Is Mining Profitable?

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Abstract

This a report for Skolkovo Institute of Science and Technology course – Introduction to Blockchain. We build a microeconomic model and use it to analyse the mining profitability of PoW-consencus cryptocurrencies among top-10 by Dec 2019 market capitalization.

1. Introduction

Cryptocurrency is a blockchain-based digital asset, meaning a decentralized database of transactions with tamper-resistant log and build-in auditability. Its mining is network participants getting paid for creating new blocks and securing transactions. The matter of interest is an important and challenging economic question whether mining is profitable, and if it is, up to what extent?

2. Related works

The hardware for mining cryptocurrencies evolved from CPUs to GPUs to datacenters powered by application-specific integrated circuits (ASICs) since the deployment of Bitcoin in 2009 (Taylor, 2017). ASICs became the most popular hardware for mining many cryptocurrencies.

3. Cryptocurrencies choice

Although we are analysing mining profitability using a microeconomic model, we are also interested in exploring its profitability as a macroeconomic concept, which is the reason why we look at top-10 cryptocurrencies for our analysis. The ranking can be found in table 1

Among these, we choose for further analysis the cryptocurrencies with PoW consensus(Nakamoto), for which the mining process is as follows:

For such a consensus mechanism, there is a well-known and in short-term precise model that allows to compute profits.

Cryptocurrency	Mkt Cap ($bln)	Consensus
Bitcoin	130	**PoW**
Ethereum	14	**PoW**
XRP	8.5	”Consensus”
Tether	4.1	PoW and PoS
Bitcoin Cash	3.5	**PoW**
Litecoin	2.5	**PoW**
EOS	2.3	delegated PoS
Binance Coin	2.0	PoS
Bitcoin SV	1.6	**PoW**
Tezos	1.0	PoS

Table 1. Top-10 coins by market capitalization. There are 5 of them in bold, which we consider, because they use PoW consensus.

4. Model

4.1. What affects mining profitability

In PoW, the probability to create a new block, and hence, the expected reward, is proportional to one's hardware hashpower. The difficulty of creating a new block $Block\ Difficulty = Network\ Hashrate \cdot Block\ Time$ is being automatically adjusted by target value TV. The expected revenue per unit of time can be computed then as

$$Revenue = \tag{1}$$
$$= \frac{Hashing\ Power}{Network\ Hashrate} \cdot \frac{Block\ Reward}{Block\ Time} \cdot Coin\ Price$$

However, due to the fact that the lower one's hashpower, the higher the variance of the realized revenue relative to the expected revenue, miners often unite in pools, the owners of which redeem fees. So, the profitability calculators that can be found on the web today often allow to take into account the reward splitting.

The costs that are usually considered are for electricity:

$$Costs = kWh\ cost \cdot W\ Consumption) \tag{2}$$

So the profit is

$$Net\ Profit = Revenue - Costs \tag{3}$$

Algorithm 1 PoW mining

Input: input={transactions, previous block hash, supplementary information}
Parametrs: hash function $f : \{0,1\}^* \to \{0,1\}^l$, target value TV
Output: new block
Step 1. Take an initial guess for nonce
Step 2. Take together the nonce and input and compute the hash of the result $f(input, nonce)$
Step 3. Compare the hash with the target value determining block difficulty
if $f(input, nonce) < TV$ or someone else has found a new block **then**
  Step 4. New block is found. Translate the result to other nodes. Return to Step 1 to start mining a subsequent block with the new input
else
  Step 4. Increase the nonce by 1 and return to Step 2.
end if

In our model, we compute daily profit using equations 1, 2, and 3.

More generally, the profit can be affected by the following factors:

1. Cryptocurrency-related:
   (a) Coin price
   (b) Block difficulty
   (c) Block reward + transaction fees
2. Hardware-related:
   (a) Hashrate
   (b) Power requirements
   (c) Space requirements
   (d) Device price + delivery cost
   (e) Breakdown rate
3. Country-related:
   (a) Electricity price
   (b) Space rental price
   (c) Income tax rate
4. Other:
   (a) USD interest rate
   (b) Pool fee

4.2. Model assumptions

We would like our model to match the results of online profitability calculators to make sanity check, and to be able to go beyond with some extended flexibility. That is why we make some simplifying assumptions obtaining the numerical results, some of which can be relaxed using our code.

