DID

How does cryptocurrency affects energy consumption

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Content

PART ONE

01

cryptocurrency

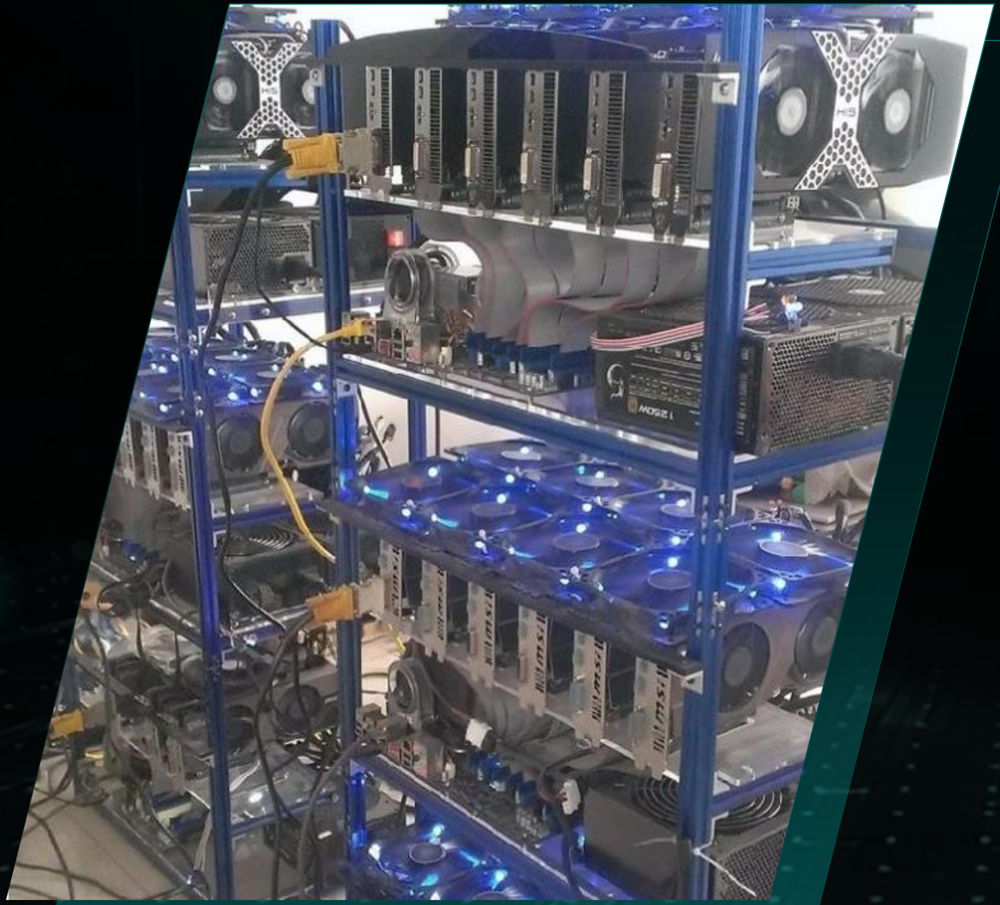
Background

1 Cryptocurrency Mining

Cryptocurrency:

The concept of Bitcoin (BitCoin) was first proposed by Satoshi Nakamoto in 2009. Peer-to-peer transmission means a decentralized payment system

1 Cryptocurrency Mining



Cryptocurrency Miner：

Bitcoin mining machine, is used to earn bitcoin, such computers generally have professional mining chips, mostly use the way of burning graphics cards to work, **power consumption is large.**

Question?

How to measure the consumption of Energy?

Introduction

Data

US energy information administration

Goal

Quantify the impact of cryptocurrency on the energy consumption in US

Method

Difference in Difference (DID)

1 US energy data

Electricity:

EIA website records all the electricity data from power stations across US 51 states and district, including commercial, transportation, residential and industrial electricity data. (In EXCEL)

1 Data Preprocessing

```
In [5]: # 缺失值比例
        df.isnull().sum()/len(df)

Out[5]: Date                 0.000000
        Year                 0.000000
        Month                0.000000
        State                0.000000
        Data Status          0.000000
        C_Residential        0.032856
        C_Commercial         0.032061
        C_Industrial         0.208532
        C_Transportation     0.049285
        C_Total              0.027822
        Cu_Residential       0.019343
        Cu_Commercial        0.019343
        Cu_Industrial        0.019343
        Cu_Transportation    0.019343
        Cu_Total             0.019343
        E_Residential        0.019343
        E_Commercial         0.019343
        E_Industrial         0.019343
        E_Transportation     0.019343
        E_Total              0.019343
        dtype: float64
```

```
In [6]: df.State.unique()

Out[6]: array(['AK', 'AL', 'AR', 'AZ', 'CA', 'CO', 'CT', 'DC', 'DE', 'FL', 'GA',
               'HI', 'IA', 'ID', 'IL', 'IN', 'KS', 'KY', 'LA', 'MA', 'MD', 'ME',
               'MI', 'MN', 'MO', 'MS', 'MT', 'NC', 'ND', 'NE', 'NH', 'NJ', 'NM',
               'NV', 'NY', 'OH', 'OK', 'OR', 'PA', 'RI', 'SC', 'SD', 'TN', 'TX',
               'UT', 'VA', 'VT', 'WA', 'WI', 'WV', 'WY'], dtype=object)
```

```
# 缺失值比例
data.isnull().sum()/len(df)

Date                 0.0
Year                 0.0
Month                0.0
State                0.0
Data Status          0.0
C_Residential        0.0
C_Commercial         0.0
C_Industrial         0.0
C_Transportation     0.0
C_Total              0.0
Cu_Residential       0.0
Cu_Commercial        0.0
Cu_Industrial        0.0
Cu_Transportation    0.0
Cu_Total             0.0
E_Residential        0.0
E_Commercial         0.0
E_Industrial         0.0
E_Transportation     0.0
E_Total              0.0
dtype: float64
```

