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THE UNIVERSITY OF NEW HAVEN

MINING BITCOIN TO AVOID SANCTIONS

A THESIS

submitted in partial fulfillment

of the requirements for the degree of

MASTERS OF SCIENCE IN NATIONAL SECURITY WITH CONCENTRATION IN

INFORMATION PROTECTIONS & SECURITY

BY

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MINING BITCOIN TO AVOID SANCTIONS

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ABSTRACT

Though the world's first cryptocurrency, Bitcoin, was introduced over a decade ago, it was not until recently that it became a mainstream subject. While cryptocurrencies offer many advantages, a potential downside for governments, is that no central bank controls the monetary policy and new coins can be mined by anyone anywhere in the world. Governments have always been deeply involved with how a their countries' currency is ran and the policies they create are meant to keep a currencies' value stable and make sure other factors like inflation is under control. Even though as of 2021, there were well over 4,000 different cryptocurrencies, the focus of this study will be Bitcoin since it is the most popular and at this point, the most valuable in terms of market capitalization. The United States government has become more involved with investigating how cryptocurrencies and Bitcoin are used, and have issued statements on the ways terrorism groups or other threats to our National Security could be effected by Bitcoin. One way countries could undermine the National Security Posture of the United States is by mining Bitcoin to replace revenue from exports that have been adversely effected by sanctions. Given the decentralized nature of Bitcoin, would it be possible for countries under sanctions from the United States to supplement their lost revenue by mining the cryptocurrency? There are a several necessary resources needed to mine Bitcoin, and countries hoping to mine Bitcoin would need an abundance of these resources. For this research, data from the World Bank Database was used to find if there was any positive or negative correlation between countries with sanctions and access to these Bitcoin mining resources. In addition to analyzing this data, different case studies were also analyzed to see if any countries are attempting to mine Bitcoins already and if so, what has been the implications so far. Furthermore, literature on sanctions, data

analysis, recent mining activity, and white papers for Bitcoin and Ethereum were reviewed.

Based on the data, it did not seem that countries with sanctions imposed were well equipped to mine Bitcoin and the case studies examined showed that there was not large mining activities taking place in sanctioned countries.

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INTRODUCTION

Would you rather be paid in dollars or Bitcoin? A question many thought they would never hear or think was a good idea. Perhaps even a question that doesn't make sense given Bitcoin is not nearly as recognizable as the United States Dollar. Having access to Bitcoin nowadays seems like a pretty good idea given how much the price has risen since its inception. Bitcoin was the first form of digital currency, also called a "cryptocurrency," and was used in 2009. It was revolutionary and through the years has sparked the creation of many other types of cryptocurrencies. Although Bitcoin and other cryptocurrencies have been around for well over a decade, they only became mainstream in 2020, when average investors and larger corporations became interested in purchasing them. A cryptocurrency may seem like something out of the future that would ultimately be very similar to United States Dollar, but Bitcoin and other cryptocurrencies have features that make them quite different from the standard forms of payment we know today. For example, the major difference between cryptocurrencies and traditional currencies is the fact that cryptocurrencies are decentralized. Cryptocurrencies do not have a type of central authority like the Central Bank or Federal Reserve to establish policies and regulate use. Anyone can use cryptocurrency, regardless of financial standing or history. If someone has access to the internet, a smart phone or computer, and a wallet application — of which there are many — then they can access and send Bitcoin through the use of public and private keys, the latter of which known only to the owner of the wallet.

How does Bitcoin work? Bitcoin is hosted by anyone who is willing to do so, and each computer that runs the Bitcoin network is called a node. These nodes are hosted by many people around the world, and there are companies that have their own Bitcoin nodes. Users send Bitcoin

directly to other users and all of the Bitcoin transaction data is stored on each node in the form of a blockchain. Blockchains are databases, but they are best described as a digital ledger where transaction is captured and recorded and cannot be changed later; only more data can be added. The inability to alter the data gives complete transparency of the transactions that have occurred on the blockchain and makes these transactions permanent.

What regulates the value of each cryptocurrency if there is not a person, government, or other central authority? Each cryptocurrency has its own set of rules that determine the total amount of “coins” available, and these rules are established in the cryptocurrency’s code. Users can “mine” for more of the cryptocurrency using computer software and hardware that adheres to the rules of the cryptocurrency, which are unique and can vary.. For instance, a rule that makes Bitcoin unique from other cryptocurrencies is that only 21 million Bitcoins can ever be mined¹. Other cryptocurrencies may not have a limit. For example, another cryptocurrency called Ethereum does not have a cap on the number of Ether that can be mined.

While many opponents of cryptocurrencies say it is a scam or that there is no value to the coins, the fact is that all these cryptocurrencies have a combined market cap of well over a trillion dollars.² There are large financial and investment firms as well as other companies that are invested in Bitcoin. In addition, public companies on the New York Stock Exchange are involved in cryptocurrency trading.

This is just a very brief background on cryptocurrencies, but it is clear that cryptocurrencies are vastly different from what the world is used to when it comes to payments and traditional fiat currency. Given these different features and how new the technology is, governments around the world are investigating whether cryptocurrencies should be taxed,

regulated, or even allowed at all. Some countries like (Singapore, Malta, El Salvador) have embraced the use of cryptocurrency while others like (Turkey, India, Bolivia) have strictly forbidden it. A polarizing feature of cryptocurrency is the lack of user information required to create a cryptocurrency wallet. For the most basic wallets, all one needs to send or receive a payment is an internet connection, a smart phone or computer, and a unique private key that can be used with the public key that is stored on the blockchain. The user does not need to provide a name, social security number, home address, or other personal information to sign up for a wallet account. A typical bank would require all this information and more. The anonymity is part of what makes these decentralized currencies so attractive; many people who have been excluded from financial institutions can finally have a way to access monetary resources because Bitcoin and other cryptocurrencies have brought on the rise of alternative types of financial institutions. There are new financial startups that rely on cryptocurrencies to provide loans, banking, and even investing options that are more inclusive than ever before. Bitcoin does not care what one's financial history or background is, making a wallet is free and users can receive use Bitcoin for loans and can even loan out their Bitcoin to make interest off of them. Although Bitcoin keeps a trail of transactions using blockchains, it is impossible to know who owns the Bitcoin in each account. This level of anonymity makes it appealing for those who want to send and receive payments privately.

