull 2012, 73-74)

| Returns from a stock | β |
|---|---|
| 3 % | -0,4 |
| 4 % | -0,2 |
| 5 % | 0 |
| 7 % | 0,4 |
| 9 % | 0,8 |
| 10 % | 1 |
| 11 % | 1,2 |
| 12 % | 1,4 |

The β of a stock when $R_F$ = 5% and $R_M$ = 10%

CAPM is however reliant on several assumptions to be functional

1. Investors are only interested in the returns and the standard deviation of the asset
2. Separate assets only correlate with each other through the market, having no intrinsic correlations between them
3. All investors are focusing on the same time period for their returns
4. Loans are equally available to all actors at the risk-free rate
5. There are no taxes
6. All investors look at the assets the same way, arriving at the same expected returns.

In the real world all these conditions will not hold true. One should be wary of using CAPM for the evaluation of single assets as results may not be very reliable. Nonetheless CAPM is a useful tool for investors if it is not taken as the be-all end-all truth. (John C. Hull 2012, 73-74)

## 2.4 **Arbitrage**

Assuming that markets are prefect we can apply the law of supply and demand to come up with the law of one price. The law of one price states that all goods should have the same price. While we might know that markets are imperfect the law still plays in to exchange rates. Take for example that apples cost 1€ in Europe and 1,5$ in the US. This would imply an EUR/USD exchange rate of 1,5. While we can see that the law of one price is imperfect, we can still use it to analyze purchasing power parity and exchange rates, as it draws a line between prices at home and prices in foreign countries.

Arbitrage is defined as “the simultaneous purchase and sale of assets or portfolios yield ing identical cash flows.” Arbitrage can be considered the most important pricing tool in modern finance. The idea of Arbitrage is that Assets that generate identical cash flows, regardless if certain or risky, should be equally priced as stipulated by the law of one price. If assets that have the same yields but are traded at different prices, arbitrage can be done by first buying the cheaper asset and then selling the more expensive one. This is called, quite obviously, an arbitrage opportunity. (John L. Teall, 2013 144-145)

Assuming that traders act rationally, when an arbitrage opportunity arises, they will immediately sell the asset at a higher price and use the proceeds to finance the buying at the lower price. These traders are called Arbitrageurs. The arbitrageurs will continue to reinvest whatever profit they have made during their last round-trip in to the arbitrage opportunity, their capital growing exponentially, unless market prices change. The arbitrageur with his ever-increasing capital should cause pressure on the markets to change prices so that arbitrage is no longer possible. Arbitrageurs therefore insure that identical assets have identical prices assuming the markets are competitive. (John L. Teall, 2013 144-145)

In its purest form arbitrage refers to classical arbitrage or trading the same specific asset immediately at a profit in 2 separate locations. Say for example a bottle of Vodka costs 20€ in Tallinn and 40€ in Helsinki so an arbitrage opportunity exists. One could buy Vodka in Tallinn for 20€ and sell it in Helsinki for 40€. Assuming the trader can move from Helsinki to Tallinn in 0 time and at 0 cost she can cash in on a classical arbitrage opportunity, making 20€ on each round-trip. In an idealized world the trades would also be executed simultaneously meaning that there would be no risk or capital required for the trader. (John L. Teall, 2013 144-145)

Were such a trading opportunity present itself it would attract more and more peddlers until the laws of supply and demand force the 2 prices to be equal. This is the reason why in unimpeded free markets, arbitrage opportunities are unlikely to be available for very long. Things are even simpler in a crossed market. Say someone is offering to sell Nokia stock for 4€ and someone is simultaneously offering to buy some at 4,5€. One could simply execute the trade between the 2 and take the 0,50€ for himself. This can happen when 2 traders are unaware of each other's offers or when prices are moving, and a trader reacts too slowly to withdraw his offer. (John L. Teall, 2013 144-145)

Classical arbitrage opportunities are quite rare and what is usually talked about when referring to arbitrage is the trading of portfolios with similar cash flows. Options can be used to replicate cash flows from different assets as well. (John L. Teall, 2013 144-145)

Also trade in offsetting securities that are strongly correlated can be considered arbitrage. For example, a mineral portfolio can correlate strongly with a mining industry stock, and if prices of the 2 diverge arbitrage opportunities might emerge. Quasi-arbitrage is a term often applied to these as they might not be subject to some types of risk either through divergence of the assets or the inability to execute the transactions immediately. (John L. Teall, 2013 144-145)

The law of one price is maintained through arbitrageurs, and as such arbitrage underlies relative securities valuation. This allows us to price individual securities or portfolios of securities relative to one another. The price of a security should be the same as the value of a portfolio built to replicate it. According to John L Teall if the law of one price does not hold it is due to 1 of 2 reasons:

1. An arbitrage opportunity currently exists
2. The market is somehow imperfect

In currency trading there is a possibility of triangular arbitrage. It functions by exploiting the relative price difference of 3 currencies. Say for example the following quotes are available for buying and selling.

| | |
|---|---|
| 1 EUR = 1,25 USD | Say you have 1000 EUR, you could do the following: |
| 1 USD = 10 SEK | Trade your euros for 1250 USD |
| 1 EUR = 12 SEK | Sell 1250 USD for 12500 SEK |
| | Buy 1045 EUR for 12500 SEK and make a 45-euro risk-free profit. |

The price discrepancy between the different currencies exchange rates create an arbitrage opportunity. This should bring in arbitrageurs looking to make a quick buck and

through the law of supply and demand bring the exchange rates to an equilibrium. (John L. Teall, 2013 184-185)

# 3 The economics of currency

## 3.1 Macroeconomics

Macroeconomics studies the effects of economic policy, and asks questions like: what policies will help our economy grow? Macroeconomics utilizes data, economic models and historical trends as a basis for decision making. (Matti Pohjola 2015, 153-268)

Economists strive for 3 goals:

1. Maintain economic growth
2. Limit unemployment
3. Keep prices stable

These are measured with 3 sets of data

1. GDP or gross domestic product
2. Unemployment rate
3. Inflation rate

These data points have had their fair share of criticisms, but to this day they seem the best indicators of economic wellbeing. (Matti Pohjola 2015, 153-268)

## 3.2 Exchange rate determination

During the times of the gold standard governments would issue money in relation to their gold reserves and thus, at least in principle, the relative values of currencies were clear. This, however is no longer the case with free floating currencies nor do nations guarantee their currencies with gold. Therefore, the research in to exchange rates started in earnest after the end of the Bretton-Woods era in 1973. The free market controls exchange rates. As one might expect currencies are subject to the law of supply and demand, and international markets can see the value of a currency change every second. (Paul R. Krugman, Maurice Obstfeld & Marc J. Melitz 2018 469-474)

In September 2010, the finance minister of Brazil declared that the world was in a currency war. He said this, believing that wealthy countries were devaluing their currencies at Brazils expense. Whatever the truthfulness of this claim, he was on to the fact that economic policy does not exist in a vacuum, and that other countries also influence each other with their policies. International cooperation on monetary policy has been on the cards but is still in its infancy. (Paul R. Krugman et al. 2018 469-474)

Most developed economies, in modern times, have had a free-floating currency exchange rate. This has however not always been the case. All the way till end of the Bretton-Woods exchange rate system, in 1973, major currencies have been tied either directly or indirectly to gold. Bretton-Woods was created in the aftermath of the second world war in 1944. The US dollar was pegged to gold and could be exchanged for 35 USD per ounce of gold. Other large currencies would then be pegged to the US dollar and their respective

governments would maintain their currencies within narrow limits in terms of valuation. (Callum Henderson 2006, 107-108)

As the US moved away from the gold standard, other countries then gave up their pegs and a large swath of the global economy now had free floating exchange rates. With the markets taking charge of exchange rates, not only relative to before but also in the way monetary policy was conducted. (Callum Henderson 2006, 107-108)

### 3.3 Government intervention

Currencies being mostly free-floating has not brought an end to government interventions in monetary policy. Many nations have pegged their currencies, vowing to maintain an exchange rate at a set price. A pegged exchange rate will however require commitment to maintain and may prove to be costly to maintain in the long run. Even countries that do not directly intervene by pegging, can affect exchange rates by changing interest rates or printing money. (Callum Henderson 2006, 107-108)

Even the strongest supporters of free trade have had to admit that governments have been able to stabilize situations that could otherwise been harmful to the economy. From this a balance has emerged between those who are for and against governments intervening in exchange rates. Where intervention is sometimes seen as necessary but letting currencies float is preferred under normal circumstances. (Callum Henderson 2006, 107-108)

Economic intervention by the central banks has mostly become a rarity in the West. What is more common however are “verbal interventions” where authorities signal their intentions and the markets react accordingly. (Callum Henderson 2006, 107-110)

A key problem limiting government interventions in the currency markets is the impossible triangle. The impossible triangle of monetary policy is a demonstration of 3 economic factors of which only 2 can exist at once. (Matti Pohjola 2015, 240)

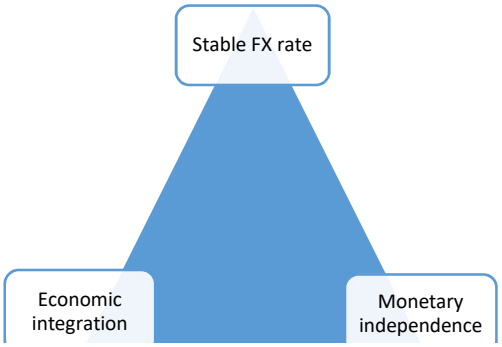


Figure 3 Impossible triangle

The points of the triangle are the following:
-Stable foreign exchange rate meaning that the national currency can reliably be exchanged with the central bank at a given rate.

-Economic integration meaning that trade of both goods and currencies can flow freely without government intervention and all the difficulties that come with it.

-Monetary independence, where the central bank can independently set monetary policy and for example devalue the national currency or adjust interest rates. (Matti Pohjola 2015, 240)

### 3.3.1 Pegging

While central banks no longer guarantee the value of their currencies with gold, they do still sometimes maintain a peg. Pegging is a policy where a government guarantees an exchange rate by offering to buy and sell at a set exchange rate. A peg can be over or undervalued depending on the political and economic goals of the one supporting it. (Daron Acemoglu, David Laibson & John A. List 2016 727-734)

In terms of the impossible triangle pegging gives up independent monetary policy as the policies of the nation will have to somehow match economic conditions of the nation the currency is pegged to.

