Bitcoin Mining and its Contribution to Rising Global Temperatures

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Abstract

While climate change is a complex issue with many contributing factors, there's no denying its reality and urgency. From rising sea levels to extreme weather, the consequences are already upon us. Even our latest technological marvels aren't immune – the booming popularity of Bitcoin mining, with its hefty energy consumption, adds another layer to this environmental challenge. But fear not, innovation can be a double-edged sword. Just as technology has fuelled climate change, it also holds the key to mitigating it. Developing cleaner methods for Bitcoin mining is just one example of how we can harness technology for a greener future The research employs Structural Equation Modelling (SEM) to analyse the interconnectedness between factors like Bitcoin mining, CO2 emissions, and global temperature anomalies. The authors discuss data collection and processing procedures, including converting CO2 measurements into parts per million (ppm) and estimating potential temperature increases linked to these emissions. the paper will explore the connection between technology, climate change denial, and environmental sustainability. Ultimately, it seeks to develop evidence-based solutions to minimize the negative environmental impacts of technology while maximizing its potential for positive change. "It's dire, but not hopeless"

Keywords: Cryptocurrency, social media, climate change

1. Introduction

Cryptocurrency mining, characterized by its voracious energy consumption primarily fueled by fossil fuels, has emerged as a significant contributor to greenhouse gas emissions and, consequently, to global climate change. The vast computational power required for mining operations exerts immense pressure on energy resources, accelerating carbon emissions and exacerbating temperature fluctuations worldwide. As a result, the ecological implications of crypto mining extend far beyond the immediate vicinity of mining facilities, with far-reaching effects on regional and global climate systems.[1]

Moreover, alongside the environmental impact of crypto mining [2], the proliferation of social media platforms has introduced another dimension to the discourse on climate change. While technology has played a crucial role in disseminating information about climate change and facilitating global awareness, social media platforms have also become breeding grounds for misinformation and skepticism regarding the reality of climate change. The phenomenon of climate change denialism, perpetuated by misleading narratives on social media, poses a formidable challenge to efforts aimed at addressing climate change and promoting environmental stewardship. However, amidst these challenges posed by technology and social media, it is essential to recognize the dual nature of technological innovation. While technology, including social media platforms, has contributed to misinformation and skepticism regarding climate change, it has also played a pivotal role in advancing our understanding of environmental issues. Early climate change research, facilitated by technological advancements in data collection, analysis, and dissemination, laid the foundation for contemporary discourse on climate change mitigation and adaptation. By adopting a thematic approach that acknowledges both the challenges and opportunities presented by technology, we aim

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to explore how advancements in technology have influenced our understanding of climate change, its ecological ramifications, and the imperative for collective action to address this global challenge. Through rigorous empirical analysis and critical inquiry, we seek to elucidate the complex interplay between technology, climate change denialism, and environmental sustainability, with the ultimate goal of informing evidence-based strategies for mitigating the adverse effects of technological advancement on the environment while harnessing its potential for positive change.

2. Literature Review

a. Sinan Küfeoğlu, Mahmut Özkuran, Bitcoin mining: A global review of energy and power demand, Energy Research & Social Science, Volume 58, 2019

This article explores the energy intensity of mining Bitcoin, with a particular focus on the amount of computing power required for the "proof-of-work" process—the process by which new currencies are created and transactions are verified. To determine the lowest and greatest possible energy consumption, we examined the performance of different mining hardware, including CPUs, GPUs, FPGAs, and ASICs, using an enormous dataset (160GB) from the Bitcoin blockchain. The time frame for our investigation was January 3, 2009, to June 5, 2018.The findings point to a worrying trend Additionally, our calculations indicate that in June 2018, the annual energy consumption of Bitcoin mining as a result of difficulty adjustments—a network mechanism—ran between 15.47 and 50.24 Terawatt-hours (TWh). This study highlights the need for more investigation into sustainable solutions within the cryptocurrency business and throws light on the substantial energy requirements linked to Bitcoin mining.

b. Chamanara, S., Ghaffarizadeh, S. A., & Madani, K. (2023). The environmental footprint of bitcoin mining across the globe: Call for urgent action. Earth's Future, 11, e2023EF003871

