

UNIVERSITY OF NOVA GORICA
SCHOOL OF ENGINEERING AND MANAGEMENT

**AN OVERVIEW OF THE CHARACTERISTICS OF
FREE MARKET ECONOMIES**

MASTER'S THESIS

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TITLE

An Overview of the Characteristics of Free Market Economies

ABSTRACT

In this work we are collecting and processing basic information that allows us a general overview of the five most popular global, free market economies which are: the exchange of currency (foreign exchange), rare metals, stocks, residential real estate and the cryptocurrency markets. By having more in-depth knowledge about the possibilities that each separate financial instrument or asset offers we are devising a strategy suited for different types of investors. Any economical system in its most natural state will create some sort of dynamic; it is possible to draw parallels between the free-economy and the Lotka-Volterra predator behaviour equations, which can help us to better visualise the behaviour of such systems. We try to compare the model with real life scenarios that had greatly affected some of the economies, one of them being the popularization of cryptocurrencies in 2017 and the other being the most recent Coronavirus epidemic. By having a rough comparison we can see a clearer picture of the practical uses and the necessities of having an increased and better selection of such models.

KEYWORDS

free market, investing, cryptocurrency, stocks, foreign exchange, Lotka-Volterra predator/prey equations

NASLOV

Pregled karakteristik prostotržnih gospodarstev

IZVLEČEK

V tem delu bomo zbrali podatke ter si ogledali postopke, ki nam dovoljujejo splošno spoznanje petih svetovno najbolj razširjenih prostih trgov: valutni trgi, drage kovine, delniški trgi, nepremičninski trgi ter kriptovalutni trgi. S poglobljenim znanjem o možnostih, ki jih vsak finančni instrument povezan s posameznimi trgi ponuja, lahko sestavimo optimalno investicijsko strategijo za tri različne vrste investorjev. Prav tako vsi prosti ekonomski sistemi že sami po sebi ustvarijo svojevrstno dinamiko. Ogledali smo si vzporednice, ki jih je mogoče potegniti med prostimi trgi ter Lotka-Volterra enačbami za opisovanje dinamike med plenom in plenilcem. To nam omogoča boljši vpogled v vedenje sistema ter ponuja možnosti za grobo napovedovanje sprememb v sistemu. Model skušamo primerjati z dogodki, ki so močno vplivali na razvoj nekaterih trgov, en od dogodkov je popularizacija kriptovalutnega trga leta 2017, drugi dogodek pa epidemija novega Koronavirusa leta 2020. Tako si lahko na realnih primerih predstavljamo uporabnost in potrebnost nadaljnjega razvoja takšnih in podobnih modelov.

KLJUČNE BESEDE

prosti trg, vlaganje, kriptovalute, delniški trgi, valutni trgi, Lotka-Volterra enačbe plenilca in plena

CONTENTS

1	INTRODUCTION	1
2	FREE MARKET	3
2.1	Ideal free market	3
2.2	Equilibrium point	4
2.3	Cases of free and pseudo-free markets	4
2.3.1	Fiat currency	5
2.3.2	Precious metals and commodities	6
2.3.3	Stocks and bonds	6
2.3.4	Real estate	7
2.3.5	Cryptocurrency	8
2.4	Volatility and stability	8
2.4.1	Fiat currency	9
2.4.2	Precious metals and commodities	11
2.4.3	Stocks	13
2.4.4	Residential real estate	14
2.4.5	Cryptocurrency	16
2.5	Costs of entering, exchanging and exiting the markets	17

2.5.1	Fiat currency	17
2.5.2	Precious metals and commodities	19
2.5.3	Stocks	19
2.5.4	Residential real estate	20
2.5.5	Cryptocurrency	21
2.6	Scenarios and external impacts on the price	21
2.6.1	”Short & distort” and ”Pump & Dump”	22
2.6.2	Heavy selling and short squeezing	23
2.6.3	Information spoofing	24
2.6.4	Large influx of users	25
3	COMPARISON, RISKS AND INVESTORS’S ADVICE	27
3.1	Market comparison	27
3.2	Risks	33
3.3	Advice for potential small time investors	34
4	THE MATHEMATICAL MODEL OF THE FREE MARKET SYSTEM	36
5	PRICE ASSUMPTION, REAL LIFE COMPARISON AND CORONA- VIRUS OUTBREAK	40
6	CONCLUSION	45

7	REFERENCES	46
8	APPENDIX 1: PYTHON CODE	49

LIST OF FIGURES

1	Linear supply & demand	4
2	Euro vs USD graph	10
3	Gold price chart	12
4	Shell stock price chart	13
5	Real estate price chart	15
6	Cryptocurrency (bitcoin) price chart	16
7	Portfolio analysis	29
8	Stock exchange SWOT analysis	30
9	Cryptocurrency SWOT analysis	30
10	Type I pie chart investment distribution	34
11	Type II pie chart investment distribution	35
12	Type III pie chart investment distribution	35
13	Buyers and seller relationship	38
14	Buyers and seller relationship vector plot	39
15	Bitcoin price 2017-2018	41
16	Coinbase user count	41
17	Bitcoin price during 2020 coronavirus outbreak	42
18	Bitcoin price during 2014	42
19	Bitcoin price during 2018	43
20	Number of users on Blockchain.com	43

LIST OF TABLES

1	Fiat volatility	11
2	Gold volatility	12
3	Stock volatility	13
4	Real estate volatility	15
5	Cryptocurrency volatility	17
6	FOREX costs	18
7	Gold costs	19
8	Stocks costs	20
9	Cryptocurrency costs	21
10	Volatility comparison	27
11	Cost comparison	28

1 INTRODUCTION

The phrase "free market" is often tied to a political system and in general to the wages of the population. It is important to note that free markets can exist within a regulated economy and have their own financial assets, independent of any other influence.

This work is to serve as an overview of the most popular global, free or pseudo-free market economies; the information and its respective analysis is usually scattered and not presented in a way that can be compared to each other. It is rather difficult for anyone that is not educated in finances to make a strategic decision regarding investing. Potential investors can therefore gain another perspective in their outlook.

We have selected five free market economies that exist in the modern world and are relatively globally popular. The data collected for assets and instruments is, due to their nature, readily available online on different exchanges. To make a complete and straightforward analysis is one of the main goals of this thesis. This is also to counteract a plethora of misinformation that is currently available regarding many of the topics we are going to cover.

We also set to try and adopt a mathematical model that will allow us to have a better insight on the behaviour of these markets. Whether the assets associated with that economy will increase in price relative to the base currency is the so-called "million dollar question". We do not strive to see the future but it is possible to somewhat determine the likelihood of market swings, especially if we can observe a known scenario happening in real time.

The first part of this work consists of extrapolating the data from their respective sources, describing the properties of each one of the markets, taking a look at different cases, costs and characteristics that can be calculated from the data. Volatility is an important factor that determines the explosiveness of the market, that is, how large are the ups and downs on average; the bigger the difference the riskier the market is. As any free market, each of them is susceptible to some form of external manipulation, therefore it is important to note the most popular strategies that have been used in the past to affect the price.

Afterwards we can compare the markets to each other and see the differences, that at the first glance seem very similar, using qualitative data visualizing tools such as

SWOT analysis, which helps us determine the strengths, weaknesses, opportunities and threats of some of the more popular markets.

Risk management is arguably one of the most important skills that anyone can develop. We try to evaluate the risks on the basis of volatility and stability of the chosen economy, and form advice for potential novice investors. Three types of investors will be defined, depending on the amount of risk management each of them is willing to apply, and a selectively portioned portfolio will be created using a percentage diagram.

To even further our understanding of the systems we are going to implement a mathematical model regarding the predator-prey relationships, which can reflect the same kind of dynamic between the buyers and sellers, adopting the model from the beginning, drawing parallels and plotting it to better represent the state of a simplified economy. Taking a practical example of the 2017 "crypto-boom" and in 2020 coronavirus outbreak we can better visualise the behaviour and help us determine the likelihood of positive events.

2 FREE MARKET

2.1 Ideal free market

There is some ambiguity regarding the definition of the free market. It is defined in the Oxford dictionary (Oxford University Press, Lexico.com, 2020) as: "An economic system in which prices are determined by unrestricted competition between privately owned businesses". That is to say, that there are no government restrictions or any legal price thresholds. One might argue then that there is not a single economy that would incorporate a truly free market, as there is always some degree of control. The definition however is still somewhat broad, as sellers can set a fixed price and choose not to stray away from it, keeping the items stored and wait for the time when the buyers are prepared to pay that price (Anderson, 1991).

We are going to constrain the definition even more, by applying a set of rules that are going to help us define and determine the properties tied to a truly free market. Sellers must have no control over the price of the items, meaning that a retailer cannot choose and impose a price, even if the price that the public is prepared to give is lower than the actual production costs. The price determination should be run much like an auction, where the buyers compete against each other to determine the price, starting with zero. Ideally, the buyer should be informed of the scarcity, usefulness and availability of any other similar products.

The supply must not be subject to modification, it has to have a fixed flow; If an item is something that has a life span, the production rate must match the rate of use and subsequently the rate of discard, or, if the items are not inherently being consumed, the supply has to be strictly limited. Any counterfeit items should be immediately recognised and discarded by the community, any substitutes should be known in order not to create localised spikes or drops in price (Kunting et al., 2004).

Buyers must not artificially create or lower the demand, such as by pretending that a service or item is not needed and is being rejected in order to buy it at a later time, for a significantly lower price than what it should be otherwise (Calo, 2014).

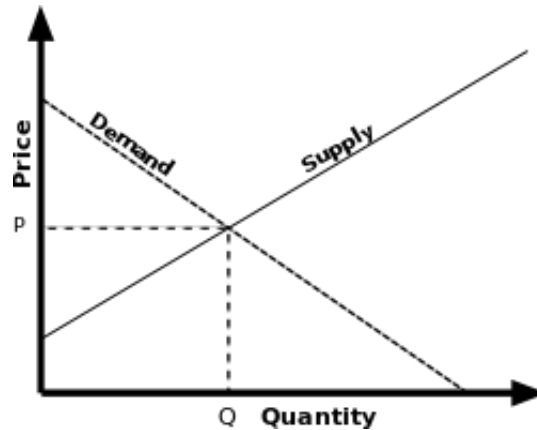


Figure 1: Linear graph of supply and demand, equilibrium point is found at the intersection of the two lines (Beggs, 2019).

2.2 Equilibrium point

In a truly open and free global market with no additions or removal of subjects, the prices do not fluctuate indefinitely. A stable point exists, at which the discrepancy between the price is substantially smaller than what it is during the growth or fallback. The point is defined as an equilibrium price, at which time, if no other external factors contribute to it, the economical system stagnates.

In general, equilibrium point may be determined from the simplified linear supply and demand graph. This might also be the stagnation period in any certain market, where sales are scarce and users are waiting for a breakthrough or external influence (Trinh, 2014).