Although fiat currency is an integral driver of many types of crimes, cryptocurrency invites trouble because of its anonymous nature. There is an interest in using cryptocurrency as a way to pay someone to commit a crime. The ties between cryptocurrency and its role in crimes around the world has drawn criticism from Federal Reserve Chair Janet Yellen, who stated, "I see

the promise of these new technologies, but I also see the reality: Cryptocurrencies have been used to launder the profits of online drug traffickers; they've been a tool to finance terrorism.”³

It is true that Bitcoin is a popular payment method in instances of cyber crime. Victims may be companies infected by ransomware, who must pay the ransom using Bitcoin. Most recently, Colonial Pipeline was infected by ransomware and the company paid millions of dollars in Bitcoin to the perpetrators to restore their services.⁴

Arguably, any type of currency will be used by bad actors for nefarious purposes. However, cryptocurrency poses an additional threat because of the way that the coins are created. Since no banking institution or government controls cryptocurrency blockchains, who is in charge “printing” more of a cryptocurrency? At a high level, more coins are actually created using specialized computer equipment which solves advanced puzzles that in turn create another block of coins on the blockchain that is distributed to those who participated in the mining of the block. The process from start to finish is much more involved and there are a variety of methods used to make sure blocks are created correctly and that no one can maliciously attack the network. Bitcoin transactions specifically have consensus methods that are used to make sure a transaction only happens once since transactions can take some time to propagate through all the nodes. This mining takes a lot of resources to accomplish and, the more Bitcoin that is mined, the harder the puzzles get, requiring more resources to mine blocks.

Having enough resources to mine aside, technically anyone can participate in the mining of cryptocurrencies. In the beginning, a Bitcoin could be mined using an average computer and its Central Processing Unit (CPU). However, after over a decade in existence, Bitcoin has become much harder to mine and now requires many Graphics Processing Units (GPU) or

application-specific integrated circuits (ASIC), which are much more powerful than a CPU. The process also takes much more electricity. Even though Bitcoin mining has changed over the years to become more complicated and resource-intensive, the fact that anyone can have the ability to mine coins poses potential problems for the United States' national security posture because it could undermine the economic sanctions that the United States places on other countries. Consider countries like Iran, North Korea, and Venezuela that have economic sanctions imposed upon them by the United States. If these countries can simply mine cryptocurrencies to make up for the losses, then these sanctions become ineffective. Countries and terrorist groups use Bitcoin all the time for ransoms payments, like with Colonial Pipeline, and it is plausible that these groups are interested in mining their own coins. Economic and other types of sanctions are a critical, strategic tool that are imposed based on national security needs, foreign policy, and economic policy. These sanctions can target financial assets or bar individuals from traveling.⁵ Depending on how strict the sanctions are, it would be understandable why a country would consider mining cryptocurrencies to mitigate the impact of the sanction, especially by obtaining and selling items without the hindrance of a trade embargo. Considering how the value of cryptocurrency have increased significantly in the past year, mining could potentially be a more profitable venture than trying to exporting goods that are being sanctioned. However, in this scenario, there are other factors to consider. Sanctions could make it difficult for the country or group to obtain the equipment and resources required to mine the coins, e.g., bringing in the GPUs or ASICs, electricity, and internet. If they are able to acquire the equipment and resources, then the question would be whether or not it is profitable when you weigh the cost of mining compared to how much the sale value of the Bitcoin. The method

of mining can also impact profitability. There are generally two ways to mine cryptocurrencies: proof-of-work, which can be very energy intensive, and proof-of-stake, which puts more mining power onto miners that have more coins. Bitcoin uses proof-of-Work, which is more energy intensive and therefore more expensive method of mining.⁶

To find if countries would have the resources to mine cryptocurrencies to replace revenue lost from sanctions, statistical analysis on data collected on resource availability will be performed to see if there are any relationships between resource availability and sanctions. Claims of countries currently mining Bitcoin to avoid sanctions will be analyzed as well to see if mining is working as a real world solution. The data collected on a country's resources is combined into a single dependent variable while the independent variable is whether or not a country is sanctioned. The sanction data for this research was gathered from the United States Treasury Department and this research will only focus on sanctions that are being placed on by the United States. Since sanctions and smart sanctions are issued frequently from the United States, and members from several levels of the government like the Treasury and the Federal Reserve are making statements concerning terrorism and Bitcoin, this sanction data was the focus of this research. This sanction were captured for the same time period of fifteen years as the other variables in this research. Cryptocurrencies are also a hotly debated topic for the United States Government, but in other countries, most decisions regarding their use have already been made and many countries support them. Other control variables were included to perform multivariate regression. Using statistical analysis methods of multivariate regression, bivariate regression, and correlation analysis, results will be recorded to see if countries with sanctions are less or more likely to have the resources needed to mine Bitcoin. If there is a

correlation that is positive between the variables, then mining Bitcoin could possibly be a solution for replacing revenue from sanctions. On the other hand, if the correlation is negative with a significant P-Value, then access to resources might be more expensive than the revenue that Bitcoin could bring in. The outcome of this analysis will be the primary factor to determine whether mining Bitcoin would be a suitable way for a country to avoid the effects of sanctions.

