Madelyn Novelli
CS 3001, Fall 2023
Term Paper

Ethical Implications of Cryptocurrency

Introduction

Watch out, gold, there's a new "hot" currency on the market. The recent years of technological development have brought us something unimaginable yet entirely intangible: cryptocurrencies. Cryptocurrencies involve the direct peer-to-peer transfer of electronic cash without the need for any financial institution as a central authority (Badea 2021). In a decentralized public ledger system known as a blockchain, any person with an Internet connection can conduct transactions, upon which every other computer on the blockchain will update their ledgers as a way of recording all relevant data of participants. As Moritz Wendl writes in his systematic review of cryptocurrencies, "Whereas the idea of a digital currency has not been new, the novel underlying blockchain technology…has been revolutionary" (Wendl 2023).

In 2008, a group of authors under the pseudonym Sastoshi Nakamoto proposed the first decentralized distributed currency known as Bitcoin (Stoll 2019). Since then, hundreds of other forms of digital currency have come into existence. Due to its completely virtual nature, the underlying blockchain technology behind crypto "provides a high level of consistency, security, and reliability," with some countries such as El Salvador adopting Bitcoin as an official currency (Wendl 2023). However, it is safe to say that "the decentralized governance of crypto assets has meant that trust is lacking," as stated by the IESE Business School of the University of Navarra. But this isn't the only foreseeable problem with the rise of cryptocurrencies.

Although cryptocurrency can only be accessed online, the blockchain technology requires excessive energy consumption which, for many years, has harmed the physical environment in inconceivable ways. In this paper I will specifically discuss ethical concerns surrounding the harmful effects cryptocurrency has left on the environment all around the globe. I will then offer recommendations and solutions to alleviate some of the damages that have already been done, and prevent more in the future before it is too late.

Energy Consumption in Crypto Mining

Much like its golden predecessor, blockchain cryptocurrencies are intangibly obtained in a process known as "mining" which, unique to the latter, require using one of the many consensus mechanisms discovered, the most notable being Proof-of-Work (PoW). PoW has been used by innumerable different blockchains, including the two most dominant, Bitcoin and Ethereum, which together represent more than 60% of the total cryptoasset market capitalization (OSTP 2022). Wendl writes that the algorithm works by relying "on a decentralized computer network that validates transactions through a search puzzle of hash functions" and rewarding the miner with "a reward that is distributed in the form of the specific cryptocurrency mined." As more miners use brute-force computing power in an attempt to be the first to solve the complex task, the PoW mechanism is designed to increase in difficulty and thus require even *more* computing power in order to maintain approximately ten minutes between each validation of ownership and transactions (*Crypto-assets are a threat* 2021). This ten minute gap serves to secure the functionality of PoW blockchain networks, as well as to take into account the limited amount of cryptocurrency to be obtained. For instance, there are a total of twenty-one million

Bitcoins available, with researchers estimating the final mining to take place in the year 2140 (Wendl 2023).

According to Wendl, while this process of mining is occurring, new transactions are simultaneously keeping record of all past transactions in the aforementioned public ledger system, leading to "a further increase in energy consumption at a given energy efficiency of mining equipment. Thus, the process of PoW generates financial value, but is requiring considerable amounts of energy with increasing competition" (Wendl 2023).

Environmental Impact of Bitcoin

Being the world's leading cryptocurrency and comprising "more than 50% of the total market capitalization of all cryptocurrencies," Bitcoin "exemplifies the largest and most successful implementation of blockchain technology." Consequently, "the decentralization of Bitcoin mining complicates the assessment and accountability of the network's actual carbon footprint" (Baur 2022).

Seeing as most Bitcoin mining companies, if not all, do not transparently report their carbon emissions, countless academic studies have produced wildly varying estimates of the blockchain network's carbon footprint. These numbers can span from 1.2 all the way up to 130.5 megatonnes (Mt) of carbon dioxide (CO_2) emissions a year (Coney 2022).

