# VIRTUAL MOBILITY (VM) GRANT REPORT

**VM grant title:** Bitcoin Mining and Its Environmental Effects; Nexus of Green FinTech
**VM grant start and end date:** 24/09/2021 **to** 31/10/2021
**Grantee name:** Dr. Esra Kabaklarlı

1. **One paragraph presentation of your VMG**

The main purpose of this is Virtual Mobility Grant to answer the following question: "**Is Bitcoin green FinTech?".** In this respect, I examined the environmental sustainability of cryptocurrencies. Bitcoin, which was introduced in 2009, is the first cryptocurrency and has the largest market share in cryptocurrencies as of 2021. Bitcoins are generated through mining and this activity demands a significant amount of electricity energy (Das and Dutta,2020). Thus, as a cryptocurrency that has the largest market share and demands electricity to increase its supply Bitcoin serves as an excellent tool to test the environmentally friendliness of cryptocurrencies. The majority of the studies in the literature bear the finding that the price increases in cryptocurrencies increase Bitcoin mining, causing more energy consumption and increasing CO2 emissions (Hileman and Rauchs, 2017; O'Dwyer and Malone, 2014, Mishra , 2017; Naughton, 2017).

2. **Main activities performed**

1. **Data Collection and Empirical analysis**: At this stage, the relationship between the income of Bitcoin miners and Bitcoin electricity consumption has been examined by employing the Dynamic Conditional Correlation - Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) methodology introduced by Engle (2002). This research aims to calculate the dynamic conditional correlation between two variables. To examine the relationship, we consider miner's revenue as the dependent variable. The independent variable is Bitcoin's energy consumption index. Cambridge Bitcoin Electricity Consumption Index has been used as a proxy of Bitcoin energy consumption. Our sample spans over 02.07.2014 to 23.07.2021 yielding a total of 2580 daily observations.
2. Presentation of the preliminary results of "Green FinTech: Sustainability of Bitcoin" research at **Women In FinTech Conference** September 22 – 23, which is the part of the cost action CA19130.

3. Presentation of the results preliminary results and Green Fintech applications at 19130 COST Action **WG1 research seminar** series.
4. **A podcast** about Green FinTech and econometric analysis results ( as a series of podcasts CA19130) recorded with Dr. Vasile Strat . Here is the link to the video **https://www.youtube.com/watch?v=5pHV-1QlOFQ.**
5. Sharing the outputs of virtual mobility grant (analysis results) and the podcast with the **İstanbul Blockchain Women** organization.

**3. Main results/outcomes obtained (also please explain how each has contributed to the Cost Action Objectives) * also touch on the points bellow**

Progress towards the Action objectives and deliverables.
COST Excellence and inclusiveness Policy, especially towards the support of researchers in COST Inclusiveness Target Countries
Stakeholder engagement and promoting participation of researchers from NNC and IPC (COST Global Networking)

1. **Analysis of the environmental impact of Cryptocurrencies** with the obtained data. Bitcoins are generated through mining and this activity demands a significant amount of electricity energy. Bitcoin's energy consumption is estimated by employing hash rate data. Hash rate gives us the total combined computational power used to mine Bitcoin and process transactions. Then the energy requirements of the hardware that miners are using is estimated by using the hash rate estimate. **The main purpose of this Virtual Mobility Grant was to answer the following question: "Is Bitcoin green FinTech?". Preliminary results imply** positive correlation between income of Bitcoin miners and Bitcoin electricity consumption. Correlation was around **20-30% during 2014** but increased consistently until the end of 2017. It fluctuated heavily between 2017Q1-2018Q2. **The average correlation was around 50 percent** during the entire sample, but it is significantly higher during boom periods where BTC prices surge. **Miners seems to increase mining activities when prices increase (or when they are expected to increase). A second rise in the conditional correlations between Bitcoins miner revenue and Bitcoin electricity has seen after Covid 19 rally effect on cryptocurrencies.** Depending on what kind of energy used during mining, we hope to say a few things about environmental friendliness of BTC.We aim to complement our findings by using TVP-VAR and TV-GC models

In accordance with this COST Excellence and Inclusiveness Policy, I am a researcher from one of the COST **Inclusiveness Target Countries (ITCs)** countries. This project provided me to research About Green FinTech and Sustainability of Bitcoin and disseminate the results with the Cost 19130 action targeted groups. According to Cost Action 19130 research goal "**disseminate to the public and share the results", I achieved this goal by virtue of VMG.**

2. We have recorded a **podcast** about Green FinTech and econometric analysis results ( as a series of podcasts CA19130) with Dr. Vasile Strat . This podcast was shared via LinkedIn .It is my first podcast about Green Fintech . Actually **Thanks to this virtual mobility grant**, I had the chance to record and share podcasts for the first time. My colleagues and Selçuk University economics department students listened this podcast and they have learned something about this project results and Green Fintech. . Here is the link to the video https://www.youtube.com/watch?v=5pHV-1QlOFQ. This podcast was disseminated with **İstanbul Blockchain Women organization**.