An alarming picture is painted by a recent evaluation of Bitcoin mining activity worldwide. In 2020 and 2021, the Bitcoin network used an astonishing 173.42 Terawatt-hours (TWh), more energy than many whole countries. This corresponds to emissions that are more than 85.89 million tonnes of CO_2 equivalent, which is the same as burning hundreds of natural gas power plants or millions of tonnes of coal. Greenhouse gas emissions are not the only environmental impact. The estimated water footprint of bitcoin mining during the same period is 1.65 cubic kilometres, which is more than the 300 million residential water users in rural Sub-Saharan Africa. Furthermore, the land footprint is far larger than Los Angeles at 1,870 square kilometres This study is an important wake-up call, pushing all parties involved to collaborate in figuring out how to make Bitcoin a cleaner platform in the future.

c. Butler CD. Climate Change, Health and Existential Risks to Civilization: A Comprehensive Review (1989⁻2013). Int J Environ Res Public Health. 2018 Oct 16;15(10):2266.

This review examines research published between 1989 and 2013 on the relationship between climate change and health hazards. It looks into the extent to which researchers recognise health effects that could endanger civilization. The substantial rise in published publications (of which 2143 were examined) is indicative of the increasing awareness of the effects of climate change on world health. A low score of 1 out of 3 was given to the bulk of research (72%) for their scant coverage of systemic and global health threats. These studies, which are frequently highly mentioned, are mainly concerned with specific topics, such as infectious disorders or heatstroke.

Citations to studies addressing serious health risks were more prevalent in the early years (1989–1996). But by 1996, this emphasis had diminished, and by 2006, it had barely returned.

d. NOAA National Centers for Environmental information, Climate at a Glance: Global Time Series, published February 2024, retrieved on March 9, 2024.

This assessment uses information from the National Oceanic and Atmospheric Administration's National Centres for Environmental Information (NOAA NCEI) ([a]) to analyse the present state of knowledge on climate change and its effects on the world. Increasing Temperatures: One important conclusion is the clear global warming trend that has been seen. This is supported by data from the NOAA NCEI, which routinely ranks recent years among the warmest on record. Extreme weather events including heatwaves, droughts, floods, and wildfires are occurring more frequently and with greater intensity as a result of this warming trend's disruption of weather patterns. The effects of climate change are not felt everywhere equally. Even though they produce fewer greenhouse gas emissions than developed nations, developing nations—which are frequently found in fragile areas like tiny island states—are disproportionately impacted. Even though our understanding of climate change has advanced significantly, there are still gaps in our knowledge. Research is undertaken to enhance climate models, increase the accuracy of regional impacts predictions, and create efficient adaption plans.

3. Climate Change: An Imminent Threat

Climate change, no longer a distant threat, is an undeniable reality unfolding before our eyes. The past two centuries have witnessed a dramatic shift in our planet's climate, with far-reaching consequences for all living beings, including ourselves. This note will delve into the history of climate change, the overwhelming scientific consensus surrounding it, and the urgency of action to avoid a future where Earth becomes uninhabitable. The story of climate change begins with the Industrial Revolution, when humanity's reliance on fossil fuels ignited a rapid rise in greenhouse gas emissions, primarily carbon dioxide. While natural fluctuations in Earth's climate have occurred throughout history, the current rate and intensity of warming are unprecedented and directly linked to human activity.[3]

Climate change, once a topic of debate and speculation, has morphed into an undeniable reality supported by an overwhelming scientific consensus. This consensus isn't based on mere belief or opinion, but rather on a robust foundation of evidence meticulously gathered and analysed through various methodologies. Let's delve into the lines of evidence, detection and attribution techniques, atmospheric fingerprints, and extreme event attribution that paint a clear picture of our warming planet.[5]

The scientific consensus on climate change isn't derived from a single study but rather a chorus of evidence echoing from diverse fields[4]. **Global Temperature Records:** Decades of meticulously collected data from land-based, oceanographic, and satellite measurements reveal an unmistakable upward trend in global temperature, with the past seven years being the hottest on record. **Glacier and Ice Sheet Retreat:** The observed melting of glaciers and ice sheets around the world, contributing to rising sea levels, serves as a visible manifestation of a warming planet.

