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Cryptocurrency competition: empirical testing of Hayek's vision of private monies

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Abstract

This study investigated the extent of currency competition within the cryptocurrency market through the Hayek's concept of the denationalization of money. Hayek's original analysis primarily centered on competition revolving around the medium of the exchange function. This study posited that cryptocurrencies compete across diverse monetary functions, particularly concerning their roles as speculative stores of value and exchange media. This assertion provided insight into the distinction between Hayek's envisaged private currencies and the cryptocurrency paradigm. Utilizing an extensive dataset encompassing 101 cryptocurrencies spanning from 2016 to 2022, an empirical exploration was conducted to scrutinize the progression and intensity of competition within the broader cryptocurrency market and its submarkets. These findings reveal a robust competition among unpegged cryptocurrencies, predominantly contending for speculative investment purposes. Similarly, there is pronounced competition among stablecoins as stable stores of value. In contrast, competition is much less pronounced concerning the medium of the exchange function, potentially entailing network effects and the emergence of monopolistic tendencies within this specific submarket.

Keywords: Hayek, Cryptocurrencies, Functions of money, Currency competition, Network effects, Monopoly

JEL Classification: B25, D40, E42, E50, E51, L11

Introduction

Almost half a century ago, Friedrich August von Hayek made the revolutionary proposal of denationalization of money. Although there are historical examples of privately issued banknotes denominated in the national currency, Hayek envisaged something more radical. He propagated a competition of currencies, that is, a competition of “*different kinds of money clearly distinguishable by different denominations among which the public could choose freely*” (Hayek 1978, p. 27).

For decades, Hayek's proposal received little academic, political, or economic attention. However, with the creation of the entire cryptocurrency universe in the 2010s, currency competition has become a reality. It is surprising that despite the prominence of Hayek's name and the fairly large literature on cryptocurrencies, he is rarely mentioned, with the exceptions of Brunnermeier et al. (2019), Fernández-Villaverde

(2018), Fernández-Villaverde and Sanches (2019), Fantacci (2019), and Sanz Bas (2020).

Regrettably, the *spiritus rector* of currency competition has thus largely been forgotten. On one hand, this results in a missed opportunity to test Hayek's hypotheses on monetary competition in a fascinating laboratory experiment. In addition, many Bitcoin (BTC) supporters seem to overlook the fact that the cryptocurrency market is increasingly competitive, in which it is very uncertain that Bitcoin will be able to maintain its strong position in the long run. Thus, with the exception of Gandal and Halaburda (2016) and Halaburda et al. (2022), who do not refer to Hayek, the concept of currency competition has so far received little attention in academic papers on cryptocurrencies.

Our study addresses this deficiency in the discussion on cryptocurrencies. We first examined how Hayek envisioned currency competition in concrete terms and the hypotheses he put forward for this competitive process. This allowed us to identify the differences and similarities between cryptocurrencies in the market today and Hayek's ideas. On this basis, we conduct an extensive empirical investigation of the competitive dynamics in the cryptocurrency market. The cryptocurrency market is an ideal object for academic research because well-defined and high-quality data on prices and volumes over time are available daily. We use these data for a large number of cryptocurrencies, thereby closing the analytical gap mentioned in the survey by Bariviera and Merediz-Solà (2021), according to which "*most past research was focused exclusively on bitcoin, or at most in the four or five most important cryptocurrencies.*"

Our study concludes that Hayek's hypothesis was only partially confirmed. The most important finding from the reality test of Hayek's proposal is that competition between private currencies is possible, in principle, without the dominance of any single currency in the sense of a natural monopoly. Thus, for the entire universe of cryptocurrencies, one can exclude winner-takes-it-all dynamics owing to network-related reinforcement effects. Instead, one can identify the stable coexistence of several cryptocurrencies and a market that is contestable, that is, always open for successful new entrants. However, beyond this fundamental agreement, there are clear differences between Hayek's theories and currency competition.

- Whereas the *stability of a currency* with respect to a specific bundle of goods or commodities for Hayek was the decisive feature for the success of a private currency, unpegged cryptocurrencies are characterized by an almost excessive volatility compared to other financial assets.
- While for Hayek the *function of the means of payment* was central to currency competition, the unpegged cryptocurrencies are primarily in demand as a *speculative store of value*.
- There is greater congruence with Hayek in the case of *stablecoins*, which have met with a strong increase in investor interest in the recent past. However, stablecoins target a stable exchange rate to the US-Dollar and are thus just as exposed to the loss of purchasing power as the latter. While the three major stablecoins are in demand as a stable store of value, there is one stablecoin (Tether) that dominates as a means of payment. Thus, the tendency toward a natural monopoly seems to

prevail for this function of money, which, in this context, calls the concept of currency competition into question.

Hayek's proposal

Hayek presented his proposal in 1976, with the impression that relatively high inflation rates prevailed in the Western world after the first oil crisis. In his view, the government monopoly over money has been the main reason for the resurgence of inflation since the mid-1960s.

"It [The monetary system at the time of Hayek's writing], has the defects of all monopolies: one must use their product even if it is unsatisfactory and, above all, it prevents the discovery of better methods of satisfying a need for which a monopolist has no incentive" (Hayek 1978, pp. 27–28)

Thus, the main motivation for Hayek's proposal was the belief that private currency competition would force money issuers to maintain their currency *stable in terms of their purchasing power*.

"Neither a general increase nor a general decrease of prices appears to be possible in normal circumstances so long as several issuers of different currencies are allowed freely to compete without the interference of government." (Hayek 1978, p. 95)

(Hayek 1978, p. 46) described the *institutional features* of his concept as follows:

- *"I would announce the issue of non-interest bearing certificates or notes, and the readiness to open current cheque accounts, in terms of a unit with a distinct registered trade name such as 'ducat'.*
- *The only legal obligation I would assume would be to redeem these notes and deposits on demand with, at the option of the holder, either 5 Swiss francs or 5 D-marks or 2 dollars per ducat.*
- *This redemption value would however be intended only as a floor below which the value of the unit could not fall because I would announce at the same time my intention [...] to keep their (precisely defined) purchasing power as nearly as possible constant.*
- *[...] it seems neither necessary nor desirable that the issuing bank legally commits itself to maintain the value of its unit."*

It is important to note that Hayek's proposal differs from 'free banking' models, as he did not envisage competition between monies of the same currency denomination, but a competition between monies that are *denominated in different currency units* (Fantacci 2019).

Hayek was unclear about the *convertibility* of private monies into national monies. However, he speaks of a "*legal obligation*" (Hayek 1978, p. 111) To convert private monies at a fixed rate into national currencies, at least in the beginning, he argued that convertibility is not decisive for his concept.

"Convertibility is a safeguard necessary to impose upon a monopolist, but unnecessary with competing suppliers who cannot maintain themselves in the business unless they provide money at least as advantageous to the user as anybody else."(Hayek 1978, p. 111)

As far as the *dynamics of private currency competition* are concerned, it seemed “fairly certain” to Hayek (1978, p. 52) that

- (a) “a money generally expected to preserve its purchasing power approximately constant would be in continuous demand so long as the people were free to use it,
- (b) with such a continuing demand depending on success in keeping the value of the currency constant one could trust the issuing banks to make every effort to achieve this better than any monopolist who runs no risk by depreciating his money,
- (c) the issuing institution could achieve this result by regulating the quantity of its issue, and
- (d) such a regulation of the quantity of each currency would constitute the best of all practicable methods of regulating the quantity of media of exchange for all possible purposes.”

Consequently, Hayek expected private monies to gradually drive national currencies out of business.

“The appearance and increasing use of the new currencies would, of course, decrease the demand for the existing national ones and, unless their volume was rapidly reduced, would lead to their depreciation. This is the process by which the unreliable currencies would gradually all be eliminated.” (Hayek 1978, p. 53)

Interestingly, Hayek did not consider the risk that, due to *network effects* (Sanz Bas 2020), competition between private issuers could lead to a private monopoly:

“I trust the banks would be wise enough not to desire even a distant approach to a monopoly position, but to limit the volume of their business may become one of their most delicate problems.” (Hayek 1978, p. 94)

This is even more surprising because Hayek focused on the *medium of exchange* as the main field of currency competition.

“There are four kinds of uses of money that would chiefly affect the choice among available kinds of currency: its use, first, for cash purchases of commodities and services; second, for holding reserves for future needs; third, in contracts for deferred payments; and, finally, as a unit of account, especially in keeping books. To treat these uses as different ‘functions’ of money is common but not really expedient. They are in effect simply consequences of the basic function of money as a medium of exchange, and will only in exceptional conditions, such as a rapid depreciation of the medium of exchange, come to be separated from it.” (Hayek 1978, p. 67)

Hayek dismissed the problems of *information and transaction costs* associated with the parallel use of several payment means.

“Shopkeepers, on the other hand, so long as they know they can instantaneously exchange any currency at a known rate of exchange against any other, would be only too willing to accept any currency at an appropriate price” (Hayek 1978, p. 67)

Accordingly, Hayek did not consider the possibility that currency competition processes could differ between the functions of the means of payment and the area of the store of values. This point was raised by Bofinger (1985), who argued that such differentiation between the different functions of money is crucial for understanding currency competition. In his view, competition in the exchange function would lead to a natural monopoly, while competition among financial assets in the store of the value function could lead to the stable coexistence of several or many competitors.

In summary, Hayek's main hypotheses are as follows:

- The quasi state monopoly on money leads to inflation.
- The problem of inflation could be solved by a system of competing private currencies. Competition would force issuers to keep their currencies as stable as possible in terms of purchasing power.
- Issuers would therefore closely observe demand and regulate the quantity of issue accordingly.
- All other functions of money are effectively dependent on the function as a medium of exchange; therefore, competition would concentrate on this function.

The question that arises is whether such a system of competing currencies leads to a stable competitive environment or, again, to a monopoly. This is the main question driving this analysis.

Cryptocurrencies and the Hayek proposal: differences and similarities

While the universe of cryptocurrencies comes close to Hayek's vision of a competition of private currencies "*distinguishable by different denominations*" (Hayek 1978, p. 21), there are nevertheless not only similarities but also differences between Hayek's monies and cryptocurrencies. They concern all the specific features of such financial assets and the behavior of suppliers.

The money flower: a taxonomy for different forms of money

A useful approach to highlight the specific features of Hayek's private money on the one hand and of cryptocurrencies on the other is the so-called money flower, which was developed by Bech and Garratt (2017) and is shown in Fig. 1. It allows a *taxonomy of different forms of "monies"* by combining four different constituent elements.¹

- Privately issued money versus money issued by the government
- Peer-to-peer exchange versus a centralized accounting mechanism
- Physical money versus digital money
- Convertible money versus inconvertible money

The specific fields in the money flower can be attributed to the existing forms of money as follows:

¹ Our money flower differs from the money flower developed by Bech and Garratt as it uses the element "convertible money versus unconvertible money." Bech and Garratt instead use the element "generally accessible versus not generally accessible."

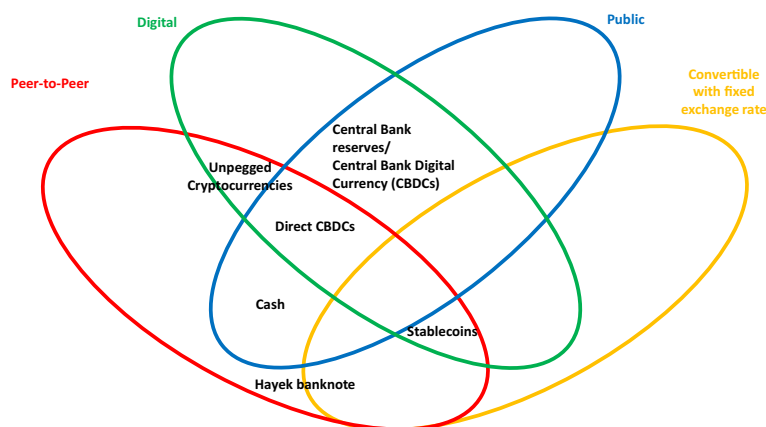


Fig. 1 The money flower (based on Bech and Garratt 2017, own adjustments)

- *Cash*: public, peer-to-peer, physical, and inconvertible
- *Traditional bank deposits*: private, centralized accounting, digital, and convertible
- *Central bank reserves and central bank digital currency (CBDC)*: public, centralized accounting, digital, and inconvertible
- *Classical cryptocurrencies (unpegged cryptocurrencies)*: private, peer-to-peer (distributed ledger), digital, and inconvertible. Because of their inconvertibility, unpegged cryptocurrencies constitute a completely new asset class. While cash and central bank reserves in the fiat currency system are inconvertible by definition, all private financial assets typically include a legal claim against the issuer (dividend payments and ownership rights in the case of shares, interest payments and redemption payments in the case of bonds, and rights to purchase or to sell a financial asset at a predetermined price in the case of derivatives). This is different with unpegged cryptocurrencies such as Bitcoin, which do not offer any legal right to the owner of such a financial asset. We therefore also speak of “unpegged cryptocurrencies.”
- *Stablecoins (pegged cryptocurrencies)*: private, peer-to-peer, digital, and convertible. Stablecoins are also a new asset class, as they are private, peer-to-peer, and digital currencies with a fixed exchange rate (even if the legal status of convertibility can be questionable). Their convertibility also separates them from unpegged cryptocurrencies, even though stablecoins are usually regarded as cryptocurrencies. At the moment, the three largest stablecoins are Tether (USDT), USD Coin (USDC), and Binance USD (BUSD).

Although the *monies of Hayek's currency competition* are private, one must differentiate between Hayek banknotes (physical and peer-to-peer) and Hayek bank accounts (digital and central accounting mechanisms). The classification in convertible and inconvertible is difficult, as Hayek, as already mentioned, makes different statements about this important feature of a financial asset.

- If one assumes *convertibility* into national currencies, Hayek bank accounts are not much different from traditional bank accounts. Abstracting from the accounting mechanism, one could also compare them with stablecoins. The specific

advantage of a Hayek bank account is the additional promise to keep the purchasing power stable so that they offer a hedge against the inflation risk. However, this raises the fundamental question how a Hayek bank could be profitable if it offers the hedge for free.

- If one for this reason assumes that the Hayek bank provides *no legal convertibility obligation*, Hayek money comes close to unpegged cryptocurrencies, except for the accounting mechanism.

The money supply process and the role of the issuers

The differences between Hayek's money, traditional money, and cryptocurrencies can also be highlighted by examining *the issuing process*.

- *Traditional bank deposits* are typically created when a bank provides a loan to its customer. This also applies to the creation of *central bank money (reserves)*, which can be created by central bank refinancing loans to commercial banks. However, central banks and commercial banks can also create money by purchasing foreign exchange or bonds.
- The creation of *stablecoins* is comparable to the creation of commercial bank or central bank money by purchasing foreign exchange.
- The creation of *unpegged cryptocurrencies* is completely different as they are “mined,” that is, created without a corresponding purchase of monies or a credit transaction. This process has some similarity with Milton Friedman's theoretical concept of “helicopter money,” where bank notes are distributed from the air to the population.

Hayek considered the traditional form of money creation to create private money:

“The issuing bank will have two methods of altering the volume of its currency in circulation: It can sell or buy its currency against other currencies (or securities and possibly some commodities); and it can contract or expand its lending activities.”
(Hayek 1978, p. 59)

Differences in the money supply process determine the role of *issuing institutions*.

- In the case of commercial bank money, the issuing institution decides on a discretionary basis about the supply of its money, which is identical with its lending policy.
- In the case of stablecoins, the issuer must regulate the supply in order to maintain the promised exchange rate to the dollar.
- In the case of unpegged cryptocurrencies, the supply process is *determined by a fixed rule* so that issuers behave passively. In the case of Bitcoin, the issuer is not even known to the public.
 - *Bitcoin's* maximum supply is limited to 21 million BTC in total. Bitcoin issuance is halved every 210,000 blocks, which is roughly every 4 years. On 9 July 2016, the block reward was cut to 12.5 Bitcoin per bloc and on 11 May 2020 to 6.25 Bitcoin. Thus, the final Bitcoin is not expected to be generated until the year 2140.

- The *Ethereum* (ETH) platform has an unlimited supply but an *annual maximum supply* of 18 million ETH. Due to the annual absolute supply cap of coins, the growth rate is slightly decreasing in relative terms.
- About 1 billion *Ripple* (XRP) were pre-mined at launch and have been released gradually into the market by its main investors. A smart contract controls the release of XRP. Ripple planned to release a maximum of 1 billion XRP tokens each month as governed by an in-built smart contract; the current circulation is over 50 billion. The Ripple network, although decentralized, is owned and operated by a private company with the same name.

