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THE IRRATIONALITY BEHIND CRYPTOCURRENCIES

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Abstract

Cryptocurrencies are one of the phenomena that has shaken the financial world the most since the 2008 crisis. One only has to scroll through the news of major financial newspapers or social media feeds to understand how much digital currencies and their derivatives, are influencing the investment decisions of many people, especially young novices.

The euphoria generated by this new trend has led me to reflect on the irrationality of certain decisions made by some individuals, in the name of their own beliefs and, above all, immediate gain. It is without a shadow of a doubt that the value of Bitcoin, and in general all new digital currencies, derives not so much from their actual intrinsic value, but from a mass hysteria that sooner or later could lead to a major downsizing of the entire sector.

With this in mind, I decided to formulate the hypothesis of the following thesis, trying to isolate some biases derived from behavioral finance, which in my opinion greatly influence the decisions of cryptocurrency investors.

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Introduction

The first theory I ever studied in my college course is the theory of Homo Economicus. This is a kind of man whose key characteristic is rationality. He acts for his own interests to derive the maximum welfare using the least amount of resources possible.

It is clear that a man completely lacking in morality, although he succeeds in satisfying his needs, cannot exist in reality. Economics is called social science because it focuses on the study of people's behavior, and it is known that people do not act according to the standard of homo economicus, but according to parameters dictated by events and characteristics that cannot be homologated. Rationality and the ideal of behavior in a perfect economic environment are used to simplify models, but it still remains a theory and not a fact.

The most glaring example is surely the Efficient Market Hypothesis (EMH), which has been criticized by people like Warren Buffet. However beautiful and perfect the Efficient Market Hypothesis may be, it will inevitably have to contend with the many shortcomings of an imperfect world.

It is undoubtedly true that behavioral finance is increasingly the focus of economic studies nowadays. Its importance has grown with the complexity and technological development of our society. Using it, in addition to making us more aware of our irrational side, can help us make better and more thoughtful financial decisions. The consequence of this is optimizing utility and decreasing losses. An individual who knows his irrational part dictated by emotions can aim for more rational choices.

Another trend that has been much debated for about 5 years are the cryptocurrencies. Financial revolution or mere speculative asset? Many have been asking this question, and I think the truth is more complex than it seems. It is undoubtedly a revolution in terms of information technology but the speculation it has brought is definitely the result of various irrational behaviors they have provoked, especially in small and medium investors. In addition, being a very complex and not easily understood

instrument, the "mystical" aura behind cryptocurrencies has certainly increased their popularity in terms of the possibility of getting rich.

In my thesis I aim first to explain the phenomenon of cryptocurrencies, how it originated and how it has developed over time. Next, I will try to connect the speculative and investment mechanisms in terms of behavioral finance, to understand how much their success is the result of thoughtful decisions by investors or simply the choices are the result of partly or completely irrational behavior.

Chapter I Cryptocurrencies

1.1 Where it all started

On May 22, 2010, in a small town in Florida, Laszlo Hanyecz decided that he would have pizza for dinner. So he orders from Papa John's, a U.S. pizza chain, two pizzas. Laszlo decides not to pay in dollars, however, but in Bitcoin. Thus occurred the first transaction of 10,000 Bitcoins. But what just the events that allowed this to happen?

The term cryptocurrency refers to a representation of digital value, based entirely on cryptography. This new type of currency was created with several key characteristics:

- It had to be entirely digital.
- It had to function outside the classical financial circuit.
- It had to be based on cryptography.
- Transactions and coin owners had to remain anonymous.

The above cryptocurrency concept was not born in 2008 with Bitcoin as everyone thinks, but much earlier in 1982 thanks to American cryptographer David Chaum. From David's mind came eCash, the world's first all-digital currency.
This new payment system was going to solve a problem that was impossible to circumvent at the time, a payment system that was completely anonymously. But David's system had one major flaw that differentiated his currency from those of today, the computer system was a centralized system, instead of a decentralized one. We will see later what this mean.

In 1998 a Chinese computer engineer named Wei Dai created b-Money, a new type of cryptocurrency that unlike eCash introduced the famous Proof of Work that will be explain in later chapters.

Another important step was the publication of the work of Nick Szabo, a computer engineer, law graduate, creator of Bit Gold and originator of smart contracts.

ECash, proof of work and smart contracts were the three building blocks that enabled the creation of modern cryptocurrencies as we know today. We arrive on January 3, 2009, when Satoshi Nakamoto creates the first "block" of Bitcoin thanks to the work done by Chaum, Dai and Szabo. Now we return to the famous pizza purchase with 10,000 Bitcoins by Laszlo Hanyecz on May 22, 2010.

From 2010 onward, the world of cryptocurrencies sells exponential expansion. The first exchanges, virtual stores where classic coins can be exchanged for cryptocurrencies, are born.

Late 2010 Bitcoin is worth $0.05, Laszlo pizzas are worth $500.

In 2011, we see the emergence of several online stores such as Silk Road, which exploit bitcoin's anonymity for buying and selling drugs and weapons. In the same year, Wikileaks suffers a freeze on its accounts and a blocking of payments by PayPal. To fix this problem, the popular disclosure site begins to accept bitcoin as a form of payment, greatly increasing its visibility.
In the same year, Charles Lee, a former Google employee, modifies bitcoin's source code, creating the world's second largest cryptocurrency, Litecoin.

Late 2011 Bitcoin is worth $5.00; Laszlo's pizzas are now worth $50,000.

Within 2012, Bitcoin falls under the eyes of authorities such as the FBI. They are categorized as dangerous assets due to their exploitation by the underworld.

End 2012 Bitcoin is worth $13.00, Laszlo's pizzas are worth $130,000.

In 2013, several events occur that greatly increase the value of Bitcoin. The Fed and the U.S. government begin to take an interest in cryptocurrency, while the Chinese

government, which sees its financial authority threatened, blocks Bitcoin transactions by Alibaba, the China's Amazon.

End of 2013 Bitcoin is worth $1,000; Laszlo's pizzas are now worth $10 million.

In 2014 we see the opening of Bitcoin's first ATM in Italy and Amazon begins accepting cryptocurrency as a payment method. The Italian parliament begins to discuss Bitcoin's potential.

Late 2014 Bitcoin is worth $300; Laszlo's pizzas are now worth $3 million.

After 2014 meltdown and a stagnation in 2015, it is in 2016 that sees the outbreak of a real euphoria. China decides to liberalize cryptocurrencies and some Asian universities decide to create specialized courses of study on this field.

The 2017 is the watershed year, when Bitcoin finally enters the world's socioeconomic fabric. From them on, the price will grow, also selling an increase in the number of new cryptocurrencies and technologies related to them.

As of today, May 2022 Bitcoin is worth $39,034, Laszlo's pizzas are now worth $390,340.00 million, the most expensive pizzas in the human history.

1.1.2 Difference between a centralized and decentralized system

The first cryptocurrency created by David Chaum had one key element that differentiated it from modern-day cryptocurrencies: it still operated with a centralized system.

A centralized system is when information, in order to be transmitted, must mandatorily pass through a single point or node. In contrast, in a distributed system there is no such

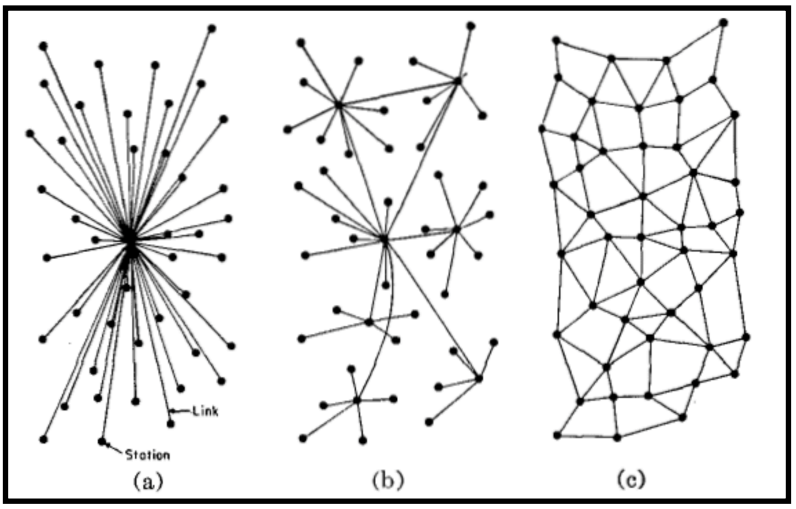

Figure 1.1, graphical exposition of different types of interconnected systems.
(a) Centralized system (b) Decentralized system (c) Distributed network

obligation and so there is a connection called peer to peer. Then there is a third decentralized type system, in which not all informations are free to flow through all nodes. The Figure 1.1 graphically displays all three types of systems.

Returning to eCash, it had a particular system for guaranteeing anonymity within a system.

In a normal centralized system, banks act as credit guarantors for those who deposit money into their accounts. Let's pretend that Mario goes to the bank and deposits €100. The bank returns a numbered sealed envelope to Mario. Anyone who owns this numbered envelope can go to the bank and take Mario's €100. However, the bank inserts a second secret code that is known only if you open the seal of the envelope. With the second code, the bank goes to authenticate the envelope, preventing clever people from counterfeiting it. If Mario wants to pay a merchant, the merchant can hand over the envelope with the identification code and the bank's authentication seal.

In this case, it is clear that the bank knows who Mario is and how much money he has deposited in the bank. To get around the problem of anonymity, David Chaum created his own encrypted protocol through complex mathematical calculations. Now Mario can go directly to the bank with the sealed envelope, the bank after studying the protocols and their authenticity, accepts the creed and places its seal in the envelope. The

envelope then is encrypted twice in this case, first by Mario and then by the bank. David Chaum in doing so solved the problem of anonymity, both vis-à-vis the merchant and the bank itself.

This type of process was accepted by several banks in the 1990s such as Credit Swiss and Deutschebank.

1.2 The technology behind cryptocurrencies: The BlockChain

As mentioned in the previous chapter, there are several distribution systems. The Bitcoin system is based on the Distributed Ledger. It is no longer based on the trust of a single system that makes up the information network, but a network of trust between parties through a consensus decision-making process.

Real breakthrough for the creation of modern cryptocurrencies is definitely the "BlockChain". I believe its creation is one of the milestone of modern finance, which will go on to shape the financial system and beyond in the coming years.
The BlockChain was born with the creation of Bitcoin by Satoshi Nakamoto in December 2008.

But what is BlockChain? Essentially, it is a digital repository that contains a set of transaction data about the cryptocurrency to which it belongs. What differentiates this technology from classical ones is the fact that the system is not located on a single server like a bank server, but the data is distributed over a network, hence the name BlockChain. Each node contains the BlockChain, which would essentially be the transaction log. If we consider Bitcoin's BlockChain, it is updated every time a transaction of the cryptocurrency takes place, going on to add a block. Then the copy of the new block is shared to the other nodes.

The BlockChain can contain not only data inherent to transactions, such as transfer amount, sender and receiver, but it can contain other kinds of data such as lines of code that are essentially nothing more than the famous smart contracts. Next we will see what they represent.

The Blockchain system has several advantages that in my opinion make it an almost perfect information system:

- In any centralized database system, if the server was damaged, the data would be lost unless there was a regular backup. Whereas in the Blockchain system, even if one server or block was damaged, the copy of the information is saved in all the other nodes.
- Transparency is another point in favour of the Blockchain. If a single entity owns the data, it can decide whether to make it public or not. In addition, a single ledger is easily modified if it is owned by a single entity.

Nodes do not know each other, but they interact through cryptography. Blocks are added whenever there is new information to be entered into the database. The First block, called the genesis block, was created in 2009 by Nakamoto himself. From there on, the other blocks were added, and each time an addition comes, all owners of the database must update the BlockChain. The Blocks are added in chronological order and are all chained together.

Within them they contain two things:

- A hash, which is simply a code identifying the individual block
- A time stamp, to know when the block was created

Each node that makes up the infrastructure, owns the entire BlockChain, this means that if I enter the chain with past blocks that have been changed, I am automatically recognized and excluded from it.

So new information that is added to the system by a node, must be accepted by the majority of nodes, and then transcribed by the whole system.

A possible limitation to this system is that the process takes a lot of time and space, thus the risk that at some point the database will be too large to be stored by everyone, since very powerful computers and memories will be needed.

