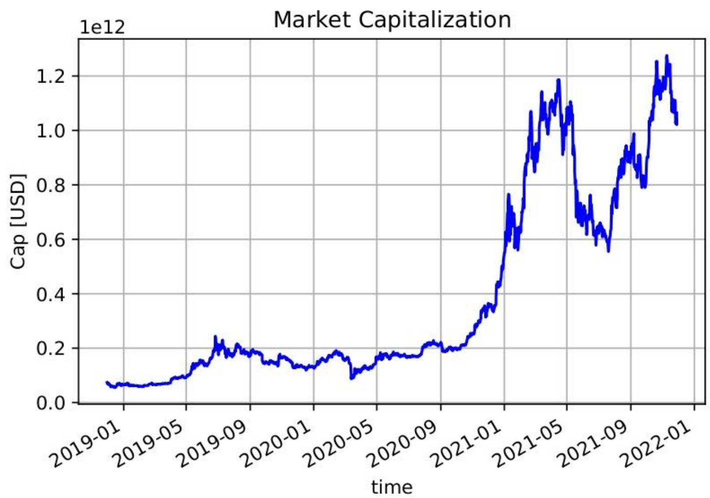
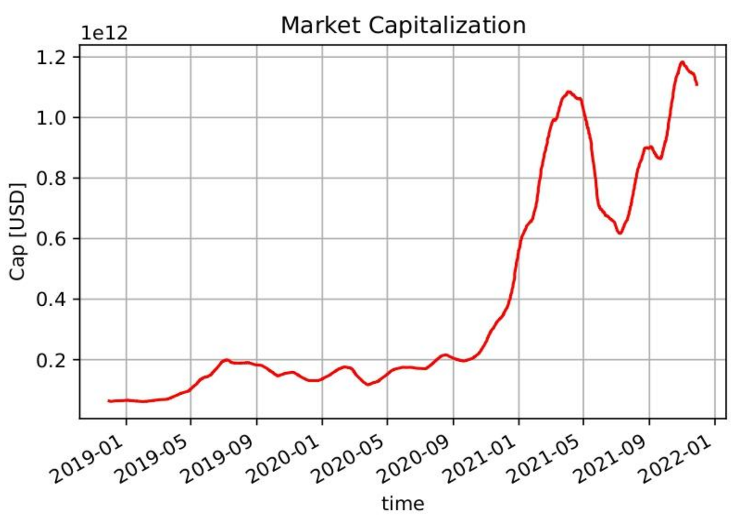
INTRODUCTION TO CODING PROJECT - 2020/2021
DATA DISCUSSION AND ANALYSIS

DATA DISCUSSION





Introduction

The market capitalisation is defined by the following equation:

$$Market\ Capitalization = Quantity\ of\ Bitcoin\ in\ circulation \times Bitcoin\ Current\ Price$$

This value depends on two variables:

- The **quantity in circulation** represents the total supply of bitcoins, the total of coins that have been mined;

- The **price** is based on how much people are willing to buy in order to have it or how much they're willing to be paid in order to sell it, so it is continuously changing.

Demand and supply are going to meet up in what we call the market capitalisation.

In order to measure the value of a cryptocurrency, we can make use of two important factors: the price, that symbolises the level of demand in the market (the larger the demand the higher the price), and the market cap, that enables miners to get a reward.

This being said, a little introduction is necessary:

The circulation of bitcoins is not only limited to mining; in fact anyone can own some bitcoins, even a fraction of it: 1 bitcoin is composed by 100,000,000 satoshis, and this is useful for the new consumers as the price grows, so that they can get at least a fraction of a bitcoin spending a relatively low price. This was organised before the launching of bitcoins by Satoshi Nakamoto, in order to ensure that it would have been possible to buy further bitcoins or, as previously said, a fraction of it, even if the price had kept increasing: like gold, bitcoins need to be mined and can't be created like fiat currencies. There is a total fixed number of 21 million bitcoins available in the economy, and as time goes by the mining reward decreases because of the predictable supply governed by scarcity making bitcoin somewhat like a digital gold.

In the early stages (2013-2017), the bitcoin price was vacillating between $200 and $13,062.15 (in December 2017, one year after the *halving** and also thanks to the spreading of awareness in this topic). Market capitalisation in this period was initially under 0.01[*Trillion USD*], and in 2017 it increased up to 0.23747[*Trillion USD*], but this sort of bubble (that happens when a good's price far exceeds its real value) burst in January.

In the following two years there were small ups and downs but the values didn't reach those of December 2017.

Graph Analysis | Market Cap

But 2019 began with a trend in increasing price followed by a market cap with a maximum of 0.23 [*Trillions USD*].

