Cryptocurrency vs. Central Bank Money

Linda M. Schilling

Olin School of Business
Washington University in St Louis

UC San Diego Roundtable
What is a currency?
What is a currency?

- unit of account
- store of value
- medium of exchange
How is cryptocurrency a currency?

- Unit of account (yes)
- Store of value (volatility)
- Medium of exchange (adoption)

- Since 2014 (with pause): Microsoft accepts Bitcoin in Xbox stores
- 2019: Ohio, U.S.A. allows tax payments in Bitcoin
- 2021: El Salvador adopts Bitcoin as parallel currency next to the U.S. Dollar
- Retail accepting crypto (via Spedn app by Flexa):
  - ⋆ Whole Foods
  - ⋆ Nordstrom
  - ⋆ Barnes & Noble
  - ⋆ Home Depot
  - ⋆ Crate & Barrel
  - ⋆ Office Depot & OfficeMax
  - ⋆ Bed Bath & Beyond, GameStop, Lowe's, Petco, Ulta Beauty, Starbucks

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Sub-Saharan Africa embraces P2P bitcoin trading

P2P bitcoin trading on LocalBitcoins and Paxful platforms ($m, past 30 days)

North America
Sub-Saharan Africa
Asia-Pacific
Latin America
Western Europe
Eastern Europe
Middle East/North Africa
Australia/New Zealand

Source: UsefulTulips
© FT

source: Financial Times ‘Cryptocurrencies: developing countries provide fertile ground’, Sept 5th, 2021
Adoption why?

- Escaping national inflation, exchangerate fluctuation and/or capital controls (China, Argentina, Venezuela)
- Unbanked or slow and costly banking and payment system (Africa)
- Speculation
Crypto Adoption: Inflation in national currencies

Venezuela: Inflation rate from 1985 to 2022
(compared to the previous year)

source: statista.com
Crypto Adoption: Inflation in national currencies

**Inflation Rate Argentina**

Source: tradingeconomics.com

Source: tradingeconomics.com
Vietnam has the highest level of crypto adoption

The index measures adoption of cryptocurrency by country across three metrics: total cryptocurrency value received, retail activity and peer-to-peer trading volume, weighted by population of internet users and purchasing power per capita.

Source: Chainanalysis; World Bank
© FT

source: Financial Times ‘Cryptocurrencies: developing countries provide fertile ground’, Sept 5th, 2021
One fundamental difference: Crypto versus CB money

- **Central Banks:**
  Can increase or lower the money supply at close to zero cost

- **Bitcoin (cryptocurr.):** Supply
  - fully predetermined
  - pinned down by a protocol (commitment to a supply path)
  - no spontaneous change in supply
Increasing supply: + 6.25 per block (≈ 10 min)
Upper bound 21 mn Bitcoin
Halving of block rewards every 210,000 blocks (≈ every 4 years)
source: statista.com
M1 United States in USD Billion

M1: (currency + deposits + traveller cheques)

(Quantitative Easing in times of Corona)
M1 United States in USD Billion

M1: (currency + deposits + traveller cheques)

Increase in M1 (January 2020 - July 2021):

\[
\frac{(19,445-3,983)}{3,983} = +388\% 
\]
Is Cryptocurrency macroeconomically relevant?
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In terms of money supply: Bitcoin << US Dollar

₿18.79 mn < $ 19,500,000.0 mn
Is Cryptocurrency macroeconomically relevant?

**In terms of money supply: Bitcoin $\ll$ US Dollar**

\[ \text{₿18.79 mn} < \$19,500,000.0 \text{ mn} \]

Market Capitalization = price $\times$ supply \hspace{1cm} (1)
Largest cryptocurrencies by market capitalization

Bitcoin: $939.3 bn (price: $49,945.75)
Ethereum: $457.2 bn (price: $3,895.02)
Cardano: $93.32 bn (price: $2.91)

source: coinmarketcap.com on [Sept 4th 2021]

M1 (currency + deposits)
United States: $19,402. bn
Euro area: $12,881. bn
China: $9,612.2 bn
UK: $ 3,162.5 bn
Canada: $1,238.3 bn
Swedish Krona (SEK): $489.8 bn

source: tradingeconomics.com in July 2021, oanda.com
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⇒ Swedish Krona (SEK) ~ Ethereum
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⇒ Canadian Dollar (CAD) ~ Bitcoin + Ethereum
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source: tradingeconomics.com in July 2021, oanda.com