1.2.1 Proof of work/Proof of stake

We understand that in order to add a new block to the BlockChain, we need the approval of most of the nodes, but we need to understand how this validation takes place each time a block is added. This process is called Poof of Work or Proof of Stake.

Bitcoin uses the PoW (Poof of Work) system to validate new blocks. It is based on solving complicated mathematical calculations done by hardware that gives a Hash at the end of the process. It is called "Poof of Work" for the simple fact that the machines that process these calculations have to do real work with a huge expenditure of energy. In the beginning, this process was relegated to simple processors that were not very powerful, and then to the more modern graphic cards that are used in Bitcoin "farms."

The power consumption of these machines is one of the most criticized downsides of this type of technology. In addition to requiring a lot of energy to operate, they require energy to be cooled and thus produce a lot of pollution if the energy comes from non-renewable sources. Miners are those who "mine" Bitcoins using PoW. They are remunerated with the cryptocurrency of the mined system based on the amount of work they have done.

Proof of Stake, on the other hand, works differently. This type of process is not based on processing, but it is based on the amount of assets held. In this case we do not have miners but we have "validators."

The first concept on which staking is based is risk. The name "staking" comes from gambling, when you put money on the table it is said to be staking. This concept is similar to what happens in a PoS-validated chain. Let's take an example that an individual owns 20 percent of a coin and decides to put all the assets into staking. This 20 percent is not allowed to be deposited in a safe and immutable account, but is affected by some risks. A classic example would be an attack on the coin's Blockchain, which would cause the coin itself to lose value. Being that with staking, you can make money from it but you cannot move the principal easily, it is a not insignificant risk. So individuals who own more coins in staking make more money but also risk a lot.

But how is the validation and BlockChain creation process composed?

1. At first, a validator is chosen based on the percentage it has staked. As mentioned earlier, the more staking, the more likely to be chosen as a validator. The person chosen at random will be the block creator. It takes all the transactions that occurred during the creation of the block and combines them into a single block and then shares it with the other nodes.
2. The other validating nodes vote on whether or not the new block is okay. If a majority of at least 2/3 says it is okay, then the addition of the block is confirmed and propagated throughout the network. Not all nodes have to vote 2/3 is enough.
3. The block producer is rewarded if the block is approved by the majority.

Within the mechanism, there is also a deterrent for validators trying to cheat the system. It exists to prevent any fraud that might occur. Primarily already the amount of staking as mentioned earlier is a deterrent to make fraud not convenient for validators. If those who have to create the block behave improperly by proposing the wrong block, there is either the Slashing mechanism that goes to requisition part of the staking, or jailing that involves banning from the process of creating and validating blocks.

1.2.2 Smart Contracts

As mentioned earlier, each individual block that makes up the BlockChain, is able to contain within it a set of data that goes to identify and categorize it. But some BlockChain, such as Ethereum's, are also able to store within it lines of code capable of running programs, these lines of code are called smart contracts.
The goal of a smart contract is to ensure trust between the parties to a transaction, as to avoid the need for intermediaries.

As mentioned in Chapter 1.1, they were created by Nick Szabo with the intent of creating a computer protocol to execute the transaction in the manner and timeframe established. Smart Contracts running on BlockChain do not need supervision or a third party, but they operate according to their own programming. We could think of them as a digital vending machine, which follows the computer logic of IF SO, if it is A then we have B.

To complete a smart contract, there are specific conditions that must be met. Once we have all the conditions, the transaction can be validated by the contract.

The strengths of smart contracts can be summarized as:

- Accuracy: the conditions that must be met are summarized explicitly, reducing the possibility of errors during transactions.
- Transparency: all parties taking part in the contract have access to all the terms of the contract
- Speed: since the contract runs on a computer code, speed is guaranteed by the network.
- Security: contracts are very secure due to the application of the latest encryption methods.
- Efficiency: it is guaranteed by both speed and accuracy.
- Autonomy and level of reliability: the contract guarantees a baias-free process due to the elimination of third parties.

- Affordable costs: again, this plus point is due to the absence of third parties that would require additional costs.

The most famous BlockChain that have implemented these types of contracts are platforms such as Ethereum, Cardano, and Polcadot, mainly to create DeFi financial products, which we will see in later chapters.

Important to mention is that, smart contracts are also used for ICOs or Initial Coin Offerings.
An ICO is an unregulated crowdfunding system used to attract capital into the financial world of cryptocurrencies. Initially used to raise funds for new cryptocurrencies, today they are used to finance all kinds of projects related to them. Famous were the ICO launches of Ethereum and Mastercoin. One project that was particularly successful with this type of funding was the launch of the Brave Browser. This new type of search engine is based on remunerating users based on the time they use the browser itself: remuneration is through their cryptocurrency: BAT.

Certainly smart contracts have many plus points, but still there are two important limitations.

- The first is that they cannot be updated to the real world. Once the contract is written, it cannot have any connection to the outside world to be modified. This limitation is related to its own security, which limits its HTTP requests.
- The second limitation is the computer size that a contract can have. The maximum contract weight is 24KB, mainly due to the cost of the so-called "fuel." Fuel is the amount of energy a system uses to run in the BlockChain. Each time a transaction takes place in ETH for example, a percentage must be paid for the cost of fuel.

1.3 DeFi and CeFi

As reported in Chapter 1.2, BlockChain was born and developed as a decentralized system.

The introduction and development of tools such as smart contracts, have undoubtedly led to the development and enrichment of the entire cryptocurrency system, and this is how decentralized finance or DeFi was born.

A DeFi platform allows the exchange of cryptocurrencies, lending money, the ability to take out mortgages and speculate on cryptocurrencies using financial products such as derivatives. All without the presence of third parties, which, as mentioned in the previous chapter, are replaced by smart contracts.

Unlike DeFi, CeFi (Centralized Finance) on the other hand has centralization mechanisms typical of a traditional financial system. In CeFi platforms we have the presence of third parties that can give more guarantees than a DeFi system in case certain problematic situations may occur.

Not all platforms that allow cryptocurrency exchanges are decentralized systems. Some of them are part of DeFi and others are part of CeFi.

In addition, there is the distinction between DEX and CEX platforms to add. A DEX platform is a decentralized finance exchange platform of which a striking example is Pancake Swap. On the other hand, we have CEX platforms, which are Centralized exchanges such as Crypto.com or Kraken. DEX platforms do not have the need for intermediaries replaced by smart contracts, while in CEX there is a classical intermediary system.

Smart contracts are the main focus for the operation of DeFi. They are the parts that make up the most extensive Dapps. We can define a Dapp as a package of functions processed by smart contracts that goes to define a DeFi platform as a Pancake Swap.

1.3.1 The functioning of DeFi

There are various functions that decentralized finance platforms provide:

1. Sending money anywhere in the world.
2. Having access to Stablecoins. A Stablecoin is a cryptocurrency that binds to a traditional currency such as the dollar or euro. These cryptos were created to avoid the excessive fluctuations inherent in the virtual currency market. They have been widely used in Latin America to solve the instability of some currencies.
3. Borrowing money. There are two systems for borrowing money in DeFI: the peer-to-peer method where I go directly to a specific creditor, or I rely on a liquidity pool. A liquidity pool is an amount of money made available by different creditors for those who would like to borrow money. While in traditional Finance an identification procedure is required to apply for a loan, in DeFi this is not the case but only one requirement is asked, the guarantee of having the ability to repay the debt. Another type of loan that is being developed experimentally is the Flash loan: this type of loan involves no identification and no collateral of real assets. It is based on the fact that if the loan is not repaid, then the entire transaction lapses.
4. Lending. The DeFi system allows users to grant loans and earn interest from them.
5. Use of financial instruments such as Options, FWD and futures.
6. Crowdfunding. DeFi platforms can be used to publicise and fund ideas.
7. Purchasing insurance. With the decentralized system, the insurance mechanism becomes more convenient, immediate and transparent than with classic systems. A good example of insurance is Etherisc's Crop coverage, which allows farmers in Kenya to protect themselves against possible disasters such as drought.

1.3.2 Advantages and disadvantages of DeFi

Certainly as reported in the previous paragraphs, DeFi has many advantages such as:

- Its degree of openness: it can be used by anyone without any identification requirement.

- It makes the financial system more efficient. It is clear to everyone how one of the goals of DeFi is to revolutionize the financial system and make it fairer for everyone.
- Speed and transparency: given by the use of Smart Contracts as reported in section 1.2.2.
- The platform is subject to continuous improvement: this is done through the continuous work of the developers who are always implementing new protocols.
- Offering advantageous rates: interest rates in the entire platform are more advantageous than in traditional finance, thanks in part to the elimination of intermediaries.

Conversely, it should not be hidden that there are numerous disadvantages due to the structure of the platforms themselves.

- The difficult use of DeFi is related to its unintuitive interface.
- High earnings equals high risk. As in traditional finance, with the possible high gain comes high risk. Much of the risk very often is related to the volatility of certain assets.
- Less regulation equals less customer protection. The other side of the coin of a system that does not provide for user identification is the complete lack of legal protection.
- Lending policies. Also related to the lack of recognition, a larger sum than the loan itself is required for loans as collateral in case of non-return.

1.3.3 The failure of the TERRA-LUNA system

Up to this point it is clear how decentralized platforms, and the crypto world in general, has many strengths and many weaknesses. One of these is certainly the immaturity of DEX platforms, which are not yet able to compete with traditional financial platforms. This can lead to inevitable exposure to speculative attacks.

One event that has shaken the crypto world in recent times, is definitely the collapse of the entire Terra-Luna system. Terra is a BlockChain network that provides the three

Figure 1.2, LUNA1-USD price collapse. SOURCE: yahoofinance.com.

basic functionalities of a financial system: possibility of payment, possibility of investment and finally the possibility of provision. Without a shadow of a doubt, it is one of the most complex decentralized systems available.

- Payments: the payment system of the Terra platform is characterized by the use of different Stablecoins. This feature comes from the background of its creator Do Kwon, who has been involved in the development of several payment systems in Korea.
- Investments: there is a tokenization system within the platform, meaning that smart contracts are created to emulate financial assets. For example, tokens can be created linked to the value of a specific stock or bond.
- Savings: there is the possibility of locking up liquidity within the Anchor project dedicated to capital accumulation and returns. Although the returns are not very high compared to the rest of the DeFi world, they are still higher than what traditional banks offer.

The Terra Luna system bases part of its operation in the issuance of Stablecoin UST, which is a cryptocurrency that is pegged to the value of the dollar. The platform's classic cryptocurrency, on the other hand, is Luna, which is pegged to the Stablecoin UST through an arbitrage system. For every UST issued there is a counterpart in Luna, and

when an imbalance occurs between the two values, there is an interest on the part of the network in bringing the values of the two assets back up to par.

Let us give an example of how Terra-Luna arbitrage works.
We have to imagine the whole system as communicating vessels, on one side we have Luna and on the other side we have UST. When the level in one pot rises, automatically the algorithm that has to maintain the "Peg", has to increase the counter value of the other pot.
Let's say the price of one UST is $0.98 and therefore it is worthwhile to trade one UST for one dollar earning 2 cents. This would increase the demand for the UST and thus also increase its value, bringing it back to one dollar. If, on the other hand, a UST were worth $1.02 then it would be worthwhile to trade one dollar of Luna for one UST, earning the 2 cents from the transition and increasing the number of USTs in the market, lowering its demand and value. All this is possible only because of the fact that the USD value of Luna is convertible at a 1:1 ratio with the Stablecoin UST. When the value of UST diverges from USD, then enough Luna is burned or produced to allow the system to balance.

The collapse of the Terran Luna system is an event that caused quite a stir, as the project was one of the most promising in decentralized finance. The failure was not due to a malfunction of the system itself, but to the exploitation of a flaw in the mechanism governing the communicating vessels.
It seems that the attack started from some investment funds such as BlackRock and Citadel, which aimed to target the UST stablecoin. First they were asked to borrow 100,000 Bitcoins (about $4,200,000,000) to open a short position, and then used 25,000 Bitcoins to buy UST.

Subsequently Do Know was approached by financial institutions to ask for a rebate if they purchased $750,000 in USTs. In doing so, the amount of UST in circulation decreased dramatically.

The next step was the sale of 75,000 Bitcoins to trigger a spillover in all cryptocurrency markets. Thus triggered the general panic sell.

