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Article

The Role of Cryptocurrencies and Blockchain in the Evolving Financial Landscape: A Global Econometric Approach

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Abstract: This study aims to examine the impact of cryptocurrencies and blockchain technology on the global financial landscape, with a particular focus on their interaction with macroeconomic indicators and traditional financial markets. The research uses a global econometric approach based on secondary data collected for the period 2013–2024. Variables such as Bitcoin (dependent), Ethereum, S&P 500, VIX, M2, inflation, interest rates, and the Crypto Volatility Index were analyzed using the GEE (Generalized Estimating Equations) model. Data analysis was conducted with STATA, while visualizations were created using Excel. The results indicate that several macroeconomic variables such as S&P 500, VIX, inflation, interest rates, and crypto volatility have a statistically significant impact on Bitcoin prices. In contrast, Ethereum and M2 did not show a significant effect in the model. The study confirms that cryptocurrencies are increasingly influenced by traditional economic dynamics, challenging the perception of complete independence from financial systems. These findings can support financial policymakers, investors, and institutions in understanding how cryptocurrencies behave in relation to global market movements. The study also offers insights for regulatory frameworks and the future development of Central Bank Digital Currencies (CBDCs). This research contributes to the existing literature by combining blockchain, cryptocurrencies, and macroeconomic analysis through a global econometric model, offering an updated and comprehensive view of their interconnected roles in financial markets.

Keywords: Cryptocurrencies; Blockchain; Financial Markets; Econometric Analysis; Central Bank Digital Currencies (CBDCs)

1. Introduction

In recent years, cryptocurrencies and blockchain technology have emerged as transformative forces within the global financial system. Initially viewed with skepticism, these innovations have increasingly gained legitimacy as alternative financial instruments and infrastructural tools. Cryptocurrencies, particularly Bitcoin and Ethereum, offer decentralized alternatives to fiat currencies, while blockchain provides a secure, transparent, and immutable method of recording transactions. As traditional financial systems face challenges related to inefficiency, lack of trust, and centralization, blockchain and digital assets offer promising solutions that could reshape the global economic architecture. This paper aims to examine the evolving role of cryptocurrencies and

blockchain in international finance through a global econometric lens, analyzing patterns of adoption, regulatory responses, and their macroeconomic impacts.

The rapid growth of cryptocurrencies over the last decade has fundamentally reshaped the global financial landscape. Originally introduced with the launch of Bitcoin by [1], cryptocurrencies have evolved from experimental digital assets into alternative financial instruments that challenge traditional banking systems. They enable decentralized, peer-to-peer transactions, bypassing intermediaries and offering lower costs, faster processing times, and greater financial accessibility particularly in underbanked regions [2].

While cryptocurrencies offer decentralized alternatives to fiat currencies, many governments are now exploring Central Bank Digital Currencies (CBDCs) as a way to modernize payment systems while retaining monetary control. Unlike decentralized cryptocurrencies, CBDCs are state-backed and regulated, which may enhance consumer trust and stability. According to the International Monetary Fund [3], over 100 countries have initiated research or pilot programs on CBDCs, highlighting a global shift toward digital monetary policy tools.

One of the key advantages associated with cryptocurrencies is their potential to serve as tools for financial inclusion and protection against inflation and currency instability. According to [4], during periods of geopolitical tension and economic uncertainty, both individuals and institutions are increasingly turning to cryptocurrencies as a hedge against volatility. This is especially relevant in emerging markets where local currencies are often subject to high inflation and weak monetary policy. Similarly, Pandya et al. [5] highlight that in regions reliant on remittance inflows, cryptocurrencies offer a faster and more cost-effective alternative to traditional money transfer channels, enhancing both efficiency and economic resilience.

This paper is divided into five main sections. The first section includes the introduction, where the purpose and importance of the study are explained. The second section is a literature review, which discusses existing studies and theories related to cryptocurrencies. The third section describes the methodology used in this study, explaining the analytical techniques and approaches employed for data collection and processing. The fourth section is dedicated to the study's results, where the main findings and the analysis of the impact of these technologies on financial systems are presented. Finally, the fifth section contains the conclusions and recommendations for future policies and the further development of cryptocurrencies, DeFi, and CBDCs.

