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Crypto-Assets Activity around the World

Evolution and Macro-Financial Drivers

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Abstract

On-chain crypto-assets transaction volumes have grown rapidly, particularly during the COVID-19 pandemic. Crypto-assets activity appears to be a global phenomenon, although it still remains modest relative to gross domestic product for most countries. Panel regressions across more than 130 countries show that the variation in countries' monthly crypto volumes is mostly driven by globally relevant factors such as real U.S. longer-term inflation expectations, U.S. real Treasury yields, and gold and crypto-asset prices, rather than recent country-level macroeconomic developments. Cross-sectional regressions offer tentative evidence that crypto activity is higher in countries with higher information and communications technology adoption and higher reliance on remittances. Taken together, the findings shed new light on the drivers behind crypto activity and offer support to the notions that crypto-assets are perceived as a risk asset, a potential macro hedge, and a potential tool to support cross-border transactions. However, the results come with caveats: a significant portion of the sample period includes extraordinarily loose global financial conditions; the crypto volume data have a short history, rely on important limiting assumptions, and do not represent all crypto activity; and crypto-assets represent a fast-evolving, increasingly diverse asset class and industry.

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Crypto-Assets Activity around the World: Evolution and Macro-Financial Drivers

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1 Introduction

Notwithstanding their significant volatility, crypto-assets present both potential opportunities and risks and are increasingly regarded as an emerging asset class by both financial market participants and policy makers, reaching over US$2.8 trillion in market capitalization in November 2021 as both retail and institutional adoption surged (Figure 1). The main objective of this paper is to document the rapid rise in "on-chain" [2] crypto-assets activity around the world -- transactions that are directly recorded on the distributed ledger that underpins a crypto-asset -- and empirically investigate key macroeconomic drivers of crypto-assets volumes to better understand the drivers behind their use. In the context of rapid growth and evolution of this space, understanding these drivers is important for policy makers, end-users, and industry alike. As crypto-assets are currently not widely used as a means of payment or to access decentralized financial services,[3] this paper's research questions focus on two common hypotheses: Are crypto-assets used as a risk asset? Do users across countries perceive them as an emerging hedge against adverse macroeconomic conditions such as high inflation or currency depreciation? We also briefly explore which country characteristics are associated with crypto activity.

While there is no commonly agreed lexicon,[4] crypto-assets can be broadly defined as private digital representations of value that can be used for payment or investment purposes or to access a good or service and rely on distributed ledger or similar technology (e.g., Financial Stability Board (2018a), Financial Action Task Force (2021), Basel Committee on Banking Supervision (2021)).[5] More specifically, crypto-assets typically operate on open, decentralized computer networks which aim to maintain an immutable distributed ledger that enables users to store, transfer, and receive funds 24/7 with global reach and relatively fast settlement in a purely peer-to-peer fashion without the need for intermediaries (i.e., "permissionless") or the potential of third-party interference (i.e., "censorship resistance"). The open-source software protocols enforced by

[2] Not all crypto-assets transactions are "on chain". "Off-chain" transactions are only recorded on centralized ledgers and private order books of intermediaries such as crypto-assets exchanges, custodial wallets, and financial institutions. These "off-chain" transactions may involve buying or selling of crypto-assets in exchange for fiat currency or exchanging one crypto-asset for another.

[3] However, Graf von Luckner et al (2021) find evidence that about 7 percent of "off chain" bitcoin transactions on a large crypto exchange reflect domestic and international payments.

[4] Several other terms are often used by standard-setting bodies, national authorities, academia, and industry, often with slightly different connotations or emphases. These include "crypto currencies", virtual currencies", "digital currencies", "virtual assets", "digital assets", "crypto coins", or simply "crypto".

[5] The definition of crypto-assets excludes e-money, central bank digital currencies (CBDCs), and digital representations of traditional financial instruments.

these decentralized networks allow for consensus formation about the "state of the world"[6] in low-trust environments without requiring a trusted third party and seek to imbue crypto-assets with certain characteristics such as scarcity, verifiability, and, more broadly, programmability (e.g., Nakamoto (2008) and Buterin (2013)). [7]

In response to the volatility of crypto-assets, stablecoins have emerged as a new type of crypto-asset which aims to maintain a stable value relative to a specified asset (typically a fiat currency and most commonly the US dollar), or a pool or basket of assets. Stablecoins have grown explosively with a market capitalization of US$136 billion in November 2021, up from US$28 billion in January 2021, according to The Block. The three largest stablecoins, Tether, USD Coin, and Binance USD, account for about 85 percent of the total. Furthermore, Decentralized Finance (DeFi) has also grown swiftly, a "smart contract"[8]-based crypto-assets financial ecosystem that uses programmability features, spanning, among others, collateralized lending, borrowing, exchange, stablecoins, investment management, and derivatives services (e.g., Harvey et al (2021), JP Morgan (2021a), Schar (2021)). These services are interoperable and can be used as building blocks by users or developers allowing for complex ecosystems to emerge (i.e., "composability"). According to CoinMarketCap, in November 2021, a total of about US$190 billion was locked in DeFi projects, up from about US$20 billion in January 2021. An important driver of this explosive growth is the recent price surge in ether. Ethereum is the dominant DeFi platform, although its share has been falling as rival platforms gain momentum.

While data gaps remain significant (e.g., IMF (2021)), it appears that crypto-assets activity is a global phenomenon. Some industry estimates claim that over 200 million people around the world own or use crypto-assets in 2021 (Figure 1). While its representativeness is not fully clear, a global Statista household survey conducted in 2020 found that there are at least 20 countries where over 10 percent of the respondents own or use crypto-assets (Table 1). According to industry analysis, global crypto-assets activity has grown by over 2,300 percent since Q3 2019 and over 881 percent to Q3 2021 and estimates suggest that the countries with relatively high activity are Emerging Market and Developing Economies (EMDEs) (Chainalysis (2021) and Table 1).

[6] For example, the ownership status of all bitcoins on the Bitcoin ledger or the status of all smart contracts on Ethereum.

[7] The benefits of decentralization come at a cost, typically by posing trade-offs with throughput capacity and/or security.

[8] A "smart contract" is a piece of software that directly controls crypto-assets (also see Szabo (1997)). A smart contract runs on a distributed ledger technology network and can be created by anyone.

The data used in this paper suggest that total on-chain transaction volumes reached US$2.8 trillion in the first half of 2021 alone. In comparison, industry data indicate that total volumes, which include "off-chain" transactions, were approximately US$16 trillion during the same period (CryptoCompare (2021)). Off-chain transactions are facilitated by intermediaries such as crypto-exchanges and are only registered on private ledgers and order books rather than the distributed ledgers that underpin crypto-assets. As such, it is important to keep in mind that the on-chain activity we study in this paper is not fully representative of all crypto-assets activity.

A limited, but growing number of institutions such as corporations, asset managers, and pension funds around the world have started to invest in crypto-assets, bitcoin in particular.[9] Crypto-asset derivatives and futures markets have grown rapidly, and spot- and futures-based exchange-traded products are already active in various countries. Several large international banks, payment card companies, and payment processors have started to offer crypto-asset wallets and related services. And new services have appeared such as crypto-asset-based lending (i.e., on a collateralized basis), borrowing, trading, asset management, and custody solutions, including by asset management companies and large banks which have expressed a desire to become more involved in the crypto-assets space (GFMA, et al (2021)).

The ascent of crypto-assets has put a welcome spotlight on various well-known weaknesses in the traditional financial and monetary system. Some of these deficiencies are related to: financial inclusion, since 1.7 billion people around the world remain "unbanked" and have limited or no access to financial services (Demirgüç-Kunt et al (2017)); (cross-border) payments and remittances, which can be slow, costly, and opaque; citizen's trust in and efficiency of traditional financial intermediaries, as in some countries competition is limited and memories of banking sector stress are still fresh; and macroeconomic policies, given that some countries experience regular bouts of excessive inflation and currency depreciation or volatility. Indeed, crypto activity has risen in various countries that have experienced sharp and persistent declines in macroeconomic conditions. Moreover, given their ease of storage and portability without the need for intermediaries, crypto-assets may also support people "living under the threat of harm by their families, people in their communities, or repressive governments" (Peirce (2021)). More broadly, crypto-assets typically operate on open platforms and open-source software protocols which are

[9] According to Coingecko.com, in November 2021, over 25 public companies around the world, many of them in the crypto industry, collectively held more than US$13.6 billion in bitcoin on their balance sheets.

not controlled by a central entity which may be prone to failure, fraud or rent seeking and are accessible to anybody to use and build upon. Proponents argue that most of the value of open and decentralized systems accrues to participants and innovators, unlike centralized platform companies which tend to become extractive with users and competitive with developers and businesses as they reach scale (e.g., Dixon (2018)). Such conditions may therefore solicit more enduring innovation and network effects and give rise to a new wave of interoperable business models, products, and services. These innovations are not necessarily of a financial nature. For example, distributed ledgers can be used to create a decentralized system for digital identification where users have control and ownership over their own credentials, not third parties (e.g., Microsoft's ION project on Bitcoin).

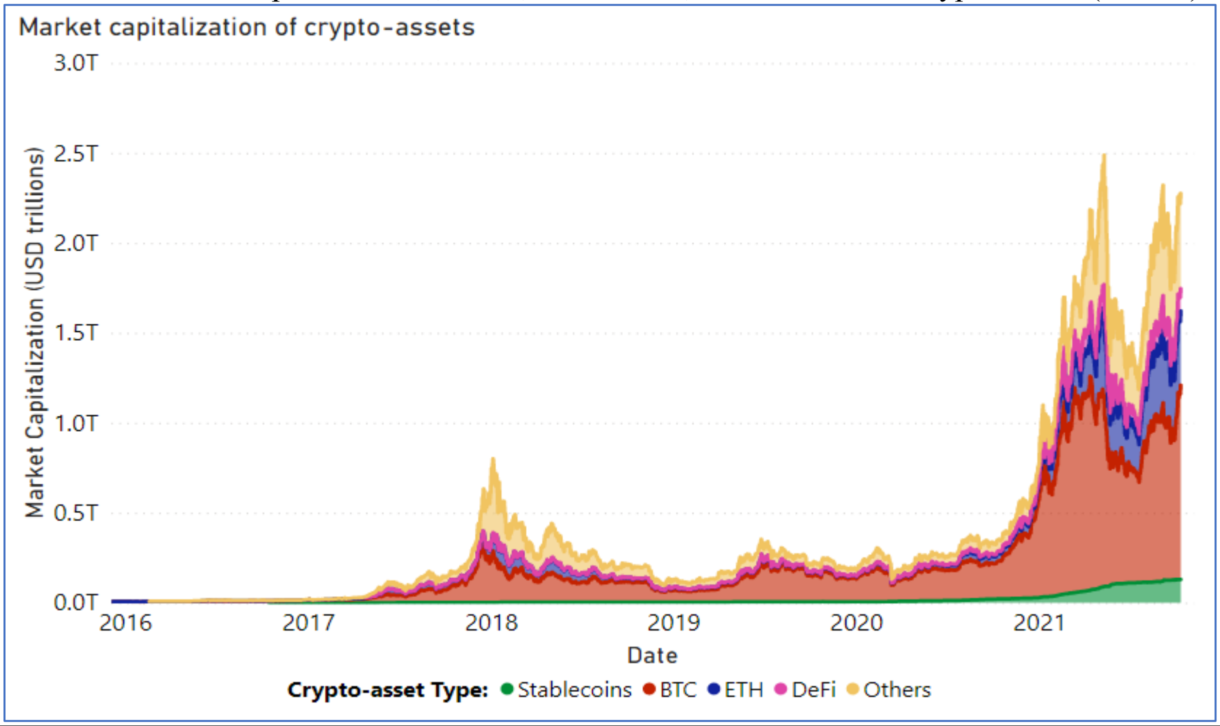
However, the nascent crypto-assets industry also poses various serious challenges and risks. For example, the G20 concluded that crypto-assets *"…raise issues with respect to consumer and investor protection, market integrity, tax evasion, money laundering and terrorist financing. Crypto-assets lack the key attributes of sovereign currencies. At some point they could have financial stability implications."* (G20, 2018). Recently, IMF (2021) re-emphasized financial and monetary stability considerations. The G7 concluded that stablecoins can pose legal, regulatory, and oversight challenges including issues related to, among others, monetary sovereignty, data privacy, cyber resilience, and fair competition (G7 (2019)). In light of their supra-national and cross-border nature, crypto-assets present international regulatory arbitrage risks. Various standard-setting bodies are closely monitoring developments and have issued guidance, recommendations, and binding international rules and minimum requirements (see FSB (2018b) for an early overview). More recent examples include the Financial Action Task Force's (FATF) revised standards and updated guidance for a risk-based approach regarding money laundering and illicit finance of virtual assets and virtual asset service providers (e.g., FATF (2021)); the Basel Committee on Banking Supervision's consultative document on the prudential treatment of crypto-assets (BCBS, 2020); the Financial Stability Board's report on the regulation, supervision, and oversight of stablecoin arrangements (FSB (2020)); and the joint report by the Committee on Payments and Market Infrastructures (CPMI) and the International Organization of Securities Commissions (IOSCO) on the applicability of the Principles for Financial Market Infrastructures to stablecoin arrangements (CPMI-IOSCO (2021)). National authorities around the world have taken very different stances towards crypto-assets: these range from supporting safe innovation and adoption to limiting or banning certain crypto-assets activities – El Salvador has adopted bitcoin as legal tender.

Understanding the main drivers behind crypto-assets usage is important for policy makers, investors, and industry alike. Although Bitcoin, the original crypto-asset, was conceived as a peer-to-peer electronic cash system without the need for a trusted third party such as a central bank or financial intermediary, crypto-assets are currently not widely used as a medium of exchange, although recent research finds evidence that bitcoin is used as a vehicle for domestic transactions and international payments (e.g., Graf von Luckner et al (2021)). Moreover, crypto-assets users may not be motivated by security concerns related to payments in cash or commercial banking services, at least in advanced economies such as the United States (e.g., Auer and Tercero-Lucas (2021)). And while growing quickly, DeFi is still nascent. We therefore explore two other often discussed drivers behind crypto-assets activity in this paper: i) crypto-assets serve as a speculative or risky investment vehicle (e.g., Baur, Lee and Hong (2018) and Athey, et al (2016)) and ii) crypto-assets are perceived as an emerging "digital, scarce, speculative store of value" (Gensler (2021)) which may act as a macro hedge providing protection against monetary and macro-financial weaknesses such as excessive and persistent inflation (e.g., Blau et al (2021) and Conlon, et al (2021)) and currency depreciation or volatility.

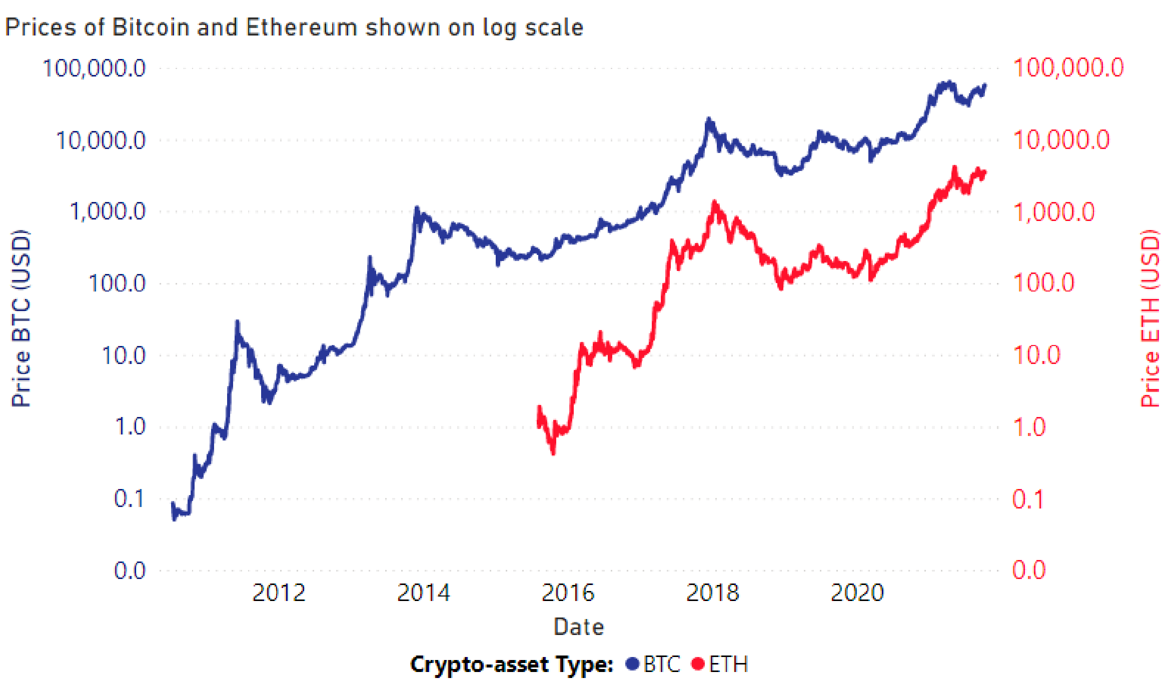
Our paper contributes to a small, but burgeoning literature which empirically investigates the potential drivers and motivations of crypto-assets activity and usage in various ways. First, using a rich monthly data set of on-chain crypto-assets transaction volume estimates at the country level, we document the evolution of usage around the world and analyze both trends at the global level and in EMDEs. Second, using panel regressions we empirically assess the association between crypto-assets volumes and a country's macro-financial fundamentals and relevant global financial conditions. Third, we use cross-sectional regressions to take initial steps to identify other potentially relevant country characteristics such as financial sector development and ICT adoption.