Since the Anchor platform, part of the Terra system, held reserves in UST, it had to sell the reserves to offset the actions of users who sold their assets en masse.

At this point, Terra's communicating vessels algorithm failed to counterbalance Luna's value, given the sudden sale of a very large amount of UST. Luna's value drops and in a few hours reaches zero. The overall graph on Luna's price trend is displayed in Figure 1.2.

1.4 The NFTs

After analyzing how the BlockChain ecosystem, and cryptocurrencies in general, has enabled the proliferation and development of countless financial applications, another big part of BlockChain's application is definitely the NFT world.

Figure 1.3, example of CryptoPunks

NFTs, Non-Fungible-Token, is a token produced by BlockChain Ethereum. We can distinguish two types of standards for NFTs: ERC 721 and ERC 1155.

The NFT by definition is the 721, which is characterized by uniqueness, that is, the non-replicability of the token. The Smart Contract, in this case, goes to manage a single token very often applied to a single work. While the 1155 with a contract one can

manage a multiple number of NFTs, and is often used for a series of artworks that are linked together.

What are the key characteristics of an NFT? We start with their rarity/uniqueness, then we have the authenticity which is provided by BlockChain itself and finally we have the ownership of the NFT itself, which can be proven by linking the token to my digital wallet address.

Mainly they are used for:

- Art and collectibles projects.
- Gaming world as an asset. Projects such as The SandBox implement the concept of NFTs to allow players to purchase virtual plots of land in digital worlds, where they can interact with other users.
- World of tokenization of physical objects. In this case, a company or entity can issue a certificate of ownership of a tangible asset through an NFT.

The first real project that implemented NFTs was Crypto Punks created by the company Larva Labs. They are low-resolution images created through an automatic generation algorithm. Each Crypto Punk (Figure 1.3) is distinguished by features that make it unique. The intrinsic value of these digital objects is the same value that an ancient coin or stamp might have for a collector.

Like a true work of art, NFTs gain value based on the popularity they manage to achieve. Without a shadow of a doubt, NFTs will change the business world, creating new supply and demand dynamics. It will also change investors' relationship with artists and the way they communicate to the community.

The other side of the coin is the very close connection these assets have with the cryptocurrency market. If the digital currency market remains stable for a medium to

long period, then we will be facing a period of NFT growth. This is not the case when cryptocurrencies are in a "pumping" phase, monopolizing investors' attention.

Since the posting of 2022 we are witnessing a period of "dumping" the entire crypto world after the collapse of Bitcoin's value and the failure of the Terra Luna project. The number of NFT sales dropped by 50 percent in the first quarter of 2022 according to the Open Sea platform. All of this, even if it goes to decrease the value of NFTs in the major exchange platforms, does not mean that it is an entirely bad thing. In a time of pessimistic markets, the projects that hold out the most are the ones that have the most value and have a concrete basis, leading to the failure of all those projects that were created in a period of FOMO (Fear of Missing out) with the only purpose of raking in easy profits.

1.5 The risks associated with cryptocurrencies

Following what was covered in section 1.3.3, there are many risks associated with this new type of currency.

- Market Risk: This type of risk is related to the normal fluctuations that exchange rates have. The crypto market is one of the very volatile markets, which makes most products unsuitable for long-term value accumulation.
- Shallow Market Problems: a problem that occurs when the market fails to meet the immediate demand for a large amount of liquidity, and thus the transaction goes into the price.
- Counterparty Risk: this is the risk associated with exchange and digital Wallet platforms. Many users do not transfer their crypto investments after proceeding with the exchange, leaving them deposited in platforms or Wallets that are very often affected by hacker attacks or other issues as happened to the Terra platform. Since platforms do not have the ability to refund users, Counterparty Risk is very high.
- Transaction Risk: This fact is related to the mechanism of operation of BlockChain. Since there is no forcing process for any wrong transaction, once the money is sent,

there is no going back. The transaction is fixed in the BlockChain and the only way to get the money back is for the counterparty to return it of its own free will.

- Operational Risk: Risk related to the possible failure or malfunction of the computer processes that govern the BlockChain. One of the main but very remote risks is the so-called 51 percent attack. This type of attack goes to change the majority of computers that host the BlockChain, and then have the ability to change the blocks in the chain. This scenario has been very remote for years now given the vastness of the computers that are part of the network.
- Privacy Risk: Risk that the sender of a transaction will be tracked and identified.
- Pseudonymus Risk: there is the risk of being traced by the pseudonym we have in the BlockChain, at the time when we go to convert cryptocurrencies to classic currency and when it is deposited in the bank. This happens because there could be a privacy issue with the banking institution receiving the money, going to share our personal data.
- Legal and Regulatory Risk: This could occur when a country believes that an exchange is operating illegally and then decides to block funds to all customers.

1.6 Cryptocurrencies and behavioral finance

The cause of the birth and development of the world of cryptocurrencies certainly has a very emotional connotation; the very concept behind the Bitcoin project is to fight the traditional financial system. The hatred for Establishment channeled into populist movements has driven the average investor to make financial choices that go against the traditional system represented by the big investment banks and hedge funds.

It can be said that there are many similarities between the success of cryptocurrencies and the 1848 Gold Rush in the United States. Easy short-term gain is one of the most driving incentives, and it certainly overshadows the primary purpose these projects had. Since cryptocurrencies have become a mass phenomenon, FOMO has taken over the masses. Social trends such as Reddit or Twitter have funnelled massive amounts of money into the system, causing the appearance of unrealistic projects such as the

famous ShitCoins (DogeCoin, ShibaInu), capable of attracting capital only out of pure bets on their takeoff, with no real vision behind them.

There is to add the fact that on several occasions such as at this time (July 2022) the crypto world has suffered very significant losses in value. Whenever the market is too excited, a natural trend adjustment occurs. The average investor tends to chase an investment idea based on rare success stories through very lucky but logic-free investments.

In the next chapters, we will cover the topic of behavioral finance, and try to understand how rational individuals are in their investment choices in the cryptocurrency market.

Chapter II The irrationality of the investor

2.1 Introduction

After learning about and analyzing the world of cryptocurrencies, a question has arisen for me about the attitude investors have toward this new instrument.

From my point of view, they do not act in a totally rational way, and very often they are subject to emotions and mental deviations that can lead to a financially inefficient decision.

In the following chapter, I will go on to analyze what, in my opinion, are the deviations that lead investors to make irrational choices toward cryptocurrency and its derivatives. Then I will try to refute this theory of mine by means of a questionnaire submitted to different individuals to see if indeed these attitudes exist.

2.2 First look at behavioral finance

Psychology and economics have always been two seemingly very distant but in practice very closely related subjects. It must be remembered that after all, economics is a human science; it is men and women with their personal characteristics and limitations who make economic choices. For the past 50 years, a new branch of economics has developed that aims to study human psychology in relation to markets and individual choices: behavioral finance.

When we speak of behavioral finance, we mean the analysis of the behavior of individuals in relation to financial markets, taking a perspective that privileges the analysis of the psychological and intrinsic factors of the individual being analyzed, which will go into influencing various decision-making processes. Over the years we have increasingly moved away from the idea of absolute rationality, to go on to explain, and then predict, certain irrational behaviors that followed an almost predictable pattern.

This discipline has developed since the 1950s, and over the years has identified the variables that prevent individuals from acting rationally:

1. Past experiences.
2. Beliefs.
3. Context.
4. The format in which information is presented.
5. The inability to have all information at one's disposal.

Since the 1970s behavioral finance has begun to have a concrete development that has led this subject to be a real theory. A great contribution during this period was made by Amos Tversky and Daniel Kahneman, who through their work "Prospect theory: Decision Making Under Risk (1979)" made it possible to change the opinion on the Von Neumann-Morgenstern neoclassical interpretive model of economics, which was based on the absolute rationality of the economy.

Another major contribution of behavioral finance is the study of inter-temporal choice problems, namely the idea of "hyperbolic discounting." In the evaluation of possible inter-temporal choices, there is a very high discount rate for short time horizons, while there is a lower discount rate for longer time horizons. This kind of attitude toward time, which we recall represents uncertainty, runs counter to classical economic theories and models in which discounting is directly proportional to time.

2.2.1 The Prospect Theory

Prospect Theory is undoubtedly the most important theory in behavioral finance. Developed by Daniel Kahneman and Amos Tversky in 1979, it represents an alternative to the neoclassical theory of Von Neumann and Oskar Morgenstern. When we are going to study theories concerning individual decisions, it is important to understand the value of individuals' preferences and especially how individuals evaluate the risk of a bet.

Von Neumann and Oskar Morgenstern's theory was based on the assumption that: if an individual's preferences satisfy a plausible number of axioms, then they can be represented by a prediction of a utility function. The axioms that must be satisfied are:

- Order: we have $P \geq Q$ or $Q \geq P$, if $P \geq Q$ and $Q \geq R$ then $P \geq R$.
- Independence: if $P \geq Q$ then $P + C \geq Q + C$
- Continuity: if an individual prefers pizza to pasta and prefers pasta to salad, in a lottery in which you can have:
    A. High probability of having pizza and a low probability of having salad.
    B. Definitely have the pasta.
    C. Low probability of having the pizza and a high probability of having the salad,

You will always go for choice $A \geq B$ but $B \geq C$.

While neoclassical theory aimed to find the ideal conditions to make sure that we have a rational decision, prospective theory aims to study human behavior under normal life conditions, focusing on situations of possible risk and the probability of a certain thing happening.

Kahneman and Tversky describe their theory by the creation of two possible outcomes with their associated probabilities: $(X, p; Y, q)$

We would have that X will have a probability of coming out p, while Y will have a probability of coming out q. We also have that $Y \geq 0 \geq X$ or $X \geq 0 \geq Y$.

People subsequently assign a value: $\pi(p)v(X) + \pi(q)v(Y)$

When the values of v and π are entered into a graph, we would have the individual go to choose the output with higher value according to his preferences. Figure 2.1 shows the result.

This result carries with it three important findings useful for understanding human behavior. We have to premise that Kahneman and Tversky operate in the domain of losses and gains in order to have more accurately represent the feelings of individuals, who do not use a graduation to describe their feelings but interpret their state positively or negatively.

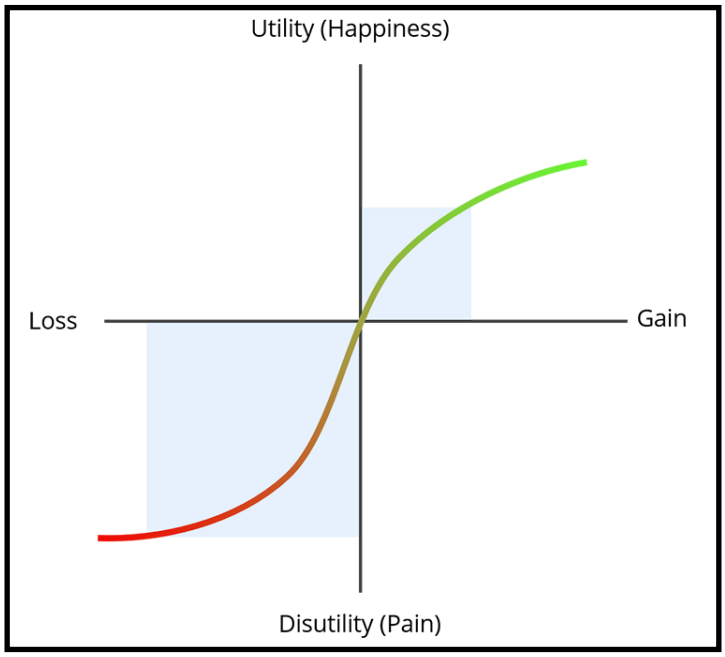

Figure 2.1, Utility graph according to Prospect Theory results.
SOURCE: Prospect theory: Decision Making Under Risk (1979).

The first important result occurs when people are asked to choose between two alternatives:

$A = (1000,0.5; 0,0.5)$ win €1,000 with a 50% chance or win nothing.

$B = (500,1)$ definitely win €500.

84% of people chose answer B.

The second choice for them to make is between:

$C = (-1000,0.5; 0,0.5)$ lose 1000 with a 50% chance or lose nothing.

$D = (-500,1)$ definitely lose 500€.

Sixty-eight percent of people chose answer D, but as is easy to see, answer A and C are identical in terms of probability, as are answer B and D. What changes is the frame with which the question is presented. This result goes against the axiom of neoclassical utility theory whereby we have that either $P \geq Q$ or $Q \geq P$. The distinction between loss and gain is essential for people, so choices will change depending on where we are within the graph in Figure 2.1.