⇒ Currently: Bitcoin = 4% U.S. Dollar
source: statista.com
M1 United States in USD Billion

SOURCE: TRADINGECONOMICS.COM | FEDERAL RESERVE
Bitcoin Market Capitalization (in bn USD)

Bitcoin market cap as percentage of USD M1

- Currently: 4 %
- In March 2021 (‘the’ Bitcoin peak): \( \frac{1100}{18697} = 5.88 \% \)
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December 2017 (‘a’ Bitcoin peak, but before Covid QE):
237.5/4000 = 5.9%
Total crypto market cap: $2.3 tn (Sept 2021), $1.5tn (July 2021)
Including stablecoins and tokens, on linear scale,
source: coinmarketcap.com
Is Cryptocurrency Economically Meaningful?
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- As percentage of **Canada** M1 (July 2021): $\frac{1.5}{1.24} = 121\%$
- As percentage of **Sweden** M1 (July 2021): $\frac{1.5}{0.49} = 286\%$

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- As percentage of **Sweden** M1 (July 2021): \( \frac{1.5}{0.49} = 286\% \)

\( \Rightarrow \) **Probably Meaningful**
How does Crypto matter for Central Banks concretely?
What a Central Bank does

The Federal Reserve System is the central bank of the United States. It performs five general functions to promote the effective operation of the U.S. economy and, more generally, the public interest. The Federal Reserve:

- conducts the nation’s monetary policy to promote maximum employment, stable prices, and moderate long-term interest rates in the U.S. economy;
- promotes the stability of the financial system and seeks to minimize and contain systemic risks through active monitoring and engagement in the U.S. and abroad;
- promotes the safety and soundness of individual financial institutions and monitors their impact on the financial system as a whole;
- fosters payment and settlement system safety and efficiency through services to the banking industry and the U.S. government that facilitate U.S.-dollar transactions and payments; and
- promotes consumer protection and community development through consumer-focused supervision and examination, research and analysis of emerging consumer issues and trends, community economic development activities, and the administration of consumer laws and regulations.

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Imagine a world with a unique national currency (no cryptocurrency)

Central Bank observes real output across time $Y_0, Y_1, \ldots, Y_t$ (today) and anticipates $Y_{t+1}$ (apple production).

Goal: Keep $P$ price stable across time, observing the price sequence $P_0, P_1, \ldots, P_t$.

$\pi_{t+1} = \frac{P_{t+1}}{P_t}$

How?

$M_t \cdot V_t = P_t \cdot Y_t$ (Quantity Theory of Money)
Imagine a world with a unique national currency (no cryptocurrency)

- Central Bank observes real output across time $Y_0, Y_1, \ldots, Y_t$ (today) and anticipates $Y_{t+1}$ (apple production)
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(Quantity Theory of Money)
How Crypto affect Central Banks?

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$$M_t^\uparrow \cdot V_t = P_t \cdot Y_t$$  \hspace{1cm} \text{(3)}

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\[
M_t^\uparrow \cdot V_t = P_t^\uparrow \cdot Y_t
\]

(Quantity Theory of Money): $\pi_t^\uparrow = P_t/P_{t-1}$

Money supply controls price level and inflation
How Crypto affects Central Banks?

**IMPORTANT**
- Classic Quantity Theory of money makes perfect sense if there exists only **one** currency in the economy with an according central bank

\[
Y_t = \left( \frac{1}{P_t} M_t^\$ \right) V_t
\]  

- Dollar in the U.S.
- Euro in the Euroarea
How Crypto affects Central Banks?