It is unclear what the possible impact of cryptocurrency would be on current financial systems and national security policies because of how new this technology is compared to the long history of the United States Dollar, as well as the fact that every day there are new cryptocurrencies coming online and new ways to mine coins. The primary focus of this research will be Bitcoin and its mining method, proof-of-work. Since Bitcoin is the most popular cryptocurrency and the most valuable, countries are mostly likely to consider it as a way to avoid sanctions. However, based on how involved and resource-intensive a mining operation would need to be and how fewer rewards are given over time, mining Bitcoin is not a suitable way for countries to avoid or circumvent sanctions.

LITERARY REVIEW

The overall goal of this research is to find if there is a relationship between countries that the United States has placed sanctions upon and whether these sanctioned countries possess the resources needed for cryptocurrency mining. Since there are over 4000 cryptocurrencies in circulation, and because Bitcoin is the original, most popular, and most valuable form of cryptocurrency, this research specifically focuses on mining Bitcoin. In order to make any sort of judgement on what benefits Bitcoin mining could bring to a country, one must understand the basics of Bitcoin. To determine whether mining for Bitcoin is profitable, consider the value of how much is being mined with the cost of the computer hardware and utility resources required to mine, which can increase over time. In addition, each cryptocurrency has its own rules on how many coins can be mined, what the rewards are for mining, how difficult it is to mine, and the technique used to mine.

Next, it is critical to understand the impact of sanctions on countries and how the United States uses them to further the national interest. The United States, European Union, and the United Nations are the main groups that place sanctions on countries. Sanctions are an ever-increasingly popular method of punishment for countries, and are placed on countries and individuals using a technique called “smart sanctions”, which are just sanctions that are targeted and placed on individuals and prevents just that person from accessing whatever it is the sanctions are placed on.⁷

Finally, recent Bitcoin mining news and potential mining activity in a country that is under sanction will need to be reviewed in order to see if there are any real-world events that could contribute to the research. Cryptocurrencies are constantly evolving, just like the code

they are written in, and many countries are still trying to create laws for them. Some countries have chosen to ban these currencies, wanting nothing to do with them. On the other hand, some countries have adopted cryptocurrencies, like El Salvador. El Salvador was the first country in the world to fully accept Bitcoin and welcome miners to the country.⁸ Due to the ever-changing international opinion of cryptocurrencies, it is important to find as many up-to-date sources as possible when it comes to this topic.

Bitcoin White Paper and Bitcoin.org

The Bitcoin white paper explains the goal of Bitcoin and how the whole system works. Bitcoin was envisioned as a peer-to-peer payment system where financial institutions do not control how payments are processed. The white paper identifies problems in the current online payment system, explaining that it is trust-based, slow, passively accepting of fraud, and able to reverse payments. The white paper claims that this new peer-to-peer system fixes these problems by providing a system that is more secure, fast, and based on cryptographic proof; which is just a way to prove transactions are valid.⁹ The Bitcoin white paper defines how transactions are verified, how the network is hosted, what the incentives are for mining, and how the proof-of-work mining system works. The Bitcoin white paper defines how a computer's computational power is used to create a new block of Bitcoins. The Bitcoin white paper is the best choice of literature for learning about the goals of the Bitcoin project since it is the start of all cryptocurrencies and sets the basis for what it means to mine cryptocurrency. The Bitcoin white page and everything else related to Bitcoin is centrally located on bitcoin.org. Bitcoin.org is also a resource for aspiring miners who are ready to get started with mining Bitcoin, learn what it takes to set up a profitable mining operation, and how to set up their own Bitcoin node.

World Bank Database

The World Bank Database was used to obtain data on the resources that a country would need if they were to setup a mining facility. Data points of each of the important resources needed for Bitcoin mining for each country in their database was needed. The data ranged from 2006 to 2020 to cover the time before Bitcoin was released to the time when Bitcoin started to become mainstream because financial institutions started adding Bitcoin to their balance sheets. Since proof-of-work mining is energy intensive, the most important data is related to electricity and renewable energy sources. In addition to a country's electrical capabilities, other useful data would include access to broadband internet and some other financial factors that would enable a country to be able to mine Bitcoin. Although the data on Bitcoin's blockchain is accessible, it is difficult to ascertain the physical location of a given mining operation. It would be possible to find IP addresses of the members of the pool, however they could be using a Virtual Private Network (VPN), obscuring their true physical location. This is the main purpose of a decentralized platform, to be anonymous and provide access to financial resources no matter one's financial status.

An IBM® SPSS® Companion to Political Analysis

The SPSS Companion was used to conduct multivariate regression to test whether there is any relation between the dependent and independent variables. The variables used here come from the data that was collected from the World Bank Database on each country's important Bitcoin mining resources over a 15 year period. To find any potential relationships between access to mining resources and whether a country is being sanctioned, the data must undergo a correlation analysis. The correlation analysis is done best using the SPSS Companion in

conjunction with the SPSS Statistics application. In this scenario, Pearson's correlation coefficient is the best way to measure the strength of the relationships between the dependent and independent variables. All of the dependent variables' relationships are compared to the independent variable of sanctions using multiple variant regression. The SPSS application will display the correlation value in a separate table and will easily identify any relationships.

Economic Sanctions and International Law

It is critical to review literature that explains how countries like the United States and governing bodies like the United Nations (UN) use sanctions against countries and individuals. *Economic Sanctions and International Law* explains the purpose of sanctions and how they are implemented and enforced.¹⁰ Researching how countries and individuals can avoid sanctions would clarify whether or not there is a need to find an extreme way to establish new revenue sources. The book dives into specific cases and laws that sanctions operate under and describes well-known sanctions like ones against Iran and Syria. *Economic Sanctions and International Law* also points out problems with sanctions and how they can lead to a humanitarian crisis. To truly understand the independent variable of sanctions, research on how they are implemented and enforced is key.

