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In search for stability in crypto-assets: are stablecoins the solution?

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Contents

Abstract

Stablecoins claim to stabilise the value of major currencies in the volatile crypto-asset market. This paper describes the often complex functioning of different types of stablecoins and proposes a taxonomy of stablecoin initiatives. To this end it relies on a novel framework for their classification, based on the key dimensions that matter for crypto-assets, namely: (i) accountability of issuer, (ii) decentralisation of responsibilities, and (iii) what underpins the value of the asset. The analysis of different types of stablecoins shows a trade-off between the novelty of the stabilisation mechanism used in an initiative (from mirroring the traditional electronic money approach to the alleged introduction of an “algorithmic central bank”) and its capacity to maintain a stable market value. While relatively less innovative stablecoins could provide a solution to users seeking a stable store of value, especially if legitimised by the adherence to standards that are typical of payment services, the jury is still out on the potential future role of more innovative stablecoins outside their core user base.

JEL codes: E42, L17, O33

Keywords: stablecoins, crypto-assets, distributed ledger technology, electronic money

Executive summary

Stablecoins are digital units of value that are not a form of any specific currency (or basket thereof) but rather, by relying on a set of stabilisation tools, try to minimise fluctuations in their price in such currencies. Stablecoins claim to stabilise major currencies directly in the market for crypto-assets, whose prices are inherently volatile due to the lack of any liable issuer, and in the broader economy.

Different types of stablecoin initiatives can be identified in accordance with the criteria that characterise crypto-assets. These criteria are: (i) the existence/absence of an issuer that is responsible for satisfying any attached claim; (ii) the decentralisation/centralisation of responsibilities over the stablecoin initiative; and (iii) what underpins the value of a stablecoin and its stability in the currency of reference.

The stabilisation mechanism at the core of a stablecoin initiative is crucial to determining whether the units issued can maintain a stable value or not. Different stabilisation mechanisms may either require the intervention of accountable institutions, in the role of issuer and custodian, or delegate these tasks to stablecoin users. More specifically, stablecoins can be described as being:

- backed by funds, which an issuer or custodian needs to hold for safekeeping, implying a commitment to their full redeemability (referred to hereinafter as "**tokenised funds**");
- backed by other traditional asset classes that require a custodian for their safekeeping and are in the possession of the issuer only as long as the user does not redeem the stablecoins, or what is left of them in the case of default ("**off-chain collateralised stablecoins**");
- backed by assets, typically crypto-assets, which can be recorded in a decentralised manner and do not need either an issuer or a custodian to satisfy any claim ("**on-chain collateralised stablecoins**"); and
- backed by users' expectations about the future purchasing power of their holdings, which does not need the custody of any underlying asset, and whose operation is totally decentralised ("**algorithmic stablecoins**").

Different types of stablecoins feature a trade-off between the level of innovation involved in their stabilisation mechanism and the stability of their value in the currency of reference. On the one hand, the least innovative stablecoin initiatives focus on the mere tokenisation of currency units: they rely on traditional systems for the safekeeping of funds, in the form of either electronic money or scriptural money, and use distributed ledger technology (DLT) to issue their mere representations in the form of claims on the entity in charge. On the other hand, most innovative initiatives currently do not keep to the promise of maintaining a stable value.

In particular, the value of tokenised funds may be truly stable (in terms of the currency in which the funds are denominated) provided that users trust the entity backing the stablecoin initiative, notwithstanding the lack of clear applicable regulation which may expose users to fraudulent behaviour. Tokenised funds do not involve a new type of asset but represent existing currency units on a distributed ledger, mirroring either the traditional electronic money approach to retail payments or the prefunding of some existing payment systems. Yet, tokenised funds initiatives might pose challenges that should be controlled by means of an appropriate regulatory framework.

Collateralised stablecoins can have a stable price only to the extent that the volatility of collateral against which they are issued is catered for by the margins applied. While off-chain collateralised stablecoins aim to tokenise traditional assets on a distributed ledger, on-chain collateralised stablecoins endeavour to turn highly volatile collateral in the form of crypto-assets into a stable asset, typically by providing economic incentives to their potential holders.

Off-chain collateralised stablecoin initiatives require accountable custodians and issuers for both the safekeeping of collateral and to allow its redemption. These stablecoins are uncommon since they address the volatility of underlying collateral and bring little innovation, owing to the need to use the typical intermediated financial systems.

On-chain collateralised stablecoin initiatives can work without the intervention of any accountable party. To the extent that these initiatives are backed by crypto-assets, collateral is recorded directly on a distributed ledger and in the custody of the network participant. Whereas an issuer could take responsibility for overseeing the rules of such initiatives and liquidate collateral on request, their operation is generally decentralised.

Algorithmic stablecoins have not yet proven capable of withstanding market shocks and maintaining a stable value in the currency of reference. **Such stablecoin initiatives do not involve the intervention of any accountable party and can be seen as an evolution of crypto-assets.** They offer the greatest level of innovation among stablecoin types, with some initiatives claiming to be able to replace central banks, although no successful track record is available to date to support such claims.

The total market value of stablecoins soared over the last year, mostly owing to the growth of tokenised funds initiatives. Their future role in the crypto-asset market and broader economy, however, is uncertain. The total value of stablecoins almost tripled from €1.5 billion in January 2018 to more than €4.3 billion in July 2019, with tokenised funds initiatives accounting for more than 97% of the market. A number of obstacles related to the lack of accountable institutions hinder the usability of collateralised and algorithmic stablecoins beyond a core user base motivated by a strong preference for privacy and an aversion to the scrutiny of trusted institutions.

While the use of a new technology is often mistaken for the introduction of a new asset class, some stablecoins are truly part of the new phenomenon of crypto-assets, with major uncertainties relating to their governance and regulatory treatment. Uptake in the usage of any stablecoin requires clear governance, including procedures to update the smart contracts at the core of the initiative and a cyber-security framework. Stablecoin initiatives with a clear governance framework could be subject to much warranted regulatory scrutiny and recognition. This may promote uptake in both the crypto-asset market and the broader economy, leveraging distributed ledger technology (DLT) while ceasing to target users who are interested in participating in an unregulated ecosystem.

1 Introduction

Stablecoins aim to provide safety in relation to the major currencies – of which reputable central banks are tasked with maintaining the purchasing power over time – on the market for crypto-assets. Crypto-assets are characterised by high price volatility, which makes them incapable of performing the three functions of money, namely acting as a store of value, a means of payment and unit of account.[1] Stablecoins have been introduced by their proponents as an attempt to protect the revenues from crypto-asset investments from such volatility.[2] More recently, financial service providers and technology companies have been working towards the development of stablecoins for payment transactions on a global scale. For example, Facebook initiated project Libra with the main aim of enhancing financial access for underserved populations and providing faster and more efficient retail payments across borders.

The emergent phenomenon of stablecoins falls into the controversially discussed debate on the potential impact of crypto-assets and the underlying distributed ledger technology (DLT) on the financial ecosystem. In the public debate and analysis, the possible benefits and challenges of DLT and crypto-assets are often lumped together, given that both are sometimes conceptually or even technically intertwined. However, in view of the differences between these phenomena, it seems helpful to distinguish between crypto-assets and DLT, in particular when studying implications for the financial sector:

A distributed ledger is essentially a record of information or database, which is shared across a network, without the need for a central validation process. It may be an unrestricted database in which case its content is public, or it may be restricted to a specified group of users with the content only being visible to vetted participants[3]. In simplified terms, DLT can be regarded as an innovative form of infrastructure, a new form of road, which can be accessed by either everyone (e.g. a street) or by defined users (e.g. a race track). The potential use of DLT in the financial sector has been explored by various market players and the first solutions are in the process of being rolled out. In addition, several central banks around the globe are experimenting with DLT[4], with the primary aim of clarifying whether efficiency and safety gains can be made by moving payment and securities settlement infrastructure to DLT. There is broad consensus within the central banking community that DLT holds promise[5], but that, given the systemic relevance of central bank operated market infrastructure, further analysis is required.

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1 See Mersch (2018) and Carstens (2019).

2 The volatility of major stablecoins is lower than that of the most popular crypto-assets. See Section 3 for a statistical comparison.

3 See ECB (2016) and Pinna and Ruttenberg (2016).

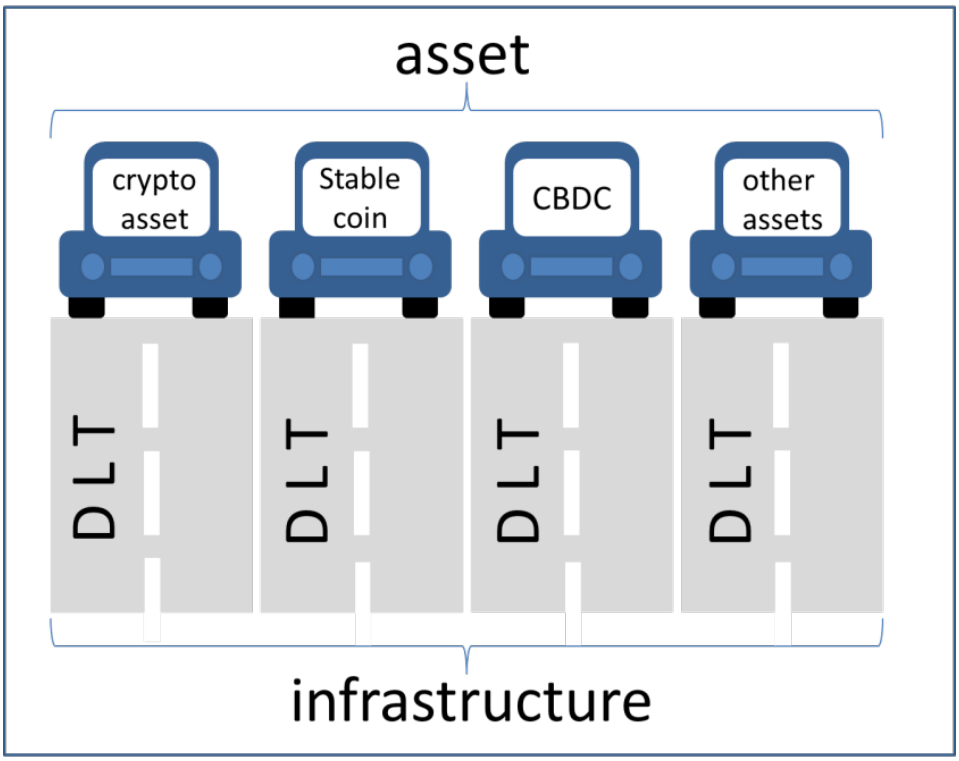
4 Examples include the ECB and the Bank of Japan (Project Stella), the Bank of Canada (Project Jasper), the Monetary Authority of Singapore (Project Ubin), the Hong Kong Monetary Authority (Project Lionrock), the South African Reserve Bank (Project Khokha), the Central bank of Brazil (Project SALT) and the Central Bank of Thailand (Project Inthanon).

5 See, for example, World Economic Forum (2019).

The infrastructure offered through DLT, be it in restricted or unrestricted form, could serve as a record of holdings and be used for the transfer of various kinds of **assets**. Following the analogy of DLT being the road infrastructure, the different, partially new types and forms of assets are the "cars on the road", as visualised by means of a few examples in Figure 1.

What started with the Bitcoin White Paper[6] in 2008 and triggered discussions about the future of money, has led to more than 2000 different **crypto-assets** being in existence today. There is currently no universally agreed definition of what constitutes a crypto-asset but the ECB has defined it for its own analytical purposes as "a new type of asset recorded in digital form and enabled by the use of cryptography that does not represent a financial claim on, or a liability of, any identifiable entity."[7] The specific risk profile and the high volatility of crypto-assets derives from the absence of a concrete claim against an issuer. There is overall agreement amongst regulators and central banks that crypto-assets are highly speculative but do not currently represent an immediate threat to financial stability[8]. They neither have significant implications for monetary policy nor do they affect the smooth functioning of payments and financial market infrastructure.

Figure 1
Differentiating assets recorded on DLT from the underlying infrastructure



6 See Nakamoto (2008).
7 See ECB Crypto-Asset Task Force (2019).
8 See, for example, Financial Stability Board (2018).

The demand for a stable asset recorded in distributed ledgers, in particular for the settlement of payments, has sparked a wider discussion around the possibility of central banks providing a digital form of their currency to the public, as they do with physical cash.[9] In fact, most central banks around the globe are currently conducting analysis into **Central Bank Digital Currencies (CBDC)**[10]. CBDCs, if they were issued using DLT, could be the ultimate stable asset, enabling funds to be transferred between platforms where crypto-assets are recorded**.** However, central banks' work on CBDCs is mainly research-driven at this stage, while examples of implementation and pilot projects still remain the exception.[11] The focal points of the central banks' analysis are the underlying motivation for issuance (e.g. decline in the use of cash), possible design features (e.g. 24/7 availability, anonymity) and to some extent technical experimentation (also involving DLT). Concerns regarding CBDCs mainly relate to the fundamental impact they could have on the current financial ecosystem, ultimately questioning the role of banks in financing economic activities, and make their issuance unlikely in the short run.

In view of the volatility of crypto-assets and given the remaining questions surrounding CBDCs, **stablecoins** have come to the fore as a potential third type of asset that aspires to bring stability to the volatile market for crypto-assets.

This paper describes stablecoins and assesses to what extent they can keep their promise to maintain a stable value, without entering into the discussion about the potential macroeconomic impact from either a financial stability or monetary policy perspective. In line with the above explanation, it focuses on the asset (i.e. stablecoin) and does not discuss the underlying infrastructure (i.e. DLT) beyond the specific software (so-called smart contracts) which some stablecoin initiatives rely on within the DLT network. The paper starts with an overview and taxonomy of the stablecoin (Section 2). It analyses the trade-off between innovation and the volatility of different types of stablecoins and their possible role, in the crypto-asset market and beyond (Section 3). The paper concludes with a summary of its main findings (Section 4).

9 The issuance of a CBDC is not contingent upon the use of a specific technology. It is a policy decision that needs to be assessed in relation to its potential drivers and implications.

10 See Barontini, C. and Holden H. (2019).

11 For example Uruguay (E-peso pilot project for retail CBDC) and Venezuela (Petro digital representation of goods/raw materials).

2 Taxonomy and description of stablecoin types

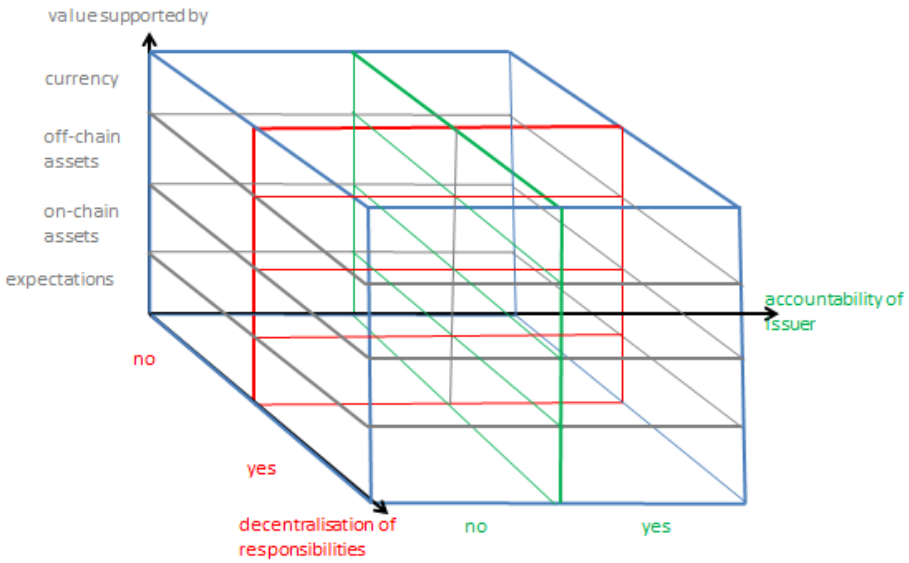
The term stablecoin identifies a phenomenon that is still under development and lacks an agreed definition. The analysis in this paper focuses on aspects of interest to central banks[12] and is therefore based on a working definition of stablecoins as *"digital units of value that are not a form of any specific currency (or basket thereof) but rely on a set of stabilisation tools which are supposed to minimise fluctuations of their price in such currency(ies)".*

While this definition is very broad, it is largely in line with public discussions and is instrumental to the approach of this paper as it differentiates between genuinely new asset types, the features and implications of which are yet to be fully understood, and traditional forms of a currency that are recorded through infrastructure that use new technologies.