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\[ Y_t = \left( \frac{1}{P_t^{\$}} M_t^{\$} \right) V_t^{\$} + \left( \frac{Q_t}{P_t^{\$}} M_t^{B} \right) V_t^{B} \]  

- Dollar in the U.S.
- Euro in the Euroarea

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**Output can be traded against 2 distinct currencies**  
(The El Salvador case)
Imagine a world with two coexisting currencies

\[ Y_t = \left( \frac{1}{P_t^\$} M_t^\$ \right) V_t^\$ + \left( \frac{Q_t}{P_t^\$} M_t^B \right) V_t^B \]  

(8)

where

- \( Q_t \) is the Dollar price of one Bitcoin
- \( P_t^\$ \) is the Dollar price level (price of one apple in terms of Dollar)
- \( Q_t/P_t^\$ \) is the price of one apple in terms of Bitcoin
- \( V_t^\$, V_t^B \) are the Dollar resp. Bitcoin velocity
- \( M_t^\$, M_t^B \) are the Dollar resp. the Bitcoin supply

How Crypto affects Central Banks?

**There is no Bitcoin central bank**

\[
Y_t = \left( \frac{1}{P_t^S} M_t^S \underbrace{\text{under CB's control}}_{\text{control}} \right) V_t^S + \left( \frac{Q_t}{P_t^S} M_t^B \underbrace{\text{given by Bitcoin protocol}}_{\text{Bitcoin protocol}} \right) V_t^B \quad (9)
\]
How Crypto affects Central Banks?

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\begin{equation}
Y_t = \left( \frac{1}{P_t^S} \underbrace{M_t^S}_{\text{under CB's control}} \right) V_t^S + \left( \frac{Q_t}{P_t^S} \underbrace{M_t^B}_{\text{given by Bitcoin protocol}} \right) V_t^B \tag{10}
\end{equation}

Multiple Issues:
Not only the Dollar money supply $M_t^S$ but also the Bitcoin supply and the Bitcoin price level may impact the Dollar price level $P_t^S$

- The central bank loses control over the Dollar price level
- There exist different Dollar supplies that support the same Dollar price level (equilibrium multiplicity!)
Equilibrium Multiplicity

- Given output $Y_t$, a Bitcoin supply $B_t$, a Dollar target price level $\bar{P}_t$
- Then the same price target level $\bar{P}_t$ can be implemented using two distinct levels for a Dollar supply $D_1, D_2$, requiring two distinct Bitcoin prices $Q_1, Q_2$

$$\bar{P}_t = \frac{D_1}{Y} + \frac{B}{Y} Q_1$$  \hspace{1cm} (11)

$$\bar{P}_t = \frac{D_2}{Y} + \frac{B}{Y} Q_2$$  \hspace{1cm} (12)
Resolution of Equilibrium Multiplicity

- Only when anticipating the Bitcoin price $Q_t$ in addition to output $Y_t$, and a Bitcoin supply $B_t$, Dollar price level targeting $\bar{P}_t^\$$ becomes possible again.

- Given $(Q_t, Y_t, B_t)$: a one-to-one relationship between $D \leftrightarrow \bar{P}_t^\$$

\[
\bar{P}_t^\$$ = \frac{D_t}{Y_t} + \frac{B_t}{Y_t} Q_t
\]

(13) known (estimated)
Who pays for the Bitcoin Block rewards?

\begin{equation}
\bar{P}_t = D_t Y + B_t Y Q \tag{14}
\end{equation}

\begin{equation}
\bar{P}_{t+1} = D_t Y + B_t Y + 6.25 Y Q \tag{15}
\end{equation}

⇒ The Central Bank pays for the block rewards by pulling Dollars out of circulation (reduce Dollar supply).
Who pays for the Bitcoin Block rewards?

Assume the Dollar price target, output, and the Bitcoin price are unchanged

\[
\bar{P}^S = \frac{D_t}{Y} + \frac{B_t}{Y} Q
\]  

(14)
Who pays for the Bitcoin Block rewards?

Assume the Dollar price target, output, and the Bitcoin price are unchanged

\[
\bar{P}^s = \frac{D_t}{Y} + \frac{B_t}{Y} Q
\]  

(14)

In \( t + 1 \)

\[
\bar{P}^s = \frac{D_t \pm ?}{Y} + \frac{B_t + 6.25}{Y} Q
\]  

(15)

⇒ The Central Bank pays for the block rewards by pulling Dollars out of circulation (reduce Dollar supply)
How Crypto affects Central Banks?

IN A NUTSHELL

- Price level and inflation-targeting becomes more tricky with a competing currency:
  ⇒ Need to pay attention to Bitcoin supply and price
How Crypto affects Central Banks?

