Source Evaluation #5

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

**Citation:**

De Vries, Alex, and Christian Stoll. " Bitcoin's growing e-waste problem". *Resources, Conservation and Recycling*, Elsevier, 2021, https://doi.org/10.1016/j.resconrec.2021.105901.

**Information on the Authors:**

Christian Stoll is currently working as a researcher at the Massachusetts Institute of Technology's (MIT) Center for Energy and Environmental Policy Research. He specifically focuses his research on climate change.

Alex de Vries is a data scientist at Dun & Bradstreet, as well as a researcher at the Vrije Universiteit (VU) Amsterdam. He has written numerous articles on Bitcoin's carbon footprint and has published to sites such as CNN and Science Direct. He also has a focus in Financial Technology and has been a speaker at conferences such as Consensus and CEBIT.

**Summary of Paper:**

De Vries and Stoll's paper focuses specifically on Bitcoin's contribution to e-waste generation, with the biggest piece of evidence being that Bitcoin's annual e-waste generation added up to 30 metric kilotons as of May 2021. They begin their paper with an introduction that introduces the problem that Bitcoin poses on e-waste, as well as what exactly e-waste is. There is also, as usual, a short history on what Bitcoin and cryptocurrency is and how there has recently been a large spike in Bitcoin's energy usage. There is also an explanation given on how detrimental to the environment e-waste really is, as it really is a representation of how much toxic chemicals and heavy metals are being leached into our soil, air, and water.

Their next section highlights their research objectives and methodology. Here, they also introduce limitations and challenges in calculating their estimations, as there is a lack of quality data regarding this issue and most estimates come from industry visits and surveys. They go into a mining device's "life cycle", or how hardware gets wore down from constant mining and eventually can not compete at an efficient enough rate. This applies for both traditional home computers as well as dedicated mining rigs. Regarding their study, there are a lot of calculations and math involved, but essentially, they are finding the duration of profitable operation per mining device, with an assumption that once the duration ends, the device turns to e-waste.

The third section is all about the results of said case study. They found that on average, it takes about 1.29 years for a Bitcoin mining device to become unprofitable. This value is slightly higher for dedicated "ASIC" (application-specific integrated circuit) mining hardware, such as the ever-popular ANTMINER manufactured by Bitmain.

Their fourth section is a short conclusion that restates how Bitcoin's growing carbon footprint has a large environmental impact with many different aspects, one being the collection of e-waste.

Lastly, the final section is a discussion on how the implications of discarding mining hardware goes far beyond just e-waste generation. They talk about how there is a supply chain disruption in silicon, leading to the silicon shortage that is still ongoing today. This shortage has contributed to silicon transistor and microchip shortages, which in turn have delayed supply chain times on commodities such as vehicles and home computers. There are also some solutions listed, such as certain cryptocurrencies being banned on ASIC miners and higher-quality graphics cards, as well as abandon a proof-of-work system for a proof-of-stake system instead.

**Key Terms and Concepts:**

The first concept I would want to add is what electronic waste is. Electronic waste, or e-waste, is a term to describe waste of electronic products that have typically reached the end of their lifespan. This includes old technology such as old televisions, CD players, and VCR systems, but can also include hardware that is modern but dysfunctional, such as an overworked mining computer. There are known to be three types of e-waste: major appliances (refrigerators, washing machines), small appliances (vacuum cleaners, blenders), and computer and telecommunication appliances (computers, phones).

Next, I would want to explain more simply what the semiconductor supply chain is. The semiconductor supply chain involves many different steps to produce quality silicon micro transistors. This includes R&D, designing, manufacturing, assembly, testing, packaging, and more. Although there is no shortage of quartz for new chips to be made, setting up the supply chains themselves is a lengthy process.

As with previous papers, I would also want to explain cryptomining, which is the process of creating new units of crypto currencies, called cryptocoin. Very powerful hardware and software is put to work, solving complex mathematical problems called hashes. Solving these problems rewards cryptominers with cryptocurrency.

Lastly it would be useful to explain what carbon emissions as the paper references them time to time. 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.

**Quotes, Paraphrases, and Analyses**

When introducing the topic of Bitcoin, the authors claim that “[most] research on the environmental impacts of Bitcoin (and similar cryptocurrencies) has focused on energy demand and carbon emissions and has thus far ignored that Bitcoin miners' cycle through a growing amount of short-lived hardware that could exacerbate the growth in global e-waste” (De Vries, Alex, and Christian Stoll 1). Although there have been many efforts to study the effect of Bitcoin on energy consumption and carbon emission releases, there has not been much work done on tracking how much e-waste Bitcoin generates. The significance of e-waste is just as important as carbon emissions as ultimately it endangers the health of the public through the pollution of air, water, and soil, and therefore our food. There is also a big strain put on global supply chains due to the raw materials that Bitcoin wastes.

To add on to sources of e-waste, the authors cite special machines used only to mint Bitcoin. “Bitcoin ASIC-based mining devices cannot be used to mine any alternative digital currency. This hyper-specialization of devices also implies that miners rapidly cycle through vast amounts of increasingly powerful mining devices” (De Vries, Alex, and Christian Stoll 1). Due to the rise in popularity of short-lived machinery that has the sole purpose of mining Bitcoin, there has been an abundance of the e-waste of such machines. Again, going back to the harmful effects of e-waste, the manufacturing of these “ASIC” machines is highly detrimental to our environment and public health. Not only does it use up valuable silicon that cripples electronic chipset supply chains, it also grossly encourages high usage of electricity to mint Bitcoins. Lastly, these machines only last on average a few years, and eventually get recycled to e-waste. Over time, this builds up to destructive levels.