Figure 1: Crypto-assets: Market Capitalization, Prices, and Estimated Number of Users

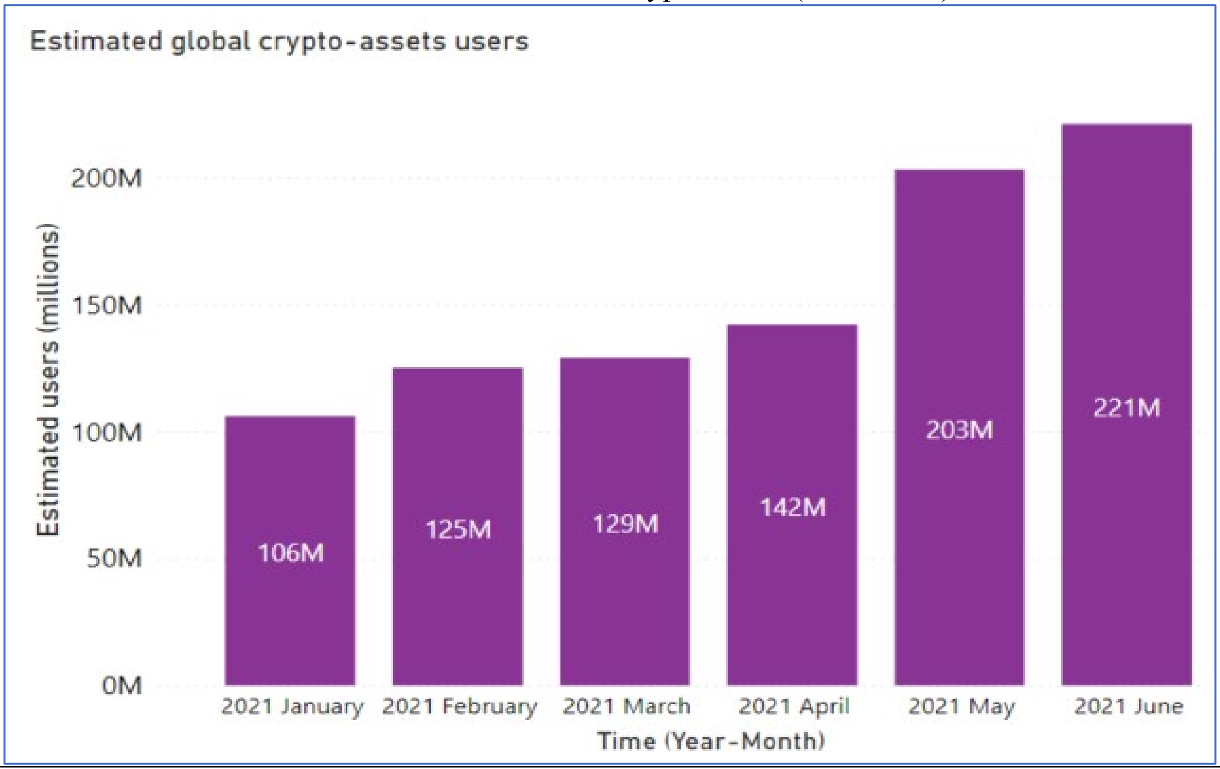
Panel A: Market Cap for Bitcoin, Ether, Stablecoins, DeFi and Other Crypto-assets (in US$)



Panel B: Bitcoin and Ether Prices (US$ on log scale)



Panel C: Estimated Global Crypto Users (in millions)



Sources: Messari; TradingView; Coinmetrics; Federal Reserve; Crypto.com. The estimated users figures should be interpreted with caution as data gaps remain significant.

Table 1: Estimates of Crypto-assets Adoption

Panel A: Statista Global Country Survey: Share of Respondents who Indicated That They Used or Owned Crypto-assets (2020)
%

Country	Share (%)	Country	Share (%)
Nigeria	31.9	Lithuania	8.7
Vietnam	21.1	Egypt, Arab Rep.	8.3
Philippines	19.8	Norway	8.1
South Africa	17.8	Portugal	8.1
Thailand	17.6	Australia	7.8
Peru	16.1	Korea, Rep.	7.6
Turkey	16.1	Serbia	7.5
Colombia	15.3	Russian Federation	7.3
Argentina	14.4	Austria	7.2
Indonesia	13	Poland	7.2
Brazil	12.5	China	6.9
Malaysia	12.3	Hungary	6.4
Chile	11.7	Romania	6.4
Saudi Arabia	11.4	Belgium	6.3
Switzerland	11.1	United States	6.2
Greece	11.1	France	5.6
Kenya	10.5	Pakistan	5.6
Dominican Republic	10.3	Canada	5.2
Netherlands	10	Germany	5.2
United Arab Emirates	10	Finland	5.1
Mexico	9.7	New Zealand	5.1
Ireland	9.6	Israel	4.9
Singapore	9.6	United Kingdom	4.7
Spain	9.4	Italy	4.7
Morocco	9.3	Denmark	4.4
Czechia	9.2	Sweden	4.3
India	8.8	Japan	3.7

Source: Statista Global Consumer Survey.
Note: Statista reported that the survey contains between 1,000-4,000 respondents per country and that the samples are representative of the online population. These figures should be interpreted with caution as data gaps remain significant.

Panel B: Chainalysis Top 20 Global Crypto-assets Adoption Index (2021)

Country	Index score	Overall index ranking	Ranking for individual weighted metrics feeding into Global Crypto Adoption Index		
			On-chain value received	On-chain retail value received	P2P exchange trade volume
Vietnam	1.00	1	2	4	3
India	0.37	2	3	2	72
Pakistan	0.36	3	12	11	8
Ukraine	0.29	4	5	6	40
Kenya	0.28	5	28	41	1
Nigeria	0.26	6	10	15	18
Venezuela	0.25	7	22	29	6
United States	0.22	8	4	3	109
Togo	0.19	9	42	47	2
Argentina	0.19	10	17	14	33
Colombia	0.19	11	23	27	12
Thailand	0.17	12	11	7	76
China	0.16	13	1	1	155
Brazil	0.16	14	7	5	113
Philippines	0.16	15	9	10	80
South Africa	0.14	16	16	18	62
Ghana	0.14	17	37	32	10
Russian Federation	0.14	18	6	8	122
Tanzania	0.13	19	45	60	4
Afghanistan	0.13	20	38	53	7

Sources: Statista; Chainalysis.
Note: The panel shows the 2021 crypto adoption index calculated and published by Chainalysis. These figures should be interpreted with caution as data gaps remain significant.

2 Literature

Drivers of crypto-assets usage

Szabo (2017) observes that economic transactions and exchanges require trust between participants. However, trust does not scale well as the number of participants in a network grows, thereby increasing transaction costs. As a result, historically, trust has been delegated to a central authority which may be susceptible to failure, fraud or rent seeking. He then posits that the technology which underpins crypto-assets can lower social transaction costs in low-trust environments without the need to delegate trust to a central third party. As such, the technology may enable more and more efficient economic interactions between large numbers of agents as they do not need to trust each other or an intermediary (i.e., "social scalability"). Raskin, Saleh and Yermack (2019) contend that non-state digital currencies could have important welfare implications for emerging markets as they can provide for an alternative asset which could serve as a check on the inflationary tendencies of the sovereign, suggesting that crypto-assets adoption may be driven by a diversification opportunity for local investment. Regarding Decentralized Finance (DeFi), Harvey et al. (2021) claim it has the best potential to provide financial services in the future to overcome the inherent challenges of the traditional financial sector of centralized control, limited access, inefficiency, opacity, and lack of inter-operability.

Early work that aims to identify drivers of crypto-assets adoption includes Hileman (2014) which proposed a Bitcoin Market Potential Index based on seven country characteristics (technology penetration, international remittances, inflation, size of informal economy, financial repression, historical financial crises, and bitcoin penetration) and posited that the greatest potential for adoption lies in Latin America and Sub-Saharan Africa. Additional relevant factors for crypto-assets adoption may also include high expected returns from speculative investment and regulatory arbitrage, particularly related to illicit financial activity (e.g., IMF (2021) and Saiedi, Brostrom & Ruiz (2020)). Feyen, Frost, Natarajan, and Rice (2021) propose a set of supply and demand side drivers of crypto-assets adoption with a focus on stablecoins. As supply side drivers they include profitability and costs of traditional payment service providers, and the availability of infrastructures such ICT and agent networks. On the demand side, they consider cost and inconvenience, confidence in financial incumbents and the government, and macroeconomic conditions.

There is a growing empirical literature that explores several of these drivers. Saiedi, Brostrom & Ruiz (2020) find some evidence that perceived failings of the traditional financial system contribute to the adoption of crypto-assets. However, using U.S. Survey of Consumer Payment Choice data Auer and Tercero-Lucas (2021), document that crypto-asset adoption in the United States is not driven by distrust in the regulated financial system and conclude that adoption is mostly driven by speculation. In addition, they also find that crypto-assets users tend to be educated, young, and digital natives. By analyzing on-chain Bitcoin transaction data, Baur, Lee and Hong (2018) and Athey et al (2016) also find that bitcoin transactions mostly reflect speculative activity. However, more recently Graf von Luckner et al (2021) study data from a centralized exchange and challenge the view that Bitcoin is only used for speculation. They find evidence that at least 7 percent of bitcoin transactions reflect its use for domestic transactions and international payments. Athey et al (2016) also document that bitcoin ownership is highly concentrated. Indeed, even as the popularity of Bitcoin has continued to grow in the past few years, Marakov and Schoar (2021) more recently confirmed that bitcoin ownership and mining capacity are still very concentrated. Auer and Claessens (2020) find that in light of significant regulatory uncertainty, regulatory news regarding crypto-assets has had a significant impact on crypto-assets market prices and trading volumes.

Box 1: Women and Crypto-assets Adoption

In their *Global Report on Women and Cryptocurrencies*, Spindler and Rodriguez (2021) conducted a small survey of crypto-asset ownership and adoption factors among 60 women from 31 countries, with a focus on residents of Latin America. 36% of participants in the survey highlighted their interest in the underlying technology, while 14% saw crypto-assets as a long-term investment vehicle. Participants cited a number of factors that increased their interest in crypto-assets, including value fluctuations of their local fiat currency, domestic and regional financial crises, lack of economic empowerment and control over finances within their household, and perceived inefficiency of legacy financial systems. Importantly, 95% of the women respondents had some form of higher education, signaling that educational background could play a role in crypto-asset adoption.

Measuring crypto-assets activity

To understand the various motivations behind crypto-assets activity, it is important to properly measure it. However, while open distributed ledgers allow anyone to observe the complete historical on-chain transaction data, their pseudonymous nature makes it challenging in practice to match individual persons or businesses to on-chain addresses, unless they, for example, underwent Know-Your-Customer checks to obtain accounts at centralized intermediaries such as crypto-exchanges.

Several studies have taken different approaches to measure crypto-assets activity. To estimate the number of bitcoin and ether owners, Wang (2020, 2021) utilizes on-chain data to count the total number of on-chain deposit addresses[10] which are required to deposit funds into crypto exchanges. One of the heuristics used by Athey, et al (2016) to analyze Bitcoin activity is to associate multiple Bitcoin addresses to user wallets. Estimating country-level activity is also challenging, as crypto-assets networks are global with no on-chain information regarding the geographic origin or

[10] Deposit addresses are temporary on-chain addresses of users transferring funds to crypto exchanges.

destination of transactions. Lischke and Fabian (2016) leverage publicly available Bitcoin transaction data and the IP addresses of transactions to gauge geographical location. However, this approach assumes that the Bitcoin node that broadcasts the transaction to the network is also its source.

Crypto-assets prices and inflation

There is a small literature that studies the link between crypto-asset prices and inflation. Using a vector-autoregressive framework, Blau et al (2021) find an empirical relationship between bitcoin prices and inflation expectations suggesting that bitcoin acts as an inflation hedge (i.e., changes in bitcoin Granger-cause changes in inflation expectations). Conlon et al (2021) confirm a link between forward inflation expectations and bitcoin and ether prices, but this relationship is only limited to the onset of COVID-19 casting doubt over the ability of these crypto-assets to hedge expected inflation going forward.

3 Data

3.1 Description of the on-chain crypto-activity data set

We use a large global monthly country-panel of on-chain crypto-asset transaction volumes of value sent in US dollars provided by Chainalysis, a global blockchain analysis company. "On-chain" transactions are directly recorded on the distributed ledger that underpins a crypto-asset. The sample spans the period April 2019 – June 2021 and covers 174 countries, 114 different crypto-assets, and five transaction size categories. We have mapped crypto-assets into four groups: 1) Bitcoin; 2) Ethereum; 3) Stablecoins[11]; and 4) DeFi and Others.[12] We also group transaction sizes into two categories: a) less than or equal to $10,000, which is more reflective of retail use and b) greater than $10,000.

While on-chain crypto-assets transaction data are fully transparent for most crypto-assets, in light of their pseudonymous nature, the destination country of a particular transaction may not be known

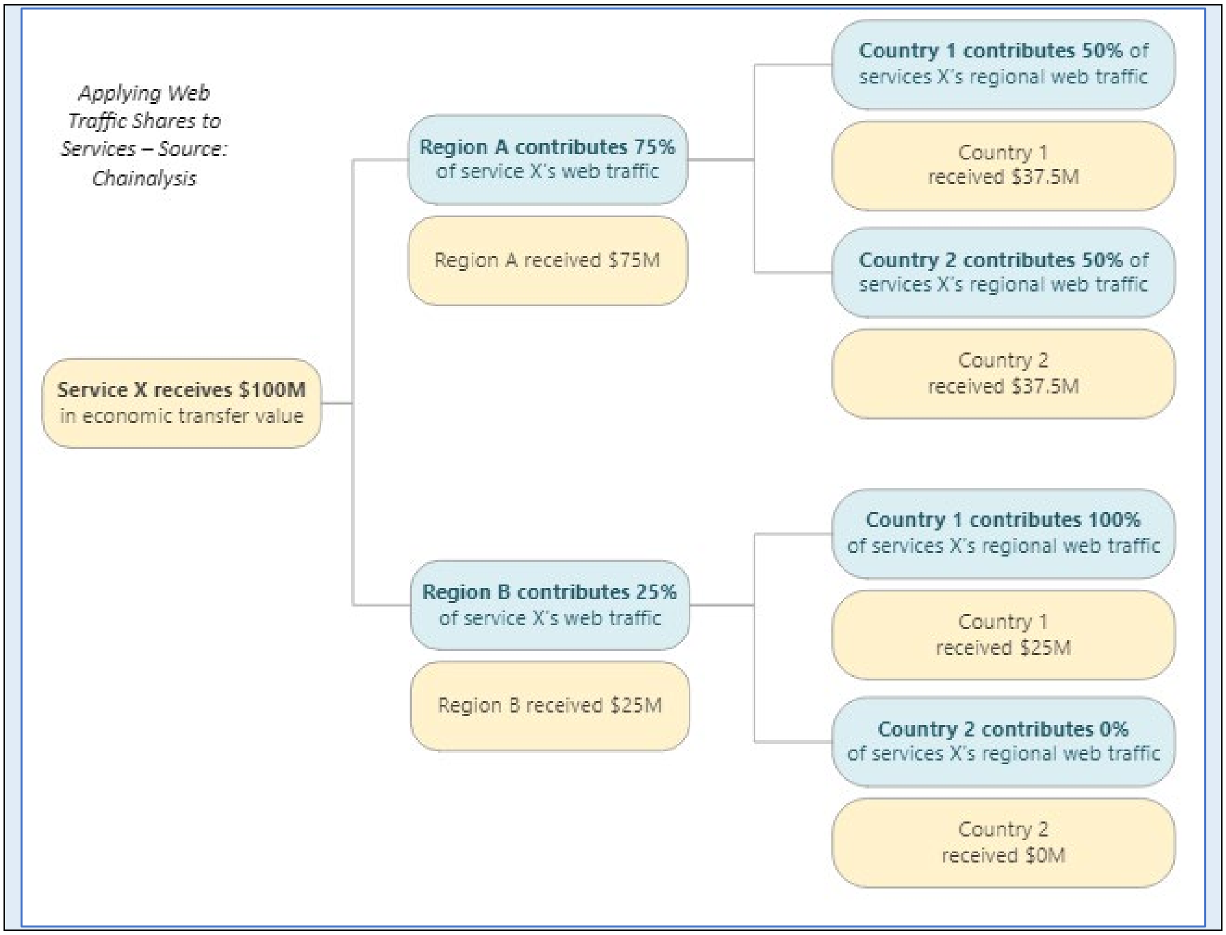
[11] These include some of the major US$-linked stablecoins: USD Coin (USDC), Tether (USDT), DAI (crypto-assets backed), TrueUSD (TUSD), Paxos USD (Dollar (PAX), Binance USD (BUSD), and Gemini Dollar (GUSD). In November 2021, the top 3 stablecoins account for about 85 percent of the total stablecoin market capitalization.
[12] This category includes 103 different crypto-assets. The top 10 with the largest volume are: Wrapped Ether (WETH), XRP, Litecoin (LTC), Wrapped Bitcoin (WBTC), Chainlink (LINK), Bitcoin Cash (BCH), EOS, Uniswap (UNI), Yearn Finance (YFI), and Sushiswap (SUSHI).

with certainty. To overcome this challenge, Chainalysis combines proprietary knowledge of crypto-assets wallets ownership with web traffic data provided by SimilarWeb, a website analytics & traffic intelligence platform, to provide estimates of the total on-chain value sent to countries (in US dollar terms). Figure 2 provides an overview of the methodology. More specifically, Chainalysis maps known on-chain addresses to services such as crypto-exchanges which can be associated with many on-chain addresses. Next, Chainalysis allocates transaction volumes of a service to a country in proportion to the web traffic that originates from that country to each service's website. To further improve classification, Chainalysis also accounts for time zones, fiat currency pairs offered, website language options, and the location of the service's headquarters.

