Source Evaluation #4

**Research Question:** How does cryptocurrency affect our global climate?

**Citation:**

Goodkind, Andrew L. et al. " Cryptodamages: Monetary value estimates of the air pollution and human health impacts of cryptocurrency mining". *Energy Research & Social Science*, Elsevier, 2019, https://doi.org/10.1016/j.erss.2019.101281.

**Information on the Authors:**

Andrew Goodkind is currently an Assistant Professor of Economics at the University of New Mexico. He has a Ph. D. in Economics from the University of Minnesota's Department of Applied Economic. His expertise is in agricultural supply chains and associated environmental impacts, as well as modeling and estimating human health impacts of air pollution to evaluate and design air pollution reduction policies.

Benjamin A. Jones is currently an Assistant Professor of Economics at the University of New Mexico and has faculty affiliations at the University of Oklahoma's National Institute for Risk and Resilience, as well as the University of New Mexico's Sustainability Studies Program. In 2021, he was interviewed by BBC World News on the environmental impacts of Bitcoin.

Robert Berrens is a Professor in the Department of Economics at the University of New Mexico and has been since 1994. His expertise as an environmental economist is in microeconomics, economics of higher education, environmental economics, and contemporary water resources issues.

**Summary of Paper:**

The authors of this paper explore the idea of estimating the per coin economic damages of air pollution emissions that cryptocurrency generate. The main argument that is made is that Their focus is mainly on America and China, as they compare mining conditions and how impactful mining is to these different regions. They begin their paper with an abstract introduction that contains a brief overview of their paper and how various cryptocurrencies (including those outside of Bitcoin) are adding to the global warming crisis. They then offer a larger introduction/background paragraph, which brings up benefits of cryptocurrency such as decentralization, security, independence, and ease of generation. A history of Bitcoin is also given; starting in 2009 with the mysterious founder of Bitcoin named Nakamoto and ending with the state of Bitcoin in the present. However, the most important part of information that the authors bring up in their information is the exact process of how bitcoin mining uses energy, and therefore is exhausting carbon emissions. As mining hardware and software get more intensive, the amount of power they need rises exponentially, resulting in the cryptocurrency energy issue they regard throughout their essay.

The next part of their paper highlights their case study. They explain that they collected data on emission rates of electricity by country (namely America and China), specifically looking at four pollutant gasses found by burning fossil fuels. They then combined the rates at which they found these particles in the air with the amount of electricity used to mine a coin (a single unit of cryptocurrency) at that time. This resulted them with a value for the average emissions released (including renewable energy sources) to generate one coin. This is also one of the more useful methods that the authors use – they create a model that readers can understand: how detrimental mining just one coin of cryptocurrency is. This data can be then scaled to the number of coins mined to see the true impact on our environment. The authors also do explain the results of their study, such as how impactful the number of particulates in the air are to humans (human exposure calculations), and how much bitcoin mining specifically is contributing to this. The authors also go one step further to explain mortality impacts per unit of emissions and connect this to their emissions per coin estimate.

The third paragraph of their paper is their analyses and conclusions of their conducted study. Some information is expected and was referenced in the previous paragraph, such as applying the mortality indexes and rates of coins mined to real-world population datasets. They also go through a multitude of different representations of mining a coin, for example, by the end of 2018 one coin was estimated to cost around $3,700 in damages, around half of which was from mortality impacts and the other half from climate impacts. There are also data representations given in charts and graphs for a visual experience.

The last paragraph is the authors conclusions. This closes off their paper by summing up all the different topics and figures they had previously mentioned into one large summarization. They consider both the economic and social sides of cryptocurrency mining, and briefly talk about some limitations of their study.

**Key Terms and Concepts:**

Cryptocurrency Mining: Cryptocurrency mining the process of creating new units of crypto currencies, called coins. Very powerful hardware and software is put to work, solving complex mathematical problems called hashes. Solving these problems rewards cryptominers with cryptocurrency.

Carbon Emissions: Carbon emissions, or greenhouse gas emissions, are harmful gas pollutants that add to the greenhouse effect and cause climate change. Most carbon emissions are carbon dioxide which is a result of burning fossil fuels to generate electricity. Fossil fuels include coal, oil, and natural gas, all non-renewable energy sources.

Climate Change Risk: Climate risk includes the consequences, the likelihoods, and the responses to the implications of climate change and how society will adapt as a result. Climate change is changing ecosystems globally and by 2030 will be rising average global temperatures, rising sea levels, and overall creating a more polluted environment for all of life. This is the main frame of the authors paper, as they are warning the public and legislators of the risk that cryptomining operations pose on climate change.

**Quotes, Paraphrases, and Analyses**

When introducing their study, the authors of the paper give a rough estimate of how much of a Bitcoin went into damages in 2018, "Results indicate that in 2018, each $1 of Bitcoin value created was responsible for $0.49 in health and climate damages in the US and $0.37 in China" (Goodkind et al. 1). In 2018, the value of a Bitcoin was approximately $3,500 per coin. This means that for each 1/3500th of a Bitcoin mined, half of the coin's shared value was responsible for environmental impacts. This model illustrates how much Bitcoin itself has been harming our environment and asks the question whether it is even worth it to mine when half the efforts are put into ultimately destructive sources. Essentially, miners have (perhaps unknowingly) put the economy and their own public position over the interest of public safety.