The image in Figure 1 depicting the equilibrium point is heavily simplified and it presumes that the relationship is linear. Which, as we will see later, is not the case.

2.3 Cases of free and pseudo-free markets

As is often the case in everyday life, ideal free-market is almost never actually accomplished, due to the human nature and the ever-changing environment. That is why we denote the term "pseudo", when something appears to be something when in reality it is not technically correct. There are plenty of markets that appear to be free competitive markets, but are, as a matter of fact, controlled and regulated by an entity, such as a bank, a large corporation or perhaps just a handful of wealthy individuals.

In this work we discuss five different types of markets, some are very open and would fit the set of rules quite comfortably, while others might break down rather easily if it were not for someone or something, backing them up.

We are taking key components of each described market and comparing it to each other, determining the positive and negative properties such as volatility, costs of managing a portfolio, risks and various scenarios affecting the price (Symanska, 2019) (Erhard, 1958).

2.3.1 Fiat currency

This is a market, created by each individual country, usually printed in the form of paper banknotes and coins and issued by the central bank. This type of market is quite far off the spectrum of a true free market, as it is almost completely regulated by the country and it is mostly backed up with the strength relative to other countries and its own sovereignty (Ray and Lotha, 2017).

Due to the man-made nature and the fact that the supply can be adjusted, fiat currency experiences inflation, that is, the perceived value of money diminishes over time. This is usually fixed by changing some of the properties related to the government and banks of the country, such as, changing the banks' reserve requirements, giving out more loans at cheaper fees and thus encourage trust in the legal tender. Financial aspects are mostly described in terms of fiat, as it is the most relatable, popular, easy to use and compare between each other at a given time (if comparing different times, inflation index must be accounted for). This is the reason that this market is used as a baseline to express the value of something. In this work, the fiat currency of choice is the European Unions Euro (denoted by €), the decision is based on the availability and recognition of the currency, but is otherwise trivial.

The free market connected to it is called FOREX (Foreign exchange market) and in itself is thinly regulated because each country can only directly affect their own currency and cannot adjust the positions that other currencies are found in (Hudson et al., 2013).

2.3.2 Precious metals and commodities

From all four selections regarded in this work, precious metals, especially gold and silver, are the most historic markets as they were used much earlier than any of the others. It oftentimes represented commodity currency in the form of gold coins, before the invention of fiat currency. Gold and silver were one of the first precious metals all due to scarcity and unobtainability. Aluminium was thought to be rare and valuable in the times of Napoleon III but was later, after the discovery of a process to improve extraction, deemed relatively worthless (Badura et al., 2018).

As more elements were discovered, metals much rarer than gold were deemed "precious". Rhenium is by far the rarest, being more than four times scarcer than gold, but due to its rareness, unknown toxicity and reduced usefulness, has not seen such success as other metals.

Precious metals are not intrinsically valueless; most of the time the actual resource is used in industrial processes, either as a conductor, catalyst or a part of a chemical reaction. Some of the rarest metals are also toxic, making them unable to be efficiently used as an exchange method.

The market of precious metals especially gold and silver does not require high education to enter, trade or exit, it is very straightforward and easily understood. Banks, shops or private sellers readily sell or buy items. In some cases it is more difficult to come by sellers who sell rarer metals, such as Platinum or Palladium, but it is still not difficult to order them online (Doroghazi, 2019).

2.3.3 Stocks and bonds

Stocks are a rather modern economical market, consisting of signed agreements between two economical subjects, to partake a share of the other. A company might issue stocks in order to receive financial boost to expand or develop, a person might pay for such a company in the hopes that their strategy would be successful and that the shares would become more valuable with time.

A person, in this case, becomes a partial owner of the company, and may (depending on the size of equity) have a say in the company decision making.

Due to its nature of open exchange and competition among companies, stocks are a pseudo-free market; The price of stocks changes in accordance to the supply and demand, however, they are tied to other things, such as the company politics, image or perceived direction that it would going to take, as well as being subjected to many regulations and taxes. The stock market requires intermediate amounts of education, as it is easy to get lost in all the information, finding the correct and fair broker and especially not falling victims to various scams that exist within the stock community (Guru, 2009).

Bonds are on the opposite side of the spectrum; When a financial entity wants to raise money, it may turn to the market to raise it, issuing bonds and promising a return rate in a period of time. Now, while the value of the bond may fluctuate during its maturity period, at the end of it, it will always be worth the declared value, plus a fee that was agreed on in the contract and to be payed upon maturity. In this sense, this is not a free market and will not be discussed further in this work, but it is important to be aware of the opposite side of stocks. Bonds require minimal education to enter, as they are mostly ran and offered by banks, so all of the information is readily available (O'Shea, 2020).

2.3.4 Real estate

The real estate market is divided into four categories: Residential real estate, Commercial, Industrial and Vacant, with all of them having different opportunities and their own markets which may, or may not be connected. In this work we are going to focus solely on Residential real estate, due to it being the most common market and it usually being the first thing that comes to mind to an average person.

Since they are also regulated by each country that the land belongs to, this is not a free market, but again a pseudo-free market, as it experiences the fluctuations according to the supply and demand. A lot of people are investing in this market, whether knowingly or by simply being homeowners, which is why it is an important aspect of any portfolio (Levinrad, 2010).

The education level to enter this market, as well as the budget, is relatively high, compared to the other markets. Even if for completely personal use, it requires a great deal of knowledge to manage, improve and understand.

2.3.5 Cryptocurrency

Being the latest and most advanced form of free market, cryptocurrency, based on the technology of blockchain, behaves very much like an ideal case of open market, where there are next to zero regulations as it is a global free market. Each individual country might try to regulate a part of it, however, due to its properties and nature, cryptocurrencies (coins) are very hard to regulate and most forms of taxes or restrictions would promote the development of underground markets.

The prices fluctuate very strictly according to the demand, supply is relatively stable, because of the limited ammount of coins (cryptocurrency) available at any given point of time. The demand can shift with time, depending on the political, economical and other factors going on at the time.

This is as close to a global free market as any other financial market has ever achieved; Due to the information era everyone with access to the internet has the same price for the coins and people from all over the world can buy and own coins. It is not dependant on any other market and it is not backed up by anything, behaving like an entity of its own. However, some of the market manipulations can still be applied, false news to drive the demand up or down or cyber attacks to destabilize the trust put from people into the system (Härdle et al., 2020) (Sathya and Jena, 2020).

2.4 Volatility and stability

These two words might seem to describe the different sides of the same thing, however this is not what they are, in fact, reffering to. Volatility is reffering to the relative difference between one financial market and the other; The higher the volatility, the riskier the market is.

It is often measured as the standard deviation or variance and it is characterised by swings in the relative value between, for example, a gold bullion and fiat currency (like the Euro) (Kurtoglu, 2019).

Stability on the other hand, is reffering to how likely the market is to crash. Stability is not as easily measured as volatility and is a combination of many factors, including political and local conditions. It is usually determined by looking at historical pro-

gressions of the market, its volatility, growth and trends through the time periods, and whether the market is backed up and by what entities. For example, the precious metals market is much more stable, as opposed to the fiat currency market, which is why in the time of crisis or sociological shifts, demand goes up (Young and Johnson, 2004).

Volatility is going to be calculated by taking a selected time period of a market with respect to the unit fiat currency (usually American Dollar) and express it with our base currency (Euro), without taking into account inflation in that particular market.

In general, to find the standard deviation we first calculate the mean of the set, subtract each number from the mean, square the results and find the mean of those. That is known as variance and it represents the amount of spread the data has on average. Then we take the square root of the variance to find the standard deviation. By dividing the standard deviation with the mean we can find the coefficient of variation, so to compare and to asses volatility we are going to use this coefficient (Haltiwanger, 2011).

For the stability of a given market, the methods are slightly more subjective and other factors must be taken into account, such as, how many times the market has crashed or been completely revamped, how old the market is, what the usefulness of it is and the direction it has been taking as well as other factors that might be linked to the special case of the market.

2.4.1 Fiat currency

The foreign exchange market is the market linked to currency trading between individual countries. This is by far the largest market in the world. By trading volume, it constitutes of parties, individuals, companies or governments, trading various currencies and capitalizing on different ups and downs, depending on the local conditions. The price is always expressed in terms of pairs, that is, relative to another currency and position. To determine the volatility we are taking a look at the pair of Euro vs USD (Dollar) and the available data from online sources (x rates.com, 2020).

Demonstrated in Figure 2, we can see the relation between the dollar and the Euro, throughout the years since it was accepted as a currency.

From Table 1 the difference between the highest peak and the lowest peak was 0,78€. The standard deviation of 0,21€ hints that the market does not drastically change. The



Figure 2: Graph showing the relationship between the Euro (€) and US Dollar (\$) from the introduction of the Euro to present year (2021) (Coinmarketcap, 2021).

coefficient of variation is 17%, meaning that this type of market does not experience huge value swings and is therefore a pretty non-volatile market.

This also gives us information about the stability of the market, since the biggest swings can be observed at the beginning, when USA was experiencing economical growth and Europe has not picked up its pace yet, and then once again in the middle of the great recession of 2008, where the market was rather rough for the American Dollar.

We can assume the stability of the market is only as stable as the country backing it up. With that in mind and the status of other countries, Euro was and still is a relatively unstable currency, mostly due to the fact that it is one of the newest currencies and has already experienced ups and downs related to the countries exiting the European Union.

During the Covid pandemic of 2020, the foreign exchange market has experienced very hard conditions, this is expressed as the Euro gaining momentum over the USD, this might be attributed to the additional printing of USD, to combat the increasingly unstable economy. This can lead to people losing faith in their respective currency and migrating their portfolio in other, less regulated markets.

Table 1: Calculated values of mean, variance and coefficient of variation for the FOREX market.

Highest value	1,6€
Lowest value	0,82€
Mean	1,2€
Variance	0.042849 € ²
Difference (Highest-Lowest)	0,78€
Standard deviation	0,21€
Coefficient of variation	17,21%

2.4.2 Precious metals and commodities

This is one of the oldest markets. Following humanity ever since the introduction of commodity trading and metal developments, and has proven itself to be the most resilient market of all.

Due to our base currency limitations, in Figure 3 we are only taking a look at the gold data that is coincided with Euro. The pair for evaluation is the price of gold per gram, without taking into account inflation.

Since gold has only increased in price since the beginning of the observation and has had relatively short periods of decrease, especially during the recession recovery efforts in 2013, it is safe to note that this coincides with the problems in the global economy, rather than gold becoming intrinsically more valuable.

This behaviour can be observed during the coronavirus outbreak, the price of gold has reached the all time high, due to people's fears of losing their assets in fiat currency and thus transferring more of their portfolio towards gold or other precious metals.