3. I have made a presentation of the preliminary results of "**Green FinTech: Sustainability of Bitcoin"** research at **Women In FinTech Conference September 22 – 23,** which is the part of the cost action CA19130. The conference aimed to bridge the gap between academia, industry, the public and governmental organizations, and propose reflections on how to support the established financial industry in the delivery of financial services.

## 4. What else do you expect to achieve until the end of the VMG?

**I am planning to publish Virtual Mobility Grant project analysis results** in the long term (6 months) This Project is intended to be used as a draft for a working paper or an academic article aimed to be published **in an academic indexed journal (Digital Finance Journal)**

This project is structured in order to contribute to the literature with an original study by examining cryptocurrencies in terms of environmental sustainability within the framework of green financial technologies and to reveal the environmental effects of technological advances. The main purpose of the project is to strengthen the cooperation between the financial sector, **academia and researchers**

**and to raise awareness about the concepts of green transformation, green finance, green FinTech, blockchain and sustainability of cryptocurrencies**

## 5. Activities and results checklist

| Activity/Result according to VMG accepted proposal | Completion level |
|---|---|
| 1.Describing the green Fintech with main pillars and collecting the data of Bitcoin price series, collection of miners income and energy consumption data | completed |
| 2.Presentation of the preliminary results at Women In FinTech Conference September 22 – 23, which is the part of the cost action CA19130 | completed |
| 3. Analysis of the environmental impact of Cryptocurrencies with the obtained data | completed |
| 4. Presentation of the results at COST Action WG1 and WG3 research seminar series. (in 2 weeks | WG1 completed but for WG3 I will plan with WG3 leader |
| 5. Sharing the outputs of virtual mobility grant (analysis results) with the İstanbul Blockchain Women organization seminar (in 1 week) and creating the **podcast** about Green FinTech and econometric analysis results ( a series of podcasts CA19130) | completed |
| 6. Publication of analysis results as papers and articles in the long term (6 months)<br>. | Not completed yet, I am writing the full paper for Digital Finance Journal |

****Also, include in this section the successful practices and the most important lessons learned

**Successful practices and the most important lessons learned**

I have shared the outputs of Virtual Mobility Grant **with İstanbul Blockchain Women Organization** (255 member including cyrpto trader, NFT artist and blockchain expert) . This organization wants to collaborate with Cost Action 19130 FinTech and AI members to produce social projects that can be designed positively in the production technology and blockchain technology of our society and to increase the employment of information software from these applications, from more ground projects in the field of production.

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The findings will help to the **goal of the COST action19130** to bringing technological, quantitative and economic researchers together, to tackle future research that can only be done in an interdisciplinary setting, and getting actively involved in the blockchain and FinTech communities across Europe, to constantly monitor developments, get input and disseminate results. Bridging the gap between practitioners from the finance industry, academics and regulators by setting up a common knowledge exchange platform. **Transfer knowledge in terms of expertise, scientific tools and human resources across the different disciplines and between academia and industry.**

I submitted VMG results to **Women in FinTech Conference** September 22 – 23. Thanks to the VMG, I had an opportunity to listen high-quality papers containing original, relevant research with potentially high-impact in the fields of AI, Fintech and statistical modelling. **I am planning to publish Virtual Mobility Grant project analysis results** in the long term (6 months) This Project is intended to be used as a draft for a working paper or an academic article aimed to be published **in an academic indexed journal (I am writing full paper for Digital Finance Journal). The Draft of the full paper is added in ANNEX part.**

## ANNEX

### 1.Introduction

Global warming has become a deeply symptom of a systemic crisis in global society. Environmental problems such as floods, wildfires, the ozone hole, and the plastic pollution have become more common in recent years. Technology is available to reduce global emissions, financial technologies and green technologies can stimulus the economic growth, also reduce inequality, poverty and environmental destruction in its wake. We need more green financial technologies to solve global warming and climate change effects (Mulay , 2019) .

