Is Bitcoin the New Internal Combustion Engine?
Research Proposal

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Overview

- Intended Audience: Policymakers concerned about economic sustainability, Institutional investors and automakers considering either investments in cryptocurrencies or usage of cryptocurrencies as purchase currency. Bitcoin / Tesla as a case study.
- The Bitcoin market is growing rapidly, recently passing $1 Trillion in total market value. The growth of Bitcoin and other markets creates a corresponding growth in electricity consumption, with total electricity devoted to Bitcoin alone projected to ultimately rival energy currently consumed by all data center uses globally (De Vries , Bitcoin boom: what rising prices mean for the network's energy consumption Joule (2021), https://doi.org/10.1016/j.joule.2021.02.006)
- Energy consumption requires energy production, and corresponding Greenhouse Gas Emissions (GHG).
- Tesla and other manufacturers are producing electric Vehicles (EVs) as a means to reduce the GHG impact of transportation.
- In February of 2021, Tesla made a major Bitcoin investment and announced that they will accept Bitcoin as a payment currency for Teslas.
- With this change in their business model to both invest in Bitcoin as well as accept Bitcoin as payment, Tesla has increased the GHG impact of their business.
- The goal of this analysis is to determine the impact that Bitcoin has had on Tesla's corporate GHG footprint. The output of this analysis can serve as a case study / produce a framework for assessing the GHG impact of Bitcoin investments or impact of Bitcoin adoption as a payment currency for other products, which will be useful for entities considering eco-conscious investments or brand positioning.

Research Question

- To what extent does Tesla's investment in and adoption of Bitcoin for automobile purchases impact the carbon footprint of Tesla?

Data

We will only be using existing data sources and a nonexperimental approach for the proposed research. As there are sufficient available open sources providing data regarding worldwide electricity consumption, electrical mix, worldwide Bitcoin mining Bitcoin network data, and Tesla delivery data, we do not anticipate collection of new data to be necessary nor feasible.

While most of our data sources provide unique data, there is a certain overlap between some of them, which will allow us to forecast future scenarios while relying on different forecasting models.

- Primary Datasets:
    - Our World in Data (Energy mix)
        - We will use this existing dataset in order to determine electricity production mix by country, in order to determine what the share of electricity produced derived from fossil fuels, in each country with Bitcoin mining operations. This will help estimate past, current and future greenhouse gas emissions caused by Bitcoin mining.
    - Tesla Data:

      Tesla is the primary data source for all Tesla production, delivery and environmental impact data. Tesla supplies information via their investor relations website and via various public presentations to different stakeholder communities.

- Supplementary Datasets:

1) Bitcoin electricity consumption from the Cambridge Centre for Alternative Finance
    a) Historical and live data on Bitcoin electricity consumption gives us the global energy consumption due to Bitcoin mining over time.
    b) This dataset also provides a static estimate of average electricity cost incurred by miners (USD/kWh)
    - Will be used for examining global electricity consumption, rather than country specific breakdowns (although rough estimates could be done as the data source includes a breakdown by country consumption percentage)

2) Bitcoin Network Data from Coin Metrics
   This dataset provides us with the mean daily network hashrate (rate at which miners are solving hashes, exahases per second). From this, we can determine the jump in BTC mining on the day Tesla made its BTC investment, which we can attribute as Tesla's contribution to the rise in electricity consumption due to Bitcoin mining.

3) Geographic Distribution of Bitcoin Miners Used in the Global Cryptocurrency Benchmarking Study (by Garrick Hileman and Michel Rauchs).
   This dataset provides us with the geographic distribution of Bitcoin miners. With this data we can examine the energy mix utilized to produce electricity and thus the GHG emissions from the electricity used to mine the Bitcoin.

Location	Power consumption (megawatts)	% of surveyed facilities
China	111	47.60
Georgia	60	25.80
United States	27	11.60
Canada	18	7.70
Sweden	10	4.3
Iceland	5	2.1
Estonia	2	0.90
Total / Weighed Average	**233**	**100.00**