The market of gold is one of the most non-volatile markets in the current economy, in Table 2 its standard deviation and coefficient of variation suggest that it experiences large swings. Those returns are usually not in a realistic way, as the price that the gold is tied to changes with the purchasing power and the stability of economy.

In itself the market is incredibly stable, oftentimes not bearing any risk at all and is therefore used as a failsafe to other currencies and markets. The increase in price is usually an indication that the economy is in a downswing and vice-versa.



Figure 3: Graph showing the value of 1 gram of gold expressed in Euro (€), for the past 20 years (bullionbypost.eu, 2020).

Table 2: Calculated values of mean, variance and coefficient of variation for the gold market (bullionbypost.eu, 2020).

Highest value	56,07€
Lowest value	7,62€
Mean	25,07€
Variance	190,22 € ²
Difference (Highest-Lowest)	48,45€
Standard deviation	13,79€
Coefficient of variation	55,02%

2.4.3 Stocks

Stocks are the poster-child of modern investing and anecdotes revolving around volatility and huge swings. When people hear about the financial instruments, stocks are the first thing that comes to mind. People getting rich by owning stocks or people losing everything they had. However in reality, stocks are (on average) not nearly as volatile or unstable as stories make them out to be.

In Figure 4 we are taking into consideration the stock of one of the most popular European oil company Shell, limiting ourselves to the past 20 years due to our base currency more closely, after the stock split in 2005.



Figure 4: Graph showing the value of 1 stock of Shell company expressed in Euro (€), for the past 15 years (sharecast.com, 2020).

Table 3: Calculated values of mean, variance and coefficient of variation for the stock (Shell's) market.

Highest value	31,00€
Lowest value	10,00€
Mean	23,44€
Variance	40,00 € ²
Difference (Highest-Lowest)	21,00€
Standard deviation	6,32€
Coefficient of variation	26,98%

The standard deviation for the stock is 6,32€, and the coefficient of variation was

more than 25%. This information in Figure 3 tells us that even though the market experienced some swings, it was not nearly as impactful as one would believe them to be. While the graph does demonstrate periods of growth and losses, its volatility is comparable to the foreign exchange market.

Stability of the market is related to the company backing it up, and since Shell has been around quite some time, as it was founded in 1907, the market is therefore relatively stable. However with the increase of electricity and the public awareness of the damage of oil refineries the stock might lose its value or require a complete revamp.

The Coronavirus pandemic has profoundly affected this company's stock, due to decrease in commercial airlines flights and other industrial processes, oil and its derivatives suffered a setback which is evident in the steep drop in the price of the stock.

2.4.4 Residential real estate

This form of free market is based around the fact that land and properties are in limited supply, although newer technologies can use the land more efficiently, it does not change the fact that it is not limitless. Focus is only directed towards the existing residential homes and not on industrial, commercial or vacant real estate. The graph in Figure 5 is shown from 2007 and values are taken quarterly.

The data in Figure 5 is normalised to 100 in 2015 in order to better represent the shifts and to exclude the large costs of entering. The 2008 start of the recession is also visible in the housing market as it dropped due to people opting to rent rather than own.

The difference between the highest and the lowest value of the market in Table 4 is relatively low, suggesting that this market does not experience large shifts. The coefficient of variation supports this, as it is only about 7,5%, which is one of the lowest among free markets, being beaten only by the adjusted gold standard (which does not have realistic variance). The lack of volatility makes this market a good option for investors, since it can function as a value holder as well as add potential returns. Stability is dependent on many factors for this market, the residential properties are influenced by the geographical location and any shifts in the city infrastructure, societal norms and political factors.

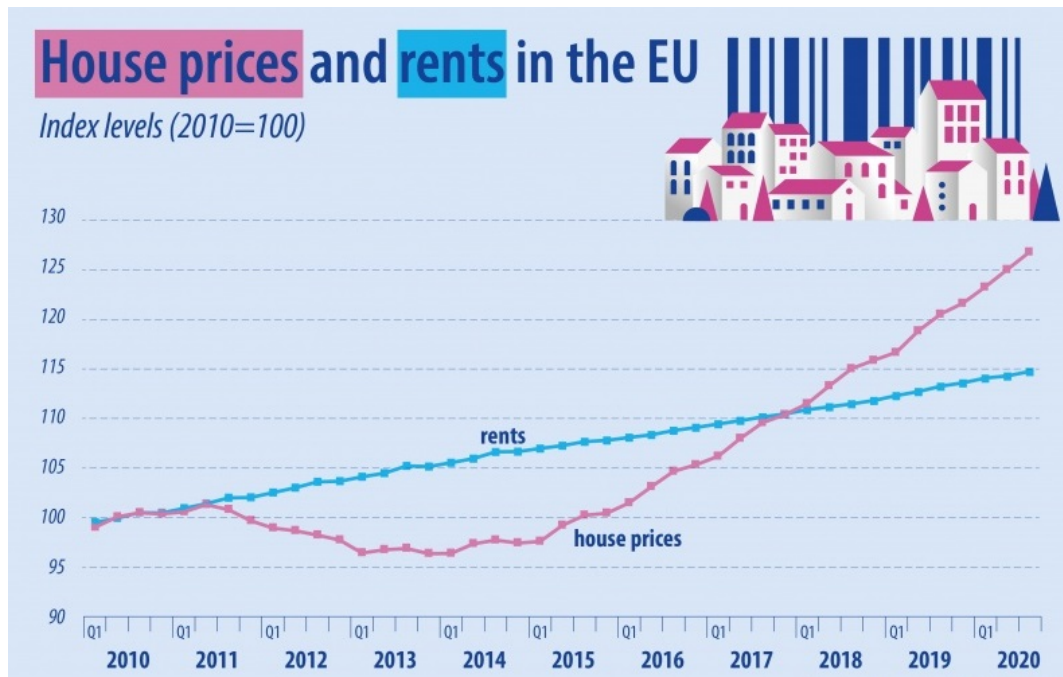


Figure 5: Residential house and rent price index, for European Union for the past 10 years. Index levels have been normalised starting in 2015 (eurostat.com, 2020).

Table 4: Calculated values of mean, variance and coefficient of variation for the residential real estate market.

Highest value	119
Lowest value	95
Mean	103,5
Variance	59
Difference (Highest-Lowest)	24
Standard deviation	7,69€
Coefficient of variation	7,43%

Unlike other economies real estate market is slower to respond to any changes in its environment, therefore any substantial effects of the 2020 pandemic or any other crisis will not be clearly visible from the price graph.

2.4.5 Cryptocurrency

Cryptocurrency is by far the most idealistic, volatile and unpredictable market that is currently available to the global general public. At face value it is similar to gold in the sense that there is no intrinsic value to it, but is used as a method of trading, transporting of funds and as a value holder. It responds to economical, political and societal changes extremely quickly. In Figure 6 we are taking a look at the first cryptocurrency ever created, Bitcoin, from mid 2016 to now, expressed in our base currency, Euro.

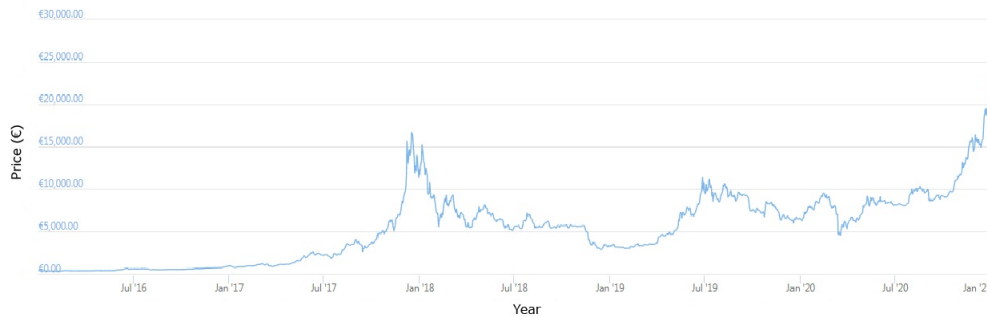


Figure 6: Price per 1 bitcoin expressed in euros, the graph has large spikes indicating large changes in the market (coinmarketcap.com, 2020).

From the start in mid 2016, bitcoin was not available to the general public and it was very hard to enter into the market. Starting in 2017, Bitcoin saw extremely large influx of new investors and the price spiked to almost 10.000 % of what it originally was.

Table 5 shows the difference in its highest and its lowest value, which is extraordinarily high, the variance and the coefficient of variation follow suit, making this market the most volatile and experiencing the largest swings. Due to its volatility it is extremely susceptible to any changes in its environment and this is expressed in its price in a matter of hours to days.

This is not considered to be a stable market, the swings, the lack of any intrinsic value, any backup and the dangers of market manipulation make it extremely risky and requiring much more knowledge to be able to successfully enter and to navigate the changes.

Table 5: Calculated values of mean, variance and coefficient of variation for the cryptocurrency (bitcoin) market.

Highest value	32.962,00 €
Lowest value	175,40€
Mean	6.724,66€
Variance	81,327.959,80 € ²
Difference (Highest-Lowest)	32.786,80€
Standard deviation	9.018,20€
Coefficient of variation	134,11%

2.5 Costs of entering, exchanging and exiting the markets

All of the aforementioned markets do have costs associated to them, when we switch from our base currency Euro, to one of the other free markets and begin applying it, there are various fees, premiums or other hoops. Mostly because of companies, exchanges or other financial institutions that offer services related to the function of the market.

Banks, exchanges and certain companies usually serve as a medium, to bring the markets closer to the general public, for example: A gold dealer would also refine gold and process it into bars or other jewelry, hence higher cost, than buying the untreated gold directly. Similar to how a bank would exchange foreign currency for a small fee that shows itself as the difference between the selling and buying price.

Since many of the markets have more individual items that are available to trade, the companies offer a way to quickly trade between them without the risks of losing assets. In this chapter we are taking a look at different ways of entering the market, costs for entering and trading.

2.5.1 Fiat currency

The forex market is almost entirely backed up by banks, where it is possible to exchange the country currency for other available currencies, this can also be done through online exchanges and forex traders or indirectly, by selling products for a different currency and accepting the price. Trading in foreign currencies is relatively easy, because the

banks offer complete and full control over the process. The online traders and brokers sometimes offer only the basic functions such as buying and trading but do not offer the customer service and help; That is often accompanied by lower fees or other perks.

Banks, exchanges and brokers do not require to pay upfront to use their service, but rather, through the action of trading, receive a small portion of the volume. In some cases, online exchanges might charge an inactivity fee, being subtracted from the account in the case that no trades have happened in a period of time determined by the exchange.

In Table 6 we are taking a look at fees from three subjects; A national bank (Banka Slovenije), a competing bank (Nova KBM) and an online forex broker (FOREX.com).

Table 6: Calculated costs for the foreign exchange market, the market price for euro at the time was 1,1141 USD extrapolated from the most popular regional options available to the user.