1 Data

```
. sum
```

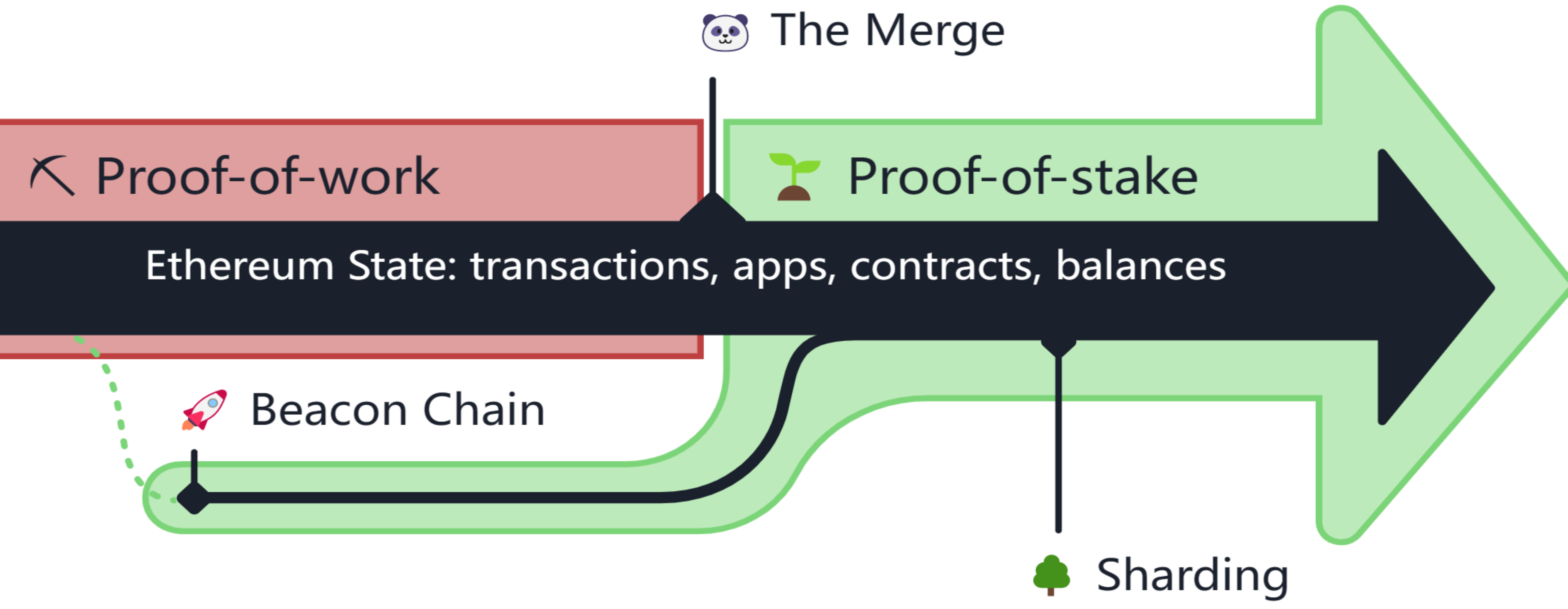
Variable	Obs	Mean	Std. dev.	Min	Max
date	0				
year	8,058	2016.089	3.799602	2010	2023
month	8,058	6.436709	3.476052	1	12
state	0				
r_revenue	8,058	299473.7	334237.3	13064	2932836
r_sales	8,058	2339413	2508844	104574	2.09e+07
r_count	8,058	2585231	2676350	226548	1.46e+07
r_price	8,058	13.39813	4.484965	6.73	45.58
c_revenue	8,058	235391.5	285746.6	20778	2890006
c_sales	8,058	2196315	2349642	126343.7	1.52e+07
c_count	8,058	358684.5	353777.1	23408	1897985
c_price	8,058	11.0317	3.956915	5.52	43.65
i_revenue	8,058	113079.8	114615.9	242.5	984988.8
i_sales	8,058	1613989	1620063	2918.65	1.27e+07
i_count	8,058	17025.82	31181.15	1	340715
i_price	8,058	8.069394	3.859961	2.02	40.19
t_revenue	8,058	649172.6	702999.6	54601	6781119
t_sales	8,058	6161709	6118571	392218.2	4.67e+07
t_count	8,058	2960943	3047764	253016	1.66e+07
t_price	8,058	11.06115	4.145098	5.74	42.76