In Hayek's vision, the issuer would be in a similar position as a stablecoin issuer who must regulate the issuance to maintain the promised fixed rate vis-à-vis the US-Dollar. However, instead of stabilizing the exchange rate vis-à-vis a national currency, a Hayek banker must actively manage the issuance with the aim of maintaining a *stable commodity value of a currency*:

“The basis of the daily decisions on its lending policy (and its sales and purchases of currencies on the currency exchange) would have to be the result of a constant calculation provided by a computer into which the latest information about commodity prices and rates of exchange would be constantly fed as it arrived.” (Hayek 1978, p. 60)

By comparing Hayek's main hypotheses with the realities of the cryptocurrency market, we present an update on the hypotheses on cryptocurrency competition:

- Issuers of unpegged cryptocurrencies are not concerned with price stability, neither in terms of purchasing power, nor relative to conventional currencies.
- Quantity supply of unpegged cryptocurrencies is usually set by a defined rule that tries to generate trust, not price stability.
- Issuers of stablecoins are concerned with price stability, though not in terms of purchasing power, but rather relative to conventional currencies.
- Issuers of stablecoins thus closely observe demand and manage supply.
- These observations question Hayek's hypothesis that currencies would mainly compete as media of exchange.

However, these similarities and differences between cryptocurrencies and Hayek's proposal leave the question of competitive dynamics unanswered but allow for a more precise framework for dealing with this question.

Related literature

Over the past few years, a rich strand of literature on the cryptocurrency market has developed. However, just as blockchain, which is mostly studied from a computer science, telecommunications or engineering perspective (Xu et al. 2019), cryptocurrencies are mostly studied regarding future returns or portfolio selection (Fang et al. 2022), rather than by market analysis. Of these crypto market studies, most of the research focuses only on the most prominent cryptocurrencies, even though more recent studies

use a larger set of cryptocurrencies. The findings most relevant to our analysis are briefly summarized here.

Theoretical findings This study is not the first to link Hayek's proposal to cryptocurrencies. In a closely connected study, Brunnermeier et al. (2019) referred to Hayek's concept of currency competition. They argue that, in Hayek's sense, currencies would primarily compete as stores of value, whereas cryptocurrencies can compete on all three functions of money. They also argue that "full currency competition" demands competition on all functions of money, especially that of the unit of account, while "reduced currency competition" focuses only on the function as a medium of exchange. They see an "unbundling of the roles of money," that is, the idea that low switching costs for digital forms of money allow for a specialization of digital moneys in one or more function of money. In their view, this can lead to increased competition between digital currencies along specialized dimensions. Although this is an important confirmation of our established hypothesis, the analysis of Brunnermeier et al. (2019) is purely theoretical and does not examine the actual competition between cryptocurrencies according to the functions of money.

Fantacci (2019) provides a close examination of Hayek's denationalization of money and its comparison to cryptocurrencies, namely Bitcoin, and the crypto market. The core ideas of Hayek's proposal are presented and subjected to critical evaluation. The author argues that Hayek did not provide convincing evidence that private currencies would not be subject to deflation and, in that case, would be hoarded and instead exchanged. Fantacci also briefly mentions currency competition but questions the possibility that cryptocurrencies do not represent liabilities for the issuers, and therefore, issuers of cryptocurrencies are not held responsible for the stability of the value of their currency in the same way as they would be according to Hayek. Although this analysis is valuable as a thorough study of Hayek's proposals, its scope is limited and purely theoretical.

Like Fantacci, Sanz Bas (2020) also closely examines Hayek's denationalization of money and compares unpegged cryptocurrencies and stablecoins to Hayek's idea of private money. He argues that unpegged cryptocurrencies (Bitcoin and Altcoins) might be classified as digital assets that lack the monetary qualities Hayek saw as crucial for successful private currencies. The author also takes a close look at stablecoins and argues that while they come closer to Hayek's idea, they are at least currently only a bridge between fiat currencies and unpegged cryptocurrencies. While Sanz Bas addresses one of the key topics of our study, the connection between Hayek's private currencies and cryptocurrencies, the focus is different. Sanz Bas asks whether unpegged cryptocurrencies and stablecoins are Hayek-imagined private currencies. We are more concerned with the question of whether *competition* exists between cryptocurrencies, as Hayek envisioned. We also examined how market dynamics are connected to the different functions of money. The approach of Sanz Bas (2020) is based on an intensive analysis of relevant literature, whereas our analysis considers the empirical realities of the cryptocurrency market.

In a more general theoretical study of currency competition without reference to Hayek's proposal, Fernández-Villaverde and Sanches (2019) provide a competitive money supply model and show that a system of competing private currencies can

work. However, they also point out that they cannot evaluate the likelihood of a stable and stationary equilibrium and that undesirable outcomes are also possible.

Filip (2021) presents a multicurrency New Monetarist Model of cryptocurrency competition. Acknowledging the argument that strong network effects in the currency market protect government currencies and suppress private currencies, this study shows that constant technological upgrades in cryptocurrencies due to competition may help overcome this disadvantage. In addition, cryptocurrencies can specialize in the distinct needs of the public and provide additional services that are not available in government currencies. This argument is relevant to our empirical analysis of the cryptocurrency competition.

Empirical studies There is a large variety of empirical research on price mechanics and the dynamics of the crypto market often with concern to price formation (e.g., das Neves 2020; Sebastião and Godinho 2021). Many research projects are concerned with whether cryptocurrencies and Bitcoin behave like currencies or speculative assets (Yermack 2015; Baur et al. 2018; Li and Wang 2017; White et al. 2020; Senner and Sornette 2019; Senner and Chanson 2021). While there is no consensus, most studies argue that cryptocurrency properties are closer to speculative assets rather than currencies. According to this argument, currency properties are means of exchange.

Regarding the hierarchy and competitive dynamics of the cryptocurrency market, Bação et al. (2018) tested the Bitcoin domination hypothesis. Their analysis covers the top five cryptocurrencies in terms of market capitalization. The finding that Litecoin and not Bitcoin seem to be the transmission leaders of the five cryptocurrencies is a surprising result that motivates further research on the dynamics of the cryptocurrency market.

Burnie (2018) analyses the connection between top ten cryptocurrencies between 2016 and 2018. Using a correlation analysis, the author finds positive relationships between cryptocurrencies, which are especially strong between forks and cryptocurrencies. The exception is USDT, which shows no robust connection to the other cryptocurrencies under consideration. They also found strong correlations between cryptocurrencies with different setups in terms of token creation and supply mechanisms, hinting at more complex underlying connections.

Lahajnar and Rozanec (2020) also examined correlations among 10 major cryptocurrencies but set their sample from 2017 to March 2020. Similar to our strategy, they also use sub-periods according to the general growth or decline in crypto market capitalization. The authors find moderate positive correlations between Bitcoin and other cryptocurrencies when examining the entire period of their sample. They also find that correlations are relatively weaker during periods of overall market growth and stronger during periods of market decline.

Stylianou et al. (2021) analyze the possible presence of network effects within the crypto market by examining the connection between valuation and user base of six prominent cryptocurrencies. They did not find a reliable connection between network effects and the future valuation of cryptocurrencies. One of the most important findings is that, according to their study, the crypto market is not characterized by winner-takes-all mechanics and that the market is therefore not headed for a monopolistic or oligopolistic market structure.

Closely connected is the study by Anisiuba et al. (2021), who examined the prevalence of reinforcement or substitution effects in the cryptocurrency market for the global market and emerging market economies of China, Russia, and India. Anisiuba et al. (2021) use a sample of seven cryptocurrencies covering August 2017 to November 2018 and find that Bitcoin and Altcoins are, on average, positively correlated. They also find evidence from a regression analysis that questions winner-takes-all dynamics for Bitcoin, which sees its position especially challenged by the USDT.

Two of the papers most closely connected to the research question are the recent works by Gandal and Halaburda (2016) and Halaburda et al. (2022), who also empirically access competition in the cryptocurrency market. However, they differ from our analysis in that they do not specifically consider Hayek as the intellectual father of private currencies, and their analysis only covers the period until 2016, which does not include more recent developments in the crypto market. They did not find consistent evidence for winner-take-all dynamics or tendencies of a natural monopoly for the first period of their sample but found a reverse trend in the second period of the sample. Therefore, their analysis lays the foundation for this study and provides additional motivation for examining the dynamics of different periods separately.

To summarize:

- There are a number of findings in the literature that question the presence of network effects and the winner-take-all mechanics in the crypto market.
- Some authors question that Bitcoin, or cryptocurrencies in general, can be defined as money. They do, however, base their assessment on the relative price behavior of Bitcoin compared to other assets and not from a more theoretical perspective on the functions of money.
- Empirical studies tend to find positive correlations among cryptocurrencies, but there is also evidence that there are changes to the pattern of relationships depending on overall market performance.

The vast majority of research analyzes a very limited number of cryptocurrencies (usually <10) over a relatively short time period (often a year or less), or suffers from a combination of these shortcomings. Therefore, one of the contributions of this study is its large sample size, both in terms of cryptocurrencies (>100) and timeframe (2016–2022). In addition, we differentiate between unpegged cryptocurrencies and stablecoins and analyze the process of currency competition for the store of value and the means of payment function of money separately.

Empirical analysis of cryptocurrency competition

Dynamic developments in the cryptocurrency market offer an ideal opportunity to test Hayek's central hypothesis empirically. Drawing on the theoretical framework established in "Hayek's proposal" and "Cryptocurrencies and the Hayek proposal: differences and similarities" sections, and the results presented in the previous section, we now develop the structure for our empirical analysis. The first issue is the fundamental question of whether a market for private currencies is competitive or whether there are tendencies toward a natural monopoly due to network effects, which would call the concept

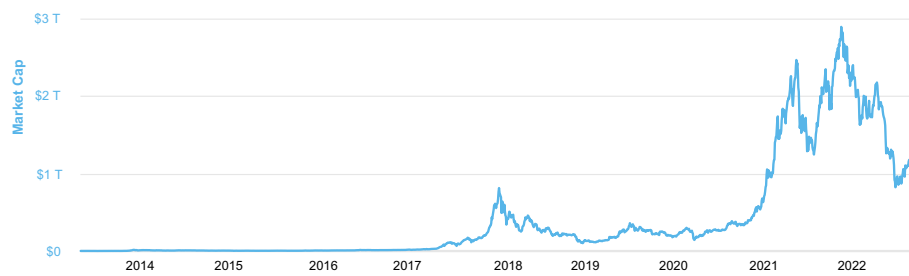


Fig. 2 Total market capitalization of cryptocurrencies in US-Dollars 2014–2022 (Source: coinmarketcap.com)

of currency competition into question. Hayek was animated by the idea of competition, in that he did not explicitly address this fundamental question.

Moreover, Hayek did not question that currencies with stable purchasing power would prevail in monetary competition, and he did not differentiate between the functions of store value and means of payment.

Based on Hayek's hypotheses, we analyze the cryptocurrency market from the following two perspectives:

- Has this market proven to be a competitive one in recent years?
- What are the characteristics of the currencies that have proven to be particularly successful in this process, as evidenced by market capitalization? Is it really price stability and the function as a medium of exchange?

In this analysis, we distinguish between the store of value function and the means of payment function and between unpegged cryptocurrencies and stable coins.

Currency competition triggered by cryptocurrencies can be analyzed from different perspectives. From Hayek's perspective, it would be particularly interesting to examine the extent to which cryptocurrencies succeeded in displacing liquid financial assets denominated as national currencies. This finding is relatively clear. Despite spectacular growth, the importance of cryptocurrencies remains limited. While the global broadly defined money supply amounted to USD 121 trillion in 2020, the market capitalization of cryptocurrencies was only approximately USD 1 trillion in the last count (Fig. 2). More recent data suggest that global money supply has risen significantly since 2020,² while total cryptomarket capitalization has remained stagnant at about 1 trillion. Thus, the competitive pressure from cryptocurrencies on conventional currencies remains limited. Therefore, we focus on the micro perspective of competition within the cryptocurrency market rather than the macro perspective of competition between public and private currencies.

Measuring the intensity of competition

As a recent OECD study (OECD 2021) pointed out, measuring the intensity of competition in markets is not simple. There are various methods for analyzing goods and

² See, for example, aggregate money growth in OECD countries: <https://fred.stlouisfed.org/series/OECDMABMM301XOBSAM>.

service markets that can be applied, at least in part, to private currency markets. Available indicators can be distinguished according to whether they conceive of competition as a static or a dynamic concept.

Among the most important indicators based on the *static concept* are Concentration Ratios (OECD 2021), which depict the market share of leading suppliers, and the Hirschman–Herfindahl Index (HHI) (OECD 2021). Following Lahajnar and Rozanec (2020), Gandal and Halaburda (2016), and Anisiuba et al. (2021), we examine the correlation between the cryptocurrencies' USD prices as an indicator of cryptocurrency substitutability from an investor perspective. We complement this analysis with a cointegration analysis, similar to that of Bação et al. (2018) and Anisiuba et al. (2021).

Dynamic indicators primarily include rank stability measures as recommended by OECD (2021). They examined how long individual providers remained among the 10 or 20 most successful companies. We conduct these analyses for the entire cryptocurrency market. In addition, we look separately at the markets for unpegged cryptocurrencies and stablecoins, which have attracted enormous demand, especially since mid-2021.

Since we use such a wide spectrum of competition indicators, we will address their technical and theoretical foundations once we apply them to our data. This was intended to enhance the clarity of the analysis, which would be diminished in our specific case by dividing the methodology and application into separate sections.

Differentiation between boom, bust, and stagnation phases

To gain better insight into competitive dynamics, we distinguish between boom, bust, and stagnation phases in our empirical analysis. We derive these from the changes in the market capitalization of the entire market.

Since 2009, when the first Bitcoin was created, the cryptocurrency market has experienced impressive growth, particularly since 2020. Market capitalization peaked at peak of 2.8 trillion USD in November 2022 and has since declined to 1 trillion USD (Fig. 2).

Based on these developments, we can identify several distinct periods³

- 1st period from January 2017 to December 2017 with the peak of the first boom,
- 2nd period from January 2018 to December 2018 with the subsequent bust of the market,
- 3rd period from January 2019 to October 2020 with a stagnation of the market capitalization,
- 4th period October 2020 to May 2021 with the second boom in the market, which was far larger than the first boom,
- 5th period from May 2021 to July 2021 with a short market slump,
- 6th period from August 2021 to November 2021 with another strong boom, and
- 7th period from December 2021 to February 2022, which is another bust period.
- 8th period from February 2022 to April 2022, which is a short period of recovery.

³ The first two periods match the first two periods of Lahajnar and Rozanec (2020, p. 70) whereas periods 3 and 4 of Lahajnar and Rozanec (2020) are part of period 3 in this study. The sample of Lahajnar and Rozanec (2020) ends in March 2020 and does not include the large growth in the cryptocurrency market that began in October 2020. The minor local peak of June 2019, identified by Lahajnar and Rozanec (2020), was part of a period of stagnation.

- 9th period from April 2022 until the end of our sample in September 2022, which was another bust period.

As we want to focus on boom and bust periods, we do not include the period before January 2017 in our analysis, when Bitcoin dominated the market (see Fig. 5).

Static analysis

Concentration ratios The concentration ratio (CR) is a common measure of market (CR) (OECD 2021, p. 11). Concentration ratios are an intuitive measure of the market share of the top *n* firms. The ratio is one if the top *N* firms make up the entire market, and approaches zero for an infinite number of firms with equal market share, of which only a fraction is part of *N*. Common values for *N* are C3, C5, and C10, which relate to the top 3, top 5 and top 10 firms respectively, (OECD 2021, p. 11). The concentration ratios distinguish only between the top *N* firms and other market participants. Therefore, it is advisable to compare different values of *N* to obtain a nuanced picture of market concentration.

To apply CR to the crypto market, we use C1, C3, and C10, which amount to the top 1, top 3, and top 10 cryptocurrencies according to market capitalization. While the top 1 and top 3 cryptocurrencies remain unchanged most of the time, the composition of the top 20 cryptocurrencies is subject to frequent changes. Market shares are calculated by dividing the combined market capitalization of the respective cryptocurrencies by the total crypto market capitalization according to coinmarketcap.com. The result for the whole crypto market is presented in Fig. 3.