Fintech includes application of technological innovations in the finance and banking industry. These innovations are mobile wallets, application programming interface (API), open banking, digital payments, robo advisers and cryptocurrencies etc. Fintech is related with an increasing number of people using a mobile banking app, based on, internet user penetration rates mobile internet usage. (Statista, 2021). Blockchain, cryptocurrencies and digital money are main

pillars of the FinTech tools in the finance. Green Fintech tools and techniques such as use of blockchain, mobile phones, open banking, bid data analysis can aim sustainable development goals. These goals are reducing poverty, protecting environment and using green energy sources. Access to digital financial services has a positive impact in addressing poverty. FinTech companies present access to banking services and money transfers at lower cost positively impacting poverty reduction (UNDP,2021).

This paper is structured as follows: In the first section a an overview of green Fintech and it is applications around the world will be expressed . In the second section a literature review is carried on related with the sustainable of the Bitcoin and energy consumption of the Bitcoin. The third section is empirical analysis part, empirical results and discussions are presented in this section. The environmental sustainability of cryptocurrencies will be examined in empirical part. In the final section, the conclusions and empirical results will be showed.

**1.Green FinTech Definition**

Fintech refers to innovative financial services such as big data analysis, AI ( artificial intelligence), blockchain, defi (decentralized finance) and mobile internet to bring innovative solutions to financial services (Asian Development Bank,2018). Banks embrace the AI technologies that have commenced from FinTech innovation. Fintech applications which are used by banks and fintech companies has the power to transform customer communication and analyzing customer demands and experiences. Chatbots and predictive analysis can assist with this process and change the way that banks interact with customers (Mohan, 2020) Green FinTech aims to protect environment and reduce poverty providing access of finance to poor people as well .

Green FinTech which includes artificial intelligence, big data analysis, internet of the things blockchain technology, are essential as improved technology and good wages for reducing poverty. Payments offered with cryptocurrencies can be selected as a FinTech for Robo-advisors (or those who benefit from based-based purchasing applications) to develop Apple, which offers mobile payment for payment on the user system or Apple training, smart phone campaign (Wilson, 2017). Green FinTech's, which are environmentally friendly, can manage many people with big data analysis, internet of the things, machine learning, artificial intelligence, mobile payment technologies and using their benefits without charging additional costs. Green FinTech companies have positive environmental impacts by reducing CO2,

helping shared vehicles, dissemination, while also reducing carbon consumption through sharing economy model (Coffman and, Mi 2019). One of the example of green fintech is peer-to-peer food sharing company in London is aimed at preventing waste of food production and green gas emissions (Gupta et al., 2020).

Green FinTech also have the potential to decrease waste generation, green gas emissions and water consumption in online food distribution (Zhou et al., 2020). Cryptocurrencies also combine monitoring technology with a big data analysis to realize rural development , serving as a critical approach to finance small farmers and increase investment in agribusiness (Hinson et al., 2019). In addition, green financial technologies can support financial intermediaries effectively monitoring and selecting green projects and calculate their environmental impact (Jiang and, Li 2017).

The main purpose of this paper is to answer the following question: "Is Bitcoin green FinTech?". In this respect, we examine the environmental sustainability of cryptocurrencies. Bitcoin, which was introduced in 2009, is the first cryptocurrency and has the largest market share in cryptocurrencies as of 2021. Bitcoins are generated through mining and this activity demands a significant amount of electricity energy. Thus, as a cryptocurrency that has the largest market share and demands electricity to increase its supply. Bitcoin serves as an excellent tool to test the environmentally friendliness of cryptocurrencies. At this stage, the relationship between the income of Bitcoin miners and Bitcoin electricity consumption will be examined by employing the Dynamic Conditional Correlation - Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) methodology introduced by Engle (2002). To the best of our knowledge, this will be the first study that analyzes the environmental sustainability of cryptocurrencies and consider their FinTech role by using the aforementioned methodology.

## 2.Methodology

Bitcoins are generated through mining and this activity demands a significant amount of electricity energy. Bitcoin's energy consumption is estimated by employing hash rate data. Hash rate gives us the total combined computational power used to mine Bitcoin and process transactions. Then the energy requirements of the hardware that miners are using is estimated by using the hash rate estimate. The problem is, we can estimate the amount of energy consumed, but we don't know how that energy is generated. It could be coming from renewables or coal. In addition, there's also a distinction between how much energy the system

consumes and how much carbon it emits. Estimates for what percentage of Bitcoin mining uses renewable energy vary widely (39%-70%). The large amount of energy consumed in the mining process of cryptocurrencies questions their environmental friendliness. Therefore, analyzing whether cryptocurrencies are environmentally friendly or not should be done in a holistic approach.

