NORTH CAROLINA JOURNAL OF LAW & TECHNOLOGY

Volume 20
Issue 5 *Online Issue*

Article 9

5-1-2019

Cryptocurrency Mining: The Challenges It Faces and How Regulations Can Help

Killian Steer

NORTH CAROLINA JOURNAL OF LAW & TECHNOLOGY
VOLUME 20, ISSUE ON.2: MAY 2019

CRYPTOCURRENCY MINING: THE CHALLENGES IT FACES AND HOW NEW REGULATIONS CAN HELP

Killian Steer [*]

The prevalence and importance of cryptocurrency has significantly increased since the introduction of Bitcoin just over ten years ago. Today, there are over 1,000 different cryptocurrencies, and recently the combined market capitalization of these cryptocurrencies peaked at over 750 billion dollars. A critical component of any cryptocurrency is the transaction verification through mining. However, cryptocurrency mining is facing significant challenges that must be solved in order for cryptocurrencies to continue their growth. Therefore, this recent development proposes regulations to address four specific challenges faced by cryptocurrency mining: energy consumption, miner consolidation, encryption security, and miner income volatility.

I. INTRODUCTION..302
II. BACKGROUND AND TECHNOLOGICAL ASPECTS OF CRYPTOCURRENCY AND CRYPTOCURRENCY MINING......303
A. *Technological Aspects of Cryptocurrency and Cryptocurrency Mining..303*
1. *Cryptocurrencies and Blockchain 306*
2. *Cryptocurrency Mining...308*
3. *The Importance of Blocks 310*
B. *History and Background on Cryptocurrency................311*
III. CHALLENGES FACING CRYPTOCURRENCY MINING...........314
A. *Cryptocurrency Energy...314*
B. *Miner Consolidation and its Effect on Local Communities 317*

---

[*] J.D. Candidate, University of North Carolina School of Law, 2020. The author would like to thank all of the editors and staff of NC JOLT for their feedback, insights, and support throughout the editorial process.

C. *Security of Cryptocurrency Mining* *321*
D. *Miner Income Volatility*..*323*
IV. SUGGESTED REGULATION TO COMBAT THE CHALLENGES FACED BY CRYPTOCURRENCY MINING............................324
A. *Regulation to Address Energy Consumption and Greenhouse Gas Emissions* *324*
B. *Regulation to Address Miner Consolidation and its Effect on Local Communities*.......................................*327*
C. *Regulation of Electronic Security*................................*328*
D. *Regulation on Miner Income Volatility* *329*
V. CONCLUSION..330

I. INTRODUCTION

One of the most important components of a particular cryptocurrency is the process, called "mining," that verifies transactions involving the currency. At this time, cryptocurrency mining faces serious challenges that may threaten the very existence of many cryptocurrencies.[1] Despite these significant challenges, there has been little discussion exploring the challenges and even less discussion about possible solutions. Therefore, this Recent Development fills this commentary void by presenting four of the most significant mining challenges and by proposing new targeted regulations that can help overcome the four challenges.

This Recent Development proceeds in four parts. The four challenges facing cryptocurrency mining stem from a combination

[1] *See Beginners Guide: What is Bitcoin?*, COIN CENTRAL, https://coincentral.com/beginners-guide-what-is-bitcoin/ (last visited Jan. 21, 2019); *Global Charts: Total Market Capitalization*, COINMARKETCAP, https://coinmarketcap.com/charts/ (last visited Jan. 21, 2019); Raz Rafaeli, *How Quantum Computing Could Wreak Havoc on Cryptocurrency*, THE NEXT WEB (Apr. 14, 2018), https://thenextweb.com/contributors/2018/04/14/quantum-computing-wreak-havoc-cryptocurrency/; Paul Roberts, *This is What Happens When Bitcoin Miners Take Over Your Town*, POLITICO MAG. (Mar./Apr. 2018), https://www.politico.com/magazine/story/2018/03/09/bitcoin-mining-energy-prices-smalltown-feature-217230; Killian Steer, *Bitcoin Mining's Staggering Energy Consumption and the Search for Cheap Electricity,* N. C. J. L. & TECH. BLOG (Nov. 12, 2018), http://ncjolt.org/bitcoin-minings-staggering-energy-consumption-and-the-search-for-cheap-electricity/.

of the technological and historical aspects of cryptocurrency and cryptocurrency mining. Therefore, it is first necessary for a discussion of the technological foundation. This foundation is then used to explore the four most significant cryptocurrency mining challenges, which are energy consumption and its effect on the global climate, miner consolidation and its effect on local communities, electronic security, and miner income volatility. Third, new targeted regulations are proposed from all levels of government that address each of the four challenges. Finally, there is a discussion that acknowledges the seriousness of the challenges facing cryptocurrency mining, but remains optimistic that the future of cryptocurrency mining is bright if the proposed regulations or other similar measures are implemented.

II. BACKGROUND AND TECHNOLOGICAL ASPECTS OF CRYPTOCURRENCY AND CRYPTOCURRENCY MINING

Starting in the 1990s, there was a desire for a method to perform secure electronic peer-to-peer transactions without the need of a central authority, such as a bank, to moderate the transaction. To satisfy this desire a new system would be needed that was secure, electronic, and decentralized. A few solutions to this problem were proposed over the following years, but a complete solution to the problem was not found until the introduction of the first cryptocurrency, Bitcoin, in 2008. Bitcoin utilized two new intertwined technologies, blockchain and mining, to finally create a system with all three of the desired characteristics. These two technologies, as well as the history of cryptocurrency and cryptocurrency mining will be further explored in the following sections.

A. *Technological Aspects of Cryptocurrency and Cryptocurrency Mining*

Prior to the advent of cryptocurrencies, payments over electronic mediums had to be based upon the trust model. Under the trust model, all electronic transactions between two peers pass through financial institutions or other trusted central authorities, who provide necessary and beneficial services such as transaction processing, transaction security, and mediation of disputes between transaction parties.[2] However, passing transactions through a central authority also has several drawbacks such as increased transaction costs, minimum practical transaction sizes, and inability to make non-reversible transactions for non-reversible services.[3] Cryptocurrencies create an entirely new system that manages to maintain the benefits of the trust system without any of its negative effects. This is done by using blockchain and mining to replace trust[4] with cryptographic proof.[5]

[2] *See* SATOSHI NAKAMOTO, BITCOIN: A PEER-TO-PEER ELECTRONIC CASH SYSTEM, https://bitcoin.org/bitcoin.pdf; *Beginners Guide: What is Bitcoin?*, *supra* note 1; Steer, *supra* note 1.

[3] *See Beginners Guide: What is Bitcoin?*, *supra* note 1; NAKAMOTO, *supra* note 2; Steer, *supra* note 1. These negative consequences can be avoided by using physical currency in person, but this is not possible over an electronic medium. NAKAMOTO, *supra* note 2.

[4] NAKAMOTO, *supra* note 2. Reaching a solution without trust is one of the great innovations of blockchain and mining because it provides a solution to the "Byzantine Generals' Problem." In this problem, several generals are preparing to attack an enemy city, and they wish to coordinate their attack for maximum effectiveness. However, the generals can only communicate by messenger and cannot be sure if one or more of their lines of communication is compromised. The solution is to entirely remove trust from the problem. *See generally* SHAWN S. AMUIAL, JOSIAS N. DEWEY & JEFFREY R. SEUL, THE BLOCKCHAIN: A GUIDE FOR LEGAL AND BUSINESS PROFESSIONALS § 1:6 (2016); Leslie Lamport, Robert Shostak & Marshall Pease, *The Byzantine Generals Problem*, 4 ACM TRANSACTIONS ON PROGRAMMING LANGUAGES & SYS. 382 (1982).

[5] NAKAMOTO, *supra* note 2. In this context, "cryptographic proof" is referring to "zero-knowledge proof," which is used to verify Bitcoin transactions. Zero-knowledge proof "is a method by which one party (the prover) can prove to another party (the verifier) that they know a value x, without conveying any information apart from the fact that they know the value x." Dmitry Lavrenov, *A Zero-Knowledge Proof: Improving Privacy on a Blockchain*, ALTOROS (Jan. 25, 2019), https://www.altoros.com/blog/zero-knowledge-proof-improving-privacy-for-a-blockchain/.

