

Bitcoin: Programming the Future of Money

Topics in Computer Science - ITCS 4010/5010, Spring 2025

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Lecture 3

Properties of Money



History of Money

TYPES OF MONEY ACROSS HISTORY

- Collectibles as “Proto-money” (Reference: [“Shelling Out”, Nick Szabo](#))
- Commodity-based public ledgers
- (Unminted) metal money (e.g., lumps of bronze)
- Minted metals, coins: Gold/silver/bronze...
- Paper money (as promissory notes for a commodity / other type of money)
- Paper money (unbacked), invasion money

RECAP: THEORIES OF MONEY

- **Commodity Theory of Money:**
 - Money as improvement over a barter system of direct trade of goods
 - Money: most salable good emerges, typically a commodity
- **Credit Theory of Money:**
 - Money as formalization of informal debt and obligations between individuals
 - Token of trust

THE GOLD STANDARD

- 1717: Isaac Newton as “Master of Royal Mint” fixes ratio between British silver and gold (via respective coins) to 15.2:1
- Overvaluation of silver, [Gresham's law](#) leads to export of British silver coins abroad
- 19th century:
 - ▶ Dominance of Great Britain in global trade
 - ▶ Global trade network and several [gold rushes](#) convinces other powers to adapt national currency standards based on gold as well (US 1834/1873, Germany 1871, France 1874)
- Silver is phased out as metal to redeem banknotes in
- In Europe: National **central banks** centralize gold supplies in economies, issue bank notes redeemable in gold, make sure that redemption/convertibility in gold is guaranteed



(Source: Cooper, Richard N., Rüdiger Dornbusch, and Robert E. Hall. ["The gold standard: historical facts and future prospects."](#) Brookings Papers on Economic Activity 1982.1 (1982): 1-56.)

THE FAILURE OF THE GOLD STANDARD

- In different countries: Temporary or permanent suspension of gold standard in times of war (US civil war, Britain, Germany in WWI)
- 1920s: Large expansion of credit in global economies
 - > **Fractional banking:** Only a (smaller) fraction of money deposits in central and commercial banks are kept in reserve, majority is lent out.
E.g.: Customer deposits \$100 -> bank lends \$900.
- 1929: Great Depression after stock market crash in the US
 - > **Bank runs, bank failures, deflation of asset prices, high unemployment**
- April 5, 1933 (Executive Order 6102) and January 30, 1934 (Gold Reserve Act):
 - ▶ Forbids private ownership of gold, U.S. citizens need to deliver any gold to Federal Reserve at ratio \$20.67/ounce
 - ▶ USD is revalued at \$35/ounce

AFTER FAILURE OF THE GOLD STANDARD: FIAT MONEY



US President Nixon on August 15, 1971:

- Stop of convertibility of US dollar into Gold (\$35 per ounce of Gold) by foreigners
- Announced as temporary measure, but never reintroduced

AFTER FAILURE OF THE GOLD STANDARD: FIAT MONEY

Background of decision to end of USD-gold convertibility of 1971:

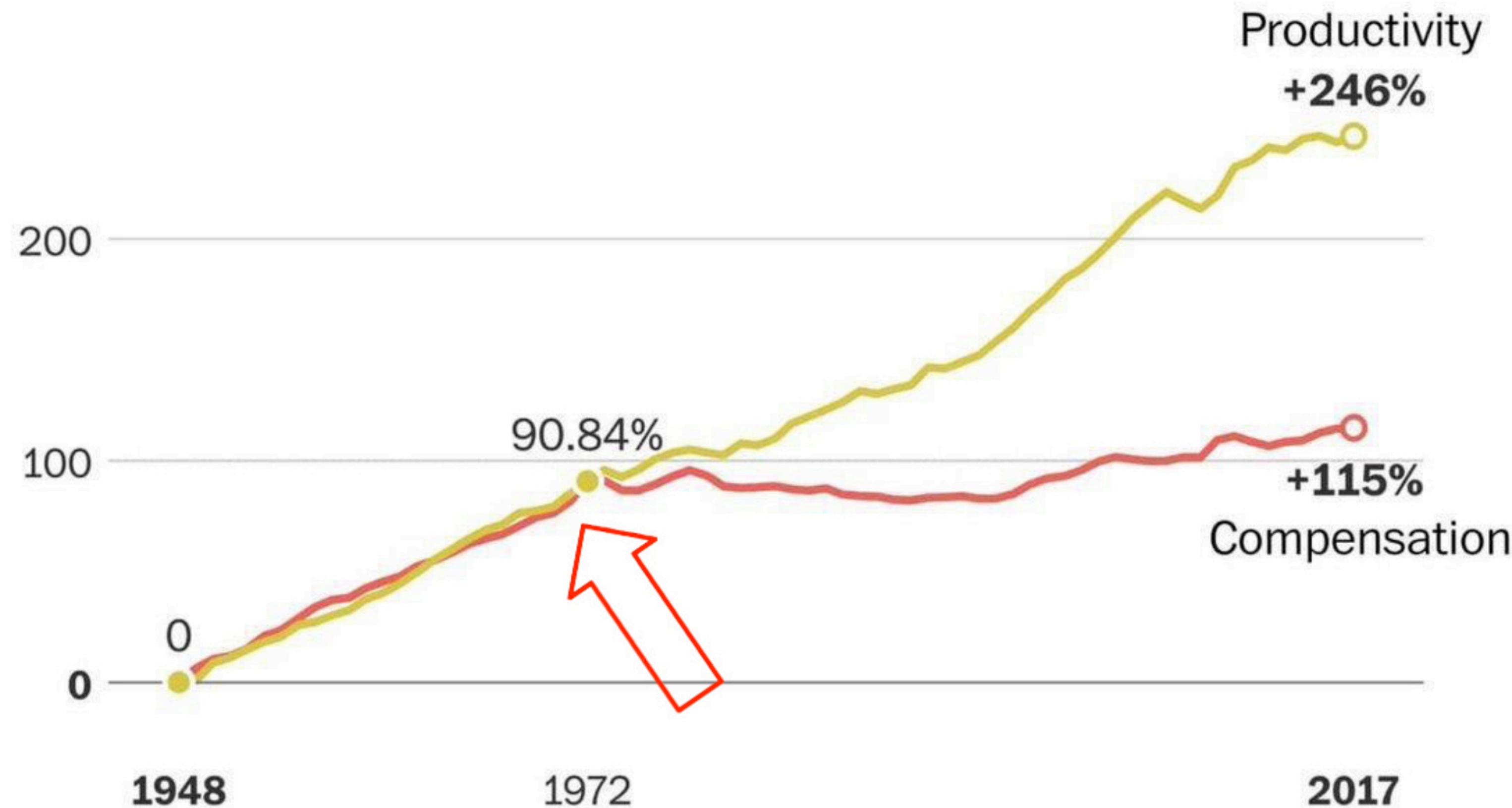
- Increasing US Balance-of-Payment deficits with international partners
- High government spending (Vietnam war, social programs)
- Declining US gold reserve, foreign conversions USD -> Gold (e.g., France)
- Political Considerations

Definition:

- A money (or currency) that **cannot be exchanged into a commodity** such as a precious metal (e.g., gold, silver)
- **“Fiat”**: Latin for “let it be done”. Represents an order or decree.

WHAT HAPPENED IN 1971?

Growth in productivity and hourly compensation since 1948



Productivity
vs.
Real Wages

Note: Compensation includes wages and benefits for production and non-supervisory workers

Source: Economic Policy Institute

WHAT HAPPENED IN 1971?