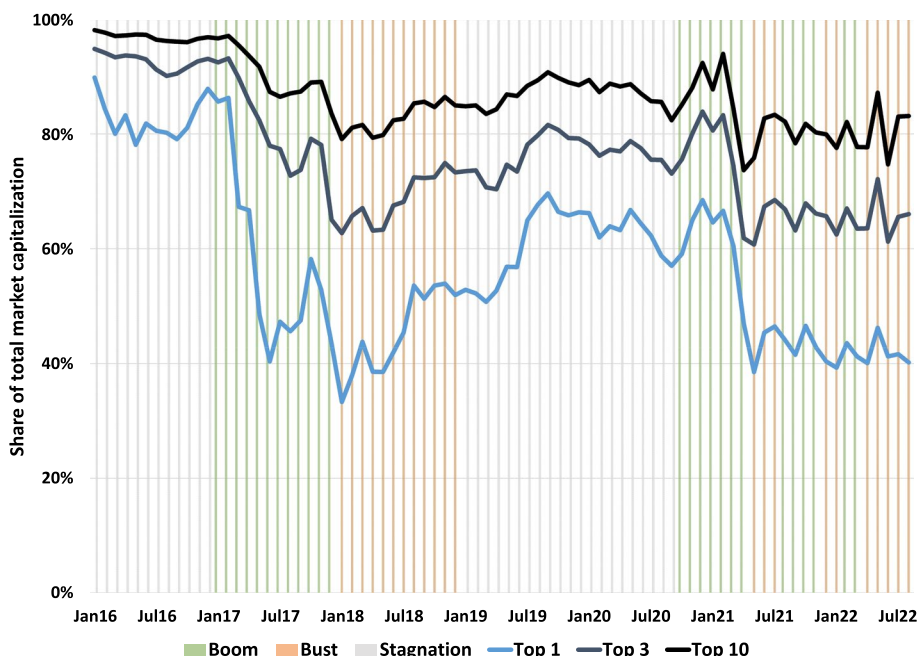


Fig. 3 Concentration ratios of the whole crypto market. The lines show share of top 1, 3, 10 currencies relative to overall market capitalization. Background color indicates overall market dynamics. (Source: coinmarketcap.com, own calculations)

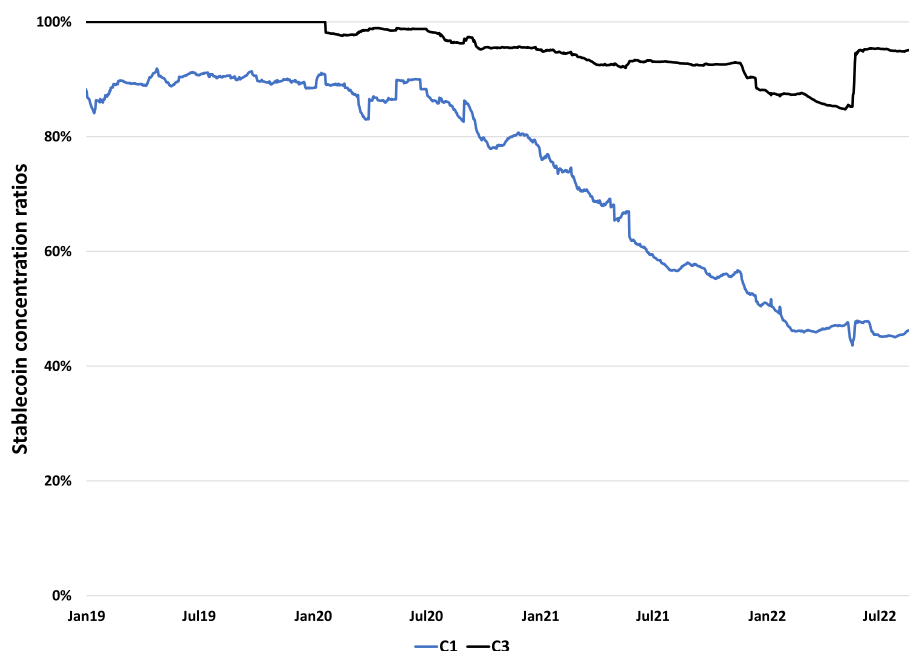


Fig. 4 Concentration ratios of the market for stablecoins. The lines show share of top 1 and top 3 stablecoins relative to overall stablecoin market capitalization. (Source: coinmarketcap.com, own calculations)

Initially, its concentration in the cryptocurrency market was extremely high. In early 2016, the top 10 cryptocurrencies accounted for more than 95% of the total cryptocurrency market capitalization, and the top cryptocurrency, Bitcoin, accounted for more than 90% of the total market capitalization. During the first boom, the CR dropped significantly but rose again during the subsequent bust, especially during the period of stagnation from early 2019 until mid of 2020. Interestingly, CR remained high during the second boom period in late 2020/early 2021 but fell dramatically during the turbulent phase of the boom-and-bust cycles afterwards.

Figure 17 in the “Appendix” shows the concentration ratios of the cryptocurrencies, but excludes stablecoins; that is, it only shows the concentration of the market for unpegged cryptocurrencies. The general development of the market concentration is the same when only unpegged cryptocurrencies are considered. However, market concentration is higher, as important competitors to unpegged cryptocurrencies are now missing.

Figure 4 shows the concentration of stablecoins in the market. This is significantly higher than the market concentration of unpegged cryptocurrencies. The market is dominated by Tether, which has lost significant market shares to USD Coin and Binance USD, and controls a similar share of the market as Bitcoin in the market for unpegged cryptocurrencies. However, compared to the market for unpegged cryptocurrencies, the top 3 stablecoins have a greater market share than the top 10 of unpegged currencies.

The Herfindahl index In public discussions, the market for cryptocurrencies is often equated with Bitcoin without considering the competition with other providers. The intensity of competition in other markets is usually described using the Herfindahl and Lerner indices. To calculate the Lerner index, prices and marginal costs are required.

This makes it inappropriate for the analysis of cryptocurrency markets, where no information on marginal costs is available.

Thus, we concentrate on the Herfindahl index (sometimes also called the Herfindahl–Hirschman index). This index is designed to capture the concentration of market power within a certain market (Rhoades 1993, p.188). It can be calculated as follows:

$$HHI = \sum_{i=1}^n (MS_i)^2, \quad (1)$$

where MS_i denotes the market share of each firm i in the corresponding market. The maximum value of HHI can reach 10.000, which indicates that there is one firm with 100 % market share, while all other firms have no share in the market. Therefore, the smaller the HHI , the more competition within a certain market.

Using the HHI , we can calculate the concentration within the cryptocurrency market. We use monthly data on 101 of the largest cryptocurrencies in terms of market capitalization, as provided by coinmarketcap.com. We analyze the period from January 1st 2016 to August 31th 2022. This period captures the most dynamic part of the crypto story. Market shares are calculated within this group, which made up more than 90 % of all cryptocurrency market capitalizations during the period in question.

In January 2016, with a value close to 8.000, the index showed a high degree of concentration in the market. This fundamentally changed in early 2017, with an abrupt decline. After a short reversal, the index reached a historical low of less than 2.000 in January 2018. Since then, the degree of concentration has increased again, reaching values fluctuating around 4.000. After another decline, the index moved around 2.000 in spring 2021.

Thus, the structure of the cryptocurrency market has fundamentally changed since 2016. New competitors were able to penetrate the market, particularly during the first boom period. As Fig. 3 shows, Bitcoin, which held a market share of 90 % in January 2016, lost its dominant role. The strongly declining market share of Bitcoin since 2016 is also reflected in the data for the market shares of the top 3 and 20.

The change in the market structure since 2016 could perhaps be attributed to investors' search for alternative currencies when the Bitcoin price was rising dramatically for the first time. While Bitcoin recovered some of its dominance in the subsequent bust and stagnation periods, after another decline in early 2021, its market share was approximately 40 %.

The horizontal merger guidelines of the U.S. Department of Justice and Federal Trade Commission (Department of Justice 2010, p. 19) generally classify markets into three types:

- Unconcentrated Markets: HHI below 1.500
- Moderately Concentrated Markets: HHI between 1.500 and 2.500
- Highly Concentrated Markets: HHI above 2.500

Thus, with a current HHI of around 2.000, the market for cryptocurrencies can be considered as “moderately concentrated.” The market for unpegged cryptocurrencies, which excludes stablecoins, is more concentrated and is oscillating between what is above

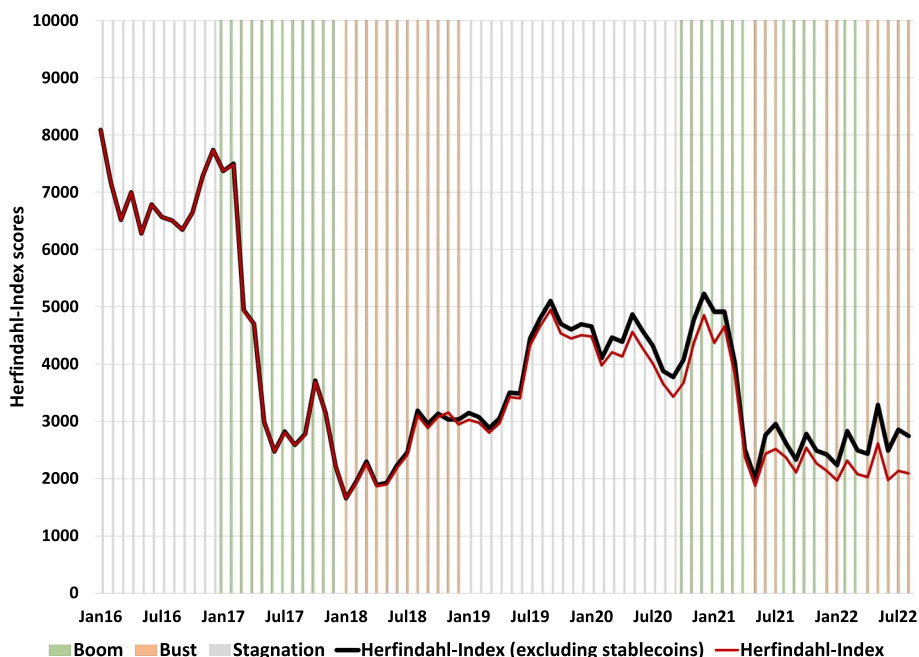


Fig. 5 Herfindahl index scores of the crypto market. Background color indicates overall market dynamics. (Source: coinmarketcap.com, own calculations)

classified as a “moderately concentrated market” and a “highly concentrated market” (Fig. 5).

A similar trend to the market for unpegged cryptocurrencies can be observed in the market for stablecoins, which, in the beginning, was even more concentrated than the unpegged cryptocurrency market (see Fig. 6). The dominance of Tether ended in 2018. Since then, the market has become increasingly fragmented, but its Herfindahl index is around 4.000, which indicates a highly concentrated market (see “Static analysis” section).

Correlation analysis Another way to analyze competition in the cryptocurrency market is to examine the correlations between the USD prices of each currency. Here, we assume that high intensity of competition is reflected in high positive correlations. The more investors switching from traditional assets to the cryptocurrency market view individual currencies as substitutes, the higher the correlation of their USD prices.

Our whole sample includes all cryptocurrencies that were in the Top 20 in terms of market capitalization at some point in time during the period from January 1st 2016 to August 31st 2022. This amounts to 101 in distinct currencies. A sample of 101 currencies indicates that $\frac{n(n-1)}{2} = 5050$ pairs can be tested for correlation.

We find strong positive correlations and very few negative correlations between currency pairs. In Fig. 7 red indicates positive correlations, blue indicates negative correlations, and white indicates no correlation (the latter is also true if a cryptocurrency is no longer traded).

To interpret the results correctly, an example with fewer currencies might help illustrate the dynamics. Consider three currencies, A, B, and C. Currencies B and C are denominated in units of currency A. If currencies B and C appreciate currency A, the

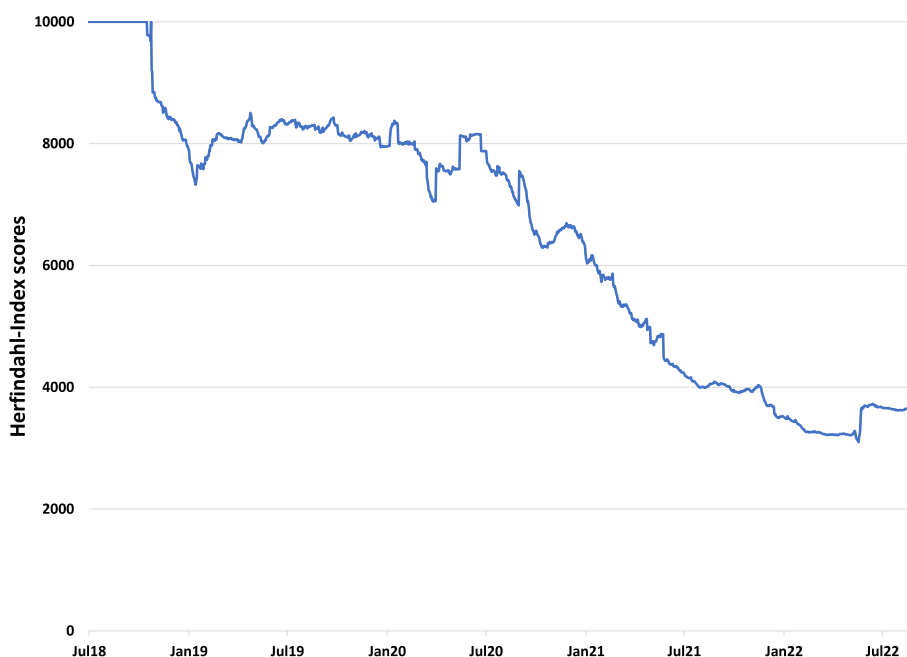


Fig. 6 Herfindahl index scores of the market for stablecoins. (Source: coinmarketcap.com, own calculations)

Table 1 Example of correlations

	B appr. rel. to A	B depr. rel. to A	B const. rel. to A
C appr. rel. to A	Pos. corr.	Neg. corr.	No corr.
C depr. rel. to A	Neg. corr.	Pos. corr.	No corr.
C const. rel. to A	No corr.	No corr.	No corr.

correlations are positive. If both currencies B and C depreciate relative to currency A, the correlation is also positive. If B appreciates relative to A and C depreciates relative to A (or vice versa), the correlations would be negative. If B appreciates relative to A, while C remains constant relative to A, there would be no correlation⁴ (see Table 1).

Therefore, the correlations presented in Fig. 7 imply that investors who switch from the USD (or other national currencies) to cryptocurrencies, and vice versa, regard most unpegged cryptocurrencies as substitutes. This finding supports the results of the Herfindahl index, which show a relatively high degree of competition in this market.

To obtain a more nuanced impression of market competition, the sample is split into nine subsamples chosen according to the overall cryptocurrency market dynamics, as shown in Fig. 2.

The correlations of the USD prices for the nine subgroups in the boom periods, bust periods, and stagnation periods are presented in Table 2. Heatmaps for the correlations in each period and also for prices in BTC are presented in the “Appendix”

⁴ Technically, a constant time series would of course result in zero variance and the resulting variance would thus be undefined, but if we consider a “relatively” constant time series, the correlation would be defined but close to zero.

