Cryptocurrency vs. Central Bank Money

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Olin School of Business
Washington University in St Louis

UC San Diego Roundtable

What is a currency?

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- unit of account
- store of value
- medium of exchange

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    All accept (Bitcoin (BTC), Ether (ETH), Litecoin (LTC), Bitcoin Cash (BCH), Celo native asset (CELO), Dogecoin (DOGE), the Gemini dollar (GUSD), and Zcash (ZEC))

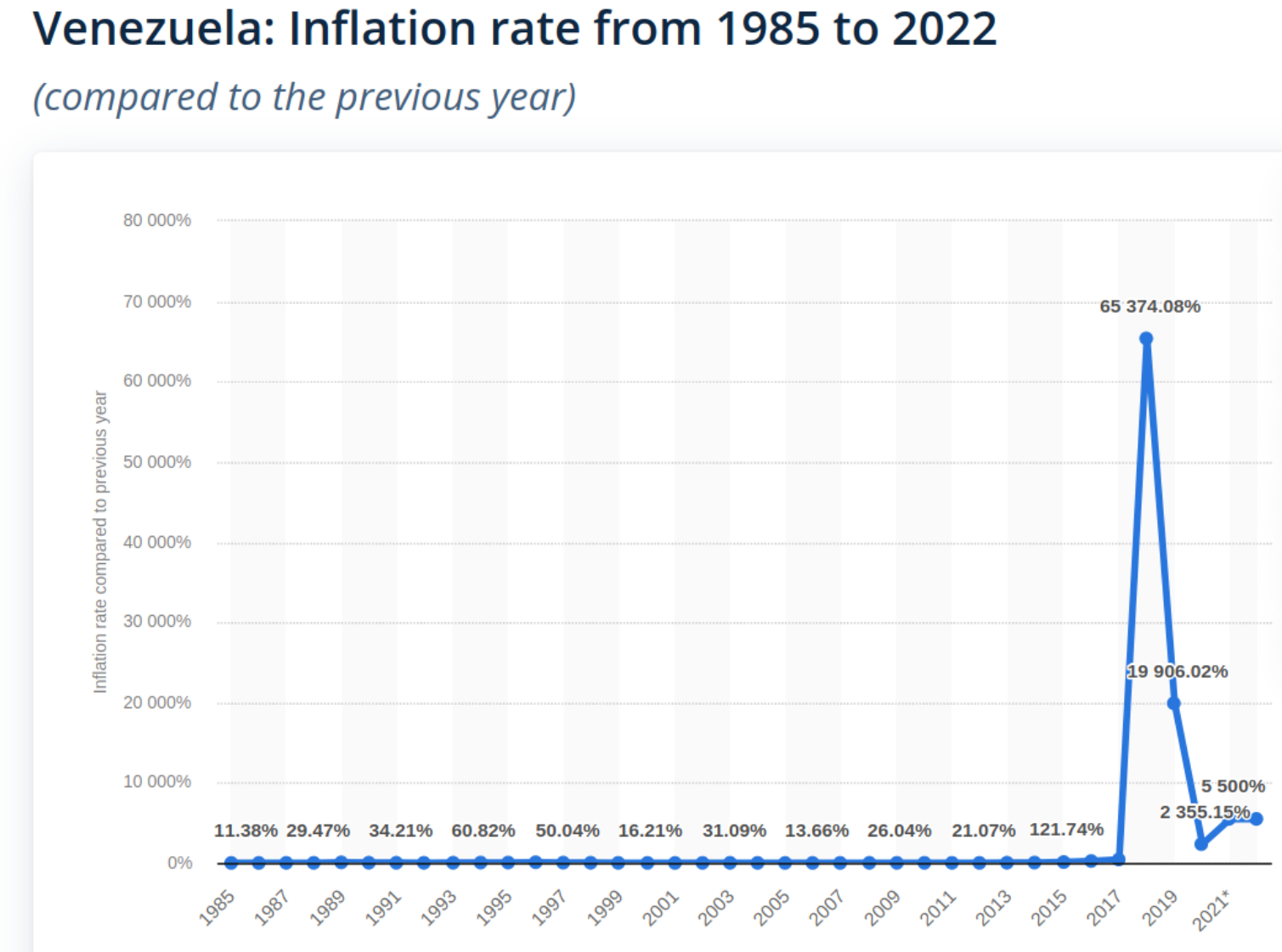
