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Original Research Article

The Role of Adoption and Expansion of Global Cryptocurrencies in Financial Globalization

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In international trade and financial exchanges, global cryptocurrencies have a prominent and effective role. In this paper, using the KOF index, the structure of financial globalization is extracted and the effect of the expansion of global cryptocurrencies is examined in the two components: Foreign Direct Investment and Portfolio Investment. The Ordinary Least Squares (OLS) model has been used separately for 2020, 2021, and 2022 to analyze the results of the expansion of global cryptocurrencies in the foreign direct investment component. Also, the price changes of Bitcoin and Ethereum from March 10, 2016, to the end of December 2022 have been used to investigate the effect of global cryptocurrencies in portfolio investment by applying Modern Portfolio Theory (MPT). Also, according to the availability of data in research sources, the data of 111 countries have been used. OLS estimated results suggest that the adoption and expansion of global cryptocurrencies has no significant relationship with Foreign Direct Investment. Also, using MPT, the results of portfolio optimization suggest that global cryptocurrencies improve the effectiveness of the selected portfolios, and with the same corresponding returns, the risk of the portfolios including global cryptocurrencies decreases as well. Therefore, the results emphasize the role of global cryptocurrencies in financial globalization only as crypto-assets.

Keywords: Global Cryptocurrencies, Financial Globalization, Foreign Direct Investment, Portfolio Investment, OLS, Modern Portfolio Theory.
JEL Classification: C61, F65, G11, G15

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1 Introduction

In his 1975 lecture, "Choice of Currency," Friedrich Hayek first proposed the radical idea of abolishing the state's monopoly on money (Hays, 2018). Hayek believed that the government's monopoly on money should end quickly and be replaced by a free market-based money creation system that is completely competitive. It can be said that Bitcoin is the idea of Hayek in action. At first, the idea of competitive money seemed impossible due to the historical monopoly of governments on money, but the situation has completely changed due to the spread of the Internet. In the financial crisis of 2008 and the decrease of people's trust in banks, the first cryptocurrency in history, Bitcoin, announced its existence. Since then, thousands of different cryptocurrencies have been competing for a better position in the market. In 2008, Satoshi Nakamoto released the famous whitepaper "Bitcoin – A Peer-to-Peer Electronic Cash System" (Nakamoto, 2008), which promised the first ever flawlessly functioning decentralized currency system operating without a central authority (Crosby et al., 2016). Actually, Bitcoin is the most familiar type of digital money for P2P or peer-to-peer transactions (Jalali-Naini & Rabie Hamedani, 2018).

Since the emergence of Bitcoin, the possible effect of BTC and other cryptocurrencies on either financial markets or transactions has been widely noticed. Cryptocurrencies have their own unique unit of account, generated by non-banks and issued on a public blockchain, commonly of the permissionless type (Adrian & Mancini-Griffoli, 2021). It possesses certain beneficial properties which contribute to its appeal as a currency. These special properties include: the ability to secure and verify transactions instantaneously; the possibility to remove barriers concerning cross-border transactions; the transfer as effortless as data from one individual to another, without the time-lag caused by relying on third-party intermediaries; the creation of an ecosystem which allows the possibility for many unbanked individuals to transfer capital around the world (Kuikka, 2019) and acting as a replacement currency in nations where the national fiat-currency has become devalued. However, in the latter case in particular, there is a particular risk that cryptocurrencies could become parallel currencies, leading to a mass exodus from national currencies and undermining the effectiveness of monetary and fiscal policies (Grym et al., 2017). Furthermore, Cryptocurrencies are useful minimum-variance hedging instruments for economic uncertainties. Koutmos et al. (2021) showed that cryptocurrencies are more effective at hedging against economic

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uncertainties stemming from equity and commodity markets, making them attractive to investors seeking to diversify their portfolios. They are relatively less effective for uncertainties arising from risks in the banking industry and firm default risk (Koutmos et al., 2021).

Also, based on the research of Braïek and Jeribi (2023), it has been recommended that portfolio managers take into account the few eligible cryptocurrencies for inclusion in their portfolios. Furthermore, they argue that cryptocurrencies can function as a medium of exchange, unit of account, and store of value, providing valuable insights into the economy's resilience to shocks. (Braïek & Jeribi, 2023)

Economic globalization refers to the increasing interdependence of the world's economies as a result of the growing trend of international trade in goods and services, international capital flows, and the vast and rapid expansion of technology. Greater interdependence as a result of globalization means a freer flow of goods, services, money, people, and ideas across national borders. The development of economic activities based on capitalism has expanded all over the world and created a truly global economy. Today we see that new technologies, especially cryptography and networks, have created fundamental changes in the structure of the global economy. Among the most important of these changes, we can mention the emerging phenomenon called cryptocurrency. Now cryptocurrencies such as Bitcoin and Ethereum, which have global expansion, are becoming popular, which are transnational and no longer governmental. The evolving role of cryptocurrencies in the global economy shows a shift from being solely a tool for personal use to becoming a significant player in global financial markets. As a result, the adoption and expansion of cryptocurrencies in most regions of the world can accelerate economic globalization and especially financial globalization.

Majewski (2019) investigated the process of globalization supported by cryptocurrencies. The emergence of cryptocurrencies has revolutionized the landscape of online payments and international transactions. By becoming the first global digital currency, Bitcoin revolutionized international payments and brought the concept of a global village closer to reality. Cryptocurrencies show that governments play a secondary role in shaping the modern global world. Although some authorities have banned the cryptocurrency trade, it is still possible to overcome these limitations. In recent years, projects such as Ripple have sought to facilitate seamless money transfers between entrepreneurs and individuals.

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This is a major step in creating a global economy instead of a merely regional economy (Majewski, 2019).

Considering the growing role of cryptocurrencies in international trade and financial exchanges, examining the effects of the adoption and expansion of this type of virtual money in financial globalization can play an effective role in creating transparency of their effect in the global economy and can be useful for policymakers and researchers in the field of international finance. Many researches have been conducted in this field, but most of them have been descriptive, and less international statistics and mathematical models have been used in the analysis of the results. Our goal is to find the role of global cryptocurrencies in financial globalization. To achieve this goal, we utilize the components of the KOF financial globalization index and examine the effect of the expansion of global cryptocurrencies in the components of foreign direct investment and portfolio investment, which is explained in detail in the conceptual framework section. Chainalysis Global Cryptocurrency Adoption Index is used as a variable for the adoption and expansion of global currencies in terms of its impact on foreign direct investment. Due to the limitation of the number of years for reported data through Chainalysis Company, which provides the most complete index in this field according to the authors' opinion, the OLS model has been used separately for 2019, 2020, and 2021 to analyze the results. Also, the price changes of Bitcoin and Ethereum from March 10, 2016, to the end of December 2022 have been used to investigate the effect of global cryptocurrencies in portfolio investment by applying modern portfolio theory.

The structure of this paper is as follows: we first review the economic reasons for the adoption of cryptocurrencies and its geographical expansion around the world in section 2.1 and then examine the effect of this adoption in financial globalization in sections 2.2 and 2.3. In fact, we conduct our analysis by examining the effect of adopting global cryptocurrencies in foreign direct investment and portfolio investment. Finally (in section 3), according to the results of the models used in this paper, the role of global cryptocurrencies in financial globalization is determined.

2 Conceptual Framework

The KOF Globalization Index measures the economic, social, and political dimensions of globalization. The sub-segment of economic globalization comprises trade flows on the one hand and financial flows on the other. De facto trade globalization is determined on the basis of trade in goods, trade in

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services, and trade partner diversity. De jure trade globalization includes tariffs, taxes, restrictions, and agreements. De facto financial globalization includes foreign direct investment, portfolio investment, etc. De jure financial globalization includes investment restrictions, capital account openness, and international investment agreements. In this research, we have used the KOF Financial Globalization, de facto index as a measure of financial globalization. Before that, in the first part, we review the factors of the adoption of global cryptocurrencies and their geographical expansion according to the studies conducted. Next, we examine the effect of adopting global currencies in foreign direct investment using OLS for 2019, 2020, and 2021. In the third part of the analysis, we will examine the effect of global cryptocurrencies in portfolio investment.

2.1 Adoption of Global Cryptocurrencies

Here, we study the factors of the adoption of global cryptocurrencies and review their expansion geographically according to previous studies.

Cryptocurrencies are being adopted rapidly and broadly (e.g., Saiedi et al., 2021). The global economy is inevitably moving towards a digital ecosystem (Dhini, 2019). Amidst the growing interest in cryptocurrencies, or digital currencies in general, researchers are investigating the motivations behind their adoption by individuals or businesses. (Cohen, 2017; Dierksmeier & Seele, 2018; Dodgson et al., 2015), global empirical studies are scarce on drivers of their adoption (e.g., Saiedi et al., 2021). The emergence of cryptocurrencies has often been viewed as driven by the opportunity for radical innovation and entrepreneurship in financial solutions as created through the spread of new Internet-based technology (Iyidogan, 2020; Teo, 2015). However, recent research highlights the significance of understanding the historical growth and future prospect of fintech innovations we must also understand the nature of the needs addressed by such innovations. (Cohen, 2017; Huang et al., 2019; Saiedi et al., 2018).

Also, the occurrence of economic crises such as unbridled inflation plays a role in the adoption of cryptocurrencies, especially stable coins. In particular, we find more adoption where distrust in banks and the financial system are greater, as well as in countries experiencing inflationary crises. Specifically, purchasing bitcoins presents a unique opportunity to hedge against (extremely) high inflation rates, similar to how gold and other assets have historically been used (Arnold & Auer, 2015). While Bitcoin has not yet proven to be the inflation hedge many believed it would be, stable coins – cryptocurrencies that are designed to stay pegged to the price of fiat

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currencies like USD – are a favorite in the most inflation-ravaged countries (Chainalysis, 2022).