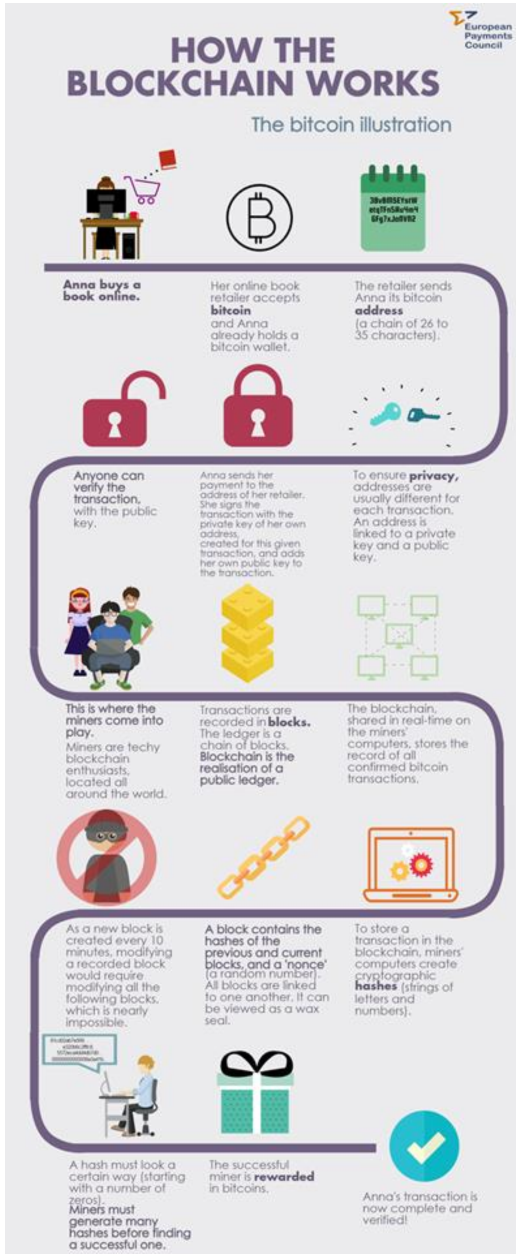

Figure One: An Example Bitcoin Transaction[6]

[6] *How the Blockchain Works: The Bitcoin Illustration*, EUR. PAYMENTS COUNCIL (Oct. 2016),

1. *Cryptocurrencies and Blockchain*

Blockchain technology is the backbone of any cryptocurrency system, because it performs many of the roles done by a central authority in traditional electronic payments. A blockchain is essentially "a decentralized peer-to-peer network that maintains a public, or private, ledger of transactions."[7] A ledger is a simple database that keeps track of transactions between the transferor and the transferee.[8] A blockchain is considered decentralized because instead of a central authority holding and maintaining the ledger, the blockchain ledger is stored on thousands of computers (called nodes) running a common software protocol that are connected to each other via the internet.[9] In blockchain, rather than a central authority determining whether transactions are correct and can be added to the ledger (as in the traditional trust model), the network nodes perform this job.[10] Working together under the common protocol, the nodes are able reach a consensus about whether a set of transactions are correct, and then they are able to combine a group of transactions into a block and add the block blockchain ledger.[11]

Before proceeding to precisely how nodes achieve consensus, it is necessary to understand the encryption technology required to facilitate transactions on a cryptocurrency blockchain. Most cryptocurrencies, such as Bitcoin, utilize a public key infrastructure ("PKI").[12] A PKI is a set of hardware, software, and policies that form what is considered the most secure encryption currently in existence: public key encryption ("PKE").[13] Under PKI, a

---

https://www.europeanpaymentscouncil.eu/sites/default/files/infographic/2017-05/EPC_Infographic_Blockchain_2016.pdf.

[7] AMUIAL ET AL., *supra* note 4, § 1:2. For example, the Federal Reserve Bank maintains a centralized ledger with all its member banks documenting their credits and debits. *Id.*

[8] *Id.*

[9] *Id.*

[10] *Id.*

[11] *Id.* The protocol refers to the rules used by the particular open source cryptocurrency software, such as Bitcoin, that is being used. *Id.*

[12] *Id.* § 1:3.

[13] *Id.*; Margaret Rouse, *PKI (Public Key Infrastructure)*, TECHTARGET, https://searchsecurity.techtarget.com/definition/PKI_(last updated Dec. 2018); *What is Public Key Infrastructure (PKI)?*, THALES,

mathematical equation produces a pair of alphanumerical "keys."[14] The first key is public, which can be shared with anyone and is often used for identification, and the second key is private.[15] In Bitcoin, the public address of a Bitcoin is identified by its public key and searchable by anyone, but it can only be decrypted (and thus used) with its associated private key.[16] Therefore, using PKI creates a system in which a person can transfer a coin they currently own to any other location (because every location can be identified by its unique public key), while simultaneously ensuring that the transfer can only be initiated by the person who currently owns the coin (because that person is the only one who knows the private key).[17]

The process used by nodes to reach consensus in a particular blockchain varies slightly based upon that blockchain's specific software protocol, but for the purposes of this cryptocurrency discussion, the consensus process used by Bitcoin is instructive. In Bitcoin, consensus between nodes about the validity of a transaction is done through a four-step transaction process (for added clarity, this four-step process, as applied to a sample transaction, is displayed in Figure One).[18] First, a computer code is generated for the particular transaction that has an input and output. The input is the public address (public key) of the Bitcoin(s) being transferred, and the output is instructions to the network on how to update the blockchain to reflect the change brought about by the transaction (this is steps one through four in Figure One).[19] Second, the transaction must be "signed."[20] Signing the transaction conclusively proves that the individual(s) spending the Bitcoin(s) possess the private key associated with the given public key (this is step five in Figure One).[21] Importantly, PKI's mathematical tools allow signing

---

https://www.thalesesecurity.com/faq/public-key-infrastructure-pki/what-public-key-infrastructure-pki (last visited Mar. 1, 2019).

[14] AMUIAL ET AL., *supra* note 4, § 1:3.

[15] *Id*.

[16] *Id.*

[17] *Id.*

[18] *Id.* An example of an invalid transaction is if an individual attempted to double spend a coin. *Id.*

[19] *Id.*

[20] *Id.*

[21] *Id.*

to be done without revealing the actual private key.[22] Third, the transaction is broadcast over the internet so other nodes in the network can learn about the transaction and verify that the transaction is not defective in any manner (step six in Figure One).[23] Fourth, Bitcoin miners combine a set of transactions into a block and add them to the most recently created block in the blockchain thereby extending the blockchain and creating a "current, immutable history of all transactions ever logged on the blockchain" (steps seven through fourteen in Figure One).[24]

2. *Cryptocurrency Mining*

Mining is the last step in the four step transaction process in which the nodes add a new block of transactions to the existing chain.[25] For the majority of cryptocurrencies, including Bitcoin, this is done using an incentive structure built into the blockchain's software protocol called "proof-of-work."[26] Under proof-of-work, cryptocurrency miners are required to expend scarce resources, electricity, and computing power to verify a block of transactions in exchange for a few coins.[27] This incentive structure performs two important jobs for a cryptocurrency.[28] First, it provides a method for issuing new currency into the existing supply.[29] Second, the introduction of scarce resources makes it almost impossible for a malicious actor to amass enough mining nodes to crowd other miners, and thus, manipulate the network.[30] These two jobs help a

---

[22] *Id.*

[23] *Id.*

[24] *Id.* In any block chain, the "first block of transactions . . . is typically called the 'genesis block' since it represents the beginning of time for that blockchain." *Id.* § 1:2.

[25] *Id.* § 1:6.

[26] *Id.* §§ 1:3, 1:6.

[27] *Id.* § 1:3.

[28] *Id.* § 1:6.

[29] *Id.* § 1:3.