Crypto Adoption

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



source: statista.com

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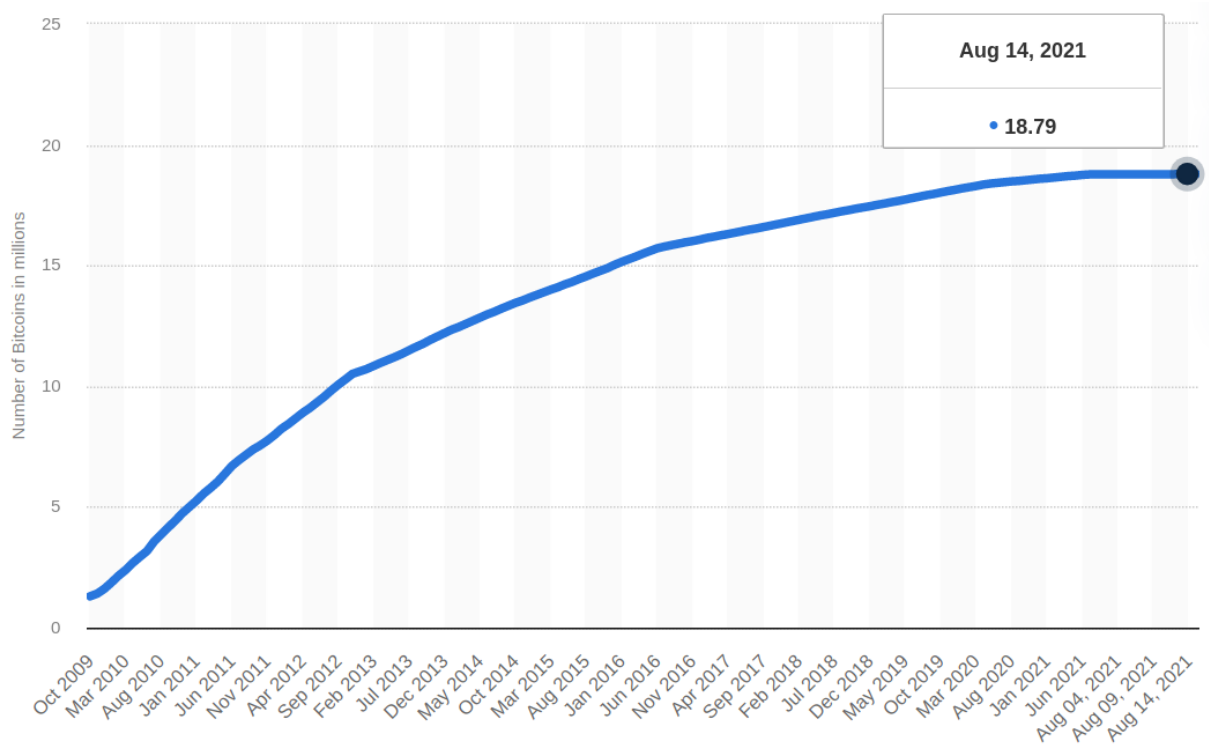
One fundamental difference: Crypto versus CB money

- 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

Global Bitcoin Supply (million)

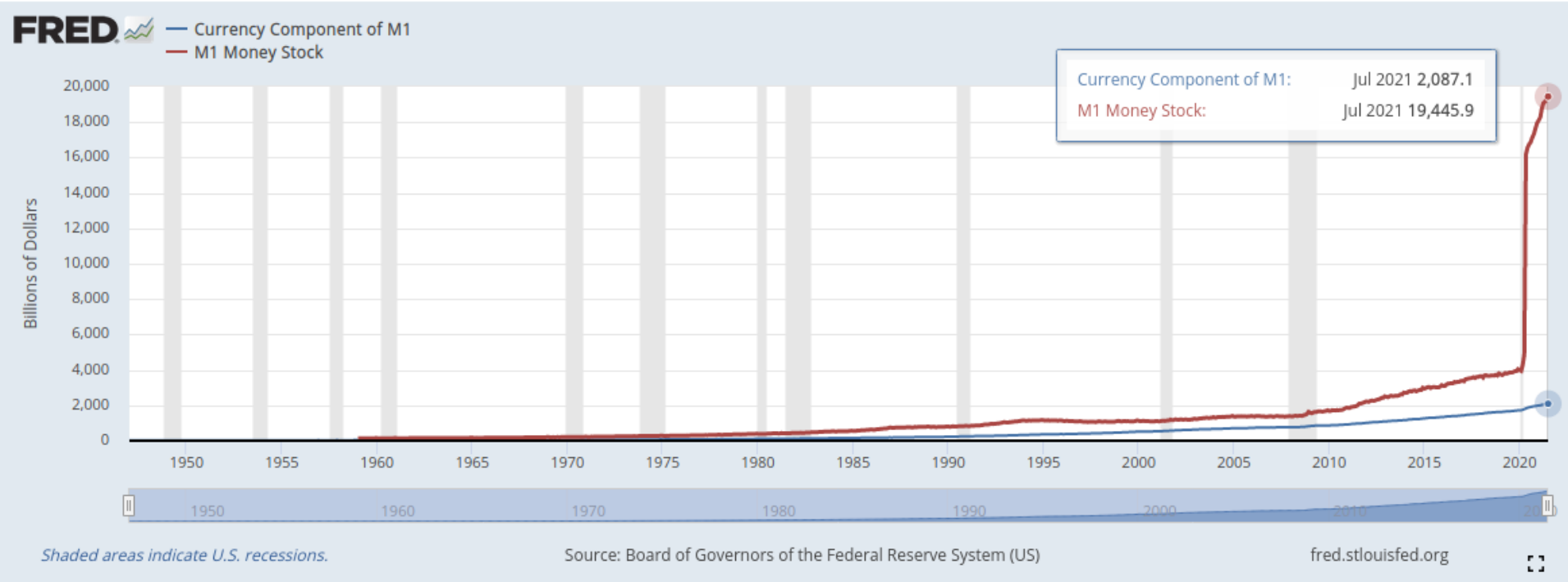


- Increasing supply: + 6.25 per block ($\approx$ 10 min)
- Upper bound 21 mn Bitcoin
- Halving of block rewards every 210.000 blocks ($\approx$ every 4 years)