Individuals will choose the least risky choice when they are in the win domain as in situation A and B, while they will choose the riskiest choice if they are in the loss domain as in the choice between C and D.

The second important feature of this theory is the shape of the "v" function. If we notice in Figure 2.1, the utility function will have a concave shape in the gain domain, given the aversion to the next loss in the case of a win, and a convexity in the loss area, due to the risk-seeking that people implement in the case of a loss. This feature of the function is called loss aversion.

The third important implication of the theory is the slope of the "v" function.
It is asked to choose between:
$A =$ win nothing
$B = (60{,}0.5; -60{,}0.5)$ win €60 with 50% probability or lose €60

Most people choose alternative A, whereas if offered to choose an amount x that would make the following two alternatives identical:
$A =$ win nothing
$B =$ win x with 50% probability or lose 25€

Most people would ask for $x = 61€$. This tells us that losses must be offset by a much higher payoff, since the negative feeling caused by a loss is greater than the happiness

of a possible win. This is why the part of the utility function in the loss domain is steeper than its counterpart in the win domain.

2.2.2 The problem of probability

One of the major problems that plagues humans is their misjudgment of probability in a general sense. Individuals try to understand how a data set A is generated by a model B, or how an element A belongs to set B. Individuals try to understand the degree of similarity that element A has with set B. This is the basis of the representativeness problem.

This was studied by Kahneman and Tversky (1974) with the case of Linda.
"Linda is 31 years old, single, outspoken and very bright. She majored in philosophy. As a student, she was deeply interested in issues of discrimination and social justice and also participated in demonstrations against nuclear power."

When asked which, between "Linda is a cashier" (statement A) and "Linda is a cashier and is active in the feminist movement" (statement B), most people choose answer B. This contradicts Bayse's law that:

$$p(statement\ B|description) = \frac{p(description|statement\ B)\ p(statement\ B)}{p(description)}$$

Generally people put too much weight in the $p(description|statement\ B)$ versus $p(statement\ B)$. This type of bias is called "Base rate neglect."

Another bias caused by the misinterpretation of probability is "Simple size neglect." In this case, people tend to make a judgment about a particular dataset without taking into account its actual size. Famous is the "hot hand phenomenon" in which one examines a player who in a basketball game manages to score three consecutive times, then one will tend to believe that he will also score a basket a fourth and a fifth time. This kind of

attitude toward data is also called the law of small numbers, which can also be applied in the case of a coin toss. When we record several consecutive tosses of a coin, and the result is always the same, either heads or tails, we will tend to believe that on the next toss it will come up tails.

If we recorded the results of ten coin tosses (T=heads, C=tails) and asked people which of the following outcomes is most likely:

$A = TCTTCCCTCT$

$B = TTTTTCTTTC$

People would tend to choose alternative A over B, but we know that by the law of probability, both answers are equal.

The lottery game exploits this kind of mental mechanism to attract more players. Think about when a win occurs at a particular place, people will be more likely to play their cards at the same place of a win than another, thinking that luck will kiss them too.

2.2.3 The efficient market hypothesis (EMH)

Efficient market hypothesis is based primarily on three arguments:

1. Individuals are assumed to be rational and to value securities rationally i.e., giving a value equal to expected future dividends discounted at a risk-adjusted discount rate.
2. Even if individuals are irrational, their trades are random and thus in the long run will cancel each other out without affecting prices.
3. In the case where there are irrational individuals in the market, we see countervailing arbitrageurs who, by selling the arbitrage opportunity, will go to offset the price effect of the irrational individuals' choices.

When new information inherent in a particular asset is released, it is immediately incorporated within the price assessment by investors. If the news, according to

investors, are positive, the price will go up, conversely if the news are negative the price will go down.

According to Andrei Shleifer, an economist and professor at Harvard University, all efforts put forth by investors to try to beat the market are null and void. The market cannot be beaten and the investor should try to implement long-term passive management of his portfolio instead of an active management.

All of these theories are based on the rationality of the investor, but remember that even if there are irrational investors, the randomness of irrational choices and the fact that they are uncorrelated will lead the trades to cancel each other out. But even in the event that there is a correlation between the trades of irrational investors (noise trade), according to EMH this will be mitigated by the action of arbitrageurs, who, recognizing an incorrect assessment of the intrinsic value of a possible asset, will proceed with counterbalancing the value.

2.2.4 The empirical evidence for EMH

We can assume the empirical test of EMH in two parts:

- First. The news that is made public must be incorporated into the price "early" and "correctly." By early is meant that already those who read the news in the paper should not be able to take advantage of the information, and by correctly is meant that the news should affect the price accurately on average.
- Second. The price should not vary much if the news released has nothing to do with the value of the asset itself. If the price value is supported by investors' future expectations, then the value should not change much.

This leads us to the conclusion that information that is not "new" is of no use to the investor to make money on a possible transaction. Whereas in the case where an

individual succeeds in making a profit on information that is "not new" he is essentially remunerated only for the risk taken to implement his strategy.

Eugene Fama created a distinction between different types of news, distinguishing efficient market assumptions based on them. We can have:

1. The weak form of EMH, "it is not possible to earn profits in excess of the risk taken, based on knowledge of price and past earnings." Market prices are efficient when they reflect all available information about the past.
2. EMH's semi-strong, "investors cannot earn more than the risk-adjusted using published information." This means that we could never make money from public information because it is immediately incorporated into the price.
3. The strong form of the EMH, "it is not possible to make money by having information that has not yet been published because that information is immediately embedded in the price." This refers to the practice of insider trading, which is illegal in finance.

2.3 The irrationality hypothesis

It is clear that there is a high probability that the investor will implement a series of irrational choices over the course of his or her career. The question I asked to myself is: **What mechanisms govern investment decisions in the crypto environment?**

Starting from the basis exposed up to this point, applying efficient market theory to reality, it seems that the rule $Price = fondamental\ value$ does not exist. This is clearly the case even with cryptocurrencies, whose fundamental value is even more difficult to understand given its fully intangible nature.

This is where behavioral finance comes in, which attempts to understand how the market actually acts by trying to implement studies in psychology and sociology. Market fluctuations could be related to a problem of expectations investors have about

the future value of assets. It is clear that I am more inclined to place a high value on a project that I believe has a not inconsiderable future development. Think of the example of Terra-Luna, which set out to create a totally decentralized financial platform. This belief may be the result of excess optimism created by a series of good news regarding a specific asset.

This can cause the value to rise even abruptly, but that in the long run, if not supported by the right intrinsic value, will lead the price of the asset to collapse. Tied to this, we think of the crisis that the entire digital currency sector is experiencing right now. Those holding out are the projects that still have their own intrinsic value. This mechanism is at the root of Speculative Bubbles such as the famous Tulip Mania of the 1600s in Holland, which drove the value of tulip bulbs to levels above gold itself.

2.3.1 How anomalies develop

Having reached this point, it is clear how the individual fails in formulating his or her judgment, relying on models familiar to him or her, assuming future scenarios similar to past ones while avoiding considering the meanings of the model and its probabilities as reported in the previous chapter.

This way of acting is the result of our brain's poor ability to process the amount of data with which it comes into contact, going about implementing strategies to simplify the world around us. The resulting errors are results of cognitive distortions that plague the different stages of the judgment-making process:

- Information acquisition.
- Processing of information.
- Issuance of judgment.

According to Tversky and Kahneman in their work "*Judgment under uncertainty: Heuristic and biases*", individuals tend to overestimate the goodness and accuracy of

the information they acquire in addition to their ability to process it. When people are faced with an uncertain event, they use the "heuristic principles".

- Availability at the time of information acquisition.
- Representativeness and anchorage at the time of processing.

In the financial field, this translates into investors who engage in excessive trading, overestimating their ability to make money, exploiting information that in their mental distortion, they believe they are the only ones to have.

2.4 The anomalies of a Crypto-Investor

Below, I will list a number of anomalies that, in my judgment, are typical of an investor relating to the world of digital currencies and its derivatives such as NFTs. The choice of them is based on my personal observations that I have had the opportunity to analyze over the years, being primarily a Crypto-Investor like so many people close to me.

These are, however, assumptions that I will try to refute in Chapter 3 by subjecting a series of subjects to a questionnaire with specific questions inherent in behavioral and economic choices.

2.4.1 Premium and loss anticipation

Emotions play a key role as we saw earlier, leading the individual to seek out those moods that are most fulfilling to him or her. If we think about the fact that we will eat our favorite dish, we can say that we are already savouring it, anticipating the emotion of happiness. This also happens with less pleasant things, which can cause us to feel a state of discomfort even before they happen. These emotions are related not only to the anticipation of future events that make us pessimistic or optimistic, but also from present conditions of course.

Famous is the research conducted by Hirschleifer and Shumway (2003) who found a correlation between rainy days and return on investment over 15 years. While according to Bassi's (2013) research, there is more risk tolerance on sunny days.

Above all, positivity makes us less careful and more willing to take risks, while we are more cautious on rainy days.

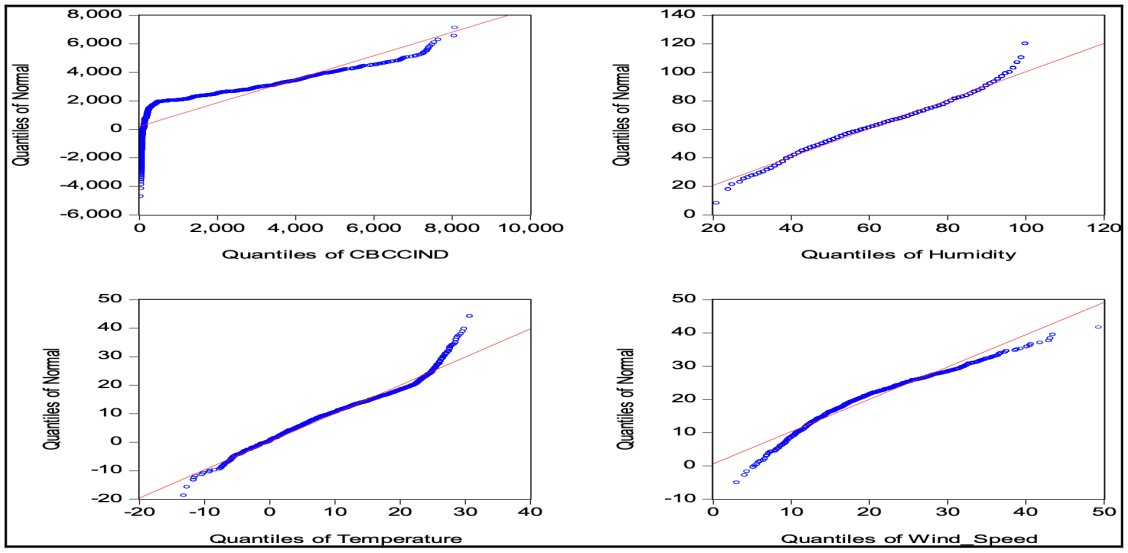

Figure 2.2, Scatter (regression line) for the returns of CBCCIND index and whether factors (temperature, humidity and wind speed) from 1st January 2015 to 30th June 2018.

Fonte: Compiled from Federal Reserve Economic Data (FRED) database (https://fred.stlouisfed.org/series/CBCCIND) in Federal Reserve Bank of St. Louis, National Climatic Data Center (https://www.ncdc.noaa.gov/cdo-web/)/and computed using E-views 7 version.

Very interest was the research conducted by Chinnadurai Kathiravan, Murugesan Selvam, Sankaran Venkateswar and Bala Maniam in May 2019, in which the scientists studied data on three climatic factors, humidity, wind speed and temperature, in New York City over a period of about four years. They then analyzed the trend of the CBCCIND index, which represents the general trend of the cryptocurrency market.

It turned out that there is a strong correlation between the climate factors examined and the return of the digital coin market.

It is clear how in Figure 2.2, the regression lines of all variables moved upward, showing positive sign having a strong linear correlation. This shows the fact that there was an interrelation between the weather factors and the Coinbase index.

