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Impact of Cryptocurrency in Global Economy

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ABSTRACT: The features of a new global economy appear stronger and faster than the changes recorded by the economy throughout history, and the “Covid-19” pandemic has accelerated these transformations, achieving on the ground a global experience to deal with digital payment via credit cards and the use of online payment applications, and it marks the beginning of the end of the era of paper currencies. And the trend towards investing in crypto and digital currencies on the part of investors, in conjunction with the competition of countries around the world to win the issuance of the first digital currency issued by central banks. There are many questions about replacing the digital currency with gold or the dollar in a rapid transformation that changes the trends of the global economy, and the number of cryptocurrencies around the world has reached about 4337 currencies with a market value of 1.003trillion, “Bitcoin” holdsthe largest share by 666 664 billion. Despite many official warnings against investing in these unregulated currencies, fintech startups are witnessing a surge in demand from consumers who are rushing to invest in cryptocurrencies amid great interest and momentum in Bitcoin. Like Revolut, eToro and Luno, cryptocurrency demand surged on their platforms amid the resurgence of Bitcoin prices.

KEYWORDS: Economics , Cryptocurrencies, Global Economics, Bitcoin

I. INTRODUCTION

The advent of cryptocurrencies has garnered immense popularity due to their core tenets of decentralization and the potential for substantial returns. Luchkin et al., (2020) the volatile nature of these digital assets continues to pose a significant risk, often surpassing that of conventional investment options. By employing cryptography, cryptocurrencies encode information in a manner that is easily decipherable with the correct key, yet extremely challenging to interpret without it. Consequently, while the manufacturing of these coins can be intricate, the verification of transactions becomes relatively straightforward.

Despite the expanding popularity and growth of the cryptocurrency realm, traditional financial institutions have exhibited reluctance in embracing these digital assets. Their reservations primarily stem from the perceived risks associated with cryptocurrencies outweighing the potential benefits. In a recent development, the OCC issued several interpretive letters outlining how traditional financial institutions can engage in transactions involving digital currencies or even develop services centered around them.

These efforts aim to acquaint banks with these assets, thereby increasing their comfort level. In early January, the OCC announced that national banks and federal savings associations are now permitted to utilize public blockchains and stablecoins for conducting payment activities. Azarenkova, Shkodina, Samorodov, & Babenko, (2018) newfound allowance enables banks to process payments more swiftly and efficiently without requiring the involvement of third-party agencies. It is imperative for these institutions to overcome their reservations and embrace the potential that cryptocurrencies offer. The blockchain functions as a public ledger that undergoes verification by a multitude of nodes, making fraudulent activities exceedingly arduous, if not impossible. Additionally, the transparent nature of the blockchain enables the tracking of specific transactions between anonymous user accounts or wallets with relative ease. The recent allowances for the use of public blockchains and stablecoins in payment activities highlight the potential efficiency and innovation that can be derived from embracing cryptocurrencies. ### Literature Review on the Impact of Cryptocurrency on the Global Economy

Cryptocurrencies, particularly Bitcoin, have evolved from a niche technological innovation to a significant financial asset class. Their influence on the global economy is multifaceted, touching upon areas such as financial markets, monetary systems, international trade, and the banking sector. This literature review aims to synthesize the existing

body of academic and industry research on the economic implications of cryptocurrency, offering insights into its potential and the challenges it presents.

II. LITERATURE REVIEW

1. The Emergence of Cryptocurrency and Its Role in the Economy

The first major research on cryptocurrencies was spurred by the creation of Bitcoin in 2008 by an anonymous individual or group known as Satoshi Nakamoto. Bitcoin's underlying technology, blockchain, was presented as a decentralized ledger that could facilitate peer-to-peer transactions without the need for intermediaries such as banks (Nakamoto, 2008). This led to the creation of a completely new type of currency and financial system.

In subsequent years, cryptocurrencies were discussed primarily in the context of their technological and security aspects (Böhme et al., 2015), but it was their potential economic implications that garnered increasing attention. Studies soon began to focus on how cryptocurrencies could disrupt or transform traditional financial systems and monetary policies (Catalini & Gans, 2016).

2. Impact on Financial Markets

One of the most debated aspects of cryptocurrency is its impact on financial markets. Research on this topic has generally focused on three primary areas: market volatility, cryptocurrency as an asset class, and market liquidity.

- **Volatility:** Cryptocurrencies are well known for their extreme price volatility, with Bitcoin often experiencing large daily swings in its price. Yermack (2013) and Liu & Tsyvinski (2021) explored the volatility of cryptocurrencies and found that their behavior is far less stable than traditional assets such as stocks, bonds, and commodities. This volatility can deter broader adoption, as it makes cryptocurrencies unsuitable as a medium of exchange or store of value in some instances.