Moreover, the authors continue by explaining that the offsets of mining may not be worth the profits, " … mining generates financial value but consumes electricity in doing so. The complication is that the supply of any cryptocurrency coin is typically finite and made available according to prescribed rules that asymptotically approach some fixed amount at a specified point in time" (Goodkind et al. 1). Due to the electrical costs of cryptocurrency mining, the net profit that a cryptominers makes is sometimes negligible to none. The fact that cryptocurrencies are typically finite (though not all) add to the fact that as supply decreases, demand increases. This mixed with the limitation that coins will increasingly get more and more difficult to mine (a hardware limitation imposed by Bitcoin developers) will end up with minimal profit margins for miners. All these factors will simultaneously create spikes of carbon emissions.

The authors also try exploring how to capitalize on the energy usage of cryptomining, "our focus here is on beginning to monetize these electricity-related social costs. As with any emergent technology, there needs to be careful consideration of its environmental and health impacts on society" (Goodkind et al. 1). There is a lack of effort put into making cryptomining green, which has led to it being detrimental to public health and safety due mainly to global warming. A solution to mining with large profit margins is using renewable energy sources that are also green energy sources. By eliminating the need to pay for electricity, miners can utilize natural energy sources to help their economy.

**Synthesis**

Like all previous sources I have evaluated, there is a discussion regarding legislation or regulation of cryptocurrency in the conclusion paragraph. However, the authors of this paper talk more about how such restrictions would be extremely difficult to impose given the decentralized nature of cryptocurrency, the very basis of privacy which it was founded on. For example, in "Coupling of cryptocurrency trading with the sustainable environmental goals: Is it on the cards?" by Mustafa, Fairouz, et al. there is a call to action that asserts that businesses and corporations should keep renewable energy/energy saving measures in mind. The authors of this source, however, explain why measures such as these would be difficult to enforce, i.e. that due to the anonymity of cryptocurrency (which entails the production of and transfer of currency), international cooperation would be required to maintain some form of "decarbonization".

Another similarity between this source and previous is that they all introduce some form of a case study, though they are all unique in their own ways. I personally believed that attributing a percentage of a cryptocoin to how much estimated damage it has made was an interesting representation to create. All these case studies though had one thing in common, which was a method to calculate how much emissions per capita mining created. This is most properly seen in Stoll et al.'s “The Carbon Footprint of Bitcoin”, where the methodology behind capturing these figures was explained in detail.

**Overall Evaluation of Source**

Overall, this is a very strong source for my research project. Just the analysis of the case study specifically is useful to me because it helps readers understand where our data and analysis falls short. Otherwise, the case study itself and its approaching and methodology can directly be applied to my research question. One of the authors is also extremely well versed in the ways the cryptocurrency is affecting our climate, which lends strong credibility to this source. The frame of the authors paper is climate change, as they talk about all of these different sources (bitcoin mining, carbon emissions, greenhouse gas effect) that all ultimately come down to climate change.

I would say that the biggest limitation to this source also acts as a big strength. The authors have a short explanation of the short fallings of their case study, but the reasons are not due to miscalculations, but instead oversights that can not always be accounted for (e.g. mining boomtowns, limited information to health and climate impacts, etc.) This shows readers that there is still a great deal of research and effort to be done regarding this issue, and it is far from over.

The biggest surprise I got from this source were the results of the case study. I had not imaged that approximately half a coin's value was the amount of financial damage it caused, ranging from economic issues to environmental concerns and even mortality rates. This is useful information that I can reference in my research paper as it shows the extent of the damage that cryptocurrency mining can produce.

This source was written in January 2020, which makes it recent, but before the Covid-19 pandemic and the huge mining boom. I would be interested in knowing what updated figures using their case study's methodology would be, as this data is no longer the most accurate (although the historical data is). There are 43 sources in total.

There is a variety of different papers referenced by this source, almost all of which are available publicly on Google Scholar. There are other case studies, research papers, predictions, and even my previously evaluated sources referenced (namely Stoll et al.'s “The Carbon Footprint of Bitcoin"). One source that caught my attention is Chelsea Harvey's " Should the Social Cost of Carbon Be Higher​?" featured on Scientific American. Although the source is from 2017, it introduces an interesting (but not new) topic which is whether carbon emissions itself should be what consumers are paying for, rather than raw electricity usage. This would put consumers in the hands of their environmental waste, instead of letting it go freely as has been going on. These ideas could possibly be weaved into my research paper, as I expect to be talking a great deal about carbon emissions in general.

I also thought it was interesting that at the bottom of their paper in their acknowledgements section, they say that they were granted a special agreement to use an air quality model developed by the Center for Air, Climate and Energy Solutions in their case study. This further strengthens their source as their methodologies are proven to be strong/renowned.

Overall, this source is useful to my research paper. The entirety of the paper regards cryptocurrency's effect on our climate and has numerous estimates that I can reference. Some new questions I have after doing this research are: Should there be legal action taken against cryptocurrencies such as Bitcoin for contributing so greatly to global warming? Also, is there any way to force or incentivize cryptocurrency miners into using renewable energy sources to mine?