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Investigating the role of central banks in the interconnection between financial markets and cryptoassets

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Abstract
Over the past two years, financial markets have been heavily affected by central banks' unconventional monetary policies, in particular quantitative easing (QE). Accommodative monetary policies have also brought interest rates down to zero and/or negative territory as a mean to stimulate business investments. The recent rise of cryptocurrencies (The terms cryptocurrencies and crypto assets are used interchangeably.) poses, in turn, urgent challenges to central banks' efforts to face the multiple pandemic-driven unprecedented consequences. Private currencies may lead to a relatively cashless society, thereby threatening central bank monopoly of issuance, a situation in which businesses, households and financial markets could lose access to risk-free central bank money. In addition, Decentralized Finance (DeFi) promises to transform the traditional financial system into an open, permission-less and autonomous financial system. The present paper discusses the rise of digital payments across the euro area, the spread of cryptocurrency trading and the intention of the European Central Bank (ECB) to issue a central bank digital currency (CBDC). We provide evidence on the existence of cointegration between selected cryptocurrencies, stablecoins and traditional financial assets. Both the rise of digital payments and the increased popularity of cryptocurrencies can be seen as the main drivers behind the prospective issuance of the digital euro, significantly affecting financial markets and business models alike.

Keywords Digital payments · Cryptocurrencies · Stableocoins · Cointegration · CBDC · Decentralized Finance

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1 Introduction

The application of innovative technologies in finance is not a recent phenomenon; the history of the financial system's transformation goes back to the end of the nineteenth century, first with the use of cheques, then credit and debit cards, cash dispensing machines (ATMs) and, more recently, phone and web banking. However, what is different in recent years is the speed of change. Advances in digital technology have been an important force in the transformation of financial products, business models and services (Alfonso et al., 2021).

Technological advances have transformed the financial ecosystem by boosting innovation (Didier et al., 2021; Frost et al., 2021), which has greatly improved quality, sped-up processing time and lowered transaction costs (Barber and Odean, 2001; Hayashi and Keaton, 2012; Goldfarb & Tucker, 2019). The use of algorithms, big data, blockchain and digital platforms have implications for both financial service providers and customers, improving online procedures, promoting regional entrepreneurial activity and advancing operational efficiency and transparency (Nambisan et al., 2019). At the same time, verification costs (Catalini & Gans, 2016; Catalini & Tucker, 2017; Economides & Jeziorski, 2017), competition costs (Jullien & Sand-Zantman, 2021; Kretschmer et al., 2020; McIntyre & Srinivasan, 2017) and transaction costs have all been reduced (Einav et al., 2017; Ockenfels et al., 2006; Varian, 2010).

Hence, the digital wave in finance is changing the way businesses operate, as it promotes sustainability, openness and "green transformation", ensuring efficient electronic communication between the financial and the business sector, as well as availability of services (Forman et al., 2005, 2008, 2012; Wareham et al., 2014; Eichengreen et al., 2016). The ongoing digitalization of the financial system and the recent technological advances in the payments ecosystem have both drawn the attention of central banks to the issuance of a central bank-backed digital payment instrument, a Central Bank Digital Currency (CBDC). In fact, money digitalization is not something new in monetary systems, as advancements in technology have driven monetary transformations in history, including convertible fiduciary money and the evolution of fractional reserve banking (Bordo, 2021).

Decreasing costs and ease of use have prompted consumers to embrace digital payment instruments (Jakobsen, 2018). Credit and debit cards, online and mobile phone payments have gained popularity versus cash payments, as they are easier, faster, cheaper, time-efficient and more accessible. Furthermore, such transactions are particularly efficient for cross-border businesses, where the costs of banking services are relatively high.

Moreover, the unprecedented popularity of cryptocurrencies, e.g. Bitcoin and Ethereum, and more recently stablecoins, mainly driven by rising interest not only from retail but also from institutional investors and corporates, has led central banks to reconsider the concept of "cash". On the one hand, the COVID-19 crisis has fueled digitalization, as reflected by the increase in the crypto assets

market capitalization to all-time peaks; on the other hand, market participants have argued that these alternative asset classes could serve as an inflation hedge, given the similarities of crypto asset with gold (Brière et al., 2015; Conrad et al., 2018; Dyhrberg, 2016a, 2016b). As crypto asset activity is evolving rapidly, increased interconnectedness of decentralized finance with traditional financial markets could give rise to spillover risks, threatening major financial markets and their core business models.

Crypto asset trading platforms are gaining high traction with users, as they provide benefits to financial market participants in terms of speed of execution and transaction costs. These benefits are driven by innovation technologies such as the distributed ledger technology (DLT) and the replacement of third party intermediation by software code of smart contracts.

Traditional payment service providers, listed blue chip companies, traditional exchanges and FinTechs have started to expand their activities to crypto assets and offer user-friendly interfaces and products linked to decentralized protocols, while major international commercial banks have piloted the use of blockchain technology for banking services. In particular capital-intensive, high-technology startups, which are in a position to leverage blockchain technology, have started to use initial coin offerings (ICOs) to raise funds for products and services usually related to cryptocurrency. Increasing integration of decentralized finance with the conventional financial system, seen as the course of evolution, could have a beneficial effect on traditional financial markets. Such integration could result in stronger competition and lower transaction costs, which means that the adoption of both crypto assets and decentralized peer-to-peer models will have a significant impact on the global financial system and the way it currently operates.

From a business perspective, decentralized finance has the potential to transform the current centralized global financial infrastructure by introducing an internet-based decentralized model that relies on open-source protocols (instead of traditional financial intermediaries), thereby enhancing innovation in the financial ecosystem. Furthermore, DeFi will also affect B2B interaction, as smart contract-based decentralized applications could start acting as intermediaries between firms. Hence, business transactions can be executed automatically, e.g. wallet-to-wallet exchange of two digital assets simultaneously in a single operation or delivery versus payment instantaneously, without central counterparties to guarantee the transaction. However, such an evolution would come with high risks that would need to be dully assessed and mitigated accordingly.

In light of the above, central banks started exploring the issuance of a central bank digital currency (CBDC), weighing potential benefits, shortcomings and impact on the traditional financial system and businesses. The concept of central bank digital currencies is based on creating a form of money that merges the functions it has been fulfilling for centuries and the opportunities offered by digitalization. Digital money issued by a central bank will be used just like cash, will be risk-free, simple, convenient and fast (Bech & Garratt, 2017). At the same time, designing a CBDC is not straightforward, therefore important implications for financial stability, such as the role of financial intermediation, which should be carefully considered (Brunnermeir and Niepelt, 2019).

In examining the design and implications of a CBDC, central banks have to take into consideration the rapid expansion of cryptocurrencies, the increasing demand for digital payments, innovation in financial technologies and related products, which have all affected consumers' payment behavior. In the same vein, the ECB has recognized the importance and has begun evaluating the costs and merits of issuing a digital euro.

In this paper, we address the rise of digital payments across the euro area and the connection between selected cryptocurrencies, stablecoins and the traditional financial markets and businesses, outlining that these two key trends have motivated the ECB to consider introducing a CBDC in the Eurosystem's payment landscape. Furthermore, we investigate whether a statistically significant connection exists among the rise of the most widely traded cryptocurrencies and stablecoins, the exchange rate of the euro against the US dollar and the major equity indices, by testing for the existence of cointegration. Taking into account that cryptocurrencies can be used both as a means of payment and as a financial asset, we focus on the comparison with the euro exchange rate against the US dollar and leading stock market indices globally. In addition, we present evidence related to the rise of digital payments across the euro area and we discuss the surge of crypto assets and the evolution of the decentralized finance market.