2. Literature Review

Empirical studies using panel data and time-series analysis have found significant correlations between cryptocurrency adoption and macroeconomic factors. For instance, Bouri et al. [6] applied GARCH models and found that Bitcoin serves as a hedge in some developed markets but remains highly volatile. Their findings suggest that while cryptocurrencies may play a role in financial diversification, they also introduce new risks for policymakers and investors.

Decentralized Finance (DeFi) refers to financial services built on public blockchains that operate without central intermediaries. These platforms, such as Uniswap or Aave, allow users to borrow, lend, and trade assets through smart contracts. Schär [7] notes that DeFi is redefining financial intermediation, reducing costs, increasing accessibility, and challenging regulatory frameworks worldwide.

Blockchain, the underlying technology behind most cryptocurrencies, extends beyond digital

payments and offers broad potential in improving transparency, reducing fraud, and optimizing operations across various sectors, especially finance. Zohar [8] notes that the immutability and decentralized nature of blockchain records foster trust and minimize the need for third-party verification, thereby increasing operational efficiency. In financial markets, smart contracts and decentralized finance (DeFi) platforms are already being deployed to replace traditional mechanisms such as clearinghouses and escrow services [9].

Despite its advantages, cryptocurrency adoption is uneven across the globe. Regulatory uncertainty, cultural resistance, and infrastructural limitations remain significant barriers (Pandya, et al. 2019). Countries vary widely in their approach from full legalization and integration into national systems, as in El Salvador, to outright bans, as seen in parts of Asia and Africa. These disparities demonstrate that the integration of cryptocurrencies and blockchain into mainstream finance is not solely a technological challenge but also a socio-political and economic one [9].

Raymaekers [10] focused on Bitcoin's potential as a payment method, emphasizing key challenges, significant risks, promising applications, and core issues tied to cryptocurrency. While Bitcoin may not immediately replace conventional payment systems, the study suggests banks should monitor its technology for its potential to revolutionize wealth transfer. Similarly, Baur et al. [11] examined Bitcoin as a disruptive payment innovation, using interviews with 13 participants from three groups to explore factors like usability, perceived benefits, and social norms. The study found that Bitcoin is seen as difficult to use, and its usefulness is perceived differently by various users. Meanwhile, Ram [12] analyzed whether Bitcoin could evolve into a distinct asset class, offering insights into its role in portfolio diversification. His findings indicate that Bitcoin possesses unique investment characteristics and has both strong market potential and sufficient capitalization. In addition, Fang et al [13] highlights that Bitcoin's low correlation with traditional asset classes further strengthens its value as a diversification tool, making it an appealing option for investors looking to reduce portfolio risk and enhance returns.

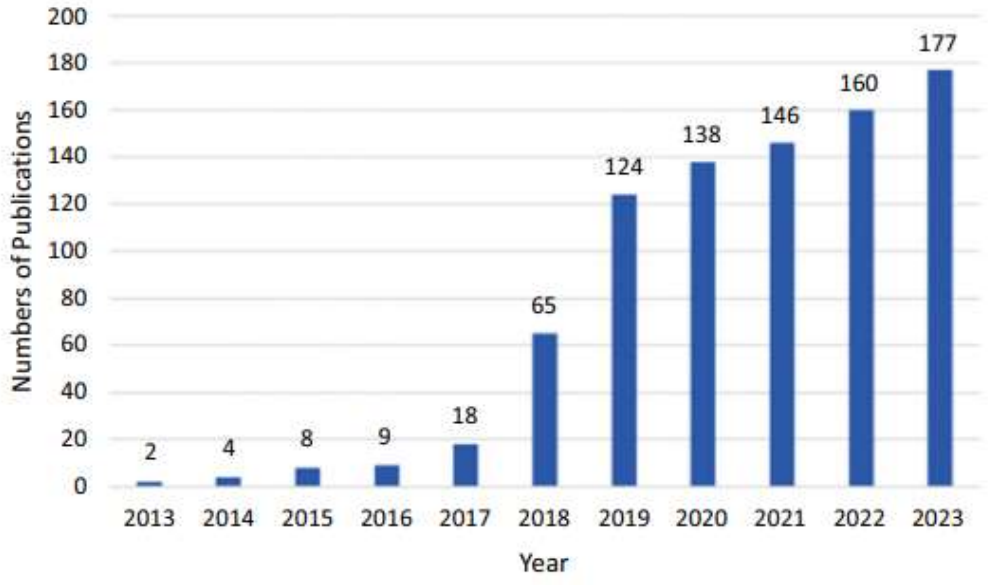


Figure 1. Cryptocurrency trading publications (cumulative) during 2013–2023 (December 2023).