- **Cryptocurrency as an Asset Class:** Many researchers have looked at how cryptocurrencies are increasingly being integrated into traditional investment portfolios. For example, Brière et al. (2015) examined Bitcoin as a "safe haven" asset, finding that during times of global market distress, Bitcoin did not behave like traditional assets. They concluded that Bitcoin's role as a diversifier in investment portfolios was significant but that its risk profile remained high due to its volatility.

- **Market Liquidity and Access:** Cryptocurrency markets operate 24/7 and provide more accessible entry points for both retail and institutional investors, especially those from countries with underdeveloped financial systems. Zohar (2020) argues that cryptocurrencies, especially Bitcoin, can provide liquidity in markets where traditional banking systems are inefficient or inaccessible, contributing to financial inclusion and expanding global access to investment opportunities.

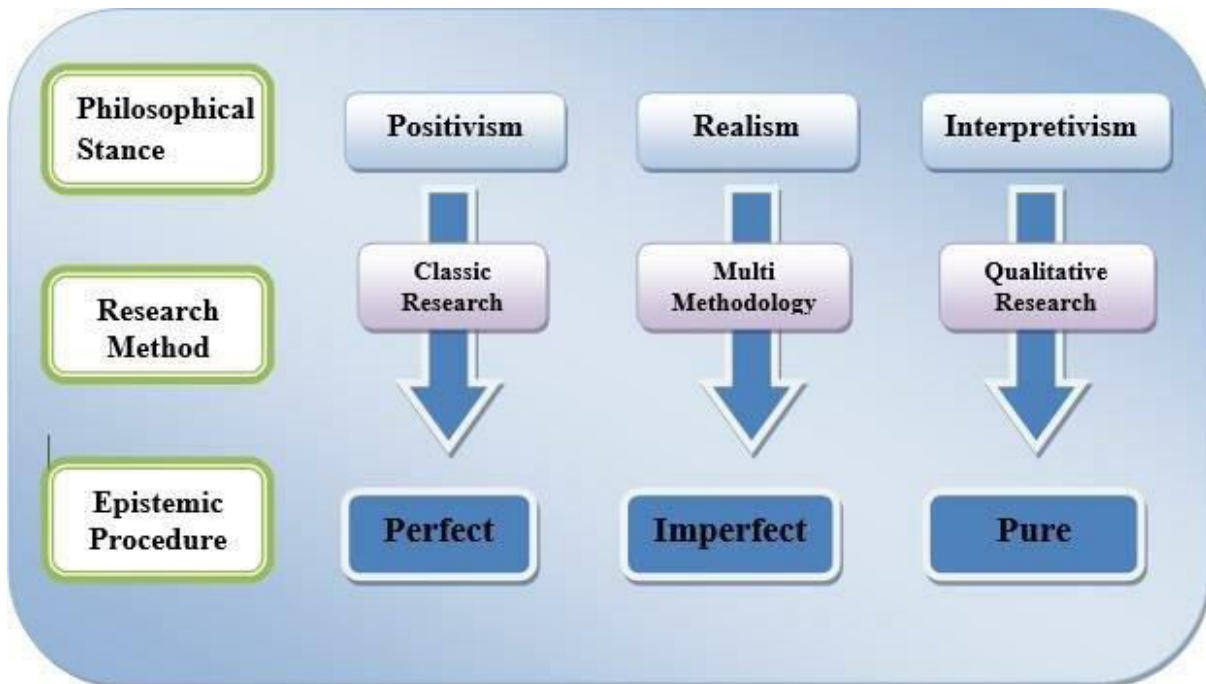
3. Impact on Monetary Policy and Central Banks

The rise of cryptocurrencies challenges traditional monetary systems, which are governed by central banks and state-issued fiat currencies. Several studies have analyzed the relationship between cryptocurrencies and monetary policy, especially their effects on inflation control, interest rates, and money supply management.

- ****Challenges to Central Banks**:** Studies such as those by Goodhart et al. (2017) argue that the decentralization inherent in cryptocurrencies undermines the authority of central banks. As digital currencies are not controlled by any government, they bypass traditional mechanisms of monetary control, including interest rate manipulation and money printing. This is particularly problematic in economies with volatile currencies or unstable fiscal policies.

- **Hedge Against Inflation:** A number of studies (e.g., Liu & Tsyvinski, 2021) have explored the potential for Bitcoin and other cryptocurrencies to serve as hedges against inflation. In economies where inflation is high, cryptocurrencies provide an alternative to fiat money, which may be devaluing rapidly. For instance, Bitcoin's fixed supply cap of 21 million coins offers a stark contrast to the inflationary nature of traditional currencies that can be printed by central banks at will.