A currency board is the hardest form of pegging without dollarization. The central bank that has adopted a hard peg gives up its ability to do independent monetary policy in exchange for the currency to maintain the value of the currency. The board pledges to exchange its own currency to the pegged currency, generally the dollar, at the rate set by the board. The exchange rate is thus unable to change as the board guarantees it. (Callum Henderson 2006, 114-119)

The policy provides reliability and transparency but requires the nation to do whatever it takes to maintain the exchange rate. This often means adopting draconian measures to stop the exchange rate from changing. (Callum Henderson 2006, 114-119)

An overvalued peg is where for example the Mexican peso is maintained at a price slightly higher than it might otherwise be. This will reduce prices of foreign good within Mexico and control inflation. However, such a strategy requires foreign exchange reserves as the central bank must be ready to buy pesos in exchange for other currencies. This approach is aimed at increasing the demand of the currency in question, therefore pushing the equilibrium upward. (Daron Acemoglu, et al. 2016 727-734)

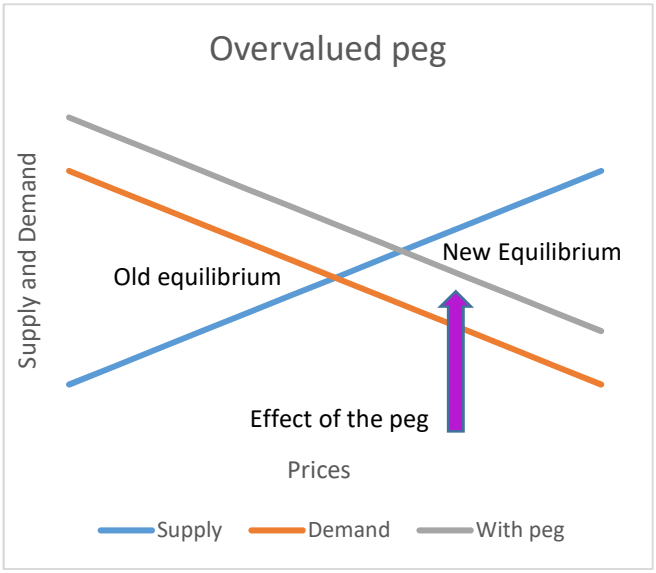



Figure 4 Effects of overvaluation

An undervalued peg is what many consider China to do. Whenever the Chinese currency, the renminbi or yuan gains in value the central bank starts a buying programme, where it buys foreign currencies, pushing down the value of the renminbi. This type of a peg is much easier to maintain as the bank only needs to hold domestic currency to maintain the peg, and if needed can print more of it. Here the bank brings the equilibrium price of the currency down by increasing the supply of its domestic currency. (Daron Acemoglu, et al. 2016 727-734)

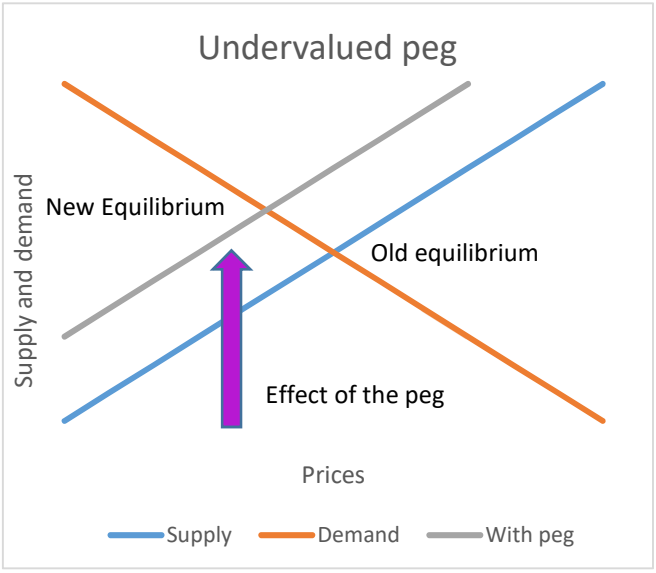



Figure 5 Effects of undervaluation

The “durability” of a peg can be tested and it can yield large profits for the winning side. Currency trader George Soros took a loan of 10 billion pounds and exchanged them for German marks expecting the relative value of the currencies to change. As the British government had a peg on the exchange rate between pounds and marks, they were forced in to selling their currency reserves to maintain the peg. In the end the British authorities proved unable to support the peg as they ran out of reserves, bringing about a crash in the value of the pound. Soros was then able to pay back his loans at a discount as he took loans in pounds but was holding German marks. (Daron Acemoglu, et al. 2016 727-734)

### 3.3.2 Currency controls

Currency controls are a way or a country to manage its currency FX rate. This can be done to protect small and vulnerable economies from rapid exchange rate fluctuations. When trading volumes go down it requires less resources to change or maintain a market equilibrium. This can be useful to limit the harmful effect of crises and markets "overshooting", where the markets expect for the currency to lose value and it becomes a self-fulfilling prophesy. In countries like China currency controls are also a way of limiting capital flight. (Investopedia (1), ZeroHedge)

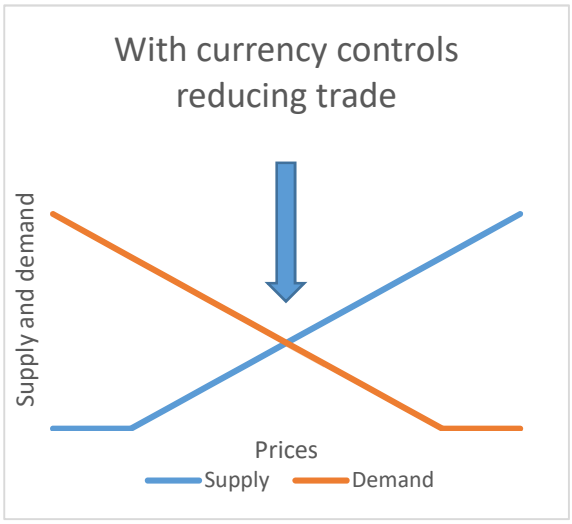



Figure 6 "thinning" the markets with currency controls

Currency controls work by reducing the supply or demand of the currency, effectively lowering quantities traded. There are a few ways a government can control currency exchange. Firstly, individuals can be banned from holding or using, all or specific foreign currencies. Secondly the government can monopolize exchanges, the monopoly can then set exchange rates, effectively making the person unable to sell his currency at the right price. Thirdly the quantities that can be exchanged can be limited. In China a citizen can only exchange 50 000 dollars worth of Renminbi a year. (Investopedia (1), export.gov)

As we apply the law of supply and demand and what we know about currency controls we can conclude that when governments restrict trading in their respective currency they are distorting supply and demand. This is to mean that more people would like to buy or sell more currencies than is possible at the time.

This in turns causes there to be a price difference between what the official exchange rate is and what is the real exchange rate according to supply and demand. When the difference between the 2 prices gets large enough black markets will emerge. Black-markets comprise mostly of individuals who want to trade something that they would otherwise be unable to get, at least not at the same price. This can be crime-related like drugs or in some extreme cases even necessities such as food. Trades are done "under the table" meaning without any official involvement, one of the reasons for black-markets existing is tax avoidance. (Investopedia (2))

### 3.4 **Case of South Korea**

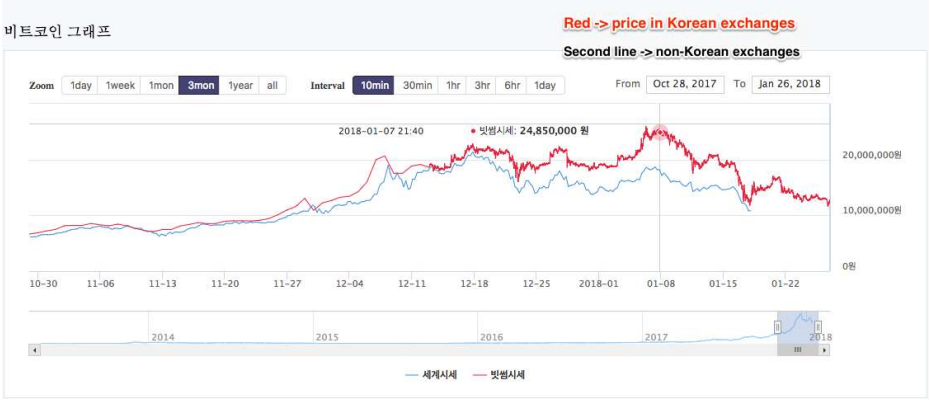
South Korea is a relatively small country, with an independent currency the Korean Won. The Korean won has suffered several crises for example during the 2008 financial crisis where the currency plummeted. The troubled history has caused the Korean government to be vary of fluctuations in the value of their currency. (The Economist (2), 2010)

To minimize risks the Korean won is subject to currency controls. The range of measures extend from capping annual exchanges worth more than 50 000 dollars for individuals as well as setting limitations on banks in holding foreign derivatives. All this is meant to limit destabilizing currency flows. (The Economist (2), 2010)

Despite restrictions South Korea has seen a Cryptocurrency boom with 3 out of 10 salaried workers owning bitcoins directly. This has made South Korea the third largest Bitcoin market in the world with roughly 2 million investors or 1 in 25 South Koreans. With the rise of “cryptocurrency zombies”, people who can’t stop checking on their investments, there are even fears of “social or pathological phenomena” (Hailey Jo, 2017)

The Korean government has aimed to limit trading in cryptocurrencies to domestic actors. This is achieved by limiting Korean cryptocurrency exchanges to people with a Korean ID. The KimChi premium had already born before the government stepped in, so the premium cannot be blamed on cryptocurrency regulations. The Korean government has also not defined whether bitcoins are currency or goods. Goods are controlled by the “Foreign Trade Act” and the “Foreign Exchange Transaction Act” requiring that bitcoins be declared to customs as imports. (Medium, 2018)

The KimChi premium is a relative overpricing of cryptocurrencies, chiefly bitcoin, in relation to the exchange rate of Korean Won to other currencies. The overpricing of bitcoin in relation to the US dollar reached as high as 50% on the first of January 2018. (Medium, 2018)




Graph 1 The KimChi premium (Medium, 2018)

# 4 Bitcoin

## 4.1 Bitcoin

To give Bitcoin a backdrop one needs to take one step back. Therefore, I have chosen to see Bitcoin as a part of fintech. Fintech is short for financial technology. Fintech is not generally considered to contain platforms, but rather software for already existing platforms. An example of this would be mobile banking applications. The goal of fintech is to provide electronic services for banking and finance through technology. (Ferratum, 2018)