A series of research studies have shown that bitcoin adoption is greatest where the risk of narcotics-related money laundering is greatest. For example, it is mentioned in the 2014 FATF report. The pseudonymous nature of cryptocurrencies like Bitcoin has made them a target for money laundering activities. (FATF, 2014; NDIC, 2008). Money-laundering refers to processes whereby the proceeds from illicit trade are being transacted through financial institutions so as to hide its origin in illicit activities. A substantial share of such activity is directly related to drug trade. While money laundering may take place across as well as within nations, locations with high levels of trade in drugs would typically rate high on measures of money-laundering activity (Saiedi et al., 2021).

It is stated in some studies that bitcoin adoption is driven by perceived failings of traditional financial systems. (e.g., Cohen, 2017; Shiller, 2019; Vigna & Casey, 2015). In particular, we find more adoption where distrust in banks and the financial system are greater (Saiedi et al., 2021). As expected, speculative interest in Bitcoin has been a partial driver of adoption of bitcoin. (e.g., Baur et al., 2018), Saiedi et al. (2021) find more Bitcoin infrastructure where the willingness to take risks is higher.

DeFi[1] is still where many of the most cutting-edge cryptocurrency projects are built, and these tend to catch on first in North America and Western Europe. In addition, many DeFi use cases, such as yield farming and trading of new tokens on DEXs[2], are highly speculative, which will naturally attract investors who have either built up solid crypto holdings already or otherwise have money to play with. DEXs, on the other hand, with their bigger transfer sizes and higher transaction volume, appear to get more usage from professional and even institutional users. NFT platforms lead the way, driving the most web traffic of any other DeFi protocol type in the regions (Chainalysis, 2022).

Analysis of Latin America identified three key use-cases driving crypto adoption: storing value; sending remittances and seeking alpha. In this

[1] Decentralized Finance eliminates intermediaries by allowing people, merchants, and businesses to conduct financial transactions through emerging technology. Through peer-to-peer financial networks, DeFi uses security protocols, connectivity, software, and hardware advancements.

[2] DEXs are decentralized crypto exchanges that offer access to digital assets without an intermediary.

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region, there are countries that face high year-on-year inflation rates. So that their fiat currencies have lost half of their value over the past years. As a result, people use stablecoins to modernize the way they save. Latin America's formal remittance market is estimated to reach $150 billion, and the adoption of crypto-based remittance services has been uneven, but swift, throughout the region. In addition to using cryptocurrencies for savings, residents of advanced Latin American economies, like Brazil, are driven by the prospect of financial gains. In these countries, large numbers of crypto users are engaging with permissionless protocols that enable them to lend, trade, stake, and borrow tokens of all kinds – a speculative activity with significant risk and upside potential (Chainalysis, 2022).

Risky and illicit activity is prominent in Eastern Europe's on-chain activity. After all, the war had a serious economic impact on citizens of both Russia and Ukraine. Ukraine has seen extremely high inflation, in July 2020 New York Times article citing 90% increases in fuel costs and 35% increases in food costs. Russia has also seen high inflation at times since the invasion, and has faced difficulties in international commerce — in particular, exporting commodities like oil — due to its removal from the SWIFT banking network. We can see that both countries saw an initial increase in cryptocurrency transfers in March 2022, soon after the war began on February 24 (Chainalysis, 2022).

The main drivers of – and barriers to – grassroots cryptocurrency adoption in Central & Southern Asia and Oceania (CSAO) are also analyzed. For instance, web traffic patterns suggest NFTs are perhaps the biggest on-ramp into DeFi for CSAO today. The websites of play-to-earn blockchain games are the second. Play-to-earn games and non-fungible tokens (NFTs) are intimately related. In most blockchain games today, the in-game items are NFTs, like Axie pets in Axie Infinity and Sneakers in STEPN, which can be resold on a number of different NFT marketplaces, like MagicEden and OpenSea. For countries with high web traffic to NFT marketplaces – especially Thailand, Vietnam, and the Philippines – a large portion of that NFT-related traffic may therefore come from players of blockchain games (Chainalysis, 2022).

The data shows that Eastern Asia, especially China, has surprisingly low DeFi adoption. This is likely due to Chinese government crackdowns on cryptocurrency activity over the last year. But Japan's cryptocurrency market has grown substantially. One reason could be Japan's comparatively high embrace of DeFi. Many have pointed out that Japan has lots of quality IP from anime, comics, and video games, which could be utilized in Web3 in

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the future. Chainalysis data confirms that these services have played a big role in Japan's DeFi market. As mentioned above, China has seen a large dropoff in cryptocurrency activity, likely due to governmental crackdowns. While governmental crackdowns have clearly had an effect, China's cryptocurrency market remains strong, with healthy transaction volumes across both centralized and DeFi services (Chainalysis, 2022).

Middle East & North Africa (MENA) is the fastest growing in crypto adoption. Use cases around savings preservation and remittance payments as well as increasingly permissive crypto regulations help explain why (Chainalysis, 2022).

Sub-Saharan Africa's retail market and outsized usage of P2P platforms make it unique compared to other regions. Retail transfers dominate the market, accounting for a staggering 95% of all transactions. Moreover, small-value retail transfers below $1,000 make up a whopping 80% of the total, surpassing any other region. The adoption of P2P exchanges is another reason. In addition to trading and saving, there are two other use cases powering crypto adoption in Sub-Saharan Africa: remittances and commerce. Remittances from overseas have long been important for Sub-Saharan African economies. These areas have many people who immigrate to Europe and work there. Using cryptocurrencies, people working in Europe are able to send money to their families instantly and at almost zero fees. Commercial transactions are another use case. Due to strict capital controls in the region, many businesses dependent on foreign suppliers have turned to cryptocurrency for payments, as traditional methods of sending funds abroad have proven cumbersome (Chainalysis, 2022).

As can be seen, various economic reasons in different places of the world have led to the adoption and expansion of global cryptocurrencies, and this expansion can have significant effects in the world economy. One of these effects can be in the field of financial globalization, the examination of which can be effective in making the new global economy more transparent.

2.2 The Role of Adoption and Expansion of Global Cryptocurrencies in Foreign Direct Investment

2.2.1 The Adoption and Expansion Variable of Global Cryptocurrencies

In this section, the global cryptocurrency adoption index of the Chainalysis Company has been used as the adoption and expansion variable of global cryptocurrencies. Three versions of the report of this company have been

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published in 2020, 2021, and 2022, and the following three sub-indexes are common in all reports:

1) On-chain cryptocurrency value received, weighted by purchasing power parity (PPP) per capita: The goal of this metric is to rank each country by total cryptocurrency activity, but weight the rankings to favor countries where that amount is more significant based on the wealth of the average person and value of money generally within the country. The metric is calculated by estimating total cryptocurrency received by that country and weighting the on-chain value based on PPP per capita, which is a measure of the country's wealth per resident. The higher the ratio of on-chain value received to PPP per capita, the higher the ranking, meaning that if two countries had equal cryptocurrency value received, the country with the lower PPP per capita would rank ahead (e.g., Chainalysis, 2020; 2021; 2022).
2) On-chain retail value received, weighted by PPP per capita: The goal of this metric is to measure the activity of non-professional individual cryptocurrency users, based on how much cryptocurrency they are transacting relative to the wealth of the average person. Individuals' cryptocurrency activity is approximated by measuring the amount of cryptocurrency moved in retail transactions, which designate as any transaction for under $10,000 worth of cryptocurrency. Then each country is ranked according to this metric but weight it to favor countries with a lower PPP per capita (e.g., Chainalysis, 2020; 2021; 2022).
3) Peer-to-peer (P2P) exchange trade volume, weighted by PPP per capita and number of internet users: P2P trade volume makes up a significant percentage of all cryptocurrency activity, especially in emerging markets. For this index, countries are ranked by their P2P trade volume and weighted to favor countries with lower PPP per capita and fewer internet users, the goal being to highlight countries where more residents are putting a larger share of their overall wealth into P2P cryptocurrency transactions (e.g., Chainalysis, 2020; 2021; 2022).

These reports have examined about 150 countries in which cryptocurrency exchanges are taking place. The final index of Chainalysis, which is a number between zero and one, has been calculated by weighting the sub-indexes presented in the reports based on the population and size of the economy of each country. The aim has also been to highlight the countries where most of the residents have done a greater share of their financial activities through cryptocurrencies.

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Table 1 shows the top 15 countries in the Chainalysis 2021 Global Crypto Adoption Index.