However, although these estimates may vary greatly, recent studies show that they have steadily trended upwards each year. From January 1, 2016 to June 30, 2018, it is estimated that the PoW blockchain networks of Bitcoin, Ethereum, Monroe, and Litecoin were responsible for up to 15 $MtCO_2$, of emissions, and annually consumed up to 30 terawatt-hours (TWh) of power (Krause 2018). Two years later in 2020, Alex de Vries, the data scientist responsible for creating the Bitcoin Energy Consumption Index, estimated Bitcoin's carbon emissions alone to be 90.2 $MtCO_2$ (Livni 2021). The next year, a different group of researchers found an estimated average of 108.92 $MtCO_2$. Even further, another study forecasted Bitcoin's annual emissions to be 130.5 $MtCO_2$ in the year 2024, assuming there are no policy interventions (Wendl 2023).

Despite these disparities, Baur writes that most studies can agree that the "Bitcoin network consumes more energy than most countries," which was initially proven in the year 2018 when the electricity consumed by Bitcoin equaled that of countries like Ireland, Austria, and Hong Kong (Baur 2022). And in the year leading up to July 2022, Bitcoin alone consumed the same amount of electricity as the states of Maine, New Hampshire, Vermont, and Rhode Island combined (*The environmental impacts of cryptomining* 2022).

So where is all this energy coming from? Cryptocurrency miners procure their electricity in four different ways. One way is the outright purchase of power plants that supply mining rigs "behind-the-meter." For instance, fossil-fueled power plants like the Scrubgrass and Panther Creek waste coal plants in Pennsylvania, and the Greenidge and North Tonawanda gas plants in New York, were purchased and converted into PoW mining facilities. Another method is through Power Purchase Agreements (PPAs), in which power plants or utilities sell a specific amount of electricity to miners. One specific arrangement between Marathon Digital and the Hardin coal plant in Montana, which had been nearing almost complete retirement, saw a 800% increase in CO_2 emissions in just one year. The next method is electricity purchases from a local utility, in which miners seek low-cost and rapidly-available electricity. This can end rather poorly, however, as "in 2018, a mining operation in Washington State left more than $700,000 in utility bills unpaid after it declared bankruptcy" (DeRoche 2022). Finally, miners can burn gas at oil and gas wells. No matter the method of procuring electricity, it is undeniable that "each type of

mining produces excess emissions, and impacts electricity and energy consumers" (DeRoche 2022).

Electricity and energy consumption isn't the only factor researchers and climate change activists are worried about. With cryptocurrency mining comes an enormous amount of both solid and electronic waste, which is a term used to describe discarded electronic or electrical devices. ASICs are specialized machines used exclusively in PoW mining. Today, a well-kept machine is projected to have a lifespan of around 3 to 5 years, but can deteriorate in as little as a few months if kept in poor conditions. Once it reaches the end of its lifespan, it becomes unusable, and turns to waste. According to DeRoche, in just 2021 alone, "PoW mining generated more than 30,000 metric tons of waste," which is comparable to the e-waste produced by all of Netherlands (DeRoche 2022). This is a serious threat to the environment as it can result in the emission of toxic chemicals, heavy metals leaching into soils, and the pollution of soil, air, and water. De Vries writes that in 2019, "only 17.4% of the 53.6 million metric tons of e-waste generated globally was collected and recycled" (De Vries 2021).

Additionally, crypto-asset mining operations exacerbate the environment of communities and disrupt the daily lives of civilians. Because most mining occurs at all times of the day, seven days a week in small, enclosed spaces, communities are at risk of fire due to the tremendous amounts of heat being produced. Communities also suffer from a great deal of noise pollution. The website of Compass Mining explicitly states that "Bitcoin mining isn't a quiet activity…A typical ASIC's noise levels range between 50 DB and 75 DB, or a noise level similar to a food blender or a loud vacuum" (De Roche 2022). In small towns such as those in Elk County, Pennsylvania, the constant noise from nearby mining sites has severely impacted the daily life of residents, with one local farmer claiming that "it has led to death for some of [his] animals as well as health issues with [his] horses" (Stockman 2022).

Counterarguments for Crypto Mining

There is a reason for cryptocurrency's sudden burst of popularity—there are innumerable economic benefits that draw consumers in. By removing a third party such as a bank or credit card company from the process, transferring funds directly between two parties has become easier and faster than ever (Frankenfield 2023). But the most captivating advantage of all is the potential for personal gain. Over the past decade, the cryptocurrency market has skyrocketed, making investments valuable and extremely profitable. CNBC claims that if a person had purchased $100 worth of Bitcoin in 2010, back when a bitcoin was worth $0.10, in 2021 those 1,000 bitcoins would be worth over $48 million (Reinicke 2021).