	Banka Slovenije		Nova KBM		FOREX.com	
	Buy price	Sell price	Buy price	Sell price	Buy price	Sell price
EUR(€)/USD(\$)	1,1132	1,1098	1,126	1,101	1,1142	1,1141
Relative difference	0.31%		2,22%		0.01%	
Other fees and costs	10,00€		4,99€		15€ (inactive fee)	
Costs (1000€ trading)	13,50€		27,19€		0.09€	

It is completely rational that a bank, with a physical location, would need to have higher returns from this activity in order to pay the larger maintenance cost. The buy and sell price, that is, whether we are selling or buying from the bank, is slightly higher or lower than the actual market price. The most expensive option (Nova KBM), has just over 2% but a much lower monthly fee, while the second most expensive (Banka Slovenije) has a higher monthly fee and lower difference of about 0,3%.

The online exchange has an almost negligible difference in the price of trading between the same currencies, about 0,1%. This is due to the fact that, as an online establishment, it does not need to pay any costs related to a physical location and likely requires less workers to manage and run. However, exchanges such as FOREX.com also have a minimum deposit and trading value, which is in our case, 2500€, in order to maximise their return on the low margins. Exiting the markets does not impose any other costs or risks and withdrawing from the online exchange is relatively easy, requiring an existing bank account or other types of wallets.

2.5.2 Precious metals and commodities

Contrary to foreign exchange and other markets which are more or less digitalised, precious metals are usually obtained in the physical form and stored in a location to be sold at a later time. That is why the costs vary, depending on the source of the metal, the supplier and the bank or the shop that is offering it. In this process of selling and buying, they make money for running physical locations and managing production and refinery solely by the margin difference from the purchasing and selling price, as is the case with forex markets.

In Table 7 we are taking a look at three different organisations that offer and buy gold products and we are examining the most prevalent product, that is, a 10 gram bar of gold. The first two are local (Slovenian), a bank and a jewelry maker, the third one is the Croatian competitor and the prices have been converted from the local Croatian currency (Kuna) to Euro. There are no other costs besides the price difference from the actual market value. The cheapest of the options to buy from and to is the Croatian competitor, who also takes the least margin in the process. In most cases the margin is above 10%.

Table 7: Calculated costs for the precious metals (gold) market, the market price for 10 grams at the time (1st January 2020) was 450€.

	Abanka		Zlatarna Celje		Banka Zlata	
	Buy price	Sell price	Buy price	Sell price	Buy price	Sell price
Gold (10g)/EUR(€)	447,0€	492,00€	442,00€	488,00€	449,00€	486,00€
Relative difference	10,07%		10,41%		8,24%	
Costs (1000€ trading)	100,67€		104,7€		82,41	

2.5.3 Stocks

Stocks can be bought and sold directly through the company that represents them, however the costs of managing multiple stocks often adds up, making it economically unviable. Stock exchanges or brokers are a medium to allow buyers and sellers maximum efficiency in transactions, usually taking a small fee or commission for their service.

Table 8 shows two competing local banks, Nova KBM, SKB and a local stock exchange.

Table 8: Calculated costs for the stocks market, stock exchanges usually have fixed fees per trading and do not have a spread between buying and selling.

	SKB	Nova KBM	Ljubljanska borza
Account costs(\$)	7,00€	3,69€	n/a
Trading costs	1,00%	0,5-1,00%	0.08%
Costs (1000€ trading)	1017,00€	1010,69€	1000,80€

None of them have any immediate cost of entering the market, but have fees and commissions to cover administrative costs and services provided. Most of the time the commission is taken during the trade or sale of a stock, the percentage varies depending on the type of broker in question.

The competing banks are relatively close to each other, with the difference of only few Euros in monthly fees and less than 1 % percent in trading costs. A specialised exchange however, is able to lower the trading costs to below 0,1%, which is almost one hundred times cheaper than the broker competitor (the bank in this case acts as a broker) and with zero monthly fees it is a clear-cut choice.

The only downside at stock exchanges is the limitation that is usually imposed, such as a minimum monetary deposit value or perks that are available only to buyers that exceed a certain trading threshold.

2.5.4 Residential real estate

Real estate has costs that cannot be generalized the same way as other forms of markets, therefore the analysis of costs is omitted. It should be noted that the costs are usually high, with the lowest ranging from a few thousand Euros to hundreds of thousands of Euros or even millions, for a single piece of property or land.

There are also regulations from each respective country that the land is part of, including taxes and property fees.

For Slovenia, the taxes for selling a property are not generalized and are case specific, usually from 2 to 5% of the total price, there are also notary fees which might cost hundreds of Euros.

2.5.5 Cryptocurrency

To enter, this market requires a "wallet", a digitalised encryption protocol, designed to keep the currency safe and secure. Usually, a broker of some sort is required to set up such a wallet, or if the user is computer savvy enough, they can do it themselves. However to trade with such currencies it is necessary to open an exchange account at an online cryptocurrency exchange. Such an exchange usually takes a small amount during each trade in order to pay for costs of running the exchange. A large number of different cryptocurrencies are available to trade in, which otherwise require their own wallet, an exchange is in that way, a wallet for multiple currencies at a time.

Due to the nature of the exchange it can offer extremely low trading costs with the lowest limit on quantity of funds that can be deposited.

Table 9: Costs for the cryptocurrency market, exchanges that deal with cryptocurrency have a variety of ways to keep running, different withdrawal and deposit fees as well as some trading fees or spread, dependant on the volume of each separate coin.

	Bitfinex	Coinbase	Stex
Trading costs	0.02%	0,5%	0,25%
Withdrawal/deposit cost	0,10%	n/a	0,50%
Costs (1.000€ trading)	1001,20€	1.005,00€	1.002,00€

Among all the competitors Coinbase appears to be the most expensive, while Bitfinex and Stex are very close, by a small margin. The main differences then, arise from withdrawal terms and different limits.

Cryptocurrency is one of the least expensive markets to enter, but, by being cheaper to enter, often require a higher degree of knowledge to successfully manage and apply different strategies.

2.6 Scenarios and external impacts on the price

The only factors that should affect the price in a free market environment are supply and demand. However, both of the factors are susceptible to other variables and manipulations themselves. This chapter will be devoted to researching, describing and evaluating possible scenarios and factors that affect supply and demand. Whether

through natural progression or conscious decisions to manipulate the market using various methods (McKeon and Durston, 2020).

We are taking a look at 4 different methods of subduing the market or warp it so it fits an idea of how it is supposed to perform, making it easier to predict the sell or buy points. Three of the four methods are man-made and do not happen regularly in an unbiased setting, they all include misrepresenting the current state, diffusing the supply or producing false credentials in order to modify the demand. The one happening naturally is the large influx of users; Once a product, idea or a currency gets very popular, it shows its ability to be scaled upwards. With the supply being fixed, the only other thing that can increase is price. The synthetic market modifying strategies are as unpredictable as human factors and are therefore very hard to model mathematically, which is why the focus of modelling a scenario will be limited to only natural progressions and very basic human interactions, excluding the complex convey of information needed for the market to become well-known and stable in a defined community.

2.6.1 "Short & distort" and "Pump & Dump"

"Short and distort" is a strategy used predominantly in the stock market, referring to the act of borrowing stock, item or other instances of free market mediums and immediately selling it to a buyer. Then, hoping that the price will continue to trend downwards so the seller can buy it back at a lower price, to return it to the original owner.

Let us take a concrete example; A trader speculates that the stock X will lose 20% of its value in the next two weeks. He finds an owner willing to borrow the same share for 3% of its current value. After two weeks the traders predictions have come true and the company has been doing badly. He purchases the stocks and in turn, makes 17% profit (minus the borrowing fee) on his initial position.

Distorting refers to the actions of deliberately doing actions or spreading information that will lead to the stock depreciation, such as an inside job at the company, consciously making bad decisions to ruin the company image, conveying false information regarding quality, performance or practices. In most cases, there are very strict rules regarding such doings and are mostly punishable by law.

Its counterpart, "pump and dump" is a similar technique only done in reverse. In the first step, the trader or company buys an item that is largely unknown or has recently gone through large losses. Buying the majority of the item available, putting them in a monopolized position. The next step requires either waiting for the share to become popular on its own or by fabricating positive information. The same can also be done with the company suggesting to the other possible investors to buy the stock (or the other item). When enough people have become involved with the project and the price increases two or even three fold, the company sells all of its shares (dumps), thus releasing the "limited" supply of it and reducing the price even below the initial offering.

Since availability and spreading or withholding of information are often the key component to driving the price to the desired trend, we are taking a look at this specifically in the chapter regarding information spoofing. It includes different kinds of mediums for the various examples of free markets and requires different approaches.

2.6.2 Heavy selling and short squeezing

Not as aggressive as the previously mentioned strategies, heavy selling and short squeezing have a much more natural way of manifesting and are not necessarily created in order to gain profits. Rather, they start showing in the times of an unbalanced market, where the traders have some kind of resistance to overcome in order to minimize losses (Woo and Kim, 2019).

In the case of heavy selling, there are many sellers with an instrument that is presumed to be short lived and is going to either depreciate in value or completely lose its value due to limited time-frames. Each of the sellers would like to sell it for as much as possible, but since the buyers are very scarce, competition between the sellers is ensured. Every time a sale is made, the price drops lower in order to sell the next share faster, the buyers become aware of this fact and begin to wait in order for the price to plummet or forego buying completely.

Short squeezing, is a kind of conjecture to the heavy selling and can occur if there is a lack of supply or the demand becomes increasingly high. This is especially a risk in the technique of short selling, as whenever the prices increase, some of the short sellers might become frightened at the impending losses and sell their position, thus creating

more volume, and in turn driving the price even higher. This results in a feedback loop which oftentimes crashes and is in general non-sustainable, as it does not reflect any fundamental properties of the instrument.

Opposite to the short squeezing is the long squeezing, representing the exact reverse situation as in the previous case. It usually manifests itself when sellers use automatic methods (namely: bots) that perform sales on their own, once the price hits a certain threshold. Usually called a stop-loss, this refers to the price that was deemed a point of no return and required to sell the item. These stop-losses are mostly applied in long position, where a seller is looking to have profits over a longer period of time and the long squeezing requires more time to actually develop and demonstrate its effect.

We can look at an example of a seller who is holding his position at a stock X and is expecting a return over a longer period of time. Due to the stability (average deviation of less than 5%) of the stock he has set a stop-loss limit, which sells the stock when it loses 10% of its value. In a turn of events, the company decided on taking a loan (to a proportionate amount), which has decreased the price of the stock by 10%. The seller's stop-loss has activated and sold his shares on the market, increasing the supply for the stock, creating a domino effect, where now other short sellers started closing their positions and adding to the supply. Since the supply is now becoming increasingly large with the number of buyers getting smaller, the prices drop even further. Prompting an induced fear of missing out (FOMO) and a landslide of sell-off, this often means that the price will drop extremely low or even lead to bankruptcy.