The paper is structured as follows: Section II offers a brief literature review. Section III presents evidence related to the rise of digital payments across the euro area. Section IV discusses the rapid rise of crypto assets, describes the data of the crypto and the traditional financial assets, presents the statistical investigation and discusses on the motivation behind the ECB's decision on the issuance of the digital euro. Finally, concluding remarks and further research suggestions are presented in Section V.

2 Literature review

Taking into account that concepts related to CBDCs are relatively new, literature can be distinguished into three major categories: (1) studies analyzing the general purpose, the definition and the design of a potential CBDC issuance, (2) research papers, which examine the implications of the introduction of a CBDC on monetary policy and analyze possible risks and benefits to the public and (3) studies focusing on cryptocurrencies, highlighting the relationships with traditional financial markets and central bank digital currencies.

Regarding the first strand of literature, the latest BIS survey, published in January 2021, indicates that the share of central banks actively engaging in some form of CBDC work stands at 86% and almost 60% worldwide are conducting experiments or proofs-of-concept (Boar & Wehrli, 2021).

Against this background the ECB published in October 2020 a comprehensive report on the possible issuance of a digital euro, prepared by the Eurosystem High-Level Task Force on central bank digital currency (CBDC) and approved by the Governing Council. The Eurosystem Task Force identified scenarios that would require the issuance of a digital euro including (1) an increased demand for

electronic payments in the euro area; (2) a significant decline in the use of cash; (3) the launch of global private means of payment; and (4) a broad take-up of CBDCs issued by foreign central banks (ECB press release, January 2021). Also the ECB launched a public consultation on a digital euro, which ended on 12 January 2021. The consultation aimed at collecting the views of citizens (as users) and professionals—in the field of finance, payments, regulation and technology—resulted in 8.221 responses. According to the results, as published in April 2021, privacy is the most important concern for both citizens and professionals. Other issues raised concerned security, usability across the euro area, absence of additional costs and usability offline. Following the findings of the consultation, the ECB decided to start a pilot project on the issuance of the digital euro as a complement (not a replacement) to banknotes and coins in mid-2021, while there will a two-year investigation phase and a two to three year implementation phase.

In the academic landscape, Fung and Halaburda (2016) propose a framework for examining why a central bank should consider issuing a digital currency and how to implement it in order to improve efficiency of the retail payment system. Bech and Garatt (2017) present a taxonomy of money that identifies two types of central bank cryptocurrencies—retail and wholesale—and differentiates them from other forms of central bank money, such as cash and reserves. Engert and Fung (2017) propose a two-tier remuneration of CBDC, as a test and simple tool to control the quantity of CBDC both, in normal times and periods of crisis. Kumhof and Noone (2018) identify the core principles that a central bank digital currency must follow, while Keister and Sanches (2019) study the optimal design of a digital currency in this setting, including whether it should pay interest and how it should circulate. In this context, Williamson (2019) investigates the role of a CBDC not only as an interest-bearing asset but also as a means of payment alternative to cash and bank deposits.

Another strand of recent research explores the potential effects of a CBDC on monetary policy, financial stability and the financial system in general. Kumhof and Barrdear (2016) examine the long-term and cyclical macroeconomic effects of issuing CBDC using a dynamic stochastic general equilibrium (DSGE) model. Bordo and Levin (2017) state that a well-designed CBDC could transform all aspects of the monetary system and facilitate the systematic and transparent conduct of monetary policy, while enhancing the stability of the financial system. Berentsen and Schär (2018) argue that interest on CBDC would simplify monetary policy as the "central bank would simply use the interest rate paid on these accounts as its main policy tool". Meaning et al. (2018) investigate how CBDC could affect the various stages of monetary policy transmission, from markets for central bank money to the real economy. They conclude that monetary policy would be able to operate much as it does now by varying the price or quantity of central bank money and that this new transmission mechanism may even prove beneficial for it.

A third strand of the literature studies the characteristics of cryptos and their relationships with a variety of financial assets. Among others, Grinberg (2012), Yermack (2013),Dwyer (2015), Böhme et al. (2015) analyze the key concepts of the Bitcoin, while Wei (2018) extends Urquhart's (2016) analysis to 456 different cryptocurrencies showing that return predictability diminishes in cryptocurrencies with high market liquidity. Evidence by Chan and Peiris (2018) show

that several major cryptocurrencies do not seem to follow a certain distribution but each crypto follows a different one. Cheah and Fry (2015), Katsiampa and Gkillas (2018) and, more recently, Ghorbel and Jeribi (2021) examine cryptos' volatility and find that they are prone to significant speculative bubbles. Gandal and Halaburda (2016) examine early dynamics of exchange rates among different cryptocurrencies while Corelli (2018), Corbet et al. (2018), Krückeberg and Scholz, (2019) and Bianchi (2020) investigate the relationship between the return of different cryptocurrencies and a variety of other financial assets, showing lack of relationship between crypto and other assets. Shen et al. (2019) examine the causal relationships among four cryptos showing that there exists significant influence among them. On the dynamic linkages between cryptos and other financial assets, Kostika and Laopodis, (2019) show that they remain mostly independent of other traditional financial assets. Fernandez-Villaverde and Sanches (2019) implement a model of currency competition that captures some of the main mechanisms of cryptocurrencies concluding that these new currencies are not compatible with the price stability rule and do not maximize social welfare. In addition, Ren et al. (2020) provide a network analysis framework in order to explore tail-risk network effects in the cryptocurrency market during the COVID-19 crisis. Finally, Jabotinsky and Sarel (2020) analyze one hundred cryptocurrencies and find that the inflow of Coronavirus cases is, on average, positively associated with the market cap and trade volume of cryptocurrencies.

Overall, most of the literature concentrates on the characteristics of cryptos, without discussing the idea that their increasing popularity and their interconnection with the traditional financial markets could motivate a central bank to consider issuing a CBDC. Indeed, few authors have studied the properties of cryptocurrencies and stablecoins, discussing their linkages with central bank digital currencies. Bullmann et al. (2019) propose a taxonomy of stablecoins based on different primary mechanisms used to stabilize their value showing a trade-off between the level of innovation offered by different types of stablecoins and their capacity to keep their price stable in the currency of reference. Sandner et al. (2020) analyze the impact of digital programmable euro initiatives, such as the Libra stablecoin and CBDCs, on banks and the financial system. Bindseil (2020) compares the financial account implications of CBDC with the ones of crypto assets, stablecoins and narrow bank digital money in a domestic and international context. Moreover, Bindseil (2020) explores stylized scenarios of global stablecoin (GSC) adoption in order to demonstrate their possible monetary effects, while Mita et al. (2019) put emphasis on the type of the collateral (crypto, fiat currency or commodity) in defining stablecoins. Finally, Zuluaga (2021) outlines a "peaceful cohabitation" that could be achieved between CBDCs and private digital currencies.

We investigate below the existence of cointegration among the most tradable crypto assets, stablecoins, the euro/US dollar exchange rate and major equity indices. Furthermore, we present evidence on both the rise of digital payments, the increased popularity of cryptocurrencies and their impact on the financial market business model, which could be among the main drivers behind the issuance of the digital euro.

3 The rise of digital payments across the euro area

The payments landscape is under a fundamental transition across the euro area, driven by digital revolution, innovative technologies and consumer preferences for new forms of payment. Moreover, the massive growth of e-commerce has led households to adopt a new, very low cost and more convenient digital instrument for electronic retail payments, triggering lower use of cash. The rise in digital payments has also been driven by the COVID-19 pandemic, as evidenced by the latest ECB survey on payment attitudes of consumers in the euro area, which indicated a significant shift from cash to cashless payments (ECB, 2020).