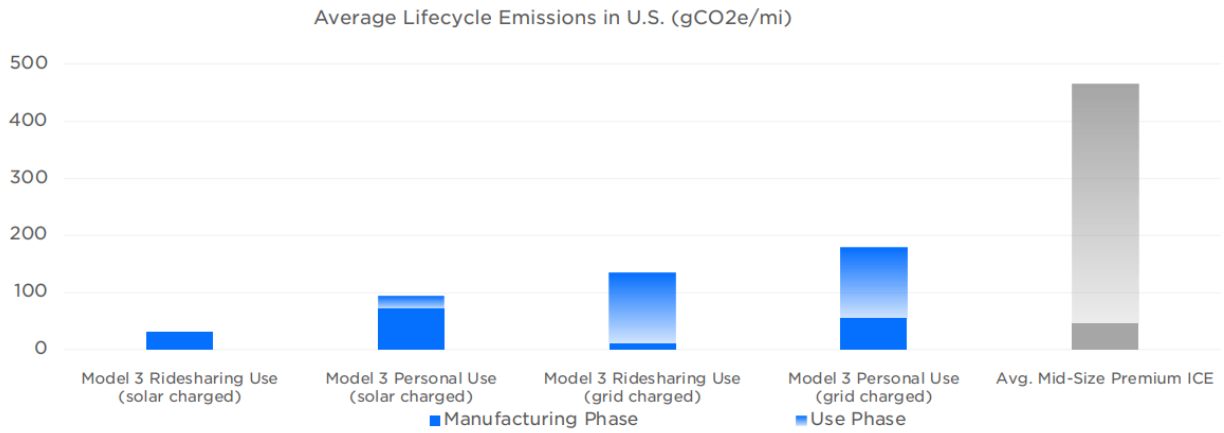
The share of global Bitcoin mining per country allows us to locate Bitcoin miners and estimate the electricity mix due to global Bitcoin mining.

4) Bitcoin price data from “Coin Desk”
This data set provides the price of Bitcoin, which we will use to demonstrate the impact of Tesla’s investment on the market in Feb 2021

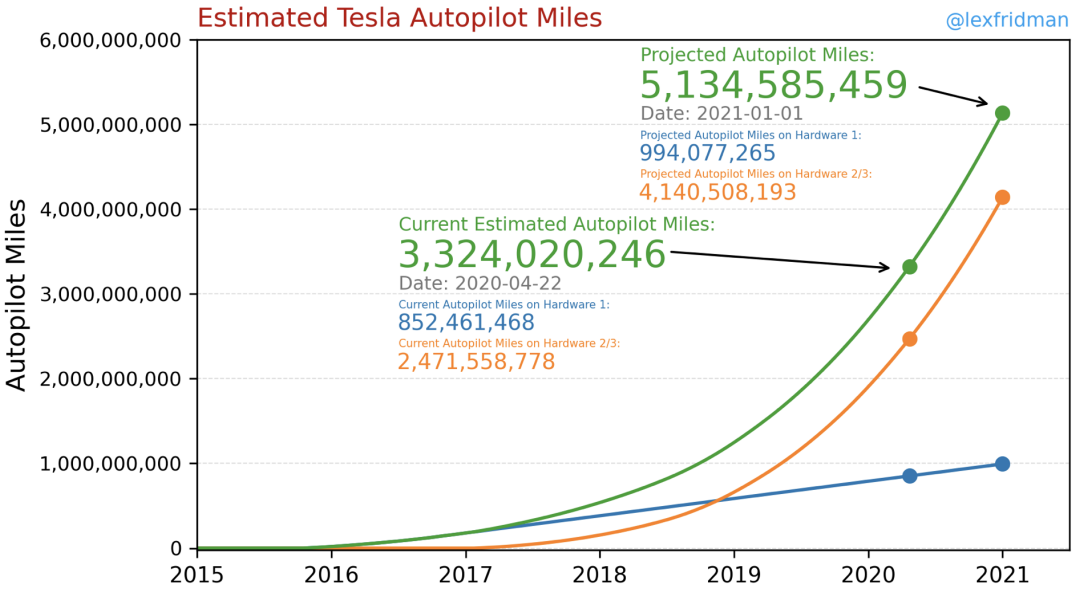
5) Carbon Intensity of Electricity from Our World In Data Organization
Additional electricity mix dataset with more recent data by country to supplement our primary dataset.

6) Monthly Production of Tesla Vehicles
A combination of data sets to calculate the number of Tesla vehicles delivered each month from 2016 January to 2020. This will be used to determine the active Tesla fleet during the time period in focus for this study.

7) Tesla Impact Report 2019
Will be helpful in calculating the potential Tesla GHG emission vs. traditional vehicles. Provides data regarding different models’ average lifecycle emissions in U.S., Battery Pack emissions, battery materials lifecycle. Additionally provides baseline assumptions for the GHG footprint of internal combustion engine powered vehicles for comparative purposes (see diagram below).