PART TWO

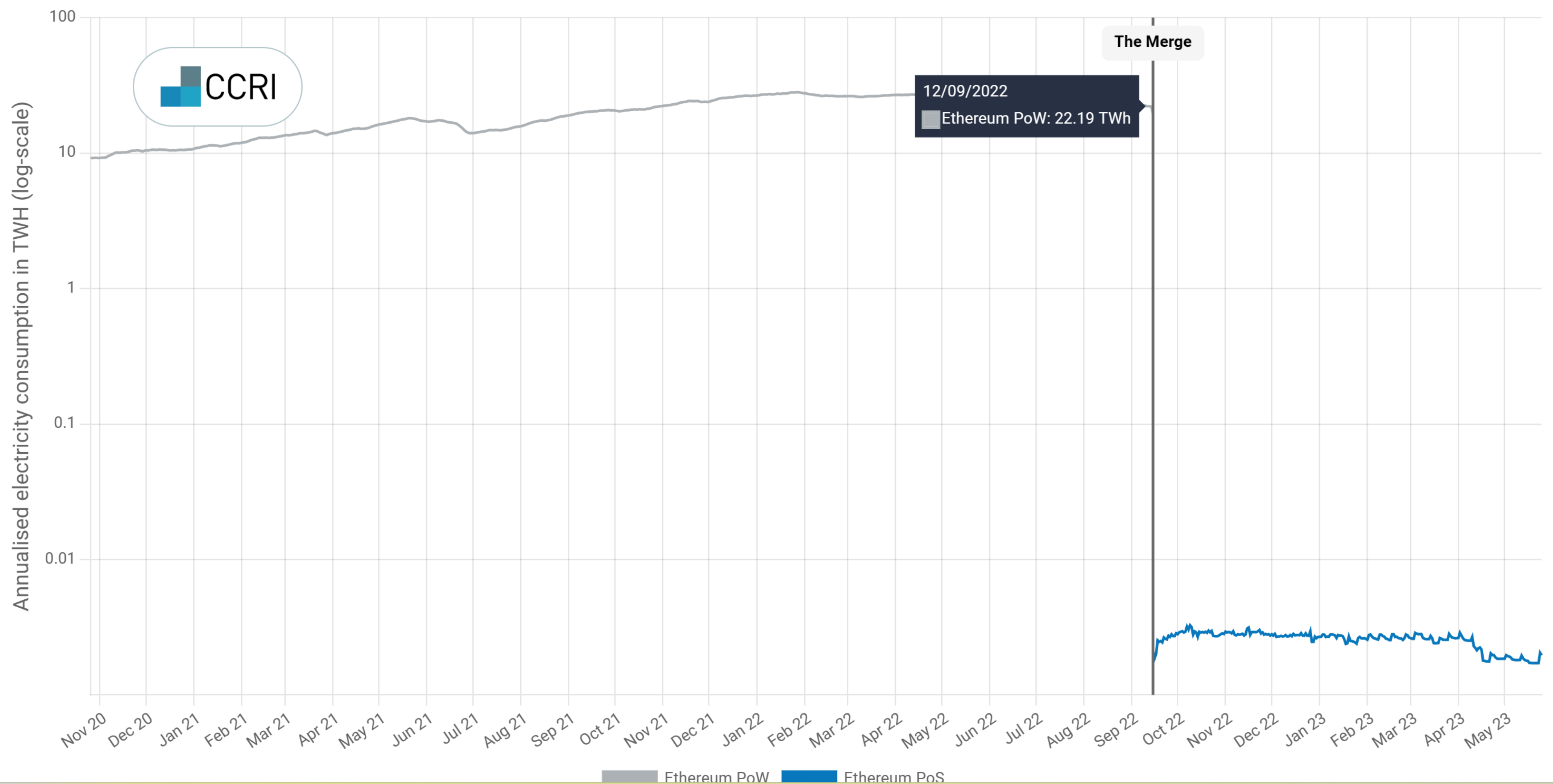
02 Merge Policy Proposition

2 Merge Policy

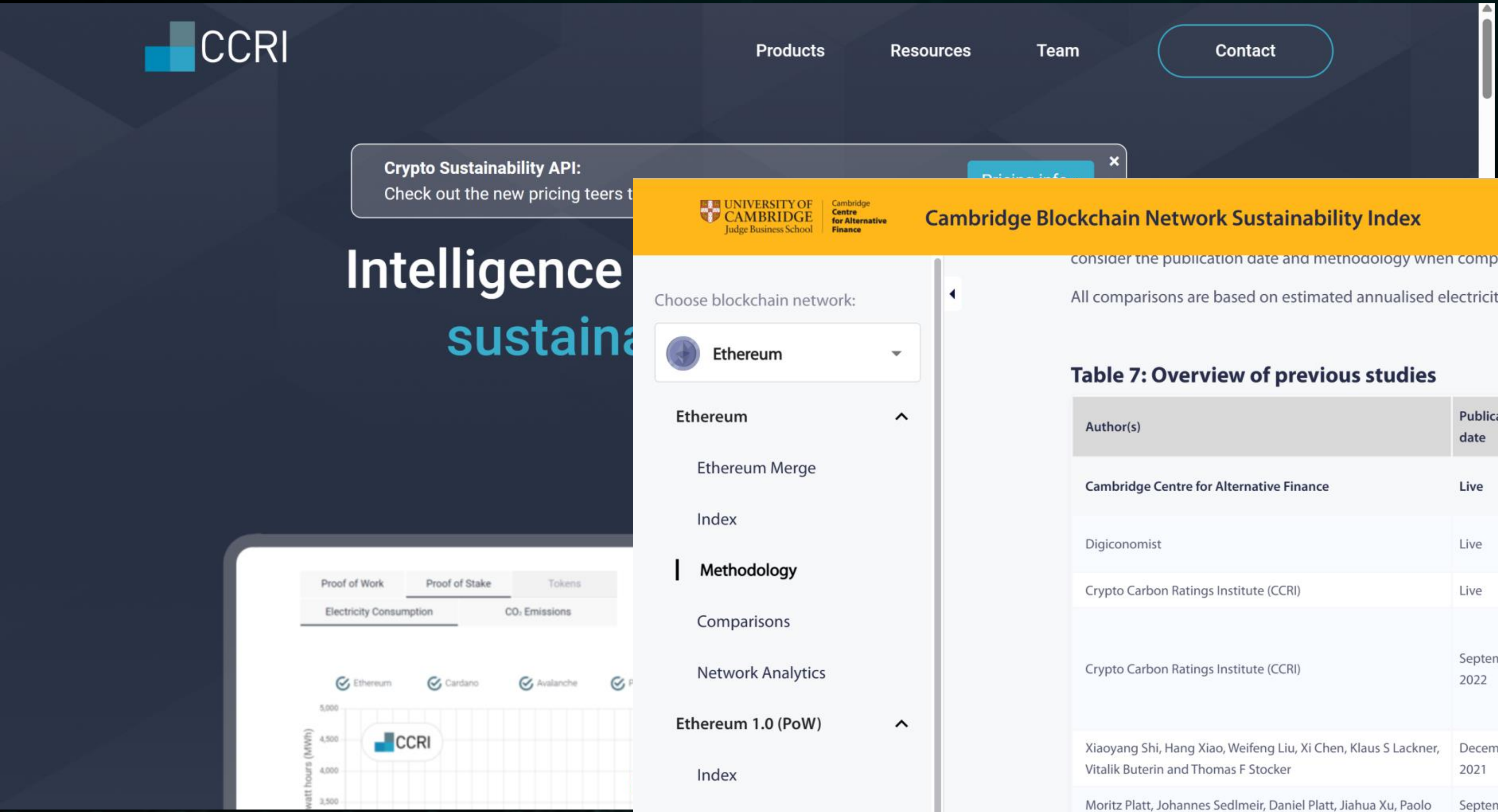
- The Merge reduced Ethereum's energy consumption by ~99.95%.