Taking into account that the Eurosystem has a key stake in the digital transition of payments, their policies are continuously adapted to ensure that payments remain resilient, efficient and inclusive. Indeed, from a legal perspective, the revised Payment Services Directive (PSD2) supports the development of a wide digital single market, making online payments more secure for EU customers and businesses; the new e-commerce legislation facilitates cross-border e-commerce and the General Data Protection regulation (GDPR) protects consumers and personal data, thereby enhancing cybersecurity.

On the operational side, the Eurosystem has already reacted to technological change by launching the SEPA instant credit transfer (SCT Inst) scheme, the provision of instant payment clearing services by a number of European automated clearing houses, and the TARGET Instant Payment Settlement (TIPS) service.

Turning to data analysis, statistical data on payment systems across the Eurosystem are drawn from the ECB's statistical Data Warehouse for the period 2015–2020. Table 1 describes the evolution of electronic payments per country across the euro area including credit transfers, direct debits, card payments with cards issued by resident, payment service providers (PSPs) (except cards with an e-money function only), e-money payments, cheques and other payment services on a yearly basis. From the data reported, we observe the following:

First, during the 2015–2020 period, there is an overall 6.7% increase of electronic payments across the euro area. Second, the most substantial increase (of around 24%) is registered in Greece. This can be explained by the fact that in June 2015 capital controls were introduced in Greece, when Greece's government came to the end of its bailout extension period, without having come to an agreement on a further extension of its debt payments with its creditors, and following the ECB decision to not further increase the level of its emergency liquidity assistance for Greek banks. As the imposition of capital controls included restrictions on cash withdrawals from bank accounts, households and enterprises turned to e-payments. On the other hand, the lowest e-payments increase of around 5% is registered in France, Portugal and Slovenia. Third, there are sizeable differences among euro area countries for the use of electronic payment instruments, which may be a result of consumer preferences and attitudes across the euro area. Figure 1 displays the evolution of total electronic payments across Europe (EU) and the euro area in 2015–2020.

In addition, as described in Table 2, the total number of payment transactions per capita has risen in all euro area countries during the period under review.

Table 1 Total number of payments transactions involving non-MFIs and annual percentage changes: 2015–2020. Source: ECB Statistical Warehouse. Total number of payments per year and per country across the euro area (millions) and their increase/decrease (annual percentage changes)

	Total number of payments (in millions)						Increase/decrease in the number of payments (% annual change)				
	2015	2016	2017	2018	2019	2020	2016	2017	2018	2019	2020
BE	3193.80	3459.80	3773.80	4243.60	4626.80	4853.10	8.3	9.1	12.4	9.0	4.9
DE	19,798.60	20,372.40	21,417.80	22,679.20	24,202.70	16,192.90	2.9	5.1	5.9	6.7	8.2
EE	402.1	430.9	466.2	504.4	548.6	553.5	7.1	8.2	8.2	8.8	0.9
IE	1010.20	1218.20	1416.40	1650.60	1909.90	2139.30	20.6	15.3	16.5	15.7	12
GR	616.2	794.7	1067.30	1199.60	1357.30	1772.30	29	34.3	12.4	13.2	30.6
ES	6204.60	6877.40	7837.90	8184.60	9265.30	9454.10	10.8	14	4.4	13.2	2
FR	20,208.00	20,907.90	21,964.30	23,498.00	24,915.10	24,224.00	3.5	5.1	7	6	-2.8
IT	5288.10	5746.20	6035.00	6784.00	7529.00	7736.00	8.7	5	12.4	11	2.8
CY	86.4	94.6	102.1	117.7	133.1	145.20	9.5	7.9	15.3	13	9.2
LV	362.5	399.3	455.8	489	538.5	563.90	10.2	14.2	7.3	10.1	4.7
LT	426.1	457	505.5	577.3	663.2	861.20	7.2	10.6	14.2	14.9	29.9
LU	2036.50	2388.40	2849.50	3334.60	3662.80	4773.50	17.3	19.3	17	9.8	30.3
MT	44.7	48.7	56	68.7	80	80.60	8.9	15	22.7	16.5	0.8
NL	6795.90	7174.10	7800.20	8707.00	9420.50	9192.20	5.6	8.7	11.6	8.2	-2.4
AT	1554.50	1657.40	1787.80	1951.70	2120.20	2242.90	6.6	7.9	9.2	8.6	5.8
PT	2041.50	2193.20	2352.10	2510.90	2499.40	2355.60	7.4	7.2	6.8	-0.5	-5.8
SI	376	391.4	409.6	434.9	467.9	459.70	4.1	4.7	6.2	7.6	-1.8
SK	720.7	791.3	887.7	973.2	1072.10	1034.30	9.8	12.2	9.6	10.2	-3.5
FI	2299.70	2447.30	2588.30	2808.50	3014.40	3006.10	6.4	5.8	8.5	7.3	-0.3
Euro area	**73,466.30**	**77,850.30**	**83,773.30**	**90,717.50**	**98,032.10**	**101,640.10**	**6**	**7.6**	**8.3**	**8.1**	**3.7**
EU	**114,480.70**	**123,222.70**	**128,294.10**	**112311.10**	**122,088.70**	**127,092.80**	**7.6**	**4.1**	**9.1**	**8.9**	**4.1**

In addition, the total number of payments (millions) and their increase/decrease (annual percentage changes) per year for Europe and the euro area are in bold

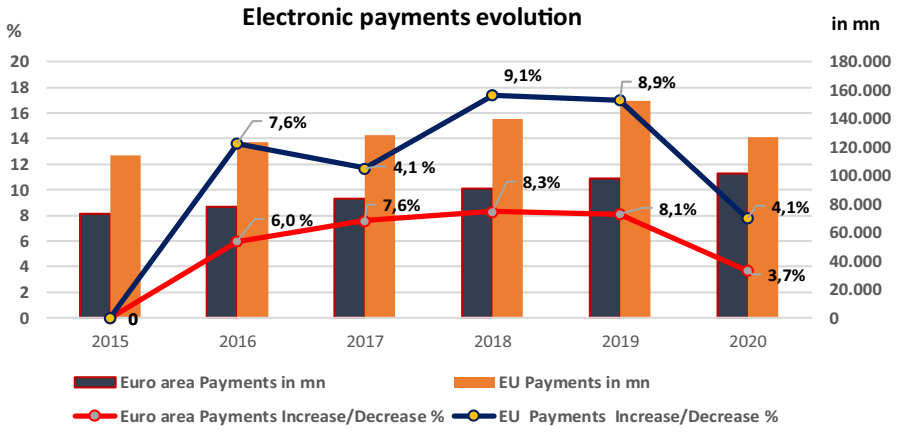

Fig. 1 Electronic payments evolution across the EU and the euro area: 2015–2020. Source: ECB Statistical Warehouse. Total number of payments across the euro area (millions) and Europe and their increase/decrease (annual percentage changes)

However, in 2020, in some euro area countries, the total number of payment transactions fell, owing to lower consumption amid extended COVID-19 related lockdowns.

Looking at the breakdown of payments by type of payment service for the 2015–2020 period, credit cards and e-money payments by resident PSPs accelerated, contrary to *cheques* and other payment services, whereas their share decreased by 33% and 19% respectively.[1] It is noted that other payment services encompass money remittances, payments via telecommunication, digital or IT device, OTC cash deposits and OTC cash withdrawals. Finally, in all euro area countries, both POS transactions with credit cards and at terminals have risen by over 100% since 2015,[2] indicating a major change in customer behavior with a clear preference to digital payments.