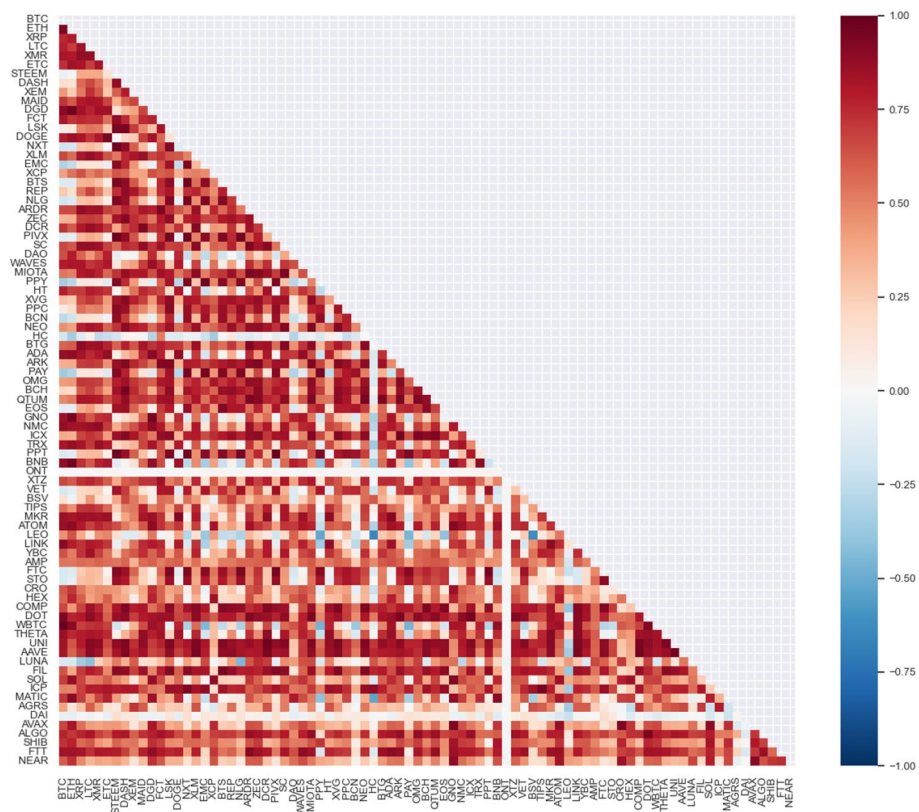


Fig. 7 Correlation of selected cryptocurrency price developments 2017–2022 denominated in USD (Source: own calculations)

Table 2 Correlations of cryptocurrency USD prices in boom, bust and stagnation

Boom periods	Corr.	Bust periods	Corr.	Stagnation	Corr.	Whole period
1	0.53	2	0.71	3	0.34	
4	0.76	5	0.71			
6	0.29	7	0.69			
8	0.53	9	0.79			
Average	0.53		0.73		0.34	0.42

(Figs. 25, 26, 27). For the entire period, cryptocurrency prices denominated in Bitcoin are positively correlated. Although the correlation is relatively weak in the stagnation period (0.34), it is more pronounced in periods with strong overall market movements. During boom periods, the average correlation was 0.53, and during bust periods, it was 0.73. For the entire period, it is difficult to identify trends in these correlations (see Fig. 8).

From the perspective of currency competition, the positive correlations indicate that investors who switch from the USD (or other national currencies) to cryptocurrencies, and vice versa, regard most unpegged cryptocurrencies as substitutes. As is apparent from our analysis, investors consider cryptocurrencies as substitutes more in bust periods than in boom periods. Our findings support the results of the Herfindahl

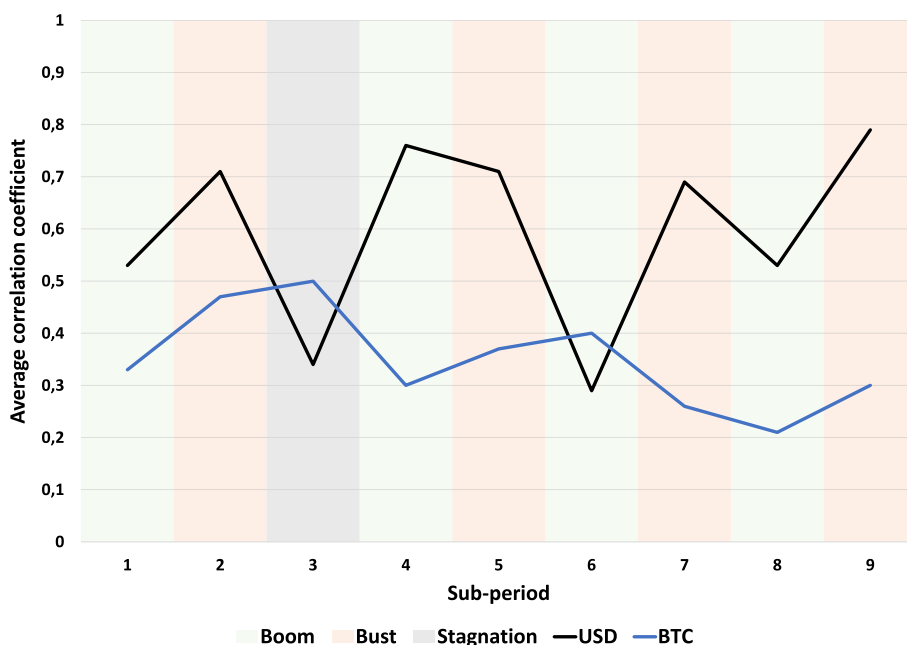


Fig. 8 Average correlations for sub-periods in BTC and USD. Background color indicates overall market dynamics. (Source: own calculations)

index, which show a relatively high degree of competition in this market. In stagnation periods, which are characterized by constant market capitalization, investors seem to differentiate more between cryptocurrencies, which show a relatively low overall correlation coefficient (0.34 for stagnant periods, compared to 0.53 for boom periods and 0.73 for bust periods). This is again in line with the Concentration Ratios (Fig. 3) and the Herfindahl index, which rose by approximately 2.000 points during the stagnation period (Fig. 5), indicating an increase in market concentration.

Our results confirm the analysis of Lahajnar and Rozanec (2020), which ended in October 2020. The authors analyzed bilateral currency pairs and found weaker correlations for bull than for bear periods.

Cointegration Analysis Next, we determine which price time series of the cryptocurrencies are cointegrated. Cointegration testing provides a measure of whether a time series follows a common trend. A common dynamic in price development, cointegration, can again be interpreted as an argument that investors consider cryptocurrencies to be substitutes. As demonstrated by many examples, correlations can be spurious. One way to overcome the problem imposed by the possibility of unit roots in the relevant time series is to examine the long-term relationship between two time series, which can be done by testing for cointegration. Thus, the cointegration analysis is a check of our correlation analysis using more advanced techniques. For the cointegration test to make sense, we first check whether each series is stationary by testing for a unit root process in the series. This is done using the standard approach of a Dickey–Fuller test in its augmented form⁵ The sample consists of daily data of the cryptocurrencies that

⁵ This standard approach will not be discussed here, for further information please refer to Hamilton (2003).

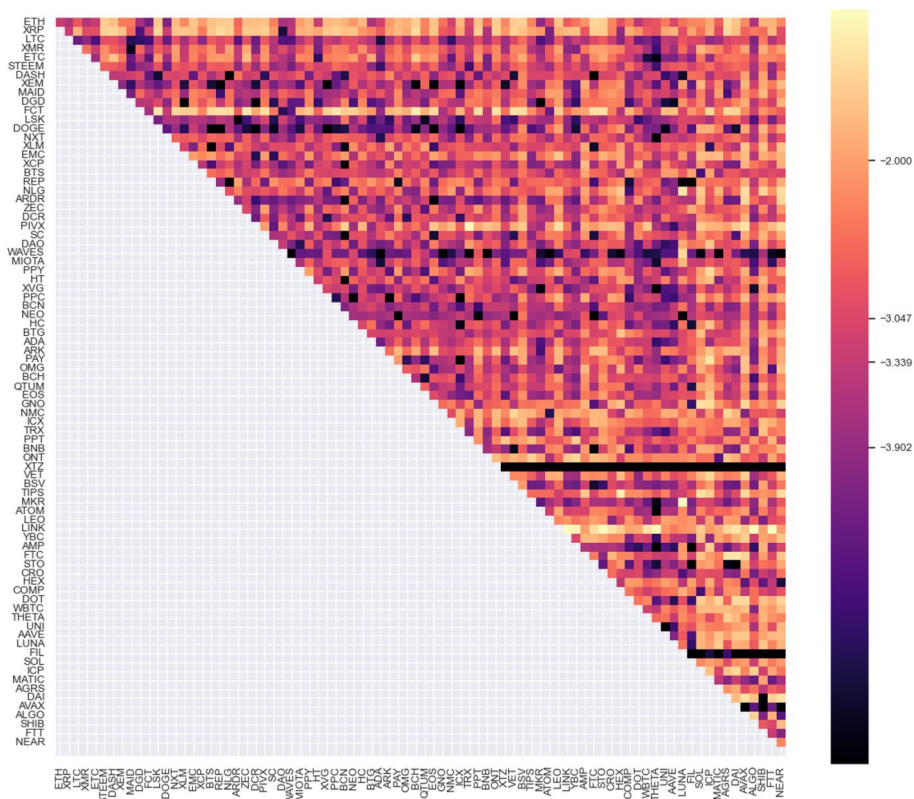


Fig. 9 t-statistics of Engle–Granger cointegration tests for selected cryptocurrency price developments 2017–2022 denominated in USD (Source: own calculations)

were in the top 20 of cryptocurrencies for at least one month during the period in question (see above). The time series are available via the API of CryptoCompare,⁶ accessed using Python. Seven cryptocurrencies are omitted from the analysis because the data are not available.⁷ Both the Augmented Dickey–Fuller test and the cointegration test were conducted using the Statsmodels package for Python. The results of the Augmented Dickey–Fuller test provided a mixed picture. For approximately half the cryptocurrencies, we cannot reject the hypothesis of a unit root in the series.

The standard two-step Engle–Granger cointegration test is implemented, again using the Statsmodels package for Python. Because the method is designed for univariate equations, each pair of cryptocurrencies is tested separately for cointegration, where the null hypothesis is that there is no cointegration, and the alternative hypothesis is that there is a cointegrating relationship between the pair of cryptocurrencies tested. Figure 9 shows the t-statistics of the Engle–Granger cointegration test, the critical values can be obtained from the index. The average t-statistics for USD prices can also be obtained from Table 3. The results show that there is a co-moving component as we can on average reject the null hypothesis for the whole sample, which would again be a confirmation of the hypothesis that cryptocurrencies

⁶ See <https://min-api.cryptocompare.com/documentation>.

⁷ The omitted cryptocurrencies are BCC, VASH, ADCN, 999, AGRS, TAGZ5, and ACA.

Table 3 Average t-statistics of Engle–Granger cointegration tests

Boom periods	E-G	Bust periods	E-G	Stagnation	E-G	Whole period
1	−1.82	2	−2.91	3	−2.26	
4	−2.28	5	−2.77			
6	−2.39	7	−2.74			
8	−2.08	9	−2.69			
Average	−2.14		−2.78		−2.26	−3.44**

Critical values for 1% (***), 5% (**) and 10% (*) significance levels are −3.99, −3.39 and −3.08 respectively

are seen as substitutes by investors. However, there is no clear pattern in the overall picture of cointegrating relationships within the crypto market. Instead, some currencies show strong comovements, while others show none at conventional significance levels. Interestingly, some currencies seem to have strong relationships with many other cryptocurrencies, whereas others seem to move on their own. Further research could tell us more as to why these currencies show such strong dependencies, while the overall picture shows little co-movements.

Again, we repeat the test with a decomposed sample split into nine periods, as in “[Static analysis](#)” section. The main result is that for the average t-statistics of the sub-periods, we cannot reject the null hypothesis of no cointegrating relationship. Without exception, the t-statistics are slightly closer to the conventional significance level during bust than during boom periods. This result was also observed when examining correlations.

Overall, the empirical analysis indicates a high degree of competition for unpegged currencies and a relatively high concentration of stablecoins. Competition within the market seems to have increased after overall market capitalization began to rise. The Herfindahl index fell from a very high score to one, which is now lower than that in most industries. When looking at correlations and cointegration, cryptocurrencies show strong dependencies when looking at the entire sample, which indicates that cryptocurrencies are seen as substitutes and are thus an argument in favor of competition. However, this connection is weaker during recent subperiods of growth. In general, the results from both the cointegration and correlation analyses suggest that the price movements of cryptocurrencies show a stronger connection during periods of bust.

Dynamic analysis

One drawback of a static analysis is that it does not reveal the extent to which new entrants succeed in entering the market, displacing existing entrants in the process. This aspect, which is important in competitive processes, can be identified using dynamic analysis methods.

Rank analysis Figure 10 provides a different perspective on crypto market competition, which might appear curious at first glance. This figure tracks the rank of each of the top 20 currencies in terms of market capitalization from January 2016 to May 2022.

This figure shows impressive dynamics in the cryptocurrency market. Many currencies stayed in the top 20 for only a very short period, and very few were able to stay in the top 20 for the entire period under consideration. A clear change in this pattern is

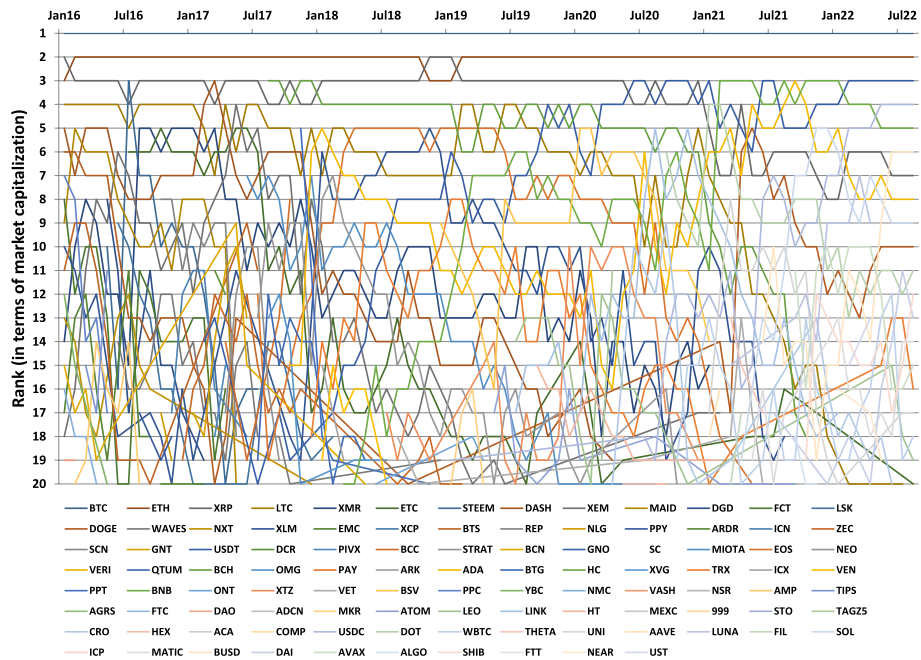


Fig. 10 Rank of top currencies in terms of market capitalization (Source: coinmarketcap.com, own calculations)

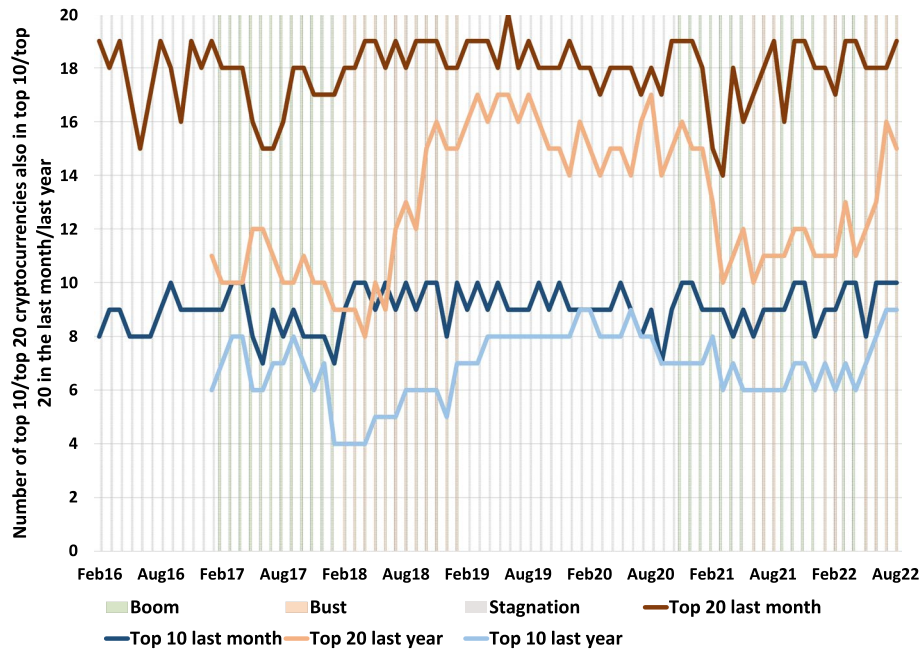


Fig. 11 Rank persistence measured by number of top currencies already in top ranks in the previous month. Background color indicates overall market dynamics. (Source: coinmarketcap.com, own calculations)

observed over time. While the first years were characterized by rather chaotic movements, the dust seems to have settled somewhat between 2018 and 2020, only becoming chaotic again afterwards.