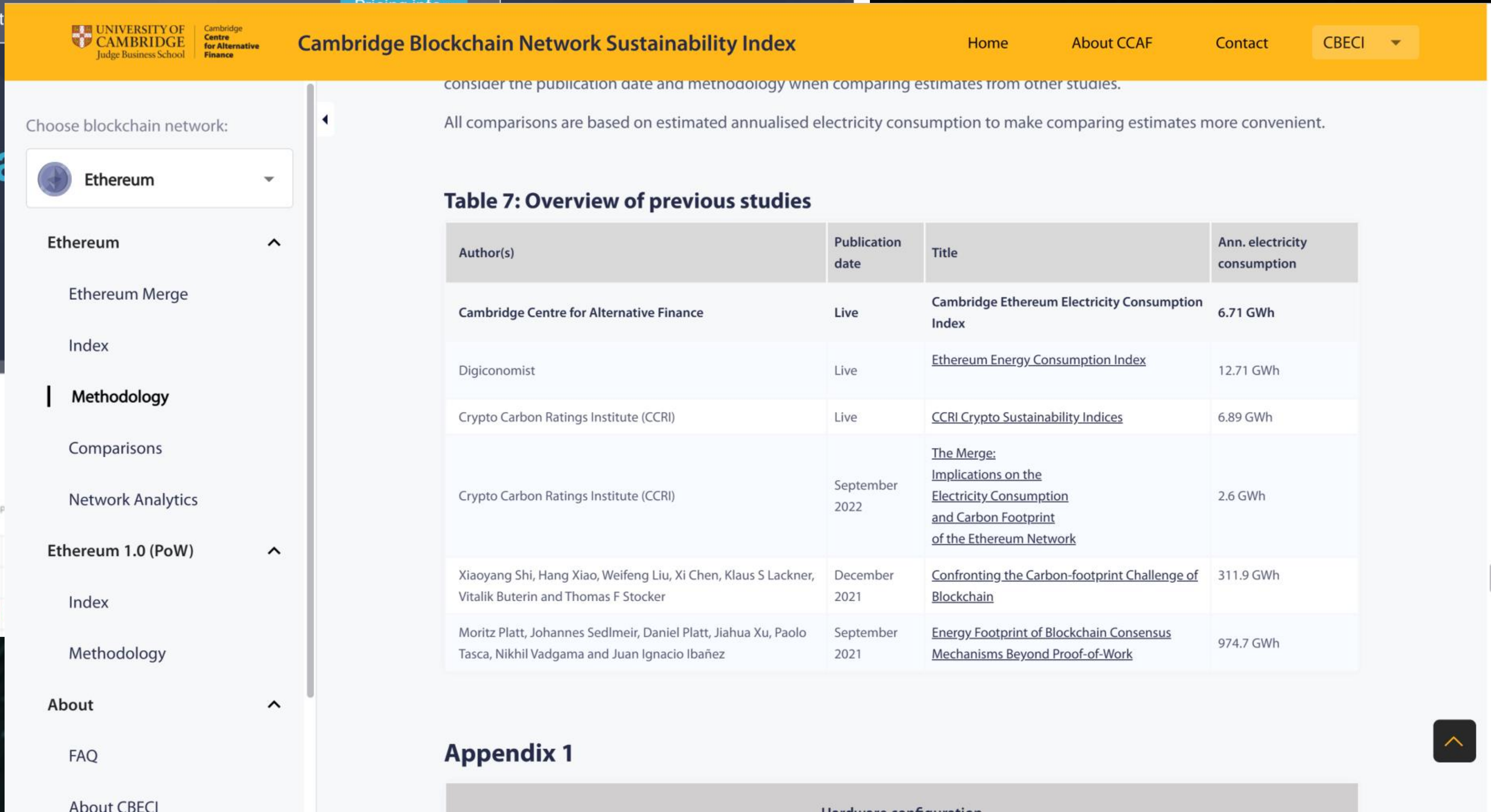


2 Merge Policy



2 Merge Policy





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Cambridge Blockchain Network Sustainability Index

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Choose blockchain network: Ethereum

- Ethereum
  - Ethereum Merge
  - Index
  - Methodology
  - Comparisons
  - Network Analytics
- Ethereum 1.0 (PoW)
  - Index
  - Methodology
- About
  - FAQ
  - About CBECI

consider the publication date and methodology when comparing estimates from other studies.

All comparisons are based on estimated annualised electricity consumption to make comparing estimates more convenient.

Table 7: Overview of previous studies

Author(s)	Publication date	Title	Ann. electricity consumption
Cambridge Centre for Alternative Finance	**Live**	**Cambridge Ethereum Electricity Consumption Index**	**6.71 GWh**
Digiconomist	Live	Ethereum Energy Consumption Index	12.71 GWh
Crypto Carbon Ratings Institute (CCRI)	Live	CCRI Crypto Sustainability Indices	6.89 GWh
Crypto Carbon Ratings Institute (CCRI)	September 2022	The Merge: Implications on the Electricity Consumption and Carbon Footprint of the Ethereum Network	2.6 GWh
Xiaoyang Shi, Hang Xiao, Weifeng Liu, Xi Chen, Klaus S Lackner, Vitalik Buterin and Thomas F Stocker	December 2021	Confronting the Carbon-footprint Challenge of Blockchain	311.9 GWh
Moritz Platt, Johannes Sedlmeir, Daniel Platt, Jiahua Xu, Paolo Tasca, Nikhil Vadgama and Juan Ignacio Ibañez	September 2021	Energy Footprint of Blockchain Consensus Mechanisms Beyond Proof-of-Work	974.7 GWh

Appendix 1

2 Proposition: Cryptocurrency and Energy

	Reasons		Impacts
P_1	Computing power to solve complex algorithms	→	Computing energy
P_2	Cooling systems to prevent overheating	→	Cooling energy
P_3	Non-renewable energy sources	→	Unpredictive environmental concerns

2 Proposition: Energy and Electricity

Reasons

TOTAL			
Revenue	Sales	Customers	Price
Thousand Dollars	Megawatthou	Count	Cents/kWh
275,110	1,099,790	1,504,074	25.01
283,319	1,187,554	1,503,606	23.86
351,343	1,316,440	1,503,157	26.69
384,680	1,360,142	1,502,969	28.28
375,159	1,066,934	1,502,845	35.16
413,823	1,433,132	1,501,807	28.88
451,655	1,443,965	1,501,210	31.28
532,148	1,543,315	1,500,642	34.48