source: statista.com

M1 United States in USD Billion

M1: (currency + deposits + traveller cheques)



(Quantitative Easing in times of Corona)

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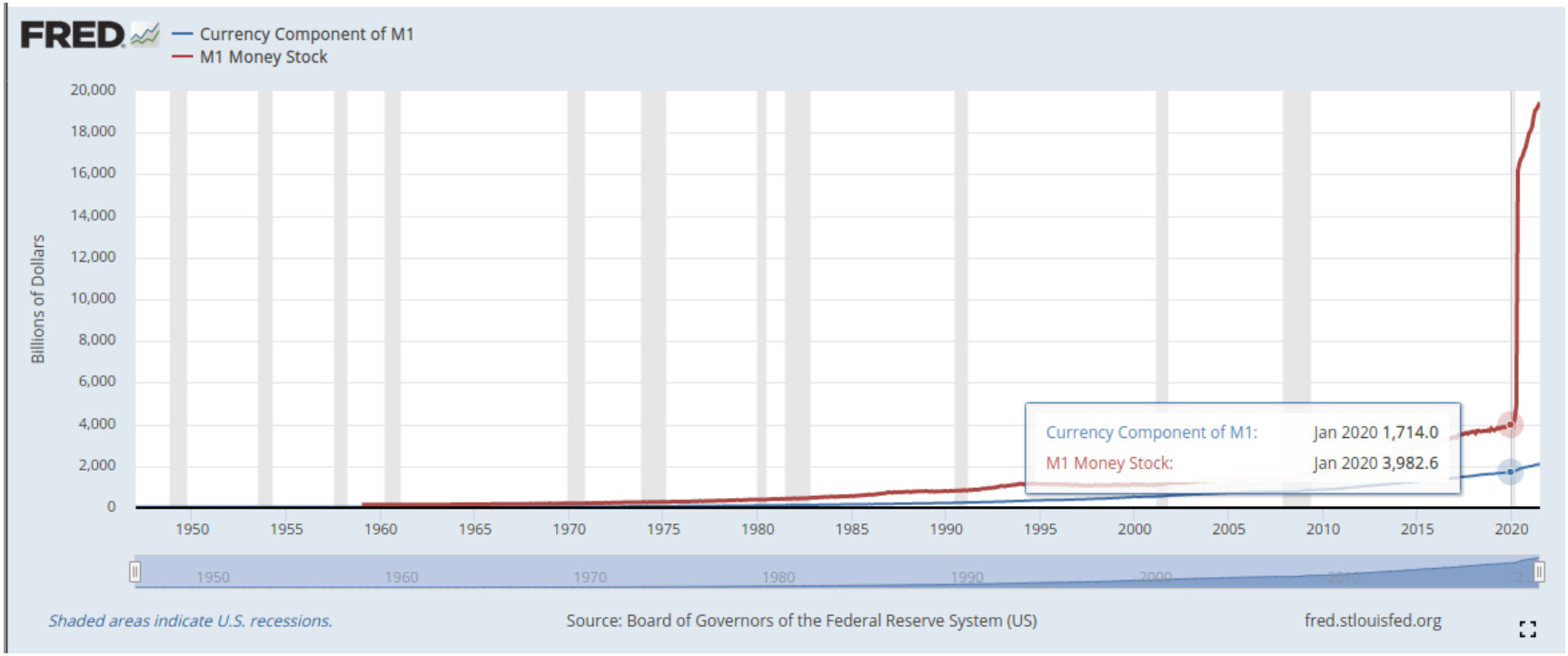

Increase in M1 (January 2020 - July 2021):

(19,445-3,983)/3,983= **+388%**

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$$\text{Market Capitalization} = \text{price} \times \text{supply} \tag{1}$$

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- Ethereum: $457.2 bn (price: $3,895.02)
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M1 (currency + deposits)

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- Euro area: \$12,881. bn
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$\Rightarrow$ **Swedish Krona (SEK) $\sim$ Ethereum**

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$\Rightarrow$ **Canadian Dollar (CAD) $\sim$ Bitcoin + Ethereum**

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⇒ **Currently: Bitcoin = 4% U.S. Dollar**