- **Central Bank Digital Currencies (CBDCs):** In response to the growing popularity of cryptocurrencies, many central banks have been investigating the possibility of issuing Central Bank Digital Currencies (CBDCs). Research by Barontini & Holden (2019) provides an overview of the potential benefits and challenges of CBDCs, arguing that they could combine the advantages of cryptocurrencies with the stability and regulatory oversight of traditional fiat currencies.



Research methods and underlying paradigms Source

4. Impact on International Trade and Cross-Border Transactions

Cryptocurrencies have the potential to revolutionize international trade by making cross-border transactions cheaper, faster, and more accessible. Researchers have explored several facets of this impact.

- **Lower Transaction Costs:** Traditional cross-border payments involve multiple intermediaries (e.g., banks, remittance companies, and payment processors), which result in high fees and long processing times. Cryptocurrencies can eliminate these intermediaries, thus reducing transaction costs. According to Chuen et al. (2017), cryptocurrency transactions can be processed in minutes at a fraction of the cost of traditional international money transfers.

- **Financial Inclusion:** Cryptocurrency has the potential to provide financial services to people in regions with limited or no access to traditional banking services. According to Narayanan et al. (2016), blockchain technology offers the unbanked population access to financial tools such as savings, loans, and insurance. Cryptocurrencies offer a secure, borderless alternative to existing financial systems, potentially reducing poverty and fostering economic development in underserved areas.

- **Currency Exchange and Volatility in Trade:** Another key feature of cryptocurrency is the elimination of foreign exchange risk in international trade. Studies such as those by Catalini & Gans (2016) highlight how using a universal digital currency like Bitcoin could streamline cross-border transactions by removing exchange rate fluctuations, making trade more predictable and efficient.

5. Impact on Traditional Banking and Financial Systems

The rise of cryptocurrencies has disrupted traditional banking systems by introducing decentralized alternatives for financial services. Researchers have explored various aspects of this disruption.

- **Decentralized Finance (DeFi):** The emergence of decentralized finance (DeFi) platforms is one of the most significant developments in the cryptocurrency ecosystem. These platforms use blockchain technology to offer financial services such as lending, borrowing, and insurance without the need for traditional financial institutions. Zohar (2020) suggests that DeFi could fundamentally transform the financial industry, reducing the reliance on intermediaries and creating more efficient, transparent, and inclusive financial services.

- **Banking the Unbanked :** Cryptocurrencies can offer financial services to people who do not have access to traditional banking infrastructure. According to Narayanan et al. (2016), the accessibility of cryptocurrencies via smartphones could help bridge the financial inclusion gap in underdeveloped and developing economies, where banking services are often unavailable or unreliable.

- **Impact on Bank Profits and Roles:** The proliferation of cryptocurrency and blockchain-based alternatives has the potential to reduce banks' revenue from traditional services such as cross-border payments, loans, and money transfers. Studies by Böhme et al. (2015) discuss how blockchain could reduce the need for banks in financial transactions, particularly for cross-border payments, putting pressure on traditional financial institutions to innovate or risk losing market share.

6. Regulatory and Security Concerns

Despite their potential, cryptocurrencies also present challenges in terms of regulation, fraud prevention, and market security. The anonymity provided by cryptocurrencies has raised concerns about their use in illegal activities, such as money laundering, tax evasion, and terrorism financing.

- **Regulatory Challenges:** The decentralized nature of cryptocurrencies complicates the creation of regulatory frameworks. While countries like Japan and Switzerland have embraced cryptocurrency regulation, others like China have imposed bans. According to Zohar (2020), this regulatory uncertainty is one of the biggest obstacles to the widespread adoption of cryptocurrencies. Regulatory clarity is needed to balance innovation with consumer protection and financial stability.

- **Security and Fraud Risks:** While blockchain technology is generally considered secure, there have been cases of hacking, fraud, and theft in the cryptocurrency space. The Mt. Gox incident, which involved the theft of 850,000 Bitcoins, remains a significant event in cryptocurrency history. Researchers, such as Catalini & Gans (2016), argue that to gain mainstream acceptance, cryptocurrencies must overcome concerns related to security and fraud.

7. The cryptocurrency research conference

To promote and advance research on cryptocurrencies, Dr. Larisa Yarovaya initiated the first Cryptocurrency Research Conference (CRC) in 2018. The conference aims to bring together an international group of academics conducting research in cryptofinance and related disciplines, as well as practitioners and policymakers, to foster debates on current issues surrounding cryptocurrencies and digital finance. The first conference was held at Anglia Ruskin University, Cambridge, UK, and the subsequent one took place at the University of Southampton in 2019. Amidst the COVID-19 pandemic, the ICMA Centre, Henley Business School, hosted the event virtually in 2020, and this special issue was attached to it. The conference continued to be held virtually in 2021. Following that, in 2022, the conference took place at Durham University, and in 2023, it was held at the International University of Monaco. For the 2020 version, more than 80 papers were submitted to this conference by scholars all over the world and after careful consideration, 40 papers were invited for presentation in the conference. After a double-blind review process, seven papers were accepted for this Special Issue. The conference keynote speakers were Professor Douglas Cumming from Florida Atlantic University and Professor Sean Foley from Macquarie University, two leading academics in the cryptocurrency space.