Table 1
Top 15 Countries in Chainalysis 2021 Global Crypto Adoption Index

Country	**Index Score**	**Overall index ranking**	**Ranking for individual weighted metrics feeling into Global Crypto Adoption Index**		
			On-chain value received	On-chain retail value received	P2P exchange trade volume
Vietnam	1.00	1	4	2	3
India	0.37	2	2	3	72
Pakistan	0.36	3	11	12	8
Ukraine	0.29	4	6	5	40
Kenya	0.28	5	41	28	1
Nigeria	0.26	6	15	10	18
Venezuela	0.25	7	29	22	6
United State	0.22	8	3	4	109
Togo	0.19	9	47	42	2
Argentina	0.19	10	14	17	33
Colombia	0.19	11	27	23	12
Thailand	0.17	12	7	11	76
China	0.16	13	1	1	155
Brazil	0.16	14	5	7	113
Philippines	0.16	15	10	9	80

Source: https://blog.chainalysis.com/reports/2021-global-crypto-adoption-index

2.2.2 Foreign Direct Investment

The high volatility of cryptocurrencies due to most people's ignorance, low market depth, the existence of speculative motives and mass behavior will cause high turbulence and fragility and create a bubble in the price of these virtual currencies. Also, due to the negative viewpoint of many governments and central institutions towards cryptocurrencies and preventing their natural expansion in the economy, the high time of transaction approval for domestic exchanges and the impossibility of using them widely in micro-payments, their monetary functions have been seriously questioned. But with the advancement of technology and people's familiarity, the depth of the virtual money market will increase, decreasing their volatility and increasing their use in small payments. Also, the existence of their unique features such as freedom in payment and international access, very low transaction costs, high speed in international and cross-border transfers, the absence of excessive Issuance of money in the economy, the inability of governments to

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confiscate and block, the possibility of creating tokens and the initial supply of coins, the possibility of using smart contracts, facilitating the globalization of domestic businesses and increasing foreign investment, divisibility, the impossibility of counterfeiting virtual money unlike common money, is expected that with time, their monetary functions will become more prominent and can be one of the types of future money of the global economy (Nori 2019).

In recent decades, various forms of international capital flows have enjoyed a high growth; among them we can mention foreign direct investment. This increase in investment and trade can be seen to a large extent as a result of the extensive commercial and financial liberalization policies in different countries of the world. Foreign direct investment is a process by which the home country acquires ownership of assets in the host country in the long term to control production, distribution, and other related activities. Historically, the role and position of investment in the process of growth and development is such that investment is called the driving engine of economic growth. Foreign direct investments are not only the transfer of capital, but also the transfer of technology and access to international markets. During the studies carried out by Kiyoshi Kojima, he explained the foreign direct investment patterns of the United States and Japan as developing countries and the consequences of these investment patterns in the development of international trade and global prosperity. According to Kojima's theory (1973 & 1975), foreign direct investment is a tool for transferring technology, capital, and management skills from the home country to the host country (e.g., Kojima 1973; 1975).

The degree of economic openness (financial and trade), market size, and inflation can be considered as factors affecting foreign direct investment (Moradi, 2017). Also, the Corruption Perceptions Index has a significant economic effect on FDI (Huu Cung & Hong Nhung, 2020). Closed economic policies create a big obstacle in the way of access to financial markets and new global technologies. Therefore, developing countries, understanding this reality, have started to modify their structure and policies to facilitate communication and trade exchanges. Increasing the degree of openness of the economy by expanding the competition between domestic and foreign enterprises helps to improve the productivity of enterprises, that is, domestic enterprises will have more motivation to improve their efficiency to survive in the market. A large-scale economy also increases the incentive of profitability and foreign investment, because in this case, the productivity of technology and investment increases. In most economic

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studies, the GDP of each country is used as an index of market size to estimate the research model. Turbulence in the domestic market and disruption of economic balances and fluctuations in macroeconomic variables, including the price index, will lead to instability in the domestic economy, and the foreign investor will be confused in predicting the profit and loss of his investment and will be hesitant in the amount of his investment. Therefore, economic stability will be necessary to attract foreign investors. One of the variables that can be used as an indicator of economic stability is the inflation rate in each country, because the approximate stability of prices will create a stable environment for predicting the profit from investment. Corruption can also affect badly countries' development. So, it can have many serious consequences in all fields of the economy, especially FDI. Recent econometric analyses that have exploited the existence of natural experiments on the level of corruption and compared the Corruption Perceptions Index with other subjective indicators have found that, while not perfect, the Corruption Perceptions Index is argued to be broadly consistent with one-dimensional measures of corruption (Hamilton & Hammer 2017). The Corruption Perceptions Index is an index that ranks countries by their perceived levels of public sector corruption, as determined by expert assessments and opinion surveys (Transparency International, 2022).

Since the early 1980s, FDI has become a more widely recognized tool for transferring resources across national boundaries to enhance economic quality, industrial and foreign competitiveness, and exports. With the emergence of cryptocurrencies, we see fundamental changes in financial exchanges, trade, and international capital flow, but as far as the authors' knowledge, extensive research has not been done in this field, and especially in this case, the literature has not paid sufficient attention. Therefore, in the next section, using the Ordinary Least Squares (OLS) model for the years 2019, 2020, and 2021 and the variables introduced before, we will examine the role of the adoption and expansion of cryptocurrencies in international trade and financial exchanges.

According to the reports of Chainalisys Company, the data of the adoption of global cryptocurrencies was obtained for 150 countries during the years 2020 to 2022. In this paper, according to the availability of data in research sources, the data of 111 countries (see Table A in Appendix) have been used. Because the reports of each year are based on the data of the previous year, we have considered the report of each year for the data of the previous year. Data of Foreign Direct Investment (FDI), GDP Per Capita,

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Inflation Rate, Financial Openness, and Trade Openness were obtained from the World Bank for these 111 countries. The Corruption Perceptions Index is also published annually by the non-governmental organization of Transparency International since 1995. It is worth noting that financial openness is achieved as follows:

$$\text{Financial Openness} = \frac{\text{FDI Net Inflow + FDI Net Outflow+ Net Portfolio Investment}}{\text{GDP}} \quad (1)$$

Trade openness is also calculated from the following formula:

$$\text{Trade Openness} = \frac{\text{Export of goods and services + Import of goods and services}}{\text{GDP}} \quad (2)$$

Foreign direct investment as an explained variable and other variables (global cryptocurrency adoption index, GDP per capita, inflation rate, Corruption Perceptions Index, and financial and commercial openness) as independent variables in the OLS model are specified as follows:

$$\text{FDI}_t = C_t + \beta_{1,t}\text{CrypIndex}_t + \beta_{2,t}\text{GDPPPP}_t + \beta_{3t}\text{InfRate}_t + \beta_{4,t}\text{FinOpn}_t + \beta_{5,t}\text{TrdOpn}_t + \beta_{6,t}\text{CorPerc}_t + \varepsilon_t , \quad t = 2019,2020 \,\&2021 \quad (3)$$

Where *t* represents time, FDI_t is the explained variable, CrypIndex_t is the index of adoption of global cryptocurrencies, GDPPPP_t is the GDP per capita, InfRate_t is the inflation rate, FinOpn_t is Financial Openness which is measured by formula (1), TrdOpn_t is the Trade Openness which is measured by formula (2), and CorPerc is the Corruption Perceptions Index.

Because that the Global Cryptocurrency Adoption Index of Chinalysis Company has only been published for the 3 years, we estimate model (3) for each year independently.

2.2.3 Results

Using the obtained data (on 111 countries), we estimate model (3) for the years 2019, 2020 and 2021 separately. The estimation of the model for 2019 using EViews software (version 13) is shown in Table 2.

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Table 2
Results of OLS estimation for 2019

Explained Variable		**FDI**		
Variables	Coefficient	Std. Error	t-Student	Prob.
CrypIndex	-0.350108	1.405773	-0.249050	0.8038
GDPPPP	-4.23E-05	2.60E-05	-1.628892	0.1064
InfRate	-0.008427	0.009914	-0.850017	0.3973
FinOpn	38.95740	0.596061	65.35812	0.0000
TrdOpn	0.018359	0.005688	3.227740	0.0017
C	-0.009974	0.026028	-0.383189	0.7024
R-squared				0.978180
Adjusted R-squared				0.976909
F-statistic				769.5666
Prob(F-statistic)				0.000000
Durbin-Watson stat				1.917736

Source: Research findings

Estimated results for 2019 suggest that the model has statistical significance through Prob (F-statistic) = 0.000000 < 0.05. The Durbin-Watson test statistic value is 1.918 (at 5% significance level, $d_L = 1.550$, $d_U = 1.803$), therefore this model has no auto-correlation phenomena. We use Breusch-Pagan-Godfrey test for heteroskedasticity. The Breusch-Pagan-Godfrey Prob-F value is 0.4023 (at 5% significance level), therefore this model has no heteroskedasticity phenomena. Eventually, Estimated results in Table 2 suggest that CrypIndex variable has no significant relationship with FDI for 2019 through Prob = 0.8038 > 0.05 (at 5% significance level).

The estimation of model (3) for 2020 using EViews software is shown in Table 3.

Table 3
Results of OLS estimation for 2020

Explained Variable		**FDI**		
Variables	Coefficient	Std. Error	t-Student	Prob.
CrypIndex	-9.091692	7.420808	-1.225162	0.2233
GDPPPP	-4.98E-05	8.91E-05	-0.558716	0.5776
InfRate	-0.008058	0.015822	-0.509281	0.6116
FinOpn	21.78314	2.429433	8.966346	0.0000
TrdOpn	0.074934	0.019520	3.838904	0.0002
C	-0.072685	0.087800	-0.827847	0.4097
R-squared				0.520272
Adjusted R-squared				0.492327
F-statistic				18.61753
Prob(F-statistic)				0.000000
Durbin-Watson stat				1.972847

Source: Research findings

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Estimated results for 2020 suggest that the model has statistical significance with Prob (F-statistic) = 0.000000 < 0.05. The Durbin-Watson test statistic value is 1.973 (at 5% significance level, dL = 1.550, dU = 1.803), therefore this model has no auto-correlation phenomena. We use Breusch-Pagan-Godfrey test for heteroskedasticity test. The Breusch-Pagan-Godfrey Prob-F value is 0.3130 (at 5% significance level), therefore this model has no heteroskedasticity phenomena. Eventually, estimated results in Table 3 suggest that CrypIndex variable has no significant relationship with FDI for 2020 through Prob = 0.2233 > 0.05 (at 5% significance level).