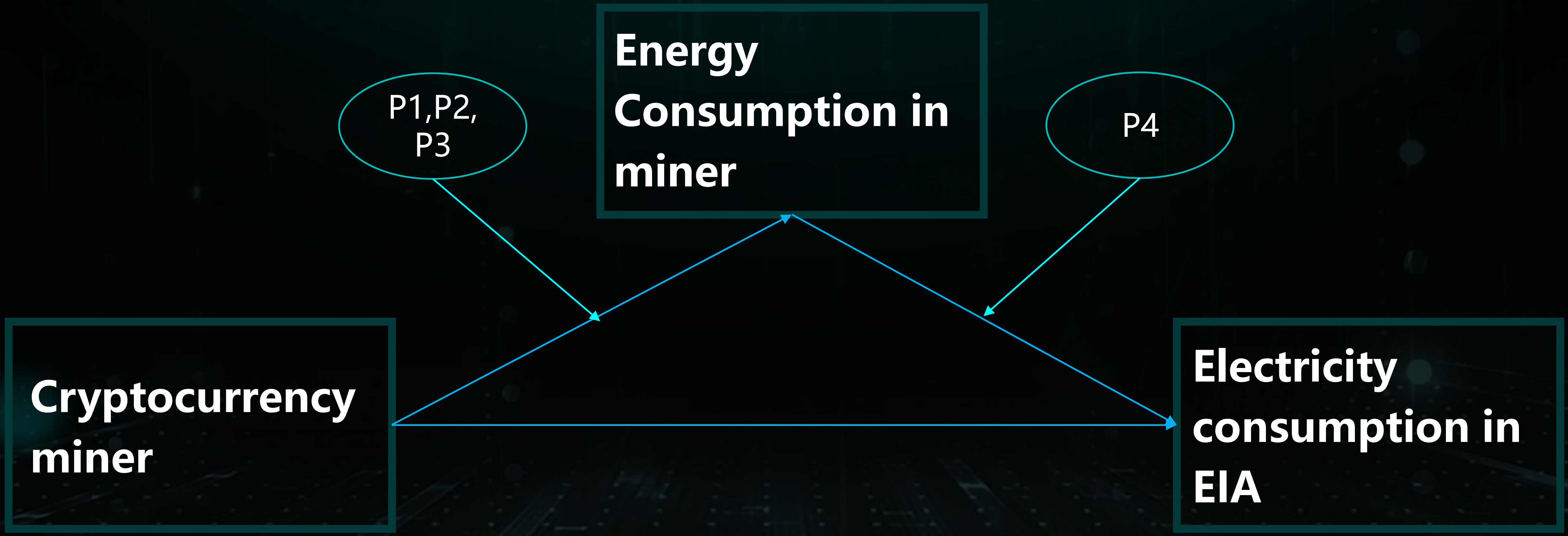
P_4

Energy reduction will lead to sales reduction in electricity

Impacts

Sales in all categories, including residential, industrial, transportation, and commercial

2 Model

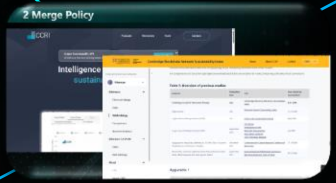

Energy Consumption in miner
P1,P2, P3
P4
Cryptocurrency miner
Electricity consumption in EIA

2 Model

P1,P2, P3

Energy Consumption in miner

P4



Cryptocurrency miner

Electricity consumption in EIA

2 Method

$$\ln(\boldsymbol{sales}_{it}) = \beta_0 + \beta_1 \boldsymbol{treat}_i + \boldsymbol{\beta}_2 \boldsymbol{after}_t + \boldsymbol{\beta}_3 \boldsymbol{treat}_i * \boldsymbol{after}_t + \boldsymbol{a}_i + \varepsilon_{it}$$

- $\boldsymbol{sales}_{it}$: *numerical sales data of electricity from EIA*
- *Treat: proportion of the state's mining activity at 2021*
- *After: binominal data which is 1 after 2022-09-15(merge policy)*