Firstly, we are assuming the cryptocurrency-related parameters to be constant. We consider the coin price to be a rough estimate of market expectation of its future price. The block difficulty can change in ways that are hard to anticipate, e.g. when the block reward is halved, some miners may stop make profit, throw away their devices, which would reduce the network hashrate, making some profitable again, etc. Continuing this view, we make similar assumptions for all the cryptocurrency-related parameters – there is no well-known model for these changes proved useful yet.

Secondly, regarding the parameters of mining hardware. We assume it does not require any space, because it is exactly the case with sole proprietary mining with rig in an apartment where the space is free. Moreover, in case of mining on a larger business scale, rental costs may usually vary more than for electricity. Further, we are neglecting breakdown rate, because hardware often has a warranty for a period comparable or exceeding the time to halving of the block reward, on which the model is applicable. The hardware delivery costs is also beyond the scope of our project, however, it can be just added to its price.

Thirdly, concerning the parameters of countries, for simplicity we are assuming there is no price discrimination in electricity prices, whereas in reality it may depend on whether the consumer is the country's citizen or not, on the time of the day, on business scale, and so on. For similar reasons, we are not taking into account income taxes.

Finally, for the purpose of reducing computational complexity, we are assuming USD interest rates structure to be flat when computing discounted cash flows (DCF, equation 4), and take current long-term LIBOR value – the scale of the model applicability and the payback times we got have at least an order of a year. The pool fees are neglected, because pools are decreasing them competing with each other.

For some of these assumptions we have left in the code the ability to be relaxed. The code can take into account pool fees, country taxes, costs of space rent for large mining rigs. It is worth noting that from the qualitative viewpoint, analysis of profit dependency on space rental costs does not differ from its dependency on electricity cost – similarly, it is a product of one hardware and one country parameters. Analogously, qualitatively taxes and interest rate influence profitability metrics in the same direction.

5. Metrics

We use various metrics of profit – daily profit (equation 3), payback time (equation 5) and return on investment (ROI, equation **??**).

$$DCF = \frac{Daily\ Profit}{1 - \exp(-\frac{r}{365.25})} \tag{4}$$

$$Payback\ Time = \ln\left(1 - \frac{Device\ Price}{DCF}\right) \cdot \frac{365.25}{r} \tag{5}$$

6. Results

6.1. Bitcoin, Bitcoin Cash and Bitcoin SV

Bitcoin (BTC) is the number one cryptocurrency by market capitalization. It was created in 2009 by an entity known under the pseudonym of Satoshi Nakamoto, whose specific identity is unknown. BTC is a distributed network based on blockchain and it is considered the most secure and important cryptocurrency.

Bitcoin Cash (BCH) is the cryptocurrency number five by market capitalization and it is an alternative implementation of Bitcoin. It has its origins in the coordinated division of the Bitcoin network (BTC) of August 1, 2017. Its irruption in the ecosystem is the result of a prolonged disagreement about the scalability of Bitcoin that took place between 2015 and 2017. It has several differences in relation to Bitcoin but the algorithm for making the consensus remains the same (PoW).

Bitcoin SV (BSV) is the cryptocurrency number nine by market capitalization, software project under OpenBSV license and spin-off of Bitcoin Cash created during the network fork of November 15, 2018. Its existence is a consequence of the confrontation between two contentious proposals to update Bitcoin Cash and a ”hash” war. Bitcoin SV keeps differences and similarities with Bitcoin and Bitcoin Cash, even so, the mining of these currencies can be done in the same way, which is why we have decided in our project to analyze them together.

For the profitability analysis of these three cryptocurrencies, we decided to use several popular equipment for mining during 2019 (AntMiner U3, Ebit E9+, Avalon741, Avalon761, AntMiner S9, Ebit E9++ and Ebit E10), taking into account that these have different characteristics that directly affect the profitability of the miner such as power consumption, hashing power, and hardware price. For the calculation of the model, it is necessary to take into account the main characteristics of the network for each of the cryptocurrencies, such as network hash rate, cryptocurrency price, block reward, block time and difficulty. And as a final step, we must choose the place where the mining will take place, which is directly related to the electricity tariff that the miner must pay, in our case it seemed right to choose Russia with an electricity tariff of 0.069 KWh in average for a normal citizen.