Digital currency and digital transactions have been around for some time. Digital currency refers to money stored and transferred electronically. This can refer to money on a bank account. Whenever you use your credit card you are using digital money. The money on your bank account is supposed to represent real money that physically exists. (Andrew Wagner 2014)

Digital currencies have so far been based on a trusted third party as an intermediary to record and verify transactions. With the increasing digitalization of our society is slowly becoming cashless. There have been attempts to make fully digital currencies, like E-gold in 1996 but they have not taken off for a variety of reasons. (Andrew Wagner 2014)

Takeshi Nakamoto, the supposed creator of Bitcoin defines it in his white paper titled “Bitcoin: A Peer-to-Peer Electronic Cash System” as a form of electronic cash that can be used peer-to-peer (P2P) without the need for a financial institution as an intermediary. (Satoshi Nakamoto 2008)

In the paper Nakamoto outlines his solution to the weaknesses of the “trust-based model” that makes financial institutions act mediators for disputes. This cost then increases service prices making small transactions impossible. A second issue Nakamoto refers to is the impossibility of making an irreversible payment for a non-reversible service. Reversible payments require trust from traders as customers can defraud the trader. Bitcoin with this P2P system could solve this problem by acting more like cash, ensuring payments cannot be reversed. (Satoshi Nakamoto 2008)

The success of Bitcoin has brought with it other cryptocurrencies or alternative coins known as Altcoins**.** Altcoins usually try to improve on the blockchain technology of Bitcoin,

for example the Etherium blockchain among other new features is a platform for smart contracts. (Pavel Ciaian, Miroslava Rajcaniova & d'Artis Kancs)

A study by Pavel Ciaian, Miroslava Rajcaniova and d'Artis Kancs on Virtual relationships, studying the interdependence of cryptocurrency prices found that a large majority of alt-coins are purchased with Bitcoins and that Bitcoin and altcoin prices are interdependent, but more in the short than in the long run. (Pavel Ciaian, Miroslava, et al, 2017)

The way Bitcoin works P2P is through a blockchain. The blockchain effectively works as a clearing house of Bitcoin transactions where people mining the blockchain confirm transactions. The Blockchain then contains a ledger of all the transactions that have been made. (Satoshi Nakamoto 2008)

The more technical details of how the blockchain works have been "hashed" out by data scientists around the world. Jay Zeng in her engineer's thesis "Bitcoin ja tietoturva" (2017) outlines 2 facts about Bitcoin.

1. Bitcoin is not currently hackable
2. Bitcoin is pseudonymous

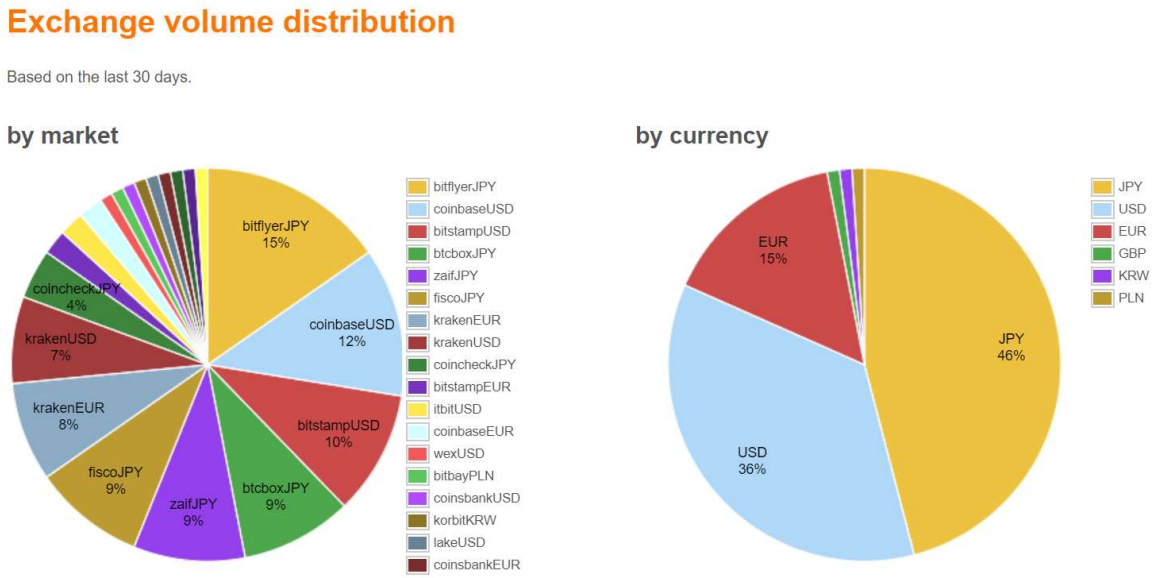
From these 2 facts we can conclude that Bitcoin is a valid asset that is not going to lose all value due to a hack. And Bitcoin can be used anonymously as long as the Bitcoin wallet and a person's identity cannot be connected due to external reasons. (Jay Zeng 2017)

The blockchain is sometimes referred to as a distributed ledger. This is in contrast to a centralized ledger. A centralized ledger is like a bank database where the bank holds a record of who owns how much money. A distributed ledger is a type of database that is shared among the users of the ledger. This means that the majority decide together which transactions are legitimate and which coins exist. (Mukesh Thakur, 2017)

This technology has far more potential than just cryptocurrencies. For example Mukesh Thakur in his master's thesis at the University of Helsinki researched the possibility of using blockchain to make an internet cloud service that would use the Etherium (an altcoin) blockchain to provide the platform for providing cloud services. This would avoid the possibility of someone hacking the cloud service providers database and attaining knowledge about the users as: "The contract transactions are immortal, anonymous, distributed and decentralized. These transactions can be verified by anyone in the network but cannot be decrypted by anyone than the owner.". The study found that the current version was not scalable, due to the slowness of transactions, but there is immense potential for future development. (Mukesh Thakur, 2017)

## 4.2 Bitcoin transactions

To use bitcoins, you will first need to create a wallet, acting as an address from which you can send and receive transactions. The wallet is combination of numbers and letters 20 characters long and contains no personal identification, making holding bitcoins pseudonymous. Bitcoins can be exchanged peer to peer, but generally bitcoins are traded in exchanges, where they can be turned in to other currencies. (Krista Uusitalo, 2017, Mukesh Thakur, 2017)




Graph 2 retrieved: 26.3.2018 (bitcoincharts.com)

There are several large exchanges, with the 8 largest exchanges averaging a little under 10% of market share. Most trades (46%) are conducted in Japanese Yen and second most in American dollars (36%). (bitcoincharts.com)

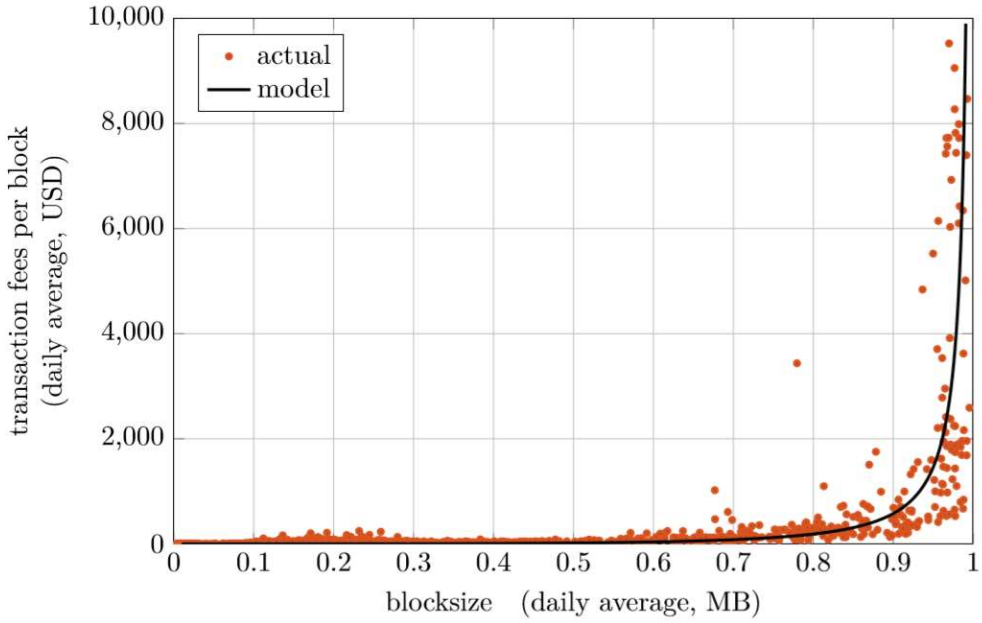
Transactions are confirmed by the computing power produced by Bitcoin miners. According to the Bank of Finland discussion papers, written by Gur Huberman, Jacob D. Leshno and Ciamac Moallemi transactions serve 2 purposes in the Bitcoin economy:

1. When new bitcoins are no longer given to miners they will receive transaction fees
2. They choose transaction priority

A trader can set a reward for his transaction, depending on how quickly he wants it completed. Miners will then accept the reward in exchange for confirming the transaction. Logically the miner will confirm transactions that yield the greatest profit, making miners price takers not setters. Transactions are stochastic, meaning that even when there is sufficient computing power available to complete all transactions some transactions will be delayed.