Figure 2 introduces the "crypto cube", which allows an asset to be identified based on criteria that define crypto-assets. Different stablecoins can be identified using the same three criteria, namely: i) the existence/absence of an issuer that is responsible for satisfying any attached claim (right horizontal axis); ii) the decentralisation/centralisation of responsibilities over the stablecoin initiative (left horizontal axis); and iii) what underpins the value of a stablecoin and its stability in the currency of reference (vertical axis).

[12] Box 4 describes the case of stablecoins that provide tools to keep market values stable in terms of what is not a currency, e.g. commodities or consumption goods.

Figure 2
The “crypto-cube”



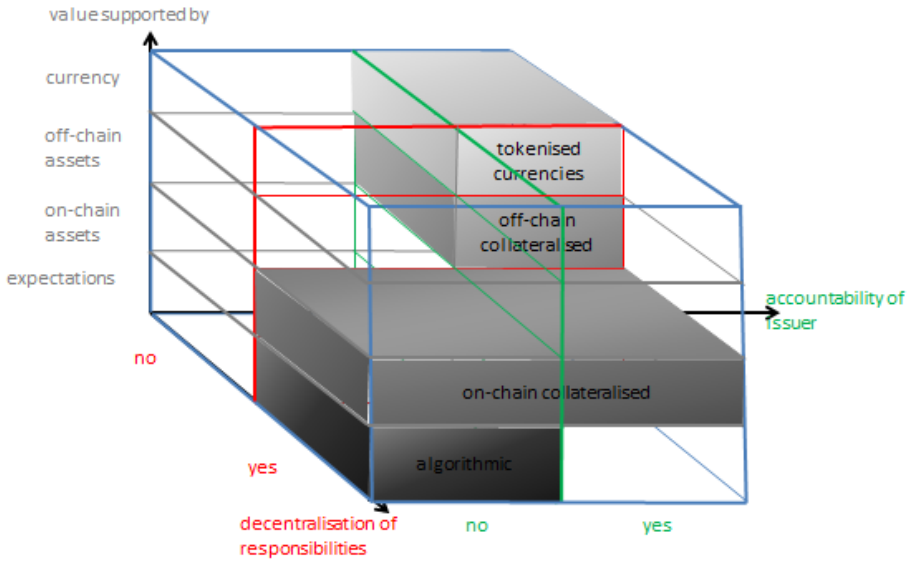
By allowing differentiation between stablecoins on the basis of what underpins their value, the “crypto cube” places emphasis on the specific stabilisation mechanism they use to limit the volatility of their price in the currency of reference (see Figure 3).

Classifying stablecoins on the basis of what is backing their value allows us to highlight that some stabilisation mechanisms require the intervention of accountable institutions (i.e. issuers and/or third-parties) that can be held responsible by regulators and users, whereas other stablecoins cannot be associated with any liable party. Specifically, stablecoins can be described as being:

- supported by funds, which implies the issuer’s commitment to their redeemability and the need for someone (possibly a custodian) to take responsibility for their safekeeping (hereinafter referred to as “tokenised funds”);
- supported by other traditional asset classes, which require a custodian for their safekeeping and are in the possession of the issuer only as long as the user does not claim them back (“off-chain collateralised stablecoins”);
- supported by assets, typically crypto-assets, which can be held for safekeeping in a decentralised manner and do not need an issuer to be identified (“on-chain collateralised stablecoins”); and
- supported solely by users’ expectations about the future purchasing power of their holdings, which does not require the accountability of any party, nor the custody of any underlying asset (“algorithmic stablecoins”).

Figure 3

Taxonomy of stablecoins within the "crypto-cube"



An element that is common to all stablecoin initiatives is the use of software that can be distributed within a DLT network (known as "smart contracts") to diminish the relevance of any trusted central party in their operation. A smart contract is a computer protocol that can execute, verify, and constrain the performance of an action involving either units or representations of assets recorded in a distributed ledger.[13] The novelty brought about by smart contracts is that, in a DLT environment, users can be allowed to audit the computer protocol, contribute to maintaining it over time, and validate its operation. Smart contracts can be used to different extents, depending on what supports the value of stablecoin units, since the need for a central institution to bear safe-keeping responsibilities hampers the possibility of maintaining and validating the functioning of the stablecoin initiatives.

A second element common to all stablecoin initiatives is their reliance on an open market to reinstitute par value by providing arbitrage opportunities. The stability of a stablecoin initiative is contingent on their capacity to assure users that the stablecoin units will return to par value.

In addition to the four described primary mechanisms, some stablecoin initiatives use secondary stabilisation mechanisms and their specificities are covered in Section 2.4. The description of primary mechanisms alone, in the remainder of this section, allows us to conclude that some types of stablecoins have the potential to maintain a stable value in the currency of reference regardless of market developments. However, the value of a stablecoin remains susceptible to operational risk and can be affected by possible misbehaviour by its issuer especially if the regulatory framework is not clear.

13 The term "contract" is used with no legal connotation here. The qualification of smart contracts as legal contracts depends on national applicable legislation.

2.1 Tokenised funds

Units of monetary value that are stored electronically in a distributed ledger to represent a claim on the issuer and are issued, on receipt of funds[14], for the purpose of making payment transactions to persons other than the issuer, are often labelled "fiat-backed stablecoins" in public discussions. As further explained in the analysis in Section 3.1 below, these do not appear to constitute a new type of asset but rather represent existing currency units (i.e. a mere "tokenisation" of funds denominated in the currency/ies of reference) in a distributed ledger. Without entering into the possible legal classification of these initiatives as electronic money schemes under the national applicable law, this paper uses the factual label "tokenised funds" to describe such initiatives.[15]

Based on this definition, every unit of tokenised funds represents a claim on the issuer over the funds it received from users. The issuer either holds and channels the funds itself[16] or involves a custodian for this purpose. In the latter case, the issuer has to be an identifiable and accountable entity to enter into an agreement with the custodian of the funds.[17] The issuer ensures the funds backing tokenised funds are redeemable according to the terms of service communicated to users, either on the basis of bilateral contracts or via rules that are publicly auditable by the users.

Figure 4 describes a typical process of issuance, transfer and redemption of tokenised funds involving a custodian. Even when the issuer relies on non-proprietary infrastructure, which is often an unrestricted DLT network, it can embed rules governing the initiative (e.g. the divisibility of the stablecoin unit) in a smart contract.[18] **Issuance** of tokenised funds start with a user who transfers funds to the account the issuer opened with a custodian who shall keep them safe. Upon confirmation that the funds have been received by its custodian, the issuer creates (in jargon – "mints") and allocates an equivalent amount of tokenised funds through the smart contract it maintains. Since the issuer is directly accountable for the redemption of tokenised funds, the responsibility to modify the number of units issued (the "notary" function) is not shared with the network of users as happens when DLT is used to record crypto-assets.

Transfers of tokenised funds follow the typical DLT approach and involve network participants. The sender of tokenised funds initiates the transfer to a receiving user by instructing the smart contract accordingly. Network participants verify that the transfer is in line with the rules of the initiative and validate the transfer.

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14 Funds are cash, electronic money, commercial bank money and reserve deposits kept at a central bank.

15 Token is defined as "generic representations of unit(s) of an asset". Tokenisation is therefore the representation of an existing asset by different means or in different forms than the original one.

16 Funds could be received and stored autonomously by the issuer in the form of banknotes and coins. This possibility is however neglected in what follows due to its impracticability and the lack of a real world example.

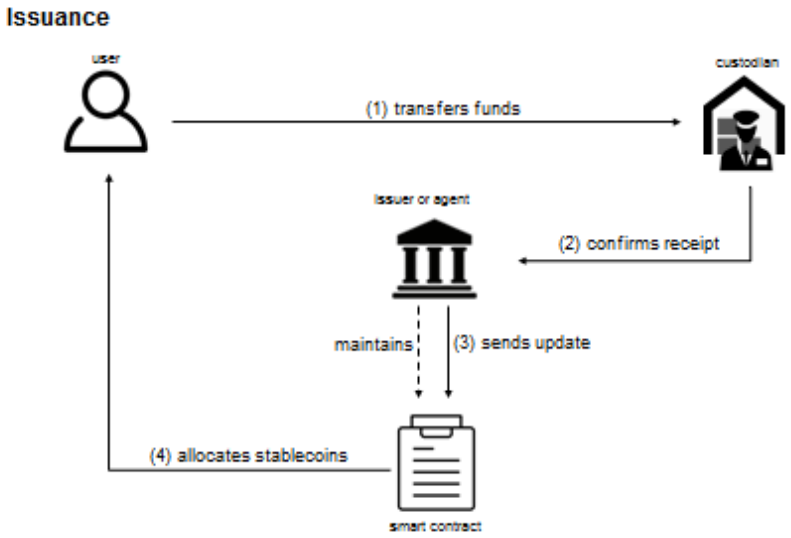
17 The case of backing in the form of assets other than funds does not constitute tokenised currency and is discussed in Section 2.2.2.

18 Since the issuer of tokenised currency is solely responsible for ensuring that funds are kept safe and can be redeemed, the auditability of its smart contract does not contribute to the stability of stablecoin price and is not considered in the description of the issuance process.

The process of **redeeming** units of tokenised funds is similar to the issuance, but works in reverse. A user may send units of tokenised funds to the dedicated network address specified by the issuer[19] who shall withdraw them from circulation (in jargon "burn" them) to maintain the redeemability of circulating units for the funds backing them. Once these units are burnt, the custodian is instructed to transfer an equivalent amount of funds back to the user.[20]

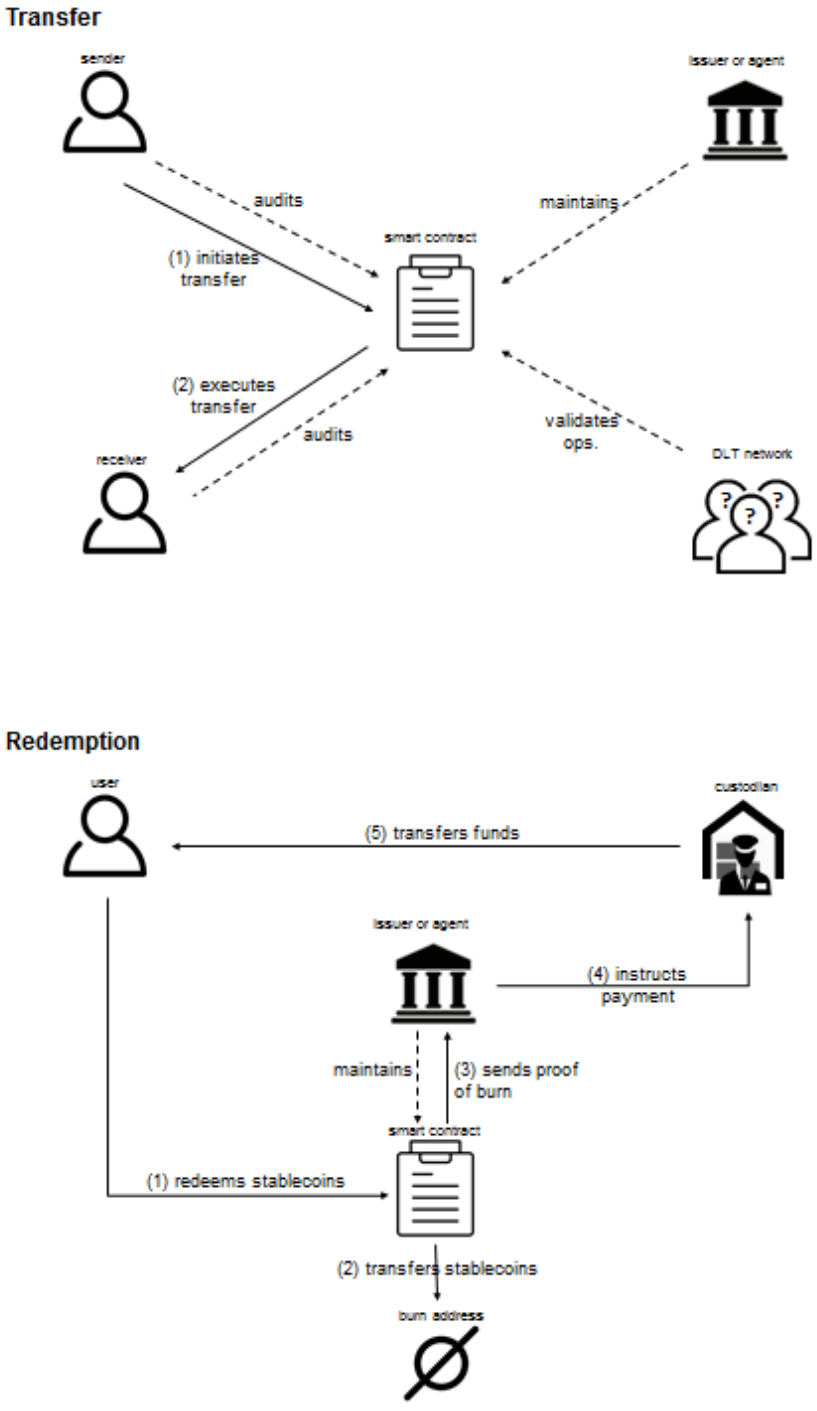
Figure 4

Issuance, transfer and redemption of tokenised funds



[19] The issuer can also rely on a "licensed agent". The concept of licensed agents refers to the fact that a tokenised stablecoin initiative may have multiple parties that can redeem stablecoin units. These parties all refer to the same governing smart contract and can apply for this role by adhering to a predefined code of conduct.

[20] Trading platforms may offer redemption by trading stablecoins against their own funds, even if they are not licensed issuing members. When that happens, the trading platform can either resell tokenised currency units or redeem them directly with the issuer for the funds backing them.



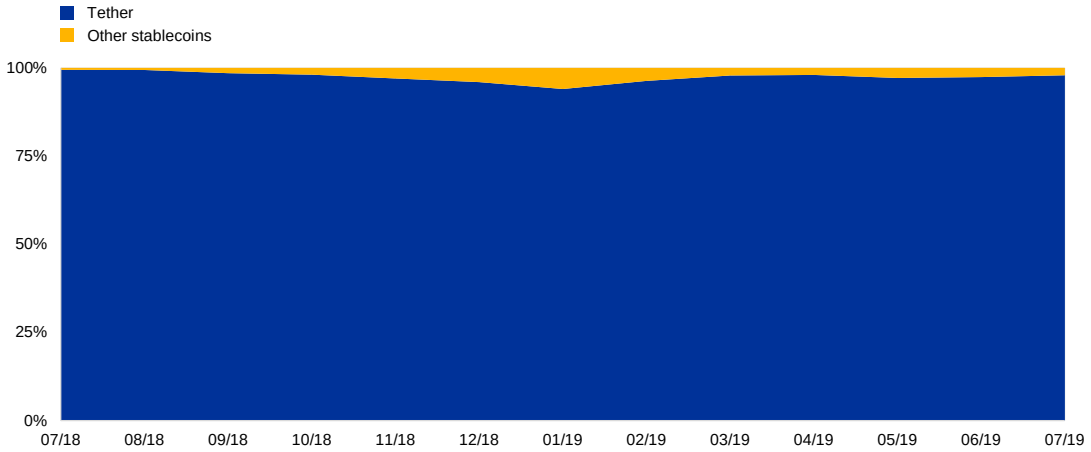
Box 1 elaborates on the rules and practices of the tokenised funds provided by Tether.

Box 1
The case of Tether

Tether[21] currently dominates the stablecoin market in terms of trading volume as well as market capitalisation. While Tether accounted for 99% of the entire market capitalisation of stablecoins in February 2018, its share declined to 81% in July 2019.[22] Tether was among the first stablecoin to surface and thus has a significant first-mover advantage. While the market has become increasingly competitive, Tether remains the most commonly used stablecoin. Tether's quasi-monopoly is shown in Chart A with the trading volumes of Tether consistently hovering around 95% of the overall stablecoin market.[23]

With a capitalisation of €3.5 billion and an average daily volume of €12.7 billion[24] Tether is also by far the largest tokenised stablecoin. These absolute figures should, however, be taken with a pinch of salt as recent research insights[25] point towards a substantial number of exchange platforms engaging in wash trading (i.e. market manipulation in which an investor simultaneously sells and buys), thus artificially increasing the volumes of traded crypto-assets.

Chart A
Trading volume of USD Tether compared to other stablecoins



Source: ECB staff elaboration based on data from coinmarketcap.com up to 28 July 2019.

Prices of USDT have generally shown a low fluctuation with an historical volatility of prices of 10%.[26] The respective development is shown below in Chart B.

21 Tether tokenises two currencies, the US dollar and the euro. The USD Tether (USDT) is recorded on the Bitcoin blockchain through the Omni layered protocol. The EUR Tether, or EURT, uses Ethereum. Tether indicates that 40 million EURT are in circulation, which is less than 1% of the circulating USDT. This information was retrieved on 28 July 2019 from here. The analysis focuses on USDT.