For each of the cryptocurrencies, negative annual profitability values were obtained, results that can be seen in Figures 1, 2 and 3. It is therefore unlikely and almost impossible for a Russian miner to recover his investment by mining any of these three cryptocurrencies.

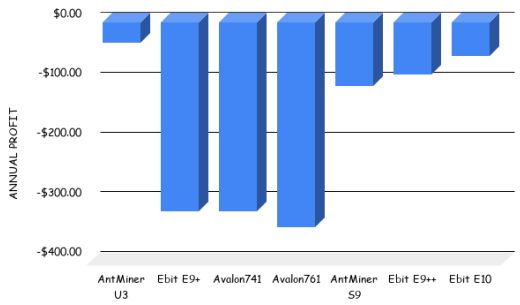


Figure 1. BITCOIN vs POPULAR HARDWARE FOR MINING

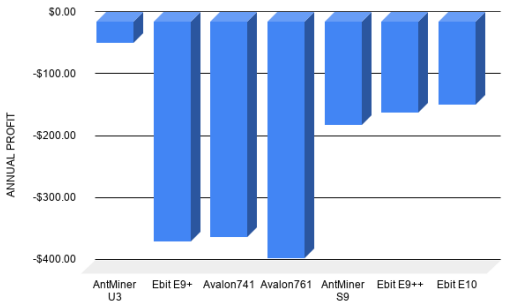


Figure 2. BITCOIN CASH VS POPULAR HARDWARE FOR MINING

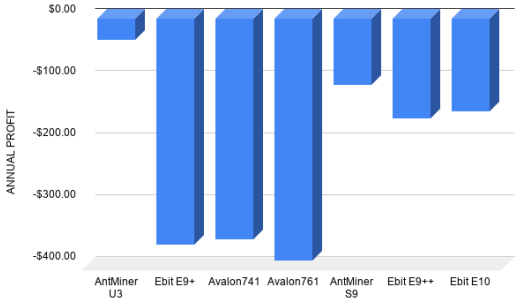


Figure 3. BITCOIN SV vs POPULAR HARDWARE FOR MINING

Having obtained such negative results for mining in Russia, we have decided to choose seven critical cases to illustrate

the behavior of mining around the world: three countries with the lowest electricity tariff in the world such as Kuwait, Venezuela and Myanmar, three countries with highest electricity tariff such as South Korea, Germany and Solomon Islands, and China, which is the country with the largest number of miners in the world. For this analysis, we have chosen the AntMiner S9 hardware because it was the one that produced the best results for the Russian example. Figures 4, 5 and 6 show the result of this analysis.

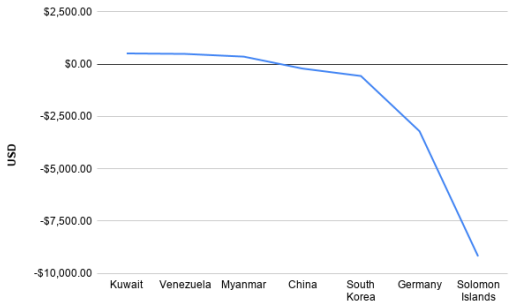


Figure 4. CRITICAL COUNTRIES vs ANNUAL PROFIT (BITCOIN)

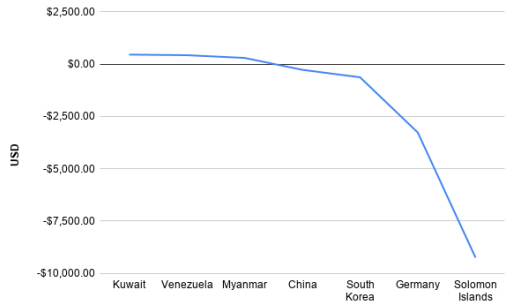


Figure 5. CRITICAL COUNTRIES vs ANNUAL PROFIT (BITCOIN CASH)

For the countries with the lowest electricity tariff, the annual profitability values for all cryptocurrencies analyzed were positive, but even when the mining looks profitable in these countries, the annual profit showed that more than 4 years are needed to recover the initial investment in hardware. On the other hand, the analysis for China and the countries with the highest electricity tariff showed that mining is non-profitable under their conditions; these results are in agreement with Russian analysis.

6.2. Ethereum

Ethereum is the second-largest cryptocurrency by market capitalization. Ether is a cryptocurrency generated by the Ethereum platform. Ethereum was proposed in late 2013 by Vitalik Buterin, a cryptocurrency researcher and programmer.