[30] *Id.* § 1:6. This type of malicious behavior is called a "51 percent attack." *Id.*; *Id.* § 4:2. In a "51 percent attack," an individual who has amassed 51 percent of the network can attack it by interfering with the process to create new blocks or prevent other user's transactions. Jake Frankenfield, *51% Attack*, INVESTOPEDIA, https://www.investopedia.com/terms/1/51-attack.asp (last updated Feb. 7, 2019).

cryptocurrency achieve the security and reliability of traditional currencies without the aid of a central authority.

The actual implementation of the proof-of-work incentive structure varies from system to system, but the implementation on Bitcoin is again instructive. In Bitcoin, each time a new block forms, a "nonce" (i.e., a mathematical problem) is created.[31] As the block is forming, miners go to work by first beginning to aggregate recent transactions that have not yet been added to a block.[32] Then, miners try to solve the nonce by repeatedly hashing the problem until the solution is found.[33] The first miner(s) to find the solution and thus successfully add the block to the chain is rewarded with a few coins.[34] Afterwards the process starts again and continues in perpetuity.

Computational power is important to miners because the more computation power being used, the faster the nonce can be solved, and the more likely they are to receive the reward for verifying a block of transactions.[35] At the advent of cryptocurrency mining, miners were using small power general-purpose computers, but this is no longer feasible due to two developments.[36] First, in order to gain an advantage over other miners, miners have not only significantly increased the number and power of their mining computers, but also they have started using specialized cryptocurrency mining circuits called Application Specific

---

[31] AMUIAL ET AL., *supra* note 4, § 1:6.

[32] *Id.*

[33] *Id.* Hashing is:

> the process of converting an input of any length into a fixed size string of text using a mathematical function. This means that any text, no matter how long it is, can converted into an array of numbers and letters through an algorithm. The message to be hashed is called input, the algorithm used to do so is called the hash function, and the output is called hash value.

Lisk, *What is Hashing? Hash Functions Explained Simply*, YOUTUBE (Aug. 8, 2018), https://www.youtube.com/watch?v=2BldESGZKB8. Many different types of functions can be used to hash a message, but for cryptographic purposes there are a few necessary characteristics. These are: a unique output for each input, high hashing speed, and security. *Id.*

[34] AMUIAL ET AL., *supra* note 4, § 1:6.

[35] *Id.*

[36] *Id.*

Integrated Circuits ("ASICs").[37] These special purpose circuits are able to solve the nonce at speeds that dwarf general purpose computers.[38] Second, in many cryptocurrencies, such as Bitcoin, there is a predetermined amount of time or pace for each block to be mined.[39] In order to ensure this pace is kept no matter the increases in computing power, the level of difficulty of solving the nonce is periodically made more difficult.[40] As a result, it has become almost impossible for any individual miner to be the first to successfully complete a block.[41] Therefore, most miners now participate in "mining pools" in which the resources of many miners are combined, and miners are then rewarded an amount based upon their contribution to the pool in terms of computing power.[42]

3. *The Importance of Blocks*

The last technical concept necessary to understanding cryptocurrency and cryptocurrency mining is the importance of "blocks of transactions" to the overall security of the system.[43] Each time miners create a new block, it is immediately assigned a specific mathematical algorithm called a "hash."[44] After the hash has been added to the block, if any of the information is changed within that block, the hash will change.[45] This will immediately alert the network that the block has been tampered.[46] After the block has been finished, the unique hash is then also carried forward to the next

---

[37] *Id.*

[38] *Id.*

[39] *Id.* In Bitcoin, this time is ten minutes. *Id.*

[40] *Id.*

[41] *Id.*

[42] *Id.* Generally, these mining pools are run by private companies/individuals that have come together to form a common mining protocol. Admir Tulic, *How Do Mining Pools Work and How to Choose a Pool to Join*, CAPTAIN ALTCOIN (Mar. 27, 2019), https://captainaltcoin.com/what-is-pool-mining/. Currently, the world's largest mining pool is AntPool. Shobhit Seth, *Top 5 Bitcoin Mining Pools*, INVESTOPEDIA, https://www.investopedia.com/news/top-bitcoin-mining-pools/ (last updated Feb. 23, 2018).

[43] AMUIAL ET AL., *supra* note 4, § 1:2.

[44] *Id.*

[45] *Id.* § 1:6.

[46] *Id.* § 1:2.

block added to the chain.[47] So in each block, two hashes are found—its own unique identifying hash as well as the unique hash that identifies the block before it.[48] This "process continues over and over again so that every block is back-linked to the blocks before it," thereby establishing a chain.[49] Therefore, for someone to successfully alter a block and compromise a blockchain, they would also have to alter every block after the altered entry.[50] This would require a computing power that is not currently in existence.[51]

B. *History and Background on Cryptocurrency*

In the last two decades, cryptocurrencies have gone from conception, to establishment, to near omnipresence in the global economy. Many of the features of today's cryptocurrencies were first proposed in the 1990s.[52] One of the most important of these early proposals was the currency B-Money.[53] Although B-Money was never actually launched, it laid the framework for future cryptocurrencies by proposing many of the key features, such as computational work to facilitate transactions, community verification, and rewarding workers for their efforts, that are used in today's cryptocurrencies.[54] Further, cryptocurrency discussions and proposals continued into the early 2000s, but a complete cryptocurrency system remained elusive.[55] Then, in 2008, a white paper entitled "Bitcoin – A Peer to Peer Electronic Cash System" by an individual or individuals using the name Satoshi Nakamoto appeared on a new website called "Bitcoin.org."[56] The white paper

[47] *Id.* § 1:4.
[48] *Id.*
[49] *Id.* § 1:5.
[50] *Id.* § 1:4.
[51] *Id.* §§ 1:2, 1:4.
[52] Bernard Marr, *A Short History of Bitcoin and Crypto Currency Everyone Should Read*, FORBES (Dec. 6, 2017), https://www.forbes.com/sites/bernardmarr/2017/12/06/a-short-history-of-bitcoin-and-crypto-currency-everyone-should-read/#2b0d11ba3f27.
[53] *Id.*; Jake Frankenfield, *B-money*, INVESTOPEDIA, https://www.investopedia.com/terms/b/bmoney.asp (last updated Jun. 22, 2018).
[54] Frankenfield, *supra* note 53.
[55] *Id.*
[56] *The World's First Decentralized Currency*, HIST. OF BITCOIN, http://historyofbitcoin.org (last visited Mar. 1, 2019); NAKAMOTO, *supra* note 2.

presented a complete cryptocurrency system, Bitcoin, to the world, and within a year, the world's first functioning cryptocurrency debuted.[57]

Since Bitcoin's debut in 2009, the number of different cryptocurrencies, their value, and their user base has greatly expanded. Some of the following facts help bring into perspective how significant this expansion has been. For example, there are now well over 1,000 different cryptocurrencies, and new ones are being created frequently;[58] combined, all cryptocurrencies have reached a peak market capitalization of over $750 billion.[59] In the first two months of 2019, Bitcoin alone has averaged over 300,000 transactions per day,[60] and there are over 7.1 million active bitcoin users.[61] These staggering statistics, all reached within the last ten years, suggest cryptocurrencies are likely here to stay for the foreseeable future.

For much of their existence, cryptocurrencies have been associated with nefarious transactions, such as drugs and other crimes, or outright fraud and deceit.[62] However, as cryptocurrencies

---

The true identity of the individual or individuals behind Satoshi Nakamoto remains unknown. *Beginners Guide: What is Bitcoin?*, *supra* note 1; Marr, *supra* note 52.

[57] Marr, *supra* note 52; NAKAMOTO, *supra* note 2. "A white paper is an authoritative report or guide . . . that informs readers concisely about a complex issue and presents the issuing body's philosophy on the matter. It is meant to help readers understand an issue, solve a problem, or make a decision." *White Paper Style Guide*, U. MASS. LOWELL, https://libguides.uml.edu/whitepaper_style (last updated Nov. 28, 2017).

[58] Matthew Frankel, *How Many Cryptocurrencies Are There?*, THE MOTLEY FOOL (Mar. 16, 2018), https://www.fool.com/investing/2018/03/16/how-many-cryptocurrencies-are-there.aspx.