- a_i*: unobserved time-invariant factors(fixed effect)*
- ε_{it} : *other unobserved factors*

2 Method

Bitcoin Mining Map
Global
United States
Mainland China
100%
Dec'21
California
Average monthly hashrate share, Dec'21:
7.93%

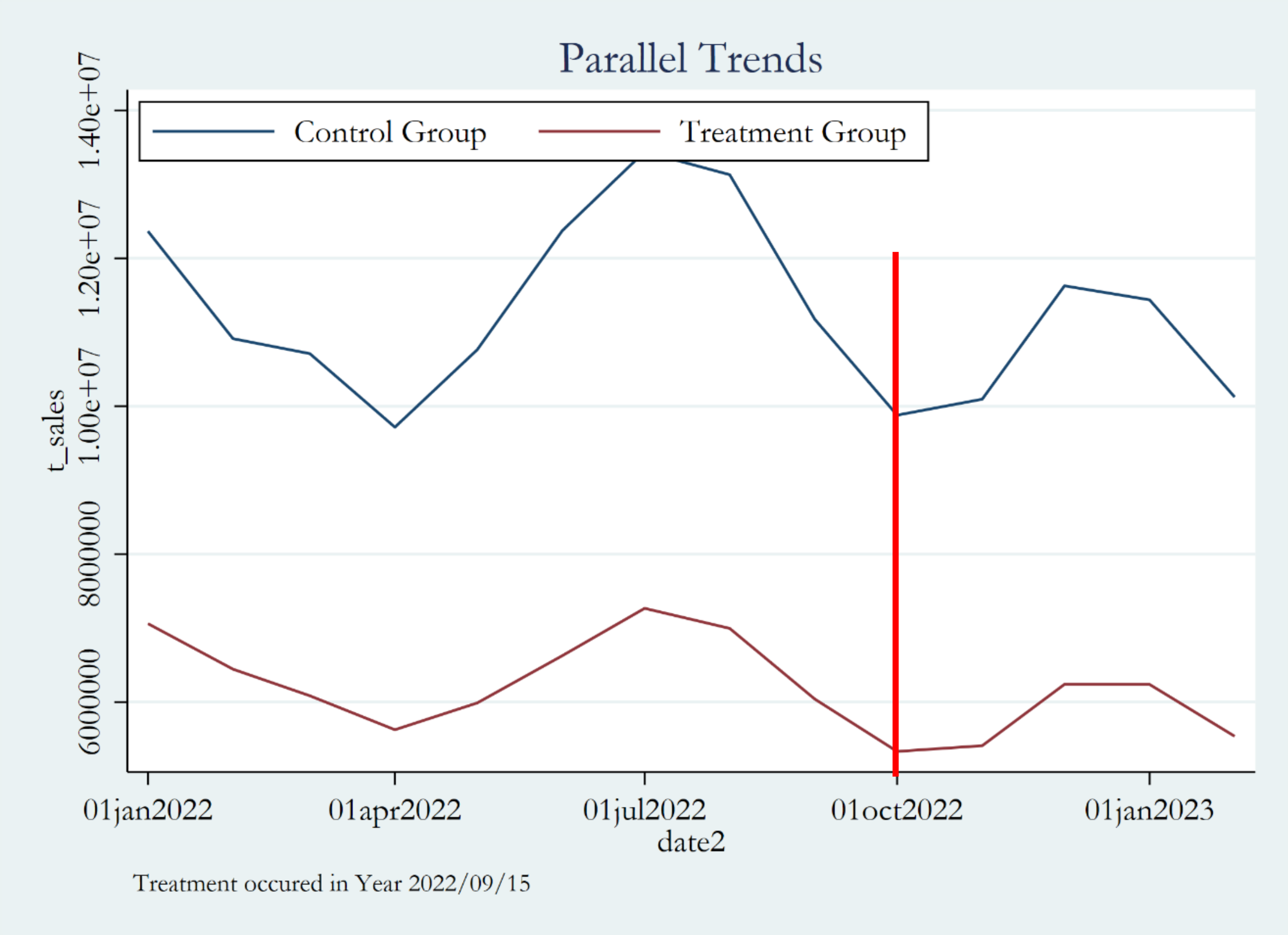
2 Method

```
. codebook treat_proportion

-------------------------------------------------------------------------------
treat_proportion                                                    (unlabeled)
-------------------------------------------------------------------------------

                  Type: Numeric (float)

                 Range: [0,30.76]                     Units: .01
         Unique values: 35                        Missing .: 0/8,058

                  Mean: 1.96255
             Std. dev.: 4.92307

           Percentiles:     10%        25%        50%        75%        90%
                              0        .03        .12       1.35       4.74
```