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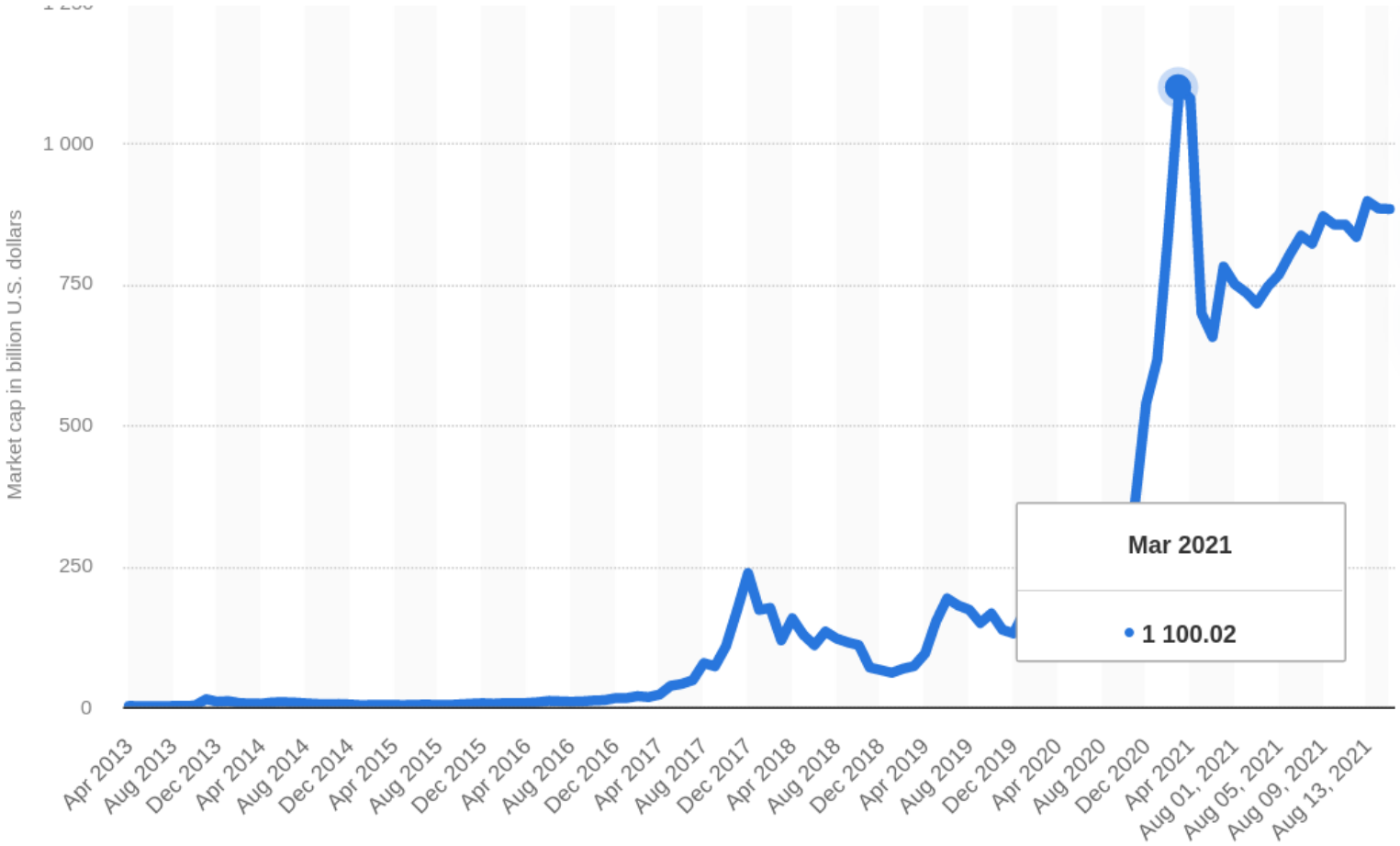