The problem with the system is according to the study that the system creates an economy where transaction times need to be significant, so there is an incentive to pay the miners. This has led to transaction times and prices rising. (Gur Huberman, Jacob D. Leshno & Ciamac Moallemi, 2017)

In 2017 CNBC wrote about people taking to Twitter when a 25$ transaction, cost 16$ to make while the average transaction cost 28$. The viability of transactions that exceed 50% of the sum transferred in costs are feared to undermine the viability of Bitcoin as a currency. There is some hope that there will be more efficient answers in the future, however the community seems indecisive in implementing updates to improve the situation. (Ryan Browne, 2017)




Graph 3 Relationship of blocksize [transaction quantity] and transaction fees (Gur Huberman, Jacob D. Leshno & Ciamac Moallemi, 2017)

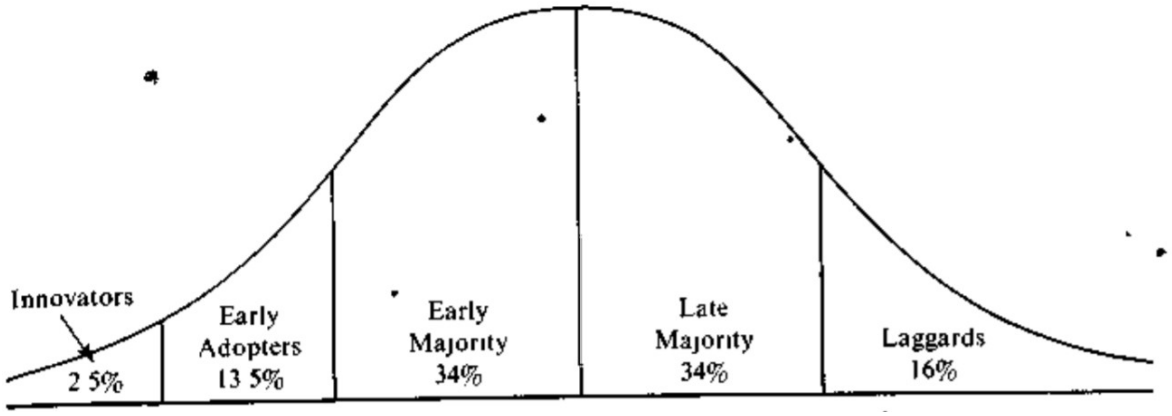
Mining bitcoins works much like a tournament, where the winner takes it all. Computers try to solve a mathematical problem by guessing and the one with the correct answer gets the reward. This process is purposefully resource-intensive as to make it impossibly expensive to hack the system. Someone with more computing power is more likely to solve the problem and get the reward. With the development of Bitcoin mining the mining has consolidated to larger players making “amateur” miners with consumer hardware ever more obsolete. (Adam S. Hayes, 2016)

Mining Bitcoin has become such a large industry that it consumes massive amounts of energy. Diginomist, a platform intended to spread cryptocurrency knowledge, assesses the

current energy consumption of Bitcoin mining to be almost 60 terawatt hours annually, making it close to equaling the annual energy consumption of Kuwait. The energy consumption is worrying environmentalists and there is growing concern over the sustainability of the growth of the Bitcoin network. (Diginomist, 2018)

### 4.3 Who owns bitcoins?

Adoption of new technologies is very aptly modeled by the adoption graph created by Everett M. Rogers. The basic idea being that not everyone starts using new innovations at the same time. Whenever a new innovation starts maturing questions of how much growth is still possible starts being asked. In this chapter we will be looking at the adoption of Bitcoin and blockchain technology, as well as which groups started adopting Bitcoin and when. (Everett M. Rogers, 1962)

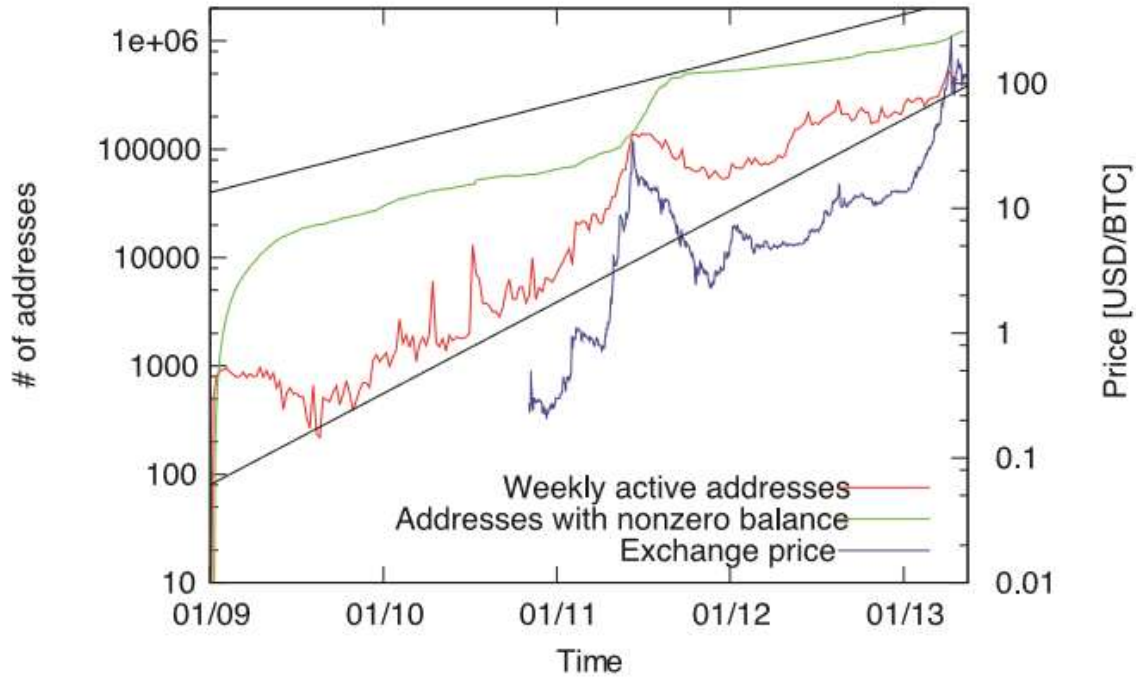


Graph 4 Adoption based on innovativeness (Everett M. Rogers, 1962, 247)

Bitcoin trading started on exchanges in late 2010 and mainstream media attention started bringing in significant numbers of users during 2011. Before this Bitcoins were mostly owned by a small number of techies. Early adopters saw great potential in Bitcoin as a currency. In 2012 Jesse Lindroos from Haaga-Helia created a questionnaire where he asked Bitcoin owners about their opinions on why they have bitcoins, almost 80% answered they were holding Bitcoin as an investment. While the sample size in the study is very small we can draw the conclusion that even in 2012 Bitcoin was acquired at least as much as an investment as a useable currency. (Jesse Lindroos, 2012)

A study by Dániel Kondor, Márton Pósfai, István Csabai and Gábor Vattay studied the data stored in the blockchain. They found that increasing your wealth in the Bitcoin network was fundamentally related to your ability to attract new connections. This is to mean that if you bring in new users, you will probably become wealthy as well. They also found that bitcoins are subject to preferential attachment, meaning in layman's terms that the rich get richer. During the writing of the study in 2014, 6,28% of addresses owned 93,72%

of the currency. At the current (3.3.2018), according to bitinfocharts.com Bitcoin rich list, 2,8% of addresses own 97% of the wealth. (Dániel Kondor, Márton Pósfai, István Csabai & Gábor Vattay, 2014)




Graph 5 Growth of the Bitcoin network, exponential graph. (Kondor D, et al. 2013)

### 4.3.1 Illegal uses

The anonymity of trading in Bitcoin then started attracting trade in illegal substances. Perhaps the most notable case of bitcoins being used for illegal trade was the Silk Road, a website where one could buy and sell practically anything in exchange for bitcoins. The site was started in 2011 and closed in 2013, although other similar sites have since been opened. The founder of Silk Road, Ross Ulbright was able to amass 1,2 Billion dollars worth of bitcoins, before the shutdown of his site and his own life sentence in prison. (Hope Reese, 2017)

In a less known case from 2017 a South Korean police officer was indicted for selling Korean won in exchange for Chinese Renminbi (Yuan). In essence the parties were running an illegal foreign exchange office that allowed anonymous customers to move Chinese money abroad anonymously. Mr. A was convicted in South Korea of violating foreign exchange laws. What this case highlights is the possibility and the profitability of bypassing capital controls with Bitcoin. (Kevin Helms, 2017)

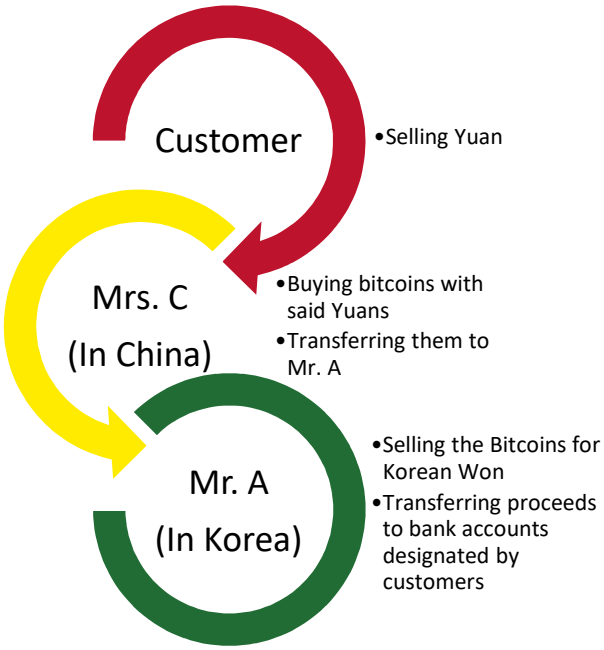
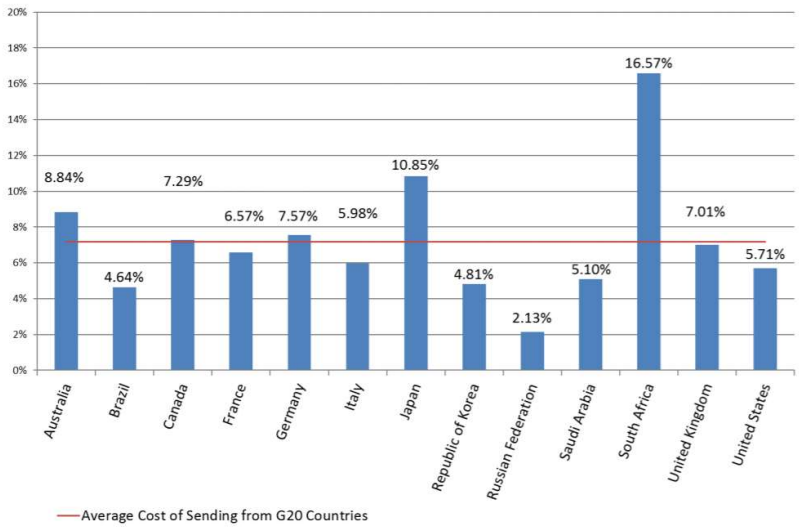



Figure 7 Trading structure of a crime

### 4.3.2 Legal uses

The positive side of free international transactions is to allow people working abroad remit money back home. The idea of remittances is that people originating in poorer countries send money back home to their families. Traditional remittance companies like Western Union have high transaction costs, with some countries averaging over 10% of the sums transferred. With the global average at over 7% (World Bank, 2017) (World Bank, 2017)