2.6.3 Information spoofing

The techniques used in the previous two sub-chapters all require to use some sort of relaying false information (spoofing) or withholding important data. This can be done in many different ways and the market has different ways to react and respond.

A company or a seller can spread positive news about the financial instrument of choice, such as a stock or a cryptocurrency. This would instill good faith in the buyers, which then spread the false information further or perform actions such as buying or using more of that instrument. The result of this behaviour will be a sudden increase in price, due to the free market rules, if the demand increases while the supply is the same, price will increase. This is mostly used when there is an introduction of a new entity or a

new stock and there is much supply but very little demand, information is twisted or distorted in such a way, which makes the aforementioned item look good and launches its popularity.

The same process can be used in spreading the negative information or to hide positive information until the setting to buy a share is ready. This might include spreading information that the company is foreclosing or that some of its products are being discontinued. The stock will then, until the information is found to be false, start depreciating in price, at that time, the person that started the rumors buys the shares as much as possible, later the stock will regain its position, once the information has been debunked and the seller can then sell the stocks for a profit. This can work by withholding information as well, if a company has big news that will have a positive impact on the shares, some employees might catch wind and buy the shares before the big announcements and then sell them off once it has reached a certain threshold (Cartea et al., 2020).

Information spoofing is largely an illegal practice and is also deemed immoral, punishable by law and most companies will not engage in such an activity. However, since there are many platforms available to trade different kinds of instruments on the daily basis, such tactics are quite popular in realms such as cryptocurrency or forex tradings.

2.6.4 Large influx of users

A large arrival of users, being the most natural progressions of the free market, is one of the fundamental things modifying the supply and demand. Since the market is a collection of buyers and sellers, the relation between the number of both will determine the price that each is willing to pay for. In the usual market setting, buyers and sellers are interchangeable, as everyone who purchased an item can also sell it for a different price later on (given that the item is not a necessity or a consumable), meaning that the liquidity of the item changes with time.

During the 2017-18 popularization of cryptocurrencies, the market has seen a huge influx of users, which has greatly impacted the price and then later when the users stopped buying and just kept the tokens to themselves. The price started to drop again and returned to the levels at which it was earlier, before the influx of new users.

We are going to apply and use mathematical methods of Lotka-Volterra predator and prey model to observe and better understand how the relationship between the buyers and sellers affects the price, and what impact there is when one of the parties is so overwhelmed. This can also be seen in reverse; Once a free market experiences a downfall and a subsequent failure, the only users that are left are the sellers, with no buyers at all, meaning that the price is either non-existent or relatively low.

3 COMPARISON, RISKS AND INVESTORS'S ADVICE

In these next few chapters we are going to compare the collected information to determine which of the markets is considered the most stable, most volatile and most profitable overall, by using methods such as SWOT analysis, portfolio matrix.

We are going to assess the risks overall and which is the appropriate risk management to take in certain cases, such as the coronavirus outbreak in 2020. The last part of this chapter will be authors advice for small time investors, readers who would like to invest smaller amounts of money ($< 10.000\text{€}$), depending on the characteristics of each individual investor.

3.1 Market comparison

The first factor we have to compare the markets in is the volatility, that is, how much the market has changed in the observed timeframe.

Table 10: Comparing markets in variance and coefficient of variation.

Market asset	Variance ($\text{€}^2 \pm 10\%$)	Coefficient of variation
Forex (USD)	0.05	17,21%
Gold	190	55%
Stocks (Shell)	40	27%
Real estate	60	7,34%
Cryptocurrency (bitcoin)	81327960	135 %

The cryptocurrency market is by far the most volatile and explosive, having very large swings, on the other hand, real estate has had the smallest changes throughout the last 20 years, even including the 2009 recession. Foreign exchange and stocks are comparable in volatility, gold is following as the most volatile of the more stable investment. However, we must not forget that gold is somewhat a reflection of the state, that the economy we are comparing it to, is in.

Cost comparison is the next thing that can outline the importance when dealing with any market. Most of the times it is not possible to enter in any market without some initial losses (costs) or, when having to go through any exchange, either spread or different fees. We try to generalize the fees and costs and normalize it to a budget of

1000. Since by having more resources, costs may get lowered but a new set of holdouts will be added, such as profit taxes or are subject to other localized laws.

Table 11: Comparing average costs of the markets expressed in percentage and applied to a budget of 1000€.

Market asset	Costs (%)
Forex (USD)	1,34
Gold	9,57
Stocks (Shell)	0,95
Cryptocurrency (bitcoin)	0,27

Real estate can not be averaged in this manner due to the need of a higher threshold of initial capital, generally meaning that it is not practical to enter a real estate market with a budget of 1000€. The foreign exchange market is among one of the highest with 1,34 % costs while cryptocurrency is the absolute lowest in terms of costs. The reason that gold has almost 10% costs is due to the fact that the precious metals industry has one of the largest spread in buying price and selling price, which is why it is often bought for a longer period of time.

Stocks also have a side to them which is not discussed in this work but has to be noted, and that is dividends, a lot of companies reward shareholders with yearly payouts depending on the profits made by the company and the decision of the management. There are also some other taxes and laws regulating their purchasing and trying to prevent any illegal manipulative tactics or abuse of information.

We are going to use portfolio analysis to show which of the markets has the most current speculative profitability and future potential. For this analysis we have limited ourselves to 2 markets; The cryptocurrency market and the stock exchange. The portfolio analysis looks at the previous, current and future state of a portfolio investment as well as the profitability of said project. The graph is then divided into positive investments, those which have high potential in bigger speculative profitability and in negative investments, which are those that are in decline. The foreign exchange market, gold market and real estate market are not going to be compared, due to the fact that the markets demonstrate lower volatility and are in most cases dependant on many factors, however they will be mentioned as all three of them are a potentially useful investment, depending on the type of investor.

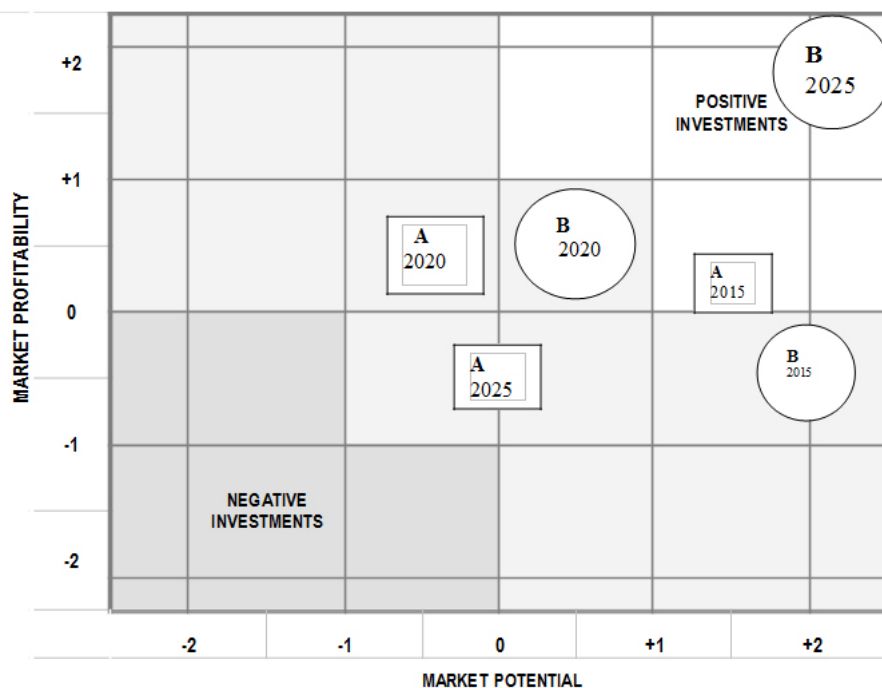


Figure 7: Portfolio analysis of stock exchange market (A) and cryptocurrency market (B), for the period of 2015, 2020 and 2025.

Our next method is going to consist of SWOT analysis on both the stock exchange market and the cryptocurrency market. This tool will give us a clearer description of strengths, weaknesses, opportunities and threats that exist for a certain market.

S W O T analysis (stock exchange)	
Strengths <ul style="list-style-type: none"> ✓ Ownership of a growing asset ✓ Easy to understand and get involved ✓ Regulatory support and troubleshoot ✓ Possibility of dividends 	Weaknesses <ul style="list-style-type: none"> ▪ Relatively high costs ▪ Relatively low liquidity ▪ Requiring bureaucratic knowledge ▪ Difficult to enter with smaller amounts of money
Opportunities <ul style="list-style-type: none"> ✓ Influencing the company ✓ Future employment ✓ Discussing with shareholders 	Threats <ul style="list-style-type: none"> ▪ Hostile company environment ▪ Added costs in taxes ▪ Company merging or foreclosing ▪ Buy outs

Figure 8: SWOT analysis of the stock exchange market, the strengths are primarily dividends and the fact that by having stocks a person is owning a chunk of the company, one of its most pronounced weaknesses are its costs and the relatively low liquidity.

S W O T analysis (Cryptocurrency)	
Strengths <ul style="list-style-type: none"> ✓ Technological potential ✓ Preferable for smaller investments ✓ High liquidity ✓ Low costs 	Weaknesses <ul style="list-style-type: none"> ▪ Relatively high volatility ▪ Requiring technical knowledge ▪ Limited customer support ▪ Prone to market manipulations and scams
Opportunities <ul style="list-style-type: none"> ✓ Learning technological literacy ✓ Using the cryptocurrency as payments ✓ Possibilities of digitalization 	Threats <ul style="list-style-type: none"> ▪ Local regulations ▪ High unpredictability ▪ Political swaying or tensions

Figure 9: SWOT analysis of cryptocurrency market, the strengths are noticeable in high and fast liquidity as exchanges are open 24 hours a day and very small margins. However, investing in cryptocurrencies is highly risky, as we can see from the volatility it is the absolutely highest.

By better visualizing the different aspects of the markets we can conclude which one is better for a certain investor situation. Starting with the strengths of the stock market, the main one being that in the case of purchasing stocks the user actually purchases a limited part of the company itself and as the company evolves and progresses, so does the asset (stock).

Stocks are fairly easy to get involved in and require very little knowledge of the process, brokers and stock exchanges offer a straightforward way so that everyone can start investing with minimal effort. If things go wrong or a company is experiencing bad times, there are laws and regulations protecting you from fraudulent actions and many of the manipulations that we have discussed earlier. As the company grows it can periodically share its profits with the shareholders in terms of dividends, the share of profits is, together with speculative returns, one of the main strengths of owning stocks.