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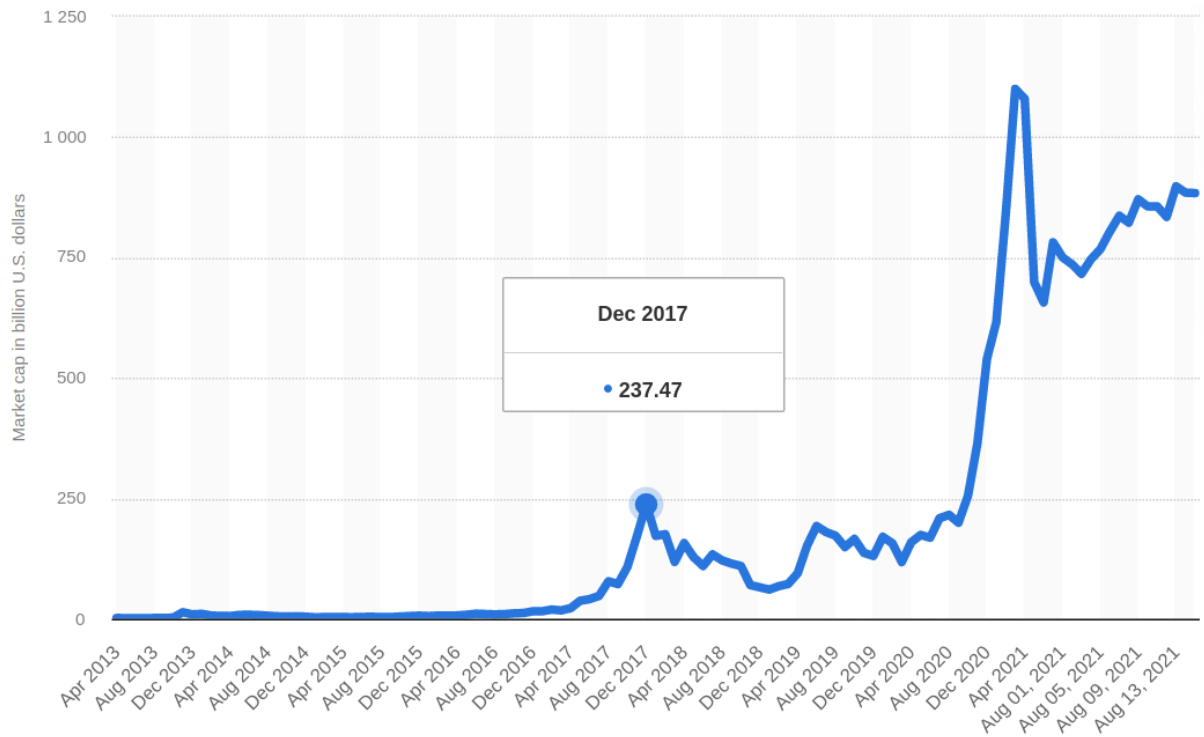

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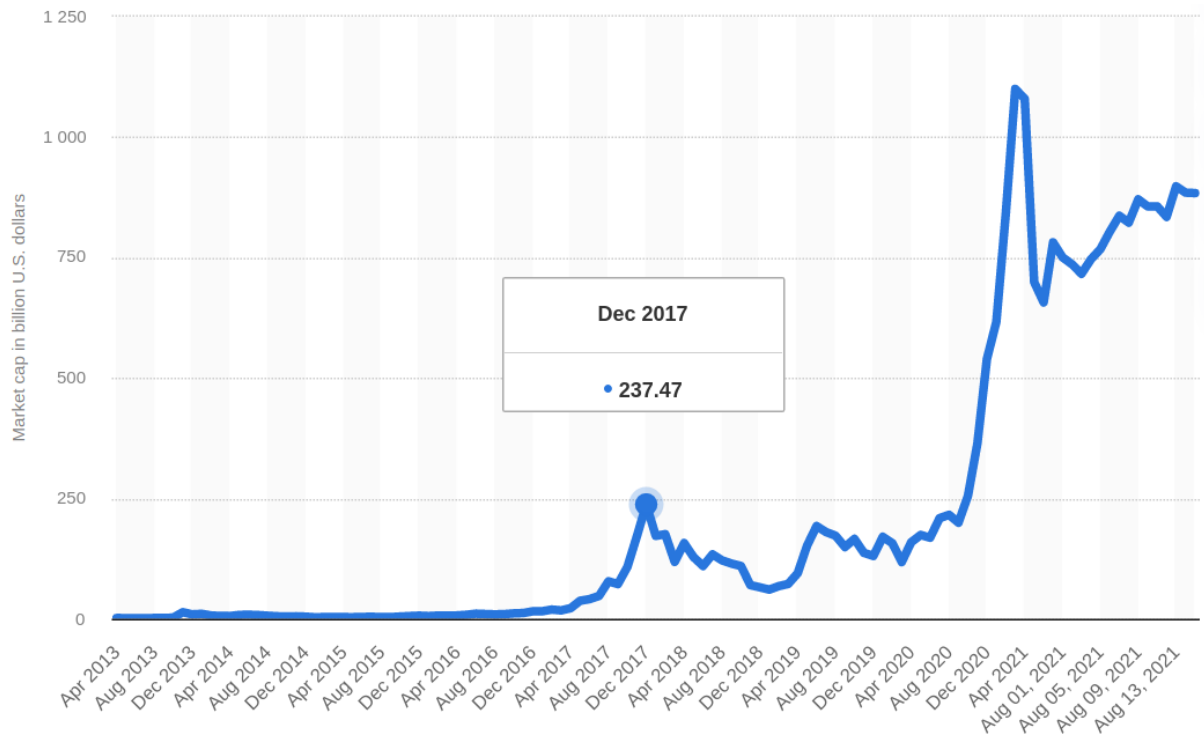

December 2017 ('a' Bitcoin peak, but before Covid QE): 237.5/4000= **5.9 %**

Total Cryptocurrency Market Capitalization

Total crypto market cap: **$ 2.3 tn** (Sept 2021), $ 1.5tn (July 2021)
Including stablecoins and tokens, on linear scale,

source: coinmarketcap.com

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$\Rightarrow$ **Probably Meaningful**

How does Crypto matter for Central Banks concretely?