The relationship between the income of Bitcoin miners and Bitcoin electricity consumption was examined by employing the Dynamic Conditional Correlation - Generalized Autoregressive Conditional Heteroskedasticity (DCC-GARCH) methodology introduced by Engle (2002).**We used Time-varying Vector Autoregression (TVP-VAR)** introduced by Primiceri (2005) and Time-varying Granger Causality (TV-GC) by Shi, Phillips and Hurn (2018).DCC-GARCH model allows calculating dynamic correlations between two series.

Variables which will be used in this paper are illustrated in table 1.

**Table 1. Data Sources and Variable Definitions**

| **Abbreviation** | **Variable** | **Source** |
|---|---|---|
| BTCp | Bitcoin Price | www.blockchain.com |
| BTCv | Bitcoin Trade Volume | www.blockchain.com |
| BTCc | Bitcoin Market Capitalization | www.blockchain.com |
| ElecCons | Cambridge Bitcoin Electricity Consumption Index | www.cbeci.org |
| Hash | Bitcoin Hash Rate | www.blockchain.com |
| Rev | Bitcoin Miners' Revenue | www.blockchain.com |
| Diff | Bitcoin Mining Difficulty | www.blockchain.com |

Depending on what kind of energy used during mining, we hope to say a few things about environmental friendliness of BTC. We aim to complement our findings by using TVP-VAR and TV-GC models.