In a nutshell

- Price level and inflation-targeting becomes more tricky with a competing currency:
  - Need to pay attention to Bitcoin supply and price
  
  (Relevant for people that interact in $)
How Crypto affects Central Banks?

**In a nutshell**

- Price level and inflation-targeting becomes more tricky with a competing currency:
  ⇒ Need to pay attention to Bitcoin supply and price
  *(Relevant for people that interact in $)*

- When people start using crypto as their medium of exchange, they no longer care for $-monetary policy
  ⇒ *Separate Monetary Eco(nomic)system*

\[
\bar{P}_t^\$ = \frac{D_t}{Y_t} + \frac{1}{Y_t} \cdot B_t Q_t
\]

(16)

- Known (estimated)
- Crypto market cap
Separate Monetary Eco(nomic)system

Central Bank

QE

$-stability

$-income

$-purchases

$-loans

$ $ B

B-income

B-purchases

B-loans
How about cryptocurrency pricing?

Cryptocurrency allows shifting consumption from the present into the future and vice versa ('savings') ⇒ Store of Value function of money

Optimal consumption-savings problem

\[
\max \xi u(c_t) + E_t [\beta u(c_{t+1})]
\]

subject to

\[
c_t = e_t - p_t \xi
\]

\[
c_{t+1} = e_{t+1} + x_{t+1} \xi
\]

\[p_t\] is price of asset (Bitcoin) in terms of apples

\[c_t\] is today's apple consumption

\[e_t\] is the apple endowment

\[\xi\] the quantity of assets (Bitcoin) to optimally buy

\[x_{t+1}\] tomorrow's asset payoff (in terms of apples)
How about cryptocurrency pricing?

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⇒ Store of Value function of money
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\]  

(18)

\[
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\]  

(19)

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- \(x_{t+1}\) tomorrow’s asset payoff (in terms of apples)
How about cryptocurrency pricing?

Solution to Optimal consumption-savings problem

\[
\begin{equation}
\begin{aligned}
\rho_t &= \mathbb{E}_t \left[ \beta \frac{u'(c_{t+1})}{u'(c_t)} x_{t+1} \right]
\end{aligned}
\end{equation}
\]

In former notation

\[
\rho_t = \frac{Q_t}{P_t^S}
\]

with

- \(Q_t\) is price of one Bitcoin in Dollar
- \(P_t^S\) is the Dollar price of one apple
How about cryptocurrency pricing?

But cryptocurrency is not isolated: competes with Dollar as medium of exchange
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But cryptocurrency is not isolated: competes with Dollar as medium of exchange

- If Bitcoin is expected to rise, people stop trading in Bitcoin, rather spend Dollar
- If Bitcoin is expected to fall, people rather spend Bitcoin on consumption rather than Dollar
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But in Equilibrium: Relative prices need to adjust for people to be indifferent
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But in Equilibrium: Relative prices need to adjust for people to be indifferent

How characterize indifference between Dollar and Bitcoin trade?
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⇒ In expectation, the real appreciation of Bitcoin and Dollar is required to be identical for Bitcoin and Dollar to be in simultaneous use

\[
\mathbb{E}_t \begin{bmatrix}
    u'(c_{t+1}) \\
    \frac{P_t^d}{P_{t+1}}
\end{bmatrix} = \mathbb{E}_t \begin{bmatrix}
    u'(c_{t+1}) \\
    \frac{P_t^d/Q_t}{P_{t+1}/Q_{t+1}}
\end{bmatrix}
\]

- \(P_t^d\) is Dollar price of one apple
- \(P_t^d/Q_t\) is Bitcoin price of one apple
Conclusions

- Cryptocurrencies are relevant to economics not via their quantity but through their market capitalization.
- Cryptocurrencies find wide adoption when financial restrictions are large (slow costly banking, capital controls), and if monetary institutions do not commit to price stability (excessive inflation).
- The existence of cryptocurrencies makes price stability targeting more tricky for central banks that do commit to national currency stability.
- Quantitative Easing might boost cryptocurrency prices.

⇒ Cryptocurrencies act as a monetary disciplining device.
Thank you !!