The estimation of model (3) for 2021 using EViews software is shown in Table 4.

Table 4
Results of OLS estimation for 2021

Explained Variable		**FDI**		
Variables	Coefficient	Std. Error	t-Student	Prob.
CrypIndex	-1.766594	2.810212	-0.628634	0.5310
GDPPPP	-1.05E-05	4.13E-05	-0.253854	0.8001
InfRate	-0.024024	0.025978	-0.924793	0.3572
FinOpn	7.440933	1.617489	4.600300	0.0000
TrdOpn	0.063941	0.009677	6.607834	0.0000
C	-0.019563	0.047183	-0.414624	0.6793
R-squared				0.489206
Adjusted R-squared				0.459451
F-statistic				16.44112
Prob(F-statistic)				0.000000
Durbin-Watson stat				1.608833

Source: Research findings

Estimated results for 2021 suggest that the model has statistical significance with Prob (F-statistic) = 0.000000 < 0.05. The Durbin-Watson test statistic value is 1.609 (at 5% significance level, dL = 1.550, dU =1.803), therefore no conclusion can be reached about auto-correlation from this test. But, Breusch-Godfrey test in this case shows that there is no autocorrelation in the model. The Breusch-Pagan Prob-F value is 0.5580 (at 5% significance level); therefore, this model has no auto-correlation phenomena. Also, we use Breusch-Pagan-Godfrey test for heteroskedasticity test. The Breusch-Pagan-Godfrey Prob-F value is 0.1734 (at 5% significance level); therefore, this model has no heteroskedasticity phenomena. Eventually, estimated results in Table 4 suggest that CrypIndex variable has no significant relationship with FDI for 2021 through Prob = 0.5310 > 0.05 (at 5% significance level).

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Therefore, separately estimated results of our data on the years 2019 to 2021 suggest that the adoption and expansion of global cryptocurrencies has no significant relationship with FDI.

2.3 The Role of Expansion of Global Cryptocurrencies in Portfolio Investment

2.3.1 Portfolio Investment

Wu and Pandey (2014) examine the effect of Bitcoin in the investment portfolio and conclude that there is an increase in portfolio effectiveness when Bitcoin is allocated. In fact, the results indicated that bitcoins could serve as a potent diversifier for an investment portfolio but with higher risk (Wu & Pandey, 2014).

In another research, Yanuar and Yoda (2018) examine the effect of cryptocurrency on investment portfolio effectiveness. The assets they used were Foreign Currency, Commodity, Stock, and ETF. Also, they used Bitcoin, Ripple, and Lite-coin as a cryptocurrency portfolio. The results suggested that Cryptocurrency improves the effectiveness of the portfolio with a higher rate of return and higher risk (Yanuar & Yoda, 2018).

Investors still rely heavily on speculation and rumors circulating in managing cryptocurrency assets. Researchers try to use a portfolio selection model developed by Markowitz (1952). This model serves to maximize return and minimize risk, by diversifying into some form of Cryptocurrency assets. Although widely used to determine the allocation of assets in the portfolio, this model has traditionally been less inclusive of cryptocurrencies. (Yanuar & Yoda, 2018).

The results of this section are expected to decrease the bias or level of speculation from investors so as to form an optimal portfolio. This paper investigates the value of Bitcoin and Ethereum as an investable financial asset by incorporating them in portfolios that include Foreign Currency, Commodity, Stock, and Indices. Modern portfolio theory is used to achieve the research goal. Following Modern Portfolio Theory (MPT), we examine the portfolios that maximize the measured Sharpe ratio.

Modern Portfolio Theory (MPT) states how an investor with a high risk aversion value can develop an investment portfolio to maximize return based on existing market risk (Yanuar & Yoda, 2018). Markowitz (1952) revealed that by establishing Efficient Frontier, one can know the level of return from each level of risk. This MPT relies on several kinds of investment instruments which are then compiled by previously measuring the level of

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correlation, covariance, standard deviation, and the rate of return using historical statistical methods. In general, MPT combines several portfolios with a high risk of low correlation, and ultimately it is expected to decrease the total level of total risk (Markowitz, 1952).

The next step is to do a return and risk analysis of the selected portfolio within a certain timeframe. We have considered this period from the beginning of the emergence of Ethereum, which is March 10, 2016, through the end of December 2022.

Measuring selected asset allocation is based on Sharpe ratio value of each allocation. Sharpe ratio proposed by William Sharpe (1994) describes the level of return earned from each measure of risk in the investment. The higher the Sharpe ratio the better the return, but it is not necessarily the optimal portfolio diversification. From the various allocations that describe the return and Sharpe ratio, they formed Efficient Frontier diagram illustrating the X axis as a risk and Y axis as a return. This method will ultimately minimize the risk of deviation than if only selecting a particular asset (Yanuar & Yoda, 2018).

The data are taken from www.investing.com to be used as analytical instruments and are processed using Solver tool in Microsoft Excel.

Our first portfolio is commodities, which includes Brent oil, gold and silver. This portfolio is chosen because it is a global investment option. The next portfolio is foreign exchange (FOREX), which includes EUR/CNY, EUR/USD, GBP/USD and USD/JPY. Foreign exchange is chosen because it is the type of asset whose characteristics are most closely related to Cryptocurrency, i.e. as a means of exchange of payment. The third portfolio is a portfolio of stocks, which includes Apple Inc (AAPL), Alibaba Group Holdings (BABA), Alphabet Inc Class A (GOOGL) and Tesla Inc (TSLA). Selecting a portfolio of stock is very common among investors. A collection of assets based on indices is fourth portfolio, which includes Dow Jones, Nasdaq 100, S&P 500, and FTSE 100 London Stock Exchange. The final portfolio is also a combination of the best performing of each portfolio.

The selection of portfolios has been based as much as possible on the global view and ease of access to data. The next step is to find the annual return, standard deviation and covariance. We use Solver in excel, which is very useful for providing solutions in linear and nonlinear programming and able to provide the constraints needed to form asset allocations. Solver will allocate assets to align with our specified goals, resulting in an optimized portfolio.

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In this section, we manage five investment portfolios. The first portfolio consists of Commodities, the second portfolio is Foreign Exchange, the third is a portfolio comprising a pool of Stock assets, and the fourth portfolio is a portfolio of indices. The fifth portfolio is a combined portfolio of the best performing assets of each portfolio. The risk-free level that researchers use in each portfolio calculation is 0.5% taken based on the 3-month return of the US Treasury Bill. Portfolio standard deviation is also considered as portfolio risk. Portfolio standard deviation refers to the volatility of the portfolio, which is calculated based on three important factors that include the standard deviation of each of the assets present in the total Portfolio, the respective weight of that individual asset in the total portfolio, and the correlation between each pair of assets of the portfolio.

The formula to calculate the rate of return (RoR) is:

$$RoR = \frac{\text{Current value} - \text{Initial value}}{\text{Initial value}} \tag{4}$$

Considering that we calculate the annual return of each asset, to calculate the return during the years 2016 to 2022, we use the time-weighted rate of return (TWRR) to calculate the final return of each asset.

$$TWRR = [(1 + RoR_1) * (1 + RoR_2) * \dots * (1 + RoR_n)]^{1/n} - 1, \quad n = 7 \tag{5}$$

We formed a portfolio with optimal asset allocation. The constraint that we use is total asset allocation equal to 100%, asset allocation is greater than or equal to 0, and return from portfolio equals the return from target that we specify. In addition, we also use the objective of maximizing the Sharpe ratio. Sharpe ratio is a measure used to assess the rate of return generated from each risk and is calculated as follows:

$$Sharpe\ Ratio = \frac{\text{TWRR} - \text{Risk Free rate of return}}{\text{Standard Deviation of Portfolio}} \tag{6}$$

Finally, using the non-linear programming model (7), the allocation of each portfolio and the inference of the relevant results are done.

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$$Maximize \ \frac{\sum_{i=1}^{n}(TWRR_i * w_i) - Risk\ Free\ Rate\ of\ Return}{Standard\ Deviation\ of\ Portfolio}$$

$$S.T: \begin{cases} \sum_{i=1}^{n} w_i = 100\% \\ w_i \geqq 0\ ,\ \forall\ i,\ i = 1, \dots, n \\ \sum_{i=1}^{n} w_i * \ TWRR_i = Return\ from\ Target \end{cases}$$

$$Where \begin{cases} TWRR_i = \left([\prod_{k=1}^{t}(1 + RoR_k)]^{\frac{1}{t}}\right),\ i = 1, \dots, n \\ Risk\ Free\ Rate\ of\ Return = \ 0.5\% \\ Standard\ Deviation\ of\ Portfolio = \sqrt{\sum_{i=1}^{n}(w_i^2 * \ \sigma_i^2) + \sum_{i,j=1,\ i<j}^{n}(2 * w_i * w_j * \ \rho_{i,j} * \sigma_i * \ \sigma_{j)}} \end{cases} \quad (7)$$

Where w_i represents the weight of each asset in the sample portfolio, RoR_i is annual Rate of Return, $TWRR_i$ is the Time-Weighted Rate of Return, t is the number of years studied, which in this case is 7 years, and n is the number of assets in each portfolio.