Figure 6 Average cost of remitting from G20 countries




Graph 6 Average remittance costs

With bitcoins the cost of remittances can, at least in theory, be reduced. Especially for smaller transactions. The benefits of using cryptocurrencies for remittances can be signifi-

cant. Sending Bitcoins can be immediate and transfer costs are often lower. Traders in receiving countries may also lack bank accounts and access to financial services making cryptocurrency transfers more accessible. (Scott Brett, 2016)

The rise of public awareness and the price of bitcoin created a self-fulfilling prophesy where more investors would be drawn to Bitcoin due to potential gains as well as FOMO the fear of missing out. Gains upon gains ever since Bitcoins started to be traded have led investors to be optimistic about its prospects. But when prices are defined by expectations of future value how realistic are they? (Annie Nova, 2017)

The investment community is split on the issue of Bitcoin. Warren Buffett for example came out saying that cryptocurrencies were fated to a “bad ending.” In response the CEO of Bitcoin exchange Binance Zhao Changpeng commented that Warren Buffett has no understanding of cryptocurrencies. (Colin Harper, 2018)

Graham Rapier at Business Insider cites a report by Barclay’s that compared Bitcoin to a virus. According to business insider members of the population are in one of 3 categories:

1. The susceptible
2. The infected
3. The immune

The idea being that the susceptible are the people who are yet unaware of Bitcoin and are still susceptible to become investors. The infected are those who own bitcoins and the immune are the ones who know of Bitcoin but don’t invest in it. What the report claims is that awareness has already risen high with 90% of the population being aware of Bitcoin. This, according to the report, means that Bitcoin will not be able to rise in price, as most of the population has become immune and significant numbers of new investors will no longer be joining the community. (Graham Rapier, 2018)

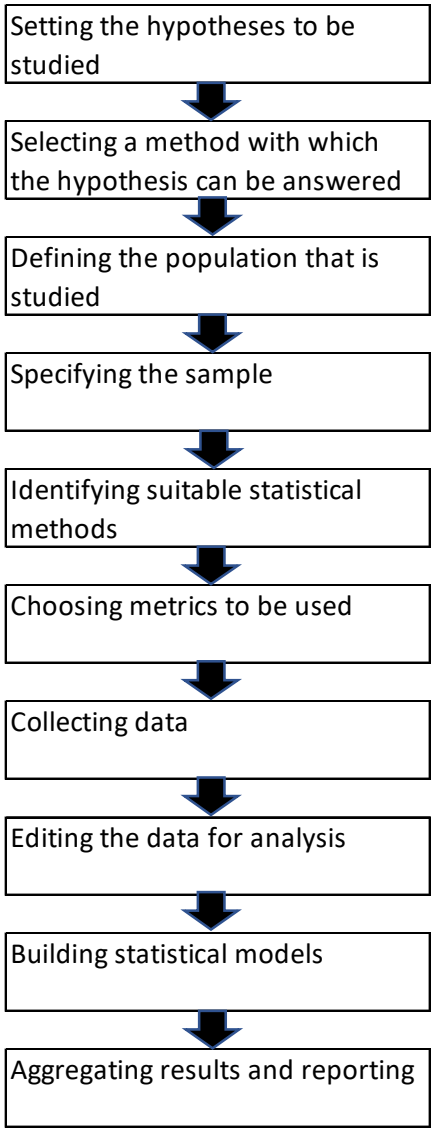
# 5 Empiricism

## 5.1 The hypothesis

The empirical part of this study will focus of statistical analysis. The structure I will use was laid out by Jouni Peltonen in his teaching materials. I will also be using the book Tutkiva toiminta ja Ilmaisu, teos, tekeminen by Pirkko Anttila as a guide to writing this part. (J. Peltonen, 1997, Pirkko Anttila, 2006)

The hypothesis we will be examining is:
1. Are there arbitrage opportunities available in exchanging Euros to Korean Won through the use of Bitcoin.
    1.1 Why does the opportunity exist
    1.2 How large are the margins of this
    1.3 Why is the law of one price not applicable

There are several ways to answer the initial question. One would be an active answer where one would look whether there was currently an arbitrage opportunity. This option would be uninformative as the result would bring a simple yes or no answer, with little possibility for further explanation or historical perspective.




Graph 7 The process of statistical analysis (J. Peltonen, 1997)

A second more reasonable approach is to look at the effects of such a phenomenon. One way to approach the effects would be to ask arbitrageurs if they were able to take advantage of the opportunity. Another would be to look at things like foreign exchange quantities that would assumably have some correlation with the arbitrage opportunity.

The most economical way to approach the question however is to look at publicly available transaction data, taken from bitcoincharts.com and compare it to exchange rate data from the European Central bank. (bitcoincharts.com, 2018 , European Central Bank, 2018)

## 5.2 Specifying the sample

What I aim to do is to take a look at whether or not there are arbitrage opportunities in exchanging Bitcoins to Korean Won and then back again to Euros. I plan to do this by first looking at the price differentials now and in the past 15 months and see if there really was or is a chance to theoretically make a profit. To do this I will need a suitably large sample to get an accurate idea of the prices at which Bitcoins have been available.

The data is from bitcoincharts.com an organization dedicated to collecting and sharing Bitcoin related data. The data I will be using is transaction data from Bitcoin exchanges namely Kraken and Korbit both being leading exchanges in EUR/BTC and KRW/BTC trades respectively and both handling roughly 50% of transaction in said currencies. The exchange price comes in a similar format from the Europen Central banks reference exchange rates.

I will be using methodology much akin to other Bitcoin research like for example the one that was used by Gina Pieters and Sofia Vivanco in their paper “Financial regulations and price inconsistencies across Bitcoin markets” where they study the price differentials between several different Bitcoin exchanges. They found that prices between exchanges did vary significantly depending on the liquidity of said markets. Prices however tended to revert to those in larger markets, with the significant difference being in volatility not fundamental price differences. From this we can conclude that the price data from two of the largest, most liquid, cryptocurrency marketplaces can accurately reflect actual prices.

| | | |
|---|---|---|
| Time (UNIX) | Price (Currency) | Quantity (bitcoins) |
| Time (UNIX) | Price (Currency) | Quantity (bitcoins) |
| Time (UNIX) | Price (Currency) | Quantity (bitcoins) |

Table 1 A visualization of the CSV data

The data is in CSV or comma separated values format where singular transactions in the marketplaces make up a single line. A single line of data would contain the time in UNIX format, the price at which the transaction was made as well as the quantity of bitcoins that was traded. The data files tended to be very large with tens of millions of rows of individual transactions.

Individual transactions are recorded by the second in this data. To manage these millions of transactions the transactions were sifted down to daily values, the values being the high price of the day, the low price of the day and the average price of the day. The daily average is the unweighted average, in part to avoid single large transactions from setting the

daily average. The exchange rate data is already a daily reference rate and needed no altering.

The obvious problem that arises is that there certainly was no single price on any single day, but a series of sporadic transactions sometimes several on the same second and other times with minutes in between two transactions. There is also the fact that in exchanges there is a bid ask spread. This problem however cannot be economically solved as it is unlikely that trades are executed at the same exact second making matching trades to each other laborious and questionable in actual value.

There is also the question of which data to use, minimum, maximum or average. I chose average as both the minimum and maximum can easily be outliers. There is also the possibility of using median or mean values, these however were not economical to acquire due to my use of Power Pivot. With 10 000 - 100 000+ transactions a day, singular outlying values should have little effect on the average. The largest number of transactions in euros at Kraken was over 150 000 transactions in a day, while at Korbit it was over 60 000. The daily average between 1.1.2017 and 26.3.2018 at Kraken and Korbit was over 32 000 and 11 000 transactions respectively.

### 5.3 Estimating arbitrage process

For an arbitrage opportunity to be realizable it needs to be accessible, therefore we will take a look at the process with which arbitrage would be done and trying to indentify key points where problems may arise.

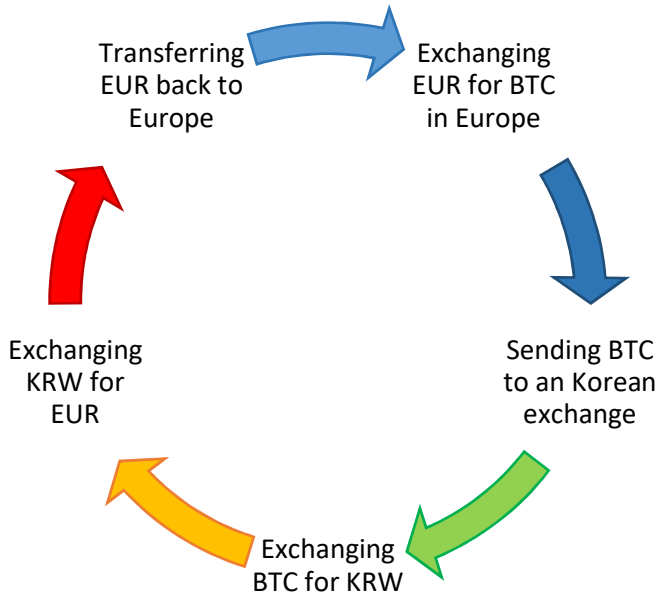



Figure 8 Transactions required for arbitrage

1. Buying bitcoins in Europe is straight forward with several exchanges available.
2. Sending bitcoins to Korea is the first point where problems may arise, as mentioned in the chapter 3.3.3 Case of South Korea, as bitcoins might have to be declared as imports possibly warranting taxes.
3. Exchanging bitcoins for Korean won requires a Korean identity document effectively limiting this part to Korean citizens.
4.

a. Once one has the won in hand one would need to find a way to bypass Korean currency controls to be able to exchange large quantities.
b. A second option would be to send the money out as Korean won, still requiring license to do so

5. Once the money is back in Europe the rest is straight forward

Questions of legality and accessibility are not the only ones relevant here either. The next things to take account of are the transaction times and costs that will factor in to the calculations of any would-be arbitrageur. Bitcoin transactions can be handled in 10 minutes at best, making buying them and sending them fast.

A prospective trader would then probably have to take the lower end of the bid-ask-spread and have the won sent to his account. Domestic transfers of money tend to take anywhere from a few minutes to a few days. For our example we can assume that the trader would find a way to optimize his transactions so as to make the transfers as fast as possible. Getting the money back to Europe is where the greatest delay would occur. International transfers go through the central banks that clear their balances during the night, meaning that all bank transactions abroad will take at least one day. All this is assuming that you have the allowance to transfer money abroad.