Most of the weaknesses are in the fact that there are relatively larger fees and cost and not all of the stocks are suited for small time investors so anyone investing would have to be careful about the selection. Similar things apply to the bureaucracy related to owning stocks, as some stocks are more difficult to acquire than others due to scarcity or perhaps the company not allowing foreign investors. Some of the stocks are more difficult to sell than the others, which is also one of the things to be considered a weakness although this might be mitigated with a thought out selection.

By owning stocks of a certain company there are many opportunities either by influencing the company's decision directly, which is related to the number of shares, seeking future employment at the said company, owning the stock might be a sign of devotion. Or simply discussing with the other shareholders about the future of the company, gaining information about other potential investment opportunities as well.

The threats of being a shareholder, beside the actual bankruptcy of the company, can be considered off-putting to some potential investors. As with the other types of free markets, but to a lesser extent, the stocks are susceptible to market manipulations and inside information, someone distrustful of that should not be part of this market. Political decisions of the country can also affect the stocks of the company and can either make or break a profitable situation, but overall there aren't many threats that an investor should keep in consideration, which is why the stock market is one of the most popular market when any person mentions investing.

With respect to stocks, cryptocurrency market is the one that is most closely related in terms of volatility and accessibility, albeit the risks are higher due to a more unrestricted and unregulated environment. Its main strength is the fact that each of the currencies has its own technological solution backing it up, meaning that they have a practical use in either forming a bigger network or functioning as a standalone entity.

Investments of all kinds of values are possible, since a particular values can range anywhere from a millionth of an Euro or a few thousand Euros. In almost all the cases liquidity is also high, meaning that any pair can be exchanged almost immediately and the exchange markets are open 24 hours a day, so there is no delay between the offering and the purchase. One of the better properties is also the fact that it is substantially cheaper to enter and trade than any other forms of free markets.

The most notable weakness is the extremely high volatility of these markets, coupled with the dangers of many different market manipulations this gives a hostile environment for investors that are inappropriately diversifying their portfolio.

Besides the risks there are technical limitations as well, IT knowledge is required in order to understand what cryptocurrencies are and how do they exist as well as how to purchase and store them safely. Customer support or any kind of help is not readily available and the information is limited.

There are great opportunities to learn in-depth about technological challenges solved by each currency and company standing behind it and to learn from one of the most pure forms of free market. Many cryptocurrencies are already being accepted as payment, there is a possibility that credit cards might be replaced with blockchain technology which might prove to be a great opportunity.

The possibility of incorporating blockchain technology into other aspect of any digital aspect in the company opens up possibilities that might entice investors who would to get involved in IT sector of the markets.

With opportunities come threats as well, due to the market being almost completely unregulated there are some fears of possible taxes or different local regulations regarding the use or possession of cryptocurrencies. With the market being susceptible to political and outside pressure there is a threat of instability.

3.2 Risks

Risks and risk management are a very important skill of every investor, whether as a career or just as a way to reinvest any savings, if the risk management is inappropriate, the investor might lose a large chunk of their portfolio at any given time whether in a crisis or negative market shifts.

All of the markets that we have discussed are prone to shifts, growths and falls at any given moment. These scenarios are very difficult to predict and in chapter 5 of this work we are going to discuss some of the factors which are involved in it.

In this chapter we will define three types of investors, among the general population, excluding people that are investing professionally and focusing on the segment that wishes to better invest their extra resources or savings. The criteria for categorization will be the amount of risk an individual is willing to take on their asset overall (Sheikh, 2020).

The first type (Type I) of investor, is a person who does not want to take risks, wants steady and continuous growth for his assets and very secure keeping of their financial instruments. Being overly conservative is not an optimal position for investing at all, since that would mean avoiding risk management entirely. Being completely risk free is impossible, but lowering the chances of losing equity to as low as possible also lowers the chances of gaining any strong positions in a given market.

The second type (Type II) is the one that makes moderate risks but still wants to see a steady increase in their assets. Risk management is applied most efficiently and the chances of losing equity are low and understood. This type of investor is arguably the most realistic and with the highest likelihood of long-term success.

The type III investor is the one that would be willing to accept maximum amount of risk if there is an appropriate possibility of return. Such an investor has a very high chance of critical failure, however, only by taking large rationalized risks it is possible to reach the potential of any opportunity that was given to the investor. Of course, the definitions proposed are not definite; Plenty of readers might find themselves between any of the above mentioned options or with different characteristics from each type category.

3.3 Advice for potential small time investors

Equipped with knowledge of different markets and investor types, we can assert which markets are better suited. It is very important for every investor to have a diverse and open portfolio with many options and large potential. The analysis will be done as author's advice, based on the data we gathered in this work. In our resource distribution we are going to assume that the investor is not looking for real estate (due to its high costs) and the resources are limited to 10.000 € (Bizjak,2008).

Any investor that is looking for stable assets and for a steady value increase should distribute his investment according to the pie chart in Figure 10:

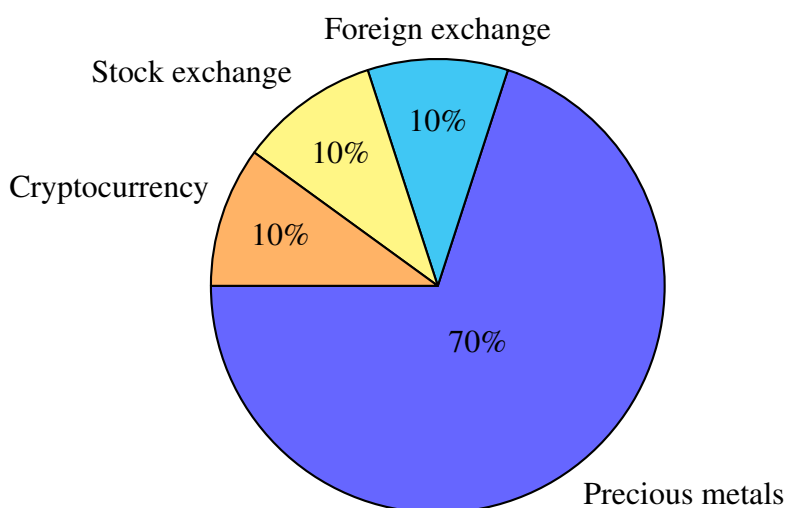


Figure 10: Investment distribution for type I investor, the risks are minimized as much as possible while still retaining a possibility of bigger returns.

The second type of investor, shown in Figure 11 is presented as more of a risk taker, therefore the whole portfolio should be distributed more towards the risk heavy options. Gold is the least volatile and should take about $\frac{2}{3}$ of the portfolio, while the rest is distributed among more volatile markets.

The last investor, shown in Figure 12, type III investor, is the largest risk taker, therefore the majority of his portfolios are going to be in the most volatile market and some smaller percentage in the safer ones.

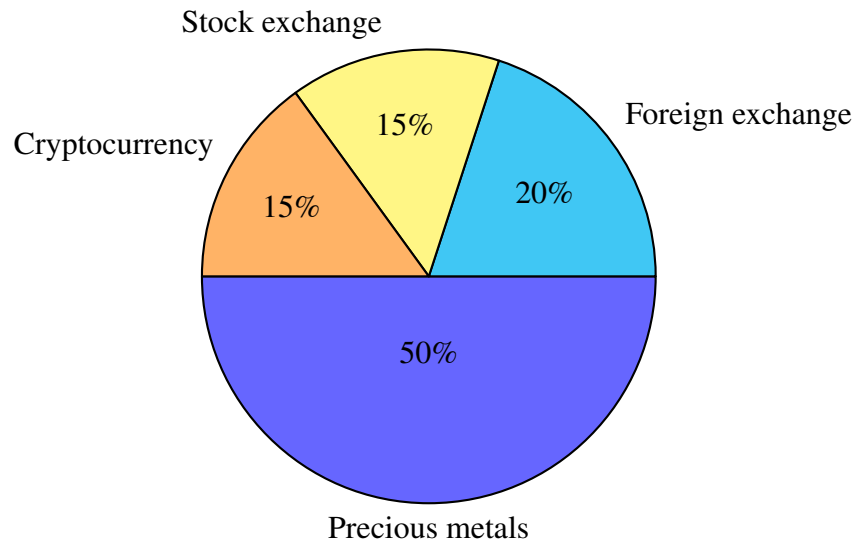


Figure 11: Investment distribution for type II investor; The risks are optimized as much as possible with about half of the portfolio being in the least explosive market.

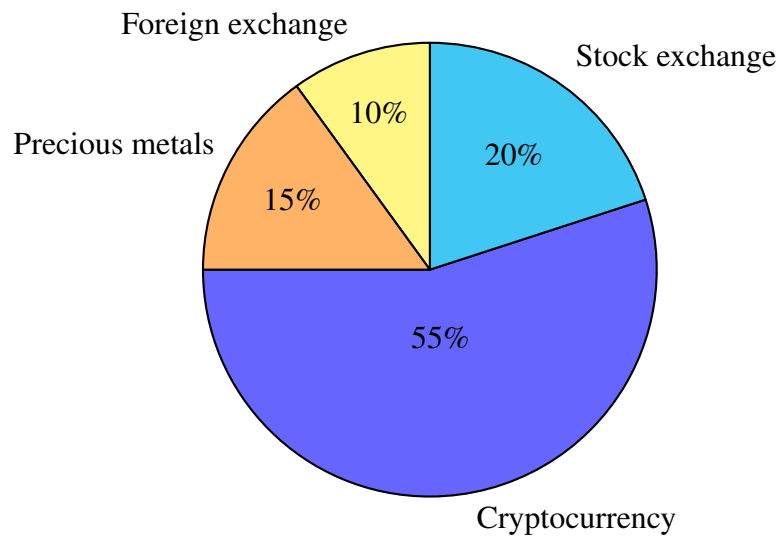


Figure 12: Investment distribution for type III investor; The risks are maximized as much as possible with more than half of the portfolio being in the most explosive markets.

4 THE MATHEMATICAL MODEL OF THE FREE MARKET SYSTEM

We have defined that a free market system is an economical system in which buyers and sellers interact freely, without any imposed constraints about the supply and demand. For practical reasons we have also set a fixed supply, that way, the market cannot be affected by mass producing the item. There exists a dynamic between the buyers and sellers, governed by the price of the item, which is, in turn, connected to the ratio between sellers and buyers.

Now, we have to take into account the interaction between the two, at first, until the item is well distributed among all actors, it will not have any price and the dynamic is not yet fully established. The dynamic is more obvious when taking a look at a more specific case. Buyer and seller can become interchangeable; When a person, that has bought an item for a cheaper price, is now selling it. Or on the other hand, when a person who bought the item expensive is now trying to sell it, because the demand (and therefore value) has fallen and the person is afraid the price will drop even further.

