A simple model of bitcoin mining

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I. Earning block rewards

Bitcoin miners generate income by discovering the solution to a hash puzzle. The reward for discovering a solution consists of a block reward, currently 12.5 BTC, and transaction fees, currently about 0.5 BTC. This model considers only the block reward.

Miners search for hash puzzle solutions by testing candidate after candidate at a rate known as the hashrate, measured in hashes per second. A miner capable of testing one trillion candidate solutions per second is said to be operating at one terahash per second (1 TH/s). The probability of a miner discovering the solution to the next hash puzzle is the miner's hashrate divided by the global hashrate of all bitcoin miners. Miner competition is such that miners now have to operate at the frontier of technological developments in Application Specific Integrated Circuits (ASICs).

The bitcoin protocol periodically adjusts the difficulty of the hash puzzle such that on average one solution is found, globally, every ten minutes. Currently, miners receive about 75 bitcoins per hour in block rewards, and a particular miner's expected share of that income stream is equal to its hashrate divided by the global hashrate.

II. Modelling the global hashrate

In recent years, the global hashrate has followed a roughly exponential increase (see Fig. 1). A linear least squares fit to the logarithm of the hashrate over the period from Aug 1, 2017 to Aug 1, 2018 yields the following trend, with t measured in days:

$$1.46\text{TH/s} \times 10^7 \exp \frac{t - \text{Jan 1, 2018}}{178.7\text{days}}$$

Over the past year, global hashrate has been doubling every 124 days, meaning that the rate at which any piece of mining hardware earns block rewards has been cut in half every 124 days. Assuming this exponential trend will continue enables projection of the global hashrate into the near future.

III. Economics of a bitcoin miner

A typical state of the art ASIC bitcoin miner operates at 13 TH/s. This hashrate, along with the model of the global hashrate, enables estimation of miner revenue into the future. A typical miner operating at that performance level requires 1.275kW of electricity. Assuming an operating cost of $0.09/kWh enables calculation of the expected gross profit from the bitcoin miner in the near future. The result is plotted in Fig. 2 at various exchange rates between bitcoin and the US dollar. These are results expected on average, an individual miner is playing a lottery and will experience a large variance in bitcoins actually mined.

The exponential rise in global hashrate leads to an exponential fall in expected bitcoins mined by mining hardware over time. Increases in bitcoin price have a positive impact on mining profitability (measured on fiat currency terms), while falls have the opposite. Finally, mining hardware is most profitable in its first days of operation, falling quickly with time. At an exchange rate of $10,000 per bitcoin, a miner operating under the assumed cost structure will be unable to mine profitably within a few months.

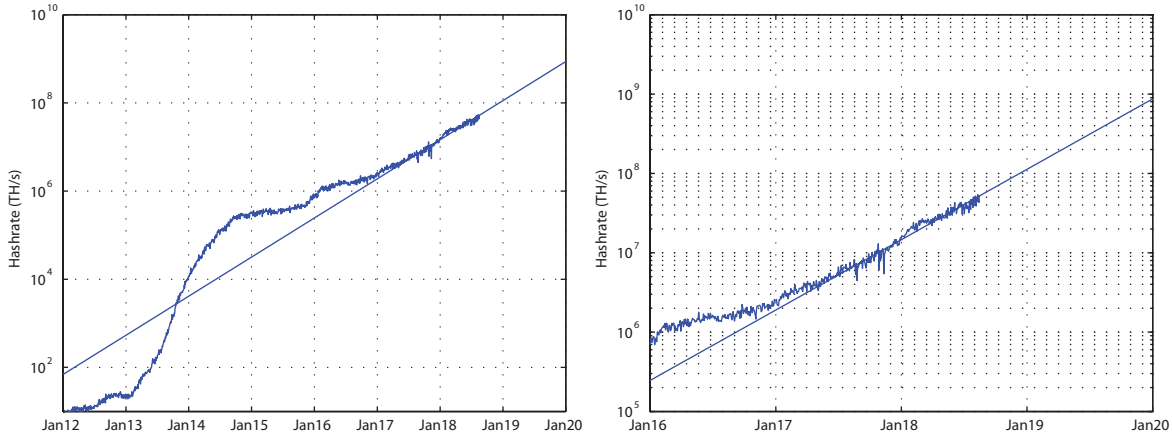

Fig. 1. Global hashrate data overall (left) and in recent years (right), plotted alongside exponential approximation used in this analysis. Data source: https://blockchain.info/charts/hash-rate?timespan=all

IV. Model assumptions and other factors

There are many factors not considered by this simple model. These include but are not limited to the following:

- Most mining occurs as part of mining pools with a variety of financial structures that generally decrease expected revenue in exchange for reduced variance. There can also be many other costs associated with mining bitcoins.
- The bitcoin network reduces the block reward over time, eventually to zero. The next change is expected in mid 2020, when the reward will drop from 12.5 BTC to 6.25 BTC.
- Transaction fees, though currently about 4% of a miner's revenue, will eventually form the entirety of a miner's revenue.
- Miners contract at different electricity rates, among other factors, and therefore experience different hourly cost outcomes that are reasonably stable in the short term.