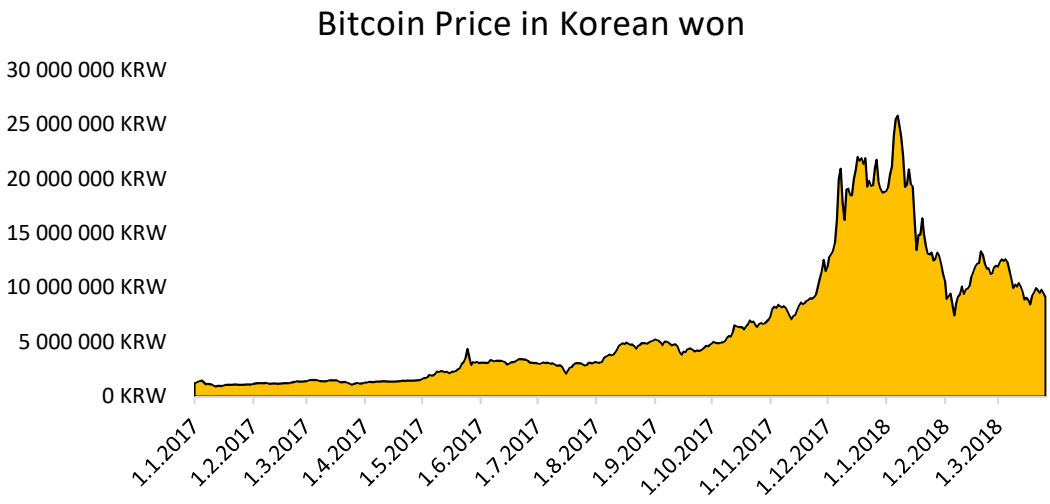
With a loop of arbitrage taking at least a full day but more likely being out of reach from a perspective of an international investor. Even with access, the volatility of the market and the slowness of the transactions means that an investor would be unable to take advantage of the opportunity more than once in a day.

The investor would then have to wait to find the perfect time to trade in his bitcoins, as he might be unable to pinpoint the peak time to sell, bringing in another layer of risk for the investor. With the time window for arbitrage being a few weeks at best, the investor would also need wait idly between periods where arbitrage is possible.

From this we can assume that transaction cost would play and I will make the assumption that transaction cost would be somewhere between 5% and 25%

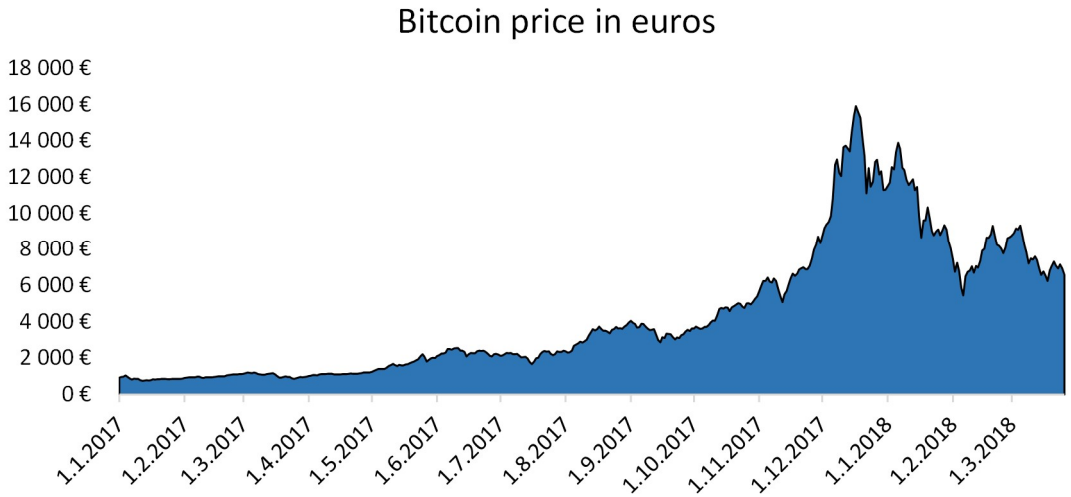
### 5.4 **The data**

With the help of Power Pivot I was able to able to assemble the data from the 2 exchanges and the ECB.



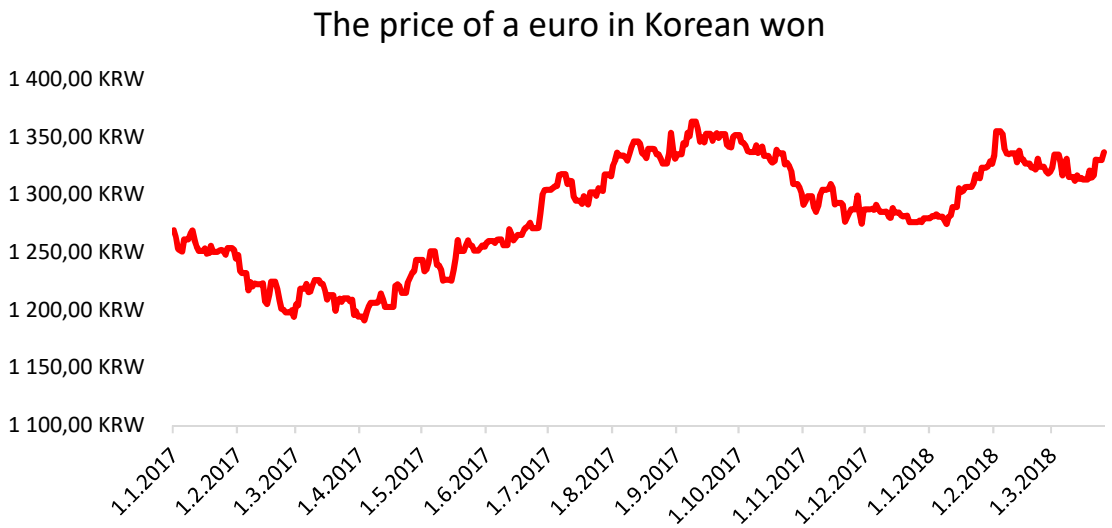

Graph 8 1.1.2017 - 26.3.2018 at Korbit

This is the price graph of bitcoin in Korean won Between 1.1.2017 and 26.3.2018.
As we can see the price of bitcoin has grown exponentially in this time period only to then significantly fall. Prices in this chart are daily averages. From this data we can calculate a standard deviation as a measure of volatility as set out by Aki Taanila in his blog on statistical methods. I did this by first calculating the logarithmic price changes and then by using the STDEV.P function in Excel. From this I took the (Aki Taanila, 2017)



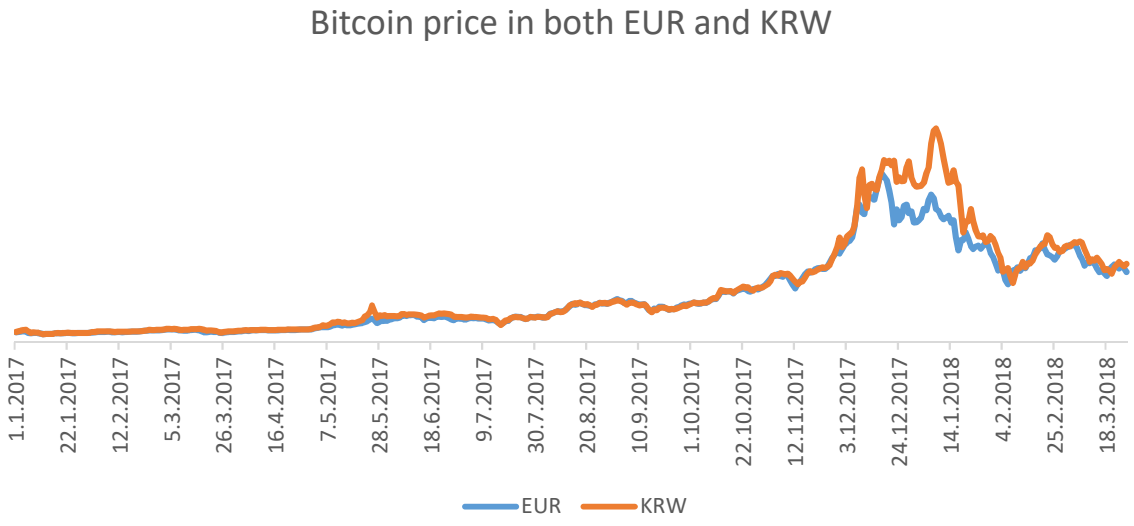

Graph 9 1.1.2017 - 26.3.2018 at Kraken

The price graph in euros is similar to the previous one, but one can already notice small differences in the graphs.



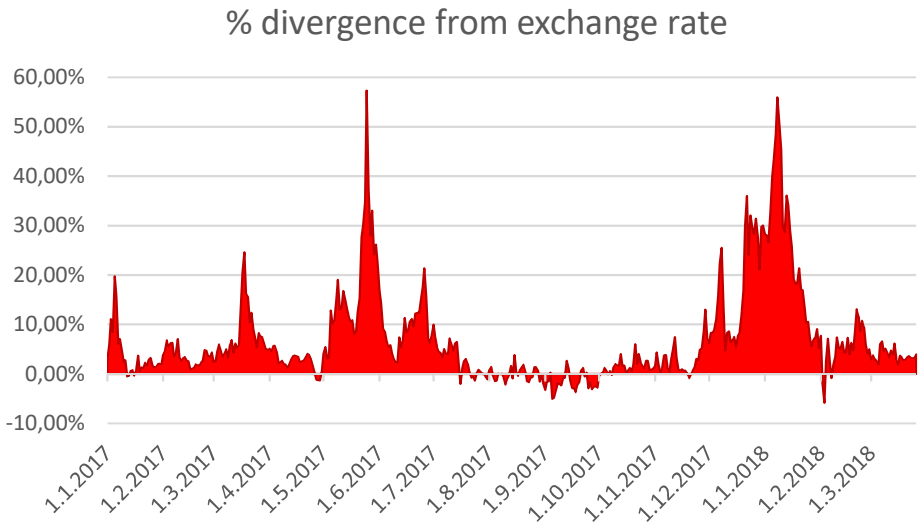

Graph 10 1.1.2017 - 26.3.2018 ECB exchange rates

The exchange rate seems to have been relatively stable in the last 15 months alternating between a little under 1200 KRW for 1 EUR and an around 1350 KRW for 1 EUR. Now we will take the 2 earlier sets of data and adjust them according to the exchange rate data.