These volume estimates come with important caveats. First, they do not capture "off-chain" transactions which are recorded on the private order books of intermediaries such as crypto-exchanges or financial institutions (with the exception of peer-to-peer exchanges such as Paxful). As such, our data do not capture activities that are facilitated by such intermediaries which include purchases of crypto-assets with fiat currency, sales of crypto-assets for fiat currency and swaps between crypto-assets. Total off-chain volumes appear significantly larger than on-chain transactions with some industry estimates suggesting the approximate ratio of off-chain to on-chain volume being roughly 6:1.[13] Total off-chain volume in the first half of 2021 was approximately US$16 trillion (CryptoCompare, 2021), compared to the on-chain volume of US$2.8 trillion. Second, the web traffic data does not account for virtual private network (VPN) activity which obscures the true destination of web traffic. Third, the transaction value associated with a known crypto-exchange wallet is assumed to be proportionate the volume of web traffic, an important limiting assumption.

[13] Chainalysis estimate based on trade volume data from Kaiko and on-chain transaction data from Chainalysis. https://blog.chainalysis.com/reports/fake-trade-volume-cryptocurrency-exchanges

Figure 2: Country-level Crypto-assets Activity Estimation Methodology



Source: Chainalysis.
Note: Example demonstrating Chainalysis' methodology for estimating country-level crypto activity using crypto-service platforms volume (in US$) and countries' web traffic data.

3.2 Trends and patterns in on-chain crypto-assets volumes

Table 3 provides summary statistics of the crypto-assets activity data aggregated by type of crypto-asset category and shows that the average transaction size for bitcoin and ether (US$57.9 mln and US$38.5mln) are much higher in comparison to stablecoins, DeFi or other crypto-assets, suggesting that activity is mainly driven by large and institutional players, rather than retail consumers.

Next, we highlight several main trends and patterns in crypto-assets activity. The Annex contains additional charts.

- *Total volume has been increasing in the past two years, driven by ether and stablecoins.*

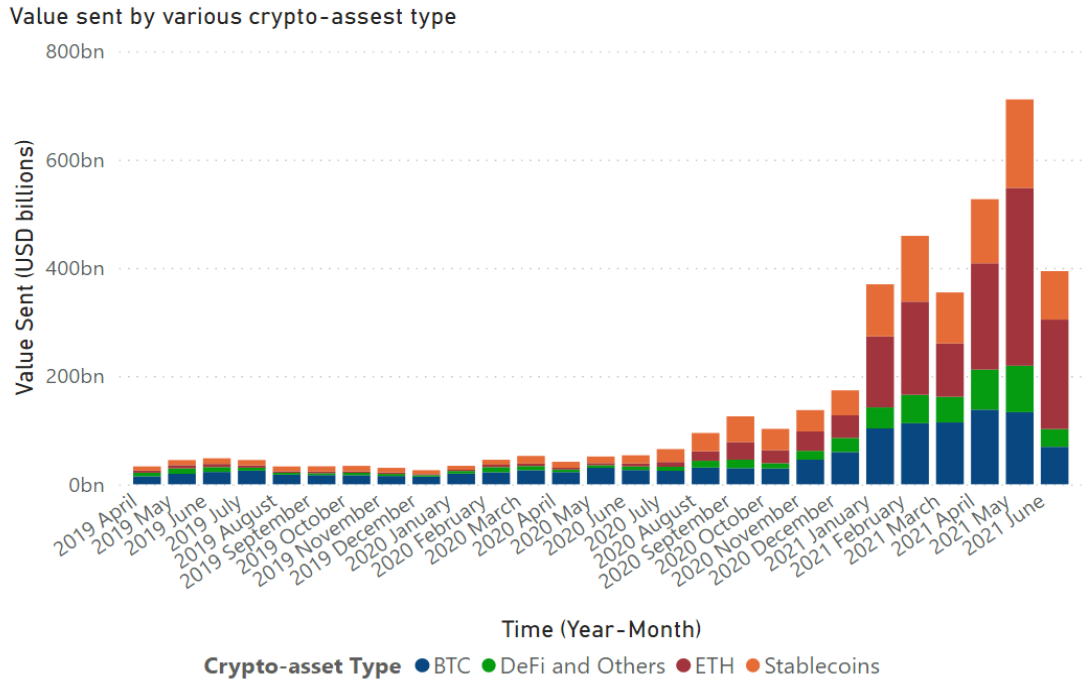
Figure 3 Panel A shows a rapid rise of total crypto-assets activity over the past two years reaching a total of US$2.82 trillion year to date in 2021. Across all transactions, the breakdown by type of crypto-asset shows that the value sent in ether (40 % of overall volume 2021 year to date) and stablecoins (24% of overall volume 2021 year to date) has gained more compared to bitcoin (24% of overall volume 2021 year to date). DeFi and other crypto-assets activity represents 12% of crypto activity year to date. The on-chain stablecoin activity (US$ 602 billion 2021 year to date) is significantly less in comparison to total stablecoin transaction volumes (i.e., including off-chain which is US$ 2.8 trillion 2021 year to date).[14] This indicates that a majority of stablecoin volume is driven by intra exchange trade for settlement of crypto-asset trading.

Figure 3 Panel B shows a similar trend for volumes associated with smaller transaction sizes. Stablecoin activity remain relatively low with 16% of overall volume year to date. When looking at the crypto activity by transaction size, we find that while large value transfers ($2.69 trillion year to date) dwarf smaller transaction size transfers ($119 billion year to date), the smaller transaction size transfers have also been rising steadily in the past two years.

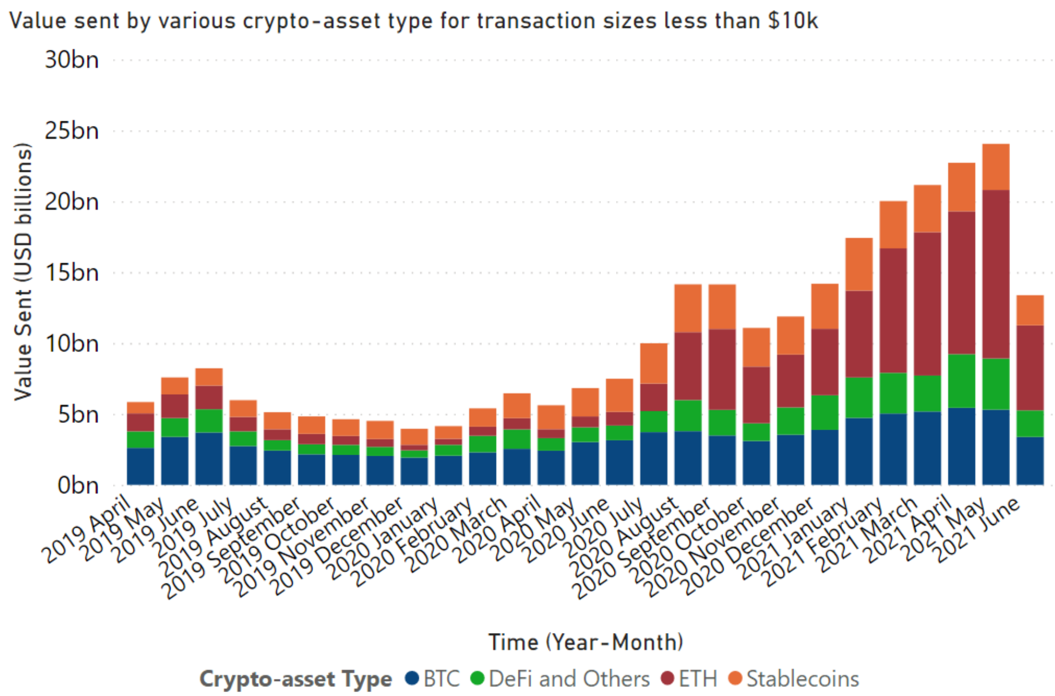
[14] Estimate based on Coinmetric data.

Figure 3: Total Crypto-assets Volume by Type of Crypto-asset
US$

Panel A: All Transaction Sizes (in US$)



Panel B: Small Transaction Sizes (<US$10k)



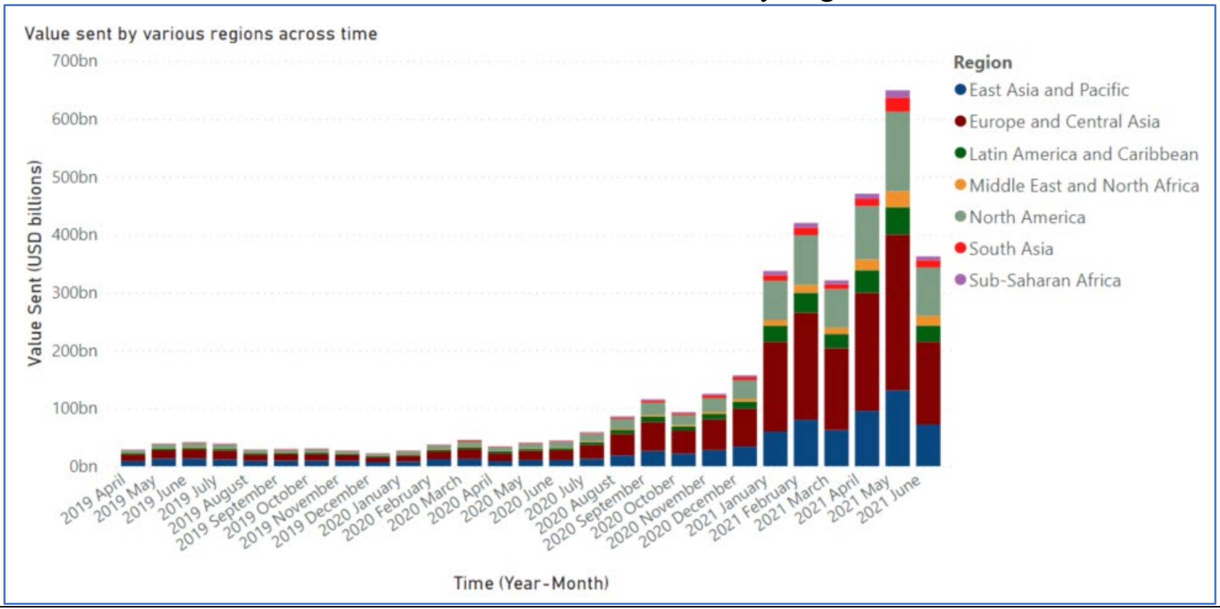
Sources: Chainalysis; World Bank staff calculations.

- *Crypto-assets activity is a global phenomenon, driven by Europe and Central Asia and North America. Small transactions represent a minor fraction of total volumes, suggesting retail participation is still relatively low.*

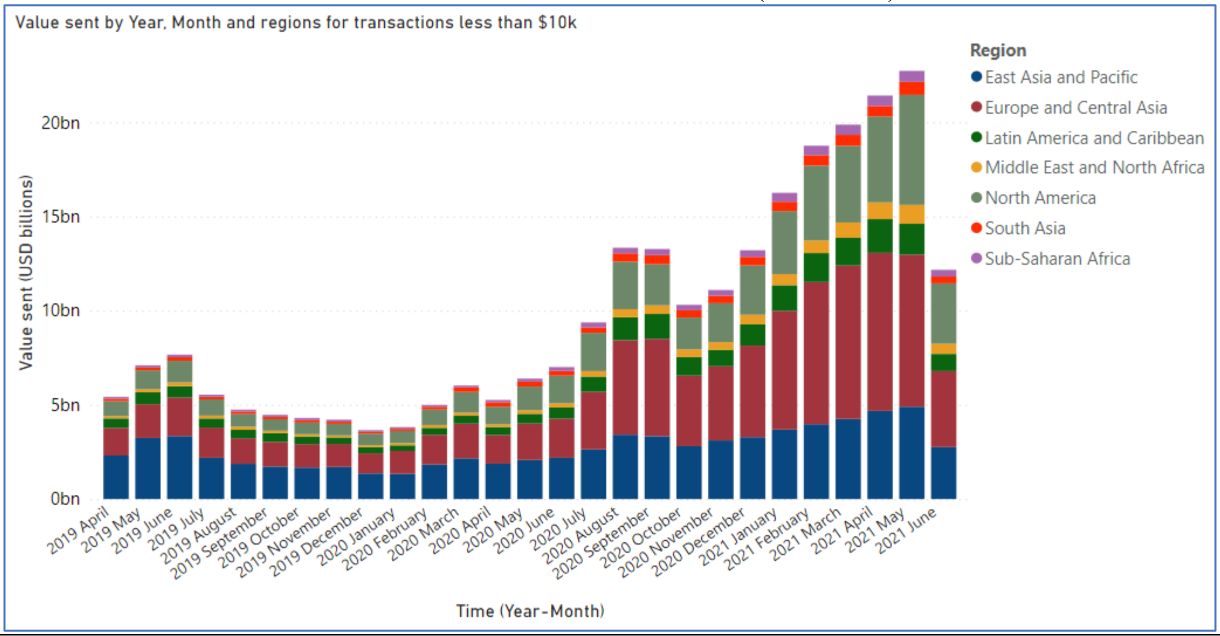
Figure 4 suggests that the geographical distribution of crypto-assets activity is already global. However, the majority of this activity is concentrated in North America (the United States in particular) and Europe & Central Asia, with these two regions combined representing 56 percent of overall activity aggregated over full sample period in all transaction sizes and 54 percent of overall activity in smaller transaction sizes less than $10k. While developed and high-income economies continue to represent a larger share of the overall crypto activity in absolute value transfers across all transaction sizes, the proportion of activity is gaining higher momentum in regions like East Asia Pacific, Latin America and the Caribbean, South Asia, and Sub-Saharan Africa. Smaller transactions account for 7 percent of the overall volume for the full sample period.

Figure 4: Crypto-assets Volume by Region and Transaction Size
US$

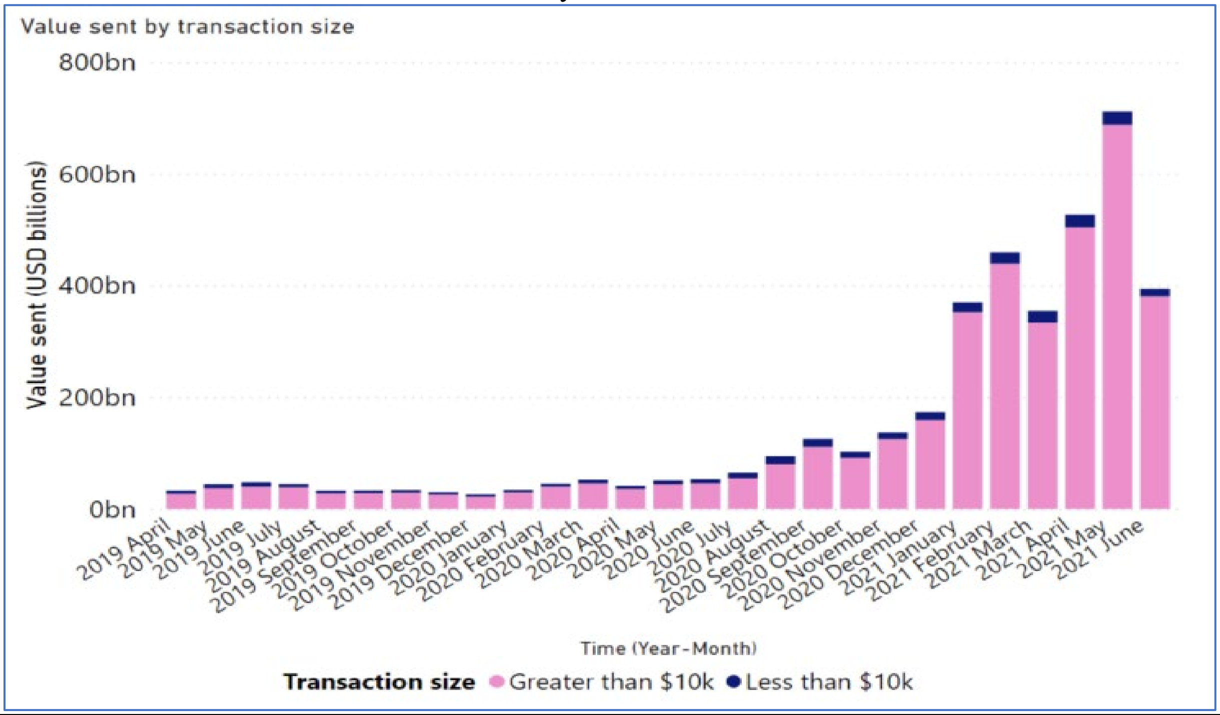
Panel A: All Transaction Sizes by Region



Panel B: Small Transaction Sizes (<US$10k)



Panel C: By Transaction Size



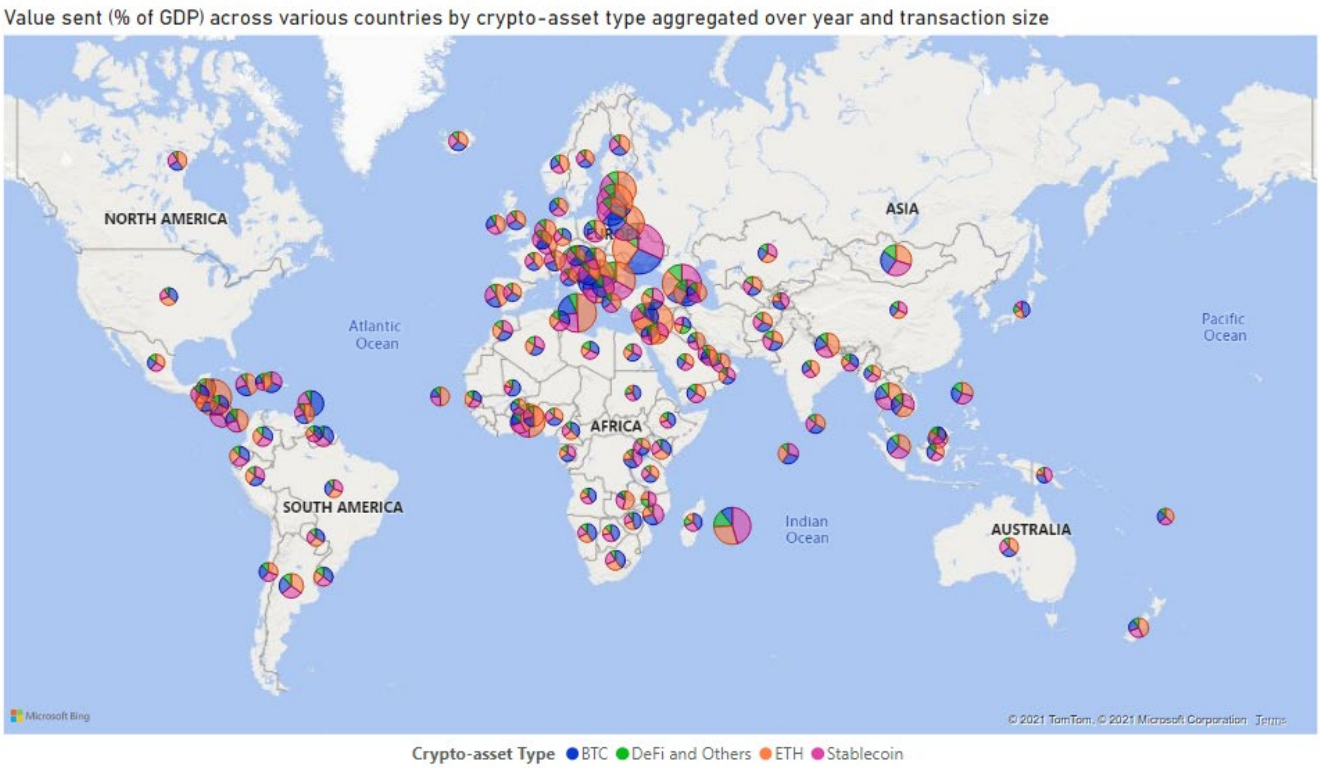
Sources: Chainalysis; World Bank staff calculations.