US Federal
Debt over the
centuries

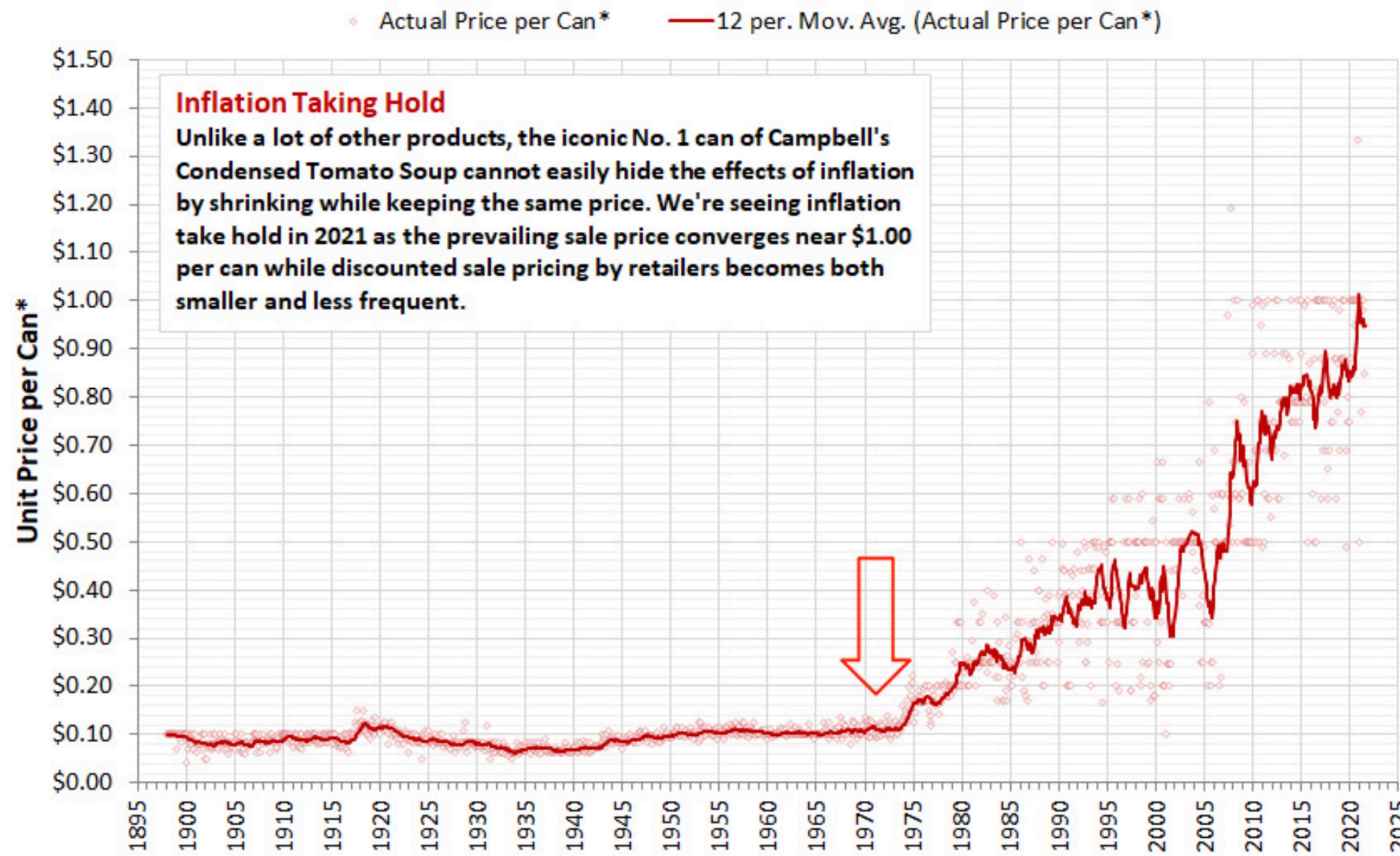
SOURCES: Congressional Budget Office, *The Budget and Economic Outlook: 2020 to 2030*, January 2020; and Office of Management and Budget, *Historical Tables, Budget of the United States Government: Fiscal Year 2021*, February 2020.

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WHAT HAPPENED IN 1971?