With these exhilarating economic benefits, cryptocurrency companies and miners also like to claim there are some environmental benefits as well. However, that is not often the case.

One popular claim is that when a mining facility is physically located near an already existing site of wind or solar power, the mining becomes sustainable. Another myth is that the PoW only uses overproduced energy that is going to waste anyway. These are both incorrect claims—"mining operations operate and draw on the grid at all hours, not just when there is excess solar or wind" (DeRoche 2022). These facilities use whatever existing energy is available in the region or in their utility. In fact, the grid may end up requiring the use of fossil generators after all, in order to keep up with the large amounts of electricity needed for the mining operation. Lo and behold, facilities that are located near sustainable energy sources may actually be driving increased emissions from gas and coal plants instead of the counterargument.

Ethical Implications and Solutions

Utilitarianism is a theory of morality that advocates for actions that foster happiness, while opposing actions that knowingly cause unhappiness. Quite simply, it is about promoting "the greatest amount of good for the greatest number of people" (Tardi 2023). Meanwhile, another ethical theory, anthropocentrism, argues for human well-being and prosperity.

With these theories in mind, it becomes of the utmost importance to acknowledge each individual's obligation to protect and respect all other people, and this ultimately includes respecting the very planet that we live on.

As the United Nations Human Rights Council explicitly writes, "Climate change impacts, directly and indirectly, an array of internationally guaranteed human rights" (Human Rights and Climate Change 2022). Assuming that the commonly believed number of 4,434 metric tons of CO_2, could unnecessarily kill a person, the emissions created by Bitcoin in 2021 attributed to the deaths of 19,000 people in the future. In addition, Ethereum, the second biggest blockchain network, is estimated to have caused 7,585 future deaths (Wendl 2023).

States have an obligation to prevent human rights harms caused by climate change, including long-term harms like these that have yet to be seen. Therefore, there are some solutions and recommendations that can be made.

Despite cryptocurrency being decentralized, state, local, and federal policymakers and regulators still have some authority in the name of protecting energy systems, communities, and ratepayers. There are challenges to regulating a decentralized technology through a centralized institution, but taking a vertical regulatory approach, focusing on the blockchain market rather than directly regulating cryptocurrencies, is one such way to combat this (Dewey 2019). Earth Justice discusses certain methods of taking stand, such as local and state officials enforcing pollution and noise ordinances, utility regulators declining harmful PPAs, and even simply banning the practicing of mining PoW cryptocurrencies in general (*The environmental impacts of cryptomining* 2022). In Sweden, the Director General of the Swedish Financial Supervisory Authority and the Director General of the Swedish Environmental Protection Agency have collaborated and discussed the possibility of introducing a tax on the production of Bitcoin.

Even those in the cryptocurrency community have felt the push to move to greener energy. Most can agree that for a cryptocurrency to truly be sustainable, a transition must be made away from PoW mining techniques. Therefore, many activists are recommending and encouraging the incentivization of transition towards green alternatives like Point-of-Stake (PoS). The PoS algorithm was first introduced in 2012 to combat the high energy consumption of PoW. In this new method, Wendl writes that "the probability to receive a reward for validating transactions is not linked to computing power provided, but to own capital staked within the system, which is also scarce and visible within the network and thus verifiable" (Wendl 2023). Essentially, the process removes the total dependency on competition, as seen in PoW, which in turn lowers the total computing power needed. The White House has been an adamant supporter of the process, writing that in 2021, the PoS algorithm "was estimated to consume up to 0.28 billion kilowatt-hours per year in 2021, less than 0.001% of global electricity usage" (OSTP 2022). As for carbon dioxide, PoS's emissions are estimated to be a thousand-fold lower than those of PoW (Frost 2021). Even further, cryptocurrencies can still be quite successful with this new algorithm. In fact, on September 15, 2022, Ethereum transitioned from PoW to PoS in a largely celebrated event known as The Merge (De Vries 2023).

While Ethereum has made the switch to a cleaner algorithm, other cryptocurrencies have found different ways to give back to the environment. For instance, SolarCoin rewards miners with the currency in return for proof that they have generated solar energy. Chimpzee is a

cryptocurrency project devoted to the protection of endangered species, and has already helped plant 20,000 trees to restore a rainforest. eTukTuk is an AI-powered blockchain with the intention of reducing noise and air pollution by building sustainable transportation in countries such as Sri Lanka. Finally, Crusoe Energy is a company that captures the flare gas from oil patches and uses the energy to mine for Bitcoin. According to Business Insider, "Its systems slash CO_2-equivalent emissions from gas flaring by up to 63%" (Robertson 2021).