8. Articles in this special issue

In this section, we summarize the findings and implications of the seven accepted articles in this special issue.

Cryptocurrencies have had a big impact on other financial markets and two papers in this special study on these flows and spillovers between markets. Elsayed and Sousa (Citation2023) study the dynamic spillovers between international monetary policies in Europe, Japan, the UK and the US and three large cryptocurrencies through a time-varying parameter vector autoregressive model. The authors find strong evidence of spillovers between cryptocurrency returns and monetary policy, especially during times when shadow policy rates became negative. The gross directional spillovers suggest that the shadow policy rates spill over more than they receive, while those to and from cryptocurrencies are, unsurprisingly, volatile. Interestingly, the authors show strong interconnectedness between monetary policy in either the US or the Eurozone and the UK, and also between Bitcoin and Litecoin. Finally, the authors show that the Fed's 'unconventional' policy, compared to 'standard' policy, spillovers are only slightly larger but their composition qualitatively changed over time.

The second paper that studies spillovers in this special issue is Hou et al. (Citation2023) who study the spillovers between Bitcoin and the crude oil market, with a special focus on the impact of the US–China trade war. Since Bitcoin has similar characteristics to commodities, there is a rationale that investors who trade commodities might also be interested in commodities causing spillovers. The authors also point out that the literature has not yet found clear evidence of the dynamics of informational linkages between Bitcoin and crude oil markets. Interestingly, this paper considers both a static and time-varying information transmission of volatility, skewness and kurtosis between two popular Bitcoin markets, Bitstamp and ItBit, and the two major crude oil markets, WTI and Brent crude oil. By implementing a two-state regime model to estimate higher-order moments and Legendre polynomials, the authors find that crude oil is an information transmitter while Bitcoin is an information receiver in terms of the static and time-varying between-market transmission of three different risk measures. The information content of Bitcoin is enhanced once the US–China trade war begins and Bitcoin becomes a diversifier for oil risk which becomes more pronounced in the post-trade war period.

The third paper of the special issue studies the impact of various types of jumps occurring in one cryptocurrency's price process on the discontinuity component of the realized volatility of other cryptocurrencies. Gkillas et al. (Citation2023) proposes a novel jump model approach to capture the asymmetric effects of various jump variations in the underlying price process, which is motivated by two stylized facts observed in cryptocurrency markets, namely very high volatility, and the existence of jumps. Another benefit of this model is that it is able to assess the impact of co-jumps too. The paper shows that downside, upside and small jumps negatively affect the jump component of other cryptocurrencies' realized volatility, while larger jumps have the opposite effect. Interestingly, the authors also show that co-jumping behaviour can trigger future jumps while upside and downside jumps in the S&P500 negatively impact cryptocurrency markets.

Yao et al. (Citation2023) is the fourth paper of this special issue and they study the issue of investor attention on idiosyncratic risk in cryptocurrency markets. To measure investor attention, Google Trends is utilized and they show that increased attention leads to significantly lower idiosyncratic risk by increasing liquidity. Interestingly, the authors show that the effect of investor sentiment is larger for smaller cryptocurrencies in terms of market capitalization and for younger cryptocurrencies. This suggests that the attention of smaller and younger coins is very important for pricing their behaviours. Finally, the authors note that this effect is stronger in more stable external market environments and a rising market state.

The fifth paper included in this special issue is by Karaa et al. (Citation2023), which is one of the first papers in the literature to study whether feedback trading is present in cryptocurrency markets and how noise-related factors, such as sentiment, volume and liquidity, affect its presence. The paper uses data from the popular exchange Bitstamp and finds strong evidence of positive feedback trading, which grows stronger as the frequency of data becomes higher. However, the presence of feedback trading is mainly during periods of high and rising sentiment, volume and liquidity. Interestingly, feedback trading is identified mostly during times when the European and North American stock markets are open and noise trading in cryptocurrency markets exhibits similar effects to feedback trading in other asset classes.

Related to the previous paper in this special, Kalyvas et al. (Citation2023) studied the mediating effect of behavioural factors on the relationship between Bitcoin returns and industry indices. This paper studies four industry indices which may have a relationship with Bitcoin, namely technology, energy, clean energy and banking indices.