8) <u>Tesla Vehicle Deliveries and Autopilot Miles (around 15% of the total number of miles)</u>
This data set provides the number of vehicle deliveries for each Tesla model by quarter and projected Autopilot miles quarterly from 2008 up until the first quarter of 2020 (before the pandemic). We can extend this dataset using Tesla corporate reporting of deliveries in 2020 and 2021.



9) <u>Emissions Associated with Electric Vehicle Charging Impact of Electricity Generation Mix, Charging Infrastructure Availability, and Vehicle Type</u> (National Renewable Energy Laboratory)
Contains data regarding emissions of electric vehicles as well as non-electrical vehicles. Data will be used for comparing the carbon emissions of EVs vs. gasoline vehicles and hybrid vehicles

Study Design

The objective of this design is to assess whether Tesla's decision to both invest in Bitcoin and accept Bitcoin as a method of purchasing Tesla automobiles meaningfully impacts Tesla's carbon footprint via the GHG emissions created by the Bitcoin network.

For this research, we will estimate the increase in carbon emissions attributable to the Bitcoin investment. We will then add this to the carbon footprint of the Tesla auto fleet to determine the relative impact of the Bitcoin investment on Tesla's extended GreenHouse Gas (GHG) footprint.

Tesla & Conventional Car Footprint Analysis Design

First, we will find the total amount of carbon footprint which is saved from the Tesla vehicles relative to equivalent internal combustion engine vehicles. For comparative purposes we will consider the most GHG efficient comparable passenger vehicle on the market today, a Toyota Prius hybrid.

In terms of carbon foot savings, we will calculate the difference in amount of CO2 emission from driving Tesla vehicles versus driving the same miles with an equivalent number of Toyota Prius vehicles. To do so, we will estimate the size of the global Tesla auto fleet and the corresponding total number of miles driven by the global Tesla fleet in a month. We will incorporate average driving distances localized to the countries where Teslas are delivered to control for regional differences. With the global miles driven in a month, we can estimate energy consumption and corresponding GHG emissions based on the local energy mix for the country-wise sub-fleets.

We will then compute comparable emissions produced by an equivalent fleet of Toyota Priuses, following the same localization approach as we applied to the Tesla fleet.

Bitcoin Footprint Analysis Design

Our assumption is that Tesla's investment in Bitcoin and acceptance of Bitcoin for auto purchases will result in an increase of Bitcoin mining and transactions, leading to an increase in energy consumption and related emissions. We will test this assumption and further investigate GHG footprint attributable to Tesla's business activities. We will identify the geographic distribution of active Bitcoin miners and use this data combined with Bitcoin hash rate data and corresponding energy consumption to estimate GHG production based on the local energy mix of the miners.

Comparative Analysis Design

Finally, we will sum the Tesla fleet footprint and the Bitcoin footprint attributable to Tesla together and compare with the conventional car fleet footprint. If the combined Tesla value is less than the conventional fleet value, this indicates that Tesla is still more environmentally friendly than car brands which sell gasoline cars. However, if the opposite happens, this indicates that Tesla's actions contradict with its declaration of saving carbon footprint with its electric cars.

Analysis Exclusions

- Tesla has not announced what it is going to do with Bitcoin it has invested and Bitcoin received from purchases. Thus we have decided to exclude energy consumption and GHG emissions associated with any transactions which are related to Tesla Bitcoin investment activities. We believe that this is a reasonable exclusion since Bitcoin storage requires infinitesimal electrical energy compared to other factors.
- Additionally, since the data on purchases made with Bitcoin are unavailable, we will also exclude emissions attributable to Bitcoin network energy consumption due to Tesla auto purchases.
- We will also exclude manufacturing and disposal footprints from this analysis, considering them to be equivalent between Tesla and Toyota Prius vehicles. This exclusion is reasonable due to comparable material composition (Aluminum / Steel construction) and energy mix for manufacturing locations.

Sample

Since Tesla announced to accept Bitcoin on February 8th 2021, we want to look into the data in February or March of 2021, as this we can then calculate the additional energy consumption due to the acceptance of Bitcoin as a payment to purchase Tesla vehicles. Since some data we are using reflect on the entire electric car industry, we will try our best to focus and use the data revolving around Tesla, and if we can not obtain it we will make inference from those existing data to match the actual data from Tesla as close as possible. With that, the results we deliver should have strong credibility.