2.4.2 Overconfidence

In 1998, Daniel, Hirshleifer and Subrahmanyam in "*Investor psychology and security market Under and Overreactions*" set out their theory of over or under reaction in stock markets. In the model, the "overconfident" investor is presented, i.e., an investor who overestimates the accuracy of the signals provided by the information in his possession and not available to the public, compared to the information that is publicly available instead. This leads in the short run to an overreaction of prices in relation to news, while in the long run public information is incorporated into the price giving a better interpretation of the news.

The behavior of an overconfidence investor reflects the characteristics of an individual in possession of nonpublic information. If after an asset purchase comes good news, or after a sale comes bad news, there is an increase in confidence. But in the case where the information does not lead to confirmation of one's beliefs, then confidence in one's abilities would not be greatly affected.

According to Gervais and Odean in "*Learning to be overconfident*", overconfidence is highest in the early stages of an investor's career, while with time and experience one learns the limits of one's information. In the work of Gervais and Odean there is the development of a market model structured in multiple periods (multi-period), studying the process of an investor's acquisition of awareness and how, any bias in the process, can lead the trader to be overconfident. In the first period, the individual fails to interpret the probability of receiving a positive signal each period, leading him or her to give too much weight to successes achieved over losses realised.

Overconfidence, caused by this behavior, leads the investor to implement aggressive trades and raise the volume of them. This causes an increase in volatility and a decrease in expected profits. The high volatility of cryptocurrencies, can also be explained by this type of bias, in addition to the low barrier to entry for investing that can lead many investors to believe they have "financial skills." Although a consecutive number of

successes may result in an increase in the probability of actual ability, a trader who is successful at his or her job may have lower expected profits than an overconfident trader.

The research Investment Literacy, Overconfidence and Cryptocurrency Investment conducted by Kyoung Tae Kim, Sherman D. Hanna and Sunwoo T. Lee from March 2022, used the 2018 National Financial Capability Study Investor survey, analyzing the association between investment literacy and cryptocurrency investment. About 13 percent of investors invested in cryptocurrency directly or indirectly. Regression analysis results show that objective investment literacy was negative while subjective investment literacy was positively associated with cryptocurrency ownership. Overconfident investors were more likely to invest in cryptocurrency.

2.4.3 Herd behavior

Returning to the discord of efficient market hypothesis, we can point out the fact that the principle that non-rational investors, who might according to EMH be present in the market, act randomly and uncorrelatedly is not quite correct.

In addition to this, we must add the incorrectness of the principle that the noise caused by irrational investors, is cancelled out in the long run by the actions of investors who act rationally in the market. Investors generally do not act randomly and uncorrelatedly, but engage in so-called Herd behavior.

A fashion effect could be created in the market, whereby a number of people are led to buy the same stock, driven solely by the fact that others have done so, perhaps a friend or relative who in turn has been influenced by other people. In this way the gregarious investor, in the event of a loss, will be able to attribute the cause to something totally unexpected, since many people made the same choice as him or her anyway.

Key role in the proliferation of Herd behavior is undoubtedly modern information.

An inescapable feature of today's information is certainly its speed of transmission through the network. We are also witnessing a phenomenon of information liquidity, that is, the degree to which information is processed and presented in a way that allows for better interpretation by the average investor. Information of a more technical nature such as financial mathematics or law finds it difficult to vent in transmission.

Another important factor that characterizes easy-to-transmit information is its source. People tend to get information through word of mouth as opposed to seeking information from newspapers or the trade press. This is mainly due to the fact that word of mouth seems to stimulate the attention of the interlocutor more than personal research.

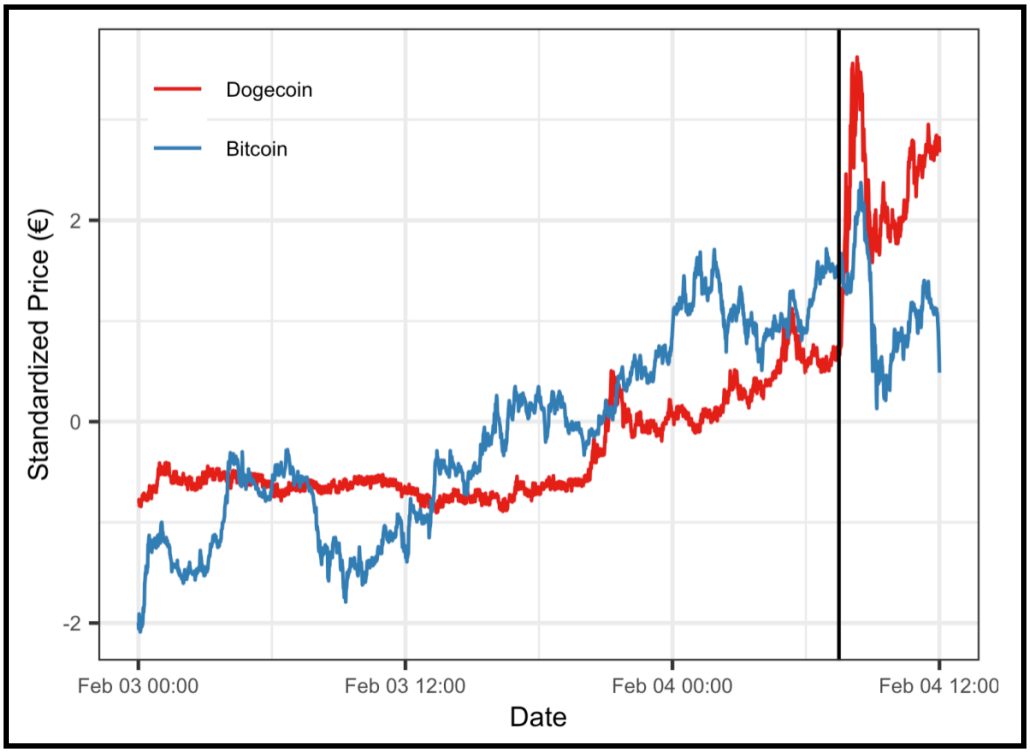

Figure 2.3, Analysis of DogeCoin price trend after Elon Musk's tweets. SOURCE: r-bloggers.com.

Emblematic was the work done by the Securities and Exchange Commission, the agency created for the purpose of preventing insider trading. A secretary was asked to photocopy confidential documents pertaining to a takeover by company X against company Y, which was scheduled to be announced a month later. The secretary reported this news to her husband, a door-to-door salesman, who passed the news on to one of

his associates who hurried to buy the shares. The news was passed on by the collaborator to another friend, who began a round of phone calls.
Word of mouth was the main source for passing on the information, leading 25 people, related to the core team, to buy a combined equivalent of half a million dollars.
This event is the famous IBM case of 1995.

Connected to the world of cryptocurrencies, the relationship between the tweets of the famous Silicon Valley entrepreneur Elon Musk, and some cryptocurrencies is emblematic. With his influence he managed to change, the value of some assets such as DogeCoin. In the figure 2.3 we can see the surge in the value of DogeCoin, in comparison to Bitcoin, after some tweets posted by Musk on February 4, 2021.

In addition to this, as the popularity of cryptos has increased, online trading platforms have seen the number of subscribers soar. These platforms provide information tools that allow comparison of all existing virtual currencies, categorizing them by performance over the last period. It is easy to think that people, using this filter, can focus only on the virtual assets that have been most profitable, with the hope that they will continue to rise. The herd effect can be seen on assets that rise or fall in value within a very short period of time (days).

Another tool that has definitely increased the impact of the herd effect, not only in the crypto world, is definitely the famous "social trading." This type of tool allows an investor, who decides to use one of the major trading platforms, to leave his or her investment decisions to a person who actively uses the platform.

2.4.4 The FOMO

Another important mental mechanism that influences an investor's choices is definitely FOMO. An acronym that stands for Fear Of Missing Out, or fear of being cut off, it is a state of anxiety that can affect any type of individual when there is a feeling of missing

out on an opportunity compared to others. Driving this state are emotions such as jealousy, envy, disappointment, but mainly a general feeling of inferiority to one's peers.

In finance this all translates into a feeling of having missed out on some essential information or some growing trend, and this can turn into a feeling of lost opportunity for profit. But even more serious is the feeling of having worse returns or generally earning less than others.

One characteristic of a FOMO-driven investor is definitely impulsiveness in making choices that result in losses, especially at times when the financial market is very volatile. Linked to this is the riskiness of these impulsive decisions, driven primarily by the desire to make as much as possible, more profit than others in a very short time.

A symbolic examples of this attitude is the irrationality of some investment choices in FOMO situations such as investing in ShitCoins or other closed assets, just out of fear of being left with empty pockets in case there is a sudden increase in price. Recall that ShitCoins are assets that are totally devoid of intrinsic value, very easy to create and used very often to tease the market. Very often it is only the creators of the coins themselves who get rich, who hope to receive enough notoriety to raise the price of their creation.

In "*Asymmetric volatility in cryptocurrencies"* (2018) by Dirk G. Baur and Thomas Dimpfl, the two scholars go on to analyze the effects of asymmetric volatility for the 20 largest cryptocurrencies. A very different asymmetry compared to stock markets is reported: positive shocks increase volatility more than negative shocks.
This leads to explaining the atypical effect for financial assets with trading activities performed by uninformed "noise traders" for positive shocks and trading activities of informed traders for negative shocks. The results are consistent with the FOMO characteristics of uninformed investors (a factor related to overconfidence) and the existence of pump and dump schemes.

Another case of market FOMO is certainly the case of the SushiSwap token, the cryptocurrency exchange platform that experienced a steep price climb after the migration of the SUSHI cryptocurrency to its own online Market Maker platform.

2.5 Concluding remarks on irrationality

We can now come to the conclusion that, without a shadow of a doubt, there is the irrational investor and that he or she acts non-randomly within the market.

We must certainly complement the efficient market hypothesis with a theory that takes into account the emotional component of investors and their influence on market trends. Behavioral finance is a relatively young science that aims to implement these notions in order to give a winning recipe or at least allow us to limit the damage of a market that is becoming increasingly complex and closer to a "random walk" trend.

It is also likely that because of the countless variables in our world, a winning model is difficult to create, but at least there is hope of getting some hints in the complex world of investing.

In the following chapter, I am going to group and study a set of data through an anonymous questionnaire to understand whether my thesis, that in the decision-making process regarding an investment in cryptocurrencies, there is the presence of the four biases that I have personally detected and have been described above: anticipation of reward, overconfidence, herd effect, and the FOMO.

Chapter III The empirical study

3.1 Introduction

After analyzing from a purely theoretical point of view, what the biases might be that afflict an investor, particularly in crypto-investors, I decided to carry out a more technical analysis to provide a more concrete result to my assumptions.

The theoretical exposition made earlier served to lay the groundwork for what will be the results of a survey submitted to individuals with very different characteristics and with reactions that could vary greatly from individual to individual.

It will begin with an analysis of the structure of the questionnaire, and how I decided, together with my lecturer, to structure it. The highlights that I will focus on most will be each individual's risk appetite, his or her connection to cryptocurrency investments, and the answers given in the behavioral finance part where I try to unearth:

- Award anticipation
- Overconfidence
- Herd behavior
- FOMO

These macro areas will allow me to understand whether the assumptions, made in chapter two, can have a concrete basis, or remain merely theories without concrete foundation. Within the questionnaire, as will be seen later, some questions related more to everyday life than purely financial questions were proposed. This choice was dictated by two main reasons:

First, given the non-homogeneity of the sample analyzed, there was the possibility of finding too little financial educated people to answer certain questions. By asking only financial questions, there was a risk that subjects would not understand exactly the topic of the question, leading to a possible answer given randomly to move on to the next one.

Second, this type of approach has been adopted in the financial literature by leading figures in the field such as Kahneman and Tversky, 1983; Tversky and Kahneman, 1974; Slovic, Fischhoff, and Lichtenstein, 1982.

The software used for the analysis is Qualtrics.xm developed by the American company Qualtrics. This program allows the creation of questionnaires in an interactive and easy-to-understand manner, and then gives the possibility of analyzing all the data collected. I tried to submit the test to a sample of subjects that was as homogeneous as possible, so as not to have any kind of bias due to purely demographic parameters. The sharing of the questionnaire was done only through telematic channels and not in physical form.

The next paragraphs will go on to analyze the structure of the questionnaire and the results given by the data collection.

3.2 The structure of the questionnaire

Excluding the introduction questions, the questionnaire was divided into 4 macro areas of analysis:

- Behavioral finance questions.
- Cryptocurrencies questions.
- Risk and return questions.
- Demographics questions.