22 ECB staff calculation based on data from coinmarketcap.com.

23 Most stablecoin initiatives are open source and low entry barriers for market newcomers exist. Network effects are a major distinguishing factor. Tokenised currency Gemini USD was offered at a 1% discount to over-the-counter traders, which indicates an attempt to create network effects.

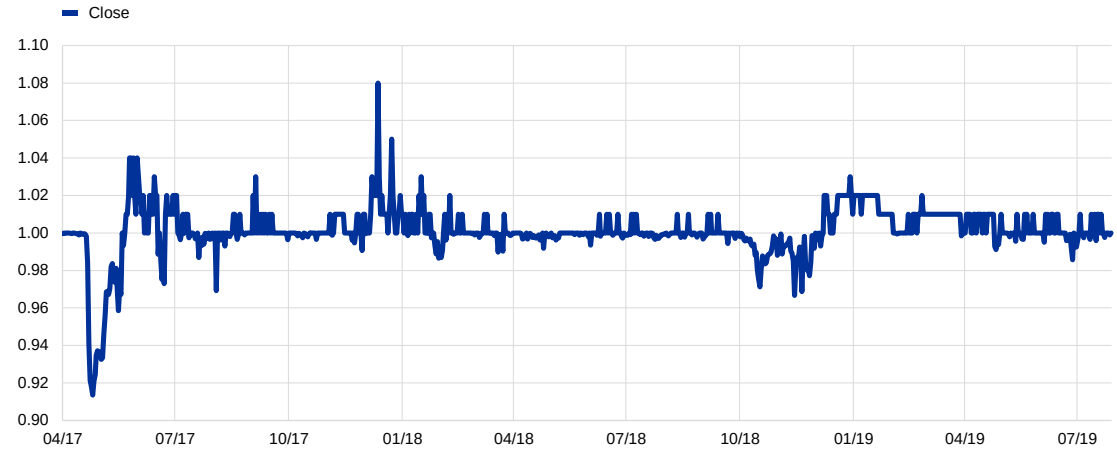
24 ECB staff calculation based on data from coinmarketcap.com. The daily volume is computed by averaging the YTD (28 July 2019) daily volumes. The conversion from USD to EUR is based on the spot price from 28 July 2019.

25 For further information, refer to Bitwise (2019), "Bitwise Asset Management: Presentation to the U.S. Securities and Exchange Commission".

26 The volatility is computed by averaging the annualised, standardised seven-day rolling averages from 27 December 2017 to 28 July 2019. Data is taken from coinmarketcap.com.

Chart B

Daily closing price of USDT in the currency of reference (USD)[27]



Source: ECB staff elaboration based on data from coinmarketcap.com up to 28 July 2019.

Following a public debate on whether Tether can prove the possession of its funds, the law firm Freeh, Sporkin & Sullivan LLP inspected and confirmed that Tether's assets exceed the balance of fully backed USD Tethers in circulation . Nonetheless, it was publicly noted that this was a snapshot analysis and not a full audit. Tether does not currently appear to be in a contractual relationship with any auditor and seems to engage a small bank based in the Bahamas, DeltecBank, as a custodian. Another source of public unrest was Tether's relationship to one of the biggest crypto exchange platforms, Bitfinex. Supposedly[28], the Paradise Papers claimed that Bitfinex and Tether were not only founded by the same individuals, but also share their CEO. Lastly, it is important to note that Tether updated its Terms of Service in February 2019 and now states, "every Tether is always 100% backed by our reserves". The composition of the reserves is, however, at the "sole control and sole absolute discretion of Tether".[29]

The business model of for-profit tokenised funds initiatives relies predominantly on fees paid for redemption in fiat currency, which are typically up to 3%.

2.2 Collateralised stablecoins

In collateralised stablecoin initiatives, which bear similarities to tokenised funds, the price of a stablecoin in the currency of reference is supported by units of an asset (or multiple assets), against which users can redeem their holdings. However, whereas tokenised funds can always be redeemed for the equivalent amount of currency in which they are denominated, collateralised stablecoins are backed by assets whose price in the currency of reference fluctuates over time.

27 Owing to the initially very low trading activity, the first two years (i.e. the first trade of USDT took place in March 2015) of trading activity is not displayed on this chart. As the target price is $1, prices are denominated in US dollars.

28 As the Paradise Papers were never published to the general public it is not possible to verify the claim made by Samuel Haig (2017).

29 The Terms of Service were updated on 26 February 2019. For further information, see Tether (2019), "Terms of Service", Item 3.

Therefore, the collateral backing these stablecoin initiatives must be adjusted through margin calls (i.e. requests for posting further assets), to ensure that every stablecoin is backed by collateral valued (at least) at par in the currency of reference. To allow users to react to margin calls before the stablecoin becomes under-collateralised (i.e. before the value of collateral falls below the threshold value that is deemed necessary to reassure stablecoin users), stablecoins are generally over-collateralised. Anecdotal evidence shows that users of stablecoins are sometimes willing to post collateral in excess for two main reasons: (i) to store the proceeds from crypto-asset sales without the need to go through the services of trading platforms and financial institutions offering conversion in any currency; and (ii) to avoid the penalty fee associated with the default of a collateral position.

Every collateralised stablecoin initiative defines what specific type of collateral is considered “eligible”, in the sense that it can be used to issue new stablecoins. Depending on the type of collateral, a custodian may be needed for the safekeeping of assets backing stablecoins. Given the relevance of this feature in the world of crypto-assets, the classification in this paper (Figure 3) differentiates between two types of collateral: (i) assets that must be held in custody “off-chain”, in which case the intervention of one or more responsible parties is necessary and (ii) assets recorded “on-chain”, for which responsibilities could be fully decentralised among participants in an unrestricted DLT network.

2.2.1 Off-chain collateralised stablecoins

The vast majority of assets currently cannot be recorded and transferred solely by means of an unrestricted DLT network, without the involvement of a responsible party. The reason for this is to some extent legal in nature, since most jurisdictions today do not grant legal effect to the transfer of many asset types outside the books of a specific category of institution (e.g. payment systems and security settlement systems). More fundamentally, only what exists in digital form can be transferred via digital means. For instance, in the typical case of a commodity, only a representation of the asset (a “token”) can be transferred electronically. This implies that an entity will always be responsible for: (i) keeping the commodity in safe custody outside the database; and (ii) delivering the commodity when requested. Off-chain collateral can be of any type and includes assets that cannot be stored digitally, such as commodities and real estate.

Figure 5 describes the process of issuance and redemption of an off-chain collateralised stablecoin. The process of transfer is not included since it works in a similar way to tokenised currencies.

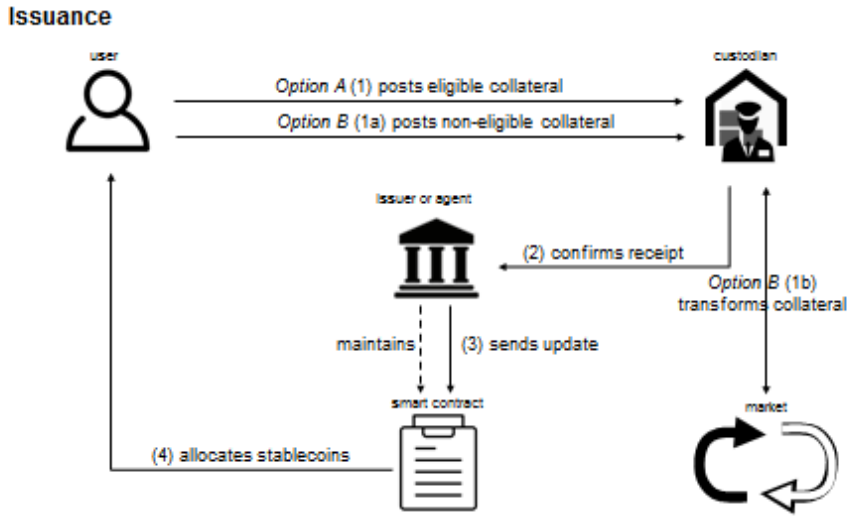
Issuance of stablecoins against off-chain collateral follows the same principle as for tokenised funds. While it is possible that the user posts eligible off-chain collateral, the additional complexity entailed in the mobilisation of assets other than funds leads many stablecoin initiatives to allow their users to request new stablecoin units by sending either funds or crypto-assets (i.e. non-eligible collateral) respectively to either the custodian or network address specified in the smart contract. The custodian/smart

contract is able to transform those funds or crypto-assets into eligible off-chain collateral on the market and, once its delivery is confirmed, new stablecoins are issued by means of an update to the smart contract.[30] Once issued, stablecoin units with different levels of collateralisation are fungible since (i) users are unable to associate any unit with its specific collateral position and (ii) the process of compulsory redemption of under-collateralised units relies on the overall pool of collateral, hence either all stablecoin units in circulation maintain minimum collateralisation or the whole initiative defaults.

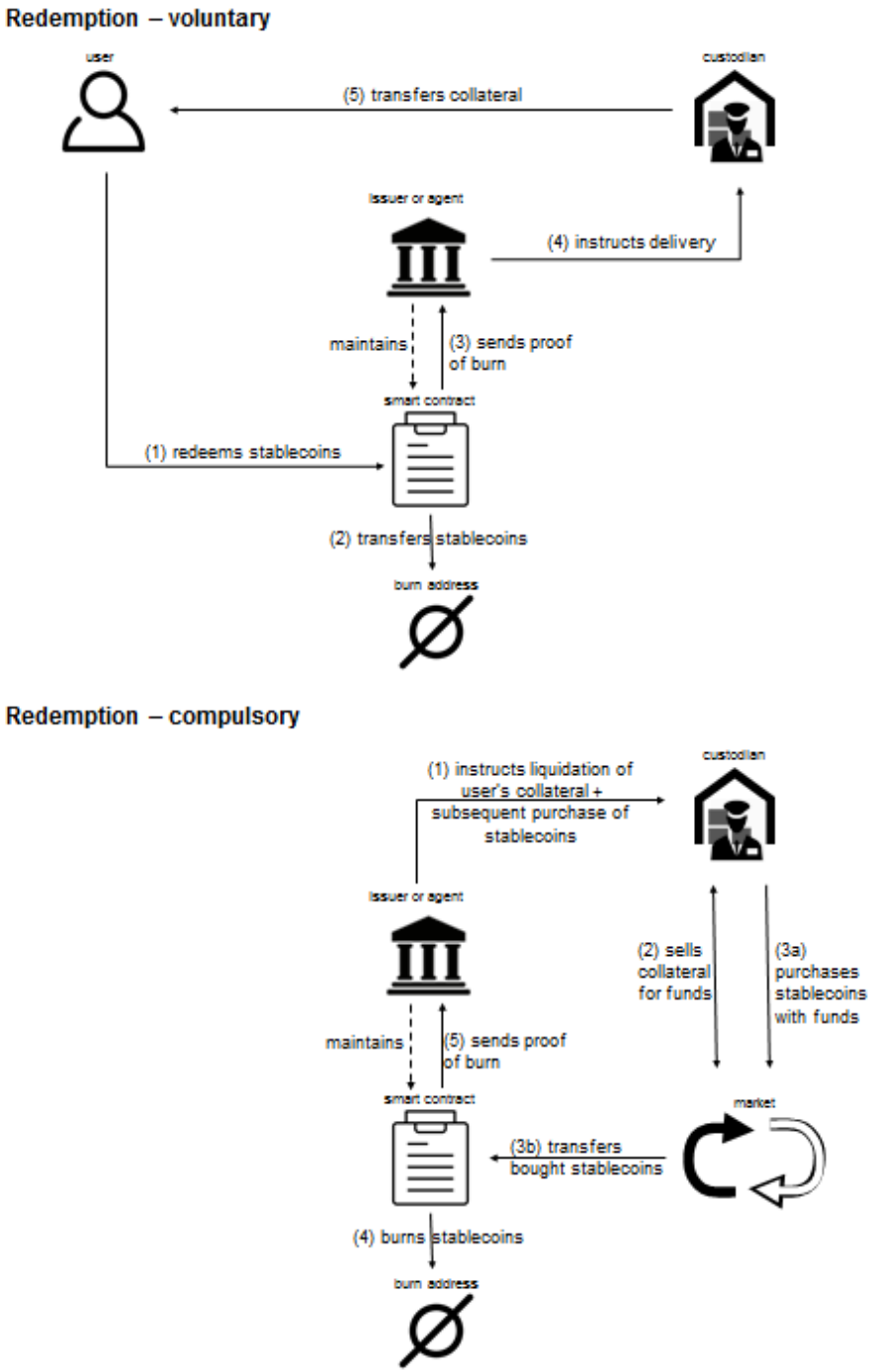
The process of **redeeming** units of off-chain collateralised stablecoins can either be voluntary, in which case it follows in reverse order the very same steps described for issuance, or compulsory. Compulsory redemption occurs in cases where the value of collateral underlying a stablecoin unit drops below the over-collateralisation ratio specified within the rules of the stablecoin initiative. When users receive a margin call and do not replenish the amount of collateral backing the stablecoin units they originally requested, the issuer may instruct its custodian or the smart contract to liquidate their collateral. Revenues from this sale are then used to contract stablecoin supply by buying back the appropriate amount of stablecoin units from the market and burning them. If revenue from such a buy-back process exceeds the value of the stablecoin units issued against the defaulting collateral position, any excess goes to the user who originally posted the collateral (a penalty fee is deducted for the default of the collateral position). Inasmuch as this sale happens before the value of a collateral position falls under the value of the associated stablecoin unit, the overall collateralisation of the initiative is not affected.

Figure 5

Issuance and redemption of an off-chain collateralised stablecoin



[30] Stablecoin units are linked to either the corresponding share of fungible collateral held in custody or, for non-fungible collateral, to the specific collateral backing each of them.



Off-chain collateralised stablecoin initiatives may be set up as a source of profit for a custodian that holds the off-chain collateral for safekeeping. Such a business model is usually built on two revenue streams: (i) issuance, transfer and redemption fees can be charged for every transaction in the stablecoin and the underlying collateral position; (ii) a storage fee may be charged on a daily basis that covers the costs of safekeeping off-chain collateral.

2.2.2 On-chain collateralised stablecoins

On-chain collateral relates to assets in digital form, the value of which does not depend on the intervention of a responsible party.[31] In this case, the smart contract allows the stablecoin initiative to be either fully decentralised or not.

Users of on-chain stablecoins can audit the smart contract and are usually involved in its maintenance, with no need for any party to be responsible for operating the initiative, although that is a possibility.[32] Users of some on-chain collateralised stablecoins can for instance: (i) adjust the minimum level of (over)collateralisation requested to have stablecoin units issued and under which a collateral position can be liquidated; (ii) change the set of eligible collateral; (iii) stop the scheme and liquidate collateral to stablecoin holders according to a rule of choice.

Figure 6 describes the processes of issuance and redemption of on-chain collateralised stablecoins cases where responsibilities are decentralised among network participants.[33]

Given the lack of any accountable party (issuer or custodian) and the decentralisation of roles among network participants, the **issuance** of stablecoin units starts with on-chain collateral being sent directly to the (address of the) smart contract that governs the scheme. The smart contract then creates stablecoin units and sends them to the user who initiated the request, in accordance with the minimum level of (over)collateralisation that has been defined. The user who initiated the request remains responsible for ensuring the appropriate collateralisation of stablecoins issued to them notwithstanding the transfer of said stablecoins to other users.

The **transfer** of on-chain collateralised stablecoins differs somewhat from the process described in the case of tokenised funds and off-chain collateralised stablecoins, to the extent that DLT network participants do not delegate any responsibilities to central parties and maintain the smart contract governing stablecoin transfers.

The process of **redeeming** units of on-chain collateralised stablecoins can be voluntary, in which case the user who was responsible for the issuance of a certain number of units can send back the said number of units to the smart contract and the issuance process is reversed, resulting in the reimbursement of the collateral. The redemption process can also be compulsory. In contrast to off-chain collateral, custody of collateral is not centralised in these stablecoin initiatives and the smart contract has no power to dispossess assets backing under-collateralised stablecoins. Instead, the smart contract needs to find sufficient resources to buy back circulating stablecoins and burn them, so that the stablecoins that were under–collateralised can be linked to the collateral position of the ones that are burnt (which have sufficient underlying

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31 This excludes collateral in the form of financial claims issued or represented (tokenised) on a distributed ledger, which use DLT as an infrastructure but require the intervention of a responsible party and could be issued by means other than DLT. These assets are to be considered off-chain collateral.