Covid didn't upset the market cap curve of bitcoin:

The actual rise began in October 2020 and never stopped until reaching 1.1 *[Trillion USD]* in March 2021. This rapid rising of bitcoin's value is due to some factors:

- The speculations about its price and worth, that had reached a high threshold but were expected by many experts to keep climbing up ;
- A serious talk about inflation had begun: inflation increases roughly by 2% per year and this is because of the introduction of money on the market by central banks; in fact, our fiat currencies are entirely controlled by them. This gives more and more credit to bitcoin: the value of bitcoin (unlike most currencies) cannot be manipulated by a central authority and is issued according to a set of rules, for example its limit of 21 millions;
- Abundance of information on the web: many documentaries and interviews that help sort out all the doubts about the mechanisms of the blockchain, many testimonials from those who have been investing since the beginning or so and who are able to give scientific proofs of the benefits of this technology;
- The halving and the stock-to-flow model (bitcoin is a sort of digital gold, since it is scarce and fixed);
- Due to inflation people prefer, instead of holding too much cash, to invest in safe-haven assets (such as bitcoin) that are not gonna lose their purchasing value, and this is the reason why public companies have started converting their cash treasuries into cryptocurrency;

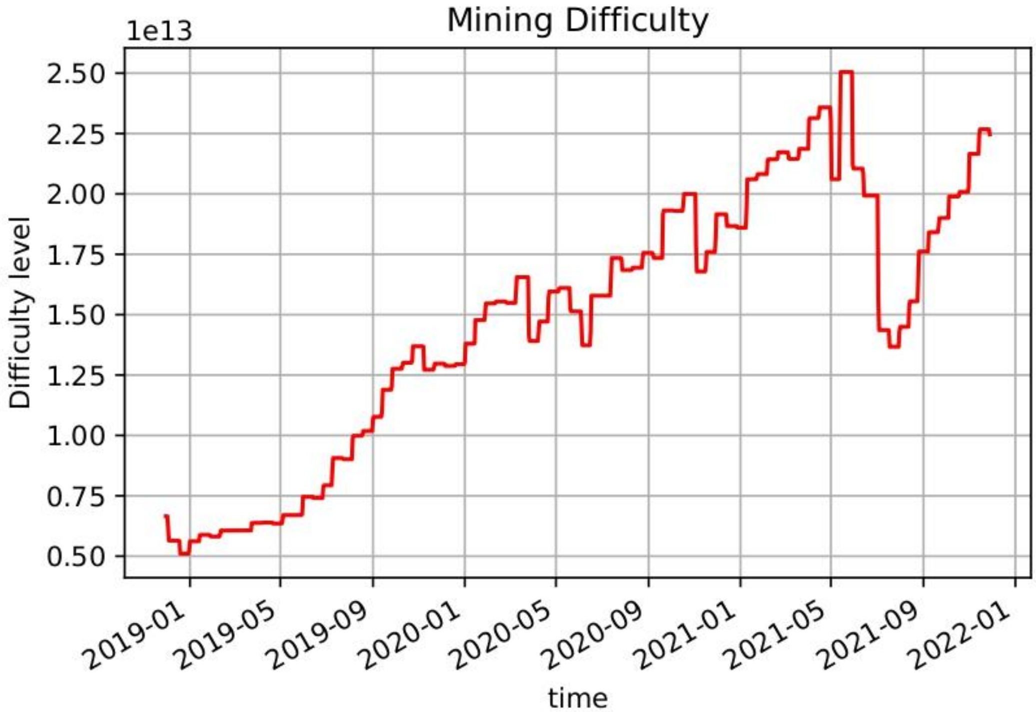
- Tesla bought bitcoins (in February 2021) of the value of one and a half billion dollars, accepting payments for its products in bitcoin and publishing positive messages about the topic on twitter.