What a Central Bank does

Board of Governors of the Federal Reserve System

The Federal Reserve, the central bank of the United States, provides the nation with a safe, flexible, and stable monetary and financial system.

About the Fed | News & Events | Monetary Policy | Supervision & Regulation | Payment Systems | Economic Research | Data | Consumers & Communities

Home

About the Fed

Transcript (PDF)

The Fed Explained

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.

Board Members

Jerome H. Powell
Chair

Richard H. Clarida
Vice Chair

Randal K. Quarles
Vice Chair for Supervision

Michelle W. Bowman

Lael Brainard

Christopher J. Waller

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(Quantity Theory of Money)

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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 \$ price P_t for output stable across time, observing the price sequence $P_0, P_1, \ldots, P_t$
  $\Rightarrow$ Inflation targeting $\pi_{t+1} = P_{t+1}/P_t$
- How?

$$\underbrace{M_t^{\uparrow}}_{\substack{\text{money}\\ \text{supply}}} \cdot \underbrace{V_t}_{\text{velocity}} = \underbrace{P_t^{\uparrow}}_{\substack{\text{price}\\ \text{level}}} \cdot \underbrace{Y_t}_{\substack{\text{real}\\ \text{output}\\ \text{(apples)}}} \tag{5}$$

(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

$$Y_t = \left(\frac{1}{P_t^{\$}} M_t^{\$} \right) V_t \tag{6}$$

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

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$$Y_t = \left(\frac{1}{P_t^{\$}} M_t^{\$}\right) V_t^{\$} + \left(\frac{Q_t}{P_t^{\$}} M_t^{B}\right) V_t^{B} \tag{7}$$

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  Output can be traded against 2 distinct currencies
  (The El Salvador case)

Imagine a world with **two coexisiting currencies**

$$Y_t = \underbrace{\left(\frac{1}{P_t^{\$}} M_t^{\$}\right) V_t^{\$}}_{\substack{\text{apples traded} \\ \text{for Dollars}}} + \underbrace{\left(\frac{Q_t}{P_t^{\$}} M_t^{B}\right) V_t^{B}}_{\substack{\text{apples traded} \\ \text{for Bitcoin}}} \tag{8}$$

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 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

source: Schilling and Uhlig (2019), 'Some simple bitcoin economics', Journal of Monetary Economics

Kareken and Wallace (1981), 'On the indeterminacy of equilibrium exchange rates', Quarterly Journal of Economics

How Crypto affects Central Banks?

There is no Bitcoin central bank

$$Y_t = \left(\frac{1}{P_t^{\$}} \underbrace{M_t^{\$}}_{\substack{\text{under CB's} \\ \text{control}}} \right) V_t^{\$} + \left(\frac{Q_t}{P_t^{\$}} \underbrace{M_t^{B}}_{\substack{\text{given by} \\ \text{Bitcoin protocol}}} \right) V_t^{B} \qquad (9)$$

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

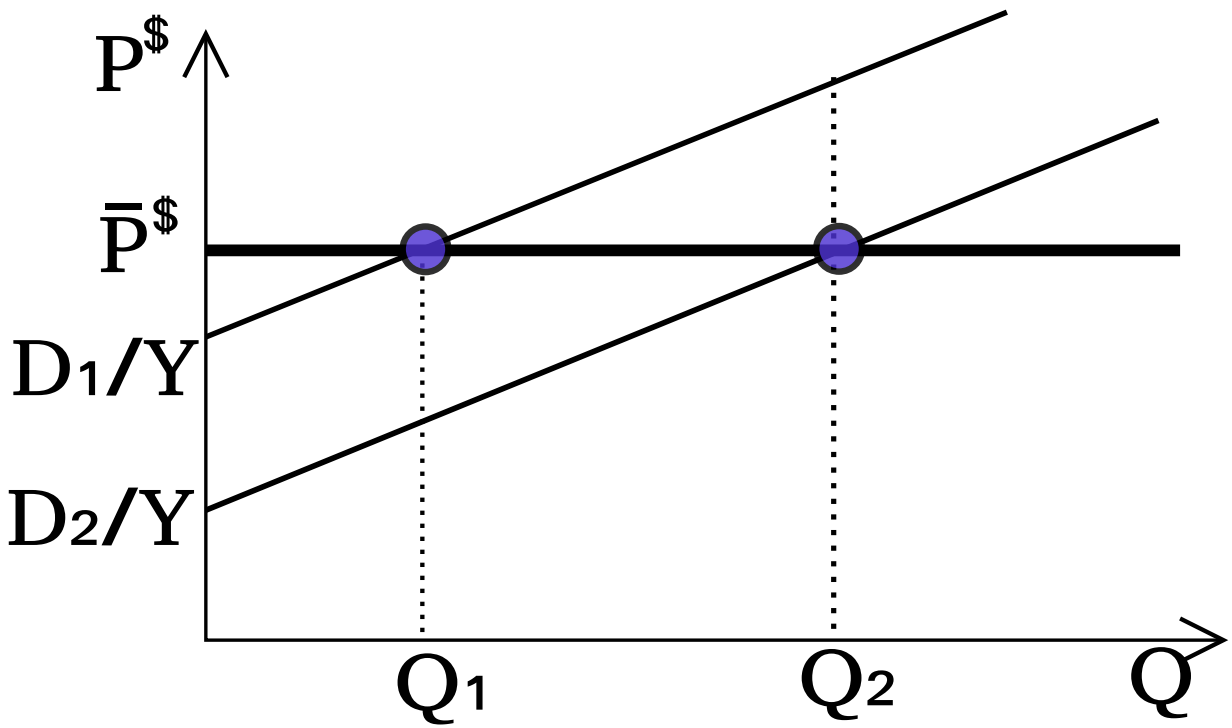
- The central bank loses control over the Dollar price level
- There exist different Dollar supplies that support the same Dollar price level (equilibrium multiplicity!)