Concluding Thoughts

By now it is clear that the mining of cryptocurrency can have horrifying consequences on the environment. This has been cause for worry for innumerable countries trying to fulfill their part of the Paris Agreement, which asks members to all agree to keep global warming below two degrees Celsius. Activists and governments alike are aware that "net-zero carbon emissions during the second half of the century are crucial" (Stoll 2019), meaning that it is of the utmost importance to "take action to limit this growing industry now" (*The environmental impacts of cryptomining* 2022).

There are many ways to harbor a healthy relationship with cryptocurrency. In the past, countries like China and Russia have imposed full and partial bans on the use of cryptocurrency, only to see an influx of new mining facilities emerging in other countries like Kazakhstan and the United States. This newfound inundation of energy usage led President Biden to sign an Executive Order on March 9, 2022 with the intention of supporting "responsible digital asset development, in line with our climate change objectives, and for the benefit of everyone in America" (OSTP 2022).

Ultimately, it is true that as the years go on, cryptocurrencies have proven themselves to have many potential advantages that can occasionally outweigh their downsides. European countries like Germany, Bulgaria, and Denmark have benefited from tax certain transactions using digital currencies like Bitcoin. Malta, nicknamed the Blockchain Island, is a country actively embracing blockchain technology through comprehensive legislation. In July 2018, the Maltese Parliament enacted three key acts forming the Digital Innovation Framework: the Malta Digitial Innovation Authority Act (MDIA), the Innovative Technology Arrangements and Services Act (ITAS), and the Virtual Financial Assets Act (VFAA), all of which create a regulatory framework for blockchain technology.

One of the most important recommendations, however, is educating the public on the environmental impacts of these mining algorithms (*The ethical concerns of cryptocurrencies* 2022). On September 21, 2022, just a week after The Merge, the World Economic Forum launched the Crypto Sustainability Coalition with the intention of investigating and highlighting "the potential of web3 technologies, such as crypto and blockchain, in accelerating action on climate change" (*New crypto sustainability coalition* 2022). The coalition is part of the greater Crypto Impact and Sustainability Accelerator (CISA), a grant-funded initiative with a mission to spread awareness and educate the public on the environmental, social and governance (ESG) impacts of blockchain technologies. With this initiative being launched, numerous pieces of work have been published, including articles, research reports, and whitepapers.

Ultimately, it is true that there is a finite number of cryptocurrencies in existence, and thus there will be one day be an end to all the mining. However, it is importance to recognize that by the time humans make it to that day, there may not be much of a planet to live on anymore. Taking precautions now will ensure that humans will not need to worry about surviving on an inhospitable planet, nevermind worrying about how their favorite cryptostock is behaving.

Bibliography

Badea, L., & Mungiu-Pupăzan, M. C. (2021). The economic and environmental impact of bitcoin. *IEEE Access*, *9*, 48091–48104. https://doi.org/10.1109/ACCESS.2021.3068636

Baur, D. G., & Oll, J. (2022). Bitcoin investments and climate change: A financial and carbon intensity perspective. *Finance Research Letters*, *47*, 102575. https://doi.org/10.1016/j.frl.2021.102575

Coney, P. (2022, September 27). *A deep dive into Bitcoin's environmental impact—News & insight*. Cambridge Judge Business School. https://www.jbs.cam.ac.uk/2022/a-deep-dive-into-bitcoins-environmental-impact/

Crypto-assets are a threat to the climate transition – energy-intensive mining should be banned. (2021, November 5). Retrieved October 27, 2023, from https://www.fi.se/en/published/presentations/2021/crypto-assets-are-a-threat-to-the-climate-transition--energy-intensive-mining-should-be-banned/fi.se/en/published/presentations/2021/crypto-assets-are-a-threat-to-the-climate-transition--energy-intensive-mining-should-be-banned/

DeRoche, M., Fisher, J., Thorpe, N., and Wachspress, M. (2022). The Energy Bomb: How Proof-of-Work Cryptocurrency Mining Worsens the Climate Crisis and Harms Communities Now. https://earthjustice.org/wp-content/uploads/energy_bomb_bitcoin_white_paper_101322.pdf