Innovative means of payment, such as stablecoins and cryptocurrencies, are transforming the retail payment landscape across the euro area, satisfying consumers' payment preferences and reducing their demand for cash. The strength of stablecoins and cryptocurrencies lies in their attractiveness as a means of payment due to low costs, cross border functionality, speed and easiness to use. Due to their open architecture, they allow seamless payments of blockchain-based assets, and are embedded into digital applications, thereby filling existing gaps and shortcomings in the current retail payments.

Overall, consumer preferences for electronic payment instruments in conjunction with the impact of the COVID-19 pandemic on payment behavior, the rise of new payment solutions provided by global technology firms, and the popularity of stablecoins and cryptocurrencies led the Eurosystem to put in place a comprehensive

[1] The relevant tables are available upon request.

[2] The relevant tables are available upon request.

Table 2 Total number of payment transactions involving non-MFIs per capital. Source: ECB Statistical Warehouse. Total number of payment transactions involving non-MFIs per capita and per year across the euro area countries

Number per capita						
	2015	2016	2017	2018	2019	2020
BE	283.3	305.3	331.8	371.1	402.7	420.7
DE	242.4	247.4	259.1	273.6	291.3	315
EE	306.2	327.4	354.3	382.4	414.1	416.5
IE	215.1	256.5	294.9	339.6	387.6	429.5
GR	56.9	73.7	99.2	111.8	126.6	165.5
ES	133.7	148.1	168.4	175.2	196.7	199.7
FR	303.5	312.9	327.5	349.3	369.4	358.1
IT	87.1	95.6	1006	113.3	126	130.1
CY	102	111.1	118.8	135.3	150.9	163.1
LV	183.3	203.8	234.8	253.8	281.5	296.6
LT	146.7	159.3	178.7	206.1	237.4	308.1
LU	3576.50	4088.90	4773.20	5477.20	5893.50	7563.90
MT	100.4	106.8	119.5	141.5	158.5	156.3
NL	401.2	421.3	455.3	505.3	543.1	527
AT	180.1	189.6	203.3	220.8	238.8	251.5
PT	197.1	212.4	228.4	244.2	243	228.8
SI	182.3	189.6	198.3	209.9	224	218.6
SK	132.9	145.7	163.2	178.7	196.6	189.4
FI	419.6	445.4	469.9	509.1	545.9	543.5
Euro area	**216.6**	**228.8**	**245.7**	**265.4**	**286**	**286.5**
EU	**224.6**	**241**	**250.4**	**272.6**	**296.1**	**283.7**

In addition, the total number of payment transactions involving non-MFIs per capita and per year for Europe and the euro area are in bold

retail payments strategy. The main elements of this strategy are the development of a pan-European solution for payments, the full deployment of instant payments, the improvement of cross-border payments beyond the EU and support for innovative digitalization in order to establish a European ecosystem for payments. This strategy is closely linked to and consistent with the current work on the issuance of a digital euro.[3] More precisely, according to the ECB, the digitalization of the economy, technological innovation and the fast evolution of the payments ecosystem are influencing consumer perceptions of payment services and fueling interest in the possible issuance of a digital euro. Furthermore, the public perception of cash relative to electronic payments is changing and its use is declining in some countries. According to recent ECB surveys, the COVID-19 crisis induced a shift in payment habits

[3] ECB, The Eurosystem's retail payments strategy.

towards contactless payments and e-commerce, with young Europeans preferring electronic payments, indicating that the share of electronic payments in total payments is increasing. In light of these developments, the ECB decided to examine the issuance of a digital euro as it could support the Eurosystem's objectives by providing citizens with access to a safe form of money in the fast-changing digital world. By issuing a digital euro, the ECB would provide an alternative to foreign payment providers for fast and efficient payments in Europe and beyond and a state-of-the-art payment service that responds to people's changing needs and actively promotes innovation in the field of retail payments, complementing private payment solutions. In addition, it enhances options, competition and accessibility with regard to digital payments, supporting financial inclusion. Finally, a digital euro could reduce costs for payment service providers, by making their business processes more efficient and supportive of new business models.

4 Crypto assets and decentralized finance: the interconnection with the traditional financial markets

With the introduction of Bitcoin in 2008, blockchain technology paved the way for disintermediation. Since then, more than 2.000 crypto assets have been issued or generated including new types of assets such as stablecoins, which are designed to have a stable value vis-à-vis fiat currency. Focusing on stablecoins, these aim at directly addressing the extreme price volatility of the crypto and other risky financial assets. Stablecoins are pegged to (the value of) fiat currency, commodities, other crypto assets or indices. They may also rely on algorithms that dynamically adjust their supply in order to stabilize their market value. Stablecoins are based on distributed ledger or blockchain technology and as such, they share many of the features of cryptocurrencies. At least 200 stablecoins have been released or are in development globally. The total market capitalization of stablecoins currently stands at around $114 billion, which represents around 8% of the total cryptocurrency market of $1.5 trillion. Total stablecoin supply surged more than tenfold during 2021 from around $10 billion in May 2020. Among them, Tether is often quoted as the first stablecoin and its issuer reports it is fully backed by legal tender. It is also the stablecoin with the largest market capitalization and is reported "to remain entrenched in the top-10 cryptocurrencies in terms of value and second only to Bitcoin in terms of daily trading volume" (Blockchain, 2019). Demand for stablecoins soared in a rush to safety by investors exiting volatile cryptocurrency positions, as the latter plummeted along with traditional assets on fears spurred by the COVID-19 outbreak in March 2020. Another driver of the increasing demand for stablecoins has been the rise of Decentralized Finance (DeFi), usually known as "Web3". DeFi, which is built upon distributed ledger technology applications and aims at providing traditional financial services without central intermediaries using smart contracts on a public blockchain, primarily Ethereum, has gained a lot of popularity.

The COVID-19 crisis has fueled digitalization as reflected by a surge in crypto asset prices and stablecoins. More precisely, the total value of crypto assets locked in decentralized finance (DeFi) applications reached $70 billion at end-March 2021,

up from $1.9 billion in July 2020, a fact that boosted investors demand and lifted crypto asset prices. In fact, since October 2020, the market capitalization of Bitcoin and Ethereum, the most tradable cryptocurrencies, has increased by almost 500%.

Interestingly, major global companies already announced that they accept cryptocurrencies as a means of payment. Among them, PayPal launched of a new service enabling its customers to buy, hold and sell cryptocurrency directly from their PayPal account and signaled its plans to significantly increase crypto assets utility by making it available as a funding source for purchases at any of its 26 million merchants worldwide. In addition, Tesla bought $1.5 billion worth of Bitcoin in 2021 while also noted that it would start accepting Bitcoins as a payment method for its products. According to its annual financial statement, at end-2021 Tesla was holding $1.99 billion worth of Bitcoin.

Indicating strong risk appetite, funds investing in the main crypto assets grew rapidly in size and the prices of these assets reached all-time peaks.[4] The rapid surge in crypto assets popularity among both retail and institutional investors led to increasing disengagement from traditional financial assets, triggering central banks to consider issuing CBDCs, including payments safety and efficiency, bringing CBDCs to the forefront of their agendas.

Should the crypto assets were also prevalent and viable payment options, their widespread adoption would limit the ability of central banks to control inflation, which is the primary, if not the only, objective of central banks. If the cryptocurrencies and stablecoins become mainstream as units of exchange or units of account, this would affect the demand for central bank liquidity and the central bank's steering of money market rates, therefore diminishing the effectiveness of monetary policy. Furthermore, a widely adoption of crypto assets would impair fiat money supply disrupting monetary multipliers.