This figure 1 illustrates a strong trend in the increase in the number of publications related to

cryptocurrencies over the last decade. By 2017, the number of publications remained relatively low, increasing with slow steps from 2 in 2013 to only 18 in 2017. However, from 2018 there is a significant increase, with publications reaching 65, to continue with a sustained increase each year, culminating with 177 publications in 2023. its impact on global finance. It also reflects the technological developments and the extent of the use of cryptocurrencies in real life, which has fueled numerous research in this area.

Currently, blockchain technology is attracting significant attention in the field of Digital Finance (FinTech). It represents a combination of various computing technologies such as decentralized data storage, peer-to-peer communication, consensus mechanisms, and advanced encryption algorithms. This technology is considered one of the most disruptive innovations of the internet era. Due to the advancements, it brings in data storage and information transmission, blockchain has the potential to revolutionize traditional operational models in the financial and economic sectors, paving the way for a new wave of technological innovation and structural transformation within the FinTech industry [14].

To support the development and application of blockchain technology, several industrial blockchain consortia have emerged, with the R3 consortium being the most influential among them. This network has brought together more than 40 of the world's leading financial institutions, including Bank of America, Citigroup, Morgan Stanley, Deutsche Bank, and Barclays. Since May 2016, Ping An Bank and China Merchants Bank (CMB) have also joined the R3 blockchain consortium, further strengthening collaboration and information exchange among key financial players in the blockchain field. Additionally, institutions such as WeBank, Ping An Bank, and CMB Network Technology have jointly established the China Financial Blockchain Consortium. Overall, major financial institutions hold a relatively positive stance toward the advancement of blockchain technology in improving operational efficiency and recognize its significant potential to reduce operating costs [15].

Blockchain serves as the foundational technology behind cryptocurrencies, functioning as a decentralized ledger across the network. It facilitates transactions and enables the secure transfer of both value and information. Within these networks, cryptocurrencies operate as digital tokens that are used to exchange value and cover transaction costs. These tokens can be seen as functional tools within the Blockchain system, and in certain cases, they act as utility assets or even represent the digital form of physical assets. Overall, cryptocurrencies exist as key components within the broader Blockchain-based ecosystem [16].

Although a relatively recent innovation, cryptocurrencies have experienced rapid growth and widespread market adoption. A growing number of hedge funds and asset managers have started to incorporate crypto-related assets into their portfolios and trading strategies. Similarly, the academic community has devoted substantial effort to studying cryptocurrency trading. This section aims to provide a comprehensive overview of the research on cryptocurrency trading, including studies focused on developing and facilitating trading strategies within this emerging asset class [17].

Over the past ten years, cryptocurrencies have transitioned from a relatively obscure digital asset into a prominent element of the global financial landscape. These decentralized currencies function independently of conventional financial institutions and government control, utilizing blockchain technology to ensure transparency, security, and permanence. Their influence on global finance has expanded quickly, challenging traditional concepts of currency, investment, and value

transfer. This literature review examines the latest trends in cryptocurrency adoption, assesses their effects on international finance, and considers future prospects for their integration into the broader financial system [18].

Cryptocurrencies play an increasingly vital role in promoting financial inclusion and providing protection against unstable local currencies. In times of geopolitical conflict and economic uncertainty, both individuals and institutions are turning to alternative assets, with cryptocurrencies emerging as a credible safe haven [4]. This trend is especially evident in regions heavily dependent on remittances, where cryptocurrencies are being adopted for their speed and low transaction costs. However, adoption is not consistent across the globe, as cultural perceptions, regulatory environments, and technological infrastructure significantly influence uptake. As countries navigate the dual challenge of leveraging the benefits of cryptocurrencies while managing their associated risks, international cooperation and knowledge exchange become essential [5,9]. Consequently, the global spread of cryptocurrency adoption reflects a complex interaction between technology, economics, and policy factors that are collectively shaping the future of global finance.

Furthermore, Corbet et al [19] and Kristoufek [20] have shown that the relationships between Bitcoin, stock markets, and volatility indices such as the VIX are time-invariant, strengthening during periods of financial uncertainty. These findings support the need for a global econometric approach that includes variables such as inflation, interest rates, and liquidity indicators to understand the true impact of cryptocurrencies on the global financial system.