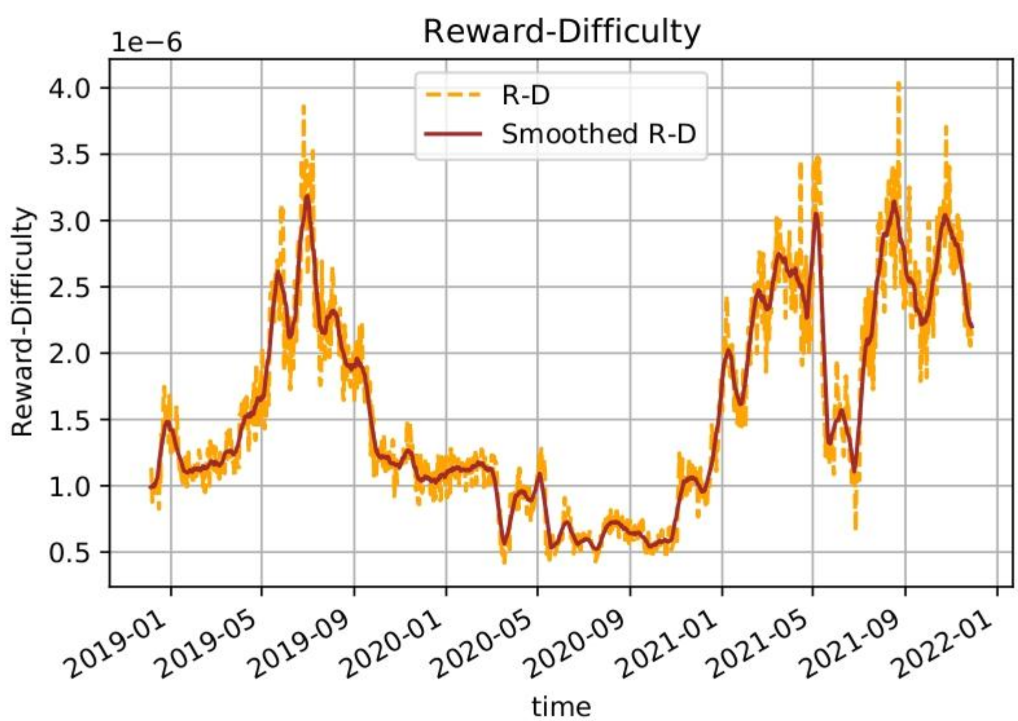
Then a rapid but short-term crash: in May 2021 the market cap started dropping and reached the value of 0.59 *[Trillion USD]* in July. Why did this happen? Well, mainly 2 things influenced this fall, such as Elon Musk expressing his concerns about the low sustainability and environmental impacts of mining cryptocurrencies, and China ordering some banks and payment firms to crack down on cryptocurrency trading.

Then price and market cap kept rising in time from August on, reaching its new maximum value of over 1.2 *[Trillion USD]* on the 10th of November 2021, partly because of a trend in converting cash to cryptos, especially by American payment companies (PayPal started in october 2020), but also because people trust the masses, so as more and more users buy you're brought to thinking there's an advantage in buying even if that's not always the case.

**halving*: process by which the supply of new crypto coins rewarded to miners gets cut in half; it happens every 4 years.

Graph Analysis | Reward-Difficulty


Mining Difficulty
1e13
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
Difficulty level
2019-01
2019-05
2019-09
2020-01
2020-05
2020-09
2021-01
2021-05
2021-09
2022-01
time


Reward-Difficulty
1e−6
R-D
Smoothed R-D
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Reward-Difficulty
2019-01
2019-05
2019-09
2020-01
2020-05
2020-09
2021-01
2021-05
2021-09
2022-01
time

The act of “digital mining” performs not only the tracking and validation of transactions and ownership, but also the creation of new bitcoins, which are possible thanks to the creation of a cryptographic system. These complicated codes help miners in verifying the transactions and receiving bitcoins as a reward just as they compute the correct mathematical code before the other miners. The **difficulty** in mining is related to the amount of time and effort put into finding the right hash (a random 64-character output) to verify transactions and ownership. This depends strictly on the number of miners in the environment: in fact the popularity of bitcoin positively affects difficulty.

In general the most effective way of mining cryptocurrencies is with a GPU or ASIC (Graphics Processing Unit or Application Specific Integrated Circuit), which are expensive hardwares. Miners also need two fundamental features if they wanna maintain a low cost profile: an unlimited internet connection in order not to be charged any fees for surfing on the internet and being connected a high amount of time; solar panels or a low-cost power because mining concerns an extremely high usage of electricity. This is why you need to be cautious when mining, paying attention to saving as much as you can, otherwise the network is gonna suck out a lot of money spent on electricity.

For this reason many miners decide to merge and cooperate , so that they split the reward (in proportion to their share of computing power) which is easier to get because of the combination of hash rates: this sort of teamwork is called mining pools. Nowadays, mining pools take up over 98% of Bitcoins total computation power (this makes us think that some sort of centralisation will be needed, since people are trying to stick together). When all the 21 million bitcoins will be mined, the **reward** is gonna come from the transaction fees. An important event when considering the difficulty is called “*the halving*”: it comes every 4 years approximately and it halves the miners’ reward; it is necessary to control bitcoin inflation and to slow the supply of bitcoins. In the months following the halving, the bitcoin price starts increasing and increasing.

Also, bitcoin difficulty is adjusted every 2016 blocks, approximately every 2 weeks, in order to guarantee that the average interval between blocks keeps being 10 minutes: we can notice the homogeneous intervals that compose the segments of the difficulty plot.

The past three years have seen the rapid increase in Bitcoin difficulty, and this resulted in miners tending to join large open pools to get a more stable reward.

Looking at the **plots**, we can notice that they are similarly shaped, even though the difficulty has been gradually increasing from 2019 until May 2021, meanwhile reward was fluctuating until December 2020, and just then the rapid growth started.