Personal questions such as those on relationship to cryptocurrencies, risk/return, and demographic questions were asked at the end, in order to avoid to influence the subject when answering the questions inherent in the bias analysis.

3.2.1 The search for bias

The bias questions were structured with the intention of looking for those behaviors that are typical in people affected by reward anticipation, overconfidence, FOMO, and herd behavior.

The questions are divided into 4 areas, one for each bias.

Anticipation of reward

A series of intertemporal questions are presented at the outset to assess how much a subject values immediate gratification versus higher gratification but a week from now.

Which of the following two options would you choose?

The answers available were 12€ immediate and then as the questions progressed 13€, 18€ and 22€ in a week's time.

The second question is more personal, referring to emotions that harken back to the subject's childhood.

Thinking back to when you were a child and you were assigned a task in school that took a few days to do, when did you usually do it?

In this case, you wanted to assess the subject's attitude at a time in his or her life, when the feeling of duty, as adults understand it, was less relevant. This should bring out the true nature of the subject, leading us to understand how he values gratification in completing a given task. Responses were posed in such a way that the subject would choose how soon the task was completed or whether they tended to procrastinate until the due date.

Overconfidence

To research overconfidence, two questions were asked, again of a personal nature, but applied to two different areas.

The first question is about people's belief that they are better than, average in an everyday situation, such as driving skill.

The following numerical scale represents the skill of a driver. Zero represents a bad driver, while 10 represents an excellent driver. Indicate how good you are at driving, knowing that 5 is the average skill of everyone who drives.

An anchor point, the number 5, is placed to give a breakdown between those who are better than average at driving and those who are less than average at driving.

Some people believe they can make better investments than others (i.e., with which they can earn more than others). Other people believe they cannot. Do you believe that your financial choices allow you to earn...

The presence of the overconfidence bias, is detected when the person places himself above the average, either in driving skill or when the subject suppose to make superior investments than others.

Herd behavior

For the analysis of herd behavior, only one question was proposed, again of a financial nature, which asked people to rate the authoritativeness of a range of information sources when they were being used to formulate a financial opinion.

Using a scale of 0 to 10, where 0 is "Not at all suitable" and 10 is "Very suitable," please indicate how much, for each of the following sources of information, you think is most suitable for getting an overall picture of today's financial situation.

The sources of information were: financial analysts, family and friends, media (TV, social, web), and finally one's own technical analysis.

The construction of the answers was designed to understand the degree of influence that the person subjected to the questionnaire has, vis-à-vis different sources that are more or less in authoritative media.

The more a person evaluates generally less authoritative, authoritative sources, then the more he or she will be subject to the influence of opinions that are not very relevant to the formation of a financial idea.

Instead in the second question, a convivial situation was created to simulate a potentially truthful situation.

You are going to lunch. After lunch you planned to buy shares of a specific company that you had been keeping an eye on for the past few weeks and now believe to be attractively priced. During lunch you discuss the stock with your friends, but to your surprise they advise you against buying it. After lunch what do you decide to do?

The available answers revolve around deciding on your reaction to the situation previously described, giving you a choice between: you refrain from making the investment after your discussion with your friends, you postpone the investment to further develop your analysis of the company, and you stick to your decision and buy the stock. This should allow you to understand how confident the individual is in his or her decisions and abilities as they are questioned by those around him or her.

FOMO

As a final behavioral question, a series of statements were proposed to be evaluated according to how well they reflected the character of the examinee.

The following is a collection of statements about your daily experience. Using a scale of 0 to 10, where 0 is "It represents me little" and 10 is "It represents me a lot," please indicate how much each statement represents you based on your general experiences. Please answer based on what really reflects your personality rather than what you think should be the morally correct answer. Please treat each statement individually by not considering the others.

The more a subject claimed that the statements represented himself, the more likely the presence of FOMO bias. The statements were purely personal in nature:

- I fear that others are more successful than me.
- I fear that my friends are more successful than me.
- I get irritated when I find out that my friends are having fun without me.
- I get anxious when I don't know what my friends are doing.
- It is important that I can understand my friends' jokes.
- Sometimes, I wonder if I spend too much time trying to keep up with others.

- It bothers me when I miss opportunities to meet with my friends.
- When I have fun, it is important for me to share it online.
- When I go on vacation, I keep keeping an eye on what my friends are doing.

3.2.2 Subjects and cryptocurrencies

The following block of questions was designed to give a clear picture of how the subject related to the world of cryptocurrency. The proposed questions had the sole purpose of collecting demographic data related to the subject's personal knowledge and investment choices.

First, the question was posed:

Suppose you were in the situation of having to choose how to invest a portion of your savings in financial securities. What proportion of your savings would you be willing to invest in cryptocurrencies? Give a percentage from 0 to 100.

In this case, the subject had to imagine that he or she had an unexpected surplus of money so as to isolate any distortions due to his or her economic situation. This question aimed to get a sense of how much a subject trusted cryptocurrencies.

Next, the following questions were proposed:

- *Have you ever invested in crypto?*
- *In relation to the total amount of financial investments you have made, how would you rate the size of your investment in cryptocurrency?*
- *How informed do you feel you are about the world of cryptocurrencies?*
- *What source of information have you mainly used to inform yourself about cryptocurrencies?*

These questions were included to understand whether the answers to the previous questions were actually given by a crypto-investor, or by a person unfamiliar with the world of digital currencies. Subsequently, these questions were used as independent variables in the statistical analysis.

3.2.3 Risk performance

The penultimate block of questions refers to the subject's knowledge of the risk-return relationship, and his risk aversion both in daily life and in financial matters.

The proposed questions were:

- *In general, using a scale of 0 to 10, are you a person who likes to take risks or do you try to avoid them?*
- *People take different behaviors depending on the circumstance in which they find themselves. On a scale of 0 to 10, how would you rate your risk-taking disposition in the following areas?* The areas were included for assessment were: driving, investing, sports and leisure, work, risky health behavior, and trusting other people.
- *Each financial product has its own degree of return (possible gain) and its own degree of risk (possibility of loss). In your experience, which of the following statements is correct?* This question is about the subject's understanding of the relationship between risk and return. The available answers were: a potentially high expected return is usually matched by an equally high risk, The return on an investment is completely independent of its degree of risk and I don't know.

The following questions were more financial nature than the previous ones.

- *Choose which of the following statements best represents your approach to a possible monetary investment.* The available answers were: very low/zero return with as little risk as possible of losing some of the money invested, acceptance of a low-medium return investment so as to have a capital with low fluctuations in value (variation between low-medium gain-loss), willingness to get a considerable return from the investment, with willingness to accept even significant fluctuations in the capital, willingness to get a very high return from the investment, with willingness to accept significant fluctuations in the capital.

As the last question on the block, the following question was proposed:

- *Each of us investors possesses the ability to bear risk differently from everyone else, as if we were one of a kind. At the time when you have found yourself making investments in the financial markets, or plan to do so in the future, what type of approach do you think is most appropriate for you? The time frame for a minimum investment is 12 months ("Little") to over 20 years ("Very High") for a long-term investment.*

The approaches available for evaluation were: prudence in managing my investments, amount of capital to devote to the investment, time available to invest, and bearable risk.

3.2.4 Socio-demographic questions

As the last block of questions, all questions designed to collect socio-demographic data from the subjects were proposed:

- *What gender do you best recognise yourself in?*
- *How old are you?*
- *Do you live in Italy?*
- *What is your level of education?*
- *In which category would you place yourself?* With distinction between: worker in financial sector and student/Worker in non-financial sector/Unemployed/Retired.
- *Imagine an income scale where zero indicates the lowest income group (poverty line) and 10 indicates the highest income group. We would like to know which group you are in. When choosing, please also include any extra wages, pensions and other income earned.*

3.3 Descriptive sample analysis

The questionnaire was submitted to 767 individuals, 63% women and the remaining 37% men, with 95% of both residing in Italy. The age range was 18 to 79 years, with an

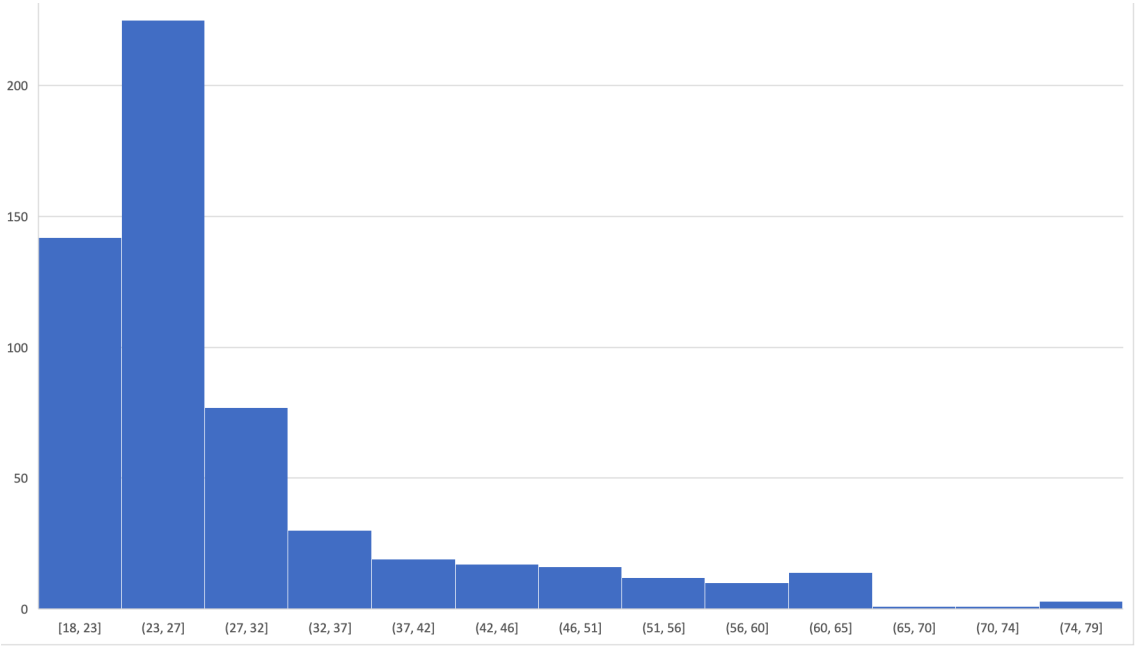

Figure 3.1. Distribution of the sample by age range.

average age of 29 years (figure 3.1). Regarding educational level (figure 3.2), 24% claimed to have a high school diploma, 34% a bachelor's degree 35% a master's degree, 1% an elementary/middle school diploma and the remaining 6% a PhD.

Eighty-nine percent of the subjects are in the group of "student/worker in non-financial sector/Unemployed/retired," while the remaining 11% say they belong to the group of "worker in the financial sector."

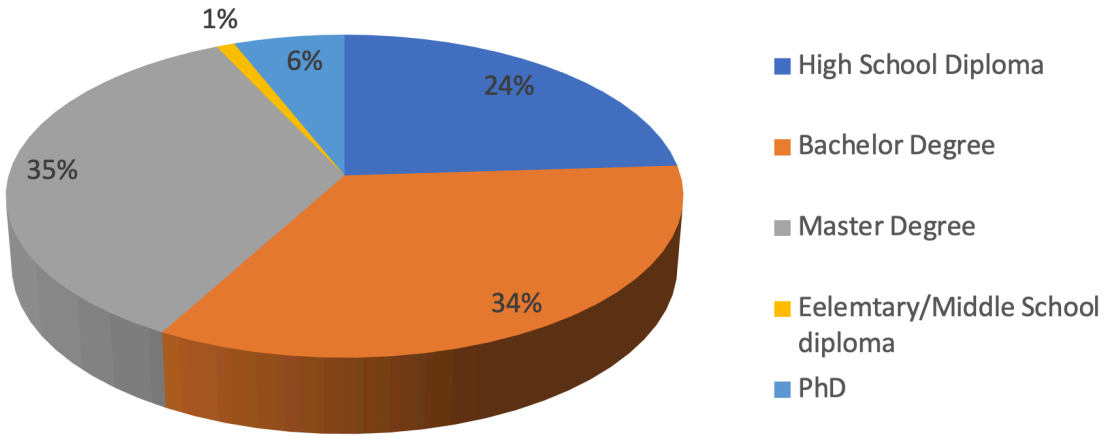

Figure 3.2. Distribution of the sample by level of education

3.3.1 The relationship with cryptocurrencies

Regarding the questions about cryptocurrencies, when asked about the degree of knowledge (figure3.3) of the world of cryptocurrencies, it jumps out as 45% of the sample say that they are little informed about the topic, only 1% say they are very informed and the remaining subjects responded that they had average knowledge of the field.