2.3.2 Results

2.3.2.1 Portfolio Performance of Commodities

Portfolio of commodities includes Brent oil, gold, and silver. As mentioned before, this portfolio is chosen because it is a global investment option. In the first step, the assets are analyzed for returns and risks in the period from March 10, 2016, to the end of December 2022. Return and risk analysis will be the basis of portfolio formation. Table 5 illustrates the performance of each asset in this portfolio.

Table 5
Asset Allocation Portfolio of Commodities

Allocation	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Return	5.00%	6.00%	6.30%	7.33%	8.00%	10.00%	11.00%
STD-DEV	0.82%	0.80%	0.83%	1.10%	1.26%	1.97%	2.35%
Sharpe	5.51%	6.88%	6.96%	6.23%	5.96%	4.83%	4.46%
Brent Oil Futures	0.38%	15.24%	19.76%	33.33%	44.95%	74.67%	90.57%
Gold Futures	80.79%	65.94%	61.42%	33.33%	36.24%	6.55%	0.00%
Silver Futures	18.82%	18.82%	18.82%	33.33%	18.80%	18.79%	9.43%

Source: Research findings

The test result shows that the allocation of assets yields return between 5.00% and 11.00%. Sharpe ratio is highest in allocation 3 of 6.96% with a return rate of 6.03% and a risk of 0.834%. The Sharpe ratio has decreased to 6.23% in allocation 4 where the assets are divided equally, but the return has increased to 7.33% and the risk has increased to 1.1%.

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Adding Bitcoin and Ethereum to commodities portfolio, we analyze Portfolio Performance again. Table 6 illustrates the performance of each asset in the portfolio adding cryptocurrencies.

Table 6
Asset allocation of Bitcoin and Ethereum in Portfolio of Commodities

Allocation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Return	5.00%	10.00%	15.00%	20.00%	25.00%	27.66%	30.00%	31.58%	35.00%	70.00%
STD-DEV	0.82%	0.78%	0.88%	1.07%	1.31%	1.45%	1.58%	1.76%	1.86%	5.27%
Sharpe	5.51%	12.26%	16.45%	18.17%	18.66%	18.70%	18.68%	17.68%	18.54%	13.18%
Brent Oil Futures	0.38%	9.12%	10.16%	11.20%	12.23%	12.79%	13.27%	20.00%	14.31%	0.00%
Gold Futures	80.79%	66.26%	58.76%	51.25%	43.75%	39.75%	36.25%	20.00%	28.74%	0.00%
Silver Futures	18.82%	17.47%	15.97%	14.47%	12.97%	12.17%	11.47%	20.00%	9.97%	0.00%
Bitcoin	0.00%	4.74%	9.91%	15.08%	20.24%	22.99%	25.41%	20.00%	30.57%	22.92%
Ethereum	0.00%	2.40%	5.20%	8.00%	10.81%	12.30%	13.61%	20.00%	16.41%	77.08%

Source: Research findings

As seen in Table 6, the result of the test shows that asset allocation has a return between 5.00% and 70.00%, which means an increase in return. Sharpe ratio is highest in allocation 6 of 18.70% with a return rate of 27.66% and a risk of 1.45%. The Sharpe ratio has decreased to 17.68% in allocation 8 where the assets are divided equally, but the return has increased to 31.58% and the risk has increased to 1.76%.

Based on the Efficient Frontier diagram in Figure 1, investors can make a choice of portfolio asset allocation in accordance with the level of risk they take.

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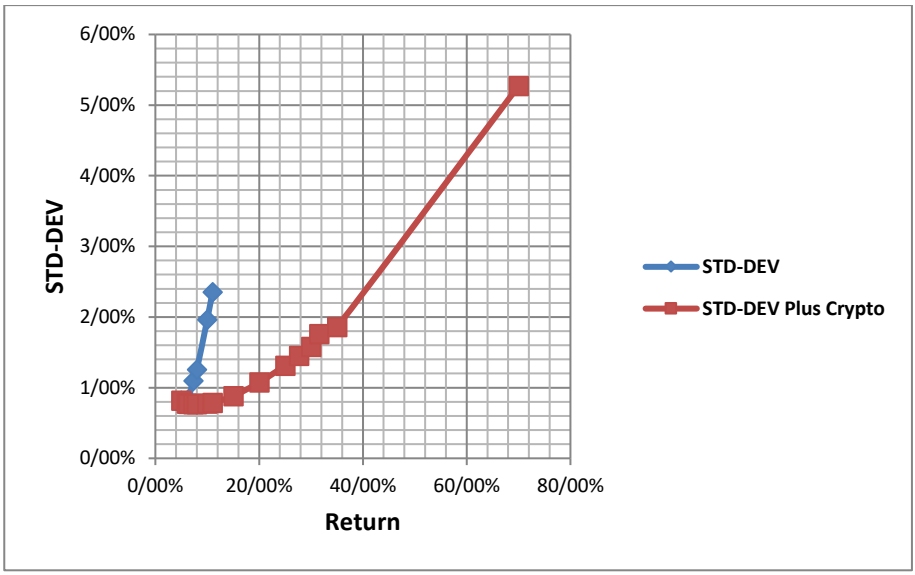

Figure 1. Efficient Frontier: Portfolio of Commodities plus Cryptocurrencies
Source: Research findings

As seen in Figure 1, adding Bitcoin and Ethereum the return has increased, also, with the same corresponding returns, the risk rates have also decreased. For example, with a return rate of 10%, the portfolio risk rate of commodities is 1.97%, while the portfolio risk rate of commodities plus cryptocurrencies has decreased to 0.775. The reason for reducing risk in portfolio including cryptocurrencies can be due to applying the regulations by countries in the field of cryptocurrencies. If the goal is to increase the return, you can choose a portfolio with a maximum return (here 70%) with a high risk, for which you must also accept the corresponding risk.

2.3.2.2 Portfolio Performance of Forex

This portfolio is foreign exchange (Forex), which includes EUR/CNY, EUR/USD, GBP/USD, and USD/JPY. This portfolio is chosen because it is the type of asset whose characteristics are most closely related to Cryptocurrency, i.e. as a means of exchange of payment. In the first step, the assets are analyzed for returns and risks in the period from March 10, 2016, to the end of December 2022. Table 7 illustrates the performance of each asset in this portfolio.

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Table 7
Asset Allocation Portfolio of Forex

Allocation	1	2	3	4	5
Return	0.00%	0.19%	1.00%	1.91%	2.00%
STD-DEV	0.43%	0.27%	0.79%	0.47%	0.50%
Sharpe	-1.17%	-1.18%	1.72%	3.014%	3.007%
EUR/CNY	0.00%	25.00%	38.80%	17.15%	10.70%
EUR/USD	0.00%	25.00%	22.45%	0.00%	0.00%
GBP/USD	53.78%	25.00%	1.25%	0.00%	0.00%
USD/JPY	46.22%	25.00%	37.50%	82.85%	89.30%

Source: Research findings

The test result shows that the allocation of assets yields return between 0.00% and 2.00%. Sharpe ratio is highest in allocation 4 of 3.014% with a return rate of 1.91% and a risk of 0.47%. The Sharpe ratio has decreased to -1.18% in allocation 2 where the assets are divided equally, and the return has decreased to 0.19% and the risk has decreased to 0.27%.

Adding Bitcoin and Ethereum to Forex portfolio, we analyze Portfolio Performance again. Table 8 illustrates the performance of each asset in the portfolio adding cryptocurrencies.

Table 8
Asset allocation of Bitcoin and Ethereum in Portfolio of Forex

Allocation	1	2	3	4	5	6	7	8	9
Return	0.00%	1.00%	2.00%	10.00%	20.00%	22.78%	28.73%	40.00%	70.00%
STD-DEV	0.64%	0.26%	0.27%	0.58%	1.11%	1.37%	1.60%	2.25%	5.27%
Sharpe	-0.78%	1.96%	5.65%	16.42%	17.54%	16.26%	17.62%	17.58%	13.18%
EUR/CNY	0.00%	32.98%	33.16%	33.96%	26.47%	16.67%	10.06%	0.00%	0.00%
EUR/USD	0.00%	29.37%	28.12%	17.51%	0.00%	16.67%	0.00%	0.00%	0.00%
GBP/USD	97.48%	15.13%	13.29%	0.00%	0.00%	16.67%	0.00%	0.00%	0.00%
USD/JPY	0.00%	21.51%	23.05%	34.99%	45.34%	16.67%	48.61%	41.48%	0.00%
Bitcoin	0.00%	0.66%	1.56%	8.84%	18.37%	16.67%	26.92%	38.11%	22.92%
Ethereum	2.52%	0.33%	0.82%	4.71%	9.82%	16.67%	14.40%	20.41%	77.08%

Source: Research findings

As seen in Table 8, the result of the test shows that asset allocation has a return between 0.00% and 70.00%, which means an increase in return. Sharpe ratio is highest in allocation 7 of 17.62% with a return rate of 28.73% and a risk of 1.60%. The Sharpe ratio has decreased to 16.26% in allocation 6 where the assets are divided equally, and the return has decreased to 22.78% and the risk has decreased to 1.37%.

Based on the Efficient Frontier diagram in Figure 2, investors can make a choice of portfolio asset allocation in accordance with the level of risk they take.