V. Discussion

Projecting hashrate trends of the past year into the future paints a grim picture for many bitcoin mining operations. Mining profitability is caught between an exponentially increasing hashrate and a bear market in BTC/USD. Under this economic pressure it is difficult to explain continued increases in global hashrate, whether it be long planning cycles for capital spending, unique advantages enjoyed by specific mining operations, or some other factor. Current trends make it extremely difficult for the typical mining operation to invest in new mining equipment and expect positive returns.

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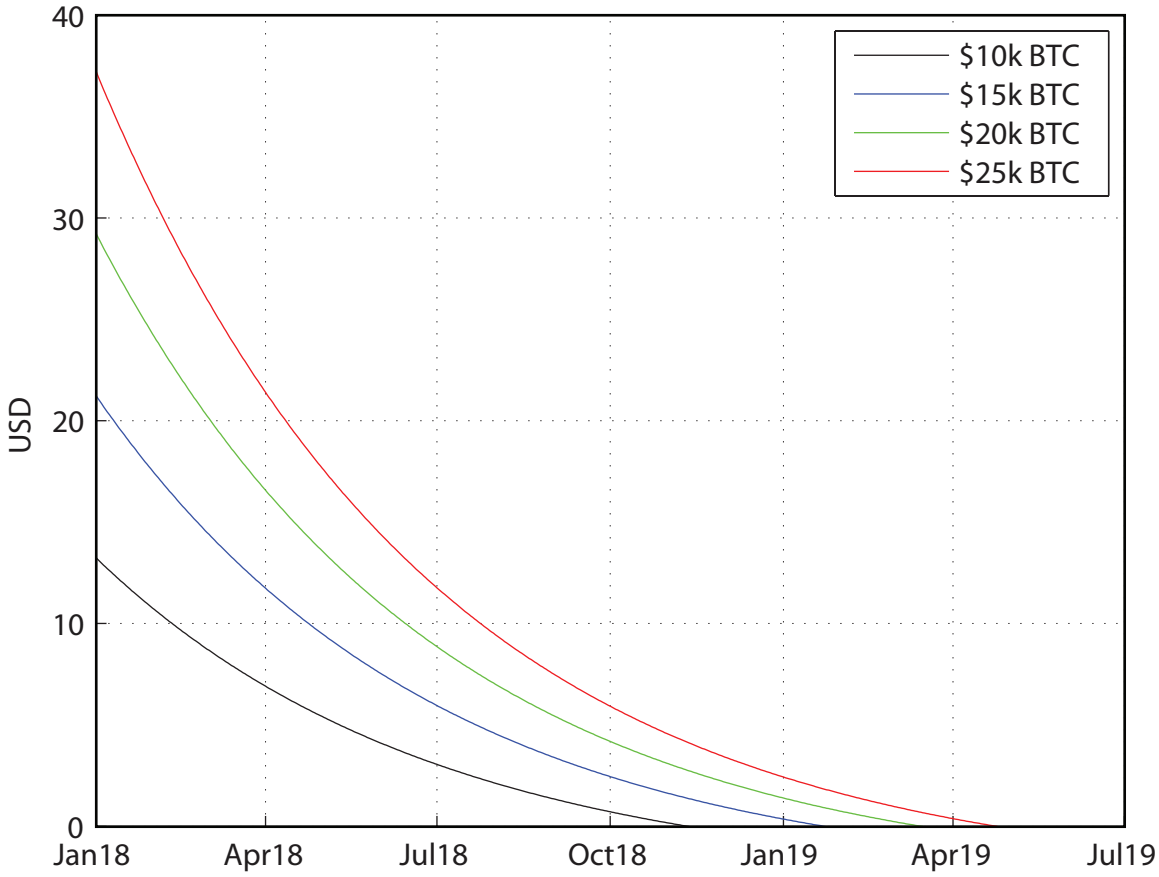

Fig. 2. Daily gross profit (USD) over time for a state of the art bitcoin miner.

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