By using the sentiment index from Thomson Reuters Marketpsych, the authors find that the sensitives of technology and clean energy indices to sentiment positively and significantly strengthen the relationship between sentiment and Bitcoin returns. Therefore, the authors show that investors' sentiment captures the association between Bitcoin and sectors related to cryptocurrencies, which is contrary to prior studies that find a direct relationship between industry indices and Bitcoin returns.

Contrary to the other papers published in this special issue that study Bitcoin and other cryptocurrencies, Hoang and Baur (Citation2023) study stablecoins, a special group of cryptocurrencies that are pegged to another asset, usually the US dollar. Stablecoin market capitalization continues to rise; however, there is a lack of understanding of their behaviour and working dynamics. This paper uses high-frequency data and shows significant evidence of excess price variations. The authors argue that Bitcoin is the likely course of the excess volatility due to its correlation with Bitcoin. They also show that through a quasi-natural experiment stablecoins increase the trading volume on Bitcoin.

9. Future research directions

In this section, we explain a few key areas that future research within cryptocurrencies should study in order to progress our understanding and appreciation of cryptocurrencies.

Firstly, and related to the final paper in this special issue, stablecoins. Stablecoins are growing in size, usage and influence on cryptocurrency markets and traditional financial markets in general. Tether, the world's largest stablecoin, has a market capitalization of over \$83 billion while the leading five stablecoins are all valued at over \$3 billion each. Footnote1 Stablecoins are used for transaction cryptocurrencies and are a real challenge to fiat currencies; however, our understanding of stablecoins is very limited. Grobys and Huynh (Citation2021) show that Tether causes Bitcoin to jump while Grobys et al. (Citation2021) and Duan and Urquhart (Citation2023) show the instability of stablecoins. A seminal paper by Lyons and Viswanath-Natraj (Citation2023) demonstrates that improved arbitrage design stabilizes the price of Tether while Catalini, de Gortari, and Shah (Citation2022) provide some simple economics for stablecoins. However, with the collapse of Terra in May 2022 and the regulatory attention stablecoins are attracting, academia needs to pursue studies on how best to design stablecoins, who trades them, how they can best keep their peg, as well as the impact that stablecoins have on other financial markets as well as cryptocurrencies.

Secondly, we encourage investigations into criminality within cryptocurrency markets. The seminal paper by Foley, Karlsen, and Putninš (Citation2019) documented that around 46% (or \$76 billion) of illegal activity involved Bitcoin per year, while subsequent studies, while Gandal et al (Citation2018) showed the suspicious trading around the Mt. Gox collapse. Dhawan and Putninš (Citation2022) showed that cryptocurrency manipulators pump extreme distortions of 65% while Amiram, Jorgensen, and Rabetti (Citation2022) show that unregulated exchanges are central to laundering funds between terrorists and operatives on the ground. However, given the scale of misconduct reported in the press and nearly every regulator in the world studying closely how these markets work and perform Footnote2 it is imperative that future research studies the criminality in cryptocurrency markets and how regulation may help to get this under control. This research area may lead to cross-discipline collaboration between lawyers, computer scientists, criminologists and well as finance/economic experts.

Thirdly, the current literature mainly concerns how cryptocurrency prices behave in relation to others and whether behaviours found in traditional markets are also present in cryptocurrency markets. But why should certain behaviours in traditional markets be present in cryptocurrency markets? Future research should use the unique characteristics of cryptocurrency to study the distinctive behaviours of cryptocurrencies. One huge benefit of most cryptocurrencies is the use of public blockchains, where researchers can track every transaction between entities and provide real in-depth analyses of the on-chain behaviour of cryptocurrencies. Only a handful of studies have used such data to provide insight into the behaviour on the chain (Foley, Karlsen, and Putninš Citation2019; Griffin and Shams Citation2020; Jahanshahloo, Irresberger, and Urquhart Citation2023; Makarov and Shoar Citation2023). Given the ability to study every block, transaction and user on the blockchain, as well as their behaviours, it would be a very fruitful future research area.

Finally, cryptocurrency research needs to interact more with climate and green finance. Both areas of research have grown substantially in recent years but the interaction between both disciplines is severely lacking. Many

cryptocurrencies, including Bitcoin, use the proof-of-work consensus mechanism which consumes a tremendous amount of energy (Cambridge Bitcoin Electricity Consumption Index). Although some cryptocurrencies use the virtually zero environmental impact consensus mechanism, proof-of-stake, some of the largest coins have a serious impact on the environment. Therefore, we encourage future research to merge these two areas and document the impact cryptocurrencies are having on the environment and how we can mitigate such issues in the future. search methodology

III. RESULT

Instant remittances

In the traditional economy, making a money transfer may take hours and even days — especially if it's international and a few intermediaries are involved. By contrast, crypto transactions are settled in minutes or seconds, irrespective of their volume and destination. This changes the way people exchange money globally — and especially in the growing economies where millions of citizens are unbanked, while high inflation rates devalue their money. Sometimes harsh tax laws in developing countries are another factor that boosts crypto transaction volume. That's what recently happened in India — the Bitcoin peer-to-peer trading volume increased 2X in 2022 even amidst the bear market.