Figure 5 shows a map of crypto-assets activity scaled by a country's GDP – larger bubbles indicate higher activity relative to the size of the economy. Activity is relatively limited in lower- and middle-income countries. Activity is dominated by bitcoin and ether (Panel A) and smaller transactions still represent a small fraction of total volumes across countries (Panel B).

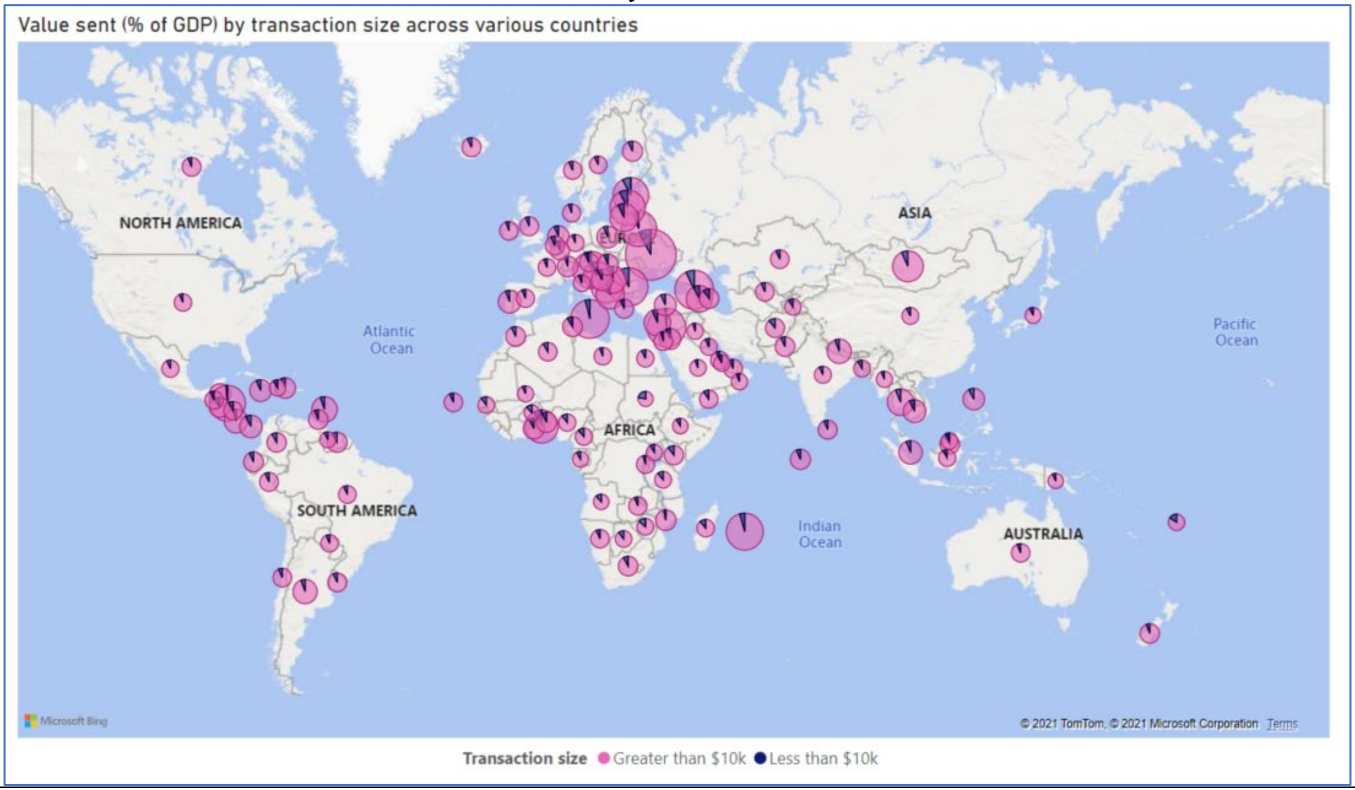
Figure 5: Total Crypto-assets Volume by Type of Crypto-asset and Transaction Size (April 2019-June 2021)

% of GDP

Panel A: By Type of Crypto-asset



Panel B: By Transaction Size

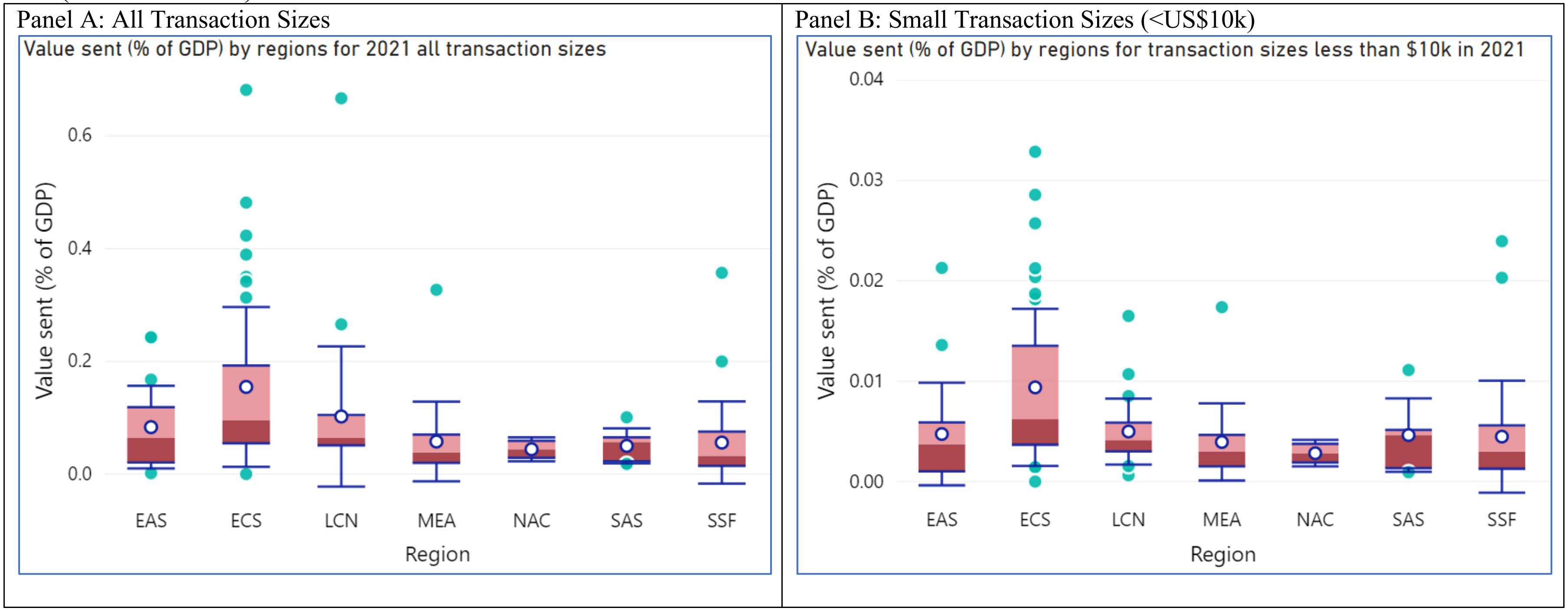


Source: Chainalysis; IMF; World Bank staff calculations.
Note: The bubble sizes representing the relative values sent (% of GDP). Outliers were winsorized at the 99th percentile.

- *Relative to a country's economic activity, volumes in Emerging Markets & Developing Economies (EMDEs) are sizeable in some regions.*

Figure 6 shows that the annualized total volumes of crypto-assets activity for 2021 relative to GDP have become sizeable, particularly in regions like Latin America and the Caribbean (median: 0.07% of GDP), Sub-Saharan Africa (median: 0.06% of GDP) and Europe and Central Asia (median: 0.10% of GDP). Some countries exhibit very high crypto-assets activity with volumes as high as 0.68% of GDP in Europe and Central Asia. There is significant variation within regions, particularly in Europe and Central Asia and Latin America and the Caribbean. The volumes associated with smaller transactions are an order of magnitude smaller, even in the most active region of Europe and Central Asia (median: 0.01% of GDP).

Figure 6: Annualized Crypto-assets Volume by Region in 2021
US$ (Percent of GDP)



Source: Chainalysis; IMF World Economic Outlook; World Bank staff calculations.
Note: Annualized figures based on data for January – June 2021 and 2021 GDP projections. EAS = East Asia and Pacific; ECS = Europe and Central Asia; LCN = Latin America and Caribbean; MEA = Middle East and North Africa; NAC = Northern America; SAS = South Asia, SSF = Sub-Saharan Africa.

3.3 Main independent variables: Macro-financial variables and other country characteristics

Table 2 provides definitions and sources of the main independent variables used in our empirical analysis. Table 3 and Table 4 provide summary statistics and correlation matrixes, respectively. In addition to the crypto-asset data from Chainalysis, we use countries' financial and macroeconomic data from various sources. We focus on a parsimonious set of monthly indicators to ensure broad country coverage. Our monthly indicators are derived from three data sets: 1) IMF's International Financial Statistics (e.g., country-month inflation and exchange rates); 2) IMF's World Economic Outlook (e.g., country-year nominal GDP); and 3) US Federal Reserve economic data for global or U.S. asset prices, interest rates, risk appetite measures, and inflation expectations. The bitcoin and ether data are sourced from Coinbase, a large U.S.-based crypto-assets exchange.

Our set of broader annual country-level variable include GDP per capita, financial development indicators such as domestic bank credit to GDP, financial account ownership, remittances to GDP, and ICT development indicators (e.g., mobile phone subscriptions and fixed broadband subscriptions). We also include indicators on countries' institutional frameworks proxied by economic freedom indicators. These indicators are taken from the World Bank World Development Indicators and the Heritage Foundation's Economic Freedom Index, respectively.

4 Empirical approach

First, we start by running monthly panel regressions focusing on a set of country and global macro-economic and financial factors with country-fixed effects. We do not include time-fixed effects since we are studying the global macro-financial factors. Second, we run basic cross-sectional regressions to explore the role of a broader set of annual variables. All estimations involve robust standard errors clustered at the country level. In light of the relatively small size and impact of crypto-assets activity on country and global macro-economic variables to date, we are not very concerned about endogeneity challenges.

We exploit within-country variation by deploying panel regressions. Our main specification is:

$$\begin{aligned} Ln(CryptoVolume)_{jt} = \beta_0 + \beta_1 CountryFactors_{jt-1} + \beta_2 GlobalFactors_{t-1} \\ + \beta_3 PandemicDummy_t + \gamma_j + \varepsilon_{jt}, \end{aligned} \tag{1}$$

where the dependent variable $Ln(CryptoVolume)_{jt}$ represents the log of the monthly value of crypto-assets transactions expressed in U.S. dollars for country j at time t -- note this is a flow rather than a stock concept. We use lagged values of country and global factors as market participants act according to the most recently available data which arrives with a lag in practice.

The $CountryFactors_{jt-1}$ consists of a set of 1-month lagged macroeconomic variables for country *j* at time *t-1*, including $\Delta CPI_{jt-1} = \frac{CPI_{jt-1}}{CPI_{jt-13}} - 1$, the lagged monthly inflation rate percent change based on a comparison to the same month in the previous year for country *j* at time *t-1* and $\Delta Exchange\ Rate_{jt-1} = \frac{Exchange\ Rate_{jt-1}}{Exchange\ Rate_{jt-2}} - 1$, the lagged month-on-month percent change in the exchange rate vis-à-vis the U.S. dollar (i.e. an increase signifies currency depreciation) for country *j* at time *t-1*. If crypto-assets are perceived as a hedge against domestic macroeconomic weakness, we expect crypto volume to exhibit a tendency to rise with a recent increase in domestic inflation or currency depreciation if investors expect such trends to continue in the future. Ideally, we would like to use measures that capture inflation expectations rather than realized inflation, but these indicators are not available for a broad range of countries. In robustness checks, we use changes in Broad Money instead of inflation, also calculated on a year-on-year basis.

The $GlobalFactors_{t-1}$ comprise a parsimonious set of 1-month lagged indicators. We use conditions in the U.S. as a proxy for global macro-financial conditions.

- *Crypto-asset prices.* We include month-on-month price changes for two key crypto-assets: bitcoin and ether to explore the impact of prices on crypto volume. These price changes are calculated analogously to $\Delta Exchange\ Rate_{jt-1}$.
- *Gold prices.* Some major crypto-assets such as Bitcoin are perceived by some crypto-asset investors as "digital gold" or "digital stores of value" with macro hedge properties. Therefore, to explore the relationship with crypto volume and gauge whether the data bear out whether they are (imperfect) substitutes, we include month-on-month gold price changes.
- *Risk appetite*. We use the VIX index, a U.S. stock market-based measure of investor uncertainty and risk aversion, as a proxy for global risk appetite. Higher values indicate higher levels of risk aversion. When risk appetite is high, investors may be more interested in risky investments such as crypto assets causing a rise crypto volume. The VIX index

rose significantly at the onset of the COVID-19 pandemic. The VIX spiked in late March 2020 amid a broad-based erosion of confidence in financial markets and subsequently fell on the back of massive policy support but remained volatile throughout the pandemic (Figure 7). In robustness checks, we use the U.S. BBB corporate bond spread as an alternative measure of risk appetite (higher values indicate higher risk aversion).

- *United States longer-term inflation expectations.* We focus on the longer-term inflation outlook in the United States as a core relevant factor for financial markets and investors. If crypto-assets are deemed to be a global macro hedge, crypto volume would increase if inflation expectations increase. When inflation expectations are well-anchored, changes in breakeven inflation may also reflect improvements in growth expectations and increased risk appetite. We use the 5-year, 5-year Forward U.S. Inflation Expectation Rate, a widely monitored market-implied proxy for longer-run inflation expectations. It is a measure of the average expected inflation over the five-year period that begins five years from today and is derived from yields on nominal and inflation-adjusted Treasury securities. On the onset of the COVID-19 pandemic, the economic outlook deteriorated which caused inflation expectations to fall dramatically (Figure 7). Inflation expectations recovered to pre-pandemic levels due to massive economic and monetary stimulus. In robustness checks, we instead use the U.S. 10-year Breakeven Inflation Rate, another widely used proxy for inflation expectations which is similarly derived.
- *Unites States real 10-year Treasury yields.* 10-year U.S. Treasury yields are a widely observed indicator in global markets as they reflect economic prospects and drive global financial conditions. We use the yield on 10-year U.S. Treasury securities which are indexed to inflation (TIPS). Higher rates are often associated with tighter global financial conditions, producing cross-border spillover effects, including to EMDEs. During the onset of the pandemic in March 2020, Treasury yields fell strongly as economic prospects deteriorated and investors fled to safety. However, yields briefly spiked in late March as investors turned to cash amid a wider erosion of market confidence and broad-based selling of financial assets. Real 10-year yields turned negative in our sample period due to the impact of the COVID-19 pandemic and the subsequent policy response which included purchases of Treasury securities by the U.S. Federal Reserve which put downward pressure on yields to support market functioning and lower longer-term interest rates to stimulate the economy (i.e., quantitative easing) (Figure 7). Low or even negative (real) yields

contribute to looser global financial conditions to stimulate the economy. They may also lead to "search for yield" effects which tend to drive up asset prices and may induce more risk taking. If crypto-assets are perceived as risk assets, crypto volumes would tend to rise when real yields are low. It is important to keep in mind that asset purchases by the Federal Reserve, including Treasury securities, took place during the sample period (e.g., to combat the impact of the pandemic) which has influenced price formation and the signals that can be extracted from it.