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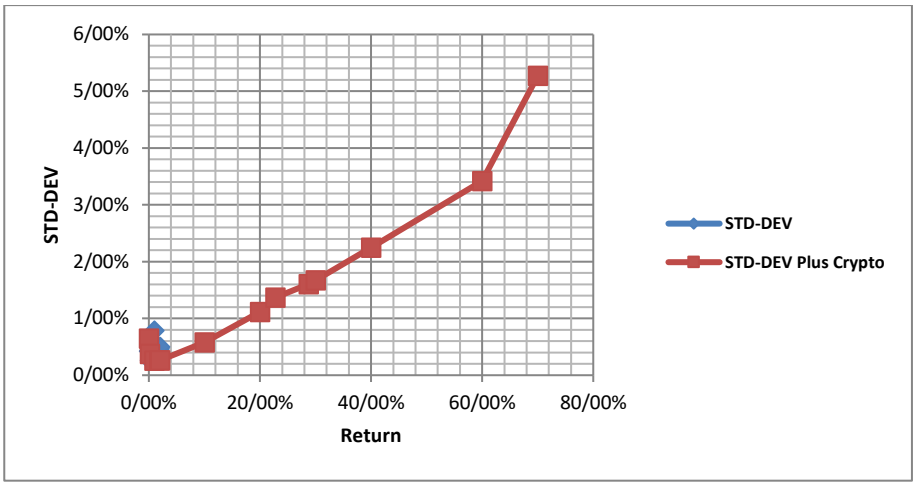

Figure 2. Efficient Frontier: Portfolio of Forex plus Cryptocurrencies
Source: Research findings

As seen in Figure 2, adding Bitcoin and Ethereum the return has increased, also, with the same corresponding returns, the risk rates have also decreased. For example, with a return rate of 2%, the portfolio risk rate of Forex is 0.50%, while the portfolio risk rate of Forex plus cryptocurrencies has decreased to 0.27%. If the goal is to increase the return, you can choose a portfolio with a maximum return (here 70%) with a high risk, for which you must also accept the corresponding risk.

2.3.2.3 Portfolio Performance of Stocks

This portfolio is a portfolio of stocks, which includes Apple Inc (AAPL), Alibaba Group Holdings (BABA), Alphabet Inc Class A (GOOGL) and Tesla Inc (TSLA). Selecting a portfolio of stock is very common among investors. In the first step, the assets are analyzed for returns and risks in the period from March 10, 2016, to the end of December 2022. Table 9 illustrates the performance of each asset in this portfolio.

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Table 9
Asset Allocation Portfolio of Stocks

Allocation	1	2	3	4	5	6
Return	5.00%	15.00%	18.33%	23.05%	25.00%	30.00%
STD-DEV	1.93%	1.13%	1.31%	1.29%	1.43%	2.17%
Sharpe	2.34%	12.80%	13.61%	17.42%	17.14%	13.58%
AAPL	0.00%	28.24%	25.00%	51.87%	58.72%	45.76%
BABA	68.29%	22.32%	25.00%	1.02%	0.00%	0.00%
GOOGL	31.71%	43.50%	25.00%	28.81%	18.52%	0.00%
TSLA	0.00%	5.94%	25.00%	18.30%	22.75%	54.24%

Source: Research findings

The test result shows that the allocation of assets yields return between 5.00% and 30.00%. Sharpe ratio is highest in allocation 4 of 17.42% with a return rate of 23.05% and a risk of 1.29%. The Sharpe ratio has decreased to 13.61% in allocation 3 where the assets are divided equally, and the return has decreased to 18.33% but the risk has increased to 1.31%.

Adding Bitcoin and Ethereum to the stocks portfolio, we analyze Portfolio Performance again. Table 10 illustrates the performance of each asset in the portfolio adding cryptocurrencies.

Table 10
Asset allocation of Bitcoin and Ethereum in Portfolio of Stocks

Allocation	1	2	3	4	5	6	7	8	9
Return	5.00%	15.00%	25.00%	30.00%	34.10%	34.88%	50.00%	60.00%	70.00%
STD-DEV	1.93%	1.13%	1.10%	1.22%	1.37%	1.62%	2.28%	3.12%	5.27%
Sharpe	2.34%	12.80%	22.32%	24.23%	24.59%	21.28%	21.70%	19.062%	13.184%
AAPL	0.00%	28.16%	33.83%	36.55%	38.79%	16.67%	26.72%	2.57%	0.00%
BABA	68.29%	22.38%	10.97%	5.36%	0.75%	16.67%	0.00%	0.00%	0.00%
GOOGL	31.71%	43.51%	31.97%	26.24%	21.54%	16.67%	0.00%	0.00%	0.00%
TSLA	0.00%	5.91%	10.03%	12.03%	13.68%	16.67%	17.65%	17.70%	0.00%
Bitcoin	0.00%	0.05%	8.73%	12.97%	16.45%	16.67%	35.66%	50.75%	22.92%
Ethereum	0.00%	0.00%	4.46%	6.84%	8.80%	16.67%	19.97%	28.98%	77.08%

Source: Research findings

As seen in Table 10, the result of the test shows that asset allocation has a return between 5.00% and 70.00%, which means an increase in return. Sharpe ratio is highest in allocation 5 of 24.59% with a return rate of 34.10% and a risk of 1.37%. The Sharpe ratio has decreased to 21.28% in allocation 6 where the assets are divided equally, but the return has increased to 34.88% and the risk has increased to 1.62%.

Based on the Efficient Frontier diagram in Figure 3, investors can make a choice of portfolio asset allocation in accordance with the level of risk they take.

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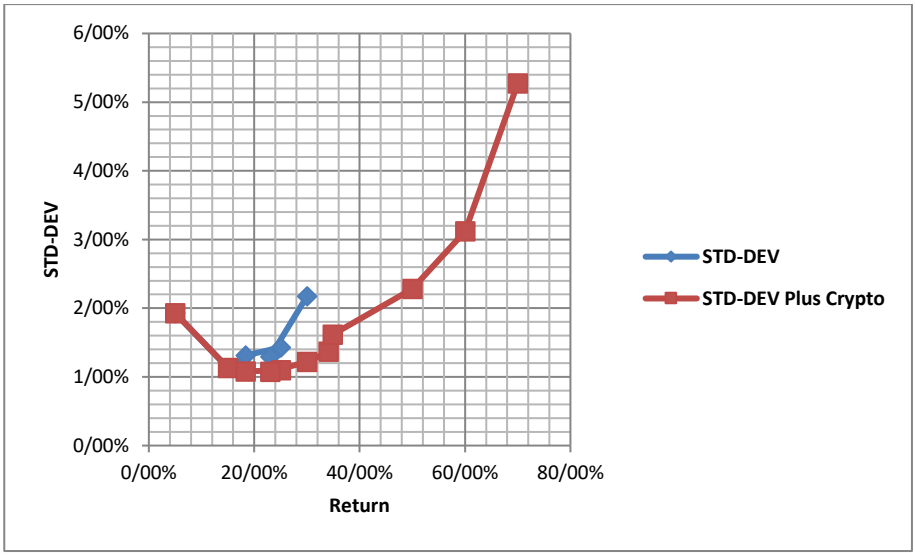

Figure 3. Efficient Frontier: Portfolio of Stocks plus Cryptocurrencie
Source: Research findings

As seen in Figure 3, adding Bitcoin and Ethereum, the return has increased, also, with the same corresponding returns, the risk rates have also decreased. For example, with a return rate of 30%, the portfolio risk rate of stocks is 2.17%, while the portfolio risk rate of stocks plus cryptocurrencies has decreased to 1.22%. If the goal is to increase the return, you can choose a portfolio with a maximum return (here 70%) with a high risk, for which you must also accept the corresponding risk.

2.3.2.4 Portfolio Performance of Indices

This portfolio is a portfolio of Indices, which includes Dow Jones Industrial, Nasdaq 100, S&P 500, and FTSE 100 London Stock Exchange. Indices have been selected in this portfolio that are famous and global. In the first step, the assets are analyzed for returns and risks in the period from March 10, 2016, to the end of December 2022. Table 11 illustrates the performance of each asset in this portfolio.

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Table 11
Asset Allocation Portfolio of Indices

Allocation	1	2	3	4	5	6
Return	3.00%	5.00%	8.84%	10.17%	12.00%	13.00%
STD-DEV	0.94%	0.72%	0.62%	0.68%	0.94%	1.25%
Sharpe	2.66%	6.24%	13.54%	14.14%	12.28%	10.00%
Dow Jones	3.14%	16.88%	25.00%	31.23%	22.04%	10.49%
Nasdaq 100	0.00%	0.76%	25.00%	29.43%	59.31%	84.63%
S&P 500	4.68%	17.44%	25.00%	30.28%	18.65%	4.88%
FTSE 100	92.18%	64.91%	25.00%	9.07%	0.00%	0.00%

Source: Research findings

The test result shows that the allocation of assets yields return between 3.00% and 13.00%. Sharpe ratio is highest in allocation 4 of 14.14% with a return rate of 10.17% and a risk of 0.68%. The Sharpe ratio has decreased to 13.54% in allocation 3 where the assets are divided equally, and the return has decreased to 8.84% and the risk has decreased to 0.62%.

Adding Bitcoin and Ethereum to indices portfolio, we analyze Portfolio Performance again. Table 12 illustrates the performance of each asset in the portfolio adding cryptocurrencies.