In their conclusion, the authors restate the effect of e-waste,

"[Most] research has overlooked the environmental impact of the usage and disposal of raw materials in the highly specialized mining equipment responsible for the energy consumption in the first place. We show in this study that the lifespan of Bitcoin mining devices remains limited to just 1.29 years. As a result, we estimate that the whole Bitcoin network currently cycles through 30.7 metric kilotons of equipment per year. This number … adds another layer to the previously identified environmental sustainability challenges faced by [proof-of-work]-based digital currencies" (De Vries, Alex, and Christian Stoll 1).

On average, a machine that mines Bitcoin is decommissioned by its owners after just 15 months. Although one machine may not seem like much e-waste by itself, when considering the vast amount and variety of such machines, there is a total of at least 30,700 tons of this type of waste. This is another source of evidence that Bitcoin mining is a non-sustainable practice and only yield benefits for the economic-minded short term. Overall, it is not worth the benefits of Bitcoin mining to practice it without either regarding renewable energy sources, or the rate at which machines get decommissioned.

**Synthesis**

One major, recurring them (or motif) that I see in all the sources I have evaluated is the concept of " decarbonization". There are many ways that Bitcoin generates a huge carbon footprint; this paper delves primarily into electronic waste, and past sources such as "Coupling of cryptocurrency trading with the sustainable environmental goals: Is it on the cards?" by Mustafa, Fairouz, et al. explain the non-renewability of the currency. Each of these papers, in their own way, describes one large issue that is wrong with Bitcoin, and ultimately, they all have to do with sustainability and environmental concerns.

One difference, however, between this source and others is that there is not much solution given on changing the legislation or regulation regarding cryptocurrency. It is possible that the authors have admitted that due to its decentralized nature, Bitcoin is essentially impossible to regulate, and therefore they have considered alternative methods. As a comparison, one such source to include regulating Bitcoin is "Coupling of cryptocurrency trading with the sustainable environmental goals: Is it on the cards?", but even the authors of that 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.

Another blatant similarity between this paper and my past ones is that they all have some form of a study. I think that the estimates given on e-waste is something particularly interesting as prior to this paper, I had not considered at all the implications of and how much waste is generated purely from Bitcoin. One thing in common regarding the study is that there is some sort of proprietary, original method of calculating the amount of damage Bitcoin has caused. This paper gives the units in forms of metric tons of waste generated per coin, and past papers have included figures such as the amount of carbon emissions or mortality rate increases per coin. 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 really good source for my research project. It gives a well written perspective on e-waste generated from Bitcoin, something most people would not consider when taking Bitcoin's environmental damage into thought. There is a very descriptive case study and analysis as well, and like other sources I have, gives a per-coin estimate of damages caused by cryptocurrency (but this time, for e-waste generated). The case study and analysis alone can directly be applied to my research question; one of the authors also contributed to a source I previously evaluated and so I can assume that he has a strong sense of knowledge regarding these topics. The frame of the authors paper, I would say, is more geared towards public health rather than climate change. They talk more about how the chemicals produced by e-waste leach into our drinking water, soil, etc. which inadvertently affects our lifetime health. This is again a better perspective than previous sources as most previous sources talked about how carbon emissions and purely air pollution affects our health; therefore there typically was a frame of climate change over public health.

Just like the last source I evaluated, "Cryptodamages: Monetary value estimates of the air pollution and human health impacts of cryptocurrency mining" by Goodkind, Andrew L. et al. the limitation of this source are the limitations of the case study. The authors of this (current) paper give a very detailed explanation of why their case study is not as detailed as they had hoped it could be, largely due to the quality of existing data and recordings they had to use.

The largest surprise I got from this source, unsurprisingly (as this was the case for previous sources), was the findings of the case study. I had not expected for the value of annual e-waste generated from Bitcoin alone to be as high as was reported, so I hope to put these values as well as a representation or real-world comparison of these values in my paper; it is a good format to show the extent of the damages Bitcoin has caused our environment.

This paper was written in December 2021, making it very recent. This means that all the implications of Covid-19 on Bitcoin mining have been considered, as well as the mining boom that followed shortly after. Therefore, I can say with certainty that if the methodology and initial data of the case study is accurate, the results are accurate to the current date.

There are a total of 49 sources in total. Most of them are publicly available on Google Scholar, and there is a variety of case studies, research papers, and columns/articles from experts in the field. One source that I could maybe use in my paper was 'Turn the tide on plastic" by UN News 2017. This paper goes into depth about a United Nations program to stop the use of single-use plastics due to its resulting microplastics being found in oceans worldwide. I can possibly apply some parts of this paper and relate it to Bitcoin, as it shows how efforts can and should be made to ban certain hardware that Bitcoin miners abuse without environmental care, just to generate a profit. Additionally, Stoll et al.'s “The Carbon Footprint of Bitcoin" was referenced, and it is a source I previously evaluated.

Some new questions I have after doing this research are: to what extent does e-waste and microplastics really have on our health? And, although Bitcoin contributes a great amount of e-waste and these contaminants, how does it compare to other sources, and what are these sources? How can we force or incentivize the proper decommissioning of mining machines or other related electronics, either to individuals who use these electronics or to the businesses that manufacture and sell them?