Banks have to adapt to the increased presence of crypto. The unprecedented opportunities have brought about 420 million users in crypto globally, and this number is predicted to hit 1 billion by 2030. That creates a challenge for traditional banks they can't ignore.

Crypto in banking

Raiffeisen Bank, Deutsche Bank, and other mastodons are obtaining their licenses to introduce crypto functionality to their customers. Neobanks and payment platforms such as Revolut and PayPal have already implemented tools allowing clients to buy, sell, hold, and stake crypto. This way financial institutions are trying to withstand the competition — and those that don't embrace crypto risk staying on the sidelines.

What's more, the improved accessibility of crypto (once it gets to major bank apps) promises to make digital assets even more popular, further strengthening their position in the global financial market.

Banking in crypto

Conversely, crypto businesses are now increasingly implementing banking solutions to expand to a massive audience. Those include crypto savings accounts with APR higher than at the banks and some more advanced investing opportunities that are only possible in the crypto landscape. For instance, an interest account at Choise.com can bring you up to 13.5% APY from digital assets. It also offers dual-currency interest accounts with ~50% APY and crypto cards.

Crypto banks introduce an asset management framework that all non-crypto bank customers are familiar with — but with digital assets instead of fiat currencies. This facilitates user experience while offering a higher yield, which makes crypto banking solutions highly demanded.

A crypto bank is one of the hardest products to develop, but there are solutions that let you launch it using pre-made software in just a few weeks — or enhance an existing platform with crypto banking features that will pay off within a year. This is possible with white label crypto banks like Vault by Choise.com. Over 6 years of operation, the platform has spent \$60M on development and licensing in 170+ countries — and now allows you to launch a crypto bank under your own brand a hundred times cheaper and faster.

Investment opportunities open to all

Never before in history has it been possible to invest so easily. Traditional banks do offer convenient investment tools, but they will never become permissionless like crypto. No registration is needed to store and exchange digital assets in a **cryptocurrency wallet** — and no one can freeze the funds

Ways to profit from crypto vary from holding and day trading to sophisticated DeFi mechanics. For many, digital assets have become a hedge against inflation. According to an NBC News poll, one in five Americans has invested in, traded, or used cryptocurrency.

Real-world asset tokenization: Changing the way things are owned

Of one the key features of crypto is that it eliminates middlemen and enables direct value exchange. One of the most promising trends at the intersection of crypto and the traditional economy today is the tokenization of real-world assets (RWA). Ownership of **stocks, bonds**, commodities, real estate, etc. is transferred to the blockchain in the form of digital tokens, making them more liquid and accessible and enabling fractional ownership.

According to Boston Consulting Group, the market of RWA will grow 25X by 2030, hitting the \$16.1 trillion mark. 10% of the entire world's GDP, compared to today's 0.4%, will be represented by tokenized assets. Tokenization appears to be more than just a trendy technology — it is changing the entire way people own and exchange physical assets.

Between peers. Smart contracts allow for translating this into a business perspective.

National digital currencies – Governments' response to crypto adoption

One of Satoshi Nakamoto's criticisms of the traditional economy was the irresponsible **monetary policy** of financial authorities that favored inflation. Bitcoin was created with a predetermined number of coins gradually entering circulation, making it resistant to inflation. But while Bitcoin hasn't become the heart of the global economy so far, cryptocurrencies do take, to some extent, one of the central banks' functions: money issuance.

To keep up with the competition, central banks have begun testing CBDCs — central bank digital currencies, or national currencies in a digital format. These state-controlled money are supposed to introduce fast and secure transactions, including cross-border remittances, and make money more inclusive. Meanwhile, critics point out that CBDCs open new surveillance opportunities to governments and may have unpredictable effects on the economy.

64 countries are now at an advanced stage of testing CBDCs, including China, India, and Australia. According to a Citigroup report, up to \$5 trillion in CBDCs will be circulating by 2030.

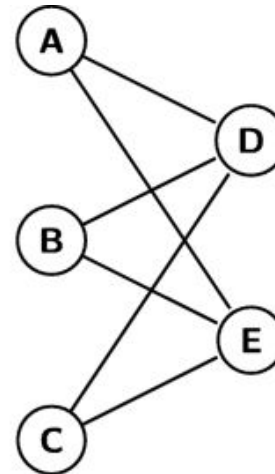
Growing ties

Cryptocurrency is a global force that the traditional economy has to reckon with. Private banks implement crypto solutions, businesses put asset ownership on-chain, while central banks introduce digital fiat money.