Table 12
Asset allocation of Bitcoin and Ethereum in Portfolio of Indices

Allocation	1	2	3	4	5	6	7	8	9	10
Return	3.00%	5.00%	10.00%	13.00%	20.38%	28.55%	35.00%	50.00%	60.00%	70.00%
STD-DEV	0.94%	0.72%	0.59%	0.63%	0.89%	1.42%	1.69%	2.65%	3.34%	5.27%
Sharpe	2.66%	6.24%	16.10%	19.84%	22.39%	19.76%	20.42%	18.657%	17.840%	13.183%
Dow Jones	3.14%	16.89%	24.25%	24.64%	25.60%	16.67%	15.19%	0.22%	0.00%	0.00%
Nasdaq 100	0.00%	0.76%	16.62%	18.79%	24.12%	16.67%	28.77%	31.41%	12.89%	0.00%
S&P 500	4.68%	17.45%	23.96%	24.21%	24.83%	16.67%	13.71%	0.00%	0.00%	0.00%
FTSE 100	92.18%	64.91%	31.70%	24.69%	7.42%	16.67%	0.00%	0.00%	0.00%	0.00%
Bitcoin	0.00%	0.00%	2.31%	5.04%	11.75%	16.67%	27.45%	44.26%	56.27%	22.92%
Ethereum	0.00%	0.00%	1.15%	2.63%	6.28%	16.67%	14.88%	24.10%	30.84%	77.08%

Source: Research findings

As seen in Table 12, the result of the test shows that asset allocation has a return between 3.00% and 70.00%, which means an increase in return. Sharpe ratio is highest in allocation 5 of 22.39% with a return rate of 20.38% and a risk of 0.89%. The Sharpe ratio has decreased to 19.76% in allocation 6 where the assets are divided equally, but the return has increased to 28.55% and the risk has increased to 1.42%.

Based on the Efficient Frontier diagram in Figure 4, investors can make a choice of portfolio asset allocation in accordance with the level of risk they take.

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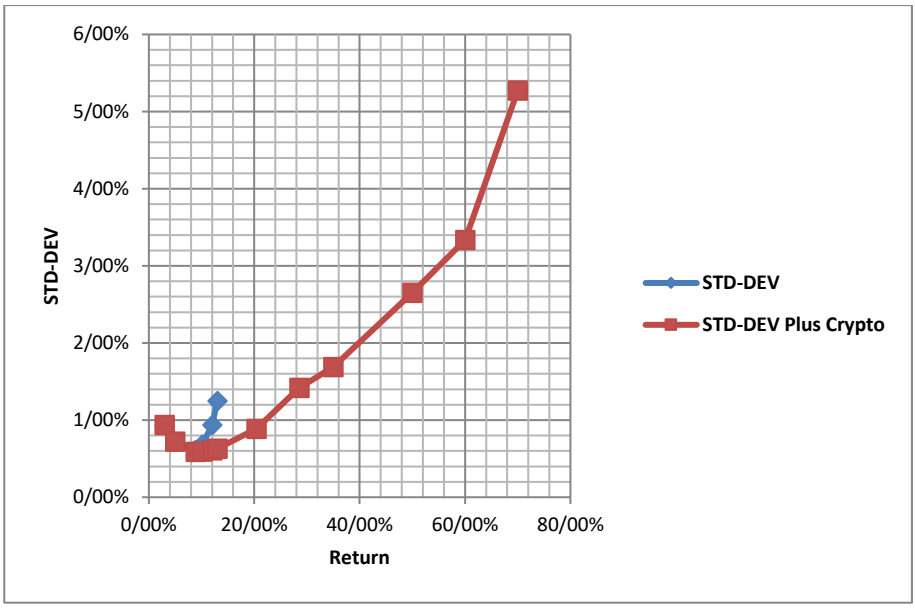

Figure 4. Efficient Frontier: Portfolio of Indices plus Cryptocurrencies.
Source: Research findings

As seen in Figure 4, adding Bitcoin and Ethereum the return has increased, also, with the same corresponding returns, the risk rates have also decreased. For example, with a return rate of 12%, the portfolio risk rate of Indices is 0.94%, while the portfolio risk rate of Indices plus cryptocurrencies has decreased to 0.61%. If the goal is to increase the return, you can choose a portfolio with a maximum return (here 70%) with a high risk, for which you must also accept the corresponding risk.

2.3.2.5 Portfolio Performance of Mixed Assets

This portfolio is a portfolio of mixed assets, which includes Gold Futures, USD/JPY, Apple Inc (AAPL), and Dow Jones Industrial. The selection of this portfolio was based on the optimization of the corresponding portfolio. In this way, each asset of the portfolio that had the highest percentage in the maximum Sharpe ratio state has been selected. In Table 5, Gold Futures in the state of maximum Sharpe ratio have taken 61.42% of the total allocation of the portfolio, which is the highest. In Table 7, USD/JPY in the state of maximum Sharpe ratio has taken 82.85% of the total allocation of the portfolio, which is the highest. In Table 9, AAPL in the state of maximum Sharpe ratio has taken 51.87% of the total allocation of the portfolio, which

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is the highest. Finally, in Table 11, Dow Jones Industrial in the state of maximum Sharpe ratio has taken 31.23% of the total allocation of the portfolio, which is the highest. In the first step, the assets are analyzed for returns and risks in the period from March 10, 2016, to the end of December 2022. Table 13 illustrates the performance of each asset in this portfolio.

Table 13
Asset Allocation Portfolio of Mixed Assets

Allocation	**1**	**2**	**3**	**4**	**5**	**6**
Return	3.00%	10.00%	20.24%	35.74%	50.00%	60.00%
STD-DEV	0.46%	0.44%	0.62%	1.01%	1.43%	1.75%
Sharpe	5.40%	21.52%	31.77%	34.96%	34.61%	34.00%
Gold Futures	20.30%	21.16%	25.00%	14.77%	6.52%	0.00%
USD/JPY	75.72%	55.22%	25.00%	15.41%	0.00%	0.00%
Dow Jones	3.98%	13.55%	25.00%	18.61%	18.97%	7.72%
AAPL	0.00%	10.07%	25.00%	51.21%	74.51%	92.28%

Source: Research findings

The test results shows that the allocation of assets yields return between 3.00% and 60.00%. Sharpe ratio is highest in allocation 4 of 34.96% with a return rate of 35.74% and a risk of 1.01%. The Sharpe ratio has decreased to 31.77% in allocation 3 where the assets are divided equally, and the return has decreased to 20.24% and the risk has decreased to 0.62%.

Adding Bitcoin and Ethereum to the mixed assets portfolio, we analyze Portfolio Performance again. Table 14 illustrates the performance of each asset in the portfolio adding cryptocurrencies.

Table 14
Asset allocation of Bitcoin and Ethereum in Portfolio of Mixed Assets

Allocation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Return	3.00%	10.00%	20.00%	36.14%	39.34%	50.00%	60.00%	70.00%
STD-DEV	0.46%	0.43%	0.55%	1.42%	1.00%	1.28%	1.55%	5.18%
Sharpe	5.40%	21.94%	35.29%	25.09%	39.03%	38.823%	38.280%	13.423%
Gold Futures	20.30%	21.02%	18.31%	16.67%	13.06%	8.95%	0.00%	0.00%
USD/JPY	75.72%	55.87%	41.47%	16.67%	13.63%	0.00%	0.00%	0.00%
Dow Jones	3.98%	13.05%	14.21%	16.67%	16.45%	17.05%	8.63%	0.00%
AAPL	0.00%	8.05%	20.74%	16.67%	45.28%	58.91%	72.70%	19.82%
Bitcoin	0.00%	1.34%	3.46%	16.67%	7.55%	9.82%	12.12%	3.10%
Ethereum	0.00%	0.67%	1.82%	16.67%	4.04%	5.27%	6.56%	77.08%

Source: Research findings

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As seen in Table 14, the result of the test shows that asset allocation has a return between 3.00% and 70.00%, which means an increase in return. Sharpe ratio is highest in allocation 5 of 39.03% with a return rate of 39.34% and a risk of 1.00%. The Sharpe ratio has decreased to 25.09% in allocation 4 where the assets are divided equally, and the return has decreased to 36.14% but the risk has increased to 1.42%.

Based on the Efficient Frontier diagram in Figure 5, investors can make a choice of portfolio asset allocation in accordance with the level of risk they take.

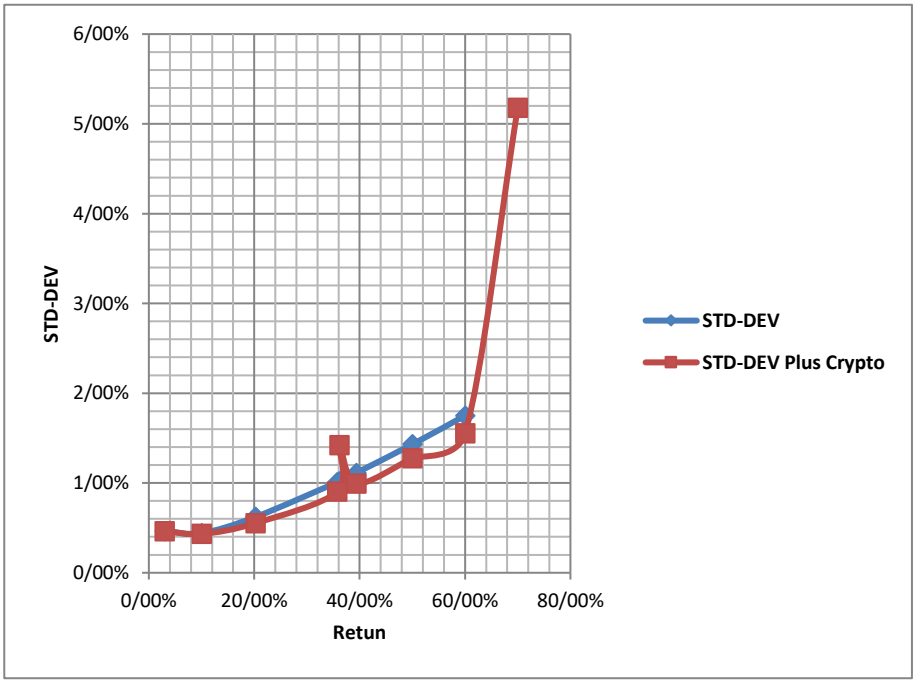

Figure 5. Efficient Frontier: Portfolio of Mixed Assets plus Cryptocurrencies
Source: Research findings

As seen in Figure 5, adding Bitcoin and Ethereum the return has increased, and, with the same corresponding returns, the risk rates have often also decreased. For example, with a return rate of 50%, the portfolio risk rate of mixed assets is 1.43%, while the portfolio risk rate of mixed assets plus cryptocurrencies has decreased to 1.028%. Of course, due to the fact that the

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selected portfolio is selected in the most optimal mode, the risk gap has been decreased in two modes without cryptocurrency and with cryptocurrency. If the goal is to increase the return, you can choose a portfolio with a maximum return (here 70%) with a high risk, for which you must also accept the corresponding risk.