When asked "*Have you ever invested in cryptocurrencies?*" only 15% of the sample said yes, while the remaining 85% have never invested in cryptocurrencies.

Regarding the source of information mainly used to get informed about cryptocurrencies, we have: websites with 53% of the answers, followed by social with 18%, friends and relatives with 15%, newspapers and magazines with 10% and finally television with 4%.

As the last question on the block, the choice of the percentage to invest in cryptocurrency was presented. As can be seen from figure 3.4, the majority of individuals chose a percentage ranging from zero to about 30 percent of the amount.

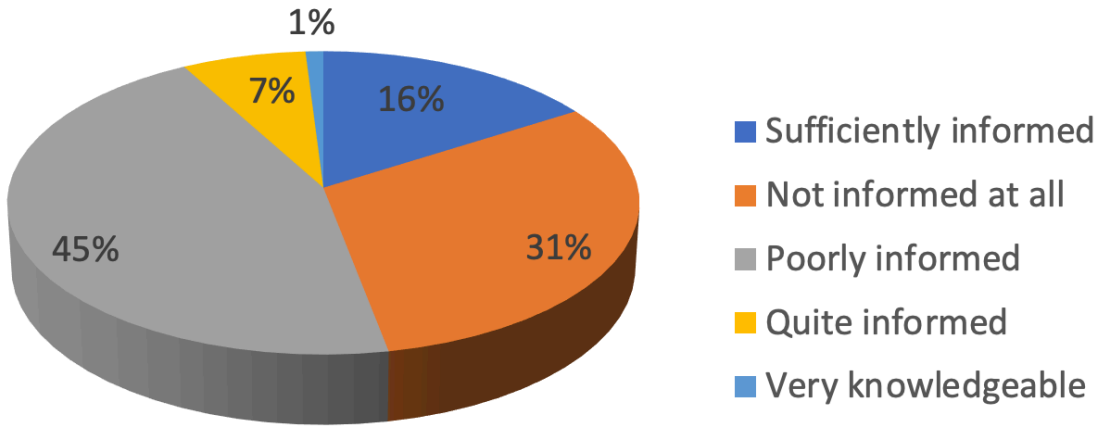

Figure 3.3. Distribution of the sample by level of cryptocurrency knowledge.

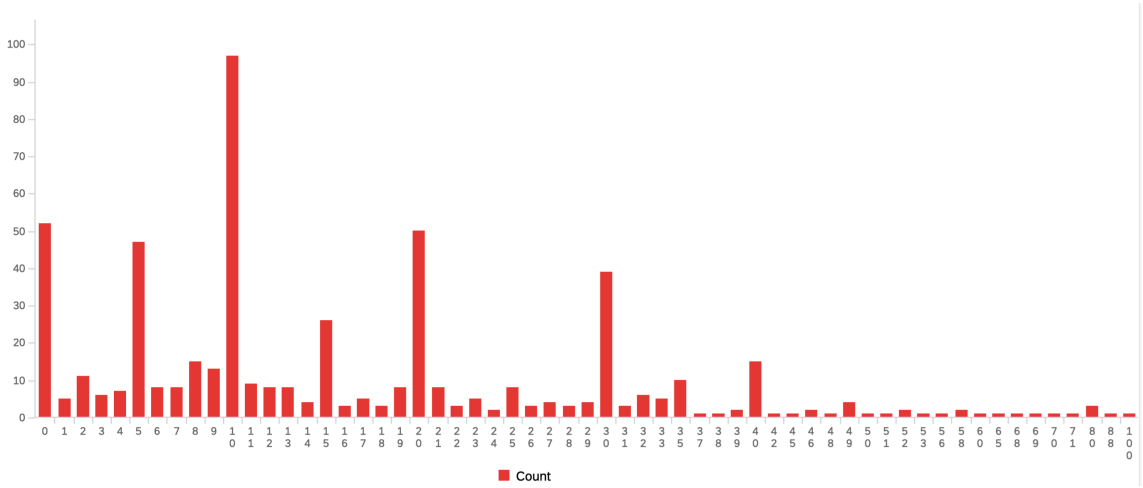

Figure 3.4. Distribution of the sample by possible share to be allocated in cryptocurrencies.

3.3.2 Risk tolerance

For the group of questions about the risk, people in general were unlikely to take risks. To the question "*In general, using a scale of 0 to 10, are you a person who likes to take risks or do you try to avoid them?*" People responded with an average of 4.17 out of 10. While for the risk rating based on different aspects of life, we have that: driving the average is 3.31, investments 3.2, sports and leisure 5, work 4.74, risky health behaviors 2.65 and trusting other people 5.

In the question on understanding the risk-return relationship, the sample demonstrated an understanding of the mechanisms of the relationship, with 85 percent of the responses given to the correct statement "A potentially high expected return is usually matched by an equally high risk."

Another relevant result, was given by the question on investment approach, with 11% responses for the statement "very low/zero return with the lowest possible risk of losing some of the money invested," 63% for "acceptance of a low-medium return investment so as to have capital with low fluctuations in value." 3% for "willingness to get a considerable return from the investment, with willingness to accept even significant

fluctuations in the capital," and finally 23% chose "willingness to get a very high return from the investment, with willingness to accept significant fluctuations in the capital."

3.4 Inferential analysis of data

Stata is the statistical software that I used for econometric analysis of the data, and a common excel spreadsheet was used for data arrangement and preparation.

In my analysis, I divided my data into three distinct groups of variables to facilitate the analysis and understanding of any possible relationships between them. I want to mention that the goal of this statistical analysis was to understand whether the 4 biases described in the previous chapters, were typical of a crypto-investor or not.

The breakdown was as follows:

- **Dependent variables**. The choice fell on the answers to two questions, either "Have you ever invested in cryptocurrency?" to isolate actual investors in digital currency (during the analysis the variable was dominated "*Investitoincripto*"), and "What share of your savings would you be willing to invest in cryptocurrency?" to analyze potential investors in cryptocurrency (during the analysis the variable was dominated "*Percentualeinvestimentocripto*").
- **Independent variables (behavioral variables).** In this case, the independent variables were all variables that are related to possible bias. We have:

- "*INTERTEMPORALVariable*" Produced by summing the results of the 3 proposed inter-temporal questions. The higher it is (0 to 3) the more it should incorporate the anticipation bias of the premium.
- "*Compitiacasa*" Variable that incorporates data from the school homework planning question. Again, the higher it is (0 to 4) the more it should incorporate the anticipation bias of the reward.
- "*Bravuranelguidare*" Variable that collects data from the question about the subject's driving ability. The higher it is (0 to 10) the more it should incorporate the bias of overconfidence.

- "*Overconfidence*" this variable refers to the subject's belief that he or she can make better investments than the average.
- "*Fontidiinformazioneadattean Fontidiinformazioneadattepa Fontidiinformazioneadatteme Fontidiinformazioneadattepe*" Variables that refer to the evaluation of the source of information from which to draw financial conclusions. The evaluation of them aims to understand whether there is a herd effect.
- "*Pranzo*" Refers, again in the context of herd behavior research, to the question about investment decisions after the influence of peer opinion.
- "*FOMOVariable*" As the last behavioral variable we have the FOMO variable, derived from the arithmetic mean of the rating of 9 statements that aimed to detect fear of being cut off.

• **Independent variables (Demographic variables)**, this group of variables encompasses all those variables that could go to influence the relationship between the dependent and independent behavioral variables. They could explain some relationships that, on initial econometric analysis, would not seem to exist. The variables are:

- "*MF*" Male or female
- "*AGE*". Age of the subject
- "*Gradodiistruzione*" Education level of the subject.
- "*Inqualecategoriaticollochi*" Job category of the subject
- "*Reddito*" subject's income
- "*RISKVariable*" the aggregate risk the individual tends to take
- "*Affermazionecorretta*" Knowledge or otherwise of the relationship between risk and return.
- "*Approccioaduninvestimento*" Approach to an investment that is always related to risk.

3.4.1 Methodology

At this point, two different statistical models were applied based on the type of dependent variable. Since the variable "*Investitoincripto*" is a dichotomous variable, the regression model employed was the Porobit model. Recall that a dichotomous variable is one that can take only two values, zero and one. The Probit nonlinear regression model, allows us to calculate the probability with which an observation can generate one or the other value of the dependent variable.

The Probit regression model is:

$$\mathbb{E}[Y \mid X] = Pr(Y = 1 \mid X_1, \ldots, X_K) = \phi(\beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k) = \phi(X^T \beta)$$

Where Y is the dichotomous dependent variable with Bernoullian distribution, while ϕ representing the distribution function of the normal.

Regarding the analysis of the dependent variable "*Percentualeinvestimentocripto*" in this case being a variable with an upper bound of 100 and a lower bound of zero, the Tobit statistical model was used.

The original Tobit model was proposed by James Tobin (Tobin, 1958), who analyzed household spending on durable goods taking into account its non-negativity. In 1964 that Arthur Goldberger called this specification the Tobit model because of its similarity to the Probit model, now also known as the censored regression model. This type of model is employed whenever there is a budget constraint, that is, the individual must decide on a finite allocation of resources.

The Tobit model can be expressed as:

$$y_i^* = x_i' \beta + \epsilon_i \qquad i = 1,2,...,N$$

With:

$$y_i = y_i^* \qquad se \;\; y_i^* > 0$$

$$y_i = 0 \qquad se \;\; y_i^* < 0$$

3.4.2 First model tested: The crypto-investor

The first model tested was the dependent variable "*Investitoincripto*," which took a value of zero if the answer was no, while it took a value of one if the answer was yes. As for the independent variables in the model, I tried to implement the variables that gave as significant result as possible to the regression.

The variables included in the first model were: INTERTEMPORALVariable, Overconfidence, Fontidiinformazioneadattepe and FOMOVariable. The results of the model can be seen in figure 3.5.

We start from the Wald test result shown in the upper right corner of figure 3.5. Recall that the Wald test is a kind of statistical test that to disprove the existence of an effect. It examines whether the independent variable has a significant relationship with the dependent variable. We consider this test for model significance, as it is indicated for models with limitations such as dichotomous variables as in this case.

```
Probit regression                                 Number of obs =    549
                                                  Wald chi2(4)  =  30.70
                                                  Prob > chi2   = 0.0000
Log pseudolikelihood = -219.4027                  Pseudo R2     = 0.0793
```

Investitoincripto	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
INTERTEMPORALVariable	-.0076145	.0776889	-0.10	0.922	-.1598819	.1446529
Overconfidence	.30424	.0889164	3.42	0.001	.129967	.478513
Fontidiinformazioneadattepe	.1253162	.0318924	3.93	0.000	.0628083	.1878242
FOMOVariable	-.0144693	.0323745	-0.45	0.655	-.0779222	.0489836
_cons	-2.156689	.2895814	-7.45	0.000	-2.724258	-1.58912

```
. mfx

Marginal effects after probit
      y  = Pr(Investitoincripto) (predict)
         =  .13573298
```

variable	dy/dx	Std. err.	z	P>|z|	[95% C.I.]		X
INTERT~e	-.0016594	.01694	-0.10	0.922	-.034854	.031535	.599271
Overco~e	.0663017	.01895	3.50	0.000	.029152	.103452	1.57013
Fonti~pe	.0273096	.00659	4.14	0.000	.014388	.040231	5.12386
FOMOVa~e	-.0031532	.00706	-0.45	0.655	-.016992	.010685	4.02505

Figure 3.5. Results of the first model tested without demographic variables.

We note that $Prob > chi2 = 0.0000$ is less than 0.05, we can reject the null hypothesis of Wald's test "all coefficients except the constant are equal to 0" so the phenomenon represented by the dependent variable is well explained by the independent variables.

Going on to analyze the four variables that are supposed to represent the four behavioral biases, we see that the variable Overconfidence and the variable Fontidiinformazioneadattepe (it is a variable that ranges from zero to 10 and measures the weight an individual associates with one's own financial evaluation) have a p-value less than 0.05. Recall that the p-value to be significant must take a value less than 0.05.
The conclusions we can say from this model are:

- As the level of overconfidence increases, the probability that an individual has invested in cryptocurrencies increases.
- As the importance given by subject, to his own financial analysis increases, the probability that the individual has invested in cryptocurrencies increases.