$PandemicDummy_t$ is a dummy which assumes a value of one after March 2020 and zero otherwise. This variable captures the broad and global impact of the pandemic on crypto-assets including public health, behavioral, and economic impacts as well as the unprecedented monetary, fiscal, and financial sector policy response.

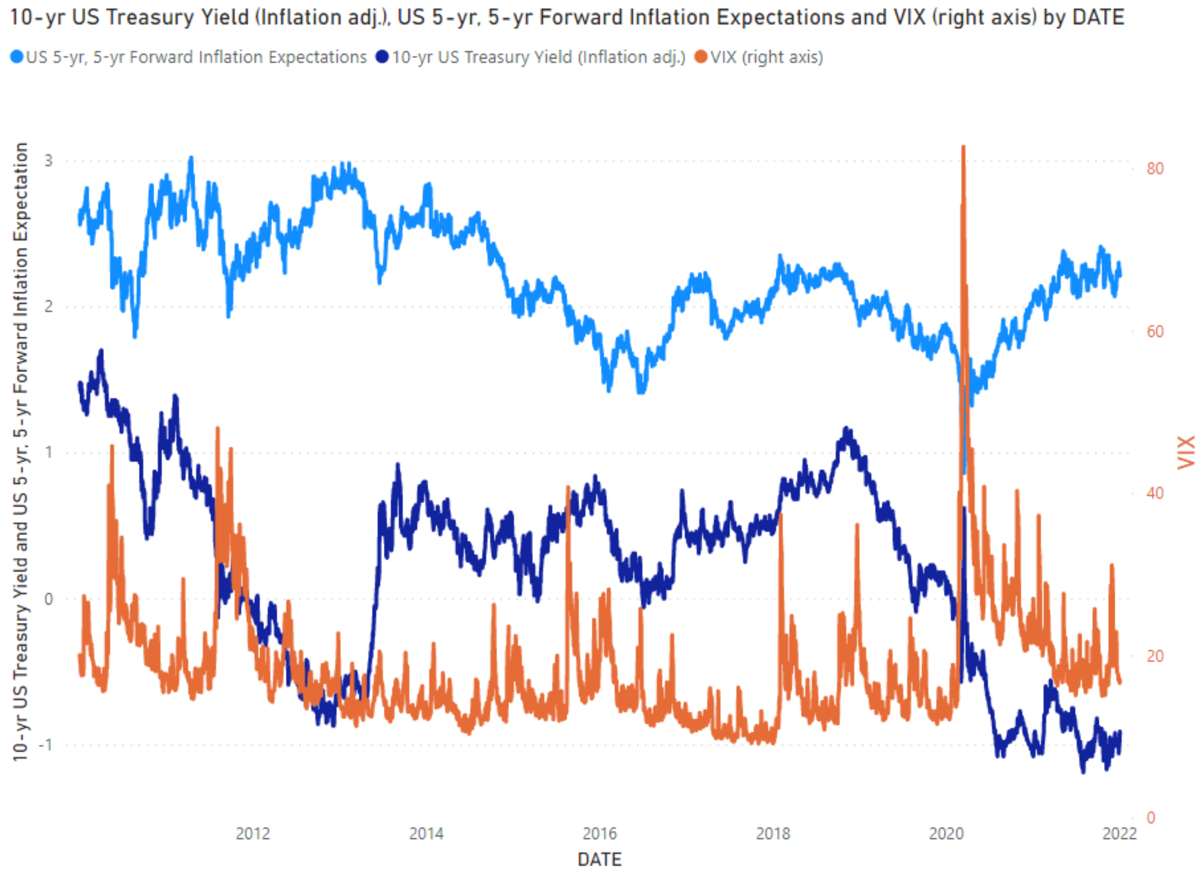
Finally, γ_j represents country-fixed effects to account for time-invariant country characteristics (e.g., level of economic development, institutional framework) that may drive differences of crypto volume across countries. ε_{jt} is the error term.

Second, we run cross-sectional OLS regressions on 2020 data to explore the role of financial development, remittances, economic freedoms, and ICT factors to explain variation of crypto volume across countries. Our main specification is:

$$Ln(\frac{CryptoActivity}{GDP})_j = \beta_0 + \beta_1 LogGDPperCapita_j + \beta_2 FinancialDevelopment_j + \beta_3 Remittances_j + \beta_3 EconomicFreedoms_j + \beta_4 ICTDevelopment_j + \varepsilon_j, \quad (2)$$

Where the dependent variable Ln $(\frac{CryptoActivity}{GDP})_j$ represents the log of the yearly value of crypto-assets transactions as a fraction of a country's nominal annual GDP for country j in 2020, $LogGDPperCapita_j$ captures the general level of economic development, $Financial\ Development_j$ includes credit to private sector (% of GDP) and account ownership (% of adult population) for country *j*; $Remittances_j$ is personal remittances received (as % of GDP) for country *j*; $EconomicFreedoms_j$ include economic freedom indexes such as Monetary Freedom Index and Financial Freedom Index for country *j*; $ICTDevelopment_j$ is mobile cellular subscriptions (per 100 people) and fixed broadband subscriptions (per 100 people) for country *j*; ε_j is the error term.

Figure 7: Selected Global Macro-Financial Factors



Source: U.S. Federal Reserve.

5 Results

This section presents the main empirical results of this paper. As indicated in the previous section, our dependent variable is the log of monthly on-chain crypto-assets volume in a country, expressed in U.S. dollars. Since we are interested in understanding crypto volume in EMDEs as well as for retail users, we 1) fit our regressions on both the total sample (about 135 countries) and on a smaller sample which only consists of EMDEs (i.e., about 85 countries that are not classified as High-Income Countries) and 2) focus as the independent variable on volumes associated with all transaction sizes and volumes for smaller transactions only (<US$10k).

Tables 5-8 offer the main results and robustness checks and are all structured similarly. Models 1-5 are fit on the full country sample, whereas Models 6-10 are fit on EMDEs only. Tables 9 and 10 provide the results of extensions which investigate the role of country and global factors for across four main crypto-asset groups separately: 1) bitcoin, 2) ether, 3) stablecoins, and 4 all crypto-assets except stablecoins.

Because the panel regressions include country-fixed effects, all our results should be interpreted as explaining the variation in country's crypto volumes rather than their level, because the country-fixed effects capture, for example, the fact that larger or economically more developed countries exhibit higher volumes in general.

5.1 Main results: Panel regressions

Table 5 presents the main results for volumes of all transaction sizes for all crypto-assets. As described earlier, the main dependent variable is the log country-month crypto-asset volumes expressed in U.S. dollars. We find that across all specifications and for all countries and EMDEs only, a set of lagged global (forward-looking) factors is robustly statistically significant at the 1-percent level. Moreover, the coefficients are of similar magnitude in both country samples. In contrast, we document that lagged country indicators which reflect recent domestic macroeconomic developments explain little variation in crypto volumes. These country factors lose statistical significance once global factors are accounted for. However, our full models suggest that country-level currency depreciation is somewhat associated with higher crypto volume. Taken together, these findings suggest that crypto volumes are mostly driven by global (forward-looking) indicators -- which may ultimately shape domestic macro-financial conditions -- rather than recent domestic macroeconomic developments.

The results for the global factors support the notion that crypto users may assign some global hedging properties to crypto assets. A 10-basis-points increase in U.S. inflation expectations (on a 5-year, 5-year forward basis as embedded in U.S. Treasury yields) increases crypto volumes by about 28 basis points. This finding holds in both advanced economies and EMDEs alike. Crypto volumes also move in the opposite direction of gold prices, suggesting that crypto-assets are perceived to some extent as a substitute for gold, a traditional global inflation hedge. A 1-percent decline in lagged gold prices is associated with an increase in volumes of about 1.1 percent.

The global factor results further imply that crypto-assets are perceived as a "risk on" asset class. Crypto volumes are higher when (inflation-adjusted) U.S. Treasury yields are lower as this supports loose global financial conditions and induces investors to take on higher risks, including investing in speculative instruments such as crypto assets: a 10-basis-point decline in yields is associated with around a 5 basis-points increase in crypto volumes. Crypto volumes also appear to be supported by a momentum effect in crypto-assets prices further suggesting that speculative motives play a role. A 1-percent increase in the bitcoin price is associated with an increase in volume of about 0.2-0.3 percent. Volumes also react positively to ether prices, but to a lesser extent and the ether price loses statistical significance in some models. These findings point to Bitcoin being perceived as the benchmark crypto-asset. Model 4 (and 9) show that crypto-volumes also increase when the VIX falls and risk appetite increases. A 10-point decrease in the VIX (about one standard deviation) results in an 86-percent increase in crypto volumes. However, the coefficient's magnitude shrinks significantly in Model 5 (and 10) and switches sign. This is due to the inclusion of inflation expectations which is negatively correlated with VIX ($\rho = -0.55$) and as such may also partly reflect risk sentiment.

Finally, accounting for all factors, the pandemic dummy is highly significant in Model 5 (and 10) and shows that since the outbreak of the pandemic in 2020, volumes have increased by about 190 percent for all countries. At 211 percent, growth is even higher in EMDEs.

Turning to the country factors, Model 1 (and 6) show that they explain little variation in crypto volumes with an adjusted R-squared of 0.01 – lagged inflation and exchange rate changes lose significance and shrink in magnitude when global factors are included. The exchange rate enters positively and statistically significant at the 10-percent level in the full Model 5 (and 10), suggesting that a 1-percent depreciation in the exchange rate is associated with an increase in 0.77 percent in volumes. While this result fits the macro hedge narrative for local conditions, it is not robust.

As described in the data section, the average transaction sizes for bitcoin and ether are well over US$20 million, suggesting that most of the trading occurs by institutions and professionals which may behave differently than smaller users who may focus more on domestic macroeconomic conditions. Indeed, large and institutional investors may provide trading, exchange, market making, and custody services and have diversified operations across countries which may make them less susceptible to local macro-economic conditions in individual countries. For Bitcoin, there is evidence that a significant amount of transaction volume occurs between exchanges (Marakov and Schoar, 2021).

In this context, to better understand the behavior of smaller investors, Table 6 contains the results for volumes associated with small transactions only (i.e., <US$10k). The results are broadly similar to total volumes in Table 5: in contrast to the country factors, key global factors are consistently statistically significant at the 1-percent level across all specifications and samples. A

few differences stand out for smaller transactions, possibly pointing to different behavior between larger or institutional and retail investors. Focusing on Model 5 (and 10), the magnitude of U.S. inflation expectations is about half compared to Table 5 but remains economically very relevant. At the same time, the bitcoin price coefficient is about twice as large, while the ether price results are weaker. Further, the pandemic dummy implies that retail volumes have grown less compared to total volumes: 105 percent and 119 percent for all countries and EMDEs only, respectively. Finally, the factors are able to explain somewhat less of the variation volumes for smaller transactions: the adjusted R-squared is about 0.58-0.65 compared to 0.70-0.75 in Table 5.

5.2 Robustness and extensions of the main results

Robustness

This section documents several robustness checks of the main results in Tables 5 and 6. Tables 7 and 8 report the results using alternative measures for three indicators. First, we use the country-level change in Broad Money instead of inflation ($\rho = 0.69$). Note that our sample size drops significantly due to missing observations for this indicator. However, the results are broadly similar: when considering small transactions, Model 1 (and 5) shows that an increase in broad money is also associated with an increase in crypto volumes at the 10-percent level of significance, but it loses significance once global factors are included. Second, we use the U.S. 10-year Breakeven Inflation Rate, the expected average inflation rate over the next 10 years which is also derived from Treasury yields, instead of the U.S. 5-year, 5-year forward Inflation Expectation Rate ($\rho = 0.97$). The coefficient on the 10-year breakeven rate has a similar sign and magnitude and is also significant at the 1-percent level. Finally, we use the U.S. BBB Corporate Bond Spread as an alternative proxy for risk appetite (higher values indicate higher risk aversion), instead of the VIX ($\rho = 0.78$). Similar to the VIX, Model 4 (and 9) show that crypto volumes fall when risk aversion increases. A 1-percent increase in the corporate bond spread reduces crypto volumes by about 0.5 percent. However, in Model 5 (and 10) the coefficient changes sign in the presence of inflation expectations, similar to the results in Table 5.

We also undertook various unreported robustness checks. First, as auto-correlation may be present in the dependent variable, in unreported results we add to the specification in Tables 5 and 6 the 1-month lagged independent variable as a separate robustness check and the results continue to qualitatively hold. Second, we winsorized the dependent variable and all independent variables at the 1st and 99th percentiles to reduce the role of influential outliers and find that our results remain.

Extensions to different type of crypto-assets

Table 9 presents the results for volumes of all transaction sizes associated with four different crypto-assets: 1) bitcoin, the largest crypto-asset by market capitalization, 2) ether, the second largest crypto-asset in terms of market capitalization, 3) stablecoins, and 4) all crypto-assets *excluding* stablecoins. After presenting detailed analyses in Tables 5 and 6, in Table 9 we focus on regressions which contain all factors as presented in Model 5 (and 10) in these tables.

Table 9 shows that the main results broadly hold across different crypto-assets for volumes associated with transactions of all sizes in both the full country and EMDEs only samples. Model 1 (and 5) shows that bitcoin volumes are most responsive to bitcoin prices, but least responsive to U.S. inflation-adjusted 10-year yields and U.S. inflation expectations. The pandemic dummy also shows that bitcoin volumes exhibited the lowest growth. Compared to other crypto-assets, the regression explains the least variation in bitcoin volumes, as indicated by the lowest R-squared. Model 2 (and 6) shows that ether is most sensitive to U.S. inflation expectations and is relatively more responsive to bitcoin than ether prices. The pandemic dummy shows that ether volumes have increased the most. Model 3 (and 7) documents that stablecoin volumes are not significantly associated with crypto-asset prices and increase the most in response to a fall in gold prices. Model 4 (and 8) shows that both bitcoin and ether prices are statistically significant for non-stablecoin volumes, although the responsiveness to bitcoin prices is much larger.

Table 10 repeats the exercise in Table 9, focusing on crypto volumes associated with small transaction sizes instead (i.e., <US$10k), and shows that the main results also broadly hold across different crypto-assets in this case. Model 1 (and 5) suggests that the 10-year yield is only not statistically significant for bitcoin volumes. Somewhat surprisingly, Model 2 (and 6) indicates that ether volumes are more responsive to bitcoin prices. More broadly, compared to Table 9, the magnitude of the U.S. inflation expectations coefficient is smaller and ether prices are less relevant for volumes. Further, the pandemic dummy shows that volumes for smaller transactions have exhibited less growth compared to total volumes across all types of crypto-assets.

5.3 Cross-sectional regressions

In Table 11 we complement the panel regressions by conducting cross-sectional regressions to take initial steps to explore whether financial development, remittances, economic freedom, and ICT adoption can help explain the cross-sectional variation in crypto-assets volumes. We focus on 2020, the year for which we have complete data. Panel A documents the results for volumes for all transaction sizes whereas Panel B focuses on volumes associated with small transaction sizes only (<US$10k). We divide the crypto volumes by nominal GDP to account for scale differences between countries to obtain a country's relative measure of crypto activity.

The results are broadly similar in both panels. In all regressions we control for the level of economic development as captured by log GDP per capita. Model 1 shows that economic development does not appear to play a significant role, but subsequent regressions (Model 4 and 5) which control for additional factors, suggest that less economically developed countries exhibit higher crypto volumes. Model 1 also shows that financial development in terms of financial sector depth or inclusion does not appear to play a substantive role, implying that crypto-assets are not perceived as an important substitute for traditional financial services. Model 2 suggests that countries with higher remittances received exhibit more crypto activity. This is consistent with the idea that crypto-assets may address some of the challenges associated with cross-border payments which can be slow and costly, but further research is necessary to substantiate this. A 1-percentage point increase in remittances to GDP is associated with a 3 to 4-percent increase in crypto-assets activity. Model 3 implies that countries with fewer monetary freedoms experience higher crypto-assets volumes (significance at the 5 percent level in both panels). A one-point decrease on the monetary freedoms scale (0-100), is associated with a 2.9 percent increase in crypto-assets volumes. This finding supports the idea that crypto-assets are more popular in countries with weaker price stability and more repressive price controls. We find however support for the opposite association for countries with more financial freedoms (i.e., more efficient banking systems and limited government control in the financial sector), perhaps because the financial sector under such conditions is more willing to facilitate crypto activity. Model 4 suggests that crypto activity is higher in countries with higher mobile penetration and fixed broadband subscriptions per capita. The coefficients are significant at the 5 percent level and the 1 percent level, respectively, and further suggest that the association with broadband subscriptions is stronger than mobile phones. One additional subscription out of 100 people is associated with around 5 percent increase in crypto activity. These findings are intuitive as crypto-assets usage requires basic ICT infrastructure and mobile crypto-assets apps are popular. Finally, Model 5 includes all factors simultaneously. Economic development, remittances, mobile phone, and fixed broadband are all statistically significant. A 1-percent decrease in GDP per capita is associated with almost 0.4 percent increase in crypto activity. Moreover, the remittances coefficient also roughly doubles in magnitude.

6 Conclusions and future research

We study recent monthly on-chain crypto-assets volume – transactions that are directly recorded on the distributed ledger that underpins a crypto-asset – in over 130 countries covering the period from April 2019-June 2021, which includes the COVID-19 pandemic and a period of extraordinary monetary, fiscal, and financial conditions in many countries. We find that crypto volumes have grown rapidly around the world reaching US$2.8 trillion[15] in the first six months of 2021, driven by North America and Emerging Market and Developing Economies (EMDEs) in Europe and Asia. However, even in high-volume regions, total volume remains modest relative to GDP and retail volume is an order of magnitude smaller (i.e., transactions less than $10k), suggesting still-limited uptake by retail users: smaller transactions represent about 7 percent of the total volume. Bitcoin, ether, and a small set of stablecoins represent the large majority of crypto volume, with a relatively minor, but growing role for Decentralized Finance (DeFi).