Unit Price per Can* of Campbell's Condensed Tomato Soup at Discounted Sale Pricing, January 1898 - July 2021



Data Sources: Selected Advertisements in U.S. Newspapers, 1897-2021

* Can refers to the iconic No. 1 "picnic" can of Campbell's Condensed Tomato Soup

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Functions of Money

MICHAEL SAYLOR INTERVIEW

Q: Which traditional defined property of money is not well satisfied by modern money?

- ▷ Scarcity, no limited supply
- ▷ Value of money is not constant, e.g. CPI (consumer price index) is not a suitable metric

Similarities between bitcoin & beach-front real estate:

- ▷ Both are property, naturally limited in Supply → desirable
- ▷ Both have "price-supply inelasticity"

WHAT IS MONEY?

Key functions of money:

- Store of Value
- Medium of Exchange
- Unit of Account

First identified by William Stanley Jevons in 1875
("Money and the Mechanism of Exchange")

WHAT IS A CURRENCY?

currency noun

cur·ren·cy ('kər-ən(t)-sē) 'kə-rən(t)-

plural currencies

Synonyms of currency >

1 **a** : circulation as a medium of exchange

b : general use, acceptance, or prevalence
| a story gaining *currency*

c : the quality or state of being *current* : CURRENTNESS

| needed to check the accuracy and *currency* of the information

2 **a** : something (such as coins, treasury notes, and banknotes) that is in circulation as a medium of exchange

b : paper money in circulation

c : a common article for bartering
| Furs were once used as *currency*.

d : a medium of verbal or intellectual expression
| ... neither side possessed any *currency* but clichés ...
| —Jan Struther

The money or other commodity which is in circulation in a particular place as a medium of exchange; the system of money in general use in a particular region or country, e.g. pounds, dollars, Euros, rupees, etc.

commodity currency, cryptocurrency, decimal currency, digital currency, hard currency, investment currency, managed currency, metallic currency, postage currency, reserve currency, single currency, soft currency, etc.: see the first element.

1675 The Merchants in the *currency* of the pieces should have allowance of so much as the charge of the Coinage amounts unto.

R. Vaughan, *Discourse of Coin & Coinage* ix. 89 ...

1691 To manage this Trade in its due *Currency*; 'twill require that the Stock employ'd in it be at least Three Fourths in Bullion.

G. White, *Account Trade East-Indies* 2 ...

1729 Money..by being coin'd..is made a *Currency*.

B. Franklin, *Modest Enq.* 27 ...

1776 The paper *currencies* of North America.

A. Smith, *Inquiry Wealth of Nations* vol. I. ii. 396 ...

1866 The *currencies* of two countries..being dissimilar.

A. Crump, *Practical Treatise on Banking* vii. 154 ...

1899 Cowry shells, commonly used in early China as *currency*, were never so employed in Japan.

English Historical Review April 228 ...

MONEY AS STORE OF VALUE

In other words: **Retention of purchasing power**

- Ability to facilitate satisfaction of needs/desires that are relevant in the future (**store of value across time**)

Examples:

- Retirement savings of individuals
 - Accumulation of value for large purchase (housing for individual, other business for an enterprise)
 - Uncertain upcoming expenses
-
- Also relevant: Ability to **store value across space**
(e.g., should be accessible if moved from one city/state/country to another)

MONEY AS MEDIUM OF EXCHANGE

- **Ability to be exchanged in trade relationships** (between individuals/companies)
- Relevant factors for this ability:
 - ▶ Cost of exchange
 - ▶ Convenience/practicality
 - ▶ Acceptance by counterparty
 - ▶ Legal situation
 - ▶ Privacy
 - ▶ Unforeseen risks

MONEY AS MEDIUM OF EXCHANGE

Example: US-Dollar exchanged using credit cards

Credit card processing fees are the fees that a business must pay every time it accepts a credit card payment. Multiple relevant fees:

Interchange Fees

The **interchange fee is a payment made directly to the card issuer** for the swiped transaction. Fees may vary based on the type of card being used, the amount of the transaction and the industry the business is in.