In addition to what has been said above, we can say that subjects are not driven by either FOMO or anticipation of the premium when deciding whether or not to invest in cryptocurrencies, remembering that in any case it is not related to the actual amount of the investment, but by whether or not they have invested (potentially the subject could have invested just one euro).
A final assertion we can make is that if subjects value their personal analysis highly when investing in cryptocurrencies, the herd behaviour does not exist, but still it is not necessarily the case that it cannot serve as an incipit for the subject's personal financial research. However, this would seem to be in line with the question "*What source of information did you mainly use to inform yourself about cryptocurrencies?*" as more than 53% of subjects answered websites, and only 15% friends and relatives.

Continuing with the model, we go on to introduce the demographic independent variables including:

MF, AGE, Gradodiistruzione, Inqualecategoriaticollochi, Reddito, Ouantoseiinformatosullecript, RISKVariable e Approccioaduninvestimento.

```
Probit regression                                 Number of obs =    528
                                                  Wald chi2(12) = 123.47
                                                  Prob > chi2   = 0.0000
Log pseudolikelihood = -149.27928                 Pseudo R2     = 0.3500
```

Investitoincripto	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
INTERTEMPORALVariable	.0069743	.0975678	0.07	0.943	-.1842551	.1982038
Overconfidence	-.0377668	.1208298	-0.31	0.755	-.2745888	.1990552
Fontidiinformazioneadattepe	.1270072	.0382532	3.32	0.001	.0520322	.2019822
FOMOVariable	.0136171	.0383845	0.35	0.723	-.0616151	.0888493
MF	-.8464053	.1653611	-5.12	0.000	-1.170507	-.5223034
AGE	-.0097751	.0076761	-1.27	0.203	-.0248199	.0052698
Gradodiistruzione	-.0968776	.0955895	-1.01	0.311	-.2842295	.0904744
Inqualecategoriaticollochi	.5169915	.2220735	2.33	0.020	.0817354	.9522476
Reddito	-.0510176	.0479299	-1.06	0.287	-.1449586	.0429233
Quantoseiinformatosullecript	-.56261	.0941979	-5.97	0.000	-.7472344	-.3779857
RISKVariable	.0469667	.068127	0.69	0.491	-.0865597	.1804931
Approccioaduninvestimento	.3689322	.1264663	2.92	0.004	.1210628	.6168017
_cons	.1641906	.6526563	0.25	0.801	-1.114992	1.443373

```
. mfx

Marginal effects after probit
      y  = Pr(Investitoincripto) (predict)
         =  .07295829
```

variable	dy/dx	Std. err.	z	P>|z|	[95% C.I.]		X
INTERT~e	.0009666	.01352	0.07	0.943	-.025522	.027456	.609848
Overco~e	-.0052345	.01684	-0.31	0.756	-.038243	.027774	1.5625
Fonti~pe	.0176034	.00558	3.16	0.002	.006669	.028538	5.0928
FOMOVa~e	.0018874	.00532	0.36	0.723	-.00853	.012305	4.02541
MF*	-.1403547	.03309	-4.24	0.000	-.205217	-.075493	.632576
AGE	-.0013548	.00107	-1.26	0.207	-.003459	.000749	28.8466
Gradod~e	-.0134274	.01303	-1.03	0.303	-.03896	.012105	2.18939
Inqual~i*	.095068	.05169	1.84	0.066	-.006236	.196372	.104167
Reddito	-.0070711	.00657	-1.08	0.282	-.019957	.005815	4.82008
Quanto~t	-.0779786	.01465	-5.32	0.000	-.106699	-.049259	2.9678
RISKVa~e	.0065097	.00937	0.69	0.487	-.01186	.024879	4.06197
Approc~o	.0511346	.01784	2.87	0.004	.016162	.086108	1.17992

```
(*) dy/dx is for discrete change of dummy variable from 0 to 1
```

Figure 3.6. Results of the first model tested with demographic variables.

With the addition of the demographic variables, we are going to answer the following statement: given the same d'individual (represented by demographic characteristics), do the following bias variables, go to influence the probability of investing in cryptocurrency?

In the model without demographic variables, we were not taking into consideration some possible interactions between the research variables. Potentially some bias could only be present if we take into account variables such as age or educational attainment. A common assumption would be to say that overconfidence would increase as the age of the analyzed subject decreased.

In this case in figure 3.6 we can see that, again based on the p-value, the variables “MF“ (male or female), “Ouantoseiinformatosullecript" (level of information about crypto), and “Approccioaduninvestimento” (level of riskiness of a possible investment), are related to the probability of having invested in crypto.

The first conclusions about the demographic variables are that:

- Looking at the sign of the coefficient of the MF variable, it is more likely that a man invested.
- Those who are more informed about crypto clearly are more likely to have invested.
- Those with a high-risk, high-return approach are more likely to have invested in crypto.

Returning instead to the bias analysis, looking at the p-values, it seems that with the same subjects, “overconfidence” is no longer a relevant bias in the choice of whether or not to invest in digital currencies, however, personal financial analysis remains a significant factor.

It must be said that the “Fontidiinformazioneadattepe” variable, as mentioned earlier, was formulated to analyze how much confidence an individual places in his or her own abilities relative to the herd. So although it was not designed to analyze the subject's overconfidence but the herd effect, we can still say that: all things being equal, those who implement a personal research strategy, avoiding the opinions of the masses, are most likely to have invested in cryptocurrency.

3.4.3 Second model tested: Percentage of investment

As the second dependent variable tested, we examined "Percentualeinvestimentocripto," which is the percentage of investment in cryptocurrency that the individual would allocate if he or she had surplus capital.

Looking at Figure 3.7, the test applied to assess the goodness of fit of the model is the likelihood ratio chi-square test. The test tells us that the null hypothesis is rejected and we will have that at least one of the dependent variables has an effect on the dependent variable other than zero.

Analyzing each individual bias variable instead, we see that only the variable "Fontidiinformazioneadattepe" and the "FOMOVariable" have a significant p-value below 0.05.

```
Tobit regression                                  Number of obs     =        516
                                                        Uncensored  =        464
Limits: Lower =   0                                     Left-censored =       52
        Upper = 100                                     Right-censored =       0

                                                  LR chi2(4)        =      24.78
                                                  Prob > chi2       =     0.0001
Log likelihood = -1982.5612                       Pseudo R2         =     0.0062
```

Percentualeinvestimentocripto	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
INTERTEMPORALVariable	-.531256	.8071187	-0.66	0.511	-2.116928	1.054416
Overconfidence	.3602927	.8942694	0.40	0.687	-1.396596	2.117182
Fontidiinformazioneadattepe	.6065416	.2913892	2.08	0.038	.034076	1.179007
FOMOVariable	1.466793	.3309406	4.43	0.000	.8166241	2.116961
_cons	6.367367	2.464978	2.58	0.010	1.524652	11.21008
var(e.Percentualeinvestimentocripto)	238.1193	15.9668			208.7291	271.6477

Figure 3.7. Results of the second model without demographic variables.

At this point we can conclude that:

- The higher the FOMO in the subject, the more likely it is that the subject will invest a considerable amount of its surplus money in cryptocurrency.
- The more a subject rates their financial analysis as relevant, the more likely the subject will allocate resources in the world of digital currencies.

We want to mention that our dependent variable: "Percentualeinvestimentocripto" in this case does not tell us how much a crypto-investor has actually invested, but how much a potential investor would allocate, in the cryptocurrency world, if he or she were to do so. Thus, we can say that the variable is outside the individual's subjective situation, since it is purely hypothetical.

Instead, introducing the same demographic variables as in the first model, following the significance of the p-value, we see in figure 3.8, the resource allocation is influenced by many demographic factors.

Tobit regression — Number of obs = 496; Uncensored = 448; Left-censored = 48; Right-censored = 0

Limits: Lower = 0; Upper = 100

LR chi2(12) = 78.91; Prob > chi2 = 0.0000; Pseudo R2 = 0.0206

Log likelihood = -1878.9493

Percentualeinvestimentocripto	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
INTERTEMPORALVariable	-.3578862	.7604371	-0.47	0.638	-1.852052	1.136279
Overconfidence	-.9385449	.9331699	-1.01	0.315	-2.772109	.8950196
Fontidiinformazioneadattepe	.2936501	.2815586	1.04	0.297	-.259578	.8468782
FOMOVariable	.987411	.3279752	3.01	0.003	.34298	1.631842
MF	4.270762	1.487195	2.87	0.004	1.348606	7.192918
AGE	-.086245	.0683959	-1.26	0.208	-.2206345	.0481446
Gradodiistruzione	-2.67338	.7822704	-3.42	0.001	-4.210445	-1.136314
Inqualecategoriaticollochi	-.8947146	2.234918	-0.40	0.689	-5.286055	3.496625
Reddito	-.1402579	.36179	-0.39	0.698	-.851131	.5706151
Quantoseiinformatosullecript	-2.386581	.8430864	-2.83	0.005	-4.043143	-.7300199
RISKVariable	1.521734	.5122335	2.97	0.003	.5152576	2.52821
Approccioaduninvestimento	3.620421	1.123803	3.22	0.001	1.412285	5.828557
_cons	14.94244	5.451981	2.74	0.006	4.229968	25.65492
var(e.Percentualeinvestimentocripto)	206.1061	14.04369			180.2794	235.6327

Figure 3.8. Results of the second model with demographic variables.

According to the results we can say that:

- If you are male you are more likely to allocate a higher amount of resources in cryptocurrencies.
- Keeping in mind the sign of the coefficient, the more educated (in a general sense) the subject is, the less amount he will allocate in cryptocurrencies.

- The more informed a subject is about cryptocurrencies, the more he or she will allocate resources in them.
- The more the subject tends to have a high degree of (generic) risk, the more he or she will allocate resources in them.
- The more the subject tends to have a risky approach of investing, the more the subject will allocate resources in cryptocurrencies.

Looking instead at the bias variables with the same subject, the FOMO component remains, while the Fontidiinformazioneadattepe variable is no longer significant. This could be explained by the fact that the percentage of investment in crypto is subject to some variable that the constructed model cannot explain.

3.5. Conclusions

Pulling together the results obtained with the questionnaire and the econometrics models, we can say that crypto-investors are subject to some of the biases that previously analyzed in Chapter 2. The biases, are subject to demographic parameters that influence their presence and degree of significance.

From the results obtained, we can extrapolate three main concepts:

- Crypto-investors are subject to a certain degree of overconfidence in approaching and analyzing the crypto financial world. They mainly inform themselves online and tend to avoid the opinion of others when deciding whether or not to invest.
- Those who tend to have a risky approach to investing will be more averse to investing in crypto.
- The degree of FOMO is directly related to the degree of exposure to digital currencies.

Unlike the assumptions made in Chapter 2, herd behavior and reward anticipation do not appear to be two biases that go into investment decisions in cryptocurrencies.

There is one limitation of the sample analyzed, which is the academic environment, to be noted. The level of education of most of the subjects is on average very high compared to a possible sample that more closely reflects the Italian population.

And connecting to this, there is, in my opinion, a second limitation that is related to our country. In countries like the United States, or at any Anglo-Saxon countries, the sentiment respect to these new financial assets is higher than in ours. In Italy there is a very different culture of risk compared to other Western realities. This factor may have influenced the presence of biases such as herd behavior or reward anticipation.

Without any doubt, it has been proved that the crypto-investor acts non-rationally when investing, and this can be seen especially from the high risk taken in relation to the type of instrument in which one is going to invest. FOMO is definitely one of the most relevant factors in this new financial world, in addition to investor overconfidence. Furthermore, we can say that the level of education greatly influences the degree of irrationality of individuals, and thus proves to be essential when learning and studying complex decisions such as the allocation of one's resources and during the decision making process for choosing the degree of strategy risk.

Investor irrationality remains a central issue that, in my opinion, should be explored further in the years to follow and implemented in any research on the subject. Having educated investors who are aware of their decisions would definitely have a positive impact on the economy, especially at the time when they are asked to put a fair value on the right asset.

Assets, that are lacking of fundamental value but priced high just for pure speculation, are a waste of resources, which could be allocated to projects with more value and a future growth.

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