Cross-border effects could also be significant. Cryptocurrencies may cause an upheaval of the international monetary system should their extensive usage expands outside national borders (Brunnermeier et al., 2019). As a result, central banks would not meet their primary objective of price stability and their goal to maximize the effectiveness of their issuance currencies, namely, their efficiency as a medium of exchange, their security as a store of value, and their stability as the unit of account for economic and financial transactions.

In addition, central banks monitor developments in the banking sector as well as other financial sectors, to identify vulnerabilities, check the resilience of the financial system and the unravelling of financial imbalances in order to preserve financial stability. Because cryptocurrencies circulate on a global network, they could have a destabilizing effect on traditional financial systems due to massive liquidity outflows. Taking into account the gained popularity of cryptocurrencies, major central banks proceeded to examining crypto assets and analyzing potential implications for monetary policy and the risks they entail for the smooth functioning of market infrastructures, payment systems, and the overall stability of the financial system. These risks and challenges led central banks to explore technologies underlying

[4] Alfonso et al. (2021), *Quarterly Review*, March.

cryptocurrencies to issue their own central bank digital currencies (CBDCs), thereby contributing to a more innovative, competitive, robust, safe and resilient payment system (Kumhof & Barrdear, 2016; Bank of England, 2021; Mancini-Griffoli, et al. 2018; ECB, 2019a, b, ECB, 2020, 2020a, b, c, d, ECB 2021a, b; Alfonso et al., 2021; Federal Reserve 2022; Prasad, 2021).

At the same time, developers of cryptocurrencies claim a number of benefits such as faster and cheaper domestic or cross-border payments, as well as greater convenience through integration of cryptocurrency 'wallets' with other technology, such as social media platforms or online shopping services. Transactions in DeFi can be executed automatically, i.e. the wallet-to-wallet exchange of two digital assets simultaneously in a single operation or delivery versus payment instantaneously and without central counterparties (CCPs) to guarantee the transaction, providing benefits of speed and costs, collateral management and clearing. It should however be noted that similar benefits are realized in permissioned DLT-based systems for clearing and settlement and are not a privilege unique to DeFi markets. While DeFi is largely separate from the traditional financial system at present, in case that cryptocurrencies gain wider acceptance as means of payment they could compete against and possibly replace commercial bank deposits, having an impact on the business models of financial service providers (Aramonte et al., 2021).

We describe below the data of cryptocurrencies and traditional financial assets that we used in our study and we present evidence of a statistically significant connection between them.

4.1 Data

Daily closing prices on cryptocurrencies Bitcoin, Ethereum and XRP were collected from the website *Coinmarketcap*.com, while daily data on the stablecoin Tether were obtained from the website *Investing.com.* Daily closing prices on the traditional financial assets were collected from *Bloomberg.* The selected cryptos and stablecoin under review are those with the highest market cap at end-March 2021.

Regarding equity markets, we focus on the major US and European stock market indices, namely Dow Jones Industrial Average, S&P500, Eurostoxx 50, FTSE 100 Index and the MSCI World Equity Index. Also, the relationship between the EUR/USD exchange rate and the selected cryptos is analyzed. For all data, the period under examination is from February 2015 to March 2021 since the stablecoin Tether started trading in February 2015.

4.2 Descriptive Statistics

As seen in Fig. 2 the price trajectories seem to move together, presenting joint episodes of runs of increasing prices followed by corrections suggesting that joint comovements and measures of association are worth investigating.

Figure 3 illustrates the return dynamics of all data series under examination, with returns showing volatility clusters (conditional heteroscedasticity) and a few extreme points.

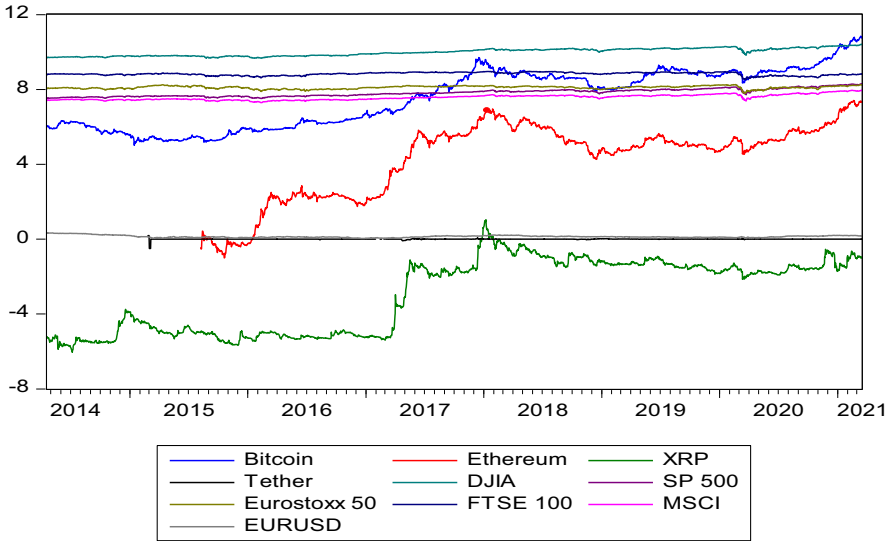

Fig. 2 Time series of log prices, 19/4/2014 to 31/3/2021

Table 3 summarizes some descriptive statistics for all data series returns for the period from 25 February 2015 to 31 March 2021.[5]

From Table 3 we observe the following: First, the means of all cryptos are positive and all have high standard deviations. Comparing the three cryptos, Bitcoin has the lowest standard deviation. On the other hand, stablecoin Tether has a negative mean and a much lower standard deviation than these observed on all cryptos. This is something expected due to its design, i.e. to have a stable value vis-à-vis fiat currency.

Second, both cryptos and Tether are asymmetric, that is, they have skewness different from zero. More analytically, while Ethereum and XRP both have a positive mean and skewness indicating that they have experienced greater chances of extreme positive outcomes (or that bad scenarios are less likely). On the other hand, Tether exhibits a deep negative skewness, the largest among all data series under examination, suggesting that its overall performance is negative. In combination with its negative mean, it highlights the risk of extreme negative events or what sometimes is referred to as "black swan events". Third, both cryptos and stablecoin Tether exhibit extraordinary positive excess kurtosis, showing heavy tails on either side of their leptokurtic distributions. Therefore, the likelihood of extreme outcomes is much higher than that predicted by the normal distribution. It is noted that Tether can be assumed to be the most risky one, as it displays the highest positive excess kurtosis, i.e. heavy tails and "peakedness" in its distribution relative to the normal distribution. Furthermore, the excessively high Jarque–Bera statistic values

[5] The returns were computed using the following formula: return = $\log(P_t/P_{t-1})*100$.