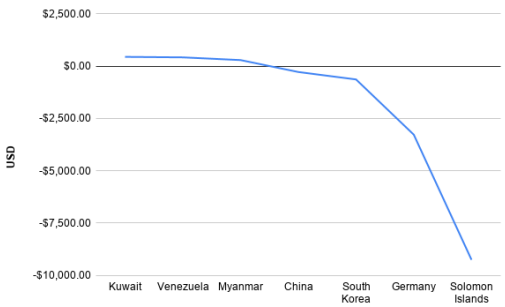


Figure 6. CRITICAL COUNTRIES vs ANNUAL PROFIT (BITCOIN SV)

The most popular hardware for mining Ether is Innosilicon A10 ETHMaster 500Mh which was released in September 2019 and cost 2895$. Before that, Innosilicon A10 ETHMaster 485Mh was the most profitable ASIC for mining Ether with a price of 5650$. Other popular models for mining Ether are Antminer E3 and Bitmain Antminer G2. We analyzed these 4 models of hardware to evaluate the Ether mining profitableness in Russia. Analogously to the evaluating profitableness for Bitcoin and its forks we made an analysis for Kuwait, Venezuela, Myanmar, China, South Korea, Germany and Solomon Islands.

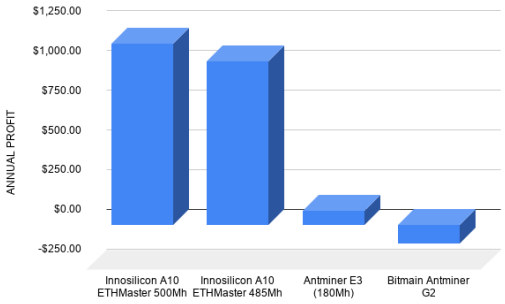


Figure 7. ETHEREUM vs POPULAR HARDWARE FOR MINING

Figure 7 shows the daily profit for mining Ether in Russia is above zero for A10 ETHMaster 500Mh, Innosilicon A10 ETHMaster 485Mh, and Antminer E3 ASIC Miners and the daily net profit for Bitmain Antminer G2 is below zero. Despite the daily net profit for mining Ether using A10 ETHMaster 500Mh, Innosilicon A10 ETHMaster 485Mh and Antminer E3 ASIC Miners the payback time is 927, 1996 1088 days respectively. Thus, it might take 3 years before the most profitable ASIC Miner pay off. Figure 8 illustrates that it is profitable to mine Ethereum in Kuwait, Venezuela, Myanmar, China, South Korea. However, the least payback time is 713 days for Kuwait. This means it

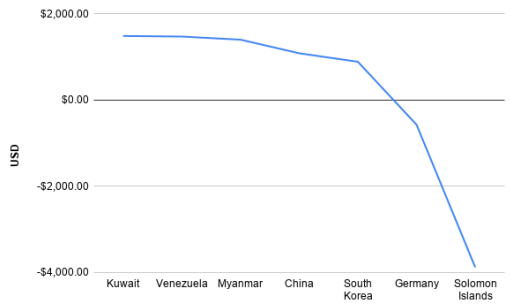


Figure 8. CRITICAL COUNTRIES vs ANNUAL PROFIT (ETHEREUM)

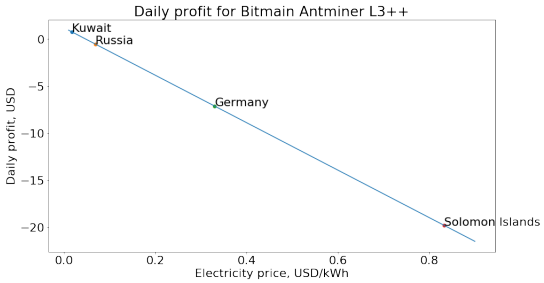
is not profitable to mine Ether worldwide. Moreover, Ether could switch from Proof-of-Work to Proof-of-Stake. Thus, it is risky to start mining this cryptocurrency at this moment.