PART THREE

03 DID Results

3 Result


Parallel Trends
Control Group
Treatment Group
t_sales
1.40e+07
1.20e+07
1.00e+07
8000000
6000000
01jan2022
01apr2022
01jul2022
01oct2022
01jan2023
date2
Treatment occured in Year 2022/09/15

3 Result

```
. reghdfe log_r_sales after_treat_proportion, absorb(date state)
(MWFE estimator converged in 2 iterations)

HDFE Linear regression                            Number of obs   =      3,950
Absorbing 2 HDFE groups                           F(   1,   3767) =       0.50
                                                  Prob > F        =     0.4789
                                                  R-squared       =     0.9821
                                                  Adj R-squared   =     0.9812
                                                  Within R-sq.    =     0.0001
                                                  Root MSE        =     0.1378
```

log_r_sales	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
after_treat_proportion	-.0008474	.0011966	-0.71	0.479	-.0031934	.0014986
_cons	14.61214	.0022327	6544.52	0.000	14.60777	14.61652

log_c_sales	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
after_treat_proportion	-.0021156	.0006898	-3.07	0.002	-.0034681	-.0007632
_cons	14.56524	.0012871	1.1e+04	0.000	14.56272	14.56777

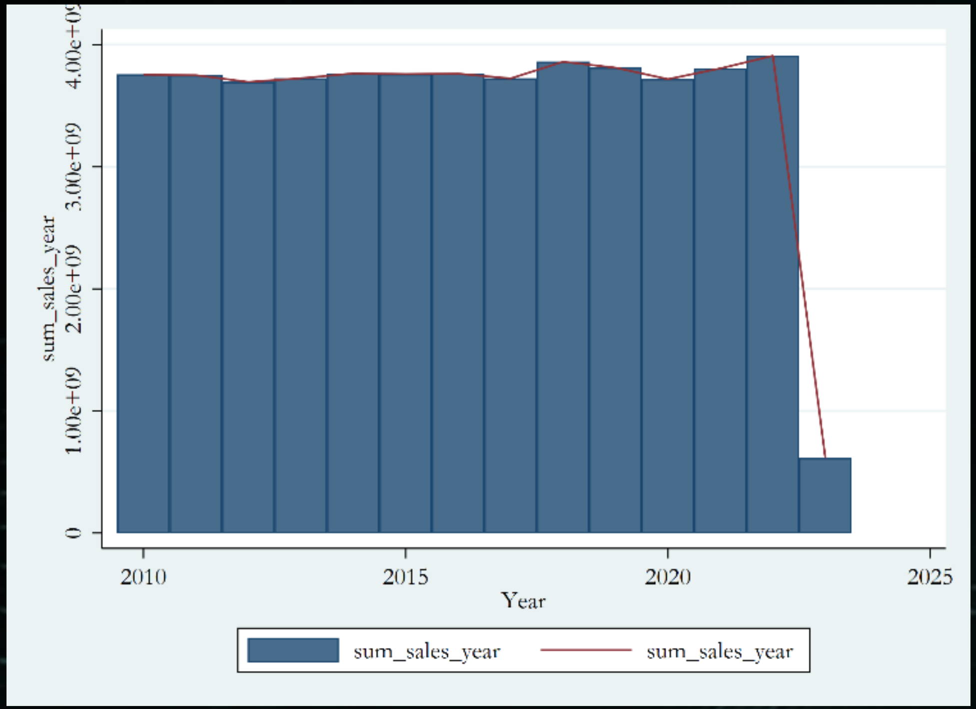
log_i_sales	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
after_treat_proportion	-.0023879	.0009934	-2.40	0.016	-.0043356	-.0004402
_cons	14.37407	.0018536	7754.47	0.000	14.37043	14.3777

log_t_sales	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
after_treat_proportion	-.0020675	.0007592	-2.72	0.006	-.003556	-.0005789
_cons	15.66591	.0014167	1.1e+04	0.000	15.66314	15.66869

