nature climate change

MATTERS ARISING

https://doi.org/10.1038/s41558-019-0533-6

Rational mining limits Bitcoin emissions

Nicolas Houy [1,2]

ARISING FROM Mora, C. et al. *Nature Climate Change* https://doi.org/10.1038/s41558-018-0321-8 (2018)

The Bitcoin network is criticized for its energy consumption[1]. Mora et al.[2] estimated that the 2017 carbon footprint of Bitcoin was 69 Mt of CO_2-equivalent ($MtCO_2e$). We criticize the inclusion of unprofitable mining rigs in their analysis—as a consequence, they highly overestimate emissions.

Energy consumption in the Bitcoin network results from the process of validating transactions. In the Bitcoin protocol, transactions are included in 'blocks'. For Bitcoin users to reach a consensus on their order and content, blocks need to be published with a proof of work; that is, a cryptographic proof that enough power has been consumed to issue the current block. Miners (the agents issuing blocks) are rewarded for their work. In 2017, the total earning by the miners was approximately 800,000 bitcoin (~US$3.4 billion, calculated using the exchange rate at the time each block was mined). Given these stakes, and because miners are in competition for rewards, it is easy to understand why mining is performed by rational industries with big players optimizing the parameters that influence their earnings.

When evaluating the energy consumption of the Bitcoin network, the main source of uncertainty comes from the hardware used. Today, mining is performed by application-specific integrated circuit (ASIC) miners[3]. In their estimation, Mora et al.[2] model the hardware used by the Bitcoin miners as an average of a list of 62 ASIC miners. Considering the price of electricity and the value of Bitcoin for each block, we can see how this assumption is not realistic: a rational miner would have turned off 14 of these 62 ASIC miners more than 99% of the time, and only 12 of the 62 ASIC miners were profitable over the whole year (see the Supplementary Information). On average, the ASIC miners mentioned in Mora et al.[2] were profitable only about 42.5% of the time. Without applying any profitability constraint, we compute that miners would have lost at least US$3 billion in 2017 (US$3.4 billion in revenue minus US$6.4 billion spent on electricity, not accounting for hardware fixed costs). When we remove the unprofitable (and thus also the most inefficient and polluting) hardware for each block, miners are found to be profitable (US$1.4 billion spent on electricity for a profit of US$2 billion profit, not accounting for fixed costs). The resulting estimation for the 2017 carbon footprint of Bitcoin is then 15.5 $MtCO_2e$. Considering the emissions from the least and most polluting hardware among the profitable options for each block, we obtain values of 2.9 and 35.1 $MtCO_2e$, respectively. From these values, we estimate that the 2017 carbon emission level given in Mora et al.[2] is overestimated by a factor of 4.5 (confidence interval: 2.0–23.9).

Data availability

The data that support the findings of this manuscript are available in ref. [2] or provided in the Supplementary Code and Data.

Code availability

The code to identify rig profitability and recalculate the 2017 carbon emissions is provided in the Supplementary Code and Data.

Received: 2 November 2018; Accepted: 19 June 2019;
Published online: 28 August 2019

References

1. Krause, M. J. & Tolaymat, T. Quantification of energy and carbon costs for mining cryptocurrencies. *Nat. Sustain.* **1**, 711–718 (2018).
2. Mora, C. et al. Bitcoin emissions alone could push global warming above 2 °C. *Nat. Clim. Change* **8**, 931–933(2018).
3. Taylor, M. B. The evolution of bitcoin hardware. *Computer* **50**, 58–66 (2017).

Competing interests

The author declares no competing interests.

Additional information

Supplementary information is available for this paper at https://doi.org/10.1038/s41558-019-0533-6.

Reprints and permissions information is available at www.nature.com/reprints.

Correspondence and requests for materials should be addressed to N.H.

Publisher's note: Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

[1]University of Lyon, Lyon, France. [2]CNRS, GATE Lyon Saint-Etienne, Saint-Etienne, France. e-mail: houy@gate.cnrs.fr