

RESEARCH BRIEF • APRIL 2024

On Digital Currencies

Based on BFI Working Paper No. 2024-17, "[On Digital Currencies](#)," by Harald Uhlig, University of Chicago

In a work summarizing his previous research, the author argues that prices of private digital currencies follow random walks, while for central bank digital currencies the challenge is to address three objectives, price stability, efficiency, and monetary trust, of which only two are achievable.

Since 2009 and the introduction of the first digital currency, Bitcoin, so-called **cryptocurrencies** quickly moved from a niche phenomenon to a mainstream currency alternative, as evidenced by the introduction of bitcoin **exchange-traded funds**, the build-up of FinTech, rising interest in the possibilities of blockchain technologies, regulatory frameworks, and the possible introduction of central bank digital currencies or CBDCs.

How best to understand the impact of the thousands of cryptocurrencies in the market? Acknowledging the vast literature on the subject, in a new paper, UChicago Prof. Harald Uhlig focuses this challenge on two key questions

related to monetary economics: How should we think about pricing cryptocurrencies? And what do CBDCs imply for the stability of central banks? The rest of this research brief summarizes the answers to these questions as described in Uhlig's recent paper, "On Digital Currencies," which is itself an explanation and illumination of two papers coauthored by Uhlig and colleagues; that is, the insights introduced in "On Digital Currencies," and described in this brief, were introduced in those recent papers.

Of course, it goes without saying that this brief barely breaks the surface of these deep subjects, and Uhlig acknowledges that his paper is also

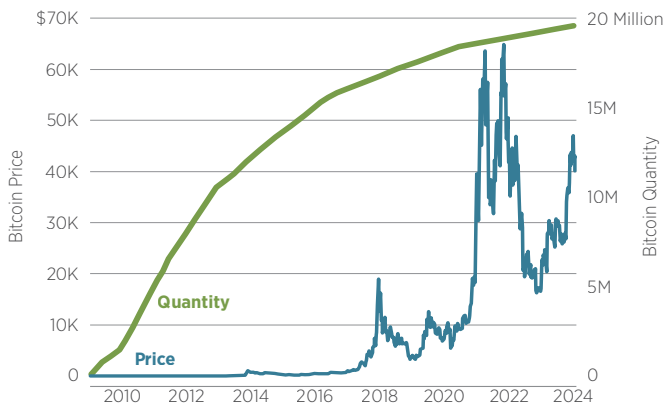
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Cryptocurrency: This is a peer-to-peer digital payment system that doesn't rely on banks to verify transactions. Cryptocurrency payments exist purely as digital entries to an online database describing specific transactions that are recorded in a public ledger.

Exchange-traded funds: Also known as ETFs, these are funds that contain bundles of assets, such as stocks, bonds, currencies, debts, futures contracts, and/or commodities such as gold. ETFs trade on stock exchanges that can be bought and sold like a common stock. Such bundled assets potentially lower your risk and exposure, while helping to diversify a portfolio.

Figure 1 - Bitcoin Quantity and Price

A) Bitcoin Quantity and Price Since 2009



Source: blockchain.com/explorer/charts/total-bitcoins

B) Bitcoin Price Since 2018



selective in its presentation. For curious readers, Uhlig offers several of his own papers that mine these topics more deeply, as well as suggestions for those who seek general explanations of digital currencies (please see accompanying article).

Cryptocurrency pricing

On May 22, 2010, a day that would be coined “Pizza Day” in crypto lore, the programmer Laszlo Hanyecz purchased two large pizzas for 10,000 bitcoins. Had Laszlo hung onto those bitcoins, they would have been worth \$440 million in February 2024. Could Laszlo have anticipated such a rise in value? Given the volatility of all cryptocurrencies, not just bitcoin, does it even make sense to use them as a medium of exchange? (See Figure 1 for a visual depiction of bitcoin prices since 2009.)

For their analysis summarized here, Uhlig et al. build on seminal research on price indeterminacy to show that there is, indeed, a “fundamental pricing equation” for pricing bitcoin and similar cryptocurrencies. In effect, the bitcoin price is what economists call a **random walk**, that is, the expected future price is the current price. In such a world, Laszlo did precisely the rational thing in

spending 10,000 bitcoins for two large pizzas; with no expected gain in value, he was better off spending the bitcoins than keeping them. The right panel of Figure 1, in effect, depicts such randomness: At any given point on the line, with the future unknown, there is no discernible reason to expect that the price would move in any direction.

The authors develop a model of this “no speculation” theorem that includes an economy with two intrinsically worthless currencies, the dollar and bitcoin, as a medium of exchange, and wherein exists the possibility of holding the currencies for speculative purposes. Their model reveals the following:

- All bitcoins are spent every period. In a world where these currencies do not pay interest, and people **discount** the future, it is better to spend all currency in every period than to hold on to it.
- Volatility does not invalidate the medium-of-exchange function of bitcoin. All bitcoins are always used in transactions, regardless of the volatility of the underlying price process.
- The “no speculation” theorem holds for economies with different growth paths for

Random walk: As noted in the text, when describing expected future prices (in this case cryptocurrencies but often applied to the stock market), random walk theory states that the expected future price is the current price. In other words, such prices are random, so that past movement or trend of a stock price or market cannot be used to predict its future movement.