Payment Processor Fees

The merchant services processor, also called a **payment processor**, can also **charge a fee to facilitate the transaction**. Merchant services fees include monthly fees, per-transaction fees, equipment lease fees and statement fees. This is how a processor makes its money since it gets none of the interchange fees.

Assessment Fees

Assessment fees are fees paid **directly to the credit card network** so that the merchant can use certain credit cards. This fee is based on monthly sales, not per transaction. When combined with the interchange fee, merchants refer to the total as a **swipe fee**.

Typical Costs From Major Credit Card Companies

Credit Card	Average Interchange Fees	Average Assessment Fees
Visa	1.15% plus 5 cents to 2.40% plus 10 cents	0.14%
Mastercard	1.15% plus 5 cents to 2.50% plus 10 cents	0.1375% (transactions under \$1,000); 0.01% (transactions \$1,000 or more)
Discover	1.35% plus 5 cents to 2.40% plus 10 cents	0.13%
American Express	1.43% plus 10 cents to 3.30% plus 10 cents	0.15%

Typical Costs for Credit Card Processing

Payment Processor	Swiped Transaction Fee	Online Transaction Fee	Monthly Fee
Helcim	Base costs plus 0.40% 8 cents	Base costs plus 0.50% plus 25 cents	\$0
National Processing	Base costs plus 0.14% plus 7 cents	Base costs plus 0.29% plus 15 cents	\$9.95
Payline	Base costs plus 0.20% plus 10 cents	Base costs plus 0.40% plus 20 cents	\$10 (retail); \$20 (online)

MONEY AS MEDIUM OF EXCHANGE

Example: US-Dollar exchanged using PayPal (**Merchant Fees**)

Standard rate for receiving domestic transactions

Payment Type	Rate
Alternative Payment Method (APM)	APM Transaction Rates Apply
PayPal Checkout	3.49% + fixed fee
PayPal Guest Checkout	3.49% + fixed fee
QR code Transactions	2.29% + fixed fee
QR code Transactions through third party integrator	2.29% + 0.09 USD
Pay with Venmo	3.49% + fixed fee
Send/Receive Money for Goods and Services	2.99%
Standard Credit and Debit Card Payments	2.99% + fixed fee
All Other Commercial Transactions	3.49% + fixed fee

Source: <https://www.paypal.com/us/webapps/mpp/merchant-fees>

Payment Settlement: Involved parties and risks

Definition of (final) payment settlement:

“the **discharge of an obligation** by a transfer of funds and a transfer of securities that have become **irrevocable** and **unconditional**. ”

Source: [Bank for International Settlements](#), 2003

Who is involved in payment settlement systems?

Payment settlement involves several different entities with specific responsibilities and functions. These entities collaborate to create secure and reliable payment systems that process [millions of credit card transactions every hour](#).

- **Business:** This is the entity that sells goods or services. Businesses accept payments from customers using merchant accounts, a type of bank account that allows businesses to accept debit and credit card payments. A [merchant account](#) holds funds before the money is transferred to the business's primary business bank account.
- **Customer (cardholder):** This is the individual or entity that purchases goods or services using a payment method such as a credit or debit card.
- **Acquiring bank (business's bank):** The acquiring bank is the business's partner in processing credit and debit card transactions. It provides the business with the necessary tools and bank accounts to accept card payments. The acquiring bank passes along the business's transactions to the applicable issuing banks to receive payment.
- **Issuing bank (customer's bank):** This is the bank that issued the customer's credit or debit card. The [issuing bank](#) is responsible for paying the acquiring bank on behalf of the customer and, later, collecting the payment from the customer.