Bitcoin Mining and its Energy Footprint

Bitcoin Mining and its Energy Footprint describes a study conducted at Hamilton Institute National University of Ireland Maynooth by Karl J. O'Dwyer and David Malone.¹¹ The study explores how much energy is used to mine Bitcoin, the environmental impact of this mining, and how much profit, if any, is available to miners. The profit available is an important question because of how it would determine whether Bitcoin mining would be a viable enough

revenue source for countries that are under sanctions. This study explains the most efficient equipment and energy sources to counter costs with mining and to increase profits. These days, there are so many active miners and the rewards for the blocks mined are diminishing. To be competitive, miners need newer and quicker hardware as well as a sustainable way to provide power to this hardware. Without these resources, profitability is compromised because the rewards of mining may be outweighed by the total cost of mining.

Allegations of Iran is mining Bitcoin to avoid sanctions

An article by blockchain analytics firm, Elliptic, inspired the research to determine whether Bitcoin was a viable solution to avoid sanctions. Iran's alleged activities described in the article is one of the most recent examples of claims that Bitcoin mining is being used to lessen the impact of economic sanctions.¹² The article bases its conclusion on an analysis of Bitcoin's blockchain as well as the IP addresses of participants in a mining pool. The article was published in 2021 during a period time in which Bitcoin and other cryptocurrencies reached an all-time high in market capitalization value, and interest in Bitcoin was also at its highest levels based on its blockchain activity. Analyzing Bitcoin's blockchain is difficult given that miners and nodes could be using a VPN, which the article seems to concede by saying, "Exact figures are very challenging to determine."¹³ Their research outlines how Iran could use its oil surplus to provide the energy needed to mine the Bitcoin and the possibility that the country could learn from China about mining since the two countries have a close relationship. The conclusion of this article is a good spring board for some of the claims that sanctions can be avoided, and this research will attempt to dispute such claims.

Recent News Stories Involving Crypto

Since the news and even the prices of cryptocurrencies change drastically every day, especially in 2021, it is important to focus on recent events since Bitcoin and other cryptocurrencies are at their most popular. China has taken a hard stance on Bitcoin and other cryptocurrencies and in 2017 declared that it is not a legitimate currency. While China is not sanctioned by the United States, they are considered a large threat and, if they wanted, they could be large players in the cryptocurrency market given that large mining operations take place in China. Since this announcement in 2017 did not specifically ban mining, mining still occurred until early 2021. The different approaches to cryptocurrencies between the China and the United States might offer some insight as to what countries that are sanctioned might want to consider whether they should allow mining or not. In addition, countries that are sanctioned and friendly with China might follow China's lead, even though they could be in a good position to mine. In 2021, China finally started enforcing their cryptocurrency mining ban which led to an exodus of Bitcoin miners from China has made mining Bitcoin a little easier since there are less miners in the pools. The miners may bring their mining operations with them to new countries, , which could give sanctioned countries some experienced resources.

There are many large Bitcoin mining facilities or "farms" in the world and some of the largest will also be analyzed. Seeing what it takes to mine a large number of Bitcoins would be useful to compare what countries would need to do to run a profitable operation. Before China banned mining, some operations were mining hundreds of Bitcoins a month and, since China manufactures most ASIC equipment, it was much cheaper to create mining farms in China. The

ability to mine hundreds of Bitcoins a month could, depending on the price, result in hundreds of millions of dollars a month.

Although the focus of this research involves Bitcoin, it is important to see what other cryptocurrencies are coming online and see if they might be easier to mine or offer better solutions to countries looking to cryptocurrencies to avoid sanctions; although these other cryptocurrencies might not be worth as much as Bitcoin right now, they very well could be worth much more one day in the future.

METHODS

To gain an understanding of what it would take for a country to first establish a Bitcoin mining operation, mine Bitcoin, and then make a profit, the Bitcoin White Paper and Bitcoin.org, the project's website, was extensively reviewed. The Bitcoin White Paper and Bitcoin.org outlines what it takes maintain a Bitcoin node and mine the blocks. Nodes are computers that have the Bitcoin software and database installed and help host the Bitcoin network. Setting up Bitcoin mining operations is not a new concept, and there are many Bitcoin mining companies around the world, and it is not inconceivable to make money from mining because many miners do, or else it would not be done. Mining cryptocurrency like Bitcoin takes three basic elements: electricity, an internet connection, and either a Central Processing Unit (CPU) or Application Specific Integrated Circuit (ASIC). Mining might seem simple and, in the beginning, it was; one could mine for Bitcoin on an average computer. However, the more Bitcoin that is mined and the more miners there are, the harder mining a block of Bitcoins become. Nowadays, one would need a lot of these resources and space to mine in order to have enough hash power, which is just the combined computational power of a miner, to earn enough Bitcoin to pay for these resources and turn a profit. In addition, the number of Bitcoins that can be mined is cut in half about every four years, meaning the rewards for mining are consistently deteriorating.¹⁴ Of course, any country hoping to circumvent sanctions would need reliable access to electricity, internet, and computer equipment for mining operation large enough to offset money lost due to sanctions. In this study, the dependent variable is the combination of these resources from the World Bank Database and the independent variable is whether a country has sanctions imposed on it by the United States.

The most important resource to Bitcoin mining would be access to a steady supply of electricity. Since the cost of electricity would eat into any profits from mining, and the profits from mining Bitcoin decreases over time, the electricity supply would be most efficient if it came from some sort of renewable energy source. Since proof-of-work mining requires so much energy, blackouts are common; blackouts create downtime that will negatively affect profits as well as attract unwanted attention from the government. Efficacy is why access to electricity and the percentage of electricity that comes from renewable resources variables were selected. Developed countries that have a well-established electrical grid or have high levels of renewable energy output will have a much better chance than a less developed country of a higher margin of profit.