Discount: In a financial sense, to discount the future value of a currency is to determine the present value of future cash flows. This is a method of calculating the value of money in the future, based on the assumption that money is worth more today than in the future.

bitcoin quantity (for example, one economy may have a constant supply of bitcoin and another a growing quantity), but where the central bank achieves the same path for prices.

Central Bank Digital Currency

As central banks worldwide ponder the introduction of CBDCs, one crucial question looms: Could such currencies lead to central bank instability? To study this important question, Uhlig et al. devise a model where a central bank can fulfill its nominal obligations regarding the value of currency, but where people may nonetheless have concerns that the central bank will fail, and that currency might be worthless in the future. In this case, people will spend their money as quickly as possible.

In effect, such an occurrence would be a type of bank run; not a typical bank run where people *run away from deposits* and demand their value in cash, but rather a spending run where people *run away from cash* into goods. In a spending run, money, whether in traditional form or in the form of a CBDC, loses its value, trust in the monetary system and CBDC evaporates, and monetary instability results. This phenomenon is familiar from [hyperinflations](#) or [currency crises](#), or more recently in the form of temporary pandemic stockouts.

In this simplified model (involving only households and a central bank that controls the economy) the central bank provides households with money, possibly CBDCs, to purchase goods. Households can sell goods to the central bank for units of money or CBDC, and the central bank invests the goods, using given investment technology. Households sell at varying rates, the central bank decides what fraction of those goods should be liquidated, market clearing prices are established, and households receive interest payments on their held currency. Please see the paper for a more detailed description of this model, but in effect the central bank faces three competing objectives:

For more on Harald Uhlig's related research:

Benigno, Pierpaolo, Linda Schilling and Harald Uhlig (2019). Global (Crypto-)Currencies and Currency Competition. *Crypto Review*, 1, 01-03. Available at cryptoreview.hk/test/wp-content/uploads/2019/09/Crypto-Review-Vol.-1.pdf.

Benigno, Pierpaolo, Linda Schilling and Harald Uhlig (2022). Cryptocurrencies, Currency Competition and the Impossible Trinity. *Journal of International Economics*, 136. Available at sciencedirect.com/science/article/pii/S0022199622000332?via%3DIihub.

Uhlig, Harald (2022). A Lunatic Stablecoin Crash. BFI WP 2022-95, Becker Friedman Institute, University of Chicago, Chicago. Available at bfi.uchicago.edu/wp-content/uploads/2022/07/BFI_WP_2022-95.pdf.

Uhlig, Harald (2023). Review Article: Eswar S. Prasad: How the Digital Revolution is Transforming Currencies and Finance. *Business Economics*, 58, 201-204.

Uhlig, Harald and Taojun Xie (2021). Parallel Digital Currencies and Sticky Prices. BFI WP 2020-188, Becker Friedman Institute, University of Chicago, Chicago. Available at bfi.uchicago.edu/wp-content/uploads/2021/01/BFI_WP_2020188.pdf.

For general background on cryptocurrencies:

Among a vast literature on the subject, the author recommends the following three articles and one book:

Allen, Franklin, Xian Gu and Julapa Jagtiani (2021). A Survey of Fintech Research and Policy Discussion. *Review of Corporate Finance*, 1 259-339.

Chiu, Jonathan, Mohammad Davoodalhosseini, Janet Hua Jiang, Francisco Rivadeneyra and Yu Zhu (2023). Central Bank Digital Currencies and Banking: Literature Review and New Questions. Bank of Canada, Staff Discussion Paper 2023-4. Available at bankofcanada.ca/2023/02/staff-discussion-paper-2023-4/.

Kosse, Anneke and Mattei, Ilaria (2023). Making Headway—Results of the 2022 BIS Survey on Central Bank Digital Currencies and Crypto. *BIS Papers*, No. 136. Available at bis.org/publ/bppdf/bispap136.htm.

Prasad, Eswar S. (2021). *The Future of Money How the Digital Revolution Is Transforming Currencies and Finance*. Harvard University Press, Boston, MA.

Hyperinflation: This term describes rapid, excessive, and out-of-control general price increases in an economy, often used to describe inflation measuring more than 50% per month.

Currency crisis: A sudden and steep decline in the value of a nation's currency, which causes negative ripple effects throughout the economy. Unlike a currency devaluation as part of a trade war, a currency crisis is not a purposeful event. The value of a currency is tied to a country's economic health, so a sudden drop in its value often indicates severe problems.

1. *Price Stability*: the traditional central bank objective of a commitment to stable prices.
2. *Efficiency*: the central bank implements policies with socially optimal risk sharing.
3. *Monetary Trust*: avoid spending runs and monetary instability.

And therein lies the rub. The authors' model reveals a trilemma: central banks can only achieve, at most, two of these objectives simultaneously. (See Figure 2.) This result holds for cash or CBDCs. Uhlig describes several scenarios worth considering but, for example, policies aiming for price stability may compromise efficiency or fail to prevent spending runs, while policies ensuring full liquidity may lead to increased prices.

Overall, the authors' model and analysis highlight the complex trade-offs and challenges that central banks face in maintaining stability in the presence of CBDCs, suggesting that careful policy design and implementation are crucial in navigating these issues.

Figure 2 · The Central Bank Digital Currencies (CBDC) Trilemma



Note: Out of three competing objectives, a central bank can achieve at most two. While that tradeoff applies to all central banks, the trilemma is particularly relevant when issuing a widely used CBDC.

READ THE WORKING PAPER

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On Digital Currencies

bfi.uchicago.edu/working-paper/2024-17

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