A common measure of market competition is the analysis of *rank persistence* (OECD 2021). Figure 11 shows the dynamic evolution of the top 10 and top 20 cryptocurrencies by market capitalization. The lines represent the number of cryptocurrencies in the top 10/top 20 that had already been in the top 10/top 20 in the month before and one year before. The lower the number, the newer entrants into the market and, thus, the more competitive the market (analogous to the top 20). During the first and second boom periods, a relatively large number of new cryptocurrencies entered the top 10/top 20, while during the stagnant period between 2019 and late 2020, there were relatively few newcomers in the top tier of cryptocurrencies. This result matches not only Fig. 10 but also the results from the previous static analysis.

Overall, one can say that, with the exception of the stagnation period, the hurdle of staying for one month in the top10/top 20 does not seem very high. However, for the one-year period, only approximately 50% of the currencies were able to maintain their position in the top10/top 20 group. This is again an indication that the cryptocurrency market is characterized by a rather high degree of market entry and exit, indicating a high degree of competition.

Metric of top currencies To further investigate the dynamism of competition within the cryptocurrency market, we use a different measure of cryptocurrency success over the entire sample period. In this case, success is quantified by minimizing the average rank held by a certain currency, as shown in the following formula:

$$S_i = \frac{\sum_{t=0}^T r_{i,t}}{T} \quad (2)$$

where S_i is the score of cryptocurrency i , $r_{i,t}$ is the rank of cryptocurrency i in period t , and T is the number of periods that cryptocurrency i spends among the top 20 cryptocurrencies by market capitalization. Ranks were calculated using monthly snapshot data from coinmarketcap.com. The top 20 cryptocurrencies in terms of the smallest score value and the overall number of periods spent in the top 20 in terms of market capitalization are presented in Table 4. Currencies in the top 20 longer than the average are printed in bold.

Table 4 again shows the dynamism of the crypto market. Many the cryptocurrencies presented here have been traded on markets prior to December 2015, the start of our sample. However, there are also numerous new entrants, particularly in 2017 and 2021. Even though they entered the market at a significantly later stage, they were able to not only compete with cryptocurrencies already in the market but also outperform them in some cases. It is also interesting to compare the ranks of the most successful currencies over time with their current ranks in terms of market capitalization. While some cryptocurrencies have a lower current rank compared to the rank calculated by their score, some that have been very successful for short or medium periods of time have vanished from the market, as in the case of Storeum, or have become irrelevant, as in the case of DAO, Augur, and MaidSafe Coin (the latter has been in the top 20 for almost a quarter of the time in our sample). This indicates a high degree of competition. Of the 20 most successful currencies during the entire period, more than 10 were no longer among the top 10.

Table 4 Top 20 cryptocurrencies according to score

Rank (Score)	Name	Score	Start data availability	Periods in top 20	Curr. rank (market cap.)
1	Bitcoin	1.00	01.01.2016	80	1
2	Ethereum	2.05	01.01.2016	80	2
3	Ripple	3.95	01.01.2016	80	7
4	DAO	5.00	17.05.2016	1	150
5	Bitcoin Cash	5.92	01.08.2017	51	29
6	Tether	6.83	01.01.2016	60	3
7	Litecoin	7.46	01.01.2016	76	21
8	Binance Coin	8.18	27.06.2017	54	5
9	Cardano	8.83	05.10.2017	59	8
10	EOS	8.88	29.06.2017	43	36
11	Polkadot	9.00	20.08.2020	24	11
12	MaidSafe Coin	9.00	01.01.2016	17	243
13	Storeum	9.00	25.07.2019	1	2683
14	Internet Computer	9.00	10.05.2021	1	33
15	Bitcoin SV	9.35	15.11.2018	26	48
16	Solana	9.53	11.04.2020	17	9
17	USD Coin	10.00	09.10.2018	27	4
18	Augur	10.25	01.01.2016	8	271
19	Dash	10.41	01.01.2016	49	73
20	Terra	10.7	28.07.2019	9	229

Current rank is rank on August 28th 2022. (Source: coinmarketcap.com, own calculations)

Table 5 Top 20 Cryptocurrencies according to market capitalization on August 28th 2022

Rank (market cap)	Name	Score	Start data availability	Periods in top 20	Rank (score)
1	Bitcoin	1.00	01.01.2016	80	1
2	Ethereum	2.05	01.01.2016	80	2
3	Tether	6.83	01.01.2016	60	6
4	USD Coin	10.00	09.10.2018	27	17
5	Binance Coin	8.18	27.06.2017	54	8
6	Binance USD	12.00	05.09.2019	15	26
7	Ripple	3.95	01.01.2016	80	3
8	Cardano	8.83	05.10.2017	59	9
9	Solana	9.53	11.04.2020	17	16
10	Dogecoin	11.22	01.01.2016	21	20
11	Polkadot	9.00	20.08.2020	13	9
12	Dai	16.44	01.11.2019	9	66
13	Polygon	16.31	29.04.2019	13	64
14	Shiba Inu	14.55	01.08.2020	11	47
15	TRON	13.49	26.09.2017	43	33
16	Avalanche	12.42	21.09.2020	12	29
17	UNUS SED LEO	15.78	20.05.2019	18	57
18	Wrapped Bitcoin	16.59	31.01.2019	22	69
19	Uniswap	13.53	17.09.2020	15	34
20	Ethereum Classic	13.30	23.07.2016	46	32

Source: coinmarketcap.com, own calculations

Table 6 Summary statistics of rank analysis

Number of cryptocurrencies	101
Number of periods	80
Average score	14.78
Median score	15.42
Average of periods per currency	13.86
Median of periods per currency	6.50

We obtained a similar picture in Table 5, which reverses the order by presenting the current top 20 in terms of market capitalization. Only 9 of the current top 20 were among the top 20 according to the score for the entire period.

Summary statistics are presented in Table 6. During the observed window of 80 months, the median time within the top 20 in terms of market capitalization was 6.5 months, while the average was more than double this time span. It is interesting that even the most successful cryptocurrencies so far, which are the cryptocurrencies in our sample, mostly spend less than half a year among the top ranks before they get replaced by other currencies. The difference between the average and median periods in the top 20 also shows that some very successful currencies manage to stay in the top 20 for a longer period, whereas the majority of currencies only enjoy a short-lived period of success, leading to a skewed distribution.

Results of competition analysis

In summary, the static and dynamic analyses have a relatively similar picture. The *static analysis* shows that the concentration of market power, measured by market capitalization, has decreased significantly since 2016, when the market was highly concentrated. With a value of approximately 2000 the crypto market can now be considered a moderately concentrated market, according to the classification of Department of Justice (2010), p. 19). Notably, the concentration of market power increased during the period of stagnation (2019–2020) and dropped again during the second boom of the cryptocurrency market in late 2020. The evolution of concentration has been relatively symmetric in the market for unpegged cryptocurrencies, showing that increases and decreases in concentration occur for the top 1, 3, and 20 cryptocurrencies in a similar manner. By contrast, the market for stablecoins is more concentrated, and the decrease in the market share of the top 1 stablecoin does not translate to a similar decrease in the market share of the top three.

Further examination of correlations and Engle–Granger cointegration provides evidence in favor of strong competition, confirming the hypothesis that cryptocurrencies are generally seen as substitutes rather than complements. When looking at subperiods defined by boom/bust cycles of cryptocurrencies, we see that connections between cryptocurrencies are generally stronger in periods of strong overall market movements and weaker during periods of stagnation. While investors seem to regard cryptocurrencies more as substitutes during booms than during stagnant periods, the connection between cryptocurrencies is the strongest during bust periods.

A rank analysis also indicates that the market for unpegged cryptocurrencies is competitive, as there is high turnover among the top10/top 20 competitors. It also shows that the market is more dynamic during boom-bust periods. During both boom-and-bust periods, we see a large number of the top 10/top 20 cryptocurrencies that were not among the top currencies in the last month or last year. During the stagnant period, the composition of the top cryptocurrencies was stable. The second boom/bust cycle starting in late 2020 appears to be slightly more stable in terms of the composition of top currencies compared to the first boom/bust cycle.

We then use an *ad hoc* metric to find the most successful cryptocurrencies for our sample. We find that the most successful cryptocurrencies are heterogeneous in both characteristics and market entry. Some of the most successful currencies were created very early, but a significant number of successful currencies entered the market only very recently. On the other hand, currencies that were successful in the early stages of the market were forced to exit, even if some still technically exist.

Overall, we argue that the competition is high for unpegged currencies. A range of methods has demonstrated the dynamism of the market, especially during booms and busts. The market for unpegged cryptocurrencies has evolved from being highly concentrated to moderately concentrated. While this is no final proof against the presence of network effects and winner-takes-all dynamics, it remains a strong argument against such tendencies. By contrast, the market for stablecoins remains highly concentrated and does not show promising signs of a decrease in concentration. This is especially interesting because the setup of stablecoins is much closer to that of Hayek's private currencies. This bifurcation of markets for cryptocurrencies with very different degrees of competition will now be examined further, but it has already become clear that opposing patterns of competition in the two markets argue in favor of a critical distinction between the two types of digital assets.

What are the features of successful cryptocurrencies?

The difference in the degree of market concentration for unpegged cryptocurrencies and stablecoins is the main result of the competition analysis described in the previous section. We now examine the key determinants of these two markets in detail. By referring to Hayek, we argue that these two markets rely on two different functions of money: the store of value and the medium of exchange.

Store of value: volatility versus valuation

When we examine the crypto market from the perspective of the function of crypto money as a store of value, we see a bifurcation: the market for unpegged cryptocurrencies and the market for stablecoins. We use market capitalization as an indicator to measure success as a store of value. The USD prices of unpegged cryptocurrencies and stablecoins allow for a comparison of volatility relative to other cryptocurrencies, conventional currencies, and assets.

High volatility assets As established previously, one of the key differences between Hayek's proposal and unpegged cryptocurrencies is the role of suppliers. While Hayek expected active quantity regulation by issuers to guarantee value stability (see "[Hayek's](#)

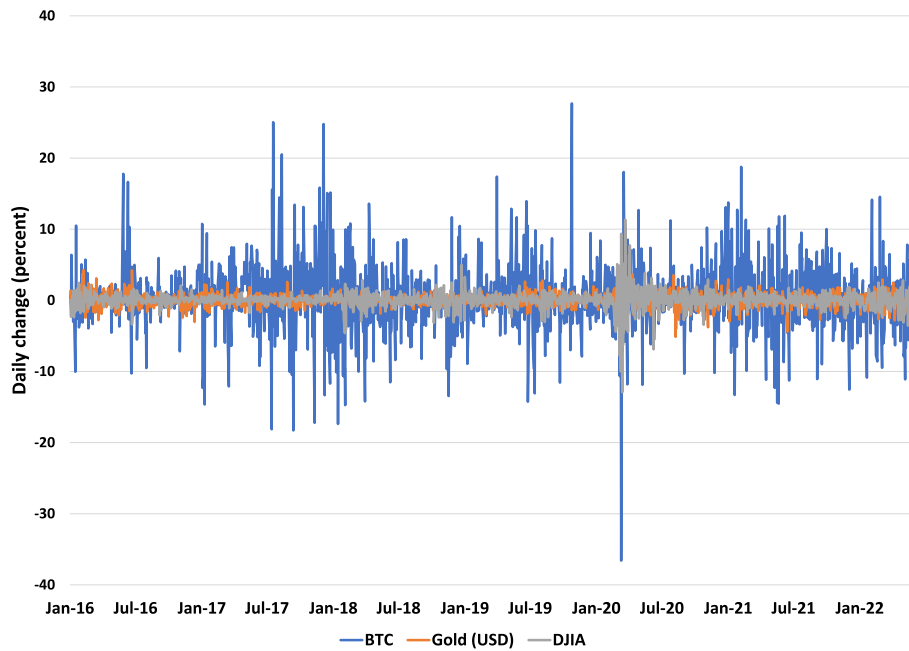


Fig. 12 Daily change of Bitcoin, Gold price in USD, and Dow Jones Industrial Average (DJIA) (Sources: FRED, World Gold Council, coinmarketcap.com, own calculations)

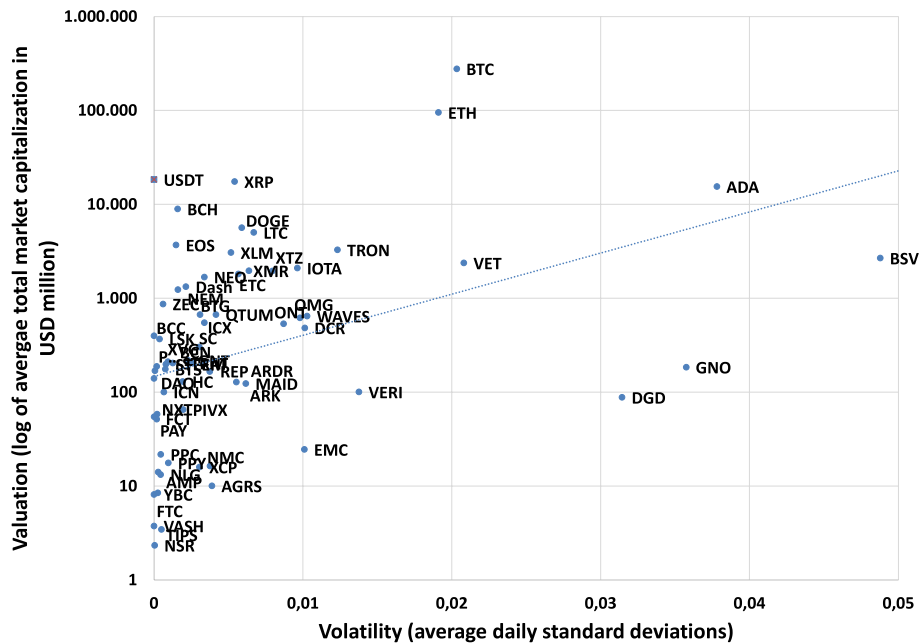


Fig. 13 Valuation to volatility of selected cryptocurrencies (Source: coinmarketcap.com, own calculations)

proposal” section), the issue of unpegged cryptocurrencies is determined by a rule that means that issuers behave passively (see also Senner and Sornette 2019).

The result of this passive behavior is the excessive volatility of unpegged cryptocurrencies (see Fig. 18 in the “Appendix”), with *daily* changes in valuation of more than 150%. The high degree of volatility also becomes obvious when one compares the volatility of Bitcoin with that of Gold and of the Dow Jones index (Fig. 12).

Thus, while Hayek expected stability in terms of purchasing power to be the decisive factor in private currency competition, the attractiveness of unpegged cryptocurrencies was at least weakly positively correlated with the volatility of such assets. Currencies with the highest market capitalization also have relatively high volatility (Fig. 13). In stark contrast to Hayek's idea, the volatility of cryptocurrencies is far greater than that of regular public currencies and comparable assets.

Stablecoins In contrast, the growing attractiveness of stablecoins shows that there is also an interest in very stable cryptocurrencies. In fact, the most widely used stablecoins, all of which are pegged to the US-Dollar, have so far been able to avoid fluctuations in their USD prices, even in very turbulent market periods (Fig. 20).⁸

Hayek notes that active quantity regulation by private currency suppliers is required to avoid inflationary and deflationary tendencies (see "Hayek's proposal" section). However, as shown above, Hayek's main concern (which led him to propose competing private currencies in the first place) was the inflationary dynamics of classical fiat currencies during the 1970s. Therefore, Hayek proposed that private currencies should have a floor value set by a fixed conversion rate to select regular fiat currencies. This floor conversion rate would not have to be legally binding, but rather be a tool to generate trust in the private currency. Owing to competition, private currencies are forced to maintain a stable value to generate demand for them. Thus, private currencies might have a floor conversion rate to regular currencies but would rise in relative value as regular currencies lose value due to inflation.

Although the inflation argument has not been at the core of stablecoins, it may receive more attention in light of the recent rise in inflation rates. Nevertheless, the market for stablecoins has been dynamic in recent times and stablecoins have not always been able to live up to their promised stability, as Fig. 20 (in the "Appendix") shows. It is also interesting to note that divergence from USD parity has been relatively symmetric, which is in contrast to Hayek's idea of a floor value that would allow for the relative appreciation of private currencies against the underlying fiat currency but not for a drop below the set floor value. Obviously, issuers still face problems defending their pegs, as Fig. 19 (in the "Appendix") shows. In May 2022, Tether issuers were required to use more than 10 billion USD in funds to stop the decoupling of Tether from USD parity at a divergence of less than 2 % from parity.