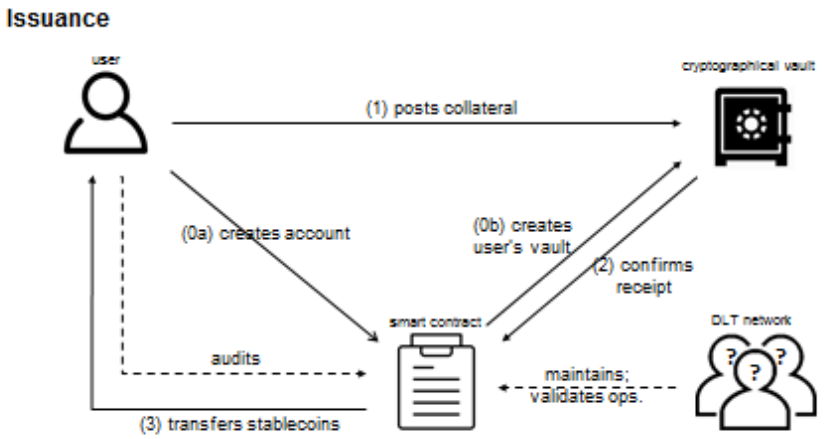
32 The decentralisation of some responsibilities is also available for tokenised currency and off-chain collateralised stablecoin initiatives but, given the need for responsible parties issuing and/or safekeeping funds and collateral, it is of less relevance in their regard.

33 The functioning of an on-chain collateralised stablecoin initiative with an accountable issuer and custodians is similar to that of off-chain collateralised initiatives described in the previous subsection and is not repeated here.

collateral). These resources can either be in the form of revenues accumulated by the stablecoin initiative (e.g. fees on transactions) or be raised on purpose. While the first case is similar to what was discussed for off-chain collateralised stablecoins, the second case is described in the figure as a sale of rights on future revenues (i.e. the allocation of such revenues to buyers of secondary units, which are explained in Section 2.4) for which the smart contract accepts only circulating stablecoins. The smart contract issues secondary units in exchange for the same number of stablecoins as those linked to the defaulting collateral position and burns them. The stablecoin units issued against the defaulted collateral position are now backed by sufficient collateral. The smart contract can then sell the collateral that was previously linked to the under-collateralised stablecoins, in exchange for the rights on future revenues it had issued when it bought the stablecoin units to be burnt.[34] If any collateral remains, it is eventually returned to its original owner, net of a penalty fee for not having provided for the collateralisation of its stablecoins.

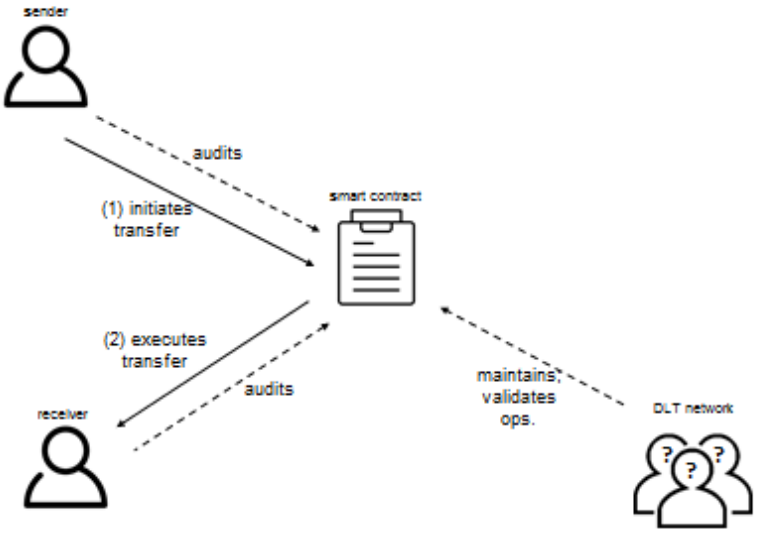
Figure 6

Issuance, transfer and redemption of a (fully decentralised) on-chain collateralised stablecoin

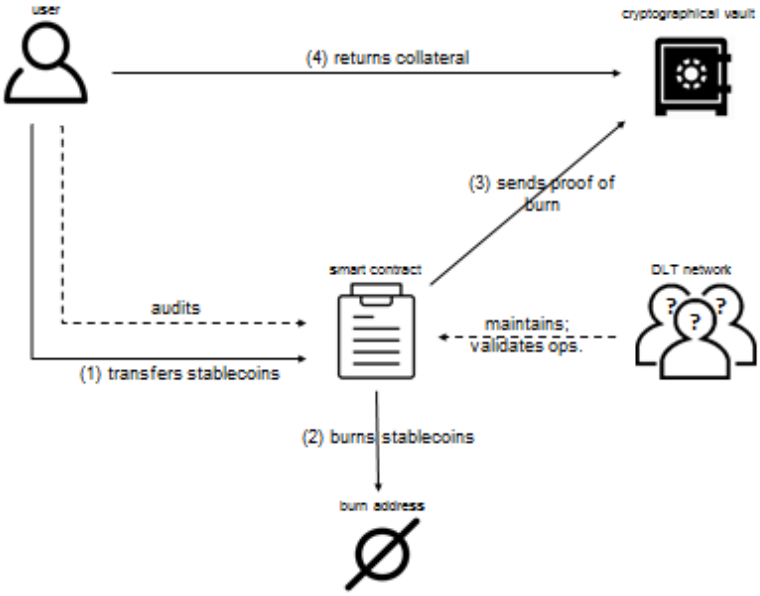


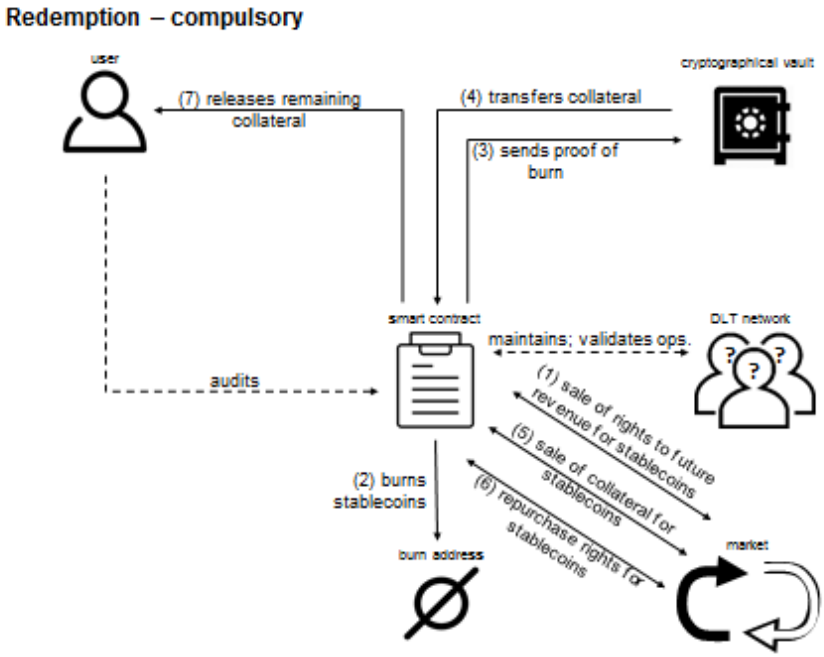
[34] If the collateral previously linked to the under-collateralised stablecoins is not sufficient to buy-back secondary tokens, the holders of secondary tokens have their rights diluted. This is part of the governance mechanism, since secondary tokens give the right to modify the governance of a stablecoin initiative and their holders are induced, inter alia, to set a high enough level of over-collateralisation to ensure that any compulsory redemption is accomplished without diluting their rights.

Transfer



Redemption – voluntary





Box 2

The case of MakerDAO

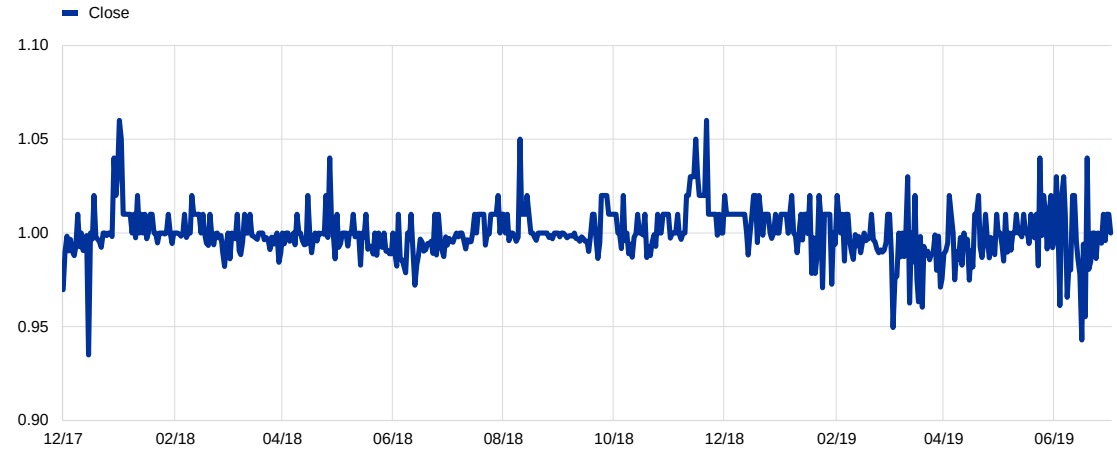
MakerDAO is a stablecoin backed by on-chain collateral (currently Ether) with a floating-peg to 1 USD. MakerDAO largely follows the generic structure described in Section 2.2.2 yet implementations can vary slightly. The model leverages a dual-token system, consisting of the stablecoin, Dai, and a secondary unit called MKR (see Section 2.4 for details on secondary units).

The historic performance of this stablecoin shows a daily maximal deviation of 6.5 US cents, with the peg deviation staying below 1 US cent for 76% of all assessed trading days (i.e. 27 December 2017 to 28 July 2019). Prices of Dai are shown in Chart A, the historical volatility is 28%.[35]

[35] The volatility is computed by averaging the annualised, standardised seven-day rolling averages from 27 December 2017 to 28 July 2019. Data is taken from Coinmarketcap.com.

Chart A

Daily closing price of Dai in the currency of reference (USD)



Source: ECB staff elaboration based on data from coinmarketcap.com up to 28 July 2019.

This performance has to be seen in the context of the value of its single deployed collateral, Ether, having dropped by 92% since its all-time-high. It appears that users must have incrementally added collateral to maintain a sufficient over-collateralisation ratio. In fact, the total amount of Ether that was posted as collateral more than doubled in 2018. On average, the system maintained an aggregate collateralisation ratio of 300% in 2018 (while not going below 215% in this period).

The process of issuance starts with posting collateral to a Collateral Debt Position (CDP) and follows the overall process described in Section 2.2.2. Similarly, **redemption** can be voluntary or compulsory. While the voluntary redemption process can be likened to the process described in Section 2.2.2, compulsory redemption, being at the core of the Dai's capacity to maintain a stable value, differs somewhat.[36] The compulsory redemption of CDPs makes use of a self-sustaining system-wide Dai pool with certain thresholds that are agreed upon by MKR investors.[37] This pool is fuelled by three revenue streams: interest payments, collateral- and debt auctions. It is depicted in Chart B. A debt auction is initiated as soon as the lower bound of the system-wide Dai pool is reached. It automatically creates and sells additional MKR units to interested parties. The upper ceiling of the system-wide Dai pool initiates a “buy and burn auction”, where Dai from the system-wide pool are used to repurchase and destroy MKR.

Whenever a CDP defaults as the system-wide minimum over-collateralisation ratio is exceeded, the respective liquidation process is initiated. Subsequently, the CDP is appropriated, effectively seizing the posted collateral and subtracting the associated Dai debt from the system-wide Dai pool. The next step is to initiate the debt auction of the appropriated collateral against MKRs. While the respective proceeds are sent to the system-wide Dai pool, the revenue from the auction may only be obtained with a time delay. Therefore, it is possible for a debt auction to be initiated in the meantime, diluting the existing MKR supply. If the revenue from the auction is sufficiently high the created MKR tokens are repurchased and burned. Should the collateral value exceed the Dai debt, the accrued interest

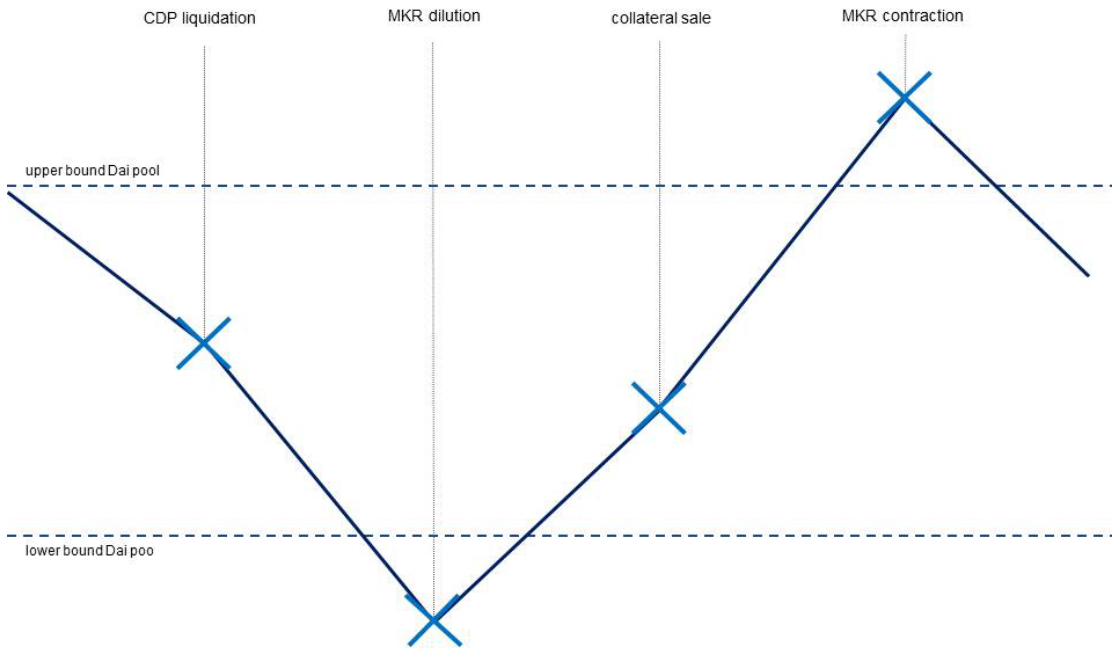
36 A future implementation, the Multi-Collateral-Dai model, follows the same stability mechanisms as the currently operating Single-Collateral-Dai model, yet allows for more collateral assets.

37 MKR can either be obtained on the secondary market or on a proprietary decentralised exchange where newly-minted MKR are offered for sale.

and the penalty fee at a discounted price, a reverse auction is held, selling as little collateral as possible. Any remaining collateral is sent to the original owner.

Chart B

Simplified representation of the Dai pool



Source: ECB staff elaboration based on publically available data.

MakerDAO is a “decentral autonomous organisation” (DAO), i.e. an organisation that is represented by rules encoded as a computer programme, which is transparent and controlled by MKR holders. MKR holders are in charge of carrying out administrative tasks such as risk assessments, data provision and emergency responses. MKR holders may participate in on-chain **governance** voting processes where they have an unrestricted ability to implement changes. Currently, the governance process is supported by off-chain media (e.g. YouTube, chat forums) to further inform interested MKR holders. MKR holders are not protected from the actions of organised minorities of users, who may decide to implement any change to the smart contract governing the stablecoin initiative.[38] As MKR holders are therefore in charge of defining the risk parameters they are ultimately responsible for maintaining a stable Dai exchange rate and are made liable for failures to act accordingly. This liability is effective on MKR holders, as they are indirectly paying for funding gaps via a dilution of MKR.[39] Besides their vested interests, MKR owners are further **incentivised** by potential seigniorage revenue. This seigniorage originates from the stability fee that is accruing over time for CDP owners. The fee is currently set at 2.5% and funds three different components: (1) the operating component

[38] While recent votes to change some rules of the initiative have passed in a timely manner, the voting turnout was very low (in March 2019 only 37 out of 9,668 addresses participated).

[39] A flash crash in the pledged collateral would make it impossible to close CDPs in time and force the issuance of additional MKR units. Not only would the base demand dwindle in such a scenario, but investors in MKR may eventually lose confidence in its capacity to recover and generate future profits. An emergency shutdown would be initiated and the collateral units would be allocated to Dai holders, constituting a credit risk to them. This is the case since the holders of a supposedly risk-free unit would suddenly be holding a drastically depreciating asset. Subsequently, the issued stablecoin cannot be considered to be entirely risk free.