As seen in various cases using Modern Portfolio Theory, including global cryptocurrencies can make better return performance in portfolios. Also, the results showed that with the same corresponding returns, the risk of the portfolios including cryptocurrencies decreases.

3 Conclusion and Discussion

Examining the effects of the adoption and expansion of global cryptocurrencies in financial globalization can play an effective role in creating transparency of their impact in the global economy. Our aim in this paper is to investigate the role of the adoption and expansion of Global cryptocurrencies in financial globalization. Therefore, using the KOF index, we extract the structure of financial globalization and examine the effect of the expansion of cryptocurrencies in foreign direct investment and portfolio investment.

First, we have reviewed the factors affecting the adoption and expansion of cryptocurrencies by investigating various studies. Then, using the global cryptocurrency adoption index of Chainalysis Company, we examined the effects of the expansion of global cryptocurrencies in Foreign Direct Investment (FDI). The estimated results from 2019 to 2021 suggest that the adoption and expansion of global cryptocurrencies have no significant relationship with FDI.

Second, using Modern Portfolio Theory (MPT), we have optimized different portfolios and examined the effect of adding global cryptocurrencies (Bitcoin and Ethereum) in those portfolios. The results suggest global cryptocurrencies improve the effectiveness of the portfolios. In addition, contrary to previous research (e.g., Wu & Pandey, 2014; Yanuar & Yoda, 2018), the results of this paper suggest that with the same corresponding returns, the risk of the portfolios including global cryptocurrencies decreases. This issue can be due to applying the regulations in the field of cryptocurrencies by international institutions and governments, which has decreased the risk of using cryptocurrencies. As the results of the paper show, global cryptocurrencies have a positive impact in portfolio investment component, and it exerts its positive influence more as a crypto-asset. This impact has forced international economic institutions to do

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research and strive to apply regulations for cryptocurrencies. For example, the report of World Economic Forum in 2023 entitled "Pathways to the Regulation of Crypto-Assets" points the function of cryptocurrencies as assets, which is consistent with the results of this paper, and the need for a global approach to crypto-asset regulation and the way policy-makers, regulators and industry work together to establish a consistent, coordinated and effective regulatory framework for crypto-assets (World Economic Forum, 2023). Also, in a report published by Chinalysis Company entitled "New UK crypto regulation expands law enforcement powers over crypto assets" on November 2, 2023, the following is mentioned:

Earlier this month, California Governor Gavin Newsom signed the Digital Financial Assets Law which establishes a regulatory framework for "digital financial asset" entities operating in the state of California, and requires licensure with the state's Department of Financial Protection and Innovation. The law goes into effect on July 1, 2025 (Chainalysis, 2023).

The Colombo Port City Economic Commission (CPCEC) of Sri Lanka authorized two crypto exchanges — Bitazza International Ltd of Thailand and Scallop (Pvt) Ltd of the United Kingdom — to operate in the Port City Special Economic Zone. This move is expected to pave the way for regional crypto exchanges to begin future operations (Chainalysis, 2023).

WisdomTree, a global financial innovator with $94 billion in assets under management, is focused on launching a US bitcoin ETF. The firm released a consumer app in July that allows customers to invest in Bitcoin and Ethereum, as well as nine digital funds (Chainalysis, 2023).

Therefore, according to the results of this research, which is in line with the studies and reports of international reputable institutions, the role of cryptocurrencies in financial globalization can be only seen as crypto-assets. In near future, the overflow effects of cryptocurrencies in portfolio investment, along with their special properties such as freedom in international access, very low transaction costs, and high speed in international and cross-border transfers, can affect financial globalization from the monetary point of view, and the monetary aspect may also be highlighted in the coming years.

In the end, we recommend future interested researchers examine the effect of the expansion of global cryptocurrencies in trade globalization and other components of financial globalization, because we expect the overflow effects of global cryptocurrencies in portfolio investment can also affect other components of economic globalization in the coming years.

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Appendix

Table A
Name of considered countries

No	Country Name	No	Country Name	No	Country Name
1	ALBANIA	38	GEORGIA	75	NIGERIA
2	ALGERIA	39	GERMANY	76	NORWAY
3	ANGOLA	40	GHANA	77	PAKISTAN
4	AZERBAIJAN	41	GREECE	78	PANAMA
5	ARGENTINA	42	GUATEMALA	79	PERU
6	AUSTRALIA	43	HONDURAS	80	PHILIPPINES
7	AUSTRIA	44	HONG KONG	81	POLAND
8	BANGLADESH	45	HUNGARY	82	PORTUGAL
9	ARMENIA	46	INDIA	83	ROMANIA
10	BELGIUM	47	INDONESIA	84	RUSSIAN FEDERATION
11	BOLIVIA	48	IRAN	85	RWANDA
12	BOSNIA AND HERZEGOWINA	49	IRAQ	86	SAUDI ARABIA
13	BRAZIL	50	IRELAND	87	SENEGAL
14	BULGARIA	51	ISLAND	88	SERBIA
15	MYANMAR	52	ITALY	89	SINGAPORE
16	BELARUS	53	COTE D'IVOIRE	90	SLOVAKIA
17	CAMBODIA	54	JAMAICA	91	VIETNAM
18	CAMEROON	55	JAPAN	92	SLOVENIA
19	CANADA	56	KAZAKHSTAN	93	SOUTH AFRICA
20	SRI LANKA	57	JORDAN	94	ZIMBABWE
21	CHILE	58	KENYA	95	SPAIN
22	CHINA	59	KOREA, REPUBLIC OF	96	SWEDEN
23	COLOMBIA	60	KYRGYZSTAN	97	SWITZERLAND
24	CONGO, The Democratic Republic of the	61	LEBANON	98	THAILAND
25	COSTA RICA	62	LATVIA	99	TOGO
26	CROATIA	63	LITHUANIA	100	TUNISIA
27	CYPRUS	64	MADAGASCAR	101	TURKIYE
28	CZECH REPUBLIC	65	MALAYSIA	102	UGANDA
29	BENIN	66	MAURITIUS	103	UKRAINE
30	DENMARK	67	MEXICO	104	MACEDONIA
31	DOMINICAN REPUBLIC	68	MOLDOVA, REPUBLIC OF	105	EGYPT
32	ECUADOR	69	MONTENEGRO	106	UNITED KINGDOM
33	EL SALVADOR	70	MOROCCO	107	TANZANIA
34	ETHIOPIA	71	MOZAMBIQUE	108	UNITED STATES
35	ESTONIA	72	NEPAL	109	URUGUAY
36	FINLAND	73	NETHERLANDS	110	UZBEKISTAN
37	FRANCE	74	NEW ZEALAND	111	ZAMBIA

Note: This table shows the name of countries studied in this paper.

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Table B
Overview of variables used in the empirical analysis

Variable	Data Source	Definition
FDI	World Bank	Foreign Direct Investment
CrypIndex	Chinalysis Company	Global Cryptocurrency Adoption Index
GDPPPP	World Bank	GDP Per Capita
InfRate	World Bank	Inflation Rate
CorPerc	Transparency International	The Corruption Perceptions Index
FinOpn 1) FDI Net Inflow 2) FDI Net Outflow 3) Net Portfolio Investment 4) GDP	World Bank	Financial Openness: (FDI Net Inflow + FDI Net Outflow + Net Portfolio Investment) / GDP
TrdOpn	World Bank	Trade Openness
Commodities 1) Brent Oil Futures 2) Gold Futures 3) Silver Futures	www.investing.com	Portfolio of Commodities: Brent Oil Futures, Gold Futures, and Silver Futures
Forex 1) EUR/CNY 2) EUR/USD 3) GBP/USD 4) USD/JPY	www.investing.com	Portfolio of Forex (Foreign Exchange): EUR/CNY, EUR/USD, GBP/USD, and USD/JPY
Stocks 1) AAPL 2) BABA 3) GOOGL 4) TSLA	www.investing.com	Portfolio of Stocks: Apple Inc (AAPL), Alibaba Group Holdings (BABA), Alphabet Inc Class A (GOOGL), and Tesla Inc (TSLA)
Indices 1) Dow Jones 2) Nasdaq 100 3) S&P 500 4) FTSE 100	www.investing.com	Portfolio of Indices: Dow Jones Industrial, Nasdaq 100, S&P 500, and FTSE 100 London Stock Exchange.
Global Cryptocurrencies 1) Bitcoin 2) Ethereum	www.investing.com	The value of Bitcoin and Ethereum as global cryptocurrencies

Note: This table shows details on the variables, including their definitions and the source of data.

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