Figures 14, 21 ("Appendix"), and 22 ("Appendix") show a massive increase in the supply of stablecoins since mid-2020, most of which can be attributed to an increase in the supply of Tether, the most prominent stablecoin. However, as presented in the shares of the stablecoin market in Fig. 23 ("Appendix"), Tether is losing market dominance, especially for USD Coin and Binance USD, which are issued by two of the largest markets for cryptocurrencies, Coinbase and Binance, respectively. One of the reasons for the relative decline in Tether's dominance might be justified concerns regarding the volume and location of Tether's 's US-Dollar reserves and its reluctance to allow for third-party audits.⁹ However, due to the extraordinary structure of the crypto market, some analysts

⁸ Still, stablecoins suffer from a dangerous vulnerability regarding attacks by short sellers. A recent example was the collapse of Terra Luna in 2022. So far, the three largest stablecoins have avoided this fate, but the risk remains high.

⁹ The Commodity Futures Trading Commission has stated in 2021 that Tether's claim that it had 1 USD in reserve for each Tether issued was "wildly misleading," see, for example, <https://www.bloomberg.com/news/features/2021-10-07/crypto-mystery-where-s-the-69-billion-backing-the-stablecoin-tether> or <https://fortune.com/2021/10/15/tether-crypto-stablecoin-fined-reserves/>.

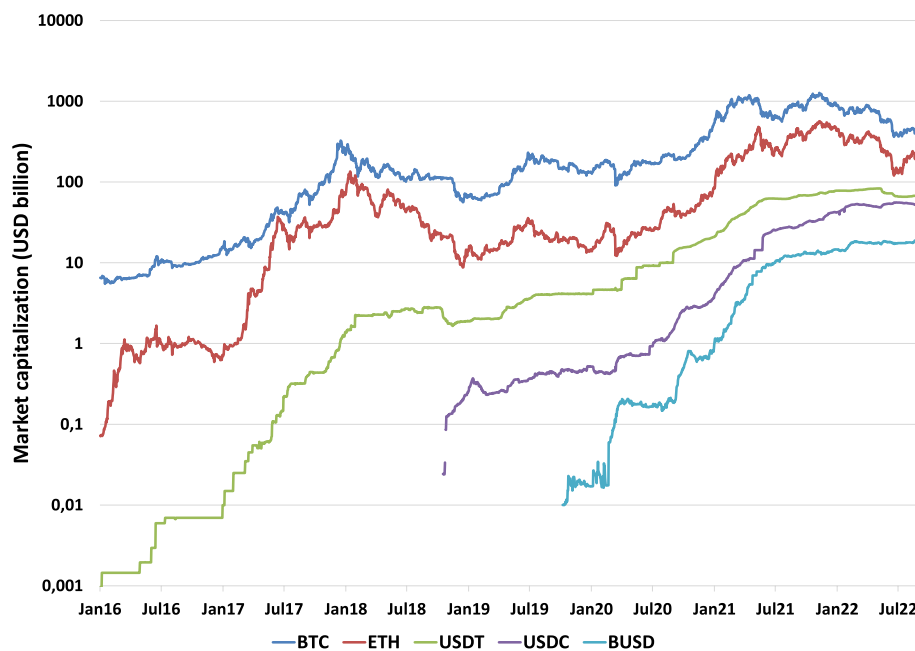


Fig. 14 Market capitalization of the two largest unpegged cryptocurrencies and the three largest stablecoins, log scale (Source: coinmarketcap.com, own calculations)

Table 7 Top 5 stable coins in terms of market capitalization

Cryptocurrency	Market capitalization ^a	Price in USD	Pegged to
Tether	67,550,878,447 \$	1.00	US-Dollar
USD Coin	52,361,614,842 \$	1.00	US-Dollar
Binance USD	19,311,789,101 \$	1.00	US-Dollar
Dai	6,971,155,000 \$	0.99	US-Dollar
TrueUSD	1,076,655,370 \$	0.99	US-Dollar
Bitcoin	383,710,102,295 \$	20,017.48	

Source: coinmarketcap.com

^a Retrieved on August 31th 2022

think that Tether can be successful in the short to medium term even though it does not have trustworthy reputation.¹⁰

The five most successful stable coins thus far in terms of market capitalization are listed in Table 7. It can be seen that all the most successful stable coins are pegged to the US -Dollar¹¹, a statement that would still be true if we would look at the top ten instead of the top five.

It must be emphasized that the most successful stablecoins thus far do not meet the criteria that Hayek demanded from private currencies. The most relevant stablecoins simply mirror existing public currencies, usually the USD, and are therefore subject to the same inflation rates as these currencies. The main point of Hayek’s proposal, that

¹⁰ <https://research.aimultiple.com/tether/>.

¹¹ USD Coin, Binance USD and Terra USD already tell this by their name, Tether has the following statement on its website: “Every Tether token is also 1-to-1 pegged to the dollar, so 1 USDT Token is always valued by Tether at 1 USD.;; (tether.to), and Dai has a similar statement in its whitepaper: *Currently, Dai has a target price of 1USD (1 Dai = 1 USD)* (<https://makerdao.com/en/whitepaper/>).

private currency competition leads to currencies that are *more stable* in value than national currencies is still not met by cryptocurrencies.

Means of payment: network effects?

The dominant role of stablecoins as a stable media for exchange is reflected in their high daily trading volumes. With the strong increase in the market capitalization of stablecoins since 2020, their trading volumes exceeded those of Bitcoin and Ethereum (Fig. 15). This figure compares the quarterly average of daily trading volume of the two most important unpegged cryptocurrencies with the corresponding trading volume of the largest stablecoin, USD Tether (USDT), and its competitors. For comparison, the figure also shows the quarterly average daily trading volume of the Standard & Poor’s 500 Index (S&P 500).

Tether’s trading volume was already larger than that of Bitcoin in the third quarter of 2019. Periodically, the trading volumes of stablecoins surpass those of the S&P 500. Figure 15 also shows the increasing share of the stablecoin trading volume taken by Tether’s rivals, namely Binance USD and USD Coin. These developments indicate a tendency toward a natural monopoly as far as the means of payment functions are concerned. This contradicts Hayek’s expectation that under currency competition a coexistence of stable monies in the means of payment would emerge.

Figure 16 also shows a ranking different from that of the market capitalization in Table 7. Although the composition of the top five currencies is similar, Tether dwarfs Bitcoin in terms of trading volume. We also see a duopoly for unpegged cryptocurrencies in transactions. Despite their volatility, Bitcoin and Ethereum are the dominant transactions. In the case of stablecoins, we observe a quasi-monopoly of Tether that could also translate to the overall cryptocurrency market. This is also reflected in Fig. 24

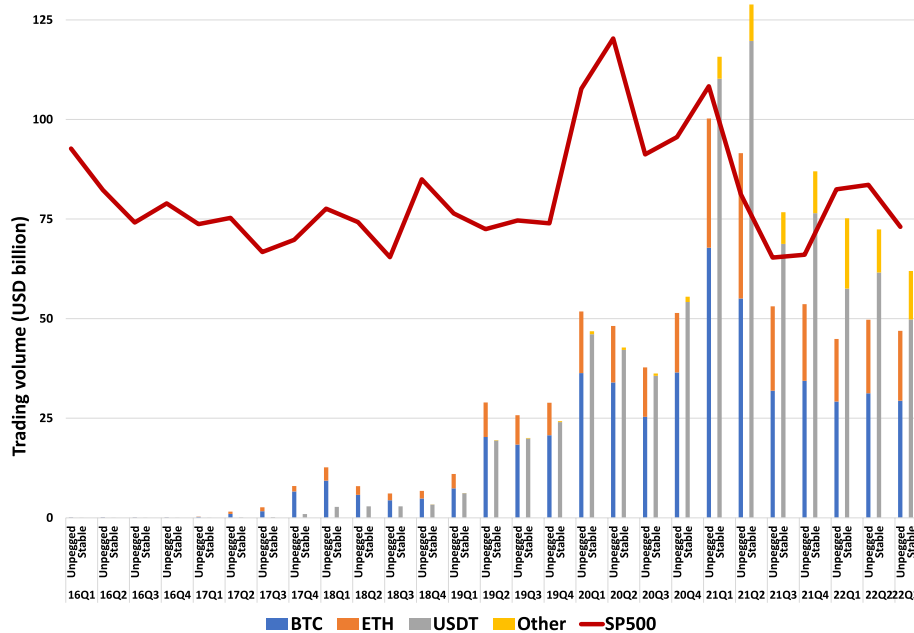


Fig. 15 Quarterly average of daily trading volume of unpegged cryptocurrencies and stablecoins compared to S&P 500 trading volume in the same period. (Sources: coinmarketcap.com, Yahoo Finance, own calculations)

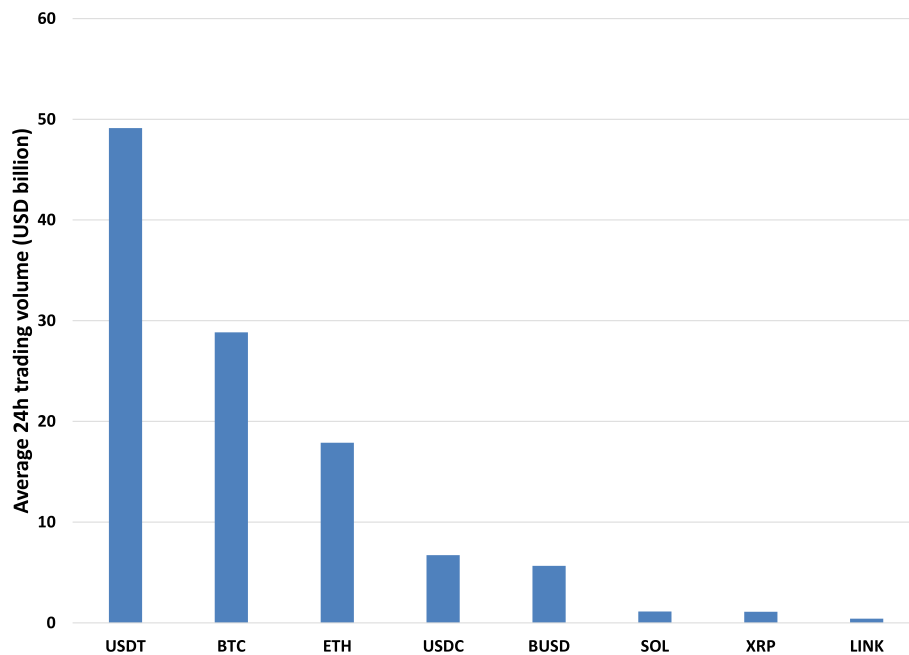


Fig. 16 Monthly average of daily trading volume of the ten most traded cryptocurrencies in August 2022 (Source: coinmarketcap.com, own calculations)

(“Appendix”), which shows that the most traded currency pairs among the cryptocurrencies consist of only four currencies. The most traded currency pair, (USDT-BTC), is the most important unpegged cryptocurrency and the most important stablecoin.

Although Tether is still clearly leading the market, USD Coin and Binance USD have some advantages for future competition. Both can be perceived as more trustworthy, as both have monthly audits by respected third parties that assess their holdings of fiat money, which in both cases is US-Dollars. Additionally, both are connected to some of the largest crypto exchanges, which provide a good connection between the crypto market and the cryptocurrency community. In contrast, Tether lacks the transparency and reputation of USDC and BUSD but nevertheless dominates the market for stablecoins.

One of the key drivers behind Tether’s leading position in terms of trading volume in the entire cryptocurrency market-not just stablecoins- may be its function as a gateway to unbanked exchanges. These cryptocurrency exchanges lack access to a regular and regulated banking system; therefore, they cannot provide trading pairs between conventional fiat currencies and cryptocurrencies. Thus, these exchanges rely on banked exchanges, where cryptocurrency users can exchange fiat currencies for cryptocurrencies, which the users can then transfer to unbanked exchanges, often attracting customers by offering services and bonuses that banked exchanges do not. The vehicle currencies for both the movement of value from banked to unbanked exchanges and trade on unbanked exchanges are often stable because they reduce the risk of value losses, which is significant for the short-term volatility of Bitcoin, for example.¹²

The importance of stablecoins to the functioning of cryptocurrencies can be inferred from Fig. 16, which shows the trading volumes of the most traded cryptocurrencies.

¹² <https://crypto-anonymous-2021.medium.com/the-bit-short-inside-cryptos-doomsday-machine-f8dcf78a64d3>.

Although Tether accounts for less than one-tenth of Bitcoin's market capitalization, its trading volume is more than twice that of Bitcoin. The other two stablecoins in our sample, USD Coin and Binance USD, are among the most frequently traded cryptocurrencies, even though they do not appear in the most successful currencies, according to our longterm metric. This indicates a high demand for a medium of exchange that is reliable in terms of value.

Another interesting observation from Fig. 16 is that while the USDC has around two-thirds of the Tethers market cap, it only has around 4% of its daily trading volume. This disproportion is less pronounced for BUSD, which has around 20% of the tethers market capitalization, but around 8% of its daily trading volume, again according to the coin-marketcap. Thus, while Tether is the most widely used stablecoin and cryptocurrency for transactions, BUSD and USDC appear to be more stable value stores, especially the latter.

When we look at the most successful cryptocurrencies in terms of means of exchange, we find that competition is much less pronounced, and market power is stronger than in the case of a store of value. Tether dominates all transactions, and it remains to be seen whether it will be challenged by its rival stablecoins USDC and BUSD in the future. Of the unpegged cryptocurrencies, only Bitcoin and Ethereum are used for transactions to a relevant degree. The different structure of transactions compared with market capitalization also emphasizes the importance of distinguishing between the two functions of money when examining the competition between cryptocurrencies. Competition for a medium of exchange is much more prone to lead to a natural monopoly than competition as a store of value.

Hayek was partially correct when he pointed out that value stability is crucial for private currencies. Tether has kept its value tied to the USD and has managed to become the most important cryptocurrency in transactions. In contrast, Tether is tied to the USD and will, therefore, copy all its inflationary dynamics. In addition, Bitcoin is still the second most traded cryptocurrency, and its value is further from stable than Hayek could ever have imagined.

Summary of results

When we look at the qualities of the most successful cryptocurrencies, we see that, despite Hayek's idea that private currencies are stable in purchasing power, price volatility appears to be a favorable feature for investors when they look for a speculative store of value. This search for volatility, in turn, reduces the tendency toward market concentration and a natural monopoly because price movements are often relatively large for smaller cryptocurrencies with low prices, creating a competitive advantage. Kou et al. (2021) show that a competitive advantage is the most important determinant for Fintech investments in general, a result that apparently also translates to the crypto market. We also see that the major stablecoin, Tether, is challenged by its main rivals, who catch up in terms of market capitalization. This indicates that competition also occurs in the field for a stable store of value.

By contrast, the tendency toward a natural monopoly seems to be much more pronounced when looking at the function of money as a medium of exchange. For

transactions, the crypto market is extremely reliant on Tether, while the share of other major stablecoins remains relatively small.

Therefore, competition in the crypto market seems to depend on money. While competition works well for the function of a (speculative) store of value, it is more limited for stable stores of value, and there is a tendency toward a monopoly on the function as a medium of exchange.

Conclusion

In Hayek's vision of currency competition, the main function of money was a medium of exchange, and the focus was on price stability. He did not consider that the functions of money could be separated or that competition could occur along all these dimensions. However, early cryptocurrencies (unpegged cryptocurrencies) did not focus on the stability of their value relative to national currencies or purchasing power. Instead of actively managing the quantity of their currency in circulation, as Hayek demanded, issuers of cryptocurrencies usually set their supply independent of demand, thus creating large volatility in the price of their currency, which is exacerbated by speculation. With the emergence of stablecoins, a type of cryptocurrency closer to Hayek's vision was created. Suppliers of stablecoins must keep track of the demand for their currency to manage their supply accordingly and keep their pegs. However, in contrast to Hayek's proposal, stablecoins are not more stable in value than national currencies, but, in the best case, are only as stable as the underlying national currency, which is usually the USD.