(e.g. support policy creation by further incentivising risk teams), (2) the Dai Risk Interest Rate (lock Dai, the accrue dynamic interest rate reflecting the current trading of Dai below or above par) and (3) the inflation rate (i.e. contraction of MKR supply). The part of the stability fee channelled into the inflation rate thus represents the seigniorage revenue of MKR holders. The manipulation of the Dai Risk Interest Rate is the primary tool to manipulate the demand for Dai. By adjusting the interest rate that Dai holders may receive for locking in their funds, the demand for Dai can be influenced in a two-fold way: (1) reducing the circulating supply of Dai will result in an increase in the price of Dai; (2) interest payments will increase the attractiveness of Dai, will result in an increase in the price of Dai. Besides carrying out these tasks, additional stakeholder groups in the MakerDAO ecosystem are market makers or "keepers", CDP owners and Dai holders:

- "keepers", may exploit arbitrage opportunities and therefore support the intended system-wide collateral-to-Dai ratio. These arbitrage opportunities may substantiate Dai listing prices on exchange platforms, the opportunity to open CDPs or access to discounted collateral from forcefully liquidated CDPs.
- CDP owners are incentivised by the opportunity to leverage their crypto-assets and the opportunity to obtain cheap credit in the form of Dai. The provision of credit is thus conditional on collateral. In this setting CDP owners may have a demand for Dai as a payment vehicle and an inherent demand for MKR to remobilise their pledged collateral. CDP owners are the dominant driving force underpinning the stability of Dai, steered by the Dai Savings Rate.
- Dai holders want to benefit from a price-stable asset compatible with the wider crypto-ecosystem.

2.3 Algorithmic stablecoins

At the time of writing, algorithmic stablecoins are largely a theoretical possibility rather than reality. The idea behind algorithmic stablecoin initiatives is to adjust the supply of stablecoin units in order to maintain their price stability in the currency of reference and to guide users' expectations on its future value.

In contrast to tokenised funds, algorithmic stablecoins are not fully backed by the funds they are meant to represent. In contrast to collateralised stablecoins, there is no risk-mitigating measure in the form of (either off-chain or on-chain) assets that are committed by users, in the issuance phase, and then maintained over time. Yet, an algorithmic stablecoin can try to stabilise its market price in the currency of reference by either using the reserves in on-chain assets it has accumulated over time (e.g. fees on transaction) or selling rights on future revenues. This and other secondary stabilisation mechanisms apply to all stablecoin types and are discussed in greater detail in Section 2.4.

The smart contract at the core of an algorithmic stablecoin initiative includes rules on how the issuance/redemption of stablecoin units will be used to match demand while maintaining parity with the currency of reference. Information on excess

demand/supply is reported to stablecoin smart contracts via the current order books at different trading platforms and market data providers (in jargon – "oracles"[40]).

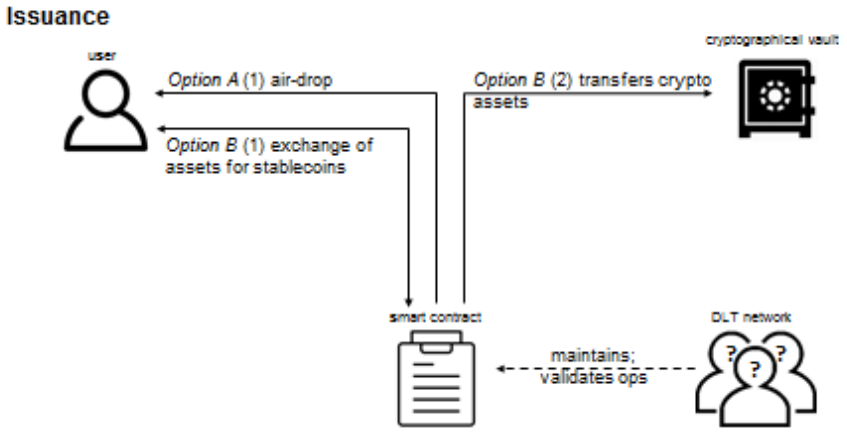
Figure 7 describes the processes by which algorithmic stablecoins are issued and how the related initiatives generally anticipate the contraction of the stablecoin unit supply amidst a falling market value.

The **issuance** of algorithmic stablecoins usually happens in exchange for on-chain assets that the smart contract will hold in the form of reserves. Additionally, the issuance can occur as an "air-drop" whereby new units are distributed to interested users.[41]

The concept of **redemption** does not apply to algorithmic stablecoins because they are not redeemable against any asset. However, the **contraction** of stablecoin supply is used to stabilise the price of algorithmic stablecoins when there is excess supply. It is similar to the compulsory redemption described for the other types of stablecoins.[42] One option is for the smart contract to issue rights on future revenues and sell them for stablecoins in circulation. Another option is to withdraw stablecoins from circulation by selling reserves against them that the stablecoin initiative has accumulated over time (e.g. transaction fees in the form of on-chain assets).[43]

Figure 7

Issuance of an algorithmic stablecoin and contraction of excess supply

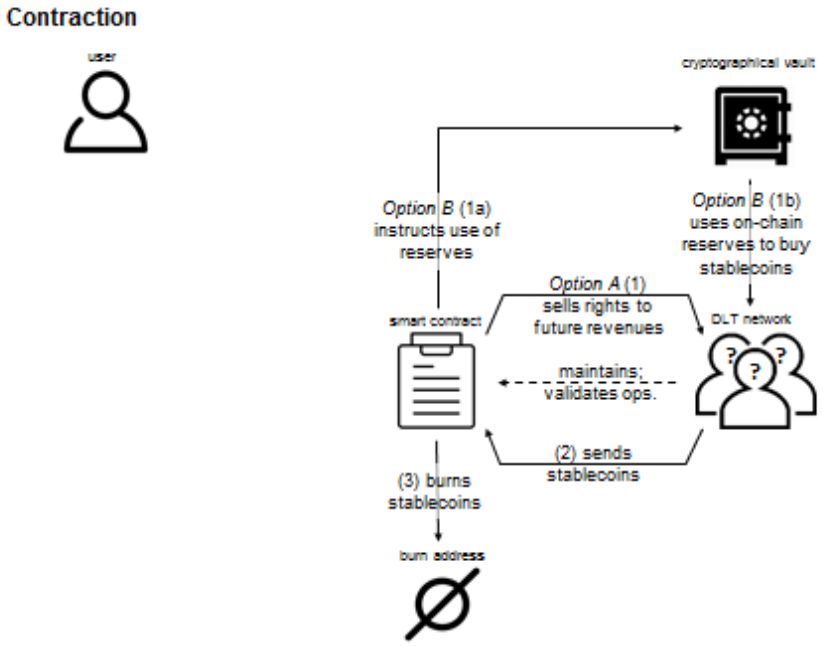


40 These data providers must behave truthfully if the initiative is to be successful. In a distributed environment, that is usually done through economic incentives.

41 Free provision of stablecoins is sometimes used to increase the user base and to attract new users by means of network effects.

42 Redemption does not typically happen as a "reverse" air-drop since such a possibility would be akin to a loss in the value of stablecoin holdings – which would not be stable anymore.

43 Even if algorithmic stablecoins decide to hold reserves as a secondary stabilisation tool, the outstanding amount of stablecoin tokens is expected to far exceed the present reserves.



Box 3

The case of NuBits

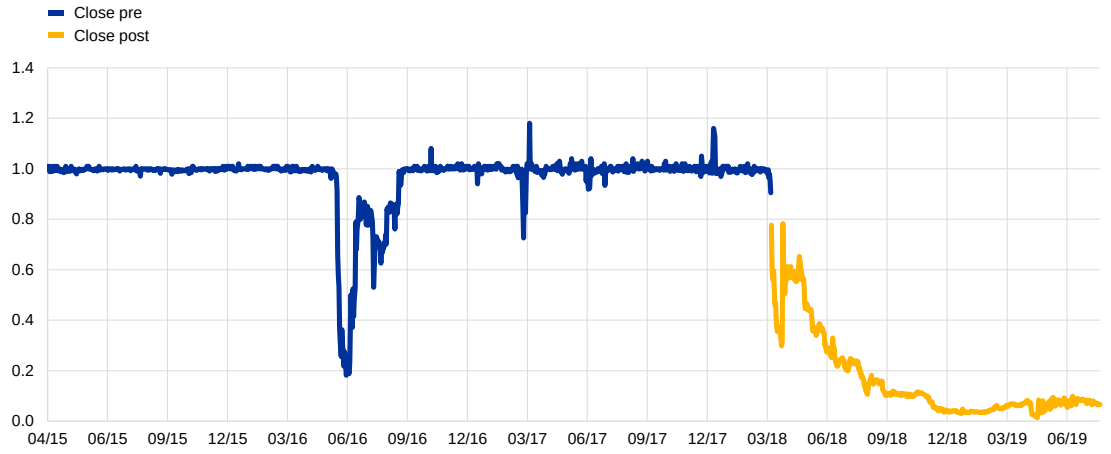
NuBits is one of the oldest algorithmic stablecoins and has been operating since 2014, with a peak capitalisation of €12.9 million in January 2018. It builds on a platform called "Peercoin" which was not only one of the earliest crypto-assets using the so-called "proof of stake" consensus mechanism[44], it was also combined with a strong focus on decentralised decision-making. While NuBits was able to withstand temporary price fluctuations and recovered from a major loss of confidence in June 2016, its value did not recover after a drop in March 2018 (see Chart A where the two periods before and after the latest and apparently permanent loss of confidence are displayed as solid dotted lines, respectively). The current market value of every unit stands at EUR 0.05. Its historical volatility is 37%.[45]

[44] Unlike proof of work, proof of stake does not require the network validators to perform a computational puzzle to proof their performed labour, but can stake tokens. They are thus essentially proving to have a stake in the correct functioning of the initiative.

[45] The volatility is computed by averaging the annualised, standardised seven-day rolling averages for 17 November 2016 to 21 March 2018. This refers to the time period in which the stability mechanism was working. Data is taken from coinmarketcap.com.

Chart A

Daily closing price of NuBits in the currency of reference (USD)



Source: ECB staff elaboration based on data from coinmarketcap.com up to the 28 July 2019.

The stability mechanism of NuBits relies on a dual-token design. NuBits is subject to the basic principles of a dynamic supply as described in Section 2.3. The creation of new NuBits can be initiated by share token (i.e. NuShares) holders. These share tokens have a fixed supply, are not pegged to any specific price and fulfil multiple roles. NuShare holders may use their tokens to validate transactions and may cast votes after a successful validation. These votes may either be targeted at the creation of new NuBits, may adjust the rewards for locking Nubits (see "Staking of stablecoins" in Section 2.4) or may be a general request to change other components of the stablecoin initiative. The contraction of the NuBits supply is incentivised through dynamic rewards for locking NuBits, in the hope that users will expect the stablecoin to return to its par value.

2.4 Secondary stability mechanisms

While the stablecoin classification proposed in this paper focuses on primary stabilisation mechanisms, additional features of interest of stablecoins are linked to their secondary stabilisation mechanisms (see Table 1).

Fees: fees in the form of either crypto-assets or funds are often imposed on users at issuance, or during the transfer and/or redemption of stablecoin units. This revenue may be accumulated by the stablecoin initiative over time to create reserves that the smart contract uses, by means of market transactions in its own stablecoin, to support parity with the currency of reference.

Secondary units: governance of the stablecoin initiative can be managed by allocating rights to some users by means of secondary units (in jargon "governance tokens"). Secondary units can also be appealing to stablecoin users because they are remunerated with part of the revenues (e.g. transaction fees) that the stablecoin initiative generates over time. Users may then be willing to pay for the issuance of secondary units, the proceeds from which can be accumulated by the smart contract as a "reserve" to be used if needed. In particular, reserves may be used to repurchase some of the issued stablecoins so as to lower any excess supply, which would

otherwise lead to a fall in their price. Especially in the case of algorithmic stablecoin initiatives, secondary units may exhibit some features that from a functional perspective resemble equity (when they allocate governance rights and residual cash flows) and bonds (when they give right to an interest payment).

Staking of stablecoins: Holdings of stablecoins which have been temporarily suspended (in jargon "frozen" or "staked") and can be remunerated to curb a temporary excess in their supply.

Redemption limits: Limits to convertibility can be used to avoid/delay withdrawals (runs) on a stablecoin initiative.[46]

Penalty fees: In the case of collateralised stablecoins, a penalty fee can be charged on users who requested the issuance of stablecoin units and did not maintain the minimum level of collateralisation.

Targeted rebates: Some stablecoin initiatives incentivise the participation of third parties to support the value of the stablecoin by granting them special conditions, usually in the form of lower transaction fees.

Reactive mining rewards: The smart contract can modify the stablecoin-denominated reward it sometime allocates to users who validate transactions in the DLT network (in jargon – "mining"), in order to fine-tune the increase in stablecoin supply and its trading costs.

Price band: Some initiatives envisage a price band within which they allow the price of their stablecoin to fluctuate, using stabilisation mechanisms only when it is too distant from parity with the currency of reference.

Re-adjusted peg and kill switch: Rather than stabilising the price of a stablecoin over time, a re-adjusted peg acknowledges the failure of the initiative to avoid fluctuations in its stablecoin and change its denomination in the currency of reference. A "kill switch" can be included to either temporarily stop market operations or to liquidate reserves and any collateral for users and to stop operations of the stablecoin initiative. This is intended to lower the users' incentive to immediately withdraw their funds/collateral in the case of an initial, possibly temporary drop in the price of the stablecoin.

Hybrid stablecoins: Whereas a stablecoin initiative can always be classified based on its primary stabilisation mechanism, the use of multiple tools to stabilise its price may create hybrid cases. In particular, collateralised stablecoins can be backed by both on-chain and off-chain assets. In that case, the stablecoin initiative requires the intervention of responsible parties that are typical for off-chain stablecoins. Tokenised currencies and algorithmic stablecoins, however, cannot display hybrid features. Tokenised funds would become collateralised stablecoins if issuance took place against anything other than funds, while an algorithm adjusting demand and supply is redundant insofar as the value of each unit is backed by a unit of the currency of

[46] Redemption limits do not apply to algorithmic stablecoins, for which no asset is backing the scheme and nothing can be withdrawn by users.

reference. Algorithmic stablecoins cannot be hybrid, since by providing redeemability for either funds or collateral they would cease to be backed only by users' expectations.

Morphing stablecoins: Some stablecoin initiatives begin their activity as one of the aforementioned types and change over time. For instance, some tokenised funds initiatives may decide to stop redeeming their units against funds and continue their operations as an algorithmic stablecoin. However, in this case maintaining the smart contract, including the supply of stablecoins over time, remains under the remit of a central responsible entity.

Table 1
Secondary stabilisation mechanisms

	Tokenised funds	Collateralised stablecoins	Algorithmic stablecoins
Secondary tools	Reserves to support price during market turbulence, Fees/redemption limits	Reserves, Fees/redemption limits, Secondary units, Staking, Penalty fees, Targeted rebates, Readjusted peg, Kill-switch, Capital controls, Price band	Reserves, Secondary units, Staking, Targeted rebates, Reactive mining rewards, Readjusted peg, Kill-switch, Capital controls, Price band

2.5 Overview of the stablecoin phenomenon

Currently, at least fifty-four stablecoin initiatives are in existence[47], of which twenty-four are operational. The overall market capitalisation of operational initiatives almost tripled from €1.5 billion in January 2018 to more than €4.3 billion in July 2019. Between January and July 2019, the average volume of stablecoin transactions was €13.5 billion per month.

Chart 1 shows the allocation of fifty-four stablecoin initiatives of the four types identified in this paper. Tokenised funds initiatives are the most common stablecoin type and account for 96.8% of the monthly volume of the six major stablecoin initiatives[48], despite recent growth in the volume of collateralised stablecoins.

Only one off-chain collateralised stablecoin is included in the chart[49], since initiatives using this kind of stabilisation mechanism are rarely denominated in currency units and all others fall outside the scope of this paper.[50]

Among the stablecoin initiatives analysed, there is almost an equal amount of on-chain collateralised and algorithmic stablecoins. At this juncture, however, on-chain collateralised stablecoins generally show higher maturity than algorithmic

47 In existence means that a stablecoin initiative is either operational or traded (source: coinmarketcap.com) or has been active by committing code and operational details (source: GitHub.com and reddit.com platforms).

48 According to data from Coinmarketcap the stablecoin initiatives with the highest trading volume are USDT, USDC, TUSD, PAX, GUSD, DAI for the time period between 1 January 2019 and 28 July 2019.