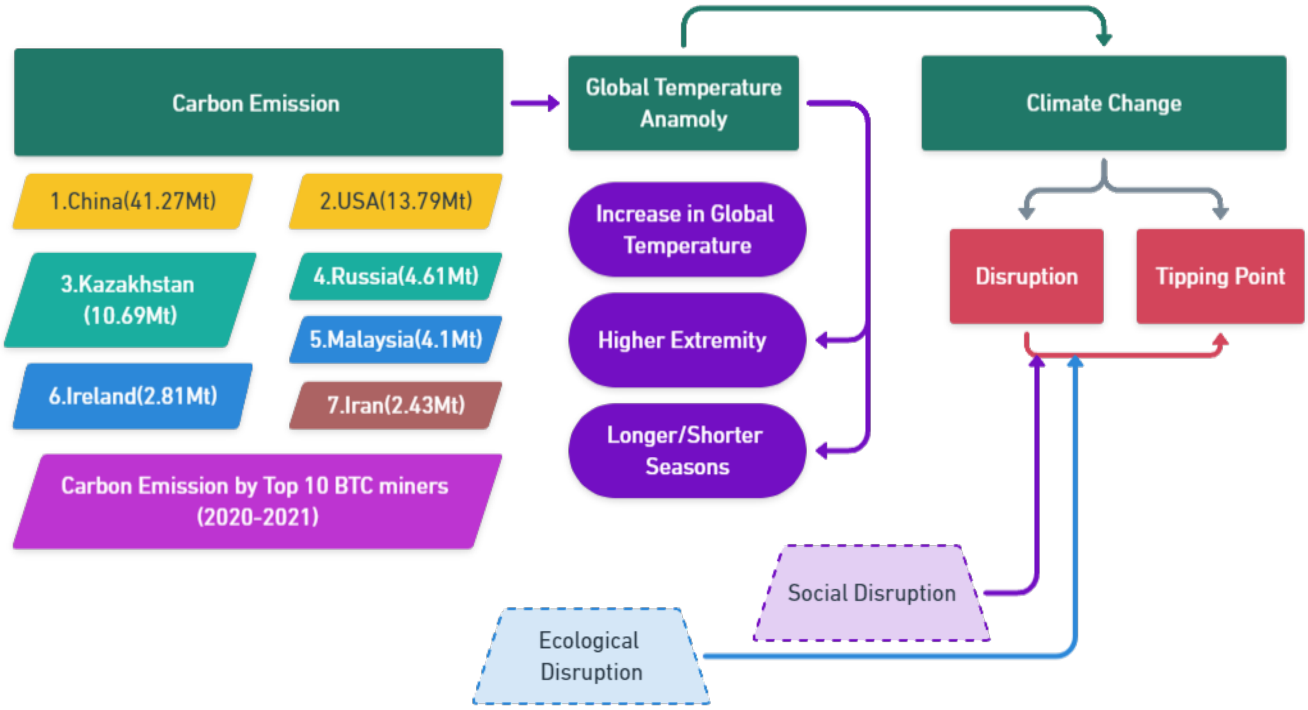

Figure 1. CO_2 emission from BTC and Climate Change

Technological Advancement and **Causes:** While climate change has numerous contributing factors, several key technologies are pushing the issue into the spotlight.

Crypto Mining: This energy-intensive process, crucial for validating cryptocurrency transactions, has a significant carbon footprint. Estimates suggest it currently consumes 1% of global electricity, comparable to Argentina's annual usage. The energy source often fuels this demand, making it heavily reliant on fossil fuels. Additionally, the heat generated by mining equipment contributes to the urban heat island effect, further exacerbating climate woes.[2]

Crypto Mining: A Double-Edged Sword of Blockchain Technology

Blockchain technology, hailed for its potential to revolutionize finance and security, relies heavily on crypto mining. Traditional proof-of-work mining methods rely heavily on energy-intensive computations, contributing significantly to greenhouse gas emissions. The energy consumption of Bitcoin mining alone exceeds that of some entire countries. Discarded hardware used in mining operations creates a growing e-waste problem, adding to the burden on landfills and posing potential health and environmental risks. However, the narrative isn't entirely bleak. Some positive trends emerge Initiatives like "green Bitcoin mining" utilize renewable energy sources for mining operations, significantly reducing their environmental footprint. Responsible development and adoption of these alternatives are crucial for harnessing the potential of blockchain technology while minimizing its environmental impact.