Hayek did not consider possible network effects that could undermine competition and lead to winner-takes-all effects. We argue that these network effects are more likely to be in place for the function as a medium of exchange, not so much for the function as a (speculative) store of value. This hypothesis is also present in the literature, where several studies question the presence of network effects in the cryptomarket (Anisiuba et al. 2021; Stylianou et al. 2021; Gandal and Halaburda 2016). However, there is a lack of research connecting Hayek's ideas, the differentiation of the cryptocurrency market according to the functions of money, and the empirical evaluation of the degree of competition between cryptocurrencies.

We close this gap by evaluating the competition intensity in the cryptocurrency market over time. Using concentration ratios, Herfindahl indices, correlation analysis, and cointegration, we find that the concentration of market power has decreased significantly since 2016 when comparing market capitalization and prices. We also find that competition increases during times of strong overall market dynamics, that is, booms and busts. By contrast, during the long period of stagnant market capitalization (2019–2021), competition decreased and market concentration rose again. Looking at the correlations, we find that cryptocurrencies are more likely to be viewed as substitutes during boom periods than during periods of stagnation. The strongest connections between cryptocurrencies occurred during bust periods. Therefore, we expect that strong downward price movements of a leading cryptocurrency will also have a strong negative impact on overall cryptocurrency market capitalization, at least in the short term.

Further analysis of the dynamic indicators reveals that the cryptocurrency market is subject to frequent changes. Over the course of the last 6 years, more than 100

cryptocurrencies have been in the top 20 in terms of market capitalization at some point in time. However, even for these cryptocurrencies, which can be considered the most successful, the median time spent in the top 20 was only 6 months.

This high degree of competition and decrease in market concentration do not completely translate to the market for stablecoins. The concentration of market power is still much larger for stablecoins, and the leading currency, Tether, clearly dominates the market, even though competitors are catching up in terms of market capitalization. We regard this as evidence that we can distinguish between submarkets for cryptocurrencies that follow different dynamics.

We find that, in stark contrast to Hayek's vision, the market for unpegged cryptocurrencies values price volatility because this allows for speculative gains. However, this encourages competition and counters network effects. In contrast, the demand for a stable store of value is one of the driving forces behind the emergence of stablecoins. The catch-up in terms of the market capitalization of Tether's main rivals, USD Coin and Binance USD, shows that competition is also possible in this submarket. Turning from the function of money as a store of value to as a medium of exchange, we see a very different picture. Transactions are completely dominated by Tether, with no signs of change. We argue that network effects are much more prevalent in the market for the media of exchange than for stores of value. There are several reasons for this difference in the degree of competition. As we have argued, demand for unpegged cryptocurrencies might, to a large extent, be driven by speculation that not only fails to sanction volatility, but might in fact seek and encourage it. However, maintaining a peg requires constant attention, system maintenance, and experienced management to react instantly to fluctuations in demand. This creates a higher entry barrier for stablecoins than for unpegged cryptocurrencies, where the low prices of newcomers usually allow for higher investment returns; thus, in some cases, even favoring new entrants. In addition, past examples show that it is almost impossible for a stablecoin to recover when there is a significant deviation from the peg. Unpegged cryptocurrencies have been proven to be less fragile in this regard. Concerning the market dominance of Tether as the medium of exchange function, first-mover advantages are very likely to play a role, given the flaws already hinted at in the discussion above. Therefore, competition in the crypto market seems to depend on the specific function of money. While competition works well for the function of a (speculative) store of value, there is a tendency toward a monopoly on its function as a medium of exchange.

Our study has some limitations. As we have shown on several occasions in this paper, the cryptocurrency market is a very dynamic field with constant innovation and frequent, strong changes. Thus, future developments may provide new insights into the competitive dynamics of cryptocurrencies. In addition, this study is only one of the first steps in the thorough analysis of the Hayek-cryptocurrency nexus, and a more detailed study of cryptocurrency competition must be conducted in the future. There are a range of interesting points regarding this topic that must be left unanswered, owing to the limited focus of this study. For example, one could argue that a mixed system of government currencies and specialized private cryptocurrencies might offer benefits that are not visible when imagining solutions. Additionally, one can discuss different ways of setting up stablecoins to avoid speculative attacks.

Overall, the evidence shows that the crypto market is still very young and dynamic and shares some characteristics close to Hayek’s idea of private currencies, even though it uses technology completely beyond imagination at the time Hayek wrote his book in 1978. Ironically, Hayek’s main argument—that competition would lead to currencies that are more stable in value and less inflated—is missed by cryptocurrencies. Hayek might have been right insofar as competition currently seems to outweigh network effects, but he focused on the incorrect function of money. Currently, it is not the medium of exchange that is the dominant function, but the (speculative) store of value. Most cryptocurrency adopters value volatility over stability. However, cryptocurrencies have evolved significantly even over a relatively short time span. In an extremely dynamic market that is almost entirely based on technology, first-mover advantages vanish quickly, and top positions are always contested. The demand for stable currencies, such as stablecoins, is rising, which might lead to at least a submarket where Hayek’s vision is fulfilled. Again, it is ironic that these stablecoins are only stable relative to the USD, while Hayek’s main argument for competition of private currencies was to establish currencies that would be independent of the inflationary dynamics of major currencies, especially the USD. Finally, we must see if Kindleberger is correct when he states that “[...] *any system with one money that proves to be not completely satisfactory in all uses, the market will create additional money or moneys to suit its needs.*” (Kindleberger 1990, p. 55)

Appendix

See Figs. 17, 18, 19, 20, 21, 22, 23, 24, 25, 26 and 27.

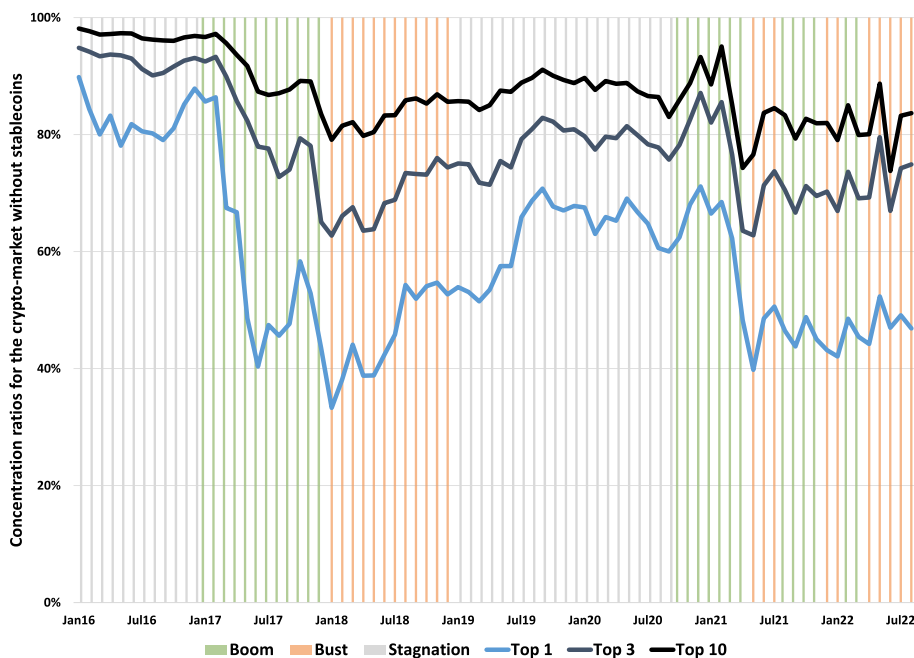


Fig. 17 Concentration ratios of the crypto market excluding stablecoins. Background color indicates overall market dynamics. (Source: coinmarketcap.com, own calculations)

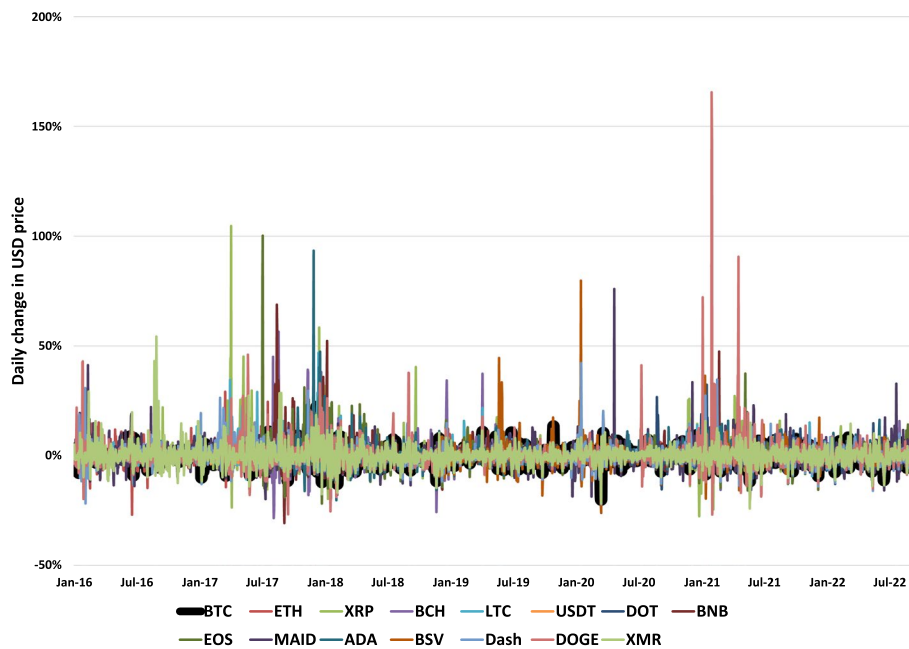


Fig. 18 Daily change of selected cryptocurrencies (Source: coinmarketcap.com, own calculations)

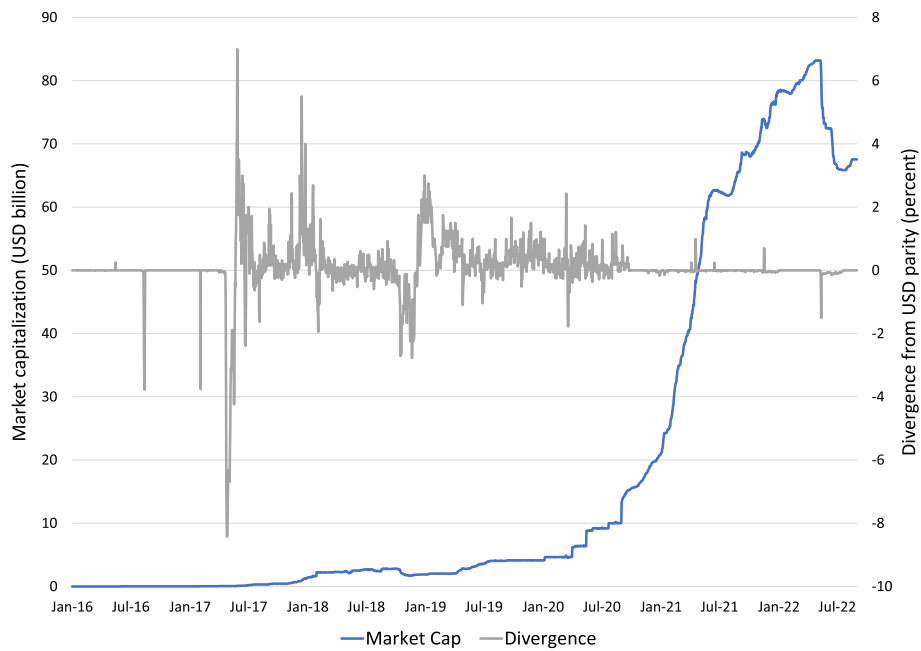


Fig. 19 Market capitalization and divergence from USD parity for USDT (Source: coinmarketcap.com, own calculations)

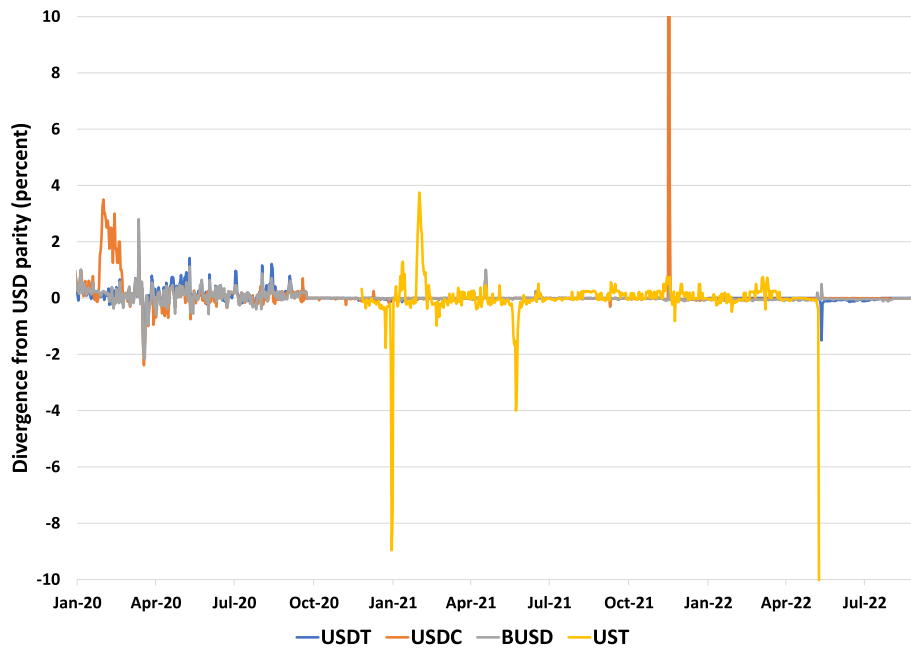


Fig. 20 Divergence from USD parity of the three largest stable coins and UST (we include UST to show the effect of a permanent decoupling from USD parity). Please note that some divergences go beyond the scale of 10% divergence from parity. (Source: cryptocompare.com, own calculations)

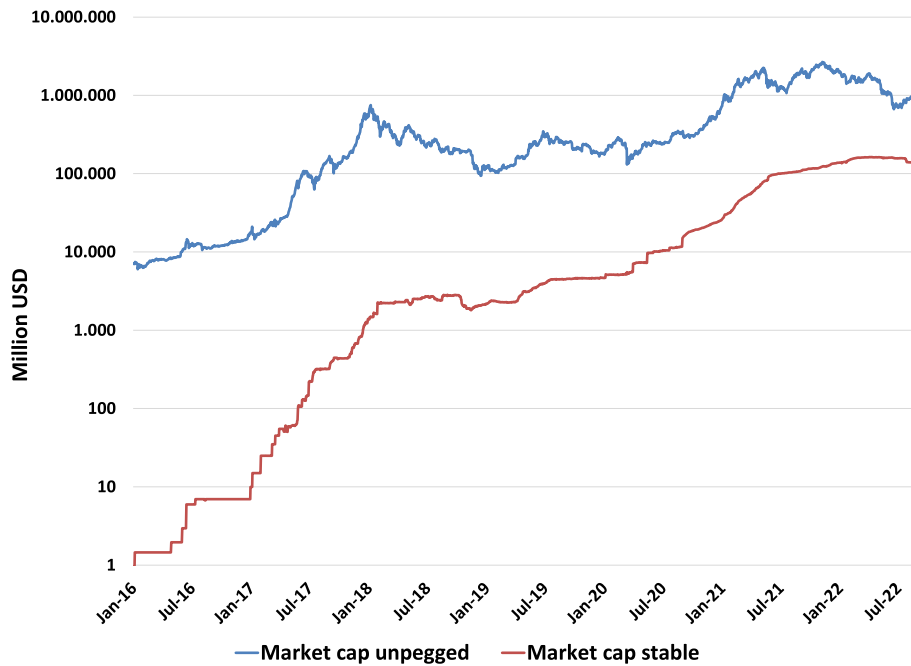


Fig. 21 Total market capitalization of unpegged cryptocurrencies and stablecoins in US-Dollars (Source: coinmarketcap.com, own calculations)