Monthly Transaction Graph (MTG) for each coin is a graph that is represented in the form $MTG_n = (V_n, E_n)$ where V_n is the set of nodes of this graph and each node $v \in V_n$ is an account address and V_n is the set of all account addresses that appeared in the $(n+1)$ -th month since beginning of the activity of that coin. E_n is the set of edges of this graph where each edge $e = \{v', v''\}$ shows transfer between two vertices $v', v'' \in V_n$. For example, in Fig. 1, a transaction with three inputs and two outputs is illustrated.

Fig. 1

| Transaction | |
|-------------|---------|
| Inputs | Outputs |
| A | D |
| B | E |
| C | |



(a) An example of a transaction with 3 Inputs and 2 Outputs

(b) Transaction graph based on the transaction in Fig. 1a

Generation of a transaction graph. **a** An example of a transaction with 3 Inputs and 2 Outputs. **b** Transaction graph based on the transaction in Fig. 1a

IV. DISCUSSION

We have conducted a comprehensive statistical analysis of the top six crypto-currencies series, covering the period from 8 August 2015 to 31 January 2020, and representing approximately 77.4% of the total market capitalization at the time of writing. To assess the effects of the COVID-19 on the crypto-market, at the end of this section we add data from the first semester of 2020 and look for changes to what was discussed.

Using static and dynamic, univariate and multivariate, and simple and complex statistical approaches, we have confirmed most of the several findings scattered about the existing literature. They include the stylized facts: extremely large kurtosis (tail thickness), mean close to zero, non-normality, extreme points, almost nonexistent autocorrelation in returns (weak predictability), volatility clustering, high persistence, and long memory in the volatility. We also verified that, like real financial assets, crypto-currencies' volatilities may be well captured by some GARCH models, which are able to provide accurate conditional risk measures. However, for the crypto-coins the tails of the GARCH conditional distribution are heavier than those found for stocks and exchange rates. Although all crypto-coins analyzed share these statistical features, Bitcoin (followed by Ethereum) seems to be more mature, with smaller risk measures, with statistics that are closer to those observed for other assets, and persistence close to those for real coins.

The existence of speculative bubbles in Bitcoin has been already tested (and rejected) in the literature. In this paper we confirmed that and made the link between speculative bubbles and episodes of runs of (consecutive) gains, the so-called drawups. We found that typically, for our series, the sum of consecutive gains was larger than the sum of consecutive losses. Even though the magnitudes of the Bitcoin drawdowns and drawups were smaller than those of other virtual coins, they were ten to twenty times greater than the values for Euro. The six crypto-currencies also presented some important episodes of joint drawups.

Our proposal for modeling the underlying return distribution—a semi-parametric mixture model, non-parametric for the bulk of the data, and an extreme value distribution (GPD) for each tail—showed an excellent adherence to the data, discriminated the left and right tails, and provided precise risk measures. We found that the right tail is riskier than the left tail for all series except for Bitcoin, which shows, in addition, smaller risk estimates. The unconditional risk measures based on a two-year rolling window sample performed even better.

It has been shown that crypto-coins are highly linearly and non-linearly correlated. Our pair-copula model uncovered new features: At extreme scenarios one can expect a highly correlated market, with extreme joint gains behaving differently from large joint losses. Simultaneous extremes may occur during periods of low volatility. All crypto-coins are positively correlated, and the strength of dependence has been increasing since 2015. However, the linear correlation coefficient ρ may not be the best statistic to inform one about the dependence between the crypto-assets.

Prices are linked together forming a cointegrated system with two cointegrating relations driven by crypto-market forces. Price information flows within the crypto-market, although the speed of adjustment to the long run equilibrium is very slow, implying that effects of a stochastic shock may last for a long time. Bitcoin is not cointegrated with Euro but it is cointegrated with each one crypto-currency.

Our data ended by the time of the onset of COVID-19 pandemic, and right now we do not know their effects on the economy, on people new habits, on stock- and crypto-markets, and so on, even though we can already see some advances in technology. To provide some insights on what may be just around the corner for the crypto-market, we add to the analysis the first semester of 2020.

We basically compared the second semester of 2019 with the first semester of 2020. The first thing that came to our attention is that all crypto-coins prices showed an upward trend during the first two months of 2020, after a dramatic loss in value during the whole second semester of 2019; see **Figure 6**. However, on 12 March 2020, all crypto-coins prices fell about 61%, reaching a point that could be expected based of the previous 6-months' downhill trend of price levels. In other words, the two initial months of January and February of 2020 could have been a speculative bubble. We carried out the dependence test of **McQueen and Thorley (1994)** and found that Bitcoin and Stellar indeed accepted the null of a speculative bubble, whereas for all others crypto-currencies the test was inconclusive.