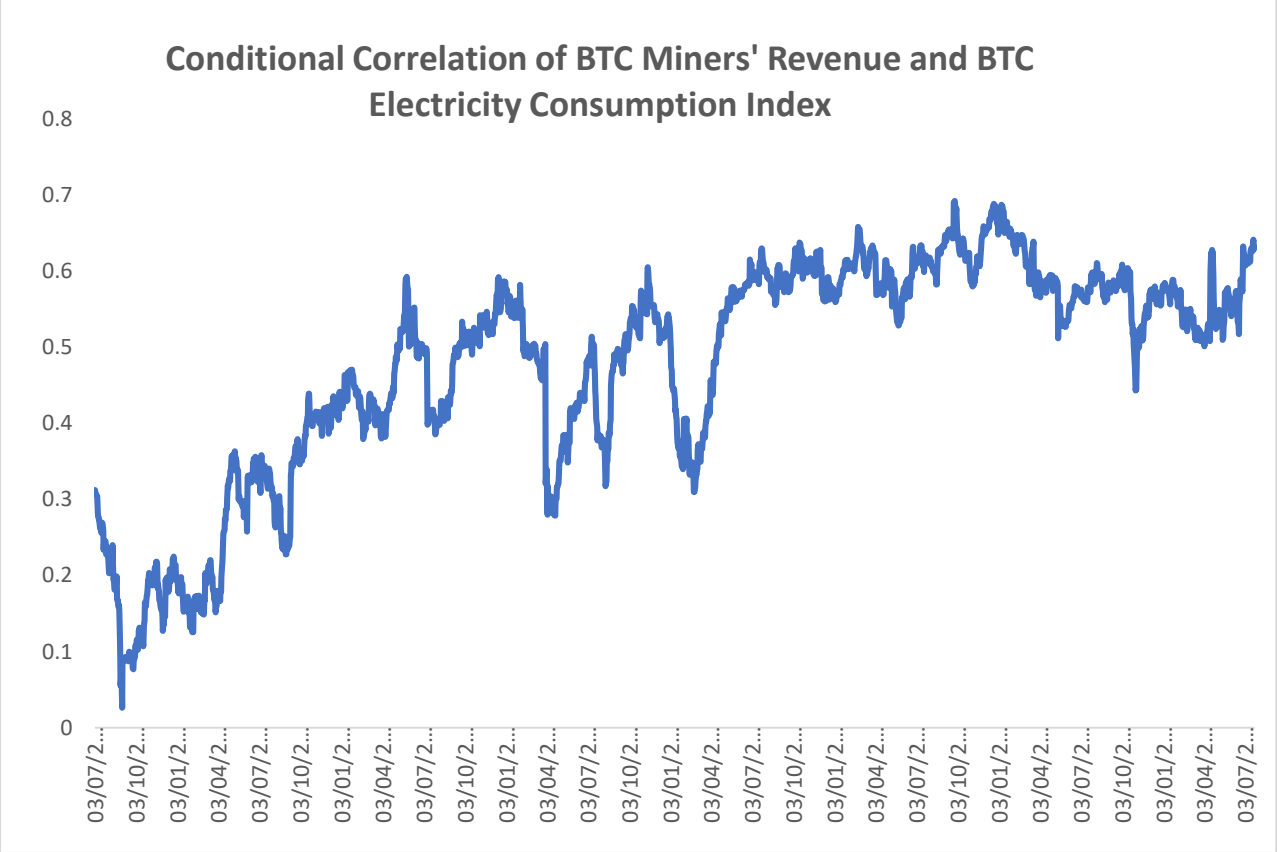
### 2.1.DCC GARCH Model

Engle (2002) extends the constant correlation model to the dynamic conditional correlation (DCC) model where C is time varying but not stochastic. For instance, in the example below it will be estimated using exponentially weighted averages of the cross products of the standardized returns . To estimate and forecast the different volatilities we may use any type

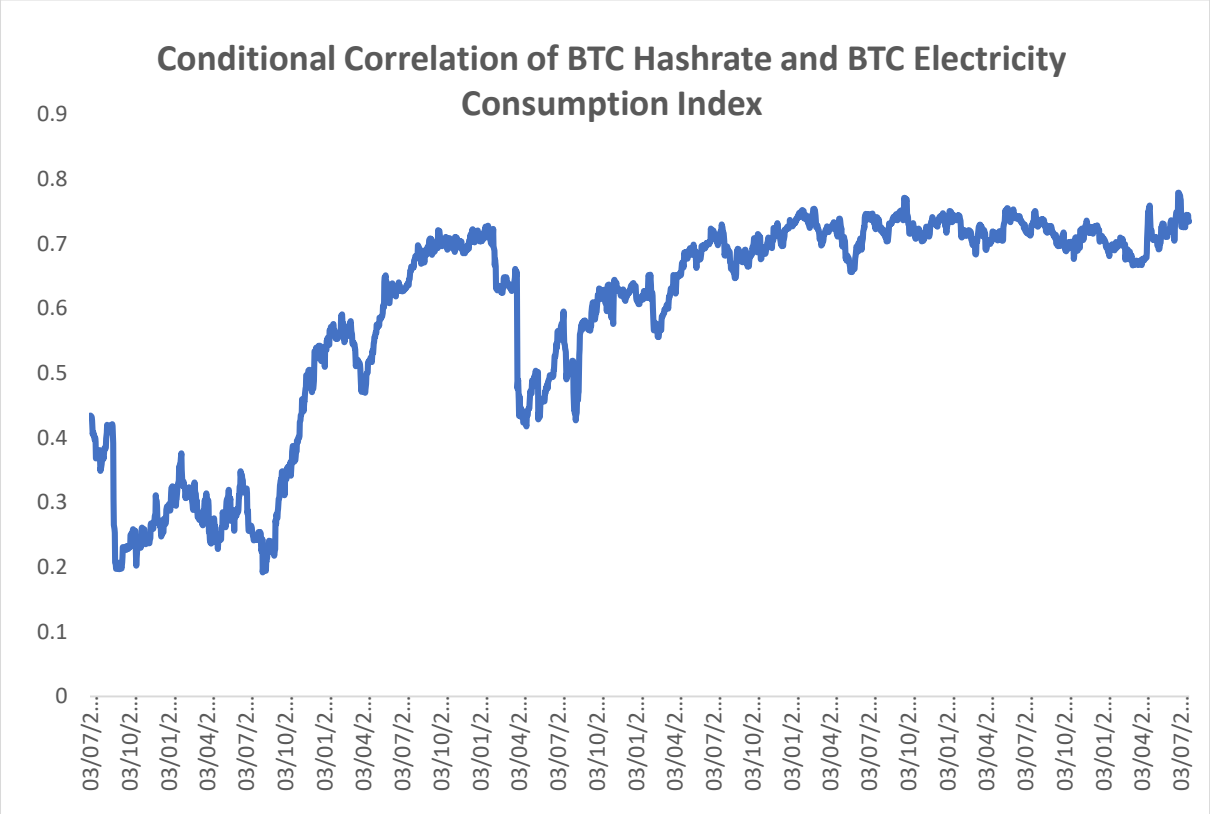
of univariate GARCH model: symmetric or asymmetric, normal or non-normal (Alexander, 2008)