[59] *Top 100 Cryptocurrencies by Market Capitalization*, COINMARKETCAP, https://coinmarketcap.com (last updated Apr. 13, 2019); *Global Charts: Total Market Capitalization*, *supra* note 1.

[60] *Confirmed Transactions Per Day*, BLOCKCHAIN, https://www.blockchain.com/charts/n-transactions?daysAverageString=7 (last visited Mar. 1, 2019).

[61] Alex Lielacher, *How Many People Use Bitcoin in 2019?*, BITCOIN MKT. J. (Feb. 11, 2019), https://www.bitcoinmarketjournal.com/how-many-people-use-bitcoin/.

[62] *See, e.g.* David Adler, *Silk Road: The Dark Side of Cryptocurrency*, FORDHAM J. CORP. & FIN. L. (Feb. 21, 2018), https://news.law.fordham.edu/jcfl/2018/02/21/silk-road-the-dark-side-of-cryptocurrency/ (explaining how

have become more prevalent, there has been some improvement in cryptocurrency's reputation and its significance to the ordinary consumer. Today, cryptocurrencies can be used at major retailers, fast food restaurants, travel agencies, and even universities.[63] Despite this expansion into the mainstream economy, cryptocurrency's criminal roots are still present.[64] For example, a 2018 study found that: "approximately one-quarter of all [Bitcoin] users (26%) and close to one-half of [B]itcoin transactions (46%) are associated with illegal activity . . . [and that] approximately one-fifth (23%) of the total dollar value of transactions and approximately one-half of [B]itcoin holdings (49%) through time are associated with illegal activity . . . ."[65] The current trend suggests cryptocurrencies will have an ever-increasing importance to the

---

cryptocurrencies helped enable the Silk Road, the world's first online drug bazaar); Nikita Malik, *How Criminals and Terrorists Use Cryptocurrency: and How to Stop It,* FORBES (Aug. 31, 2018), https://www.forbes.com/sites/nikitamalik/2018/08/31/how-criminals-and-terrorists-use-cryptocurrency-and-how-to-stop-it/; Marr, *supra* note 52 (discussing the 2014 event in which Bitcoin owners lost over 850,000 coins valued at the time at $450 Million, when Mt. Gox, the world's largest Bitcoin exchange, went offline).

[63] For examples of cryptocurrencies being used in legitimate transactions, see Jonas Chokun, *Who Accepts Bitcoins as Payment? List of Companies, Stores, Shops*, 99 BITCOINS (Sept. 13, 2018), https://99bitcoins.com/who-accepts-bitcoins-payment-companies-stores-take-bitcoins/; Jordan Gonen, *Where You Can Spend Your Cryptocurrency*, MEDIUM: HACKER NOON (Nov. 9, 2017), https://hackernoon.com/where-you-can-spend-your-cryptocurrency-e18303bcddca; Kyree Leary, *Schools Are Officially Accepting Bitcoin for Tuition*, FUTURISM (Oct. 7, 2017), https://futurism.com/schools-accepting-bitcoin-tuition; Elise Moreau, *13 Major Retailers and Services That Accept Bitcoin*, LIFEWIRE (Apr. 1, 2019), https://www.lifewire.com/big-sites-that-accept-bitcoin-payments-3485965 (giving some specific examples that include The Pirate Bay, Overstock.com, KFC, business school ESMT Berlin, and Expedia).

[64] For examples of cryptocurrencies still being used for criminal transactions, see Chelsea Pieroni, *La Crypto Nostra: How Organized Crime Thrives in the Era of Cryptocurrency*, 20 N.C. J. L. & TECH. ON. 111, 116 (2018); Corinne Ramey, *The Crypto Crime Wave is Here*, WALL ST. J. (Apr. 26, 2018), https://www.wsj.com/articles/the-crypto-crime-wave-is-here-1524753366; Malik, *supra* note 62.

[65] Sean Foley, Jonathan R. Karlsen & Talis J. Putnins, *Sex, Drugs, and Bitcoin: How Much Illegal Activity Is Financed Through Cryptocurrencies*, 32 REV. FIN. STUD. 1798, 1800 (2019).

global economy and to ordinary consumers, but this trend will also cause a reckoning with the more nefarious uses of cryptocurrencies.

III. CHALLENGES FACING CRYPTOCURRENCY MINING

Although cryptocurrency and cryptocurrency mining are beginning to see greater acceptance and success in the global economy, the staggering growth they have experienced in the last ten years has also created some significant challenges. In particular, there are four specific challenges that must be addressed if cryptocurrency and cryptocurrency mining are to continue their successful expansion into the greater global economy. These four challenges are: cryptocurrency mining's energy consumption and its effect on the global energy consumption and the global climate; miner consolidation and its effect on local communities; security concerns associated with the encryption used in cryptocurrency, and; cryptocurrencies price volatility and its effect on miners.

A. *Cryptocurrency Energy*

Solving the "nonce" (mathematical problem) required to verify cryptocurrency transactions and create new blocks requires an immense amount of computing energy.[66] This enormous energy consumption is demonstrated in Figure Two and in the following quotation:

> [I]n May 2018, it was estimated that Bitcoin[67] mining was consuming about 2.6 gigawatts of electricity per day, it has now risen to over 5 GW of electricity per day and could potentially rise to 7.7 GW of electricity per day by the end of 2018. In fact, Bitcoin mining now accounts for about 1 % of the world's total electricity consumption and now takes as much energy as mining for gold.[68]

---

[66] Roberts, *supra* note 1.

[67] Bitcoin is the cryptocurrency with the largest market share. *Global Charts: Total Market Capitalization*, *supra* note 1.

[68] Steer, *supra* note 1 (footnote added); *see also* Reuben Jackson, *Bitcoin Mining Uses as Much Energy as Mining for Gold, Study Finds*, BIG THINK (Nov. 8, 2018), https://bigthink.com/new-study-on-cryptomining-energy (stating that Bitcoin mining's energy consumption is the same as gold mining); Timothy B. Lee, *New Study Quantifies Bitcoin's Ludicrous Energy Consumption*, ARSTECHNICA (May 17, 2018), https://arstechnica.com/tech-policy/2018/05/new-study-quantifies-bitcoins-ludicrous-energy-consumption/ (estimating Bitcoin

Mining's energy consumption has now become so significant that it is beginning to make a measurable impact upon the total global energy consumption and greenhouse gas emission.[69] This is starting to cause concern among both miners and the global community and there is a belief that action is needed to address this concern.[70]

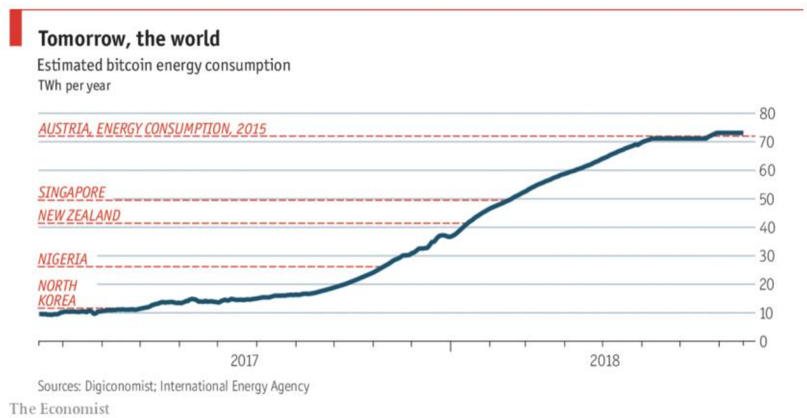

Figure Two: Energy consumption of Bitcoin compared against total annual energy consumption of several countries.[71]

Global energy demand is projected to rise by at least thirty percent by the year 2040,[72] to a total global demand of

---

mining's year end energy for 2018 at 7.7 GW); Drew Millard, *Bitcoin Mining Now Accounts for Almost One Percent of the World's Energy Consumption*, OUTLINE (Aug. 25, 2018), https://theoutline.com/post/6047/bitcoin-mining-accounts-for-almost-one-percent-of-the-worlds-energy-consumption?zd=3&zi=c2tosen5 (estimating Bitcoin mining's energy consumption accounting for 1 percent of the world's energy consumption).