3 Result

2022: 3.91e+09

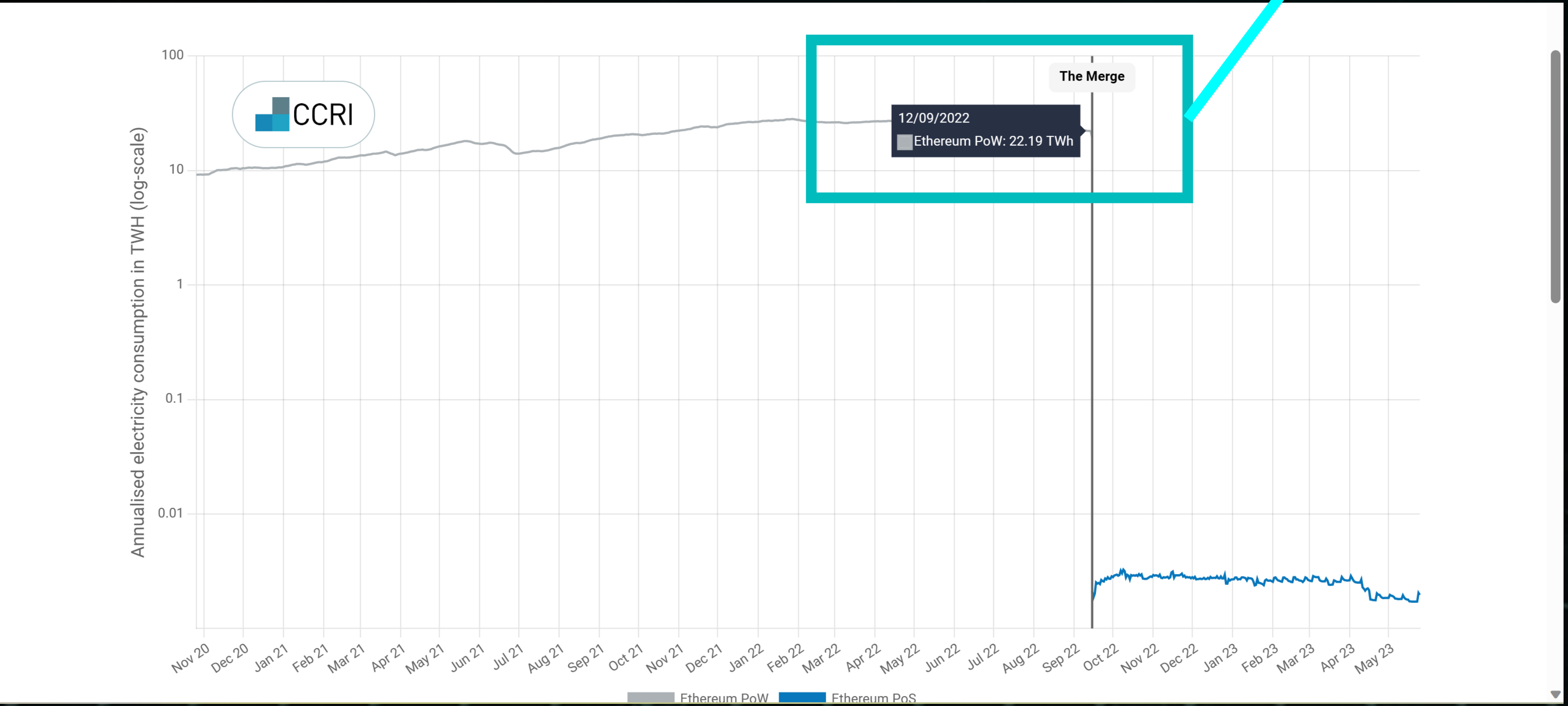
Electricity reduction: 3.91e+09 * 0.0020675 = $8.08*10^6$ MWh = 8.08 TWh



log_t_sales	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
after_treat_proportion	-.0020675	.0007592	-2.72	0.006	-.003556	-.0005789
_cons	15.66591	.0014167	1.1e+04	0.000	15.66314	15.66869

3 Result

Electricity reduction 22.19* 0.9995 = 21.96 TWh



DID VS Estimate model

8.08 VS 21.96

Why?

Limitation

1 US energy data

Electricity:

EIA website records all the electricity data from power stations across US 51 states and district, including commercial, transportation, residential and industrial electricity data. (In EXCEL)

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Energy Consumption in miner

P1,P2, P3

P4

Cryptocurrency miner

Electricity consumption in EIA

Data

Method

Model

Continuous improvement

THANKS FOR YOUR LISTENING!