49 The initiative falling under this category is called "Sweetbridge".

50 See Box 4 on initiatives aiming to issue units of value that represent a constant amount of an asset that differs from currencies on distributed ledgers.

stablecoins. Out of twelve active on-chain collateralised stablecoin initiatives, seven (i.e. 54%) are operating, whereas the same is true for only two out of eleven active algorithmic stablecoins (i.e. 18%). This is also reflected in their respective peak market capitalisations, with all operating on-chain collateralised stablecoins amounting to a total of €106 million in April 2019, while algorithmic stablecoins only reached a peak market capitalisation of €60 million in January 2018.[51]

The largest stablecoin scheme tokenising the Euro has a market capitalisation of €32 million[52], with an average daily trading volume of €0.3 million. €0.5 million[53] of tokenised funds have been issued within the last 6 months.

Almost 50% of all stablecoin initiatives identified in the drafting of this paper use the Ethereum DLT network[54] as the infrastructure on which their smart contract is executed and holdings are recorded and transferred between users. On the one hand, this has allowed a standardisation around the respective "Ethereum request for comment 20[55]" (ERC-20) standard, while on the other hand it increases reliance on a single protocol. Nonetheless, several DLT networks besides Ethereum also offer smart contract functionalities that can be leveraged by stablecoin initiatives. Notable operating examples are EOS, NEO and TRON.[56]

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51 Development of new initiatives is often stopped because their business model is incompatible with the legislative environment. One of the most popular initiatives, Basis, returned their received investment and stopped development in December 2018. Their business model relied on supporting "bond" and "share" tokens, which would, however, be classified and regulated as unregistered securities under US securities regulation. The related transfer and ownership restrictions could have not been implemented with the open and decentralised nature of the scheme.

52 Based on data from coinmarketcap.com the largest stablecoin scheme is "Stasis". The market capitalisation is based on the average for the period between 1 July and 28 July 2019.

53 It should be noted that, between September 2018 and February 2019, €2.3 million were used to purchase EURS issued by Stasis (€2.2 million) and to purchase EURT (€0.1 million). Data is taken from the internal crypto-assets dataset. Stablecoin units may have also been exchanged against crypto-assets.

54 See Blockchain (2019).

55 ERC standards are shared technical specifications that can be adopted by all users of the Ethereum platform and are created through an "Ethereum Improvement Process". The ERC-20 standard defines a technical structure for smart contracts that create record and transfer units on the distributed ledger of the Ethereum network. It is intended to make units recorded in Ethereum interchangeable with those using other ERC-20 compatible smart contracts.

56 For further information refer to: https://eos.io/, https://neo.org/, https://tron.network/.

Chart 1

Classification of 54 active stablecoin initiatives

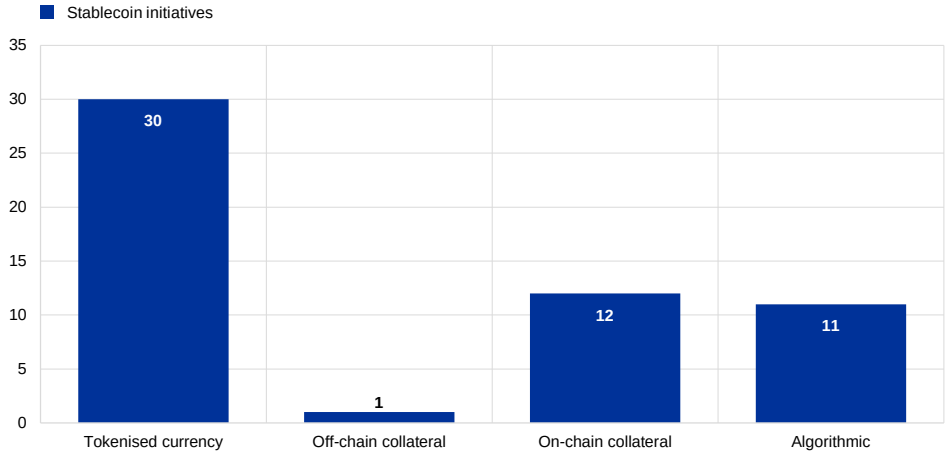
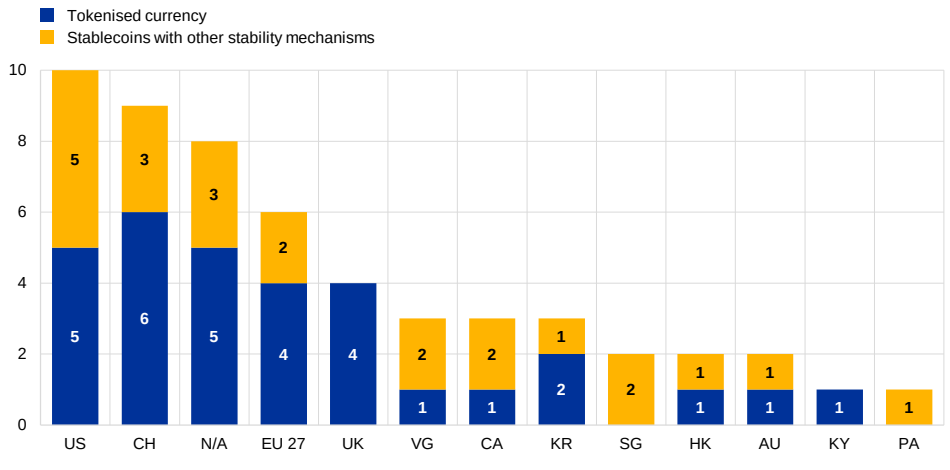


Chart 2 shows the jurisdictions where the headquarters of fifty-four active stablecoin initiatives are located. While eight initiatives did not disclose their location, almost one third of all stablecoin initiatives are based in only two countries, i.e. nineteen are located in either the United States or Switzerland. Some countries appear to offer companies favourable conditions in terms of taxation or legislative requirements (e.g. British Virgin Islands or Panama). The EU-27 hosts six initiatives, while the UK hosts four (all tokenised currencies – one referenced to the USD and three referenced to multiple currencies). Some dynamic Asian economies are also featured (Singapore, South Korea and Hong Kong).

Chart 2

Legal headquarters of 54 active stablecoin initiatives



Source: ECB staff elaboration based on publicly available data.

While the share of not-for-profit stablecoins roughly doubled over the last year, the vast majority of stablecoins (~70%) are still for profit.[57]

[57] See Blockchain (2019).

Box 4

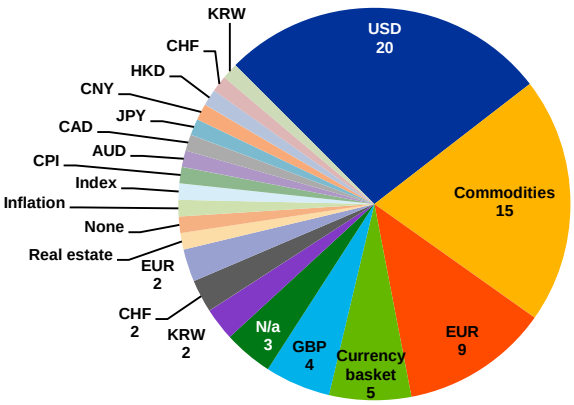
Reference units of initiatives to bring a stable store of value to the crypto-asset market

The stabilisation mechanisms typically used by stablecoins can be used to stabilise the value of digital units of value expressed in a reference other than currency units, for instance by tokenising commodities. If these are pegged to the same asset backing their value, their peg may be narrow, crawling or adjustable. A "narrow" peg will not fluctuate nor be adapted, while a "crawling peg" may fluctuate in a set price band and is automatically re-adjusted periodically to reflect the current market valuation. "Adjustable pegs" on the other hand are allowed to fluctuate within a certain price band, while a deviation that exceeds this band initiates an intervention by the smart contract governing the scheme.

Chart A shows that most of these initiatives, i.e. 72%, are referenced to a currency and fall under the definition of stablecoin in this paper. While some of these initiatives only reference one particular currency, such as the US Dollar, 11 initiatives, representing 14%, issue multiple units referencing a different currency. Similarly, 5 initiatives are pegged to currency baskets[58]. The second most popular reference units are commodities such as gold, other precious metals or oil. Lastly, several initiatives reference alternative units such as the averaged inflation rate of the G10 countries or a Consumer Price Index. Moreover, pegs to proprietary indices can be observed, for example a peg to an index of prices of diamonds. A stablecoin without a fixed peg also exists, using an "increasing target price curve". Three initiatives did not disclose their reference target but claim generically that the protocol they are developing is intended to ensure that the units issued will have a stable price.

Chart A

Reference units of stablecoins and of tokenisation of commodities



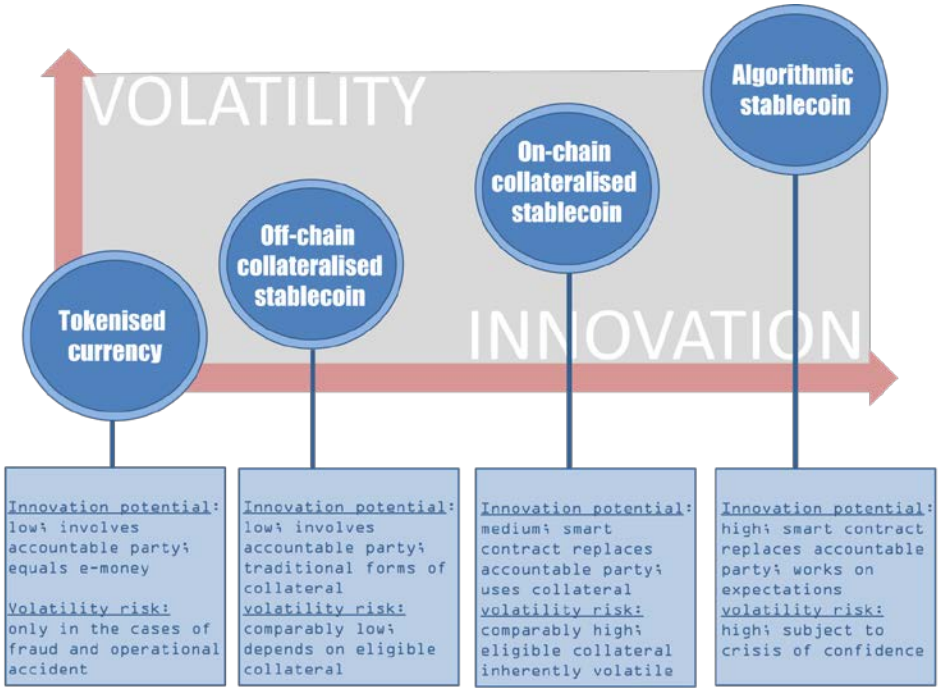
Source: ECB staff elaboration based on publicly available data.
Notes: This chart aims to reflect the reference targets of stablecoins. In the case of one stablecoin initiative issuing multiple stablecoins pegging to different reference units, all of these stablecoins have been counted separately. Labels not showing a value have a value of 1 that is not displayed in order to increase readability.

[58] Initiatives pegged to multiple currencies and currency baskets are consolidated under "multi-currency".

3 Role and implications of stablecoins in the crypto-asset market and beyond

This section focuses on the trade-off between the level of innovation involved in the stabilisation mechanism underpinning each of the stablecoin types identified in this paper and the stablecoin's capacity to provide a stable store of value, especially within the crypto-asset markets but also in the broader economy. Figure 8 anticipates the main results of this assessment.

Figure 8
Assessment of stablecoin types

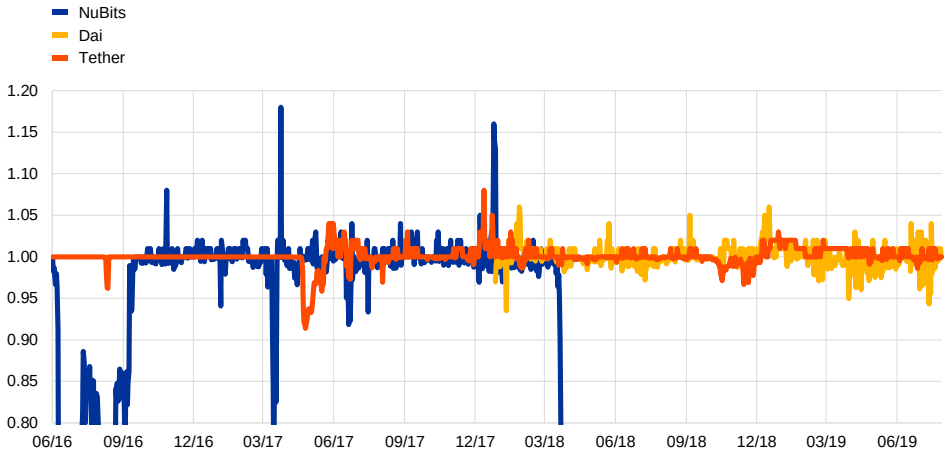


While this assessment is mostly qualitative, its findings in terms of volatility are confirmed by the three representative stablecoin initiatives that have been discussed in detail in the first three boxes in this paper (TetherUSD, Dai and NuBits).

Chart 3 shows the evolution in the prices of the three stablecoin initiatives. While only Tether USD has been active since the early stages of stablecoin development and is still traded, Dai was only introduced at the end of 2017. NuBits can be considered to have already lost its peg in March 2018.

Chart 3

Daily closing prices of representative stablecoin initiatives

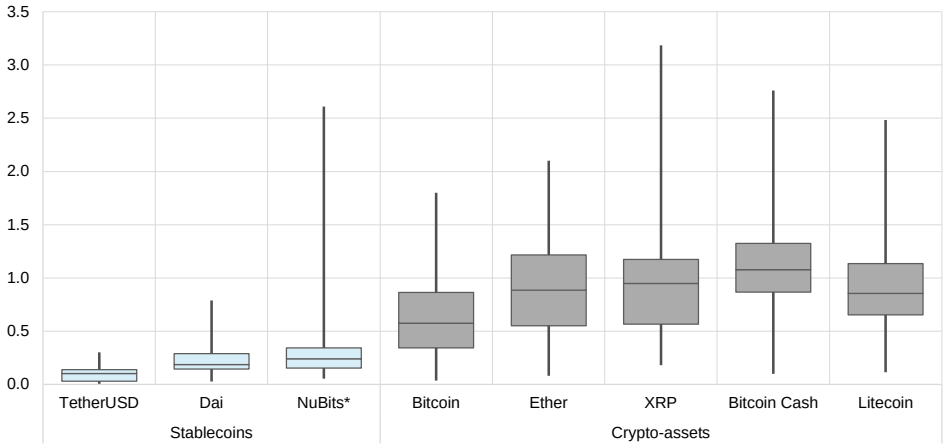


Source: ECB staff elaboration based on data from coinmarketcap.com up to 28 July 2019.

Notwithstanding the limitations due to the lack of a sufficiently long sample period where all three initiatives were active, Chart 4 compares the respective historical volatilities, including also those of major crypto-assets.

Chart 4

Historical volatility of selected stablecoin initiatives and crypto-assets



Source: Based on ECB staff elaboration with data from Coinmarketcap.com.
Notes: The assessed timeframe is the longest comparable period, (i.e. 27 December 2017 to 28 July 2019) with the exception of NuBits (*time period shifted to start in 28 September 2016 and end on 21 March 2018 due to a failure to recover the peg value). Data for the boxplot annualises standardised seven-day rolling averages of the historical volatility.

The average volatility, expressed as the annualised average seven-day standard deviation of daily returns between 27 December 2017 (the earliest date when all three stablecoins considered were traded) and 28 July 2019,[59] is10% for TetherUSD, 27% for Dai and 37% for NuBits. These numbers support the results of the qualitative analysis in Section 3.1-3.3. Below that, net of any misbehaviour and operational mistake, tokenised funds perform better in terms of volatility than collateralised

[59] For NuBits, the time series stops on the day when the stablecoin seems to have permanently lost its parity with the US dollar (21 March 2018). Considering the same time window as the other initiatives, the volatility of NuBits soars to 127%.

stablecoin. The algorithmic stablecoin taken into consideration had the highest volatility even before users lost confidence in it.

The same measure of volatility applied to the five crypto-assets with highest market capitalisation gives values of 69% for Bitcoin, 91% for Ether, 100% for XRP, 117% for Bitcoin Cash, and 96% for Litecoin. Moreover, the volatility of each stablecoin fluctuates far less over time than that of any major crypto-asset.

The main value proposition offered by stablecoins has therefore been to provide a store of value for revenues related to crypto-asset investments[60] without leaving the DLT environment. As long as the financial system does not provide an interface between the financial market and crypto-asset market[61] – something that poses difficulties given the price volatility and legal risk currently related to this activity – it is expected that stablecoins will continue to play their original role.[62]

More recently, some stablecoin initiatives offered a possible solution for the payment leg of transactions involving financial claims (e.g. equity and bonds) recorded on distributed ledgers. Issuers of financial claims are however obliged to identify holders of their claims under virtually all jurisdictions. It is also unclear why the payment rails of major currencies should not integrate with trading platforms that, by dealing in regulated financial claims, are part of the broader financial market.[63]

Some initiatives focus on international remittances and are meant to transfer stablecoins referencing a given currency to anybody connected to the internet, without using the channels of financial institutions and while avoiding the inconvenience of carrying cash. Adoption of stablecoins for remittances is therefore likely to depend on the ability of the financial sector to provide similar services conveniently in the location and currency relevant to prospective users.