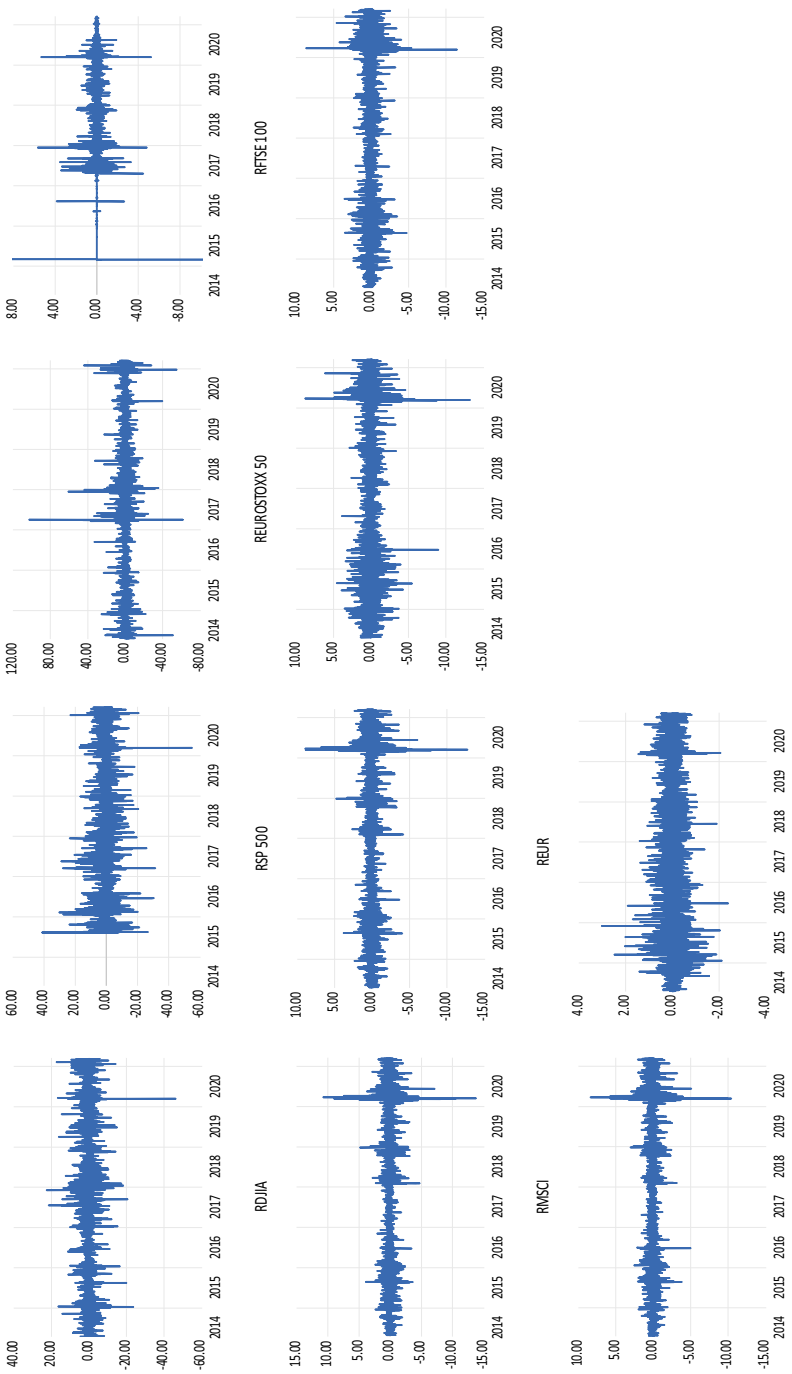

Fig. 3 Return dynamics for all the data series, 19/4/2014 to 31/3/2021

Table 3 Descriptive statistics for all data series´returns, 19/4/2014 to 31/3/2021

	RBITCOIN	RETHEREUM	RXRP	RTETHER	RDJIA	RSP500	REUROSTOXX 50	RFTSE 100	RMSCI	REURUSD
Mean	0.1891	0.3860	0.1692	− 0.0870	0.0274	0.0299	0.0079	0.0011	0.0208	− 0.0059
Max	22.5119	41.1980	102.7053	50.0498	10.7643	8.9683	8.8343	8.6668	8.4063	3.0158
Min	− 46.4729	− 55.0743	− 61.6344	− 68.7140	− 13.8418	− 12.7653	− 13.2405	− 11.5124	− 10.4417	− 2.3821
Std. Dev	3.8599	6.1508	6.6840	1.8937	0.9767	0.9429	1.0554	0.8849	0.7967	0.4201
Skewness	− 0.8431	0.0712	1.9544	− 13.4245	− 1.2943	− 1.2153	− 12.3040	− 1.0978	− 1.7549	0.0513
Kurtosis	15.6497	11.0617	40.0758	19.4900	41.2713	35.3007	22.0587	24.2977	38.6963	7.8651
Jarque–Bera	1712.20	555.80	1461.70	934.00	1547.00	1103.50	3883.21	4820.94	1351.20	2490.30
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Obs	2524	2039	2523	2177	2524	2524	2524	2524	2524	2524

Bitcoin's sample starts from 19/4/2014; Ethereum's from 8/8/2015; XRP's from 19/04/2014; and Tether's from 25/2/2015; J-B is the Jarque–Bera statistic for non-normality;DJIA's, SP500's, Eurostoxx 50's, FTSE 100's, MSCI's and EURUSD's samples start from 19/4/2014

for all data confirm these findings as they all reject the null hypothesis of normal distribution.

Turning to the US and the European traditional financial assets, they also are not normally distributed and they record positive excess kurtosis values. Comparing with the cryptos and the stablecoin, the main difference is that both returns of equity indices and the euro/US dollar exchange rate have negative skewness, implying a higher likelihood of extreme negative outcomes (returns). In addition, the euro/US dollar exchange rate can be considered the riskiest among all series under investigation, as it displays the greatest negative average return and much higher variability than the other financial assets.

4.3 Correlations

Table 4 shows the simple, unconditional correlations among the returns of the data series. -We see that all cryptos exhibit positive correlations among them. In addition, they display positive correlations with all equity indices. Bitcoin has the highest positive correlation with all equity indices and positive but very weak correlation with the euro/US dollar exchange rate. Focusing on the stablecoin Tether, it has negative correlation with all other cryptos, the highest negative correlation being with XRP. Regarding equity market indices, in contrast with the other cryptos, Tether has negative but weak correlations with both the US and the European equity indices. Overall, Tether's correlations with all other series are much weaker, implying that there is no significant relationship between Tether and the rest series under examination. Finally, only the euro/US dollar exchange rate exhibits positive correlations with both cryptos and the stablecoin.

4.4 Main empirical results on cointegration and the ECB CBDC strategy

We next check for cointegration among all series simultaneously, and for each class of series.[6]

Using the Johansen-Juselius approach (Johansen & Juselius, 1990) we ran the Johansen cointegration test in order to observe whether the chosen variables have a common stochastic trend or not. To investigate for existence of cointegration among the variables we implemented both the trace statistics tests and the maximum eigenvalue (with the null hypothesis of the number of cointegration vectors is $r = r^* < k$, versus the alternative that $r = k$), (Johansen, 1991)).

As seen in Table 5, both trace statistics and maximum eigenvalue test results reveal a single cointegrating relationship among them at 5 percent and 1 percent levels. Hence, all series[7] examined share a strong (even at the 1% level of significance)

[6] Before checking for cointegration, we examined the stationarity of these series. We used the Augmented Dickey Fuller test to do the unit root of each individual variable and we found that all data series are non-stationary. All Augmented Dickey Fuller tests are available upon request.

[7] All series are in logs.