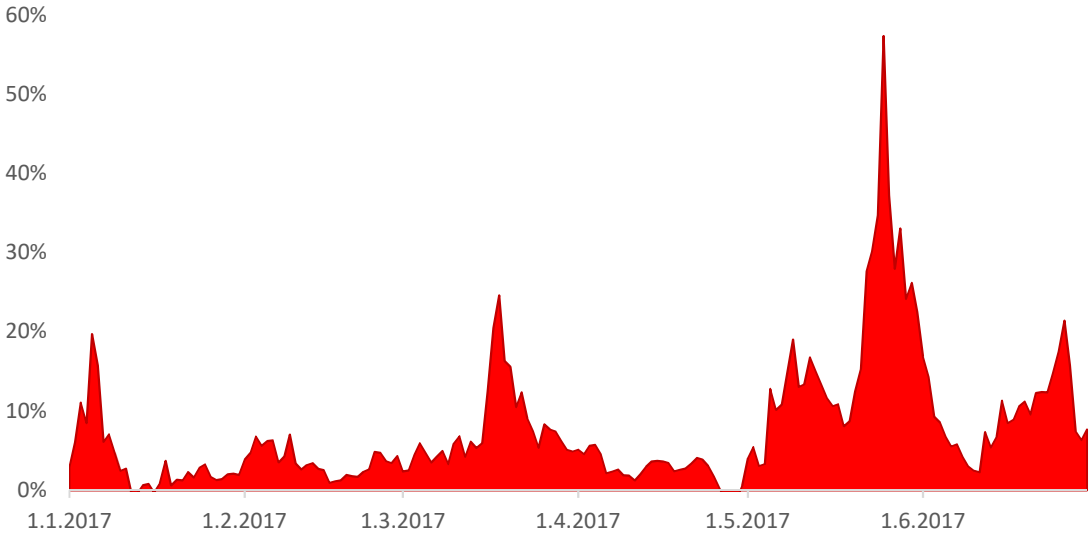

Graph 11 1.1.2017 - 26.3.2018

Here we start to see the divergence clearly, what we are interested in is the arbitrage opportunity, therefore it is meaningful to calculate the divergence in the 2 sets of data. To do this we will take the bitcoin implied exchange rate and divide it by the official exchange rate and deduct one. The result will be the divergence in %.



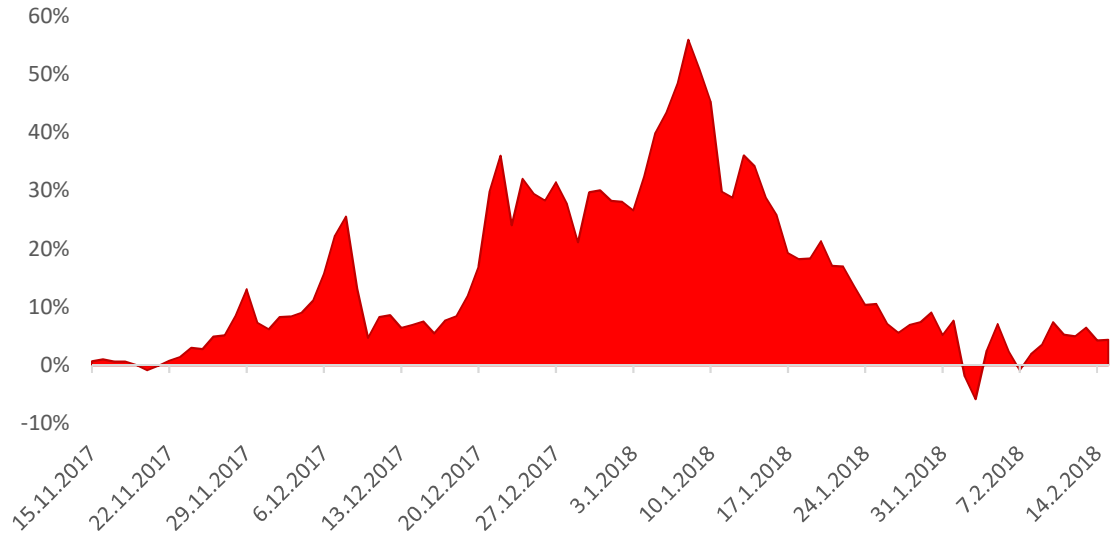

Graph 12 The divergence of the official exchange rate and implied exchange rate 1.1.2017 - 26.3.2018

Here is the graph that shows how much one could make with triangular arbitrage in a single round, assuming no transaction costs. Let's take a closer look at two periods of interest.



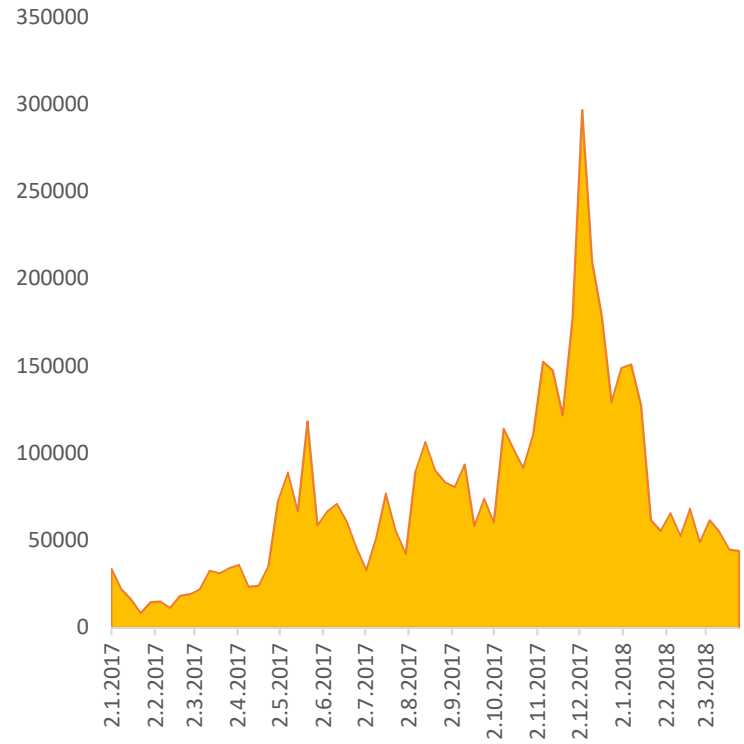

Graph 13 Premium paid on Bitcoin 1.1.2017 – 15.7.2017

Starting in January interest in Bitcoin boomed in South Korea, with buyers paying almost 20% in premium for buying Bitcoins in Korean won on the first week of the year. Notably the price of Bitcoin stayed slightly overvalued almost consistently all the way till mid-July where prices seemed to normalize. The price had several peaks in this time, with the premium going as high as 57% on the 25th of June 2017.




Graph 14 Premium paid on bitcoin 15.11.2017 - 15.3.2018

These graphs show the situation between 15th of November and 12th of February. We can also see the premium find a second peak at 55% on 5th of January 2018 as on the 8th of February one could make a small 6% profit by buying Bitcoins for won and selling them in exchange for euros. The real thing of note however is the 72-day period between end of November and the beginning of February, where the prices remained consistently overvalued. Even more the premium remained uninterruptedly over 20% between December 21st and January 16th.

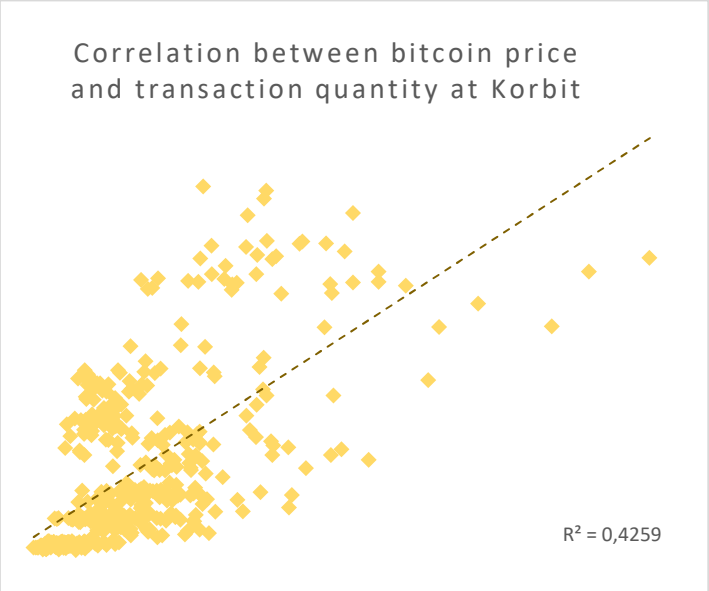



Graph 15 Total weekly transactions at Korbit 2.1.2017 - 26.3.2018

The frequency of transactions at Korbit in this time period also developed significantly in this time period. Showing a peak in interest. Interest seems to have peaked at the start of December, and it remains to be seen if there will be more peaks such as this one.

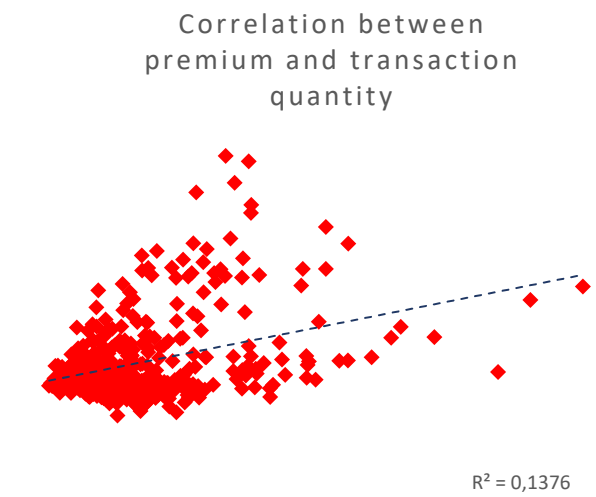
Not only were transaction quantities rising but also the extent of the mispricing in the markets. It should be noted that there were also moments where Bitcoins were underpriced in South Korea.

My initial belief was that there would be an easy correlation between trading volumes and prices and thereby with premiums as well.