Finally, some proponents of stablecoins suggest that these could become a mainstream tool in retail businesses. However, none of these initiatives have gained acceptance so far. The only retail market where stablecoins are currently used is that of the so-called “distributed applications” or “dApps”, which is discussed in Box 4. Participants in the dApp economy, similar to those in the crypto-asset market, are often motivated by an ideological aversion to standard payment channels and/or by an interest in hiding their identities.

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60 When assessing historical data YTD (1 May 2019), Tether accounts for roughly 80% of the daily Bitcoin trading volume.

61 Current examples include the launch of exchange traded funds covering crypto-assets.

62 While some investors in crypto-assets use stablecoins because conversion between crypto-assets and major currencies is rarely provided by financial institutions and can be a costly process, anecdotal evidence shows that some of them do so for the possibility of avoiding traditional financial rails and the identity checks associated with them.

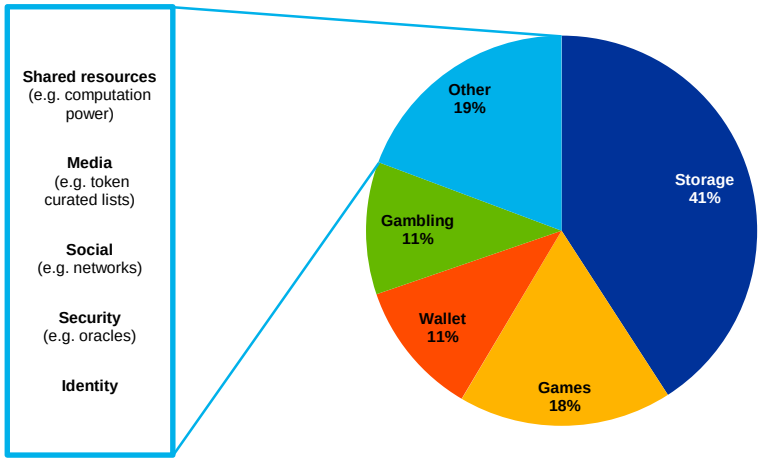
63 The joint project Stella by the ECB and Bank of Japan showed that DLT can be used to provide the infrastructure for both payment and delivery versus payment transactions, although it does not currently offer all reassurances needed for systemically important infrastructures.

Box 5
The dApp economy

Decentralised apps (i.e. dApps) build on unrestricted DLT and offer a specific service, connecting users and providers directly without the involvement of intermediaries. Due to its emerging nature and the very limited access to reliable data sources, the dApp economy has remained rather unchartered, but appears to be of non-negligible size. More than 2,000 dApps have been identified, which are being used by over 100,000 active users on a monthly basis.[64] By extrapolating historical data on the USD denominated volumes of crypto-assets interacting with non-financial sector dApps' smart contracts it can be projected that dApps will create an annual trading activity of EUR 2.2 billion.[65] As shown in Chart A, storage alone attracted almost half of all users[66], when restricting the focus to the real economy.

As anecdotal evidence suggests some inconvenience is experienced in relation to the usage of dApps and users might be attracted to this economy for other reasons. The innovative component of respective goods and services offerings seems to be restricted to the decentralised manner in which they are delivered. Respective adoption thus seems to be interlinked with users' self-ascribed ideology.[67] Alternatively, usage could be driven by the opportunity to make (pseudo-)anonymous payments (e.g. for gambling) or use money for/from illicit purposes. While no reliable projections can be made at this stage, stablecoins might be increasingly used in the dApp economy and thus promote and facilitate wider acceptance of dApps.

Chart A
Sectors of the dApp economy by active users



Source: ECB staff elaboration based on publicly available data.

64 ECB staff elaboration based on data from the websites “DappRadar” (https://dappradar.com/) and “State of the DApps” (https://www.stateofthedapps.com/).

65 This extrapolation averages the reported volumes in USD for all dApps listed on either “DappRadar” or “State of the DApps”. It averages the volumes from December 2018, January 2019 and February 2019 to obtain a base for the annual projection.

66 The category “other” includes the remaining sectors with less than 10 active users. This graph is compiled using data from “State of the DApps”.

67 The desire for greater anonymity is usually an inherent product of a decentralised structure. While this appreciation of anonymity might stem from the wish to circumvent capital controls or engage in other illicit behaviour, it might also merely reflect the personal preferences of a user.

3.1 Tokenised funds

From a functional viewpoint, tokenised funds can fall under different asset types, including electronic money, commercial bank money in prepaid payment systems and – if issued by a monetary authority acting as currency board – pegged currency. What matters for the purposes of the analysis in this paper is that the tokenisation of funds denominated in any given currency does not constitute a new type of asset. It is rather an example of a traditional asset that uses DLT as its infrastructure and, on a case-by-case basis, may fall outside the scope of the regulatory framework that is applied to similar centralised initiatives or schemes while posing similar risks to the economy. If one could prove that funds backing tokenised funds units are kept safe and risks related to the technology used are negligible, they would be more than an attempt to limit the volatility of their price in the currency of reference: they would be economically fungible with funds in the same currency.[68] To the extent that tokenised funds initiatives lack proper governance and are not subject to clear regulation, the value of these stablecoins does fluctuate due to the lack of guarantee over the custody of appropriate funds and fear of market manipulation.

Tokenised funds for retail use[69]

The stablecoin units issued as tokenised funds are sometime electronic money, as defined by the second Electronic Money Directive (EMD2) in the EU.[70] The assessment of whether any of these initiatives should also be subject to the provisions in the EMD2 goes beyond the purpose of this paper and is left to the relevant EU and competent authorities of Member States. The European Banking Authority (EBA, 2019) reported that there are cases in which these stablecoin initiatives would, in the opinion of national competent authorities, satisfy the definition of “electronic money”. Moreover, the company Circle obtained an e-money institution license in the United Kingdom for its stablecoin USDC.[71]

The use of electronic money, and therefore of at least some tokenised funds initiatives, is not free of risks to its users and to the broader economy. The specific risks that matter from the point of view of the central bank are described in detail in the seminal ECB report on electronic money[72] and in its legal opinions on related EU legislation.[73]

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68 The same result applies to any stablecoin initiative that is denominated in the same asset used to (fully) back the units it issues. Initiatives denominated in other than currencies, however, fall outside the scope of this paper.

69 The use of DLT and smart contracts for the provision of payment services in a currency of reference across a limited set of entities (e.g. banks or companies) is discussed in Section 3.4.

70 See Article 2(2) of Directive 2009/110/EC: “electronic money” means electronically, including magnetically, stored monetary value as represented by a claim on the issuer which is issued on receipt of funds for the purpose of making payment transactions as defined in Article 4(5) of Directive 2007/64/EC, and which is accepted by a natural or legal person other than the electronic money issuer. Directive 2007/64/EC defines a payment transaction as “an act, initiated by the payer or by the payee, of placing, transferring or withdrawing funds” and funds as “banknotes and coins, scriptural money and electronic money”.

71 See here for instance.

72 See European Central Bank (1998).

73 See Opinions of the European Central Bank 1999/C 189/07 and 2009/C 30/01.

Firstly, material development of electronic money in the EU could have significant implications for the conduct of monetary policy, regardless of what infrastructure is used. While currently existing volumes of tokenised funds are way too small to create problems in this regard, future developments cannot be excluded and warrant monitoring. For this reason, electronic money schemes that are licensed under the applicable legislation must supply the central bank in each relevant EU country with any information, including statistical information, which is required for monetary policy purposes.[74] The fact that most tokenised funds initiatives do not report data on their use in the different jurisdictions may raise concerns if their use grows in the future.

Secondly, with a view to supporting public confidence in the currency in which they issue electronic money, issuers are generally licensed and subject to prudential supervision. For this reason, persons and undertakings other than licensed electronic money institutions (and credit institutions) are prevented from engaging in the business of issuing electronic money. Tokenised funds initiatives are economically equivalent to electronic money schemes and may warrant a similar regime.

Thirdly, protection against criminal abuse such as money laundering must be taken into account when designing and implementing electronic money schemes. In this respect, it is worth noting that the application of the fifth anti- money laundering Directive (AMLD5)[75] to transactions in an asset that is qualified as "virtual currency"[76] rather than as electronic money requires the identification of its users only when they make use of either providers of exchange services between virtual currencies and fiat currencies or custodian wallet providers. However, some stablecoin initiatives allow users to engage directly in the exchange and custody of funds without the intervention of any accountable trading platform or custodian.

Fourthly, issuers of electronic money must be legally obliged to redeem electronic money at par, at the request of the holder of the electronic money, while redemption fees shall be proportionate and commensurate to the actual costs incurred by the electronic money issuer. Tokenised funds initiatives generally do not comply with this requirement, which aims at preserving the unit-of-account function of money, to maintain price stability by avoiding the unconstrained issuance of electronic money, and to safeguard the controllability of liquidity conditions and the short-term interest rates set by the central bank.

Finally, issuers of electronic money are obliged to hold customers' funds in a bankruptcy remote account and can only invest them, subject to conditions set out in national legislation, in very low-risk assets.[77]

If issuers of tokenised currencies were subject to similar provisions and licensing regimes, they would obtain legitimation and could possibly gain acceptance in the retail payment market where they would compete with similar businesses that use

74 Member States can grant exemptions for schemes whose average issuance is no more than €5 million.

75 Directive 2018/843 of the European Parliament and of the Council of 30 May 2018.

76 Virtual currency is defined in the AMLD5 as "a digital representation of value that is not issued or guaranteed by a central bank or a public authority, is not necessarily attached to a legally established currency and does not possess a legal status of currency or money, but is accepted by natural or legal persons as a means of exchange and which can be transferred, stored and traded electronically".

77 Licensed e-money institutions are also subject to capital and liquidity requirements.

traditional technology. At the same time, tokenised funds initiatives could lose those users who do not want to interact with the regulated financial sector and prefer to bear the risk of holding their funds with unregulated entities rather than disclose their identities.

To the extent that issuers of tokenised funds convince their users that their holdings are as safe as regulated electronic money, any volatility of a stablecoin value in the currency of reference would need to be explained through market imperfections. These typically consist of transaction costs (fees and delays that may lower the market value of the tokenised funds units) and different usability (use of tokenised funds when other solutions are not practical, which can increase their price above parity with the currency of reference[78]).

Tokenised funds outside the jurisdiction of the currency of reference

Tokenised funds could in principle be issued by a monetary authority acting as a currency board, which can be defined as “a monetary institution that issues base money solely in exchange for foreign assets, specifically the reserve currency” .[79] Such an initiative would likely not fall under the regulation of the jurisdiction issuing the main currency, due to the particular legal status of the issuer and the fact that it offers tokenised funds in a different jurisdiction. Notwithstanding the different degrees of accountability between a monetary authority and a private issuer (or network of users), the possibility of transferring tokenised funds via electronic entails risks similar to those mentioned in relation to electronic money, when the tokens can be used in the jurisdiction of the currency of reference.

An example of new asset type that could develop around the business model of tokenised funds is the tokenisation of a basket of currencies, which has been repeatedly suggested but has not yet happened on a large scale.[80][81] Such a global asset would still need the involvement of an accountable institution that needs to hold the funds in different currencies and to issue the global tokens. The value of such a “global stablecoin” would not be stable in any single currency, nor would it track the price index of any local economy, but it would follow the weighted average of currencies in the basket. The allocation of weights would need to be defined in line with the purpose of the stablecoin initiative and would be arbitrarily set by its governance. A tokenised basket of currencies seems therefore more suited to

78 For instance, the closing price of tokenised currency USDT was more than 2% above par with its currency of reference in 9.2% of the time during 2017 and 2018.

79 See Williamson (1995).

80 Special drawing rights (SDR) issued by the International Monetary Fund (IMF) are different from tokenised currency. They cannot be used for the purchase of goods and services and are neither a currency nor a claim either on the IMF or on any central bank reserve. They are interest-bearing reserve assets used as a way to support the official reserves of IMF member countries and to facilitate the sharing of liquidity in major freely usable currencies among them. See Section 4 of International Monetary Fund (2018).

81 More recently, Facebook launched the Libra project which according to the Libra White Paper is "made up of three parts that will work together to create a more inclusive financial system: It is built on a secure, scalable, and reliable blockchain; It is backed by a reserve of assets designed to give it intrinsic value; It is governed by the independent Libra Association tasked with evolving the ecosystem.“ The stablecoin Libra will be “fully backed by a reserve of real assets. A basket of bank deposits and short-term government securities will be held in the Libra Reserve for every Libra that is created.”

potentially facilitating international trade and cross-border financial transactions, including possibly remittances, than to providing either a stable store of value in crypto-asset markets or a retail means of payment for use across a number of jurisdictions.

3.2 Collateralised stablecoins

The value of assets other than funds, expressed in the currency of reference, is bound to fluctuate over time.[82] Collateralised stablecoin initiatives are often pictured as collateralised loans, where the governing entity or smart contract would lend out "money" and require the borrower to post additional collateral in case it becomes insufficient to secure the loan.

This parallel is misleading, since collateralised stablecoins are not fungible with the currency of reference. They are instead claims on the pool of collateral held by a lender whose assets may shrink and become insufficient to support the value of the overall issuance, depending on whether other users decide to maintain their collateral position or not, and who does not have access to a lender of last resort to withstand temporary shocks. In this respect, collateralised stablecoins are more similar to obligations of the lender/stablecoin initiative than to money.

The volatility of collateralised stablecoins depends on: (i) the choice of eligible collateral and the volatility of its price in the currency of reference; (ii) the collateralisation ratio; and (iii) the use of secondary mechanisms.

3.2.1 Off-chain collateralised stablecoins

The price of different assets used by off-chain collateralised stablecoins can exhibit different volatilities. While more volatile assets are less able to support a stable value of the stablecoin they are meant to back, safer assets are not per se guarantee of stability since it may be difficult to find additional eligible collateral in turbulent market conditions. The level of over-collateralisation that is needed to allow users to adjust their collateral positions ahead of any substantial deterioration depends on these considerations.

Provided the type of collateral and level of over-collateralisation are sufficient, standard arbitrage arguments should keep the stablecoin priced close to par amidst short-term fluctuations: when the stablecoin units are priced below par, traders have an incentive to increase their demand to buy units backed by good collateral; when the stablecoin units are priced above par, traders have an incentive to increase their supply to profit from selling their units.

Market imperfections need to be considered. The need to store collateral underlying off-chain collateralised stablecoins may add costs that hamper the abovementioned arbitrage argument. Moreover, the value of the stablecoin needs to be isolated from

[82] A collateralised stablecoin backed 100% by funds is clearly tokenised currency.

the value of the underlying collateral – typically by detaching any stablecoin unit from the specific collateral position underlying it and by linking it instead to the overall collateral pool of the stablecoin initiative. Efficiency in the off-chain market infrastructure and business arrangements along the custody chain is also crucial in facilitating arbitrage and limiting the volatility of a stablecoins.

While an institution could provide digital representations of value backed by off-chain collateral directly on its books, their provision on a distributed ledger may prove useful to participants in the crypto-asset market.

3.2.2 On-chain collateralised stablecoins

On-chain collateralised stablecoins use crypto-assets as collateral and are subject to their high volatility. The fact that the prices of different crypto-assets are highly correlated[83] limits potential benefits from using a basket of different crypto-assets. For this reason, the collateralisation ratio of these stablecoins is typically above 150%.[84] Still, on-chain collateralised stablecoins need to use a broad range of secondary stabilisation mechanisms to keep their value stable. The complex interaction among the primary and secondary stabilisation mechanisms may hinder the ability of their users to fully understand how the volatility of underlying assets is limited in practice.

The main innovation brought about by on-chain collateralised stablecoins is the absence of any responsible entity in the maintaining and operating the initiative. From this perspective, these stablecoins can be considered as an evolution of crypto-assets. Full reliance on a distributed network implies that there is no single point of failure, but also loose governance. It also implies that nobody is accountable for identifying users and avoiding the use of stablecoin units in illicit activities. This risk is amplified by the fact that the issuance of stablecoin units usually does not include any customer due diligence.[85] This phenomenon is particularly hard to control since stablecoins may be traded on decentralised exchanges, which have minimal setup costs and do not allocate any liability to a responsible party.