Table 4 Simple Correlations among series' returns, 19/4/2014 to 31/3/2021

	RBITCOIN	RETHEREUM	RXRP	RTETHER	RDJIA	RSP500	REUROSTOXX50	RFTSE100	RMSCI
RETHEREUM	0.5253	1.0000							
RXRP	0.3710	0.3496	1.0000						
RTETHER	− 0.0094	− 0.0166	− 0.0242	1.0000					
RDJIA	0.1575	0.1381	0.1107	− 0.0754	1.0000				
RSP500	0.1610	0.1446	0.1092	− 0.0773	0.9739	1.0000			
REUROSTOXX50	0.1279	0.0902	0.0786	− 0.0615	0.6229	0.6124	1.0000		
RFTSE100	0.1223	0.0791	0.0881	− 0.0660	0.6082	0.5939	0.8712	1.0000	
RMSCI	0.1668	0.1407	0.1159	− 0.0805	0.9390	0.9577	0.7538	0.7283	1.0000
REURUSD	0.0213	0.0290	0.0275	0.0123	− 0.0435	− 0.0529	-0.1143	− 0.0949	0.0238

See notes in Table 3

Table 5 Johansen cointegration test results among all series under examination

No. of CE(s)	Trace	5% CV	Max Eigen	5% CV
None	**271.81**	**233.13**	**89.26**	**62.81**
At most 1	182.55	192.89	44.53	57.12
At most 2	138.03	156.00	39.48	51.42
At most 3	98.55	124.24	29.63	45.28
At most 4	68.92	94.15	28.00	39.37
At most 5	40.92	68.52	18.05	33.46
At most 6	22.87	47.21	11.54	27.07
At most 7	11.32	29.68	7.83	20.97
At most 8	3.49	15.41	2.76	14.07
At most 9	0.73	3.76	0.73	3.76

Max-eigenvalue test indicates one cointegrating equation at 5% level are in bold

Series: Bitcoin, DJIA, Ethereum, Eurostoxx 50, MSCI, SP500, Tether, XRP, FTSE 100 and EURUSD. Sample period: 8/8/2015–15/3/2021. Trend assumption: Linear deterministic trend. Lags interval (in first differences): 1 to 4. Trace test indicates one cointegrating equation at 5% level

Table 6 Johansen cointegration test results among cryptos and stablecoin

No. of CE(s)	Trace	5% CV	Prob.*	Max Eigen	5% CV	Prob.*
None	**95.84**	**47.86**	**0.00**	**79.14**	**27.58**	**0.00**
At most 1	16.69	29.80	0.66	13.00	21.13	0.45
At most 2	3.69	15.49	0.93	3.67	14.26	0.89
At most 3	0.02	3.84	0.88	0.02	3.84	0.88

Max-eigenvalue test indicates one cointegrating equation at 5% level are in bold

*MacKinnon-Haug-Michelis (1999) p-values

Series: Bitcoin, Ethereum, Tether, XRP. Sample period: 8/8/2015–15/3/2021. Trend assumption: Linear deterministic trend. Lags interval (in first differences): 1–4. Trace test indicates one cointegrating equation at 5% level

Table 7 Johansen cointegration test results among equity indices and euro/US dollar exchange rate

No. of CE(s)	Trace	5% CV	Prob.*	Max Eigen	5% CV	Prob.*
None	72.41	95.75	0.64	29.85	40.08	0.43
At most 1	42.56	69.82	0.90	17.99	33.88	0.88
At most 2	24.57	47.86	0.93	13.16	27.58	0.88
At most 3	11.41	29.80	0.95	8.77	21.13	0.85
At most 4	2.65	15.49	0.98	2.59	14.26	0.97
At most 5	0.06	3.84	0.81	0.06	3.84	0.81

* MacKinnon-Haug-Michelis (1999) p-values

Series: DJIA, Eurostoxx 50, MSCI, SP500, FTSE 100 and EURUSD. Sample period: 23/4/2014–15/3/2021. Trend assumption: Linear deterministic trend. Lags interval (in first differences): 1–4. Trace test indicates no cointegration at 5% level. Max-eigenvalue test indicates no cointegration at 5% level

Table 8 Granger causality among Bitcoin, stablecoin, equity indices and euro/US dollar exchange rate

Null Hypothesis:	Obs.	F-Statistic	Prob.
LETHER does not Granger Cause LBITCOIN	2048	2.0637	0.0672
LBITCOIN does not Granger Cause LETHER		2.0021	0.0754
LTETHER does not Granger Cause LBITCOIN	2211	0.2800	0.7552
LBITCOIN does not Granger Cause LTETHER		**4.2157**	**0.0008**
LDJIA does not Granger Cause LBITCOIN	2525	0.7745	0.5680
LBITCOIN does not Granger Cause LDJIA		**6.8673**	**2.E-06**
LEUSTOXX does not Granger Cause LBITCOIN	2525	1.8106	0.1074
LBITCOIN does not Granger Cause LEUSTOXX		**2.2323**	**0.0486**
LMSCI does not Granger Cause LBITCOIN	2525	1.1392	0.3373
LBITCOIN does not Granger Cause LMSCI		**5.1929**	**0.0001**
LSP500 does not Granger Cause LBITCOIN	2525	1.2633	0.2770
LBITCOIN does not Granger Cause LSP500		**4.4291**	**0.0005**
LFTSE100 does not Granger Cause LBITCOIN	2525	1.0912	0.3631
LBITCOIN does not Granger Cause LFTSE100		1.4806	0.1928
LEURUSD does not Granger Cause LBITCOIN	2525	1.0098	0.4102
LBITCOIN does not Granger Cause LEURUSD		1.6006	0.1565

Pairwise Granger causality tests. Bolded results suggest Granger causality

common stochastic trend, as evidenced by a long-term relationship between cryptos, stablecoin, equity indices and the euro/US dollar exchange rate.

Next, we tested for each class of series separately to see if they are cointegrated within each category. For cryptos and Tether, both trace and maximum eigenvalue tests indicate the existence of one cointegration equation but only at the 5 percent level, as it is shown in Table 6. On the other hand, for the equity indices and the exchange rate, there was no cointegration. Even when the euro/US dollar exchange rate is excluded, the relevant tests reject the existence of any cointegration indicating no long run causality between the selected traditional financial assets (Table 7).

In addition, we analyze the causality relationship between each of the series variables by using the Granger causality analysis (Granger, 1969; Zapata et al., 2014). The results of the Granger causality tests[8] showed the following. First, as expected, there is mutual interdependence (or causality) between all equity indices, i.e. the direction of causation is bi-directional among all the equity indices. Second, there exists unidirectional causality from each equity index to the euro/US dollar exchange rate. For example, there is a significant causality running from Dow Jones Index to the EUR/USD exchange rate. As far as the cryptocurrencies are concerned, the results show the absence of causality in the two directions between the Ethereum and the Bitcoin and between the Tether and the Ethereum. However, there is significant causality running from Bitcoin to Tether and from XRP to Bitcoin and to

[8] Selected statistically significant ones are presented in Table 8. The full Granger causality tests are available upon request.

Tether, respectively. Furthermore, there is a bi-directional causation between XRP and Ethereum, while there exists a uni-directional causality from Bitcoin to all equity indices except the FTSE 100. Finally, both Ethereum and XRP have a causal effect to all equity indices, while a significant bidirectional causality runs only between the Tether and the EUR/USD exchange rate.

Given that a causality relationship exists between cryptos, stablecoin and all traditional financial assets, the financial system and crypto assets are both interconnected. Hence, spillover effects from cryptos and stablecoins trading may be transmitted to the financial markets, with implications for the financial stability in the euro area and the implementation of the single monetary policy. In particular, since investor and business interest, both retail and institutional, has risen dramatically for cryptos and stablecoins, these digital assets could become a credible alternative as financial assets and a means of payment in the euro area. This could affect the business models and the functioning of payment and market infrastructures, together with the Eurosystem's monetary policy mandate.

As a result, the mutual interdependence found between crypto assets and traditional financial assets leads to increased interconnectedness between traditional/centralized finance ('CeFi') and the parallel decentralized financial system; this interconnectedness is evidenced through intersection or convergence points. As a result, the increasing use of crypto assets and stablecoins makes the boundaries of the two systems more porous and increases spillovers to the traditional financial system and the real economy.