4. Methodology

Certain digital currency investments have been found to have a substantial carbon footprint, with annual energy consumption comparable to that of individual nations like Austria, the Netherlands, or Spain. Since these crypto-assets' mining and growth are entirely reliant on the availability of energy, the climate policies of the various jurisdictions have a significant impact on their worth. As a result, rising financial exposure to these crypto assets will undoubtedly put the financial system at greater risk during its transition. An overview of the causes and projected carbon footprint of some crypto assets, such bitcoin, is given in this article. The article delves into the policy role of public authorities, emphasizing their need to assess if the excessive carbon footprint of specific crypto-assets compromises their commitment to the sustainable transition. In the end, it examines potential policy measures for prudential regulatorsThe ever-growing popularity of Bitcoin has raised concerns about its environmental impact, particularly its significant carbon footprint. A recent study published in *Geophysical Research Letters* reinforces these concerns, highlighting the potential threat Bitcoin poses to sustainable development goals. The immense amount of energy required to mine Bitcoin translates directly into greenhouse gas emissions, primarily carbon dioxide (CO2). This has a ripple effect, echoing through our environment and jeopardizing our progress towards a sustainable future.

4.1 Bitcoin Mining and its CO_2 emission

The Structural Equation Models are hypotheses that describe the connections between **latent variables and observed variables as well as the relationships between the two**. Latent factors are those that are conceptually understood by humans but are not directly measurable.[6]

A suite of statistical methodologies, dignified by the title of Structural Equation Modelling (SEM), bestows upon academia the exceptional ability to scrutinize an interwoven network of relationships between one or more continuous or discrete independent variables (IVs) and a collection of dependent variables (DVs), similarly endowed with continuity or discreteness. These IVs and DVs, whether denoted as factors or quantifiable entities, fall under the purview of SEM's analytical capabilities.

Indeed, SEM, adorned with various epithets such as route analysis, confirmatory factor analysis, causal modelling, and the exploration of covariance structures, emerges as a distinguished paradigm within academic inquiry. However, it is imperative to discern nuanced distinctions; while the latter pair, causal analysis and the study of covariance structures, represent venerable branches, they stand as distinct varieties within the expansive realm of SEM.

We wanted to understand how different things were connected in our data. So, we learned about a powerful tool called **Structural Equation Modelling (SEM**) that could help us see these connections. A free program called **Lavaan** helped us use SEM on our data, which covered a ten-year period from 2011 to 2021.The data was provided by **Figshare [7].** The data we had was collected daily, but for our analysis, it was easier to work with monthly information. So, we carefully changed the data from daily to monthly chunks. One of the most important pieces of information was about carbon emissions. We started with measurements in kilograms, but to better understand the global impact, we switched to metric tons. (**1 Mt = 1000 kg)**Then, to compare it to other air pollution measurements, we used a special conversion to express it in parts per million (ppm). Approximately 5.1 x 10^18 kg makes up the mass of the Earth's atmosphere (NASA, 2022). As of 2022, the atmosphere's CO2 content is at 417 parts per million. This indicates that there are roughly 5.1 x 10^18 kg x (417/1,000,000) = 2.1297 x 10^15 kg CO2 in the atmosphere.