[69] *See Bitcoin Energy Consumption Index*, DIGICONOMIST, https://digiconomist.net/bitcoin-energy-consumption (last visited Jan. 21, 2019); Millard, *supra* note 68.

[70] *See Bitcoin Energy Consumption Index*, *supra* note 69; Lee, *supra* note 68.

[71] *Mining Cryptocurrencies is Using Up Eye-Watering Amounts of Power*, ECONOMIST (Aug. 30, 2018), https://www.economist.com/technology-quarterly/2018/09/01/mining-cryptocurrencies-is-using-up-eye-watering-amounts-of-power.

[72] *See World Energy Outlook 2017*, INT'L ENERGY AGENCY (Nov. 14, 2017), https://www.iea.org/weo2017/ (predicting that the world energy demand will rise by 30% in between 2017 and 2040); *World Energy Needs and Nuclear Power*,

approximately 700 quadrillion British Thermal Units ("BTUs").[73] For reference, the average household in the United States consumes 148 million BTUs per year.[74] Although new energy generation is being constructed, it will be difficult for supply to keep up with demand unless efficiency is also increased.[75] In this impending global reality, industries that consume large amounts of energy will likely be given intensive scrutiny and, perhaps, face punitive measures from regulators and concerned individuals. If cryptocurrency mining's energy consumption is allowed to continue at its current pace, it is highly likely it will be one of the industries facing scrutiny and punitive measures.

At the same time as increasing energy demand, there is also a concerted global effort for cleaner energy sources.[76] The desire for environmentally conscious energy consumption will put pressure on industries to only consume energy from clean energy sources.[77] Currently, cryptocurrency miners, while utilizing some clean energy

---

WORLD NUCLEAR ASS'N, http://www.world-nuclear.org/information-library/current-and-future-generation/world-energy-needs-and-nuclear-power.aspx (last updated Feb. 2019) (predicting that world energy demand will rise by more than half by the year 2040).

[73] EXXON MOBIL CORP., 2017 OUTLOOK FOR ENERGY: A VIEW TO 2040 (2017), https://cdn.exxonmobil.com/~/media/global/files/outlook-for-energy/2017/2017-outlook-for-energy.pdf. A "quadrillion" represents fifteen zeros. Anne Marie Helmenstine, *Numbers of Zeros in a Million, Billion, Trillion, and More*, THOUGHTCO. (Jan. 20, 2019), https://www.thoughtco.com/zeros-in-million-billion-trillion-2312346.

[74] *How Much Do You Consume?*, U.S. DEP'T ENERGY (Sept. 23, 2014), https://www.energy.gov/articles/how-much-do-you-consume.

[75] *Smart Energy Solutions: Improve Energy Efficiency*, UNION OF CONCERNED SCIENTISTS, https://www.ucsusa.org/clean-energy/improve-efficiency-efficiency#.XEUDWy3MxhE (last visited Jan. 21, 2018).

[76] *See generally* The Paris Agreement, Nov. 4, 2016, 55 I.L.M 740 ("The Paris Agreement sets forth a new international legal regime aimed at strengthening the global response to climate change.").

[77] The US Department of Energy currently identifies six clean energy sources: wind, water, geothermal, bioenergy, nuclear, and hydrogen fuel cells. *Clean Energy*, U.S. DEP'T ENERGY, https://www.energy.gov/science-innovation/clean-energy (last visited Mar. 1, 2019). Examples of dirty energy sources include coal, natural gas, and oil. *Coal and Other Fossil Fuels*, UNION OF CONCERNED SCIENTISTS, https://www.ucsusa.org/clean-energy/coal-and-other-fossil-fuels (last visited Mar. 1, 2019).

sources, are still responsible for significant greenhouse gas emission from dirty energy sources.[78] For example, the mining operations of Bitcoin alone contribute approximately 22,862 kilotons of CO_2 to the atmosphere annually.[79] For context, the average annual CO_2 emissions of a typical passenger vehicle in the US is .0046 kilotons, so the annual emissions created by Bitcoin mining is equivalent to 4.97 million vehicles.[80] Therefore, not only must cryptocurrency mining reduce its overall energy consumption, but it must aim to ensure that the energy it does consume is from clean energy sources that limit greenhouse gas emissions.

B. *Miner Consolidation and its Effect on Local Communities*

The second challenge facing cryptocurrency mining is miner consolidation and its effect on local communities. An interesting phenomenon of the mining revolution is the consolidation of miners in a few localities throughout the world that share energy and geographic characteristics.[81] This consolidation has brought some benefit to these localities such as investment by a new high-tech job industry.[82] However, it has also presented unique concerns about the long-term economic viability of cryptocurrency mining as well as whether miners are taking adequate electrical safety precautions.[83]

The recent trend of miner consolidation is a result of a few factors, with the most important being the availability of cheap electricity.[84] Due to cryptocurrency mining's enormous energy consumption, the price of electricity is often a primary factor in determining whether or not miners make a profit.[85] As a result,

---

[78] *See* Roberts, *supra* note 1 (explaining the use of clean energy sources geothermal and water by some cryptocurrency miners); *see also Bitcoin Energy Consumption Index*, *supra* note 69 (explaining that energy consumed by Bitcoin mining results in emits large emissions CO_2 into the atmosphere).

[79] *Bitcoin Energy Consumption Index*, *supra* note 69.

[80] *Greenhouse Gas Emissions from a Typical Passenger Vehicle*, U.S. ENVTL. PROT. AGENCY, https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle (last updated May 10, 2018).

[81] Roberts, *supra* note 1; Steer, *supra* note 1.

[82] Roberts, *supra* note 1; Steer, *supra* note 1.

[83] Roberts, *supra* note 1; Steer, *supra* note 1.

[84] Roberts, *supra* note 1; Steer, *supra* note 1.

[85] Roberts, *supra* note 1; Steer, *supra* note 1.

miners have scoured the world for locations with cheap electricity.[86] Three locations have seen a particularly high level of miner consolidation: Washington state, China, and Iceland.[87] In addition to abundant and cheap electricity, such as geothermal generation in Iceland or hydroelectric generation in Washington state, these three locations also have cool, dry winters as well as plenty of rural and undeveloped land.[88] Cool and dry winters reduce the amount of energy needed to keep the mining computers cool (to prevent overheating) and abundant undeveloped land allows new mining operations to reduce capital costs.[89]

In the communities that have seen a particularly high level of miner consolidation, there is justified concern about the long-term economic viability of mining and the effect on their community if mining operations falter. This concern is based on two indicators that the mining's economic fundamentals are unstable. First, there is a reasonable likelihood that cryptocurrency mining could be an economic bubble.[90] An economic "bubble is an economic cycle characterized by the rapid escalation of asset prices followed by a contraction. It is created by a surge in asset prices unwarranted by the fundamentals of the asset and driven by exuberant market behavior."[91] Cryptocurrencies have seen rapid price escalation,

---

[86] Roberts, *supra* note 1; Steer, *supra* note 1.

[87] Roberts, *supra* note 1; Steer, *supra* note 1.

[88] Roberts, *supra* note 1; Steer, *supra* note 1.

[89] Roberts, *supra* note 1. If a computer gets above its maximum temperature, typically around 60 ºC, permanent damage can be done to both the computer's processors and physical components. Jim Martin, *What's the Best CPU Temperature?*, TECH ADVISOR (Oct. 24, 2018), https://www.techadvisor.co.uk/how-to/desktop-pc/cpu-temp-3498564/. Cooling large computer banks is actually a challenging and expensive endeavor, and for a discussion about how Google has been a trailblazer in this area, see Rich Miller, *How Google Cools Its Armada of Servers*, DATA CTR. KNOWLEDGE (Oct. 17, 2012), https://www.datacenterknowledge.com/archives/2012/10/17/how-google-cools-its-armada-of-servers.

[90] Jeffrey D. Sachs, *The Bitcoin Bubble Will Likely Burst, and Here's Why*, BOS. GLOBE (Jan. 3, 2018), https://www.bostonglobe.com/opinion/2018/01/03/the-bitcoin-bubble-will-likely-burst-and-here-why/dJUDm2RYRoj64iHaIx0bZL/story.html.