As discussed in the Introduction, the emerging crypto-assets industry is diverse offering both opportunities and risks. In the context of recent rapid evolution, growth, and adoption of crypto-assets documented in this paper, understanding the main drivers behind crypto-assets usage is relevant for policy makers, users, and industry alike. As crypto-assets are currently not used at large scale as a means of payment or to access decentralized financial services, this paper's main research question focuses on two common hypotheses: Are crypto-assets used as a risk asset? Do users across countries perceive them as an emerging hedge against adverse macroeconomic conditions such as high inflation or currency depreciation? We also explore which country characteristics are associated with crypto activity.

To help address these questions, we deploy country panel regressions using a parsimonious set of country and global factors. In short, the results suggest that during our sample period which includes a period of extraordinarily loose global financial conditions, the variation in countries'

[15] It is important to keep in mind that these figures should be interpreted as lower bounds on total crypto-assets activity. On-chain volumes are eclipsed by approximately US$16 trillion in total volumes in the same period which include "off-chain" transactions which are only recorded on the private order books of crypto-assets exchanges and other intermediaries.

crypto volumes is mostly driven by global (forward-looking) indicators -- which may ultimately shape future local macroeconomic conditions through cross-border spillover effects -- rather than recent (backward-looking) domestic macroeconomic developments. As such, while crypto-asset markets are still relatively small, a continued rise in scale and global synchronicity of crypto volumes could produce spillover risks between asset classes and across borders. Our main findings are broadly robust across different country samples (all countries and EMDEs only), transaction sizes (all sizes and less than US$10k), and types of crypto-assets (e.g., bitcoin, ether, stablecoins, and all assets except stablecoins) and are summarized below.

First, we document evidence that lends some support to the hypothesis that crypto users across countries may perceive crypto-assets as embodying emerging longer-term macro hedging properties. Controlling for other factors, countries' crypto volumes consistently rise when U.S. longer-term inflation expectations increase (based on breakeven inflation rates as embedded in U.S. Treasury securities yields).[16] Moreover, crypto volumes move inversely with gold prices, suggesting that users may, to some extent, perceive crypto-assets as an alternative to gold, a traditional global macro hedge. Indeed, during our sample period flows into gold-linked financial instruments such as exchange-traded products have fallen, while the opposite is true for crypto-assets related financial instruments such as funds (JP Morgan, 2021b). At the same time, we do not find that the country factors (i.e., inflation and exchange rate changes) which reflect recent local macroeconomic conditions consistently support a macro hedge hypothesis once global factors are accounted for. In particular, although recent local currency depreciation vis-à-vis the U.S. dollar is positively associated with countries' crypto volumes, these associations are not robustly statistically significant across samples and specifications. Crypto volumes are currently mainly driven by professional and institutional players which may be less sensitive to local macro-economic conditions. For example, they may provide trading, exchange, market making, and custody services and may have diversified operations across countries which may make them less susceptible to local macro-economic conditions in individual countries. For Bitcoin, there is evidence that a significant amount of transaction volume occurs between exchanges (Marakov and Schoar, 2021). Smaller investors may be more sensitive to local macroeconomic conditions. However, we find that country factors also matter little for crypto volumes associated with smaller transactions. We leave deeper analysis to future research.

[16] When inflation expectations are well-anchored, changes in breakeven inflation may also reflect improvements in growth expectations and increasing risk appetite.

Second, we find empirical evidence that is broadly consistent with the hypothesis that crypto-assets are regarded as a risk asset. Global financial conditions were extraordinarily loose during our sample period. Real U.S. 10-year Treasury yields turned negative driven by the pandemic's impact and the policy response to support financial markets and stimulate the economy (e.g., quantitative easing). In this context, we find that countries' crypto volumes increase when real U.S. 10-year Treasury yields fall as it also tends to loosen global financial conditions and increase risk appetite. We further find that crypto volumes fall when our proxies of global risk aversion rise (i.e., the VIX index and the U.S. BBB corporate bond spread). Related and consistent with earlier literature (e.g., Liu and Tsyvinski 2018), we document that volumes typically respond positively to crypto-assets price momentum, suggesting speculative motives are relevant as well. Some emerging financial industry analyses indicate that crypto-assets may be a useful addition to a balanced investment portfolio, also as correlations with traditional asset classes appear relatively low (at least prior to the COVID-19 pandemic), but their short and volatile history makes it too soon to draw conclusions (e.g., Goldman Sachs, 2021a and Citi, 2021). However, others have concluded that crypto-assets are not a viable investment for a diversified portfolio (e.g., Goldman Sachs, 2021b).

Cross-sectional OLS regressions on 2020 crypto volumes for all available countries show that financial development and economic freedoms do not robustly explain the cross-country variation in crypto-assets activity associated with both all transaction sizes and smaller transactions only. However, we find tentative support that crypto activity is higher in less economically developed countries and in countries with stronger ICT penetration, broadband subscriptions in particular. We also find that crypto activity is higher in countries where personal remittances play a more important role. This finding is consistent with Graf von Luckner et al (2021) who study "off chain" transactions on LocalBitcoins.com, a large peer-to-peer bitcoin exchange. They estimate that about 7 percent of bitcoin transactions are used to make payments, of which 20 percent represents transactions across borders. While more research is necessary, these results suggest that crypto-assets may be used as a response to overcome long-standing challenges in cross-border payments and remittances (including to evade capital controls). Nascent implementations of new promising technologies (e.g., the Lightning Network, see Poon and Dryja (2016)) that could address current transaction throughput challenges of crypto-assets may help accelerate adoption for (cross-border) payment transactions, but these technologies are largely untested at scale and may also pose new risks.

Our findings shine new light on the rapid growth and diverse drivers behind crypto-assets activity and offer support to the notions that crypto-assets are perceived as a risk asset, a potential macro hedge, and a potential tool to support cross-border payments. However, our results should be interpreted with caution. The crypto-assets industry represents an emerging heterogeneous asset class and while our sample spans over 130 countries, it covers just 27 months which include the COVID-19 pandemic and an environment of extraordinary fiscal, monetary, and financial sector conditions which may change when policy support is withdrawn. Moreover, our crypto-assets volume data are based on estimates and rely on important limiting assumptions. Further, our data exclude significant volumes of "off-chain" transactions. Finally, several other factors also inhibit us from drawing strong conclusions: the industry's track record is relatively short, the technologies are still rapidly evolving, and there are significant uncertainties around future global and national adoption and regulation.

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Table 2: Variable definitions and sources

Variable Type	Data Type	Variable Name	Definition	Sources
Dependent Variable	Crypto-assets activity	On-chain crypto-assets volume	Log monthly on-chain crypto-assets volume (in US$)	Chainalysis
Independent Variables for panel regressions	Macroeconomic factors (monthly basis)	Inflation	Year-on-year change in the monthly Consumer Price Index (CPI)	IMF International Financial Statistics
		Exchange Rate Change	Month-on-month change rate in exchange rates, national currency per USD, end of period	IMF International Financial Statistics
		Broad Money	Year-on-year change in monthly broad money	IMF International Financial Statistics
	Global Financial Factors (monthly basis)	Bitcoin Price Change	Month-on-month bitcoin price change (in US$)	Federal Reserve
		Ether Price Change	Month-on-month ether price change (in US$)	Federal Reserve
		VIX	CBOE Index of market's expectation of future S&P500 U.S. equity market volatility	Federal Reserve
		U.S. BBB Corporate Spread	ICE BofA BBB US Corporate Index Option-Adjusted Spread is a computed OAS index of all bonds in a given rating category and a spot Treasury curve	Federal Reserve
		U.S. Inflation Expectation Rate	5-Year, 5-Year Forward U.S. Inflation Expectation Rate, derived from U.S. Constant Maturity Treasury Securities	Federal Reserve
		U.S. 10-Year Breakeven Inflation Rate	Average expected inflation in the next 10 years derived from 10-Year U.S. Treasury Securities and similar Inflation-Indexed Securities	Federal Reserve
		U.S. 10-year Yield (inflation adjusted)	Market Yield on U.S. Treasury Securities at 10-Year Constant Maturity, Inflation-Indexed	Federal Reserve
		Gold Price Change	Month-on-month change rate in Gold price per Troy ounce	Federal Reserve
	Other	COVID Pandemic Dummy	One if month is March 2020 or later and zero otherwise	Authors' calculations
Independent Variables for annual cross-sectional regressions	Economic development	GDP per capita	Log value of GDP per capita (PPP, constant 2017 international USD)	World Bank World Development Indicators
	Financial development	Domestic Credit	Domestic bank credit to private sector (% of GDP)	World Development Indicators
		Financial Account Ownership	Account ownership at a financial institution or with a mobile-money-service provider (% of population ages 15+)	World Bank World Development Indicators
	Remittances	Remittances	Personal remittances, received (% of GDP)	World Bank World Development Indicators
	Economic Freedoms	Monetary Freedom Index	Monetary freedom combines a measure of inflation with an assessment of various government activities that distort prices. (100 – free, 0 - repressed)	The Heritage Foundation
		Financial Freedom Index	Financial freedom is an indicator of banking efficiency as well as a measure of independence from government control and interference in the financial sector. (100 – free, 0 - repressed)	The Heritage Foundation
	ICT development	Cell Phone Subscriptions	Mobile cellular subscriptions (per 100 people)	World Bank World Development Indicators
		Broadband Subscriptions	Fixed broadband subscriptions (per 100 people)	World Bank World Development Indicators

Table 3: Summary statistics

Panel A: On-chain crypto-assets volume (country-month) (in US$ thousands)

Crypto-asset type	N	Mean	S.D.	Min	Median	Max
Bitcoin	19,765	57.92	309.87	0.00	4.05	11,516.26
Ether	33,333	38.50	298.30	0.00	0.66	21,826.42
DeFi & Others	957,603	0.50	11.38	0.00	0.00	5,077.40
Stablecoins	130,393	7.64	55.88	0.00	0.07	4,078.74
All	1,141,094	3.42	69.46	0.00	0.00	21,826.42

Panel B: Main variables (country - month)

Variable	N	Mean	S.D.	Min	Median	Max
Key dependent variables						
Log monthly on-chain crypto-assets volume (all transaction sizes)	3,855	18.31	2.46	8.35	18.42	25.45
Log monthly on-chain crypto-assets volume (transaction size < US$10K)	3,855	16.13	2.21	5.81	16.25	22.35
Independent variables						
Inflation (yoy)	3,193	0.04	0.09	-0.05	0.02	1.46
Exchange rate change (mom)	3,722	0.00	0.04	-0.43	0.00	1.29
Broad money change (yoy)	2,288	0.14	0.33	-0.66	0.10	6.75

Panel C: Global financial conditions (monthly)

Variable	N	Mean	S.D.	Min	Median	Max
Bitcoin Price Change (mom)	27	0.11	0.24	-0.36	0.09	0.62
Ethereum Price Change (mom)	27	0.15	0.31	-0.39	0.09	0.77
VIX	27	23.50	9.80	12.62	19.40	53.54
U.S. BBB Corporate bond spread	27	4.24	1.26	3.06	3.73	8.09
U.S. Inflation Expectation Rate (5-year, 5-year forward)	27	1.82	0.26	1.25	1.85	2.27
U.S. 10-year breakeven inflation rate	27	1.74	0.40	0.87	1.70	2.42
U.S. 10-year Yield (inflation adjusted)	27	-0.40	0.52	-1.08	-0.50	0.56
Gold Price Change (mom)	27	0.01	0.05	-0.07	0.01	0.12

D: Summary statistics of variables (yearly, 2020 only)

Variable	N	Mean	S.D.	Min	Median	Max
Log on-chain crypto-assets volume/GDP (all transaction sizes)	147	-4.37	1.15	-8.91	-4.31	-1.69
Log on-chain crypto-assets volume/GDP (transaction size < US$10K)	147	-6.43	1.06	-10.24	-6.43	-3.75
Log GDP per capita	194	8.63	1.40	5.54	8.53	11.67
Credit to private sector (% of GDP)	194	66.10	49.94	1.93	52.97	266.61
Account ownership (% of adult population)	165	61.63	25.73	8.57	58.84	99.92
Personal remittances, received (% of GDP)	229	4.68	6.61	0.00	2.33	38.98
Monetary Freedom Index	184	74.65	10.88	0	76.9	87
Financial Freedom Index	181	48.95	19.28	0	50	90
Mobile cellular subscriptions (per 100 people)	188	111.68	30.17	43.93	112.06	291.65
Fixed broadband subscriptions (per 100 people)	184	17.61	14.53	0.00	15.70	53.20

Table 4: Correlation matrices

Panel A: Independent variables (country - month)

	Country factors			Global factors						
	Inflation Change	Exchange Rate Change	Broad Money Change	Bitcoin Price Change	Ether Price Change	VIX	U.S. BBB Corporate bond spread	U.S. 5Y5Y Inflation Exp. Rate	U.S. 10-year breakeven inflation	U.S. 10-year Yield
Exchange Rate Change	0.15	1.00								
Broad Money Change	0.69	0.39	1.00							
Bitcoin Price Change	0.01	-0.08	0.00	1.00						
Ether Price Change	0.00	-0.11	0.01	0.66	1.00					
VIX	-0.01	0.11	0.05	-0.08	0.03	1.00				
U.S. BBB Corporate bond spread	-0.02	0.07	0.06	-0.09	-0.05	0.78	1.00			
U.S. 5Y5Y Inflation Exp. Rate	0.00	-0.07	-0.02	0.10	0.18	-0.55	-0.66	1.00		
U.S. 10-year breakeven inflation	0.00	-0.07	-0.02	0.09	0.20	-0.48	-0.67	0.97	1.00	
U.S. 10-year Yield	0.02	0.07	-0.08	-0.04	-0.28	-0.37	-0.29	-0.23	-0.30	1.00
Gold Price Change	0.02	-0.12	0.00	0.04	0.13	-0.04	0.05	-0.12	-0.18	0.09

Panel B: Independent variables (annual, 2020 only)

	Log GDP per capita	Credit to private sector	Account ownership	Personal remittances, received	Monetary Freedom Index	Financial Freedom Index	Mobile cellular subscriptions
Bank credit to private sector	0.63	1.00					
Account ownership	0.83	0.55	1.00				
Personal remittances, received	-0.45	-0.26	-0.43	1.00			
Monetary Freedom Index	0.38	0.28	0.24	-0.18	1.00		
Financial Freedom Index	0.66	0.51	0.51	-0.21	0.48	1.00	
Mobile cellular subscriptions	0.48	0.43	0.42	-0.30	0.23	0.35	1.00
Fixed broadband subscriptions	0.85	0.59	0.75	-0.30	0.29	0.57	0.37

Table 5: Panel Regressions – Main result: Volume of transactions of <u>all sizes</u> for <u>all crypto-assets</u>

Dependent Variable: Log monthly on-chain crypto-assets volume (all transaction sizes), US dollars

Variable	(1)	(2)	(3)	(4)	(5)
			All Countries		
Inflation (yoy)	1.480***	0.724	-0.024	0.444	-0.003
Change exchange rate (mom)	-3.220***	-0.754	1.765***	2.808***	0.763*
Change Bitcoin price (mom)		0.468***	0.273***	0.367***	0.271***
Change Ether price (mom)		0.611***	0.058	0.347***	0.094**
US 10-year Yield (inflation adjusted)			-0.386***		-0.490***
US Inflation Expectation Rate			2.745***		2.869***
VIX				-0.062***	0.011***
Change gold price (mom)				-2.609***	-1.380***
Pandemic dummy		1.448***	1.318***	2.344***	1.057***
N of Observations	3095	3095	3095	3095	3095
N of clusters (countries)	136	136	136	136	136
Adjusted R squared	0.008	0.450	0.751	0.575	0.755
Country-Fixed Effects?	YES	YES	YES	YES	YES

Variable	(6)	(7)	(8)	(9)	(10)
			EMDEs only		
Inflation (yoy)	1.525***	0.420	-0.144	0.169	-0.132
Change exchange rate (mom)	-2.025**	-1.132*	1.576***	1.962***	0.976*
Change Bitcoin price (mom)		0.527***	0.170*	0.376***	0.188*
Change Ether price (mom)		0.515***	0.064	0.303***	0.100*
US 10-year Yield (inflation adjusted)			-0.397***		-0.492***
US Inflation Expectation Rate			2.680***		2.722***
VIX				-0.058***	0.007***
Change gold price (mom)				-3.100***	-1.636***
Pandemic dummy		1.459***	1.343***	2.311***	1.132***
N of Observations	1837	1837	1837	1837	1837
N of clusters (countries)	85	85	85	85	85
Adjusted R squared	0.008	0.433	0.698	0.545	0.702
Country-Fixed Effects?	YES	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the country level. All independent variables are lagged by one month, except the pandemic dummy. Bitcoin, ether, and gold prices expressed in US dollars. The gold price is expressed per Troy ounce. A constant is estimated, but not reported.