6.3. Litecoin

These are the list of pairs country-hardware that turn out to be profitable from our model for Litecoin:

	Device	Country	Daily profit	Payback time	USD/kwh
22	Innosilicon A6+ LTC Master	India	0.40	11881.9	0.080
23	Innosilicon A6+ LTC Master	China	0.50	8355.6	0.078
24	Innosilicon A6+ LTC Master	Argentina	3.92	789.6	0.010
25	Innosilicon A6+ LTC Master	Russia	0.95	3656.3	0.069
26	Innosilicon A6+ LTC Master	Kuwait	3.57	870.5	0.017
27	Innosilicon A6+ LTC Master	Venezuela	3.47	896.8	0.019
28	Innosilicon A6+ LTC Master	Myanmar	2.92	1075.0	0.030
54	Bitmain Antminer L3++	Argentina	0.95	282.9	0.010
56	Bitmain Antminer L3++	Kuwait	0.77	348.6	0.017
57	Bitmain Antminer L3++	Venezuela	0.72	373.4	0.019
58	Bitmain Antminer L3++	Myanmar	0.44	612.7	0.030

Figure 9. Profitable countries and devices to mine Litecoin



As you can see, it is not profitable to mine Litecoin in Russia, even with the best hardware, the payback time exceeds the time left before the next reward halving.

7. Conclusion

Mining cryptocurrencies within the top 10 by capitalization is a task that under today conditions is not profitable in

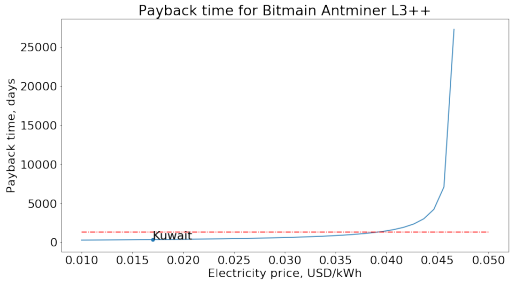
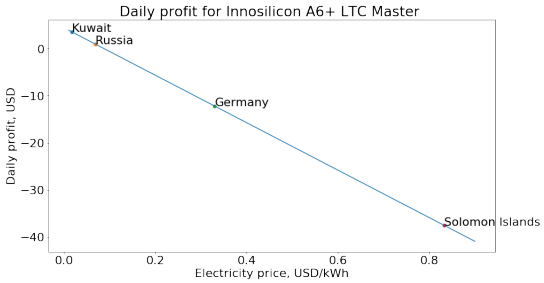


Figure 10. The red line denotes time to reward halving



Russia. If factors that affect profitability are not analyzed carefully before making investments in mining technology, you can end loosing several thousand dollars, but on the other hand instability within the cryptocurrency market always leaves an open door to what could happen in the near future.

Appendix A. List of personal contributions

- Ilya Feshchenko - economics, coding, Litecoin
- Yoel Gómez Collado - baseline model, Bitcoin
- Valeriya Strizhkova - data search, Etherium

Appendix B. List of used data sources

Hardware variables:

- https://whattomine.com/
- https://en.bitcoin.it/wiki/Mining_hardware_comparison

Cryptocurrency-related data:

- https://www.litecoinblockhalf.com/
- https://en.wikipedia.org/wiki/Bitcoin
- https://en.wikipedia.org/wiki/Bitcoin_Cash

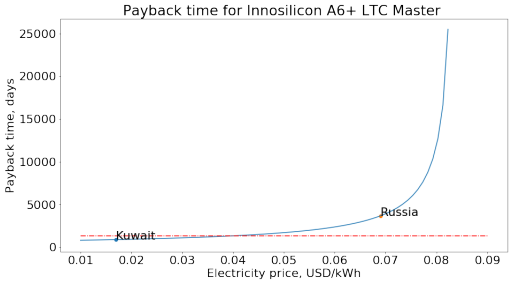


Figure 11. The red line denotes time to reward halving

- https://etherscan.io/

Electricity prices:

- https://www.worldenergy.org/assets/downloads/World-Energy-Trilemma-Index-2018.pdf
- https://powercompare.co.uk/bitcoin-electricity-cost/

Appendix C. List of links to the supplementary materials

- https://github.com/feshch/skoltech/blockchain - our main repo, contains all code implemented in this work
- https://docs.google.com/presentation/d/1Qa8JeVJk_huXNCXwm8Wd7_YfhNTf8SUrVUcgYWAUJqA - link to our presentation

References

Nakamoto, S. Bitcoin: A peer-to-peer electronic cash system," http://bitcoin.org/bitcoin.pdf.

Taylor, M. B. The evolution of bitcoin hardware. *Computer*, 50(9):58–66, 2017.