The decentralized nature of crypto assets and the dispersion of financial service providers could increase diversity in the financial system and reduce the concentration of service providers, thus enhancing competition and introducing new business models. Increasing integration of crypto assets with the conventional financial assets could also result in lower transaction costs. Real-time transparency to all users, with automated settlement, is one of the most important breakthroughs of blockchain-based financing and has important implications for trading in financial securities, collateral management, clearing and the overall functioning of trading platforms.

In terms of financial inclusion, small companies could use major crypto asset exchanges to either make direct payments or convert payment amounts to fiat money-backed cryptocurrencies for cross-border remittances. To the extent that crypto asset initiatives are supported by large companies, new "key channels" would be built to consumers and businesses – such as social media, instant messaging platforms and online marketplaces – to rapidly achieve scale and network effects.

At the same time, the absence of a central point of failure or single attack point in a decentralized setting could enhance the resilience of the financial system. If appropriately secure, decentralized systems may be more resilient to cyber risk than highly centralized systems, also in terms of the integrity of their record-keeping and service availability (Financial Stability Board, 2019).

In addition, the code underlying the crypto assets and decentralized finance protocol is in most cases open source, giving room for innovation in products and services that leverage on the accessibility of open source infrastructure to create new products, enabling a number of new business models for the provision of financial technology. The interoperability across blockchain networks could help tear down

financial sector silos, greatly promoting innovation and building vibrant financial ecosystems (Carter & Jeng, 2021).

However, the linkages between crypto assets and the traditional financial assets come with corresponding key risks that would need to be properly identified and mitigated accordingly. Although the size of the crypto asset market is not large enough to be considered a risk to the stability of the markets, the increased interest and adoption of crypto assets by retail/institutional investors and other traditional financial service providers is leading to increased interconnections between traditional/centralized finance and the parallel decentralized finance system. The lack of regulatory safeguards for investor protection, necessary across the board of financial services legislation, leaves investors and financial consumers more exposed to forms of loss or erosion of value. The significant price volatility of the crypto asset markets, price disruptions and dislocations exacerbate this challenge and expose consumers to increased risk of loss of capital. Open source code, while transparent, would not be sufficient for the average retail investor that does not have the requisite level of technological and financial literacy to understand the implicit risks, such as market manipulation associated with oracle manipulation or other malicious activity (e.g. attacks on liquidity-dependent protocols such as 'Vampire' attacks).

In addition, in case of a significantly higher use of cryptos and stablecoins, any abrupt change in their price and volatility could directly affect traditional financial products. Furthermore any rapid shift of the DeFi market participants or in the mechanisms underlying DeFi protocols would have an indirect effect on the traditional financial markets, driven by changes in liquidity and supply/demand dynamics. Equally, in case of generalized distress on the crypto asset markets, investors exposed to losses in their portfolios may have to close positions on traditional markets, propagating the shock. In the extreme scenario of a potentially significant use of cryptos and stablecoins, massive outflows could be realized from the traditional banking system, ultimately resulting in a loss of monetary sovereignty for the euro area and in the malfunctioning of the monetary policy transmission mechanism.

The introduction of a digital euro using blockchain technology and supporting—from a technical standpoint—the construction of smart contracts with capabilities similar to those used in the crypto asset markets could be seen as a convergence point of the traditional financial markets with the crypto assets markets. At the same time, not issuing a digital euro could entail unwarranted risks to the euro area, especially if one takes into consideration the interdependence between cryptos, stablecoins and the regulated financial sectors and payment transactions.

In this context, regulatory and supervisory policy tools will have to adapt as some of the characteristics of the crypto asset markets are incompatible with the existing Eurosystem regulatory framework, particularly given that the current framework is designed for a system that has financial intermediaries at its core. Potential regulatory gaps may also give rise to regulatory arbitrage opportunities, as new types of risks could arise in crypto asset markets, which may stem from the novel characteristics of financial service provision in decentralized systems.

The recent MiCA legislative proposal in the European Union, which aims at providing an EU-harmonized framework for the issuance and provision of services related to crypto assets, as well as to ensure the proper functioning of crypto asset

markets while ensuring investor protection, market integrity and financial stability, is a good example of action taken to address and mitigate potential risks. More specifically, the proposal offers a 'bespoke legislative regime' that will ensure consumer and investor protection and market integrity, by regulating crypto asset activities, such as crypto assets issuance, wallet provision, exchange and trading platforms. Moreover, in the European Union, the 'digital finance package' also includes a pilot regime on DLT market infrastructure. The DLT pilot regime allows for experimentation within a safe environment (otherwise known as 'sandbox' approach) leading to the development of a secondary market for financial instruments in crypto asset form. Successful applicants will be able to test their new products without the cost of overheads – such as compliance and exhaustive consumer protection. This allows temporary derogations from existing rules so that regulators can gain experience on the use of DLT in market infrastructures, while ensuring that they can efficiently deal with risks to ensure investor protection, market integrity and financial stability.

5 Conclusions

The wave of digitization and the abundance of new payment technologies available at increasingly lower costs are pushing the world towards a relatively cashless society. The COVID-19 pandemic has sped up digital transformation and has revealed the need for digital connectivity between consumers and financial service providers. Recent developments in the cashless payments process and rapid growth of cryptocurrencies have accelerated policy actions aimed at assessing the creation of CBDCs.

Although the behavior of the cryptocurrency markets is widely discussed in literature, higher digital payments and rising popularity of cryptocurrencies have not yet been investigated as key drivers behind a potential issuance of a central bank digital currency. To address this literature gap, we focused on the ECB's project for the issuance of the digital euro, we examined the rise of digital payments across the euro area from 2015 to 2020 and we reviewed the behavior of the most tradable cryptocurrencies against major equity indices and the euro/US dollar exchange rate. Our main conclusions are the following:

As regards cashless payments in the euro area, electronic payments have risen by 7.5% on average since 2015, while the total number of payment transactions per capita has increased in all euro area countries during the period under examination. Overall, the aforementioned consumer preferences for electronic payment instruments in conjunction with the impact of the COVID-19 pandemic on payment behavior and the rise of new payment solutions provided by global technology firms led the Eurosystem to put in place a comprehensive retail payments strategy.

Turning to the rise of cryptocurrencies and the interconnection with traditional financial assets, we have found a long-term relationship, revealing a common stochastic trend, between cryptos, stablecoin, equity indices and the euro/US dollar exchange rate. We consider these findings of critical importance for businesses, as they have an impact on the financial environment in which each and every business will soon have to operate. Furthermore, we analyzed the causality relationship

between each of the series variables by using the Granger causality analysis and we found that there are different interdependences—or causalities—between the series under investigation. In summary, an in-depth discussion is provided for the digital trend concluding that both the rise of digital payments and the increased popularity of cryptocurrencies can be seen as the main drivers behind the issuance of the digital euro. Given the rapid growth of crypto asset markets, potential risks may arise as regards consumer protection, safety, soundness of regulated financial institutions and resiliency of the financial system. While the crypto asset markets can be considered as competitive/alternative to the traditional ones, even threatening banks' business, their innovative characteristics can be used in a wide range of traditional financial services. Deeper consideration of the value added that crypto asset markets could bring to users, the financial system and the real economy will prove beneficial. Decentralized finance is fueling innovation (conventional and disruptive) and pushes established market infrastructure and players to review existing processes.

As a result, new types of businesses may emerge with a view to improving credit analysis, efficiency, risk management, product design, connectivity, customer services and more. Future empirical research is justified on exploring the association among cryptos and traditional financial assets on both long and short runs in preparation for potential policy intervention. Finally, possible ways for regulators to limit risks that could emerge in and from the crypto asset markets, together with ways to enforce existing regulation in decentralized structures, need to be further investigated.

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