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

$$\bar{P}_t^{\$} = \frac{D_1}{Y} + \frac{B}{Y} Q_1 \tag{11}$$

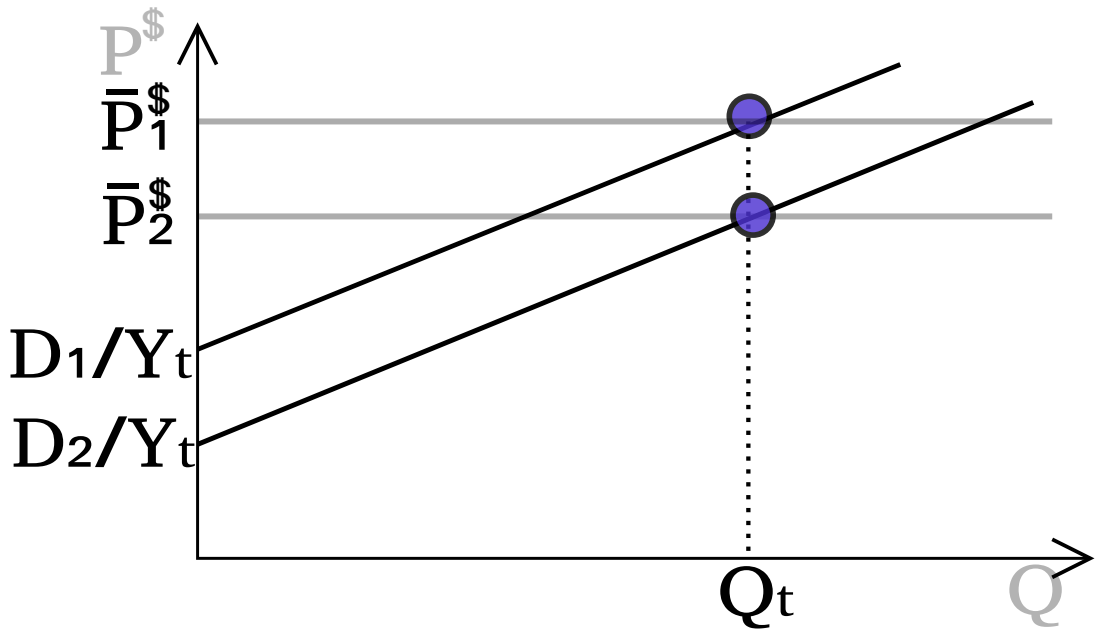
$$\bar{P}_t^{\$} = \frac{D_2}{Y} + \frac{B}{Y} Q_2 \tag{12}$$



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 $D \leftrightarrow \bar{P}_t^{\$}$

$$\bar{P}_t^{\$} = \frac{D_t}{Y_t} + \underbrace{\frac{B_t}{Y_t} Q_t}_{\text{known (estimated)}} \tag{13}$$



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In $t+1$

$$\bar{P}^{\$} = \frac{D_t \pm \textcolor{magenta}{?}}{Y} + \frac{B_t \textcolor{magenta}{+\mathbf{6.25}}}{Y} Q \tag{15}$$

$\Rightarrow$ The Central Bank pays for the block rewards by pulling Dollars out of circulation (reduce Dollar supply)