3.3 Algorithmic stablecoins

As with on-chain collateralised stablecoin initiatives, algorithmic stablecoins do not need to interact with the existing financial system and may be seen as an evolution of crypto-assets. Proponents of this type of stablecoin initiative claim to be able to set up an “algorithmic central bank” with its own “algorithmic monetary policy”.

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83 Yi, Xu & Wang (2018) find that many crypto-assets are highly interconnected with significant volatility spill over effects. Burnie (2018) found a strong correlation (i.e. Spearman’s $\rho \geq 0,5$) for more than 50 crypto-asset pairs. Irrespective of this strong interdependence neither Bitcoin nor any other individual crypto-assets have a dominant impact on the entire crypto-asset market (c.f. Ciaian, Rajcaniova & Kancs (2018) and Corbet, Meegan et al. (2018)).

84 If one uses the parallel with secured loans that would imply a loan-to-value ratio of below 66%.

85 This is the case for MakerDAO, currently accounting for roughly three quarters of the total market capitalisation of on-chain collateralised stablecoins.

To the extent that a stablecoin is not prominently used in a jurisdiction and the objective of its smart contract is limited to maintaining a stable value in the currency of reference, the "monetary policy" it can and aspires to implement is purely passive: the smart contract aspire to cope with observable fluctuations in the price of stablecoin units, rather than with the broad range of current and future shocks that could hit the economy in which the currency of reference is used.

Sometimes the parallel between smart contracts and central banks is expounded in a more ambitious way, pointing to the possibility that an algorithmic stablecoin could at some point replace the official currency of a jurisdiction. Proponents of algorithmic stablecoins support the idea that their algorithms could take on the role of a monetary authority since they are able to provide a (i) strict and (ii) publicly auditable monetary policy rule. While this paper does not deal with monetary policy, a parallel between the approach of algorithmic stablecoin initiatives and that of major central banks to the issuance of money helps us to understand the possible role of algorithmic stablecoins in crypto-asset markets and beyond. The value of central bank money hinges on the expectation that the issuing central bank will keep the purchasing power of the units it issues relatively constant over time, reacting to observable and unobservable shocks in the real economy as well as to the expectations of economic agents over future shocks.

The discussion hinges on whether central banks should base monetary policies on what can be simplistically defined here as (a) strict rules, (b) targets, and (c) full discretion. Discussion on this issue has taken place for decades in the central bank and academic communities.[86] As pointed out by Constâncio (2017)[87], one of the reasons why central banks tend not to use strict rules when setting their policy rate decisions is that these are "unlikely to be suited for all possible contingencies. The environment in which policymakers have to act is much more complex than what is assumed in any model-based analysis of [candidate] policy rules". Monetary policy responses to the financial crisis are an example where central banks reacted to changed circumstances: "not only did central banks pay increasingly more attention to many new variables, when calibrating policy interest rate to evolving economic and financial conditions but they also had to devise new monetary policy instruments to respond to new types of financial market disruptions".

Changing a smart contract to update the algorithm dealing with supply and remuneration of stablecoins would be feasible in theory, but it would require users to try to understand the implications of different options and to reach a consensus that has proven difficult for much simpler decisions relating to the governance of unrestricted DLT networks.

The fact that major central banks do not stick to a rule does not imply that they implement their policies in a discretionary way.[88] Targets are announced, independent

[86] See, for example, Svensson (1999) and Taylor (1993).

[87] "The future of monetary policy frameworks", lecture by Vítor Constâncio, Vice-President of the ECB, at the Instituto Superior de Economia e Gestão.

[88] See, for example, Kydland and Prescott (1977).

of any external interference but in line with the democratic mandate received by the elected bodies to which a central bank is generally held accountable.[89]

3.4 Stablecoins as a misnomer for new technical infrastructures

The taxonomy of stablecoins presented in this paper shows that this new term is sometimes associated with traditional assets recorded via new technology, like in the case of tokenised currencies. This is part of a tendency to include, under the umbrella term "stablecoin", any new IT infrastructure project aiming to use DLT in the payment industry.[90]

The use of DLT to record and transfer a range of financial and payment instruments (or their representation) in digital form is a future possibility that should not be mistaken for the issuance of new asset types. Doing so runs the risk of considering the use of new infrastructures as bringing new risks (beyond those of operational nature connected to a new technology) and of hampering the launch of said projects within business practices and regulatory frameworks that are technology-neutral and in principle fit for dealing with their consequences on the economy.

For instance, the use of DLT by a credit institution to either record or simply book transfers of commercial bank money on its books shall neither change the nature of said money nor have particular implications for the economy. Even when different credit institutions join forces to create a consortium clearing reciprocal payments through use of a DLT, the innovation resides in the use of a new infrastructure for a traditional business rather than in the use of any new asset. Another possibility is that a technology service provider, possibly neither a payment nor a financial institution, makes DLT infrastructure available for issuers of different types of stablecoins. Such a move would be in line with the recent tendency towards a "platformification" of the economy, which may facilitate the direct linking of financial services to fintech solutions, social media and messaging services.

A platform for the recording of stablecoins and other assets using DLT and smart contracts may either benefit interoperability and competition among different DLT-based infrastructures and issuers – if its governance aims at harmonising the business and technological standards adopted by different operators and issuers competing *in* the market –, or lead to increased fragmentation if multiple initiatives emerge that compete *for* the market.

89 According to Coeuré (2017), the target below but close to 2% constitutes "The foundation for a healthy and stable European economy".

90 Another example is labelling anything that is recorded via DLT as a crypto-asset, regardless of whether it constitutes a new type of asset, a financial instrument or a form of funds.

3.5 Outlook on the future role of stablecoins

As described in Section 2, stablecoin initiatives leverage a set of tools that allow different degrees of decentralisation – namely smart contracts, public information on excess supply/demand and the disintermediation related to users having direct access to a DLT network.

The management of smart contracts is particularly relevant for on-chain collateralised and algorithmic stablecoins, the governance of which is closer to the approach of crypto-assets since no single user (or relatively small coalition thereof) should be able to change the computer protocol at the core of the initiative. In fact, when a smart contract is modified according to the rules of an unrestricted DLT network, users who are meant to execute it and validate transactions are free to decide whether to accept the changes or not.[91] That makes it difficult to amend any possible flaw in the code and to add functionalities when it is necessary – i.e. to face new cyber risks. Current approaches aiming to manage smart contracts in an unrestricted network include some centralisation of responsibilities over their upgrading, via a multi-signature approach that allows a restricted number of users to edit the relevant smart contract (either partially or in full). Another possible strategy, which should minimise the occurrence of flaws in a new or edited smart contract, is the "formal verification" of software. Formal verification should ensure that any input processed through the smart contract generates the intended output.

Public information on excess supply/demand in the market for stablecoins is also necessary for the correct functioning of innovative stablecoin initiatives, since they constitute the basis on which the smart contracts that are intended to issue/redeem units with a view to avoiding fluctuations in their price. Malicious actors could provide false information to benefit from market movements and three distinctive approaches are commonly used to avoid this scenario. The first solution is to rely on data provided by a trusted entity, which introduces some degree of centralisation. Secondly, it is possible to use the median of multiple data providers, disregarding those outliers that deviate too much from it. Lastly, information can be obtained by providing economic incentives. For instance, users can be allowed to submit bids on the price of the stablecoin and those bids that fall outside a predefined range can be used to remunerate the winning bidders.

While unrestricted DLT networks aim to disintermediate markets by allowing direct access to anybody, reliance on a single distributed infrastructure raises the risk that peaks in its usage increase costs and execution time and so create a liquidity risk. This is especially important given the lack of proper governance to manage upgrades of the infrastructure and a cyber-security framework.

At the current juncture, the afore-mentioned issues pose a significant challenge to stablecoin initiatives and are clearly exacerbated by decentralised governance. However, stablecoins only arose relatively recently and the respective development, both in technological terms and in relation to governance arrangements, should thus

[91] If some users do not accept the edit, the network is said to "fork" and different sets of users will agree on different sets of transactions – which can affect the credibility of the stablecoin initiative and its capacity to validate further transactions.

be monitored carefully. Indeed, stablecoins remain the most stable alternative in the crypto-asset markets and demand for them may be expected to remain sustained unless other alternatives become available.

Besides crypto-asset markets and the phenomenon of dApps, some stablecoin initiatives aspire to become relevant in the areas of retail payments, remittances and markets in financial claims such as securities.

From today's perspective, stablecoins do not seem to be a game changer in the area of retail payments for economies with a stable currency and well-functioning payment systems. They may however constitute a solution in developing economies where trust in the currency and in the payment system is low. Some stablecoin initiatives might therefore be used for retail payments in those economies, provided that the aforementioned criticalities are properly addressed. Given that the cost of remittances to some countries is still high, stablecoins might also be used in this field but a solution is needed for their usability in the country of destination – either through interoperability with the local financial market or through direct acceptance in retail transactions. It should be noted that the potential usage of stablecoins in the payments domain triggers particular questions around regulatory compliance, which deserve further analysis on a case-by-case basis, but fall outside the perimeter of this paper.

Finally, in markets where either the initial recording or the subsequent tokenisation of financial claims on distributed ledgers is being considered, stablecoin proponents suggest that their solutions will be more easily adopted because they are recorded on distributed ledgers from their outset. Besides regulatory requirements to only use some specific forms of money for some types of transactions,[92] the competition from financial institutions that provide their traditional commercial bank money and/or electronic money using DLT should not be underestimated. Trusted entities could use new IT infrastructure to leverage the same alleged efficiency gains the use of this technology provides to stablecoins initiatives.

[92] The regulation of major economies requires that transactions in financial instruments be settled either in central bank money or, where not practical, in forms of money featuring minimal liquidity and credit risk.

4 Conclusions

This paper proposes a taxonomy of stablecoins based on the different primary mechanisms used to stabilise their value. While some initiatives include secondary stabilisation mechanisms, the primary mechanism alone allows us to ascertain that some types of stablecoins have the potential to maintain a stable value in the currency of reference regardless of market developments. This result shows a trade-off between the level of innovation offered by different types of stablecoins and their capacity to keep their price stable in the currency of reference.

The description of different types of stablecoins and of the current market landscape confirms that some major stablecoin initiatives follow the business model of traditional electronic money and prefunded payment systems, which means that they issue a "tokenised" form of the funds backing them, denominated in the currency of reference, on DLT networks. Initiatives of this type are dubbed stablecoins to the extent that they may, on a case-by-case basis, fall outside the current regulatory regimes.[93] However, the risks that they entail and that matter to central banks are the same as for their non-DLT competitors. These risks pertain to (i) the monitoring of monetary aggregates, which are currently unaffected by the scale of tokenised funds businesses but warrant scrutiny in case of future developments; (ii) micro-prudential supervision, the avoidance of which may impact users and their confidence in the currency of denomination; (iii) use for illicit purposes, in which case the anti-money laundering regime imposed on the use of generic "virtual currencies" in the European Union is not as restrictive as the constraints applied to traditional electronic money businesses; and (iv) protecting the unit-of-account function of the currency and the controllability of liquidity conditions in the economy and the short-term interest rates set by the central bank.

Collateralised stablecoin initiatives are subject to the volatility of the underlying collateral and involve a number of secondary stabilisation mechanisms that may be seen as truly innovative. Remarkably, some stablecoins backed by "on-chain" collateral have managed to withstand the fluctuations and downward price trend of crypto-assets used as collateral, although they do not constitute a claim on any accountable issuer.

Finally, algorithmic stablecoins are interesting from a research perspective but still economically insignificant, with the ones already in production having only a combined average market capitalisation of €9.7 million from 1 January 2019 to 28 July 2019. Proponents of these initiatives claim to be able to create an algorithmic central bank that would constitute an improvement on current monetary authorities, thanks to the transparency and time-consistency offered by a strict monetary policy rule. In fact, the debate between rules and (targeted) discretion has been taking place for decades in the central banking community and major central banks have clearly favoured the flexibility of working independently towards target levels of macroeconomic variables in the medium term, while providing forward guidance for economic actors and

[93] In the case of electronic money, see European Banking Authority (2019).

remaining accountable to the public. Therefore, while algorithmic stablecoins appear highly innovative, they are a move in the opposite direction compared with the approach taken by major monetary authorities and have not proven to be capable of limiting the volatility of their value beyond the short term.

The analysis in this paper shows that the relationship between the innovation of a particular type of stablecoin and its capacity to limit price volatility expressed in a currency of reference is strong and these two characteristics are inversely related. While less innovative stablecoins could provide a solution for users seeking a stable store of value, especially if legitimised by adherence to the standards typical of traditional businesses, the jury is still out on the role that more innovative but volatile stablecoin types may play in the future. Some on-chain collateralised stablecoins have proven they can withstand large fluctuations of underlying collateral, but it is unclear whether this is due to effective stabilisation mechanisms or to the stickiness of users driven by a strong interest in protecting their privacy and/or remaining outside the financial system. Finally, algorithmic stablecoins are still a theoretical alternative rather than a practical solution. Their development warrants close observation as they may give rise to renewed debates in the academic and central bank communities.

Uncertainties concerning the governance and regulatory treatment of stablecoin initiatives exist. An uptake in the usage of stablecoins may require improvements to the governance of such initiatives, including procedures to update the smart contracts at the core of the initiative and a cyber-security framework. However, stablecoin initiatives with a clear governance framework may nevertheless be hampered by the uncertainty relating to the lack of regulatory scrutiny and recognition. This is especially relevant given that financial institutions could use the same technology for the recording of traditional assets (commercial bank money and regulated electronic money) and make stablecoins redundant in the use of DLT outside crypto-asset markets.

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Appendix: Stablecoin initiatives considered in the paper

Stablecoin	Type	Reference peg	Status	Legal HQ
Terra	algorithmic	currency basket	in development	Singapore
Kowala	algorithmic	USD	uncertain	Cayman Islands
Steem	algorithmic	USD	live	United States
NUBITS	algorithmic	USD	live	Canada
XANK	algorithmic	currency basket	in development	South Korea
Unum	algorithmic	USD	in development	n/a
Forctis	algorithmic	USD	in development	Switzerland
MonetaryCoin	algorithmic	USD	in development	n/a
Photino	algorithmic	USD	in development	United States
StableUnit	algorithmic	USD	in development	Canada
Republia	algorithmic	USD	in development	British Virgin Islands
Sweetbridge	off-chain collateral	USD	in development	Switzerland
Dai	on-chain collateral	USD	live	Switzerland
Synthetix	on-chain collateral	currency basket	live	Australia
Reserve	on-chain collateral	USD	in development	United States
BitUSD	on-chain collateral	USD	live	European Union
Minexcoin	on-chain collateral	USD	live	Hong Kong
Celo	on-chain collateral	USD	in development	United States
Aurora	on-chain collateral	USD	in development	Panama
Cryptopeg	on-chain collateral	currencies	in development	n/a
Alchemint	on-chain collateral	USD	live	Singapore
Bitshares	on-chain collateral	USD	live	European Union
Intercoin	on-chain collateral	USD	in development	United States
IMT	on-chain collateral	USD	live	British Virgin Islands
Tether	tokenised funds	multi-currencies	live	British Virgin Islands
USD Coin	tokenised funds	USD	live	Cayman Islands
TrueUSD	tokenised funds	multi-currencies	live	United States
Paxos	tokenised funds	USD	live	United States
Stasis	tokenised funds	EUR	live	Malta
Carbon	tokenised funds	USD	in development	n/a
SAGA	tokenised funds	currency basket	In development	Switzerland
Monerium	tokenised funds	USD	in development	European Union
CementDAO	tokenised funds	USD	in development	United Kingdom
Gemini	tokenised funds	USD	live	United States
Jibrel	tokenised funds	multi-currencies	in development	Switzerland
Stably	tokenised funds	USD	live	Canada
WhiteStandard	tokenised funds	multi-currencies	live	United States
CoinPayments	tokenised funds	multi-currencies	in development	European Union
Mile	Tokenised funds	currency basket	in development	South Korea

Moneyfold	tokenised funds	multi-currencies	live	United Kingdom
HKDT	tokenised funds	HKD	live	Hong Kong
TOKEN	tokenised funds	USD	in development	United Kingdom
Stronghold	tokenised funds	USD	in development	United States
Augmint	tokenised funds	EUR	in development	United Kingdom
NOS	tokenised funds	multi-currencies	in development	Malta
PHI	tokenised funds	USD	in development	Switzerland
Globcoin	tokenised funds	currency basket	in development	Switzerland
ONRAMP	tokenised funds	USD	live	Australia
Corion	tokenised funds	USD	in development	Switzerland
KRWb	tokenised funds	KRW	live	South Korea
Gluwa	tokenised funds	USD	in development	n/a
Noku	tokenised funds	multi-currencies	live	n/a
Rockz	tokenised funds	CHF	live	Switzerland
PegUSD	tokenised funds	USD	live	n/a

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