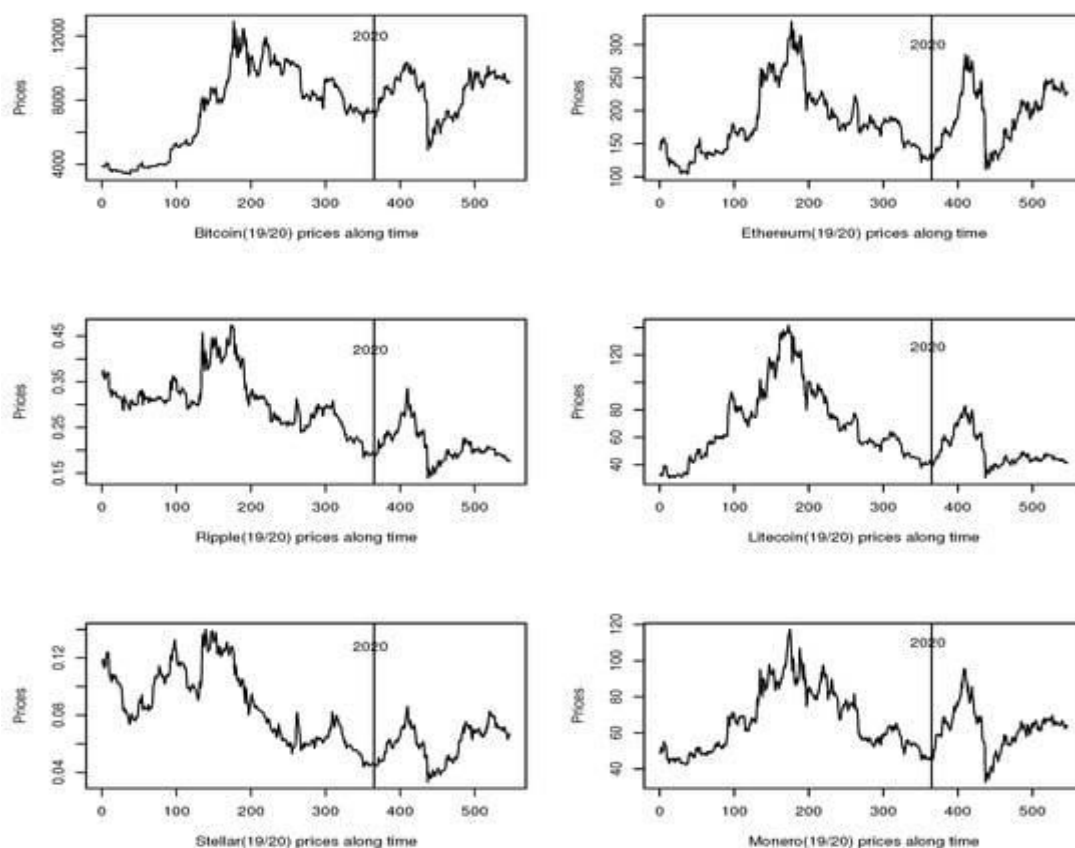


Figure 2. Price trajectories for the 2019 and 2020 years.

After the joint extreme fall of March 2020, all prices seemed to randomly walk around a new level, lower than those attained in 2017. It is interesting to observe that, in spite of the March outlying negative return, the accumulated return in the first semester of 2020 is positive for all crypto-currencies except XRP, whereas it was negative and significant in 2019/2 and for all crypto-assets. For example, for Bitcoin and Ethereum the cumulative one-semester returns was, respectively, 27.4% and 74.7% in 2020/1, and -32.4-32.4% and -56.1-56.1% in 2019/2.

The extreme negative return has a large influence on the 2020 returns' basic statistics. For all crypto-coins we observed a more extreme minimum, higher standard deviations, larger skewness coefficients, and specially very large kurtosis. All 2020 sample means, although negative, are still statistically zero.

V. CONCLUSION

The impact of cryptocurrency on the global economy is complex and multifaceted. On the one hand, cryptocurrencies offer significant opportunities for financial inclusion, lower transaction costs, and the democratization of finance. They have the potential to challenge traditional financial systems, disrupt monetary policies, and alter international trade dynamics. On the other hand, the volatility, environmental concerns, regulatory uncertainties, and security risks associated with cryptocurrencies pose challenges to their widespread adoption.

The future of cryptocurrencies in the global economy will likely depend on how these challenges are addressed. As the technology matures, more sophisticated regulatory frameworks are likely to emerge, balancing the benefits of innovation with the need for stability, security, and sustainability. Moreover, the integration of cryptocurrencies into mainstream financial systems and their coexistence with traditional currencies will shape the economic landscape in the coming years.

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