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2019 AFA Panel Slides Based on

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**“CryptoMining: Who Wins/Who Loses”**

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# Background: What is Cryptomining doing?

## Using *proof of work* to clear transactions

### *Why people like it?*

- *Proof of Work* is the only completely democratized system now in place without a central agents (banks, government) to keep account and prevent fraud

*Why does it use so much energy?* *Cryptominers* (firms with computing power) compete to clear a block of transactions (winner takes all rewards).

- Requires quintillions of searches to find a solution to win
- Result: Cryptominers have a arms race in computing power

*Why can't problem be simplified or transactions be bundled for energy efficiency?*

- Need scarcity in ultimate number of coins. System relies on a block being validated successfully only every ten minutes (on average).
- Need automatic ***Difficulty Adjustment*** to keep miner marginal profit (and thus amount of mining) in line with 10 minute goal.

# 1. The Earth Loses

# 1.1. Total consumption of electricity is large

## Digiconomist:

- Current use: **0.2% world energy**
- Could power **4.2M US households**

## De Vries (2018) in *Joule*

- ST Projection: **0.5% world energy**
- Implication: **10.5M US households**

## Bitmain IPO , Cambridge (2018)

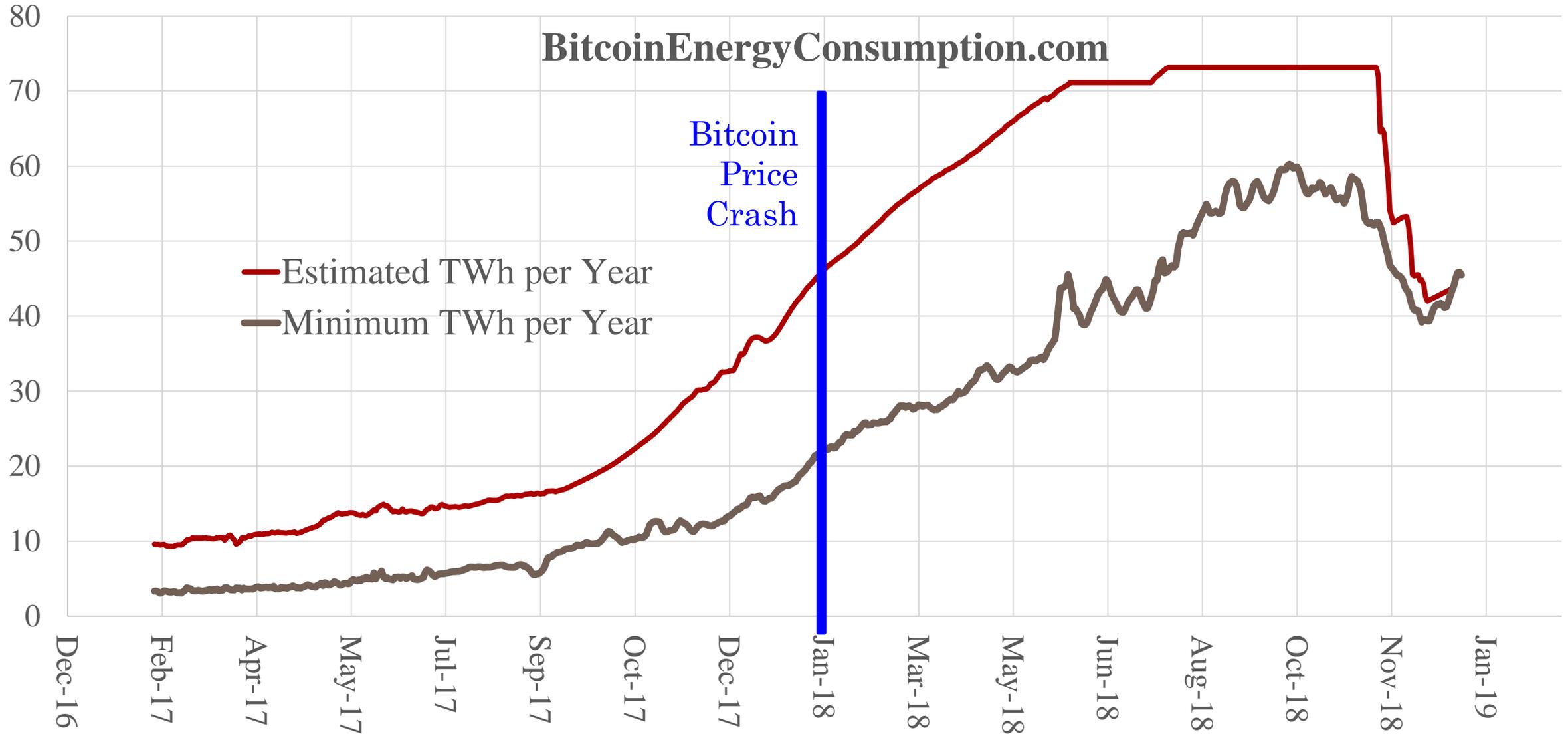
- Manufacturer – market share 67%:
- Recent sales: 4.2 million machines
- Energy use of these machines > Digiconomist estimate

## *Comparison:*

### *UN Emissions Gap Report 2018:*

- Emissions from Bitcoin energy use **unwind 5-12% of carbon reduction commitments** (private and sub-national government)