Our goal is to try and describe this behaviour mathematically, as realistically as possible with some assumptions to make the model behave more appropriately. One method is to apply the Lotka-Volterra "predator and prey equations", which are used to model the relationship between the prey and predators, in our case buyers and sellers, which share many similarities.

Alfred James Lotka and Vito Volterra, scientists with different backgrounds, one a chemist and statistician and the other a mathematician, independently developed equations that describe a natural evolution of a system where there is a predator-prey dynamic (Wangersky, 1978).

The equations can be adapted to demonstrate some of the properties of a free market, where buyers and sellers act similar to a predator and prey, both are being driven by a similar need and where food (economical items) are a finite resource.

We first start off by representing the state at which the number of buyers would change, if buyers are not allowed to sell their bought items. Equation (1) below, is the first linear differential equation, where B is the number of buyers and a is the incentive to buy, which may be a constant intrinsic rate of growth or in more complex systems, might manifest as a function of price. The variable a can also be denoted as the difference in

likelihood of a person entering the market and a person leaving the market (Dobovišek, 2011).

$$\frac{dB}{dt} = aB \quad (1)$$

The solution to this equation is an exponential growth otherwise known as a Malthusian growth. By allowing the buyers to sell their items we introduce a new population model, the sellers. Equation (2) describes the behaviour of sellers if they are not allowed to sell, where S is the number of sellers and q is the rate at which the sellers exit the market entirely.

$$\frac{dS}{dt} = -qS \quad (2)$$

If the sellers are allowed to sell, interact and interchange with buyers, the equation (2) has to be modified to express the interactions. Equation (3) is one of the main equations describing how sellers act in the presence of buyers. Where B and S represent the number of buyers and sellers respectively, the parameter c represents the increase of sellers with respect to the number of buyers.

$$\frac{dS}{dt} = cBS - qS \quad (3)$$

The number of buyers does not increase indefinitely, similar to equation (3), the rate of change of buyers in presence of other sellers has to be factored in. Equation (4) shows the change of buyers when selling is allowed, where r is the parameter that determines the interaction, whether the buyer becomes the seller or leaves the market entirely.

$$\frac{dB}{dt} = aB - rBS \quad (4)$$

Now the equations (3) and (4) describe the dynamic in a system with buyers and sellers. So far we have made some reasonable assumptions: The item that is being sold and bought cannot be consumed or manufactured indefinitely. There is limited amount and the item has intrinsic demand, as in, every subject in the economy would like to have it.

Noone can be a buyer and a seller at the same time, a sale and a buy must be performed at a different time and a different pair, this is in order to simplify the interactions and avoid more complex factors.

Human thinking, speculating and scheming is kept to a minimal, as well as any communication between sellers and buyers and neither can be aware of any economy and outside factors. Money or the currency at which the subjects exchange the item is arbitrary and will be expressed as a ratio between the number of buyers and the number

of sellers. Equation (5) shows the concept of price for an item at a certain time, the price is a function of time and in this model, dependent only on the number of buyers and sellers, f denotes a price correction factor:

$$P = f \frac{B}{S} \quad (5)$$

The solutions to equations (3) and (4) have to have some initial conditions, conveniently there are programs and websites that allow us to set the initial conditions and then calculate and plot the rest automatically. The initial conditions in our case are trivial and not relevant, as we are only looking at the overall behaviour of the system. The result of plotting the two differential equations is shown in Figure 13.

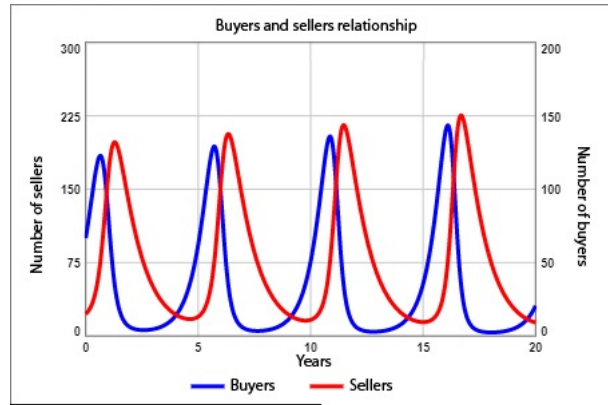


Figure 13: Buyers and sellers have a cyclical relationship, the number of buyers slightly lags behind the number of sellers as both of them eventually catch up (Darkow, 2015).

By using a script in Python we can plot vectors for every point in the graph, showing their actual direction. This results in the so called orbits, where the behaviour of the system is cyclical as observed in Figure 14.

The graph contains information about the number of sellers and buyers as well as the price of a such item, according to equation (5). We can explain this graph by looking at a specific point, for example 20 buyers and 5 sellers; The number of buyers is far greater than the number of sellers, prompting a larger demand and an increase in price. As the number of buyers starts increasing, more of them will decide to sell their assets thus decreasing the demand. While the demand decreases, the number of sellers will start dropping again, starting the cycle over.

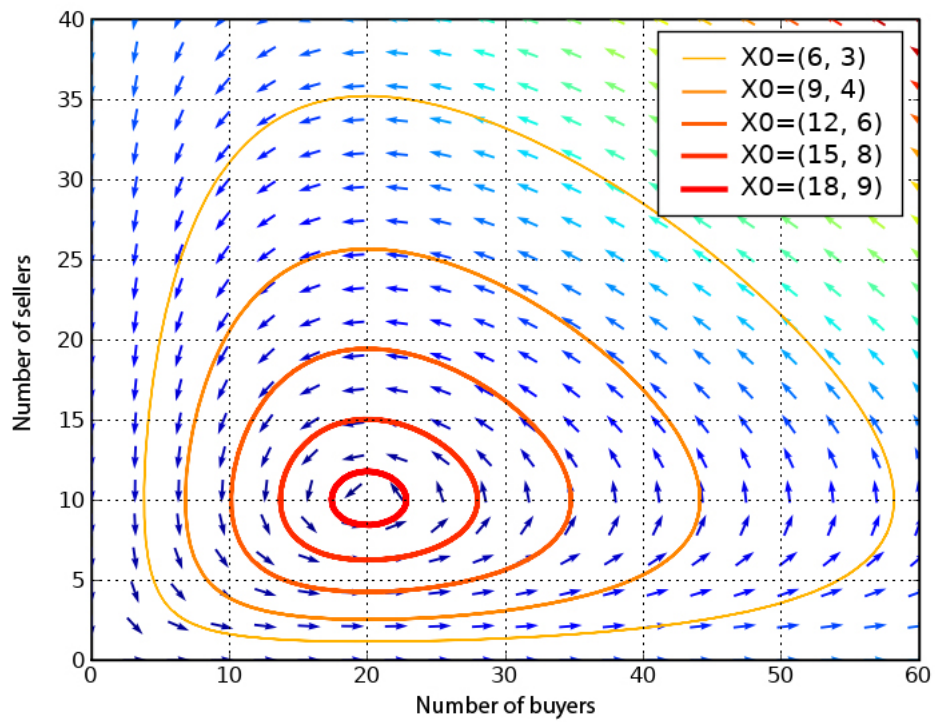


Figure 14: Vector field of the equations (3) and (4), the graph also indirectly suggests, through the use of equation (5), the price of any financial instrument in the active market (Darkow, 2015).

5 PRICE ASSUMPTION, REAL LIFE COMPARISON AND CORONAVIRUS OUTBREAK

We are interested in what the price of any item circulating in a free market would be. From equation (5) we can conclude that the price will only be defined by the volume of the demand or the relationship between buyers and sellers. The more the item will be sought after, the higher price it will have. The price will, in case no new buyers or sellers arise in the market, become stable, at which point no more changes will occur, that equilibrium point is visible in the Figure 14 as the innermost point around the draw trajectories.

We can notice the price changing behaviour whenever there is a relatively larger arrival of buyers who want to purchase the item or when the buyers leave the market. Both of them can be expected using the model stemming from equations (3), (4) and (5). We will compare the model to the 2017 wave of cryptocurrencies. In the period of late 2017 and early 2018 cryptocurrency became increasingly more popular, at first starting as a few reports on the news, highlighting the existence and then rapidly evolving into hype phenomenon. The arrival of many new investors, who wanted to purchase any form of cryptocurrencies was expected, as was a large increase in price.

We can use equation (5) to roughly calculate the expected price, knowing only the number of buyers and presuming that other factors haven't had any bigger influence, therefore we will set the correction factors f to 1, we also presume that the number of sellers stays the same. The number of buyers in November 2017 was (from Figure 16) 2,2 million users and the price of one Bitcoin at the time was about 6000€. The number of buyers towards the middle of December of 2017 was about 6 million. Putting these numbers in equation (5) and setting the price at the end of December as unknown (X):

$$6000 = 1 * \frac{2,2}{1} \quad (6)$$

$$X = 1 * \frac{6}{1} \quad (7)$$

The increase in the number of buyers was 272 %, that would mean that the expected price of 1 Bitcoin at the middle of December 2017 would be 16,300€, the observed price for the time in Figure 15 was 15,000€. This suggests that the 2017-18 surge in Bitcoin prices were mainly due to the new users and the supply not keeping up. Many users then left the market, which accounts for the negative trend in the next few months.



Figure 15: In the period of 2017 to 2018 bitcoin became one of the most popular currencies worldwide with millions of new users entering the market (Coinmarketcap.com, 2021).

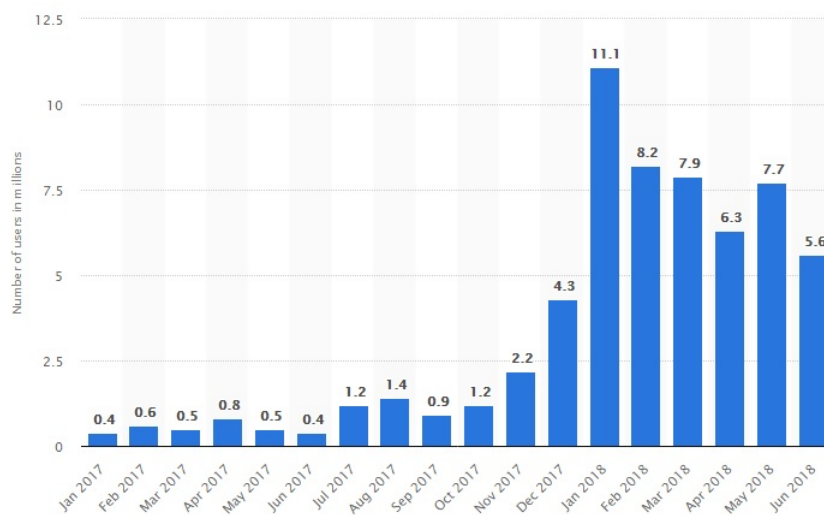


Figure 16: Number of users for one of the largest cryptocurrency exchanges from early 2017 to mid 2018 expressed in millions (Statista, 2020).