We must remove enough CO2 from the atmosphere to reduce the total mass of CO2 by one part per millionth of the total mass in order to lower CO2 levels by one ppm [8]. This is equivalent to:**1 ppm = 2129.7 metric tons of CO2**.To convert ppm to mg/m3, you'll need to know the molecular weight of the gas, standard molar volume, temperature, and pressure. The formula is: $X = ppm \times M / (V_m \times T \times P)$ [9]We were able to collect the required values, which were expressed in parts per million by volume (ppmv), by using the **Lenntech** calculator [10]. We were able to comprehend the amount of several compounds, specifically carbon dioxide (CO2), in the atmosphere thanks to this procedure. After obtaining this ppmv data, we used a **Climate Sensitivity Calculator [11]** provided by **UCAR**. This tool aids in estimating the possible rise in temperature linked to CO2 emissions from a variety of sources, including coal, fossil fuels, and other activities like Bitcoin mining. Essentially, our goal in using these calculators was to understand how CO2 emissions affect world temperatures, especially those that result from mining Bitcoin. This procedure comprised determining the atmospheric CO2 content and then projecting the ensuing temperature variations linked to the release of CO_2.Our exploration of climate change has highlighted the urgent need to understand the root causes of rising global temperatures. To achieve this, we'll utilize data from NOAA [12] to examine temperature anomalies, deviations from historical averages. Finally, with our data all set up, we used SEM to explore how these different factors, like carbon emissions, were related. It was like a detective story, where SEM helped us find the hidden clues and piece them together to understand the bigger picture.

5. Result

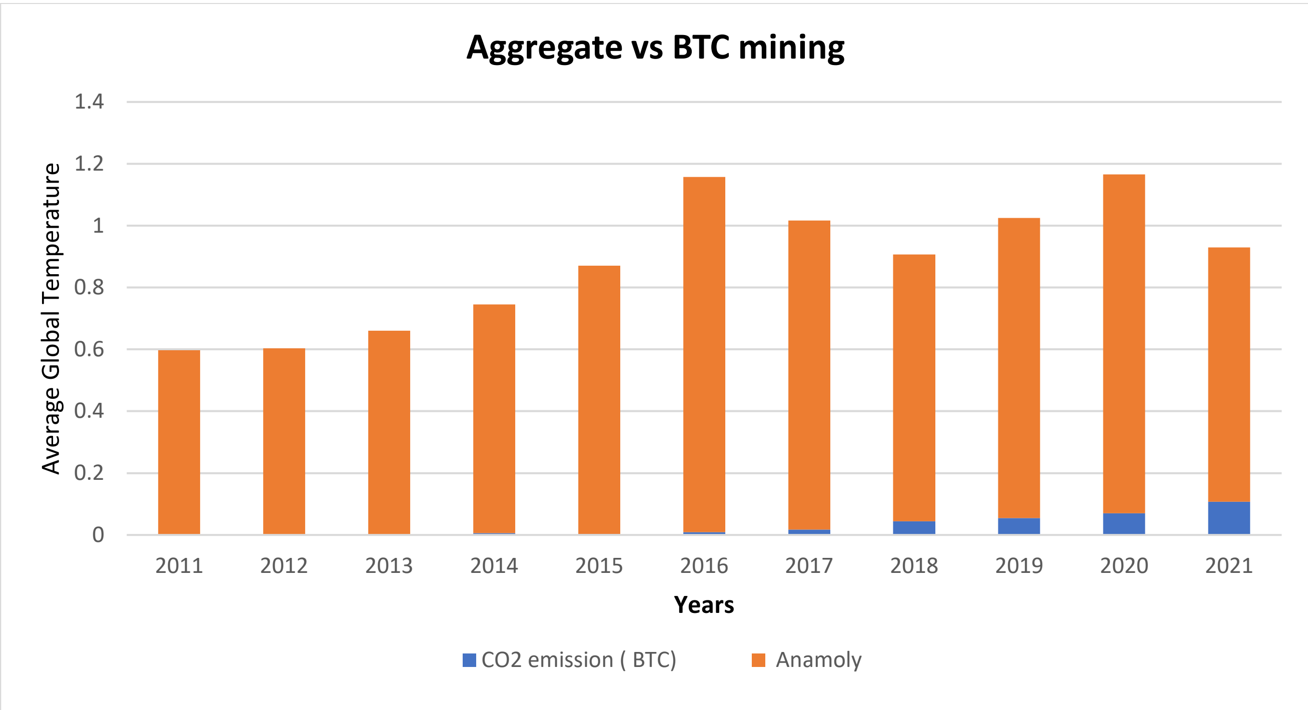

Figure 2. Charting the Rise of Bitcoin Mining CO2 Emissions and Global Temperature