## 1.2. Energy consumption did not crash with price of Bitcoin



## 1.3. Mining does happens in coal-producing regions

- China: 70-83% market share in cryptomining
- *“The majority... use some share of renewable energy ... in their energy mix”*
- I’m quite skeptical on the “some share” terminology
- Coal Regions: China(except Sichuan), Russia, Caucuses, New York State, etc.
- Reopening coal facilities: Australia, Montana, Texas



- 2018, Cambridge Center for Alternative Finance, *2<sup>nd</sup> Global Cryptoasset Benchmarking Study*

## 1.4. Scaling up is environmentally infeasible

1 transaction cleared by bitcoin uses the equivalent of 15 U.S. households daily energy consumption

<b>Transactions / day</b>		<b>Equivalent in U.S. daily household energy use if transactions occurred in bitcoin</b>
Paypal	16.7 M	16.7 M transactions /day * energy use of 15 households / transaction = Energy use equivalent of 250 million US households /day
Visa	144 M	Energy use equivalent of 2.16 billion US households /day

## 1.5. Pollution externality is not priced.

- Standard free-entry equation for cryptomining (Ma, Gans, Tourky, 2018):

$$Nc(x^*) = P$$

$x^*$ : electricity use by a cryptominer

$Nc(x^*)$ : expected private hashing cost for a successful mine given  $N$  miners

$P$ : is the exogenously-priced reward for a successful mine

- Total private cost  $Nc(x^*)$  equals reward in equilibrium
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- But if electricity use  $x$  causes **pollution externality**  $\varphi(x)$  social optimum requires:

$$N[c(x^*) + \varphi(x^*)] = P$$

- Social optimum involves lower  $N$  or lower  $x^*$ : Lower energy consumption.
- Not easy to solve via tax; need global restriction on quantity.

## 1.6. Governments have incentives to allow access to electricity for cryptomining, despite pollution.

Collected news stories from local media:

- Anecdotes from China: **Tax Revenues**
- Anecdotes from Caucuses: **Tax Revenues**
  - But electricity networks blackouts such that people were freezing last winter
- Anecdotes from U.S. and Scandinavia: **Local Economy Spillovers**
  - But similar concerns about electricity shortages for other uses

2. New empirical evidence on:  
(i) pollution, (ii) tax revenues, (iii)  
crowding-out other energy use

# Local Economy Estimations

Data: China city districts statistical yearbooks 2005-2017

Outcomes:

- **Pollution**
- **Tax Revenues generated from local economy energy use**
- **Energy crowding out**

$$outcome_{city,t} = \alpha M_{city,t} + \mu_{city} + \mu_{year} + covariates_{city,t} + \varepsilon_{city,t}$$

$M_{city,t}$  : indicator for the city being in a **cryptomining province** (Inner Mongolia, Xinjiang, Sichuan, etc) and t being **post2012**

*Note: these are very preliminary, suggestive estimations, please do not quote magnitudes*

# Pollution

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Dependent Variable:	<u>Log Sulphur Dioxide</u>	
Cryptomining	0.0714	
	[0.0473]	
Hydro-Cryptomining		-0.024
		[0.0663]
Coal-Cryptomining		0.115*
		[0.0608]
Controls	Province	Energy
Observations	99	99
R-squared	0.686	0.69
Number of cities	16	16
Year FE	Y	Y
City FE	Y	Y

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## Take Aways:

Coal cryptomining pollutes.

# Tax Revenues

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Dependent Variable:	Log GDP / Kilowatt	Log Corp. Tax Revenues
Cryptomining		1.528** [0.685]
Hydro-Cryptomining	-0.00771 [0.0662]	
Coal-Cryptomining	0.106** [0.0481]	
Log Province Energy	-0.406*** [0.0808]	0.604 [0.373]
Log GDP		1.308*** [0.337]
Observations	636	307
R-squared	0.864	0.873
Number of cities	60	60
Year FE	Y	Y
City FE	Y	Y

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## Take Aways:

... but generates tax revenues coming from sources of GDP that seem to use energy better

# Energy Crowding-Out & Tax Revenues

	Dependent Variable: <u>Log Fixed Assets Investment</u>			<u>Log GDP / Capita</u>
Cryptomining	-0.208*** [0.0431]			
Coal-Cryptomining		-0.179* [0.0901]		-0.151*** [0.0410]
Hydro-Cryptomining			0.159* [0.0918]	-0.0353 [0.0451]
Log GDP	0.992*** [0.297]	0.879*** [0.297]	0.896*** [0.300]	
Log Population	-0.918** [0.358]	-0.673 [0.416]	-0.701 [0.420]	
Log Province Energy				-0.346*** [0.0753]
Observations	515	515	515	564
R-squared	0.901	0.904	0.903	0.965
Number of cities	44	44	44	54
Year FE	Y	Y	Y	Y
City FE	Y	Y	Y	Y

## Take Aways:

Despite added tax revenues, evidence suggests that cities in coal cryptomining areas either:

- experience net crowding out
- or offer a positive selection of mining locating in declining cities

# Conclusion

Anecdotes supported:

- Concerns about pollution should be taken seriously.
- Local governments have incentives (tax revenues) to allow cryptomining.
- Cryptomining potentially crowds-out other use of energy.

Our next draft: More on remedies and better evidence on causation

Big Picture Plea: More research attention on supply-side of cryptoassets

Thanks for you time,

Matteo, Giovanni & Adair