Table 6: Panel Regressions – Main result: Volume of small transactions for all crypto-assets

Dependent Variable: Log monthly on-chain crypto-assets volume (transaction size < US$10K), US dollars

Variable	(1)	(2)	(3)	(4)	(5)
			All Countries		
Inflation (yoy)	1.032***	0.500	0.073	0.334	0.098
Change exchange rate (mom)	-2.685***	-0.878**	0.698**	1.159***	0.156
Change Bitcoin price (mom)		0.587***	0.498***	0.521***	0.491***
Change Ether price (mom)		0.292***	-0.035	0.139***	-0.004
US 10-year Yield (inflation adjusted)			-0.394***		-0.431***
US Inflation Expectation Rate			1.434***		1.398***
VIX				-0.038***	0.001
Change gold price (mom)				-2.008***	-1.486***
Pandemic dummy		1.023***	0.784***	1.566***	0.717***
N of Observations	3095	3095	3095	3095	3095
N of clusters (countries)	136	136	136	136	136
Adjusted R squared	0.010	0.452	0.643	0.551	0.649
Country-Fixed Effects?	YES	YES	YES	YES	YES
Variable	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
			EMDEs only		
Inflation (yoy)	1.175***	0.393	0.054	0.237	0.064
Change exchange rate (mom)	-1.756***	-1.106**	0.528	0.797*	0.307
Change Bitcoin price (mom)		0.536***	0.360***	0.441***	0.370***
Change Ether price (mom)		0.249***	-0.025	0.120**	0.001
US 10-year Yield (inflation adjusted)			-0.390***		-0.416***
US Inflation Expectation Rate			1.413***		1.322***
VIX			-	-0.037***	-0.002
Change gold price (mom)				-2.199***	-1.564***
Pandemic dummy		1.031***	0.810***	1.564***	0.785***
N of Observations	1837	1837	1837	1837	1837
N of clusters (countries)	85	85	85	85	85
Adjusted R squared	0.010	0.411	0.574	0.498	0.579
Country-Fixed Effects?	YES	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the country level. All independent variables are lagged by one month, except the pandemic dummy. Bitcoin, ether, and gold prices expressed in US dollars. The gold price is expressed per Troy ounce. A constant is estimated, but not reported.

Table 7: Panel Regressions – Robustness of main result to alternative indicators: Volume of all transactions for all crypto-assets

Dependent Variable: Log monthly on-chain crypto-assets volume (all transaction sizes), US dollars

Variable	(1)	(2)	(3)	(4)	(5)
			All Countries		
Change in broad money (yoy)	0.779	0.028	-0.057	-0.026	-0.061
Change exchange rate (mom)	-1.865	-0.597	0.940***	0.972***	0.633
Change Bitcoin price (mom)		0.580***	0.406***	0.641***	0.342***
Change Ether price (mom)		0.574***	-0.021	0.049	0.054
US 10-year Yield (inflation adjusted)			-0.242***		-0.353***
US 10-year breakeven inflation rate			1.911***		2.337***
US BBB Corporate bond spread				-0.533***	0.196***
Change gold price (mom)				-1.305***	-0.754**
Pandemic dummy		1.494***	1.395***	2.417***	0.969***
N of Observations	2258	2258	2258	2258	2258
N of clusters (countries)	102	102	102	102	102
Adjusted R squared	0.017	0.451	0.749	0.635	0.756
Country-Fixed Effects?	YES	YES	YES	YES	YES

Variable	(6)	(7)	(8)	(9)	(10)
			EMDEs only		
Change in broad money (yoy)	0.671	0.034	-0.065	-0.027	-0.069
Change exchange rate (mom)	-1.195	-0.467	1.084***	1.102***	0.811**
Change Bitcoin price (mom)		0.548***	0.364***	0.606***	0.302***
Change Ether price (mom)		0.560***	-0.038	0.036	0.041
US 10-year Yield (inflation adjusted)			-0.298***		-0.411***
US 10-year breakeven inflation rate			1.904***		2.303***
US BBB Corporate bond spread				-0.535***	0.187***
Change gold price (mom)				-1.502***	-0.963**
Pandemic dummy		1.529***	1.385***	2.457***	0.967***
N of Observations	1689	1689	1689	1689	1689
N of clusters (countries)	78	78	78	78	78
Adjusted R squared	0.014	0.443	0.731	0.623	0.737
Country-Fixed Effects?	YES	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the country level. All independent variables are lagged by one month, except the pandemic dummy. Bitcoin, ether, and gold prices expressed in US dollars. The gold price is expressed per Troy ounce. A constant is estimated, but not reported.

Table 8: Panel Regressions – Robustness of main result to alternative indicators: Volume of small transactions for all crypto-assets

Dependent Variable: Log monthly on-chain crypto-assets volume (transaction size < US$10K), US dollars

Variable	(1)	(2)	(3)	(4)	(5)
			All Countries		
Change in broad money (yoy)	0.663*	0.136	0.070	0.108*	0.066
Change exchange rate (mom)	-0.974	-0.045	0.873**	0.734	0.604
Change Bitcoin price (mom)		0.648***	0.570***	0.677***	0.527***
Change Ether price (mom)		0.276***	-0.070	0.009	-0.004
US 10-year Yield (inflation adjusted)			-0.311***		-0.405***
US 10-year breakeven inflation rate			0.990***		1.252***
US BBB Corporate bond spread				-0.284***	0.131***
Change gold price (mom)				-1.324***	-1.190***
Pandemic dummy		1.057***	0.842***	1.541***	0.530***
N of Observations	2258	2258	2258	2258	2258
N of clusters (countries)	102	102	102	102	102
Adjusted R squared	0.021	0.432	0.605	0.538	0.613
Country-Fixed Effects?	YES	YES	YES	YES	YES

Variable	(6)	(7)	(8)	(9)	(10)
			EMDEs only		
Change in broad money (yoy)	0.584*	0.136	0.062	0.105	0.059
Change exchange rate (mom)	-0.441	0.094	1.015***	0.886*	0.776
Change Bitcoin price (mom)		0.607***	0.527***	0.634***	0.485***
Change Ether price (mom)		0.262***	-0.090	0.000	-0.016
US 10-year Yield (inflation adjusted)			-0.372***		-0.475***
US 10-year breakeven inflation rate			0.978***		1.232***
US BBB Corporate bond spread				-0.284***	0.131***
Change gold price (mom)				-1.558***	-1.463***
Pandemic dummy		1.088***	0.821***	1.571***	0.496***
N of Observations	1689	1689	1689	1689	1689
N of clusters (countries)	78	78	78	78	78
Adjusted R squared	0.019	0.416	0.580	0.516	0.589
Country-Fixed Effects?	YES	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the country level. All independent variables are lagged by one month, except the pandemic dummy. Bitcoin, ether, and gold prices expressed in US dollars. The gold price is expressed per Troy ounce. A constant is estimated, but not reported.

Table 9: Panel Regressions – Volume of all transactions across different crypto-assets

Dependent Variable: Log monthly on-chain bitcoin volume (all transaction sizes), US dollars

Variable	(1) Bitcoin	(2) Ether	(3) Stablecoins	(4) Non-stablecoins
		All countries		
Inflation (yoy)	-0.286	0.358	-0.115	0.017
Change exchange rate (mom)	0.582*	0.934	1.035	0.709*
Change Bitcoin price (mom)	0.522***	0.420***	0.089	0.329***
Change Ether price (mom)	-0.020	0.087*	0.047	0.111***
US 10-year Yield (inflation adjusted)	-0.160***	-0.803***	-0.959***	-0.338***
US Inflation Expectation Rate	1.953***	4.311***	2.518***	2.998***
VIX	0.007***	0.022***	0.008***	0.012***
Change gold price (mom)	-1.106***	-1.165***	-2.182***	-1.139***
Pandemic dummy	0.891***	1.427***	0.976***	1.095***
N of Observations	3095	3095	3095	3095
N of clusters (countries)	136	136	136	136
Adjusted R squared	0.634	0.828	0.726	0.752
Country-Fixed Effects?	YES	YES	YES	YES

Variable	(5) Bitcoin	(6) Ether	(7) Stablecoins	(8) Non-stablecoins
		EMDEs only		
Inflation (yoy)	-0.402*	0.246	-0.247	-0.115
Change exchange rate (mom)	0.608	1.076	1.428*	0.882*
Change Bitcoin price (mom)	0.415***	0.286**	-0.073	0.270***
Change Ether price (mom)	-0.032	0.157**	0.096	0.105*
US 10-year Yield (inflation adjusted)	-0.202***	-0.751***	-0.935***	-0.357***
US Inflation Expectation Rate	1.850***	4.089***	2.399***	2.834***
VIX	0.003	0.021***	0.005*	0.008***
Change gold price (mom)	-1.374***	-1.322***	-2.427***	-1.411***
Pandemic dummy	0.960***	1.500***	1.099***	1.149***
N of Observations	1837	1837	1837	1837
N of clusters (countries)	85	85	85	85
Adjusted R squared	0.590	0.780	0.672	0.698
Country-Fixed Effects?	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the country level. All independent variables are lagged by one month, except the pandemic dummy. Bitcoin, ether, and gold prices expressed in US dollars. The gold price is expressed per Troy ounce. A constant is estimated, but not reported

Table 10: Panel Regressions – Volume of small transactions across different crypto-assets

Dependent Variable: Log monthly on-chain bitcoin volume (transaction size < US$10K), US dollars

Variable	(1) Bitcoin	(2) Ether	(3) Stablecoins	(4) Non-stablecoins
		All countries		
Inflation (yoy)	-0.117	0.192	0.451	0.006
Change exchange rate (mom)	0.041	0.030	0.465	0.055
Change Bitcoin price (mom)	0.416***	0.814***	0.466***	0.491***
Change Ether price (mom)	-0.018	-0.031	-0.109***	0.021
US 10-year Yield (inflation adjusted)	-0.058	-0.737***	-0.996***	-0.328***
US Inflation Expectation Rate	0.683***	2.720***	0.696***	1.598***
VIX	-0.001	0.011***	-0.008***	0.004***
Change gold price (mom)	-0.853***	-2.505***	-1.651***	-1.496***
Pandemic dummy	0.512***	0.914***	0.694***	0.707***
N of Observations	3095	3095	3095	3095
N of clusters (countries)	136	136	136	136
Adjusted R squared	0.363	0.741	0.570	0.655
Country-Fixed Effects?	YES	YES	YES	YES

Variable	(5) Bitcoin	(6) Ether	(7) Stablecoins	(8) Non-stablecoins
		EMDEs only		
Inflation (yoy)	-0.141	0.206	0.272	0.012
Change exchange rate (mom)	0.013	0.510	0.552	0.222
Change Bitcoin price (mom)	0.323***	0.655***	0.331***	0.363***
Change Ether price (mom)	-0.035	0.010	-0.090	0.028
US 10-year Yield (inflation adjusted)	-0.073	-0.685***	-1.110***	-0.281***
US Inflation Expectation Rate	0.640***	2.663***	0.579***	1.544***
VIX	-0.003	0.010***	-0.013***	0.002
Change gold price (mom)	-1.057***	-2.503***	-1.951***	-1.555***
Pandemic dummy	0.569***	0.955***	0.769***	0.771***
N of Observations	1837	1837	1837	1837
N of clusters (countries)	85	85	85	85
Adjusted R squared	0.299	0.684	0.544	0.575
Country-Fixed Effects?	YES	YES	YES	YES

*** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at the country level. All independent variables are lagged by one month, except the pandemic dummy. Bitcoin, ether, and gold prices expressed in US dollars. The gold price is expressed per Troy ounce. A constant is estimated, but not reported.

Table 11: Cross-sectional Regressions – Volume for all crypto-assets (all countries, 2020)

Panel A: Volume of all transactions

Dependent Variable: Log annual on-chain crypto-assets volume as a fraction of nominal GDP (all transaction sizes)

Variable	(1) Financial development	(2) Remittances	(3) Economic Freedoms	(4) ICT development	(5) All
Log GDP per capita	0.107	0.317***	0.113	-0.383***	-0.366*
Credit to private sector	-0.001				-0.004
Transaction account ownership	0.004				0.009
Personal remittances received		0.040**			0.097***
Monetary Freedom			-0.029**		-0.002
Financial Freedom			0.017**		0.010
Mobile cellular subscriptions				0.008**	0.011***
Fixed broadband subscriptions				0.052***	0.042***
N of Observations	107	139	143	118	88
Adjusted R squared	0.026	0.102	0.088	0.174	0.311

Panel B: Volume of small transactions

Dependent Variable: Log annual on-chain crypto-assets volume as a fraction of nominal GDP (transaction size < US$10K)

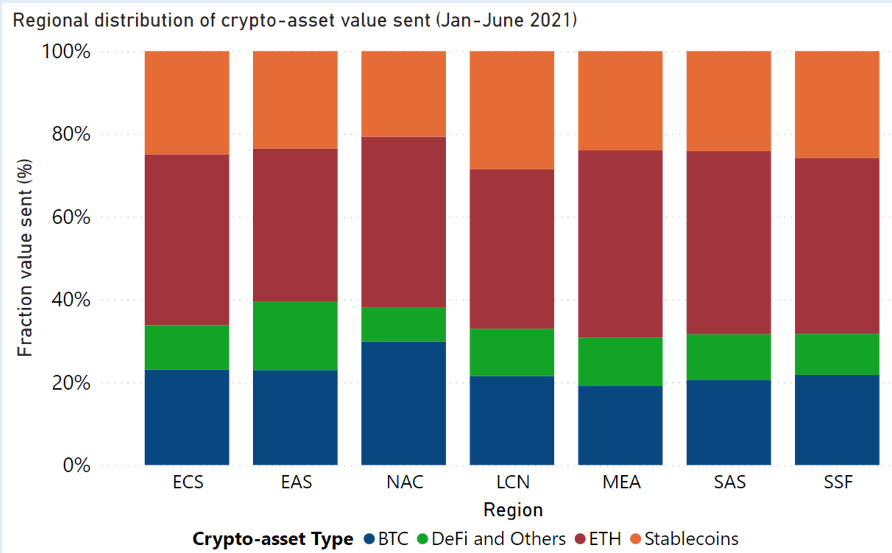
Variable	(1) Financial development	(2) Remittances	(3) Economic Freedoms	(4) ICT development	(5) All
Log GDP per capita	0.038	0.204***	0.058	-0.414***	-0.379**
Credit to private sector	-0.001				-0.004
Transaction account ownership	0.004				0.008
Personal remittances received		0.032*			0.062**
Monetary Freedom			-0.029**		-0.013
Financial Freedom			0.013*		0.009
Mobile cellular subscriptions				0.007**	0.010**
Fixed broadband subscriptions				0.046***	0.037***
N of Observations	107	139	143	118	88
Adjusted R squared	-0.007	0.049	0.056	0.127	0.172

*** p<0.01, ** p<0.05, * p<0.1 OLS regressions. Robust standard errors. Constant is estimated but not reported.

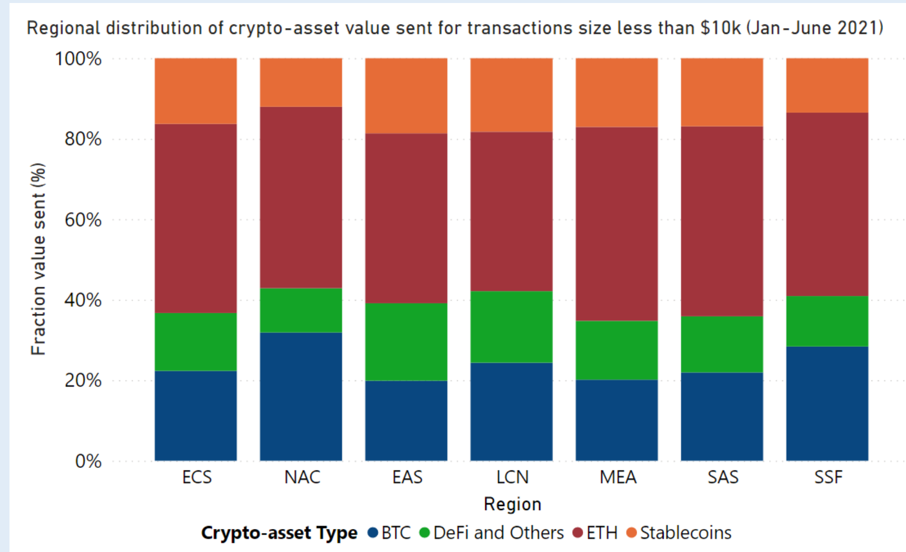
Annex: Additional charts

Figure A1: On-chain Crypto-assets Volume (2021)

Panel A: Volume by Region for All Transaction Sizes
% of total

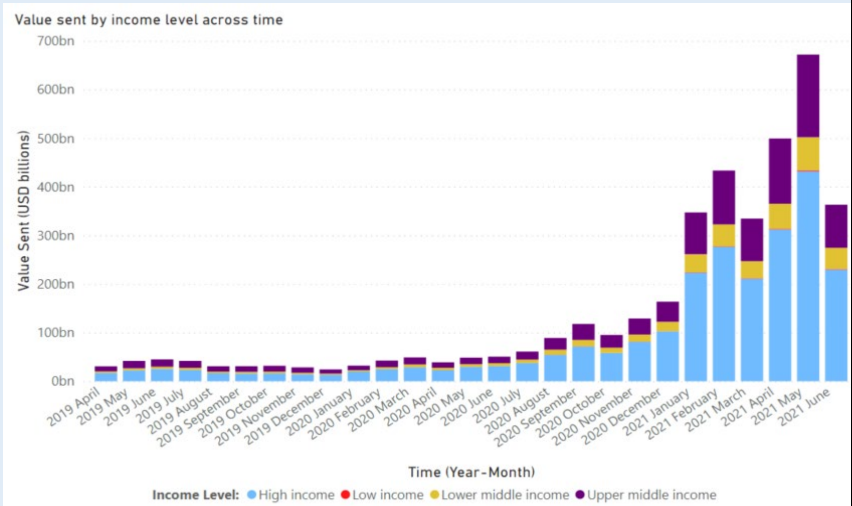


Panel B: Volume by Region for Small Transactions (<US$10k)
% of total

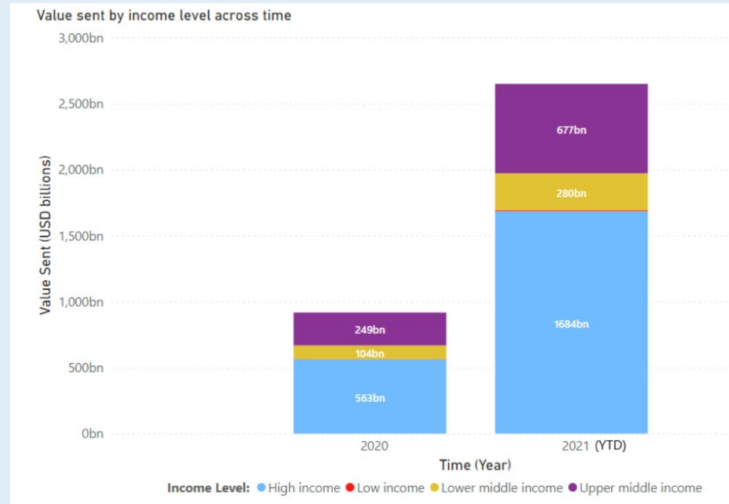


Source: Chainalysis; World Bank staff calculations.
Note: EAS = East Asia and Pacific; ECS = Europe and Central Asia; LCN = Latin America and Caribbean; MEA = Middle East and North Africa; NAC = Northern America; SAS = South Asia, SSF = Sub-Saharan Africa.