Review the DCC GARCH Model

- Introduced By Engle (2002)
- Aims To Calculate The Dynamic Conditional Correlation Between Two Variables
- It Is A Generalization Of Bollerslev's (1990) Constant Conditional Correlation Estimator
- The Biggest Advantage Of Using The Dcc-Garch Model Is The Detection Of Possible Changes In Conditional Correlations Over Time
- It Takes Into Account Heteroscedasticity And Is Often More Accurate Than The Traditional Garch Estimators
- There Are Two Steps In The Estimation Of The Dcc-Garch Model
    1) Estimating A Univariate Garch Model
    2) Obtaining Time-Varying Conditional Correlations



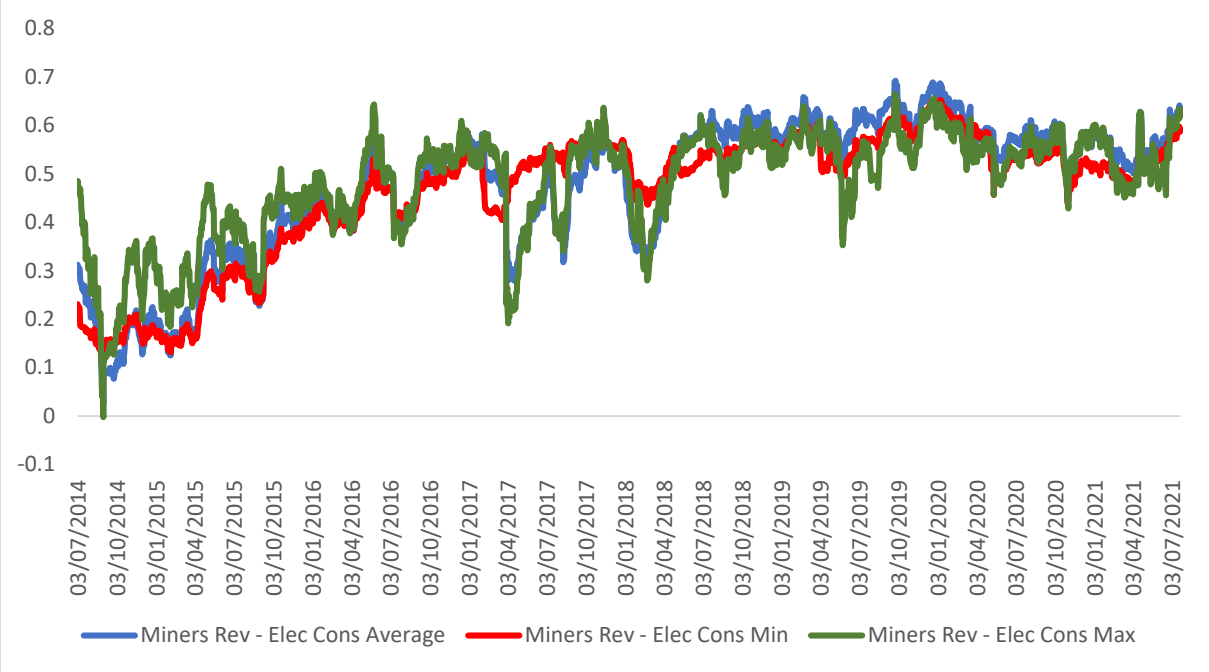
Preliminary results imply positive correlation between income of Bitcoin miners and Bitcoin electricity consumption. Correlation was around 20-30% during 2014 but increased consistently until the end of 2017. It fluctuated heavily between 2017Q1-2018Q2. The average correlation was around 50 percent during the entire sample, but it is significantly higher during boom periods where BTC prices surge. Miners seems to increase mining activities when prices increase (or when they are expected to increase). A second rise in the conditional correlations between Bitcoins miner revenue and Bitcoin electricity has seen after Covid 19 rally effect on cryptocurrencies.




The DCC analysis suggests not surprisingly, positive correlation between Bitcoin's hash rate and electricity consumption. The hash rate shows the amount of electrical power used by crypto miners to create blocks from the devices they use for bitcoin. The conditional correlation has increased heavily between 2015Q1-2017Q2. A second rise in the conditional correlations with Bitcoin Hash rate and Bitcoin Electricity consumption index followed the Covid 19 rally for cryptocurrencies.

Bitcoin mining requires significant computational power, which requires electricity, expensive hardware, and space. Bitcoin mining can only be profitable for those with the most efficient

hardware, in terms of energy and capital efficiency, and cheapest electrical power. if you have sustainable energy resources like wind farm or solar panel array, you might be able to mine bitcoins profitably. (Barski, and Wilmer,2014)




**Resources**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