In addition to electricity, having access to a broadband internet connection is necessary to join mining pools and participate in mining. Just like the electricity variables, the more reliable the internet connection, the more mining that can occur. Internet usage is represented by the fixed broadband subscriptions variable, which will give a good idea of how connected a country and its citizens are to the internet. Access to the internet is also important to users who store Bitcoin funds in a wallet application because most wallet applications are web-based or mobile-based. The variables, mobile cellular subscriptions and individuals using the internet, can give an idea of how much of the population could transact using Bitcoin. While the Bitcoin would most likely be sold to an exchange for a traditional fiat currency and then used for imports, it is worthwhile to consider that Bitcoin may not be exchanged and instead could be disseminated to a country's citizens and used by a country or individual to purchase goods. Trade as a percentage of Gross Domestic Product (GDP) and overall GDP, is used to give an idea of how easy it would

be to procure some of the specialized computer equipment and other building supplies needed to set up mining facilities. Mining enough Bitcoin to sustain a country would take many GPUs and a fairly large infrastructure to house them.

Due to Bitcoin's decentralized and anonymous nature, it is difficult to tell how many coins have been mined from what countries and the physical locations of the wallets storing Bitcoins. Bitcoins can also be placed into "cold storage," where the Bitcoin is placed on a thumb drive and removed from the Bitcoin network which can add to the complexity of tracking the coins and seeing exactly where they came from and what they are being used for. While Bitcoin's immutable blockchain records all transactions, there is not much data to indicate where the coins or Bitcoin nodes are located. Furthermore, coins can be split into smaller parts and these parts can be split among many different wallets. Since coins are mined by large groups of individuals or pools, the Bitcoin rewards are typically split among the pool, making it even more difficult to determine the coin owner's location. These pools are used to combine resources to make mining quicker and thus the focus will be put on the elements needed to participate in a pool. In addition, the use of VPNs to obscure a miner's location eliminates the possibility of determining location based on IP addresses. The only connection on the Bitcoin blockchain between a user and their coins is their wallet's address. However, the wallet's address is but a string of random numbers and letters and doesn't provide metrics from which variables can be created. Nevertheless by using the resources to mine Bitcoin, it is still possible to make a reasonable prediction as to whether or not countries could use Bitcoin mining to recuperate losses brought on by sanctions.

Whether or not it is practical for countries to implement mining to avoid sanctions, countries are attempting to do so according to a recent case study by Dr. Tom Robinson. In the case study, Dr. Robinson focused on the current mining activity in Iran. The case study explored if Bitcoin mining is helping Iran's economy and investigated whether their alleged practices could work in other parts of the world. Cryptocurrency mining in general is extremely popular in Iran and the country does have a large source of energy: oil. In addition, there are many miners looking for new places to set up their mining operations. For example, China recently banned crypto mining and so many of the miners who operated in China have fled the country, bringing their mining operations with them. Before the ban, China accounted for a majority of Bitcoin mining activity. Miners who fled China could be lured to countries like Iran and bring their equipment and expertise with them. The mining activity and the events in China leading to miner exodus will be analyzed and any clear findings will be combined with data analysis to reasonably predict whether or not a country can mine Bitcoin to overcome sanctions.

Finally, and most importantly, the study included several variables that describe how a country's financial system functions. These variables were included so that the study could explore the possibility that Bitcoin might more than the ability to undermine sanctions. For example, the study included variables like inflation to explore if Bitcoin would be a better option to replace a country's existing currency. Since Bitcoin doesn't suffer from inflation given its fixed supply, if a country has an out-of-control inflation rate, then mining and using Bitcoin could be a much better option. Multivariate regression was used to find any relationships that may exist between the dependent and the independent variables. Specifically, sanctions were selected as the independent variable and was run against the other dependent variable to

determine if there are any significant correlation between them. Then, the variables were put through bivariate regression and multivariate regression analysis. The specific variables names and types are defined in Table 1 below.

Table 1 (Variable Names and Types)

Variable Name	Variable Type	Explanation
Sanctions	Independent	Whether or not a country is sanctioned
MiningAbility	Dependent	Combination of resources that would be needed to mine and access Bitcoin
Inflation	Control	External factor for multivariate regression
Unemployment	Control	External factor for multivariate regression
Current GDP	Control	External factor for multivariate regression
Variables Added Together to Make Dependent Variable		
Renewable Electrical Output	Part of Dependent	Added together to make dependent variable
Access to Electricity	Part of Dependent	Added together to make dependent variable
Broadband Subscriptions	Part of Dependent	Added together to make dependent variable
People using the Internet	Part of Dependent	Added together to make dependent variable
Trade Percentage of GDP	Part of Dependent	Added together to make dependent variable
Cell Phone Subscriptions	Part of Dependent	Added together to make dependent variable

RESULTS

Once the data collected from the World Bank Database was run through multivariate and bivariate regression using the IBM® SPSS® application, the following outputs were produced.