Variables and/or Intervention

Multiple variables will need to be taken into account in order to reach our final research conclusions. Those will include:

- Relative part of electricity produced by every energy source for each of the relevant countries where Bitcoin is being mined and Tesla cars are driven.
- The greenhouse gas emission (GHG) caused by each of those energy source
- Estimated electricity consumption and cost caused by miners (USD/kWh) for each country, as well as the respective GHG emission
- Daily network hashrate (rate at which miners are solving hashes, exahases per second) by day, in order to determine Tesla's influence on electricity consumption due to Bitcoin mining
- Bitcoin daily price, used to calculate Tesla's influence with their investment in Bitcoin
- GHG emissions from representative internal combustion vehicles.

Statistical Methods

<u>Overview:</u>

1. Conduct a high level analysis of the emerging EV market as it relates to carbon offsets. Compare this data to internal combustion engines with a particular focus on Tesla EVs.
2. Analyze the volatile cryptocurrency market and the way its energy usage (through the process of coin mining) affects the environment
3. Determine the overall environmental effect of the intersection of Tesla and cryptocurrency

4. Use Hypothesis Testing to determine whether the usage of Bitcoin as purchase tender negates positive GHG impacts of EVs, or not. The hypothesis will be tested with different confidence intervals ranging from 0.85 to 0.95 (Alphas ranging from 0.05 to 0.15).

Process:
Ultimately, create an equation to calculate the net environmental impact of mining Bitcoin vs. the benefit of utilizing Tesla electric cars.

Potential Risks

1. Sample Size:
    a. The data that we will be looking at is limited to Bitcoin and Tesla. These two are the major players in cryptocurrency and EVs, respectively. Bitcoin and Tesla are intimately related due to Elon Musk's backing of cryptocurrency as payment.
    b. Our scope will be limited in both the cryptocurrency and EV markets which contain a plethora of competitors that could affect the research in the coming years.
2. Multiple variables in play at the given time of the research
    a. The price of Bitcoin -- Extremely volatile based on past research
    b. The price of electricity -- Several different competitors
    c. The different charging methods utilized by Tesla vehicles
    d. A changing EV landscape with several emerging competitors (ex. GMC)
3. Privacy Issues around Bitcoin
    a. Due to Bitcoin being a decentralized currency it will be difficult to track the amount and value at given times
4. Accessing the correct data from Tesla
    a. Access issues -- This analysis depends heavily on data related to Tesla automobile deliveries and usage. This data is not readily available. We will attempt to gain Tesla's cooperation and access to an anonymized dataset which covers the needed variables. If Tesla declines to collaborate, we will carefully estimate the variables required and document our assumptions and calculations
    b. Tesla's latest "Impact Report", specifying their vehicles' lifecycle emissions, was published for 2019 and does not include the latest data
5. Forecasting what the market will become
    a. Both cryptocurrency and EVs are emerging and volatile markets that will change as time goes on
6. Bitcoin regulation
    a. The US, specifically, is still waiting to see how the government will regulate cryptocurrency moving forward
    b. Legislation and volatility might make the research irrelevant or force Tesla to ban the use of Bitcoin for vehicle purchases

Deliverables & Timeline

1. Establishing a repeatable process to extend the Life Cycle Analysis of Tesla EVs to more externalities, such as currency

➢ *Expected within 2 weeks*

2. Data collection and analysis of:
    a. Emissions from Bitcoin Mining
        i. The projected effect of increased demand for Bitcoin
        ii. Consideration of electricity costs in mining hotspots
    b. Emissions of Tesla EVs
        i. Usage
        ii. Charging

➢ *Expected to take 4 weeks*

3. Comparison of total Tesla emissions (Bitcoin + EVs) vs comparable internal combustion engine fleet

➢ *Expected to take 2 weeks*

4. A set of conclusions around our research question: Is the carbon footprint saved by using EVs offset by the increased energy consumption of Bitcoin mining?

➢ *Expected to take 2 weeks*

➢ *Overall projected timeline- 10 weeks for final deliverables*

Statements of Contribution

- **Hanan:** I looked into the Data, Statistical Methods, Variables and/or Intervention and Potential Risks.Also did some work on modifying and designing the presentation slide.

- **Kevin:** For this project I am responsible for finding the data which best suits our research, explaining the procedure on how we are doing the experiment, and selecting sample data in which we are going to use for our research.

- **Michael:** For this project I will be looking at the deliverables, potential risks and the statistical methods for the research design.

- **Jeremiah:** For this project, I am responsible for the overview and research question. I am also responsible for overall editing of the paper to ensure internal consistency and completeness.

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