- **Payment processor:** Often a third-party company, the [payment processor](#) is the entity that manages the transaction flow between businesses, acquiring banks, and card networks. It provides the technology and services needed for processing transactions including authorization, batching, and settlement functions.
- **Card networks (payment networks):** These networks facilitate the electronic transfer of financial information and funds between parties. Examples include Visa, Mastercard, American Express, and Discover. Card networks set the rules and standards for card transactions and provide the infrastructure for processing them.
- **Payment gateway:** Payment gateways process credit card payments for businesses. They facilitate the transfer of information between a payment portal (such as a website or mobile phone) and the payment processor or acquiring bank.
- **Central banks:** In the broader context of payment systems, central banks regulate and oversee the national payment system, ensuring overall financial stability and the integrity of the settlement process.
- **Regulatory bodies:** These entities establish the legal framework and standards for payment systems, monitor compliance, and ensure consumer protection. They can be national or international organizations, depending on the scope of the payment system.
- **Clearing houses:** In certain payment systems, especially in interbank transfers, clearing houses act as intermediaries that facilitate the clearing and settlement of payments, securities, or derivatives transactions. The [Automated Clearing House \(ACH\)](#) network is one example.

Typical settlement time for credit card payments:
- 2-3 business days
- 60-120 days: [Dispute still possible \(Source 2\)](#)

Source: [Stripe, Payment settlement explained: How it works and how long it takes](#)

MONEY AS UNIT OF ACCOUNT

- **Measurement unit** that allows to value a good, service or transaction

Examples:

- The price of the latte at Starbucks is \$5.00.
- Your hourly wage for this job is \$12.50.

- **Coordination mechanism** of individuals/ economic participants through “accurate” pricing

Q: **What properties** make some type of money a **good unit of account?**

Properties of Money

DIVISIBILITY OF MONEY

- Ability to be easily subdivided into various sizes and units

Scale: 1 to 5
means: not divisible means: very divisible

Q: How divisible are following monetary goods?

Gold coins :	3
Gold (unminted/bullion) :	1
Fiat currency as bank deposit :	5
Fiat currency as bills :	4
Bitcoin	?

Relationship with functions of money?

- Relevant for appropriateness as unit of account as granularity of pricing / accounting is improved
- Relevant for appropriateness as medium of exchange as specific amount of units need to exchange hands in a trade
- Less relevant for store of value.

PORABILITY OF MONEY

- Ease of moving across long distances
- Relationship portability/value

think about it yourselves!

Gold coins:



Gold (unminted/bullion):

Fiat currency as bank deposit

Fiat currency as bills

Bitcoin

Q: Which function of money is facilitated?

→ Medium of Exchange:

Portable items enable easier use in the exchange with goods

→ Store of Value:

Portable items are potentially more desirable, especially when relocation is necessary.

Example: > Jews fleeing Europe in WWII

> Ukrainian refugees who can move across borders with portable money.

DURABILITY OF MONEY

- Ease of preservation across time
- Relevant: Cost of maintenance, risk of loss

Facilitates:

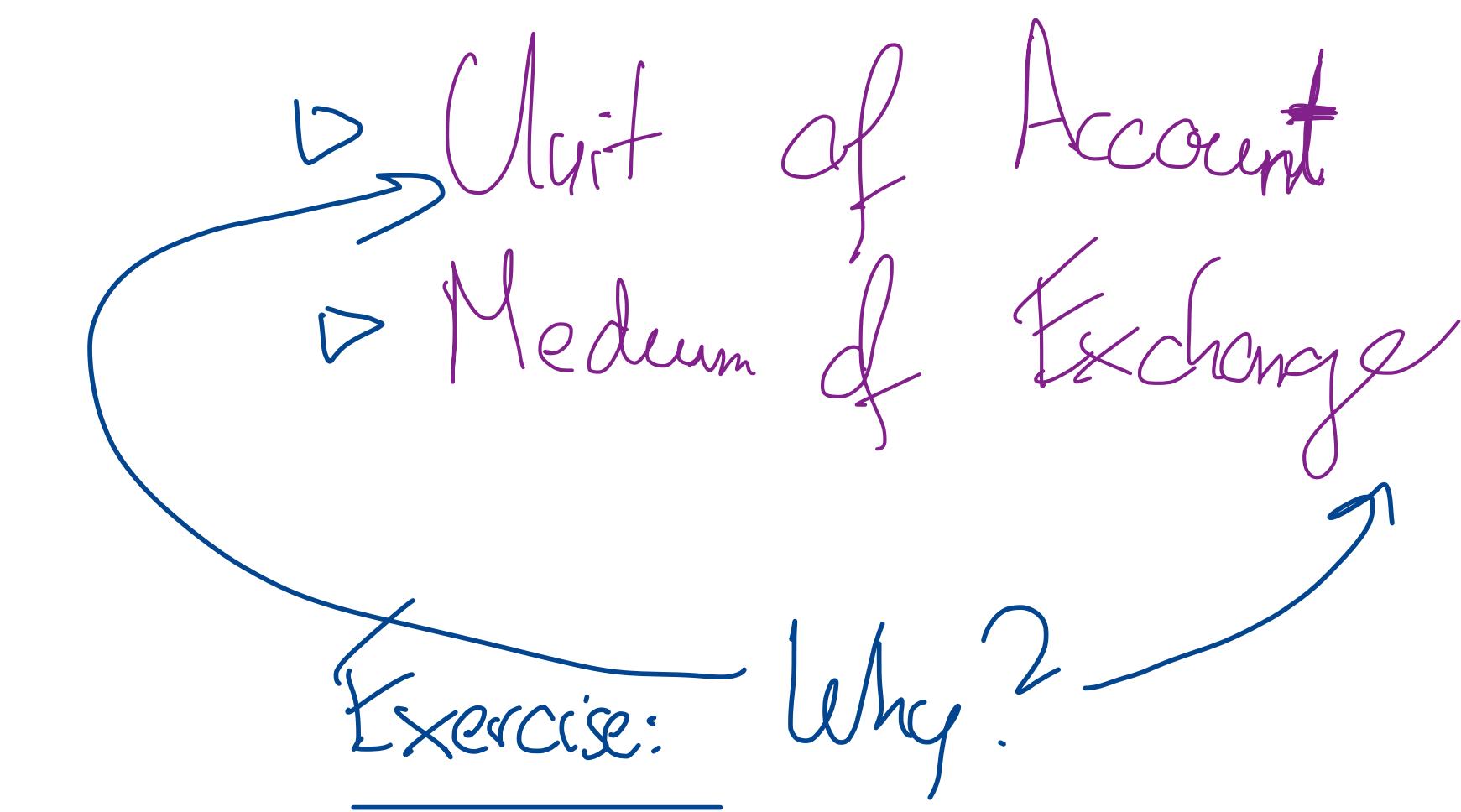
- ▷ Store of Value
- ▷ Unit of Account

FUNGIBILITY OF MONEY

Meaning of Fungibility:

- Different units/ items do not differ significantly for each other

Facilitates the monetary functions of:



VERIFIABILITY OF MONEY

- Ability for user of money (in either function) to easily check whether money item is what it appears to be

Facilitates the monetary functions of:

- Medium of Exchange:
If not easily verifiable, transaction costs are high.
E.g., costly verification process hinders use in trade
- Store of Value: Counterfeits are hard to detect, potential to (seemingly) increase Supply → less effective scarcity.

SCARCITY OF MONEY

- Cannot be abundant or easy to produce (“unforgeable costliness”)
- Related to total (available) supply or change in supply

↳ Store of Value

Relationship with VoA & MoE is
more complex:

Scarce money can be a practical
problem for being a good exchange
medium! → look up coin shortages in
▷ Colonial America, ▷ French Revolution in 18th
century

NON-MONETARY UTILITY OF MONEY

- Is the good intrinsically desirable for other purposes than money?

Example:

Gold as jewelry, electric conductor in industry.

- Q: Does non-monetary utility of a monetary item/ a money make it a **better** money or a **worse** money?

State arguments for both views!