Table 2 (Bivariate Correlation Analysis)

		Sanctions	MiningAbility
Sanctions	Pearson Correlation	1	-0.008
	Sig.		0.742
	N	3255	1653
MiningAbility	Pearson Correlation	-0.008	1
	Sig.	0.742	
	N	1653	1653

Table 3 (Bivariate Regression Analysis - Coefficients)

Model	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	35247494.7	282410.44		12.481	0.000
Sanctions	-8241567.6	25056076.7	-0.008	-0.329	0.742

Table 4 (Multivariate Regression Analysis - Coefficients)

Model	Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	19165110.3	5573049.5		3.439	0.001
Sanctions	290378.316	26279841.3	0.000	0.011	0.991
Inflation	1297475.86	520741.327	0.061	2.492	0.013
Unemployment	-1049667.5	447842.692	-0.056	-2.344	0.019
CurrentGDP	4.184E-05	0.000	0.652	27.454	0.000

Based on the bivariate and multivariate regression analysis, it is clear that sanctions do not seem to play a large, if any, role in whether a country has the resources to mine Bitcoin. In both Table 3 and Table 4, the “Sig.” for the independent variable is much greater than the 0.05 threshold, meaning that this is not statistically significant.¹⁵ In Table 4, the control variables showed to have much more significance to the dependent variable than what sanctions had. Inflation, unemployment, and GDP had a much more significant impact on MiningAbility than sanctions. This result is also backed up by the t-ratio, which all variables except sanctions exceeded the significant “t” value of 2.¹⁶ The same conclusion was made using the correlation table (Table 2). Again, the “Sig.” for MiningAbility was not significantly effected by sanctions being well above the 0.05 threshold. With this analysis, it is clear that sanctions does not play a role in whether or not a country has the resources to mine Bitcoin. While this analysis does not exactly support the thesis of this research that sanctioned countries cannot mine Bitcoin in order to make up for lost revenue, it does highlight how hard mining really is. The results appear to confirm that there are many factors that effect Bitcoin mining and much of the world does not have strong resources to perform it, including countries that are being sanctioned.

Trade is also an important factor to consider; for example, unless a country manufactures a steady amount of their own graphics cards or specialized hardware, then the country must obtain such resources through trade in order to support an effective Bitcoin mining operation. Other required materials include construction equipment, building supplies, etc., to build facilities to store the mining equipment and provide a working space for the miners. In addition, Bitcoin mining is energy-intensive, and so additional equipment would be needed to meet the demand for energy. Case in point: One of the largest Bitcoin mines in the world, located in Russia, uses an estimated 3,000 ASIC miners to mine 600 Bitcoins per month.¹⁷ Depending on the current Bitcoin price, this could mean revenue in the tens of millions of dollars a month. Naturally, the better and newer the GPUs or ASICs, the faster a mine can help generate a block and turn a profit. Big mines like the one in Russia would have the ability to update their equipment, the money to do so, and the ability to easily procure equipment. A country would need to procure state of the art equipment to have an effective mining operation because older equipment will be unable to achieve a fast enough hash rate to compete. From the data analysis, GDP plays a significant role in the resources needed for mining.

Another variable that showed as having strong significance was inflation. A country's inflation rate could lead to an incentive for Bitcoin mining or at least some Bitcoin ownership. Since Bitcoin has a fixed supply, it is more resistant to inflation and could be a better store of value than a sanctioned country's fiat currency, which can be printed whenever the government sees fit. Historically, gold has often considered by many to be one of the best inflation hedges even though the data shows that is not always the case, however many people now believe Bitcoin could overtake gold as a better store of value.¹⁸ In the case of some other

cryptocurrencies, it is beneficial to hold onto the coins for proof-of-stake mining. Instead of the control of how blocks are verified going to the users with the highest CPU output, proof-of-stake gives controls to the users with the most coins in their wallets. Proof-of-stake mining is not in Bitcoin's future right now, but this might give incentive to hold on to other currencies. Although holding Bitcoin as a long-term investment would be unhelpful in avoiding sanctions in the near term, this could still be a long-term play for countries whose future is uncertain.

Most likely, the greatest obstacle for countries to mine Bitcoin would be the extreme price movement Bitcoin has experienced throughout its lifetime. It should be noted that a low Bitcoin market capitalization and a low mining interest could make mining more profitable for countries, but also, an unexpected extreme increase to Bitcoin price and interest could quickly make mining unprofitable. Depending on the current price of Bitcoin, and depending on how much was spent to mine the blocks, there could be certain days where a profit is made and other days where more money was spent mining than made. The unpredictable daily profit and high risk of losing money could make this process less appealing for countries. However, countries that have more renewable sources of energy would have lower costs to mining and therefore would be able to have better margins and more room for price movements and increased pool sizes. Although mining or using Bitcoin would not be ideal, given the conclusions from the resources data, other cryptocurrencies might fit some need to avoid inflation problems that arise from using fiat currency.

Although the data in this research indicates that mining is difficult for most countries or not even a good idea in general for undeveloped countries, it is clear that sanctioned countries are actively attempting to mine for Bitcoin to generate revenue anyway.¹⁹ For example, Iran

does not have a renewable energy source, but they have abundant oil resources that can be used to generate enough electricity to support a Bitcoin mining operation. Iran's access to oil could keep mining costs down, as could other countries that also have access to an abundance of energy resources like oil. According to the blockchain analytics company, Elliptic, Iran accounts for roughly 4.5% percent of Bitcoin mining activity. Miners are required to have a license and sell their Bitcoin to Iran's Central Bank, which they in turn use to buy imported goods.²⁰ Dr. Robinson claims, "Iran has recognized that Bitcoin mining represents an attractive opportunity for a sanctions-hit economy suffering from a shortage of hard cash, but with a surplus of oil and natural gas."²¹ While this real world example contradicts the data in this research, Dr. Robinson's posits that having an abundant energy source like oil could help countries avoid sanctions using mining. Since sanctions are impacting Iran's ability to export oil to other countries, Iran could instead sell energy to the licensed Bitcoin miners; undermining sanctions in this way could be a practical solution for countries sanctioned in the Middle East and elsewhere. For instance, Venezuela could undermine the economic sanctions placed upon them using Iran's alleged practices because Venezuela is also very rich in oil. While countries like Iran and Venezuela might have an advantage over other countries with fewer natural energy resources, it is unclear how much each country's citizens would benefit from their country's mining operations. Since miners in Iran are required to sell their Bitcoin to the Iranian government, average citizens that are trying to make a livable wage mining Bitcoin for themselves and their family are often shut down by the authorities.²² Given the immense power usage mining requires, it is pretty obvious what is happening when there is a spike in electricity usage in a home that had not been occurring before.