[91] Will Kenton, *Bubble*, INVESTOPEDIA, https://www.investopedia.com/terms/b/bubble.asp (last updated Apr. 18, 2018).

followed by rapid price contraction. In the last two years, the market capitalization of all cryptocurrencies has fluctuated from a few billion to almost a trillion dollars and then back down to just above one hundred billion.[92] Furthermore, there is evidence that these price fluctuations have not been in line with the cryptocurrency economic fundamentals, such as supply and demand, but rather by exuberant market speculation.[93] If cryptocurrencies do result in an economic bubble, it will lead to serious economic consequences for localities in which cryptocurrency miners have become a major part of the local economy.[94]

Figure Three: Combined market capitalization of all cryptocurrencies between January 2017 and January 2019.[95]

A second worrying sign about the economic fundamentals of cryptocurrency mining relates to some of the technical aspects of the proof-of-work incentive structure. To help control the supply of cryptocurrency and limit the ability of one mining operation to

---

[92] *Global Charts: Total Market Capitalization*, *supra* note 1. Market capitalization is the number of coins outstanding times the price of the coin. *Id.*

[93] *See, e.g.*, Jimmy Aki, *BitPay CEO: Speculation is a Major Aspect of Bitcoin's Value, Mass Adoption Soon*, BLOCKONOMI (Dec. 18, 2018), https://blockonomi.com/bitpay-ceo-speculation-of-bitcoins-value/ (reporting that the CEO of a major Bitcoin payment processor, BitPay, believes that a major aspect of Bitcoin pricing comes from investor speculation); Chris Burniske, *Bitcoin & Ethereum: Prices Are Down More Than the Fundamentals*, MEDIUM (Dec. 9, 2018), https://medium.com/@cburniske/bitcoin-ethereum-prices-are-down-more-than-the-fundamentals-88fd18a86d14 (explaining a time when some cryptocurrency prices are lower than their fundamentals); Leslie Kramer, *How Does the Law of Supply and Demand Affect Prices?*, INVESTOPEDIA, https://www.investopedia.com/ask/answers/033115/how-does-law-supply-and-demand-affect-prices.asp (last updated Mar. 1, 2019) (explaining how supply and demand are economic fundamentals that affect prices).

[94] *See* Roberts, *supra* note 1; Steer, *supra* note 1.

[95] *Global Charts: Total Market Capitalization*, *supra* note 1.

control too many mining nodes, most cryptocurrencies are designed such that the nonce periodically become harder to solve, and the number of coins rewarded for verifying a block of transactions decreases.[96] Therefore, more computing power is needed over time for a smaller reward of coins. If the value of a coin in a particular cryptocurrency does not consistently remain above an increasing threshold, the energy costs required to verifying a block of transactions will be greater than the value of the coins rewarded for verification. If this happens, it will no longer make economic sense to mine cryptocurrency and miners will likely immediately cease operations, which could devastate localities that have begun to rely on cryptocurrency mining. [97]

In addition to concerns about long-term economic viability, consolidation of mining operations has also brought about electrical safety concerns. When a miner is using a large amount of power, they must be sure that they are taking the appropriate safety precautions to prevent electrical overloads or fires.[98] In some cases, these precautions are not always taken.[99] For example, a brush fire

---

[96] Roberts, *supra* note 1; Steer, *supra* note 1. For traditional currencies, a central regulatory authority takes measures to assert at least some level of control. For example, in the United States, the Federal Reserve Bank can stimulate the economy by increasing the supply of US Dollars through quantitative easing, or they can reduce inflation by increasing the interest rate at which they lend money. Kimberly Amadeo, *Quantitative Easing Explained*, THE BALANCE (Jan. 30, 2019), https://www.thebalance.com/what-is-quantitative-easing-definition-and-explanation-3305881. These measures can help ensure a currency's stability. *Id.* Since there is no central authority for cryptocurrencies, the software protocol must control the currency supply. AMUIAL ET AL., *supra* note 4.

[97] For example, local utilities have added significant energy capacity in localities that have experienced influx of cryptocurrency miners (such as new power plants and new power lines). Roberts, *supra* note 1; Steer, *supra* note 1. These actions are significant investments for utilities that will take years for them to pay off. Roberts, *supra* note 1; Steer, *supra* note 1. If miners suddenly leave town, utilities will be left with stranded assets. Roberts, *supra* note 1; Steer, *supra* note 1.

[97] Roberts, *supra* note 1; Steer, *supra* note 1.

[98] Roberts, *supra* note 1; Steer, *supra* note 1.

[99] Paul Roberts, *Bitcoin Backlash as 'Miners' Suck up Electricity, Stress Power Grids in Central Washington*, SEATTLE TIMES (May 29, 2018), https://www.seattletimes.com/business/bitcoin-backlash-as-miners-suck-up-

occurred in Washington state after a miner did not take adequate safety precautions, resulting in a transformer overload.[100] Fortunately, this fire was contained before greater damage was done, but unless adequate safety measures are in place, similar events will likely occur, potentially resulting in catastrophic consequences, such as forest fires and widespread electrical blackouts.[101]

C. *Security of Cryptocurrency Mining*

Another challenge the industry faces is the security of cryptocurrency encryption. It currently appears that the cryptocurrency system is safe from electronic attacks because it uses PKI to encrypt transactions and users' currency accounts.[102] Currently, PKI is effective because it is mathematically unfeasible for a hacker to determine the alphanumerical private keys used by cryptocurrency using binary computers.[103] However, there is a new type of computer currently being researched called a "quantum computer."[104] In a binary computer, all operations are performed using switches that are either 1s (On) or 0s (Off).[105] In contrast, a quantum computer operates using qubits (quantum bits) rather than

---

electricity-stress-power-grids-in-central-washington/; Roberts, *supra* note 1; Steer, *supra* note 1.

[100] Roberts, *supra* note 1; Steer, *supra* note 1.

[101] Roberts, *supra* note 1; Steer, *supra* note 1.

[102] *How Cryptography is Used in Cryptocurrency*, WORLD CRYPTO INDEX, https://www.worldcryptoindex.com/how-cryptography-is-used-cryptocurrency/ (last visited Jan. 21, 2019); AMUIAL ET AL., *supra* note 4, § 1:3; Rouse, *supra* note 13; *What is Public Key Infrastructure (PKI)?*, *supra* note 13.

[103] AMUIAL ET AL., *supra* note 4, § 1:3; *How Cryptography is Used in Cryptocurrency*, *supra* note 102; Rouse, *supra* note 13; *What is Public Key Infrastructure (PKI)?*, *supra* note 13. A binary computer is the computer used in today's world. *Binary*, TECH. TERMS, https://techterms.com/definition/binary (last visited Mar. 1, 2019).

[104] Rafaeli, *supra* note 1. Currently, there is much debate about when practical quantum computers will actually arrive, but most experts believe it will be about ten to twenty years. Larry Greenemeier, *How Close Are We—Really —to Building a Quantum Computer*, SCI. AM. (May 30, 2018), https://www.scientificamerican.com/article/how-close-are-we-really-to-building-a-quantum-computer/.

[105] *Binary*, *supra* note 103.

switches.[106] Qubits are similar to the switches in binary computers in that they can be encoded as 1s (On) or 0s (Off), but unlike the switches used in binary computers, qubits can exist in both states, 1 (On) or 0 (Off), at the *same*[107] time.[108] As a result, quantum computers can process exponentially more data and information than traditional binary computers. It is likely that this increase in computer speeds would be enough to make it feasible to determine the alphanumerical private keys of another and thus compromise the security of the entire cryptocurrency system.[109]

Although most commentators agree that quantum computers could likely eventually overcome PKI encryption, there is significant dispute about the effect it could have on the cryptocurrency system.[110] Commentators present two arguments to support their belief that there will only be a minimal effect on cryptocurrency encryption from quantum computers.[111] First, they argue that the cryptocurrency system will be able to quickly adapt to quantum encryption breaking challenges by employing quantum encryption counter-measures (such as private keys created using quantum computers).[112] Second, even if quantum computing does overcome encryption, society will have significantly larger problems than compromised cryptocurrencies since much of the world's financial institutions and governments rely on this type of encryption.[113]

Although these arguments do have some merit, there are two compelling counterpoints that suggest quantum computers could likely have a devastating effect on cryptocurrencies and cryptocurrency mining. First, although it is possible that there will be quantum solutions to quantum encryption challenges, these

---

[106] Dom Galeon, *How Quantum Computers Would Destroy Today's Encryption Methods*, FUTURISM (Dec. 18, 2016), https://futurism.com/1-evergreen-how-quantum-computers-would-destroy-todays-encryption-methods.