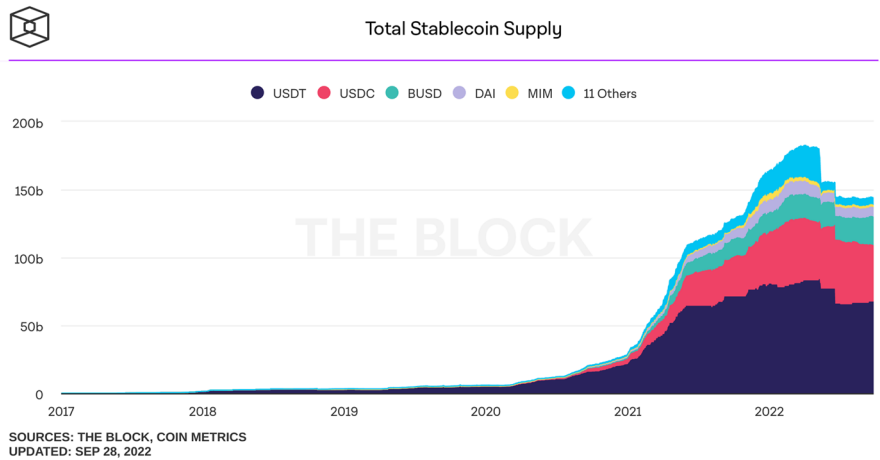


Fig. 22 Total stablecoin supply (Source: theblockcrypto.com)

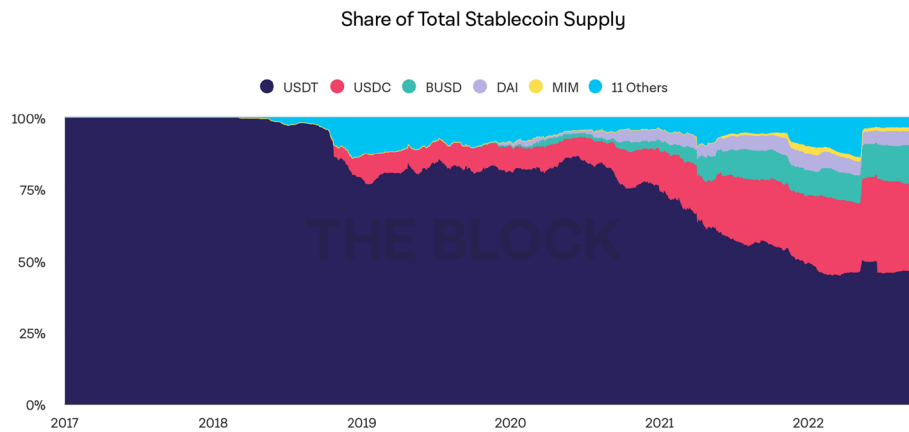


Fig. 23 Share of top stablecoins of total stablecoin supply (Source: theblockcrypto.com)

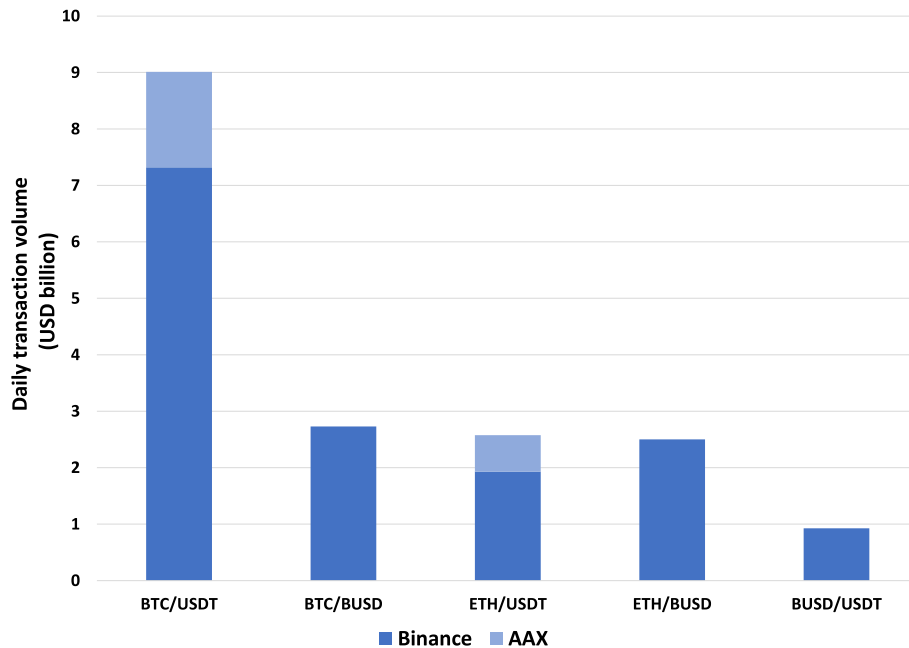
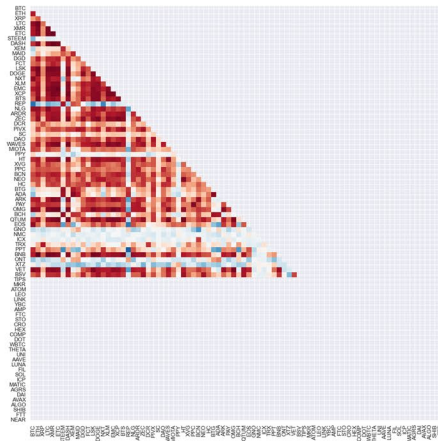
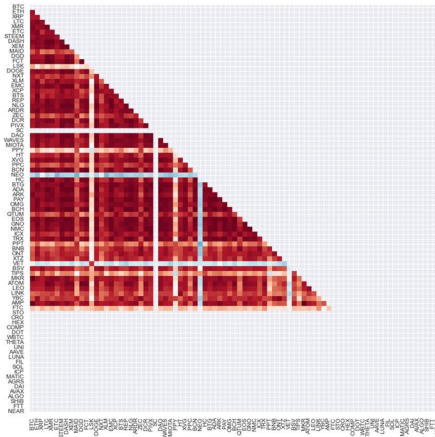


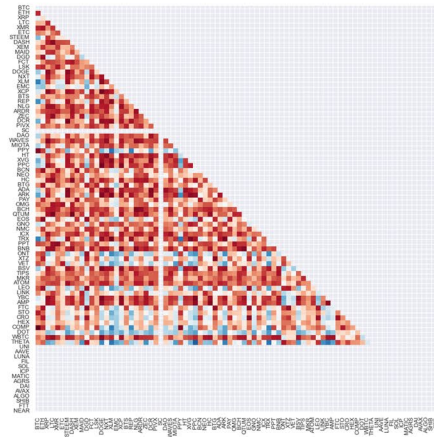
Fig. 24 Daily trading volume of the most traded currency pairs among cryptocurrencies in August 2022 (Source: coinranking.com, own calculations)



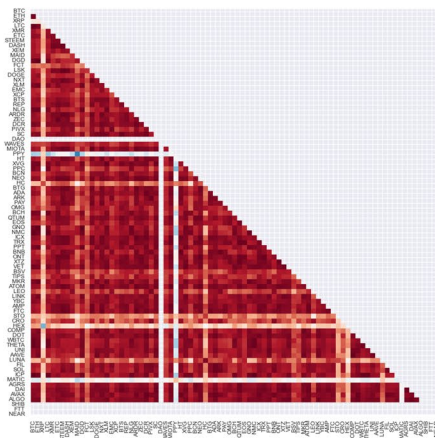
(a) Jan 17 to Dec 17, USD



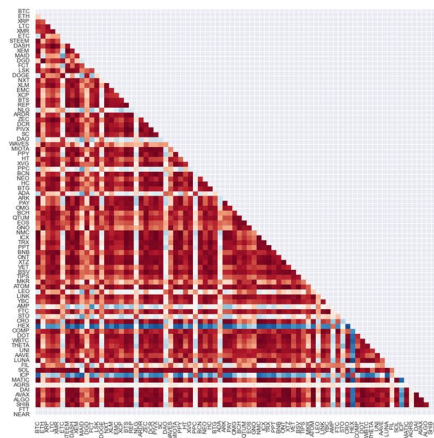
(b) Jan 18 to Dec 18, USD



(c) Jan 19 to Oct 20, USD

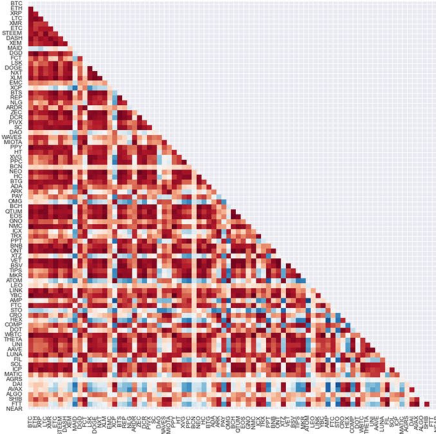


(d) Oct 20 to May 21, USD

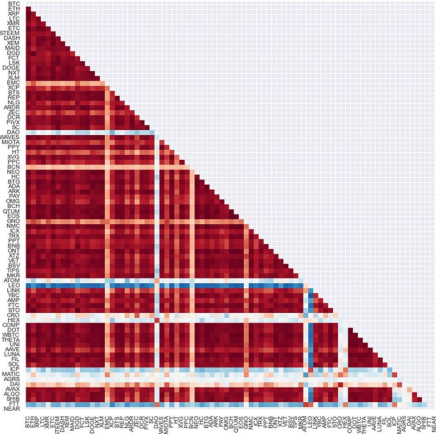


(e) May 21 to Jul 21, USD

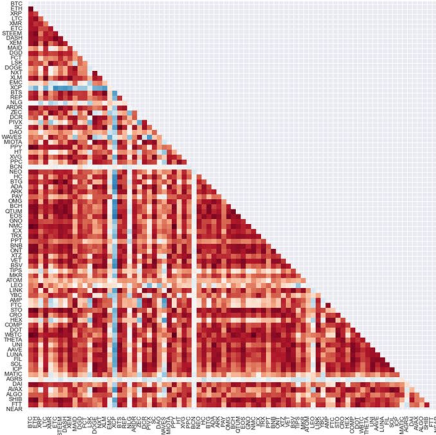
Fig. 25 (Source: own calculations)



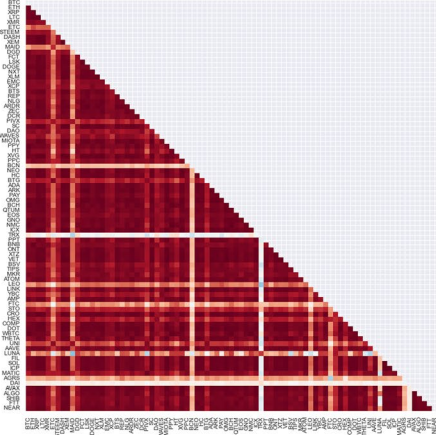
(f) Aug 21 to Nov 21, USD



(g) Dec 21 to Feb 22, USD



(h) Feb 22 to Apr 22, USD



(i) Apr 22 to Sep 22, USD

Fig. 25 continued

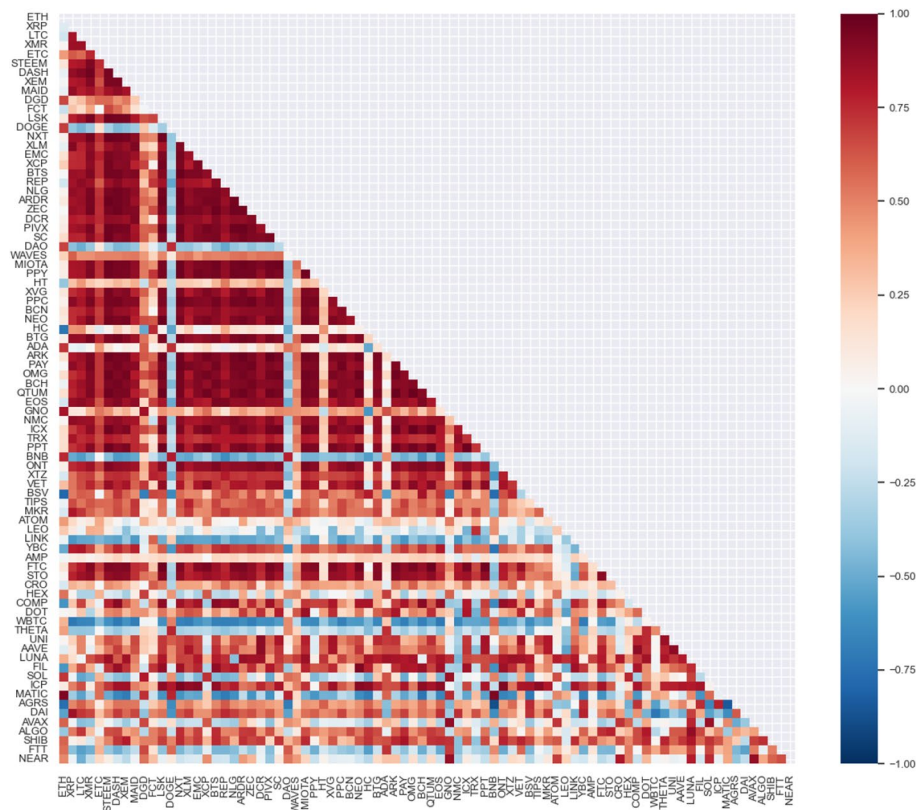


Fig. 26 Correlation of selected cryptocurrency price developments 2017-2022 denominated in BTC (Source: own calculations)

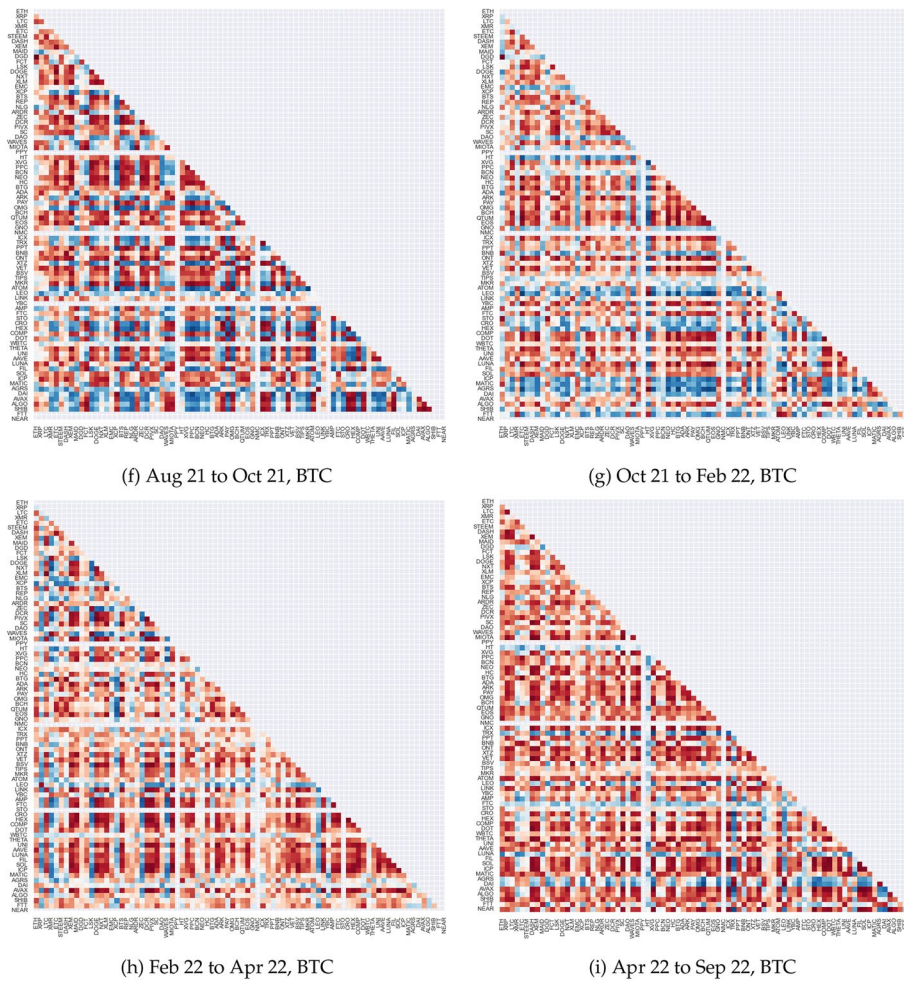


Fig. 27 continued

Abbreviations

BTC	Bitcoin
CBDC	Central Bank Digital Currency
USDT	US-Dollar Tether
USDC	US-Dollar Coin
BUSD	Binance US-Dollar
ETH	Ethereum
XRP	Ripple
OECD	Organisation for Economic Co-operation and Development
HHI	Hirschman-Herfindahl Index
CR	Concentration Ratio
DJIA	Dow Jones Industrial Average
S&P500	Standard and Poor's 500 Index

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Author contributions

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Declarations**Competing interests**

The authors do not own or speculate with cryptocurrencies and also declare no other competing interests.

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