The second more negative wave was the most recent 2020 Coronavirus outbreak, where Bitcoin has seen a drop to almost half its price, due to people selling their assets in order to purchase other necessities that would be needed during the crisis. This is visible in Figure 17 as a sudden drop in the middle of March.

We can roughly analyze some of the years from 2014 to 2020 in order to see the general behaviour of such a system with some other changes in the outside world. Figures 18 and 19 will give us insight at what movements can be expected in the market in general.

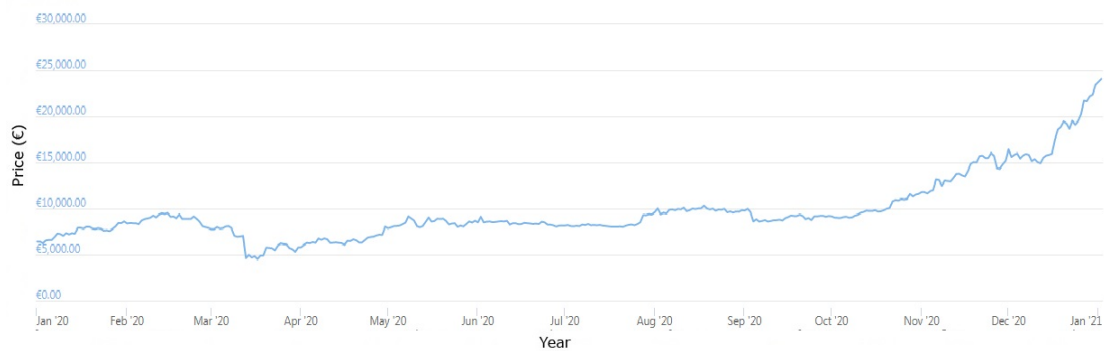


Figure 17: The start of widespread quarantine restrictions happened in March, reflecting a steep drop in the cryptocurrency, while the restrictions were lifted at the end of May. The price has slowly risen back to its initial value and the market started experiencing a historically large upswing (Coinmarketcap.com, 2021).

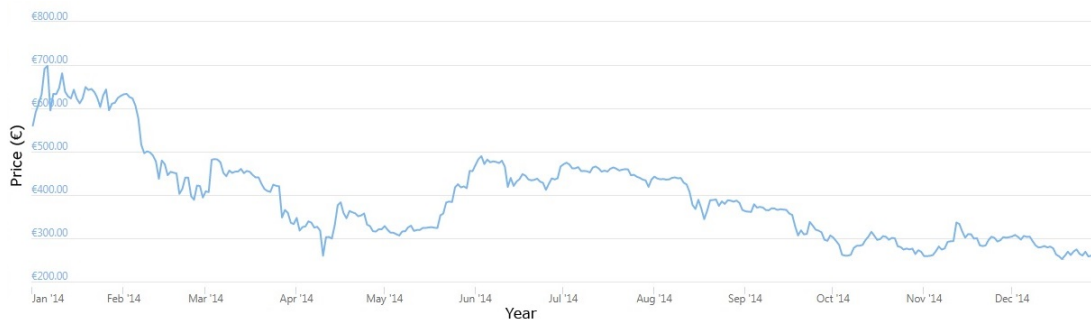


Figure 18: Bitcoin price in the year 2014, where in early February one of the largest cryptocurrency exchanges (Mt. Gox) was found to be hacked and subsequently filed for bankruptcy, leading to a drop in price (Coinmarketcap.com, 2021).

In the year 2018, right after the big cryptocurrency boom, nothing really eventful happened, we can observe a downward trend in price but overall the swings were pretty standard for a stagnant market.

Furthermore, we can take a look at the number of different unique addresses on the website throughout their history. Blockchain.com, a website block explorer service, which can show us how many unique addresses to store cryptocurrencies are being used, this is shown in Figure 20. This roughly translates to the increase or decrease in number of users in the cryptocurrency market altogether.

Coronavirus outbreak can negatively or even positively affect other markets, we are briefly discussing the impact that it might have on each of them and speculating how the number of buyers and sellers can change in the future.

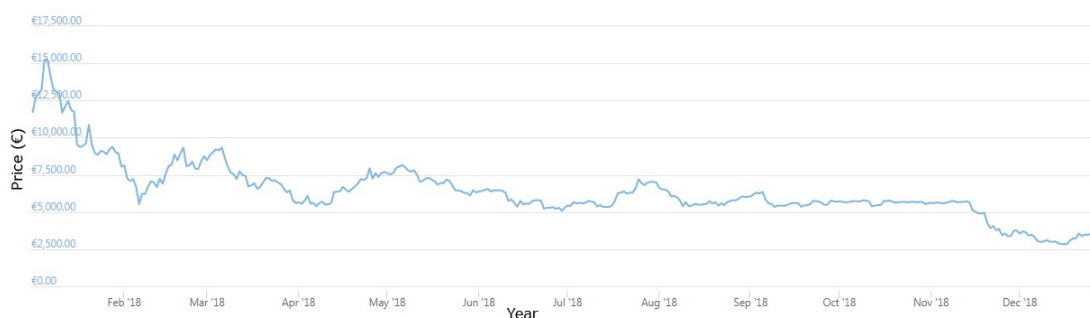


Figure 19: One of the most uneventful year that we have examined so far. The cryptocurrency market was at this time very stagnant and not particularly inviting for any new investors (Coinmarketcap.com, 2021).

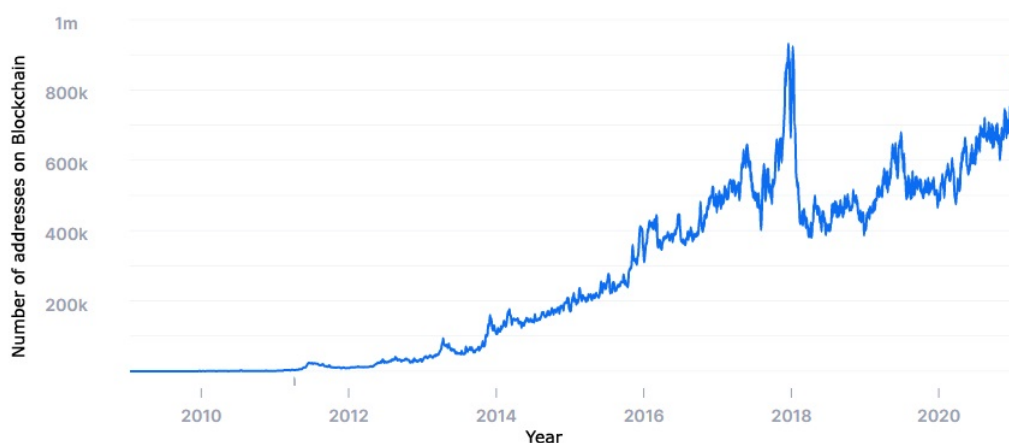


Figure 20: Historical chart of Blockchain.com users, expressed in unique addresses. By visually comparing this graph to Figure 6 we can observe the correlation between the number of users and the price (Blockchain, 2020).

With the pandemic and most of the public life and companies closed the economy overall is going to take a turn for the worse. Foreign exchange markets will probably see an overall drop in price, with the possibility of worldwide unemployment rates rising, the foreign currency markets could require different types of investors to restart their momentum.

Precious metals are the market which is most resilient in times of any sort of crisis, presumably the demand for gold, silver and other rare metals would rise, taking the price along with it. For investors this an interesting choice for keeping their assets safer and not risking them in an economy turn for the worse.

The stocks and bonds markets have taken a large swing at the start of the worsening

conditions in March of 2020, as the companies began closing down, it is expected however, that the companies which have not been bankrupt will pick their pace up and regain the lost assets.

As people are trying to find a more peaceful way and trying to get out of the city, many of them would want to spend more of their time in a more rural or suburban area, the increase in demand for such real estate can be expected, as well as people trying to buy or rent a piece of agricultural property.

6 CONCLUSION

We have compared the different free market economies by their most important characteristics and the results will hopefully give the reader a better insight about their investments. The cryptocurrency market has proven itself to be very volatile, indicating a better suit for a very knowledgeable and risky investor.

While gold on the other hand, is the most stable of the markets, parring only with the real estate, however investing in real estate presents in itself much more challenges than just the knowledge of the market. Gold is the perfect alternative to saving money in the bank for any investor who is looking at very small risks. While foreign exchange and stock exchange are similar to each other, they are appropriate for anyone who is moderately risky and knowledgeable.

Having adequate knowledge about a particular economy one wishes to invest into is a very important factor in understanding your assets. The mathematical model we adopted from Lotka-Volterra predator-prey equations will help us form a general understanding of the complex relationship between supply and demand. The linear model of supply and demand in Figure 1 is too simplified to demonstrate an actual market dynamic, which is why improvement is necessary.

By knowing each market as much as possible and having the proper mathematical models, it is possible to make an educated and a more profitable guess about whether the price of an asset in a certain economy will move up or down and how long will it continue in that fashion. The model can be improved by accounting for trends and introducing more variables in the system, to even better approximate it to a realistic scenario.

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8 APPENDIX 1: PYTHON CODE

Python code as an example that can be used to plot population models, the code outputs an animated version of Figure 13 (Miller, 2020).

```
import matplotlib.pyplot as plt
from matplotlib import animation

#Set your constant values
alpha = 3
beta = .1
gamma = .8
delta = .03
x1,y1 = [0],[50]
x2,y2 = [0],[20]

#simulate out for 100 steps
for n in range(100):
    new_y1 = y1[-1] + ((alpha - beta*y2[-1])*y1[-1]).1
    new_y2 = y2[-1] + ((delta*y1[-1] - gamma)*y2[-1]).1
    x1.append(n)
    y1.append(new_y1)
    x2.append(n)
    y2.append(new_y2)

fig = plt.figure()
ax1 = plt.axes(xlim=(0, 50), ylim=(0,100))

line , = ax1.plot([], [], lw=2)
labels = [ 'Prey', 'Predator' ]
lines = []
for index in range(2):
    lobj = ax1.plot([],[],lw=2)[0]
    lines.append(lobj)
```

```

def init():
    for index in range(2):
        line = lines[index]
        line.set_data([],[])
        line.set_label(labels[index])
    legend = plt.legend(loc='upper_left')

    return lines

def animate(i):
    xlist = [x1[:i+1], x2[:i+1]]
    ylist = [y1[:i+1], y2[:i+1]]
    #And setting the data in the lines
    for lnum, line in enumerate(lines):
        line.set_data(xlist[lnum], ylist[lnum])
        line.set_label(labels[lnum])
    legend = plt.legend(loc='upper_left')
    return lines + [legend]

anim = animation.FuncAnimation
(fig, animate, init_func=init, repeat=False,
frames=50, interval=50, blit=False)
plt.show()
anim.save('lotka_volterra_test.gif', writer = 'imagemagick')

```