[107] This is due to the quantum principle superposition, which is the ability to be in two states simultaneously (they can be off and on and the same time). *Id.*

[108] *Id.*

[109] *Id.*; *see also* Greenemeier, *supra* note 104; Rafaeli, *supra* note 1.

[110] AMUIAL ET AL., *supra* note 4, § 1:4.

[111] *Id.*

[112] *Id.*

[113] *Id.*

quantum solutions would have to be deployed and implemented prior to any quantum-based attack. This seems unlikely because as soon as quantum computers reach maturity, both the quantum encryption challenges and quantum solutions will likely become available at the same time. Therefore, there will not be enough time for complete deployment and implementation of the quantum solutions before the quantum-based attacks begin. Second, although many other sectors of the global economy rely on PKI encryption, it is likely the effects felt by cryptocurrencies and cryptocurrency miners will be worse. By their very nature cryptocurrencies are completely electronic and decentralized, so it will be almost impossible for any recourse after an attack.[114] Therefore, it would be prudent to take steps now that help protect cryptocurrency and cryptocurrency mining from any future encryption challenges.

D. *Miner Income Volatility*

In addition to potentially effecting mining localities, concerns about long-term economic viability of cryptocurrency mining could also affect miners themselves. Cryptocurrency mining requires significant capital investment to begin operations and also has substantial operating expenses.[115] As a result, cryptocurrency mining is only worth the investment if it can be assured that enough revenue will be generated to cover start-up and operating costs. The revenue earned through cryptocurrency mining comes from new coins that are rewarded in exchange for verifying a block of transactions.[116] Therefore, miners need the price of the cryptocurrency to be consistently high enough that their expenses are covered.[117] However, as shown by Figure Three, this has not occurred with any consistency over the past two years.[118] In the last two years, the market capitalization of cryptocurrency has fluctuated from a few billion to almost a trillion dollars and then back down to just above

[114] For example, other institutions will have things like a central authority and paper backups that will help them manage the crisis.
[115] Steer, *supra* note 1.
[116] *Id.*
[117] *Id.*
[118] *Global Charts: Total Market Capitalization*, *supra* note 1.

one hundred billion.[119] This volatility makes cryptocurrency mining a risky endeavor because if a down stretch lasts too long, most miners will be unable to meet their expenses.[120] As a result, the volatility could create a system in which most miners can only survive for a short period of time when the market is doing well.[121] If the role cryptocurrencies play in the global economy is to continue to grow, then the volatility of the market should be addressed to ensure that an essential component of any cryptocurrency, the miners, are sustainable.

IV. SUGGESTED REGULATION TO COMBAT THE CHALLENGES FACED BY CRYPTOCURRENCY MINING

In recent years, there has been significant discussion about imposing, and some implementation of, regulation on cryptocurrency.[122] There has also been discussion about the best methods for imposing cryptocurrency regulations.[123] In contrast, there has been significantly less discussion of regulation concerning cryptocurrency mining. Regulation of the mining process, however, could address the four challenges to cryptocurrency mining that were presented in Section III.

A. *Regulation to Address Energy Consumption and Greenhouse Gas Emissions*

The enormous energy consumption and greenhouse gas emissions resulting from cryptocurrency mining can be best addressed by new regulations. These regulations could incentivize

---

119 *Id.*

120 *See* Hannah Murphy, *Crypto Miners Fight for Survival as Market Turmoil Continues*, FIN. TIMES (Dec. 18, 2018), https://www.ft.com/content/98d52c50-fd37-11e8-aebf-99e208d3e521.

121 *Id.*

122 Gregory M. Karch, *Bitcoin, the Law and Emerging Public Policy: Towards a 21st Century Regulatory Scheme*, 10 FLA. A&M U. L. REV. (2014); Misha Tsukerman, *The Block is Hot: A Survey of the State of Bitcoin Regulation and Suggestions for the Future*, 30 BERKELEY TECH. L.J. 1127 (2015).

123 *See* Ed Howden, *The Crypto-Currency Conundrum: Regulation an Uncertain Future*, 29 EMORY INT'L L. REV. 742 (2015) (suggesting that the World Trade Organization would be the best option for regulating cryptocurrencies to allow for flexibility and for countries to assert more stringent regulations).

new and existing cryptocurrency blockchains to switch to a more energy-efficient method of transaction verification, instead of the current energy intensive proof-of-work method.[124] There are currently two promising alternatives to proof-of-work verification: proof-of-stake and proof-of-authority. Both options could significantly reduce the energy demands of the mining operations. However, these alternatives have drawbacks that the traditional proof-of-work verification process does not. Therefore, the best approach is to incentivize some, but not all, cryptocurrencies to move to one of these two new verification methods.[125]

Under a proof-of-stake model, each node in a network has a level of influence over the network that is dynamically adjusted based upon the node's economic stake in the network.[126] Since the node operators have an economic stake in the overall network, they are incentivized to ensure the market is functioning properly because if the network suffers a failure it would reduce the value of their assets.[127] Furthermore, in this model, there is no reward for verifying a block of transaction; instead, node operators are rewarded with the transaction fee associated with each transaction, so maintaining proper market function usually leads to a greater number of transactions and in turn a greater profit.[128] By using this incentive structure, proof-of-stake is able to preserve the integrity and security of the network without the enormous energy consumption of proof-of-work.[129] However, this solution does have drawbacks.[130] First, it can be susceptible to shorts by malicious actors.[131] In this scenario, an operator of a node shorts "his position on another exchange in order to profit from a decline in the price of the network's assets."[132] Second, this verification method requires node operators to be more

---

124 Cryptocurrency Mining Power Needs Could Be Eased, Senate Panel Told (Aug. 27, 2018), 2018 WL 4056356.

125 Incentivizing could be done by giving green tax incentives, at national, state, or local level, to the users of cryptocurrencies that use either of these methods.

126 AMUIAL ET AL., *supra* note 4, § 1:6.

127 *Id.*

128 *Id.*

129 *Id.*

130 *Id.*

131 *Id.*

132 *Id.*

financially invested in the overall economic health of the network than in the traditional proof-of-work method.[133]

A proof-of-authority verification method works by running them through some central authority, such as a state actor or financial institution.[134] Under this structure, proof-of-authority manages to create an electronic currency that maintains many of the benefits of proof-of-work while reducing energy consumption. However, it sacrifices decentralization, which is often the most important feature to many cryptocurrency users.[135] Therefore, it would only be appropriate for situations in which decentralization is not essential.

Encouraging some cryptocurrencies to reduce their energy consumption and greenhouse gas emissions by switching to more energy efficient verification methods could be done with two new regulations. First, a "green tax" could be proposed at the national, state, or local level to reward cryptocurrencies that utilized one of the two energy efficient verification processes. This green tax could also be offered to cryptocurrencies that continue to use proof-of-work but commit to doing so using only green energy sources. Second, governments, most likely at the national level, could set up and run central authorities at reduced costs. This would likely provide greater incentive for miners to switch to proof-of-authority, because they would not have the added cost and responsibility of setting up a trusted central authority themselves. Since both of these two new methods have drawbacks, it is important that the incentives aren't so strong that they force the traditional proof-of-work model out of existence. Rather, an appropriate strength is needed to ensure a balance in the marketplace that retains the positive aspects of proof-of-work while using the two new methods to reduce the overall energy consumption and greenhouse gas emissions. Therefore, it would be prudent if the incentives for these two new methods were first tried in a pilot program.

---

[133] *Id.*

[134] Cryptocurrency Mining Power Needs Could Be Eased, Senate Panel Told, *supra* note 124.