Dewey, J. (2019). Blockchain & Cryptocurrency Regulation. *Global Legal Insights.* https://www.acc.com/sites/default/files/resources/vl/membersonly/Article/1489775_1.pdf

De Vries, A. (2023). Cryptocurrencies on the road to sustainability: Ethereum paving the way for Bitcoin. *Patterns*, *4*(1), 100633. https://doi.org/10.1016/j.patter.2022.100633

De Vries, A., & Stoll, C. (2021). Bitcoin's growing e-waste problem. *Resources, Conservation and Recycling*, *175*, 105901. https://doi.org/10.1016/j.resconrec.2021.105901

Frankenfield, J. (2023, November 2). Cryptocurrency explained with pros and cons for investment. Investopedia. https://www.investopedia.com/terms/c/cryptocurrency.asp

Frost, D. L. (2021, May 19). *Researcher suggests ethereum 2. 0 will use 99. 95% less energy*. Decrypt. https://decrypt.co/71353/ethereum-foundation-eth-2-0-will-use-99-95-less-energy

Human Rights and Climate Change. (2022). United Nations Human Rights Office of the High Commissioner. https://www.ohchr.org/sites/default/files/Documents/Issues/ClimateChange/materials/KMClimateChange.pdf

Krause, M. J., & Tolaymat, T. (2018). Quantification of energy and carbon costs for mining cryptocurrencies. *Nature Sustainability*, *1*(11), 711–718. https://doi.org/10.1038/s41893-018-0152-7

Livni, E. (2021, October 10). Can crypto go green? *The New York Times*. https://www.nytimes.com/2021/10/10/business/dealbook/crypto-climate.html

New crypto sustainability coalition to investigate potential of web3 technologies in fighting climate change. (2022, September 21). World Economic Forum. Retrieved November 10, 2023, from https://www.weforum.org/press/2022/09/new-crypto-sustainability-coalition-to-investigate-potential-of-web3-technologies-in-fighting-climate-change/

OSTP (2022, September 8). Climate and Energy Implications of Crypto-Assets in the United

States. White House Office of Science and Technology Policy. Washington, D.C.
Reinicke, C. (2021, February 12). *Bitcoin hits another record. Here's how much you'd have if you invested $100 in 2009.* CNBC. https://www.cnbc.com/2021/02/12/how-much-youd-have-today-if-you-invested-100-in-bitcoin-in-2009.html
Robertson, H. (2021, June 20). *Meet the company mining bitcoin using the flare gas from oil drilling—And drawing investment from Coinbase and the Winklevii*. Markets Insider. https://markets.businessinsider.com/currencies/news/bitcoin-mining-flare-gas-btc-energy-crusoe-energy-coinbase-winklevoss-2021-6-1030537177
Stockman, B. D. (2022, June 22). Bitcoin mine brings heated residents to Ridgway Township meeting. The Ridgway Record. https://www.ridgwayrecord.com/news/bitcoin-mine-brings-heated-residents-to-ridgway-township-meeting/article_00184b60-f27e-11ec-8220-134307a1c971.html
Stoll, C., Klaaßen, L., Gallersdörfer, U. (2019). "The Carbon Footprint of Bitcoin." *Joule, 3*(7), 1647–1661. https://doi.org/10.1016/j.joule.2019.05.012
Tardi, C. (2023, April 27). *Utilitarianism: What it is, founders, and main principles*. Investopedia. https://www.investopedia.com/terms/u/utilitarianism.asp
The environmental impacts of cryptomining. (2022, September 23). Earthjustice. Retrieved November 10, 2023, from https://earthjustice.org/feature/cryptocurrency-mining-environmental-impacts
The ethical concerns of cryptocurrencies. (2022, November 16.). IESE Insight. Retrieved November 10, 2023, from https://www.iese.edu/insight/articles/cryptocurrencies-blockchain-crypto-assets-ethics/
Wendl, M., Doan, M. H., & Sassen, R. (2023). The environmental impact of cryptocurrencies using proof of work and proof of stake consensus algorithms: A systematic review. *Journal of Environmental Management*, *326*, 116530. https://doi.org/10.1016/j.jenvman.2022.116530