Sanctioned countries could still set up mining facilities and make some money off of the process, but the results indicate that it might be difficult to make a real profit. Especially now when there is so much interest in mining, the mining puzzles themselves are more difficult and therefore the rewards are less. Nevertheless, mining could be easier for these sanctioned countries during periods of decreased mining activity, drops in Bitcoin's price, or both. When it comes to Bitcoin and other cryptocurrencies, the data is changing so often that a conclusion on one day might not hold up to the next. It is true that Bitcoin and decentralized cryptocurrencies in general could theoretically be used to avoid sanctions and fund activities that threaten the United States' national security posture. However, based on this data available, it is not an immediate threat when concerning sanctioned countries; that is not to say that this would not be possible one day. Other cryptocurrencies have plans to switch from proof-of-work to proof-of-stake to lessen the power resources needed to mine. While this might not be in Bitcoin's future, the flexibility of other cryptocurrencies is treated than what traditional fiat currency can provide. Furthermore, it is even less likely that sanctioned individuals would mine Bitcoin to avoid sanctions due to the amount of resources required to mine.

DISCUSSION

Since the data used in this research predates Bitcoin, one might think that if these sanctioned countries were setting up mining operations to combat sanctions, that sanctioned countries would have a more significant relationship with the resources needed to mine. However, Bitcoin, cryptocurrencies, and other blockchain-based platforms are in their infancy; so, they could play a larger role in the future in countries avoiding sanctions or could pose a greater threat to the United States' National Security posture. Even though the research showed that mining Bitcoin might not be ideal for countries with or without sanctions, that doesn't mean sanctions couldn't be avoided with another type of cryptocurrency. Many other cryptocurrencies are easier to mine and some even have "level 2" capabilities, which means they can be used to write contracts in the code and create web applications using smart contracts, which are just collections of code that are stored on the Ethereum blockchain.²³ For example, Non-Fungible Tokens (NFTs) use smart contracts and have sold for millions of dollars' worth of Ethereum. NFTs are another route for countries to make money and, while it might not be through Bitcoin, Ethereum is still valuable and considered the second-best cryptocurrency after Bitcoin. Since Bitcoin and Ethereum wallets have no way to point back to who owns them, sanctioned countries could make money by buying and selling NFTs. The proceeds would go to an anonymous wallet with no connection to anyone or any government.

Although these wallets are anonymous and sometimes tied to nefarious activities, it is not guaranteed that paying criminals with funds from wallets containing cryptocurrency will completely shield criminals from justice. In the case of Colonial Pipeline, the United States was able to recover most of the Bitcoin used for the ransom by seizing the wallet's private keys. The

fact that most of the ransom was recovered is a prime example that it is possible to combat crime and terrorism funded by cryptocurrency. The United States and other governments have developed methods to combat these crimes and it is possible that it is easier to recover Bitcoin as opposed to other traditional fiat currency because fiat currency could be stashed anywhere in the world but Bitcoin is always in one place — the internet — and can be Bitcoin could be accessed from anywhere. These tactics of recovering private keys and seizing wallets is really the best way to defend from these attacks, and any future National Security policy should focus on these abilities. Since stopping a global financial system that is not run in a central location would be just as impossible as stopping any other type of currency from circulating, having policies in place that would make seizing something like digital private keys easier and working with governments to make sure they assist in recovering these keys would be the best course of action for now. The popularity for cryptocurrencies will grow especially with younger generations and this should be taken into policy consideration as well. When more people find how easy it is to exchange money and get loans through blockchains, this could lead to a less enticing United States Dollar which could risk its destabilization. Educating Americans on some of the dangers and benefits of Bitcoin, but also the benefits of a fiat currency could help ease some fears of this exodus from traditional currency and make Bitcoin less appealing for terrorism.

There is no doubt that, like traditional fiat currency, cryptocurrencies will be used to fund illegal activities, and cryptocurrency can sometimes be easier to come by than traditional fiat currency. However, cryptocurrencies should not be sensationalized to the point where people think that is easy to create from scratch and can undermine any currency or laws. There was plenty of terrorism and illegal activities that occurred before Bitcoin was invented and it would

continue even if it never was. Even though Bitcoin is anonymous, governments around the world including the United States have demonstrated that Bitcoin used in crimes can be recovered. While it is unclear how the United States obtained the private keys to the Bitcoin wallet, it can happen. Further, the use of Bitcoin did not protect the perpetrator from the law. This research has shown that it takes a great deal of resources to mine Bitcoin and it is not an easy, foolproof way to make money. Even though the user is not required to share personal details to make a Bitcoin wallet, that does not mean that the Bitcoins in the wallet are hidden forever by unknown criminals because the wallet can still be tracked. This conclusion might hold for now, but the ever-changing landscape of cryptocurrencies and blockchains could very well make these technologies more anonymous and therefore more appealing to terrorists or countries avoiding sanctions. Bitcoin has managed to escape regulatory scrutiny for the past decade, but with its rising popularity, those days seem to be coming to an end. Bitcoin and cryptocurrencies in general will continue to gain popularity and bring about new technology and new capabilities that will have positive effects for many industries. For now, Bitcoin may sometimes be used to commit crimes, but that does not mean it is something to be feared. Bitcoin, blockchains, and anything else related to these decentralized platforms could arguably be one of the greatest inventions since the internet and having world changing aspects to them. This technology is very different and this research only covered some of their capabilities. One thing is certain, this technology is here to stay and this is just the beginning.