Our analysis using a structural equation model (SEM) revealed a concerning trend: a positive relationship between Bitcoin emissions and global temperature change. This means that as Bitcoin mining activity increases, so too does the average global temperature. While the specific values in the model might indicate a relatively small impact compared to overall global emissions, the statistical significance highlights the potential of Bitcoin to be a contributing factor to climate change, especially if its adoption continues to grow. This finding underscores the importance of further research into the environmental impact of Bitcoin mining and exploring ways to promote sustainable practices within the cryptocurrency industry.

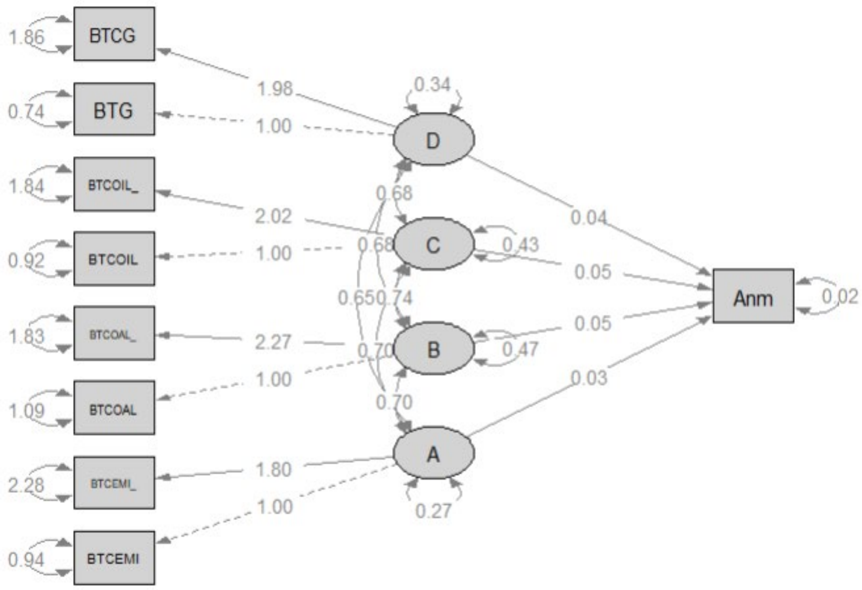

Figure 3. Path diagram between Anomaly and BTC CO_2 Emissions

6. Conclusion

Our journey into understanding climate change has unveiled a complex landscape, and our analysis has brought forth crucial insights. We've uncovered a concerning truth: the undeniable link between Bitcoin mining and the rise in global temperatures. While we see a glimmer of hope with mining shifting away from coal-reliant China, the overall environmental impact of Bitcoin remains significant. Its massive energy consumption, even with a move towards renewables, looms large. Amidst these challenges, a beacon of hope emerges: innovation. Cryptocurrency miners are increasingly turning to renewable energy sources, signaling a positive shift towards mitigating environmental harm. This underscores the potential of technological advancements in addressing environmental issues. The key message here is empowerment. Individuals still have agency to make informed choices, and the crypto industry bears a responsibility to prioritize sustainability. Standardized carbon footprint calculators can guide individual action, while the crypto sector must adopt renewable energy solutions as the norm, not the exception.

7. Future Scope

Moving forward demands a comprehensive approach, with a renewed focus on innovation. Standardized carbon footprint calculators and robust media literacy initiatives are crucial to empower individuals. Research into mitigating AI's potential for harm should be prioritized, alongside a global push for responsible practices in the crypto industry.

Ultimately, addressing climate change requires a collective effort. From individuals making conscious choices to scientists developing solutions, policymakers enacting change, and the crypto industry embracing sustainability – every action counts. This research underscores the interconnectedness of these efforts, illustrating how diverse actions contribute to a shared goal: safeguarding our planet for future generations. This research paper might ignite a torch for future scholars. We fervently trust that our findings will serve as a springboard for further exploration, propelling us towards a future rich with innovative solutions and a profound understanding of this multifaceted challenge.

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