[135] *Id.*

B. *Regulation to Address Miner Consolidation and its Effect on Local Communities*

Impacts from miner consolidation on local communities are likely best addressed by state and local regulations in localities with significant mining operations. The regulations should aim to ensure that any negative economic consequences for cryptocurrency miners will not have a significant detriment to the locality, and that there are sufficient methods for preventing any electrical safety hazards associated with mining. In creating and implementing these regulations, it is important that a balance is struck that address the concerns felt by local communities while not being so significant that they drive miners out of the area.

There are a few specific regulations that could be implemented to protect localities from long-term economic viability of cryptocurrency mining. Utility companies must be given effective tools for negotiating long-term contracts that include sufficient collateral requirements with cryptocurrency miners.[136] Utility companies are required by law to consider any legitimate request for power.[137] However, if miners request a large amount of power and then suddenly depart after the utility has built the infrastructure, the utility and the local rate payers are left covering the bill for infrastructure that will be extremely difficult for the utility to repurpose.[138] Long-term contracts with sufficient collateral could give the miners an incentive to work for the long-term payoff, and provide utility companies with at least some remedy if the miners choose not to keep their end of the bargain. Additionally, states could propose quotas on the amount of mining that takes place in a particular geographic area. Quotas would ensure that the mining energy consumption is at a level that can be handled by the defined area. This would not only ensure that miners do not completely overrun a particular locality, but also mitigate some of the damage if the miners suddenly left town after a down period.

Due to the large quantity of electricity used by cryptocurrency miners, it is necessary that sufficient safety

---

[136] Steer, *supra* note 1.
[137] *Id.*
[138] *Id.*

measures are put in place through regulations to prevent fires, blackouts, and other electrical hazards.[139] The electrical safety measures put in place should be similar to those of large-scale industrial power consumers. These safety measures include: circuit protection between the grid and the mining operation;[140] circuit protection between portions of the mining operation;[141] up to date fire suppression methods;[142] and a contingency plan[143] in place in case of electrical emergencies.[144] These measures will help prevent dangerous electrical fires and will also help ensure that any mishaps are quickly contained. In addition, the safety measures should be bookended with periodic inspections by electricians and representatives of the Occupational Safety and Health Administration ("OSHA").[145] The safety measures and other regulations proposed in this section should help ease tensions between miners and other residents in some mining localities, but it is important that they are appropriately scaled and targeted to ensure they do not push away miners and the economic benefit they bring.[146]

C. *Regulation of Electronic Security*

Although the potential quantum computing challenges to cryptocurrency and cryptocurrency mining are still likely somewhat in the future, there are three carefully measured proactive steps that should still be taken now to prepare. First, encryption users, researchers, and regulators must remain in conversation about the advancement of the technology and also about potential counter

---

[139] *Id.*

[140] This helps prevent any mishaps and helps the mining facility spreading to the larger grid.

[141] This helps contain a mishap to a particular portion of a mining operation rather than harming the entire operation.

[142] These could include sprinklers, fire retardant building materials, and access to an adequate water supply.

[143] Pre-determined roles and measures in the case of an emergency.

[144] *Electricity in the Workplace*, HEALTH & SAFETY AUTH., https://www.hsa.ie/eng/Topics/Electricity/Dangers_of_Electricity/Electricity_in_the_Workplace/ (last visited Mar. 1, 2019).

[145] *Id*.

[146] Roberts, *supra* note 1.

measures to encryption-breaking quantum computers. Second, as these conversations progress, new research should be used to propose the most up-to-date regulations. These regulations could be designed to take effect when the need arose. For example, if technologies that could be used to counter this effect become available, a pre-determined time period could be started within which encryption users would have to implement counter measures. Third, in recent years, the federal government has significantly stepped up its prosecution of hackers.[147] These efforts must continue unabated to discourage this behavior.

D. *Regulation on Miner Income Volatility*

Variable income is perhaps the cryptocurrency mining challenge least in need of regulation. Rather than regulation, individuals entering the market could simply acknowledge that they are aware of the risks associated with the market and have accepted them. Furthermore, this problem will likely be self-correcting, because as the market for cryptocurrencies matures and becomes more diverse, the volatility associated with cryptocurrency mining will likely decrease.[148] However, if a no regulation solution is to be accepted, society must be comfortable with a certain amount of fraud and loss in the market.

If regulation is implemented, one possible option is creating or incentivizing the creation of a central authority, such as a governmental organization or a financial institution, to help control

[147] Hanni Fakhoury, *The U.S. Crackdown on Hackers is Our New War on Drugs*, WIRED (Jan. 23, 2014), https://www.wired.com/2014/01/using-computer-drug-war-decade-dangerous-excessive-punishment-consequences/.

[148] Cole Petersen, *Analyst: Low Volatility is a Positive Sign for the Cryptocurrency Markets*, NEWS BTC (Oct. 26, 2018), https://www.newsbtc.com/2018/10/26/analyst-low-volatility-is-a-positive-sign-for-the-cryptocurrency-markets/. It also appears that the volatility in the market is already decreasing. *See* Charles Bovaird, *Bitcoin Price Volatility Falls to Lowest of 2018*, FORBES (Oct. 5, 2018), https://www.forbes.com/sites/cbovaird/2018/10/05/bitcoin-price-volatility-falls-to-lowest-of-2018/#63c720745017.

the market.[149] For example, JPMorgan Chase recently became the first national bank to create its own cryptocurrency dubbed "JPM Coin."[150] Similar to traditional cryptocurrencies it will allow users make money transfers instantaneously, but—in contrast to traditional cryptocurrencies—the central authority JPMorgan Chase will control the currency, and it will not trade freely.[151] Depending on specific circumstances, a cryptocurrency user may prefer decentralization or stability.[152] Therefore, any incentives or regulations should aim to create the appropriate balance between centralized and decentralized cryptocurrencies. The performance of JPMorgan's JPM Coin over the coming months and years should be an important clue about where this balance should be struck.[153]

V. CONCLUSION

In recent years, there has been significant discussion and incremental regulation on cryptocurrencies. Conversely, there has been little discussion of regulations of cryptocurrency mining or how these regulations could be implemented. This is despite the fact that cryptocurrency mining is facing several serious challenges. This Recent Developments fills this commentary void by first identifying the four most significant challenges facing cryptocurrency mining: energy consumption, miner consolidation and its effect on local communities, encryption security, and volatility. Then, it proposes and discusses targeted regulation solutions to these challenges as well as the best method for implementing the regulations.

---

[149] Eric Petroff, *The Fed's Tools for Influencing the Economy*, INVESTOPEDIA (Oct. 5, 2018), https://www.investopedia.com/articles/economics/08/monetary-policy-recession.asp.

[150] Chris Isidore, *JPMorgan is Creating Its Own Cryptocurrency*, CNN (Feb. 14, 2019), https://www.cnn.com/2019/02/14/investing/jpmorgan-jpm-coin-cryptocurrency/index.html. An interesting aspect of this development is the apparent change of heart by the bank's CEO, Jamie Dimon. In 2017 he "described [B]itcoin as a 'fraud,' 'stupid,' and 'far too dangerous' to people who traded it . . . .Dimon said that he supported blockchain technology for tracking payments, his company would fire anyone at the bank that traded in [B]itcoin 'in a second.'" *Id.*

[151] *Id.*

[152] *Id.*; *Beginners Guide: What is Bitcoin?*, *supra* note 1.

[153] *Beginners Guide: What is Bitcoin?*, *supra* note 1; Isidore, *supra* note 150.

Despite the significance of the challenges facing cryptocurrency mining outlined in this Recent Development, there are reasons to remain optimistic about the future of both cryptocurrency and cryptocurrency mining. In the ten years since cryptocurrencies debuted, they have reached valuations approaching a trillion dollars, had interactions with millions of users, and been used as payments in a wide variety of settings. In this time period miners have also created and enjoyed significant economic opportunities and are continuing to perform the critical task of verifying cryptocurrency transactions. Any industry that has experienced such rapid growth will face challenges along the way. Appropriate steps taken by regulators, cryptocurrency users, and cryptocurrency miners will help ensure these challenges are overcome and lead cryptocurrency and cryptocurrency mining to even greater successes.