After the halving, since lower supply is available in the market, the demand bursts and price becomes higher (as we can notice in the market cap plot at the beginning of 2021), but miners are still stimulated to stay even though the rewards are smaller, and this is because of the increase in the bitcoin value: once one finds the correct hash, they can expect a big revenue since the difficulty is high!

In May-June 2021 bitcoin reached an all-time high, meaning that the harshing power competing for a reward had never been higher and the number of miners was extremely high.

Both had a low peak in their value after May 2021, but then gained height almost reaching previous values (may's). The drop happened after China's government banished the country's crypto miners, and this affected more than 50% of the network, causing the hash rate to drop off, leading to fewer blocks solved each day. Also Elon Musk, as previously said, contributed to this drop by sharing his doubts about the sustainability of bitcoin (speaking in terms of pollution).But we have to remember that bitcoin is a self-regulating market, provided of the tools to fix a situation of increase or decrease of mining machines. Experts thought 6 to 15 months would have been needed for the surplus to find a home. Less computing power meant decreasing difficulty level, but also decreasing security level (as the computational power gets high, hackers will need an enormous amount of energy in order to control the transactions).

PROJECT ANALYSIS

PART 1

In the first part of the project we were asked to analyze the market capitalisation and smooth the graph.

- **Task A** → After importing the data and the json library, we decided to isolate the values from the original file, and then to separate them into xs and ys to simplify the subsequent steps. Then we wrote the function *"timeconvert(x)"* mainly because we had to convert time from *timestamp* to *dates* for the whole project, and therefore it has been enough to copy it in the other tasks. Then we plotted the graph specifying the values in the two axes and using the converted dates in the xs.

  Clarification: We opted to change the code given in class [line 46] with an alternative one taken from the web [line 47] which selects more intervals in the x axis in order to have a less precise but larger amount of vertical lines in the graph.

- **Task B** → In the second task we imported again the data and isolated them as we already did in task A, then we developed the function *"smooth(delta)"*: we used a <u>nested *for loop*</u> and decided to work with the dictionaries and not separately with the isolated values because the values of time and market cap were already matched. By doing it in this way, it was sufficient only to impose the existence condition of the timestamp in the interval to add the associated value, without browsing the two separated lists by position.

  One detail that has to be specified in the function we wrote consists in the way we dealt with multiple measurements in the same day: we opted for considering the interval of one month and all the measurements in it. This means that if in some days there were <u>more than one value available we inserted all of them</u>, taking into account the "surplus" and dividing by the total amount of data when calculating the average.

In conclusion, we again converted the time format and plotted the smoothed graph in the same way we did in task A.

PART 2

In the second part of the project, the objective consisted in studying the relation between miners' reward and the mining difficulty, to finally identify the better periods to operate the mining.

Note - We divided the code into two subparts in order to better divide the tasks and to easily manage the amount of lines written.

- **Tasks A-B** → As we did in part 1, we imported the values of both files and isolated them. From a technical point of view, the procedure does not differ much from the one developed in the first part of the project: apart from changing the time interval delta in the smooth function (15 days instead of 30), the two functions used were analogous:
    - *timeconvert(x)* to convert timestamps to dates
    - *smooth(delta)* to remove the noisy fluctuations

- **Tasks C-D** → In this final part, after importing the data, we decided to change the isolation procedure to "eliminate" from the beginning the time discrepancies in the two files by using two while loops: the reasoning we followed was based on the fact that the days in which one of the values was missing (either miners revenue or difficulty level) weren't relevant for our analysis. Therefore we opted for directly removing them and isolating the values after this passage. By doing so, we could immediately work on the useful data.

  The second step consisted in computing the reward per difficulty: we developed the *"reward_difficulty(x, y)"* function that uses a for loop to compute the ratios. Since the two lists have the same length (and considering that the values in the same position refer to the same day because of the isolation previously done), we simply created a list dividing the elements in the same position.

Then the other function *rew_dif_f (x,y)* was implemented to create a list of tuples in order to associate the ratio to the corresponding timestamp. This passage was crucial to accomplish task D.

The structure of the smooth function as well as the timeconvert function and the code for plotting the graph remained unchanged.

Note - We decided to smooth the function but to insert into the graph both the curves, the original and the smoothed one, just to point out the effect of the correction and the impact of the approximation.

Then, we solved task D by making use of two different functions:

1. The function *highest(x)* selects the ratios precedently computed and sorts them in descending order. We made this choice because then it has been sufficient using a while loop to select the highest 10%;
2. The function *periods(x)* was built on a for loop which browses the reward difficulty function created in task C. We decided to develop the code in such a way to isolate the timestamps from the original function by checking their existence in the list created with the function highest(x).

At the end we simply created a list with the converted profitable dates by making use of the classic timeconvert function. In conclusion, as its name suggests, we gathered all the most profitable periods in the list "profitable_dates".