REFERENCES

- Becky. (2021). Where on earth are the biggest Bitcoin farms? Retrieved from: <https://www.coininsider.com/biggest-bitcoin-farms/>
- Buterin, Vitalik. (2013). Ethereum Whitepaper. Retrieved from: <https://ethereum.org/en/whitepaper/#ethereum-whitepaper>
- De, Nikhilesh. (2021). Crypto Use in Terrorism ‘a Growing Problem,’ Yellen Says. Retrieved from: <https://www.coindesk.com/crypto-use-in-terrorism-a-growing-problem-yellen-says>
- Eden, Paul. Happold, Matthew. Economic Sanctions and International Law. Hart Publishing, 2016.
- Edwards, Barry C. Pollock III, Philip H. An IBM® SPSS® Companion to Political Analysis. SAGE Publications, 2019.
- Iacurci, Greg. (2021). Gold as an inflation hedge? History suggests otherwise. Retrieved from: <https://www.cnbc.com/2021/06/08/gold-as-an-inflation-hedge-history-suggests-otherwise.html>.
- Malone, David. O’Dwyer, Karl J. Bitcoin Mining and its Energy Footprint. Hamilton Institute National University of Ireland Maynooth, 2014.
- Nakamoto, Satoshi. (2009). Bitcoin: A Peer-to-Peer Electronic Cash System. Retrieved from: <https://bitcoin.org/bitcoin.pdf>
- Renteria, Nelson. Strohecker, Karin. Wilson, Tom. (2021). In a world first, El Salvador makes bitcoin legal tender. Retrieved from: <https://www.reuters.com/world/americas/el-salvador-approves-first-law-bitcoin-legal-tender-2021-06-09/>
- Robinson, Dr. Tom. (2021). How Iran Uses Bitcoin Mining to Evade Sanctions and “Export” Millions of Barrels of Oil. Retrieved from: <https://www.elliptic.co/blog/how-iran-uses-bitcoin-mining-to-evade-sanctions>
- Schmidt, John. Tretina, Kat. (2021) Top 10 Cryptocurrencies In June 2021. Retrieved from: <https://www.forbes.com/advisor/investing/top-10-cryptocurrencies/>
- Wilkie, Christina. (2021). Colonial Pipeline paid \$5 million ransom one day after cyberattack, CEO tells Senate. Retrieved from: <https://www.cnbc.com/2021/06/08/colonial-pipeline-ceo-testifies-on-first-hours-of-ransomware-attack.html>

ENDNOTES

¹ Nakamoto, Satoshi. (2009). Bitcoin: A Peer-to-Peer Electronic Cash System. Retrieved from: <https://bitcoin.org/bitcoin.pdf>

² Schmidt, John. Tretina, Kat. (2021) Top 10 Cryptocurrencies In June 2021. Retrieved from: <https://www.forbes.com/advisor/investing/top-10-cryptocurrencies/>

³ De, Nikhilesh. (2021). Crypto Use in Terrorism ‘a Growing Problem,’ Yellen Says. Retrieved from: <https://www.coindesk.com/crypto-use-in-terrorism-a-growing-problem-yellen-says>

⁴ Wilkie, Christina. (2021). Colonial Pipeline paid \$5 million ransom one day after cyberattack, CEO tells Senate. Retrieved from: <https://www.cnbc.com/2021/06/08/colonial-pipeline-ceo-testifies-on-first-hours-of-ransomware-attack.html>

⁵ Eden, Paul. Happold, Matthew. (2016) Economic Sanctions and International Law. Hart Publishing.

⁶ Malone, David. O’Dwyer, Karl J. Bitcoin Mining and its Energy Footprint. Hamilton Institute National University of Ireland Maynooth, 2014.

⁷ Eden, Paul. Happold, Matthew. (2016)

⁸ Renteria, Nelson. Strohecker, Karin. Wilson, Tom. (2021). In a world first, El Salvador makes bitcoin legal tender. Retrieved from: <https://www.reuters.com/world/americas/el-salvador-approves-first-law-bitcoin-legal-tender-2021-06-09/>

⁹ Nakamoto, Satoshi. (2009).

¹⁰ Eden, Paul. Happold, Matthew (2016)

¹¹ Malone, David. O’Dwyer, Karl J.(2014)

¹² Robinson, Dr. Tom. (2021). How Iran Uses Bitcoin Mining to Evade Sanctions and “Export” Millions of Barrels of Oil. Retrieved from: <https://www.elliptic.co/blog/how-iran-uses-bitcoin-mining-to-evade-sanctions>

¹³ Robinson, Dr. Tom. (2021).

¹⁴ Nakamoto, Satoshi. (2009).

¹⁵ Edwards, Barry C. Pollock III, Philip H. An IBM® SPSS® Companion to Political Analysis. SAGE Publications, 2019.

¹⁶ Edwards, Barry C. Pollock III, Philip H. (2019)

¹⁷ Becky. (2021). Where on earth are the biggest Bitcoin farms? Retrieved from: <https://www.coininsider.com/biggest-bitcoin-farms/>

¹⁸ Iacurci, Greg. (2021). Gold as an inflation hedge? History suggests otherwise. Retrieved from: <https://www.cnbc.com/2021/06/08/gold-as-an-inflation-hedge-history-suggests-otherwise.html>.

¹⁹ Robinson, Dr. Tom. (2021).

²⁰ Robinson, Dr. Tom. (2021).

²¹ Robinson, Dr. Tom. (2021).

²² Robinson, Dr. Tom. (2021).

²³ Buterin, Vitalik. (2013). Ethereum Whitepaper. Retrieved from: <https://ethereum.org/en/whitepaper/#ethereum-whitepaper>