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In a nutshell

- Price level and inflation-targeting becomes more tricky with a competing currency:
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- Price level and inflation-targeting becomes more tricky with a competing currency:
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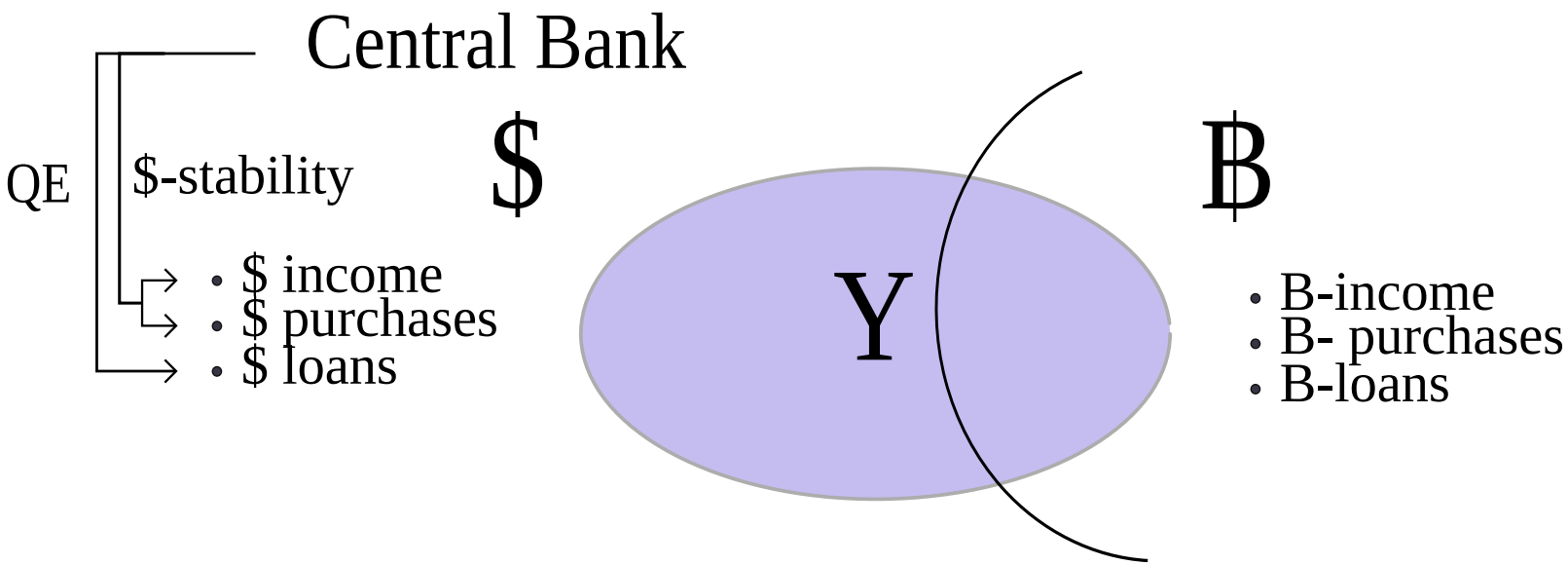
  (Relevant for people that interact in \$)
- When people start using crypto as their medium of exchange, they no longer care for \$-monetary policy
  $\Rightarrow$ **Separate Monetary Eco(nomic)system**

$$\bar{P}_t^{\$} = \frac{D_t}{Y_t} + \underbrace{\frac{1}{Y_t}}_{\text{known (estimated)}} \cdot \underbrace{B_t Q_t}_{\substack{\text{crypto} \\ \text{market cap}}} \tag{16}$$

Separate Monetary Eco(nomic)system



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Optimal consumption-savings problem

$$\max_{\xi} \; u(c_t) + \mathbb{E}_t[\beta \, u(c_{t+1})] \tag{17}$$

subject to

$$c_t = e_t - p_t \xi \tag{18}$$

$$c_{t+1} = e_{t+1} + x_{t+1} \xi \tag{19}$$

- p_t is price of asset (Bitcoin) in terms of apples
- c_t is today's apple consumption
- e_t is the apple endowment
- ξ the quantity of assets (Bitcoin) to optimally buy
- x_{t+1} tomorrow's asset payoff (in terms of apples)

How about cryptocurrency pricing?

Solution to Optimal consumption-savings problem

$$\underbrace{p_t}_{\substack{\text{Bitcoin price} \\ \text{in apples}}} = \mathbb{E}_t \left[\underbrace{\beta \frac{u'(c_{t+1})}{u'(c_t)}}_{\substack{\text{marginal rate} \\ \text{of substitution}}} \underbrace{x_{t+1}}_{\substack{\text{quantity of apples} \\ \text{for one Bitcoin}}} \right] \tag{20}$$

- In former notation

$$p_t = \frac{Q_t}{P_t^{\$}} \tag{21}$$

with

  - Q_t is price of one Bitcoin in Dollar
  - $P_t^{\$}$ is the Dollar price of one apple

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$\Rightarrow$ In expectation, the real appreciation of Bitcoin and Dollar is required to be identical for Bitcoin and Dollar to be in simultaneous use

$$\mathbb{E}_t \left[u'(c_{t+1}) \underbrace{\frac{P_t^{\$}}{P_{t+1}^{\$}}}_{\substack{\text{inverse} \\ \text{Dollar inflation}}} \right] = \mathbb{E}_t \left[u'(c_{t+1}) \underbrace{\frac{P_t^{\$}/Q_t}{P_{t+1}^{\$}/Q_{t+1}}}_{\substack{\text{inverse} \\ \text{Bitcoin inflation}}} \right] \tag{22}$$

- $P_t^{\$}$ is Dollar price of one apple
- $P_t^{\$}/Q_t$ 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

$\Rightarrow$ **Cryptocurrencies act as a monetary disciplining device**

Thank you !!