Graph 16 Correlation 1.1.2017 - 26.3.2018

Taking a look at graph 16 there is a correlation between prices and transaction quantities with a correlation coefficient of 0,65 but the results are very spread out. Prices can not be predicted accurately with transaction quantities, rather transaction quantitites seem to set the bounds for prices. While from a statistical point of view the correlation is significant, the data is not useful when trying to pinpoint singular points in time.




Graph 17 Correlation 1.1.2017 - 26.3.2018

The inapplicability of transaction quantity for our purposes becomes clear when we compare the premiums and the transaction quantities, as the correlation coefficient becomes 0,37, still not insignificant but not useful for precise calculations. When using the data from Kraken we get similar graphs and coefficients. From this data we can conclude that we cannot assume that transaction prices will peak while arbitrage opportunities are available.

# 6 Conclusions

To recap the questions, we set out to solve were:

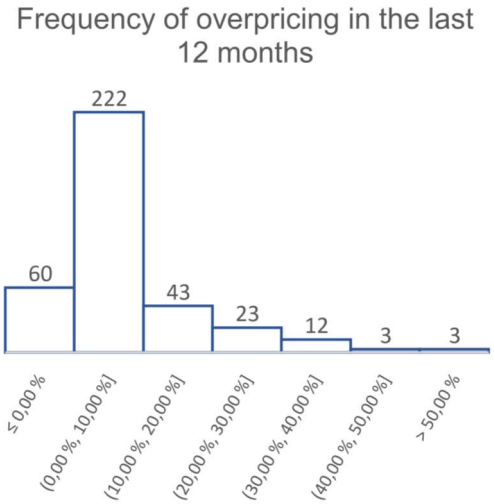
1. Are there arbitrage opportunities available in exchanging Euros to Korean Won through the use of Bitcoin.

1.4 How large are the margins of this?

1.5 Why does the opportunity exist?

1.6 Why is the law of one price not applicable?

## 6.1 Data approach




Graph 18 Number of days with overpricing

By using the data, we can give answers to the questions. The data shows that there have been several days where bitcoins were overvalued in South Korea. For example, in 1 year (26.3.2017-26.3.2018) there were 41 days where the overpricing was over 20%. From this we can conclusively say that there exist arbitrage opportunities, at least on paper, on a semi-regular basis.

The data gives no conclusive answer as to why the mispricing is happening. There was however increase in trading quantities as well as a correlated increase in prices. The results seem to confirm what was written by Dániel Kondor et al. that the rise in the value of Bitcoin is tied to an increase in the number of users, which can be shown in the strong correlation between the number of transactions and bitcoin prices.

## 6.2 Supply approach

To solve the question of why the opportunity exists, a step back to supply and demand is needed. Price changes are driven by changes in supply and demand, price changes are driven by either decrease in supply or increase in demand. The increase in trading volumes that is visible in graph 15 can be considered a signal that demand has increased as more people have entered the market and started trading, it also stands to reason that since the number or the supply of Bitcoins is almost fixed, prices should rise with the rise in demand.

Even with increased demand, supply and demand should maintain the law of one price globally. So, something is happening in South Korea that is preventing the law of one price from equalizing Korean prices with global prices. The initial assumption is that markets are free and should function normally. However as was mentioned in chapter 3.3.3 on the case of South Korea, we already know that markets are not allowed to function fully freely. As it is known that South Korea applies currency controls, we can ask if the currency controls can explain the price discrepancy. The currency controls reduce the supply of Korean won in global markets, pushing the relative value of the currency up in foreign markets where under free markets more people would buy Korean won. In domestic markets the effect is the opposite, where under free markets more people would sell Korean won in exchange for foreign currencies but are unable to. It should then be expected that the won would be undervalued inside South Korea.

The observations show that bitcoins are overvalued in South Korea. Over- and undervaluation are always related to each other as being overvalued means to be overvalued in relation to something. It can therefore be claimed that the undervaluation of the won in Korea is the same thing as the overvaluation of bitcoins in Korea. It can therefore be said that the currency controls have a connection to the mispricing of bitcoins.

A hypothetical bitcoin trader in South Korea could for example notice that bitcoins are cheaper abroad. He would then go to the bank and exchange his won in exchange for a foreign currency, there however he would be limited to the annual maximum of 50 000 dollars worth of foreign exchange allowance. This would mean that once the trader had exhausted his allowance he would be unable to import more bitcoins, effectively stopping him from doing arbitrage.

In this scenario, once all traders had exhausted their allowance, no more bitcoins could enter Korea, effectively making the Korean market trade with the bitcoins that are currently in the country. Assuming no more bitcoins could enter the country, prices should develop independently as long as prices remain overvalued. If prices were to drop, bitcoins could still leave the country meaning that the price discrepancy should only go in one direction.

### 6.3 **Transaction cost approach**

The third thing to note from the data is the consistency with which prices are not in an equilibrium. The average day during the last 12 months had a price mismatch of over 7%,

this was in a situation where traders had nonzero access to foreign currencies. It is therefore reasonable to assume that there are other obstacles as well that are faced by arbitrageurs. The obvious one is transaction costs that were mentioned first in chapter 2.2 on markets and then examined in chapter 5.3 on the process of arbitrage. The fact that prices even under “normal” conditions are tending to be off by a few percentage points.

The cost of transferring bitcoins is dependent on several factors, making accurate predictions difficult. An assessment of what the costs generally are can be made through how large the arbitrage opportunities are before the price mismatches start to normalize. When the price mismatch did not grow rapidly, prices tended to diverge +/- 5% from a full equilibrium. Another clue can be found in the largest undervaluing of euros in Korea, where the mismatch peaked at just under 6%.

With no currency controls in Europe we should assume that any undervaluedness of the euro should be arbitraged out as fast as possible, with maximum efficiency. The best proof for this is that there wasn’t a single case where euros were undervalued over 6% giving a good clue of the effects of the bounds set by transaction costs, not only directly in terms of money, but also the value of the volatility risk and other costs endured by the arbitrageur.

### 6.4 **Conclusions**

It can be concluded that the phenomena of the KimChi Premium really does exist, but actual arbitrage opportunities are presented sporadically, there have been several cases where over 50% interest on investment could be earned in a single round of arbitrage.

While there are many ways to approach the question of why the phenomena exist, a connection can be drawn between currency controls and the mispricing of bitcoins. Transaction costs also play a role when the costs of doing arbitrage are higher than the profit from said arbitrage. While it can be said that the law of one price is not working, actually prices have tended to revert to more normal levels over time, this shows that there are arbitrageurs out there, they just lack the ability to consistently maintain the law of one price in the short term.

If the main obstacle for arbitrage is capital controls, there will be an economic incentive to find ways to bypass them. A case was mentioned earlier in chapter 4.3.1 where a Korean police officer was a part of what in essence was a money smuggling ring. If the profitability

of circumventing currency controls stays high, potential profits will pull people to illegal activity. With the help of invisible transactions internationally money smuggling can be done on a level never seen before. The viability policies that attempt to artificially alter currency prices will be tested in the coming years as cryptocurrency markets mature.

There is a sound argument to be made that markets will mature at some point and become more stable. With more stable prices the odds of the market overshooting would decrease, and arbitrageurs would be able to maintain the price equilibrium more easily. Therefore it is not impossible that large arbitrage opportunities will no longer appear.

Whatever the case, the value of bitcoin has seen exponential growth. Exponential growth has to reach a limit somewhere and investors expecting more exponential returns will be disappointed at some point. There will eventually be a reality check in the market and prices will then either become more stable, based on a more sustainable prediction of value or the markets will implode, with investors scrambling to cash in their bitcoins.

Initially it was believed that the value of Bitcoin was directly related to the amount of illegal trade being done with it. As law enforcement will also inevitably become better at dealing with cryptocurrency related crime. Assuming it is no longer possible to hide illegal activity with Bitcoin, should it not logically also follow that the value of bitcoins would fall? If this is true the ever increasing regulation on bitcoin exchanges could affect bitcoin prices in the long run.

The Bitcoin ecosystem does not produce any added value over time, there is no dividend paid on bitcoins owned. The market should essentially function as a zero-sum game, where all the money exchanged between traders came from other traders at some point. When in a stock market stocks pay dividends essentially making it possible for all parties to walk away with more money than they started with. As transactions are not free, if no new money enters the market, the markets should end up in a slow downward spiral depending on what transaction expenditures are.

A final point to consider should be the initial investors to invest in Bitcoin, who ended up making huge profits, these individuals often hold millions of euros worth of bitcoins and seem to have been “hodling” what they own. Or in other words not selling significant amounts of them. These investors will however have increased their expenditures to match their new-found wealth, meaning that large holders are likely to start regularly selling more and more of their bitcoins as they get used to a higher standard of living. If its considered, that 97% of bitcoins are owned by under 3% of the community, who are likely

not actively circulating their portfolios, an increasing tendency to spend money by the 3% may significantly upset the balance of buyers and sellers.

## 6.5 Thoughts

The study was able to use hard data from exchanges. The parts that utilize this data can be considered very reliable. The currency controls explanation is certainly a crude simplification of a more complex situation, there are also other things that could be used to explain oddities in pricing. One explanation could be, for example that there are no large arbitrageurs in this market. The explanations using currency controls and transaction costs required the least speculation, in that there is factual data about these phenomena, in the form of transaction data and government transcripts.

Research in to cryptocurrencies and the blockchain are still in their infancy. The blockchain technology seems very likely to be adopted more widely in the future, however the full extent of the practical uses of this technology are yet to be discovered. Cryptocurrency markets seem quite undeveloped and it is likely there will be more interesting phenomena to research in the future.

The methodology used in this study was not exhaustive and much more information could be gained by taking an approach that is built on different sets of data, for example interviews with arbitrageurs or central bankers.

The theoretical chapters could have been structured in a very different way, in order to put a focus on different theoretical aspects. For example there is a mathematical basis for arbitrage, Chau Ngoc Huy wrote a 100-page thesis in the mathematical foundations of arbitrage with the name “A Study Of Arbitrage Opportunities In Financial Markets Without-Martingale Measures”. Choices had to however be made on what to include and whether such an approach was economical and relevant for this study. (Chau Ngoc Huy, 2016)

Writing the thesis has been a learning experience, being the first project of this size that I have done on my own. During this time I have had to learn time management skills to be able to keep writing this thesis. The ability to set out a project and work on it more or less independently is a skill I will need in my future career.

Getting immersed in the world of arbitrage has also opened my eyes for possible career opportunities in the financial sector.

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