Panel C: Volume by Income Level for All Transaction Sizes US$

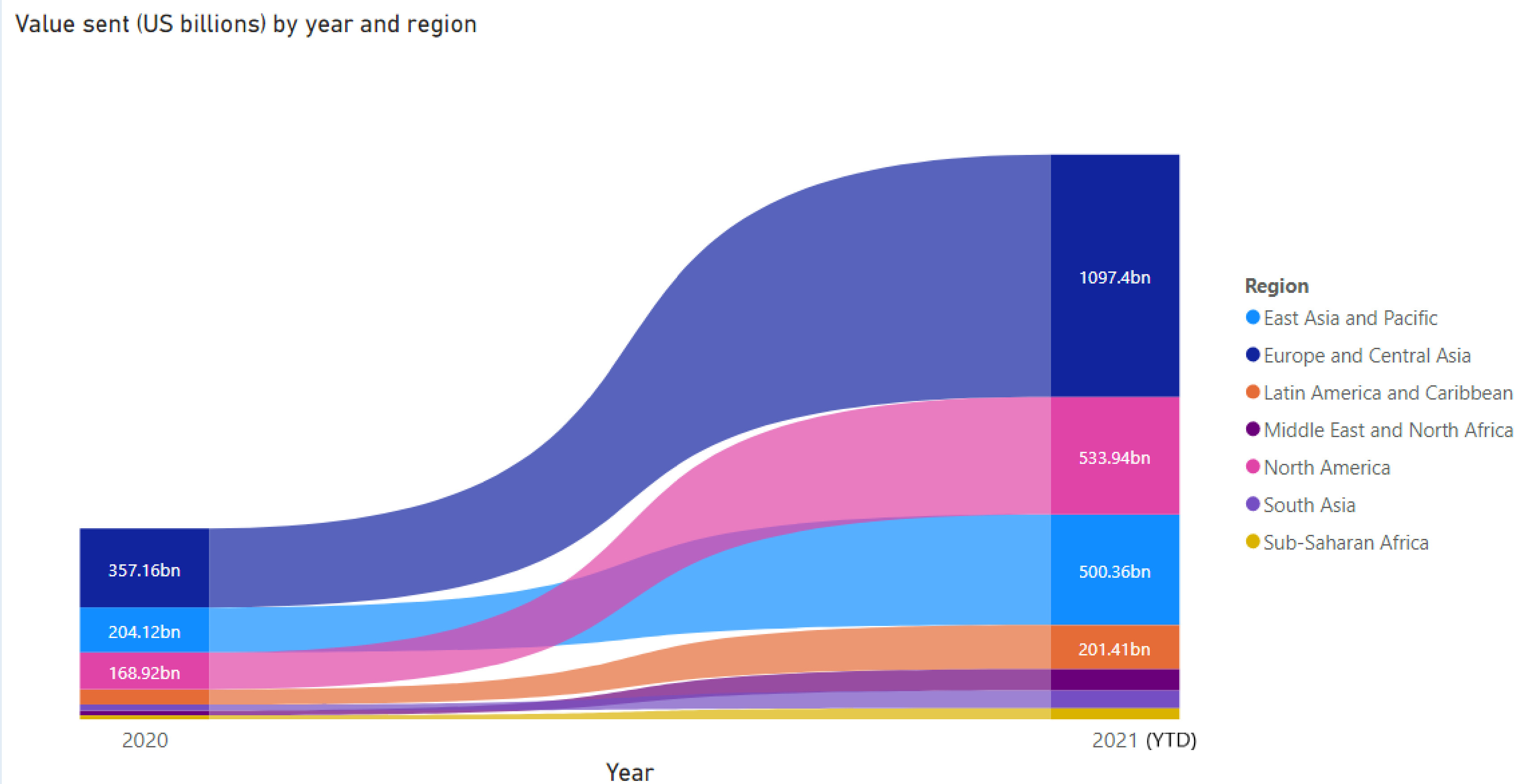


Panel D: Volume by Income Level Aggregated by Year US$



Source: Chainalysis; World Bank staff calculations.
Note: 2021 data cover the period January - June.

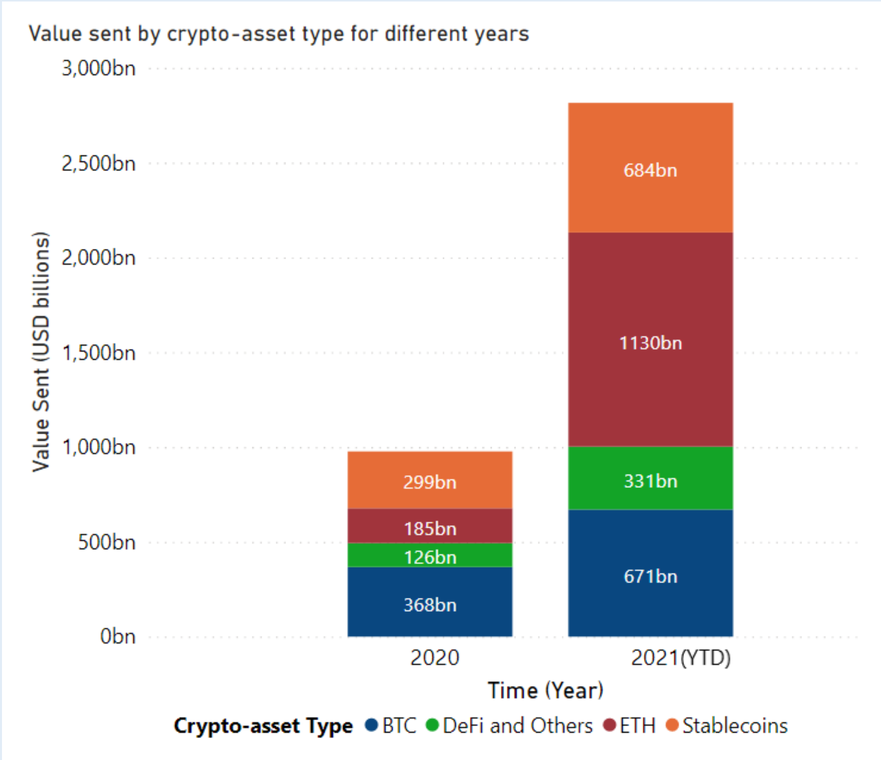
Panel E: Crypto-assets Volume Breakdown by Year and Region
US$



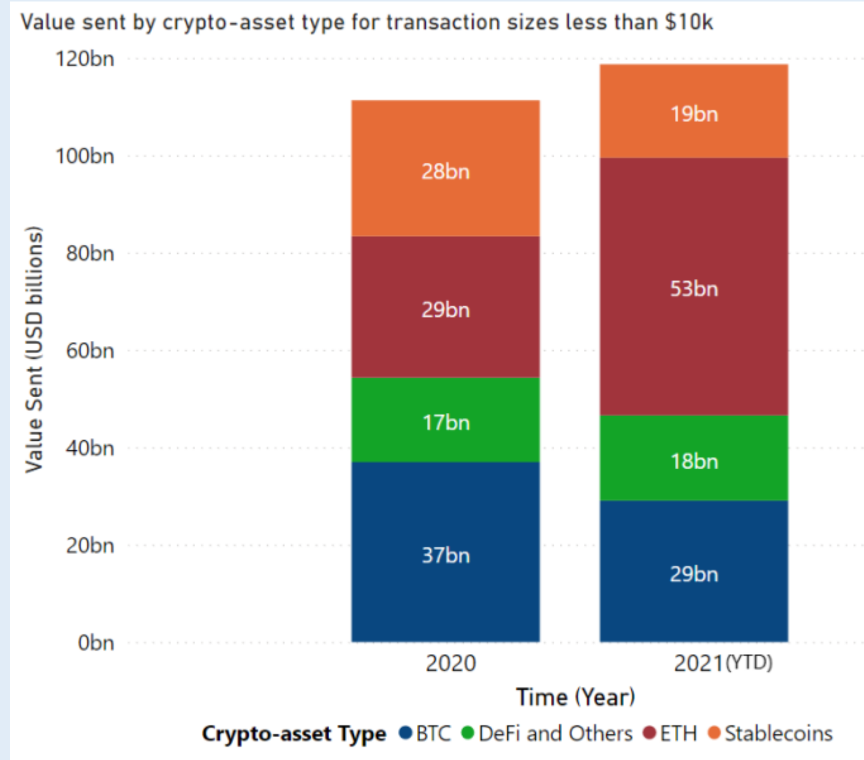
Source: Chainalysis; World Bank staff calculations.
Note: 2021 data is year to date and cover the period January - June.

Figure A2: On-Chain Crypto-assets Volume by Type of Crypto-asset

Panel A: All Transaction Sizes
US$

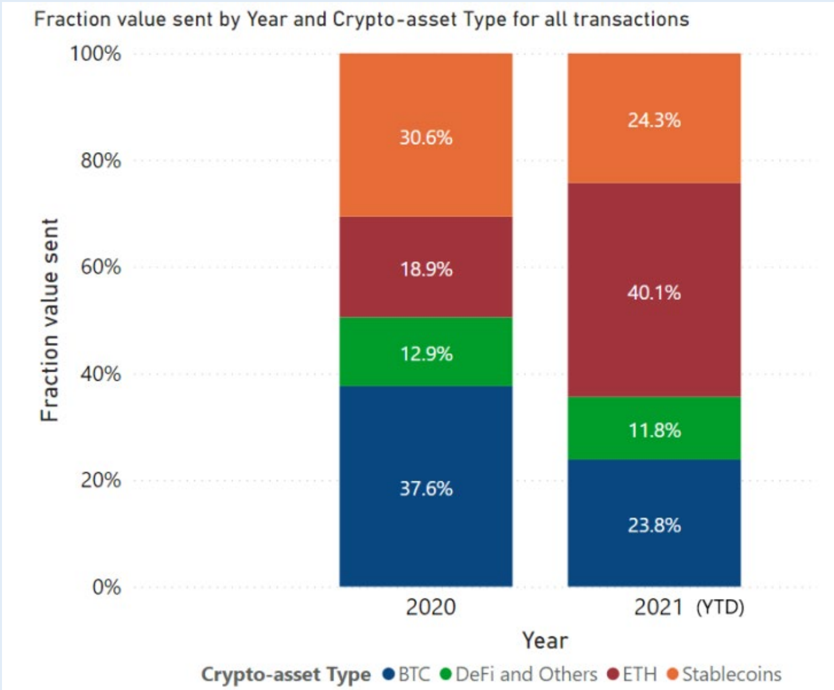


Panel B: Small Transactions (<US$10k)
US$

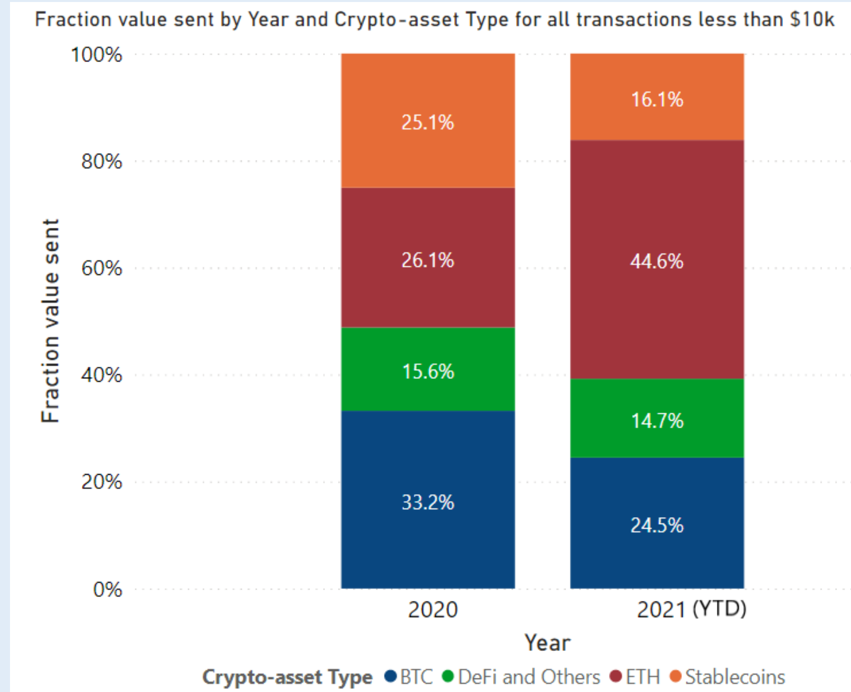


Source: Chainalysis; World Bank staff calculations.
Note: 2021 data is year to date and cover the period January - June.

Panel C: All Transaction Sizes
% of total volume

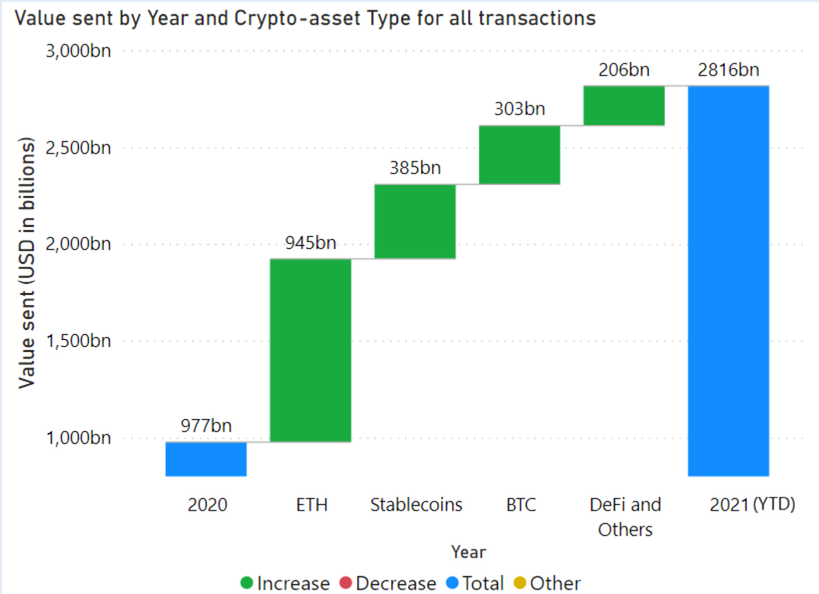


Panel D: Small Transactions (<US$10k)
% of total volume

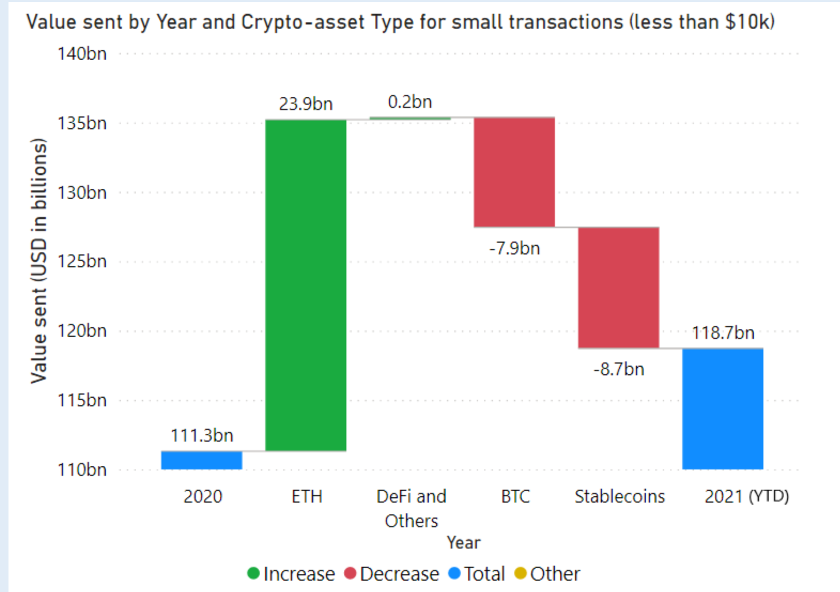


Source: Chainalysis; World Bank staff calculations.
Note: 2021 data is year to date and cover the period January - June.

Panel E: All Transaction Sizes
US$



Panel F: Small Transaction Sizes (<US$10k)
US$



Source: Chainalysis; World Bank staff calculations.
Note: 2021 data is year to date and cover the period January - June.