Table 1. Cryptocurrency exchanges lists.

Exchanges	Category	Supported Currencies	Fiat Currency	Registration Country	Regulatory Authority
CME	Derivatives	BTC and Ethereum (Cme 2020)	USD	USA (cME 2020)	CFTC (Cme 2020)
CBOE	Derivatives	BTC (cBoE 2020)	USD	USA (cBoE 2020)	CFTC (cBoE 2020)
BAKKT	Derivatives	BTC (BAKKT 2020a)	USD	USA (BAKKT 2020b)	CFTC (BAKKT 2020a)
BitMex	Spot	12 cryptocurrencies (Bitmex 2020a)	EUR	Seychelles (Bitmex 2020)	–
Binance	Spot	98 cryptocurrencies (Binance 2020)	NGN, RUB, TRY	Malta (Maltatoday 2020)	FATF (Binance 2020)
Coinbase	Spot	28 cryptocurrencies (Coinbas 2020)	EUR, GBP, USD	USA (Bloomberg 2020)	SEC (Coinbase 2020)
Bitinex	Spot	>100 cryptocurrencies (Bitinex 2020)	EUR, GBP, JYP, USD	British Virgin Islands (Bitinex 2020)	NYAG (Bitinex 2020)
Bitstamp	Spot	5 cryptocurrencies (Bitstamp 2020b)	EUR, USD	Luxembourg (Bitstamp 2020)	CSSF (Bitstamp 2020)
Poloniex	Spot	23 cryptocurrencies (Poloniex 2020)	USD	USA (Poloniex 2020)	

Source: Fang et al [13] 2022.

On the other hand, the literature on blockchain technology emphasizes its role as an

infrastructural basis for the decentralization of markets and the creation of new forms of financial intermediation. Catalini and Gans [21] argue that blockchain reduces verification costs and enables greater transparency, but creates new regulatory challenges and systemic risks, especially in the decentralized finance (DeFi) sector. Along the same lines, Aramonte et al. [22] emphasize that the rise of stablecoins and DeFi platforms has created "illusions of decentralization," increasing vulnerability to market shocks.

Tabel 1 provides a comparative overview of ten major cryptocurrency exchanges, categorizing them by trading type (derivatives or spot), supported currencies (both crypto and fiat), country of registration, and regulatory authority. It highlights significant differences among exchanges in terms of the range of cryptocurrencies offered, geographic reach, and level of legal regulation. While some exchanges like Binance and Coinbase support over 100 cryptocurrencies and operate globally, others like CME and CBOE focus solely on derivatives and are regulated by U.S. authorities such as the CFTC. The table serves as a useful reference tool for users seeking transparency, security, and variety in cryptocurrency trading.

3. Materials and Methods

This study uses secondary data to examine the role of cryptocurrencies and blockchain in the development of the global financial landscape. The secondary data have been collected from reliable sources such as reports from international financial institutions, academic studies, global financial databases, and industry reports. To conduct the analysis, a global econometric approach was applied, including advanced data modeling techniques to identify the relationships and impacts of cryptocurrencies and blockchain technologies on financial markets. The period analyzed in this research is from 2013 to 2024. The variables included in the study are: the dependent variable Bitcoin, and the independent variables Ethereum, S&P 500, VIX, M2, inflation, interest rate, and the Crypto Volatility Index. For data processing, the Stata software was used, while Excel was used for creating the charts and graphs. The analyses conducted in this research include: descriptive statistics, correlation analysis, and the GEE model test.

The hypothesis of this research is:

H1: *Cryptocurrencies and blockchain technology have a positive impact on the development of global financial markets.*

Table 2. Description of variables.

Variables	Calculation / Unit	Data Sources
Bitcoin (Y)	Average monthly price	CoinMarket Cap
Ethereum (X1)	Average monthly price	CoinMarket Cap
S&P 500 Index (X2)	Monthly average value of the index	Yahoo Finance / FRED
VIX (Volatility Index) (X3)	Monthly average value	CBOE / Yahoo Finance
M2 (Money Supply) (X4)	Monthly average value	FRED – Federal Reserve
Inflation (X5)	Annual inflation rate (%)	World Bank / Trading Economics
Interest Rate (X6)	Base interest rate (%), monthly	OECD / World Bank
Crypto Volatility Index (X7)	Crypto volatility index, monthly average	Crypto Compare / T3 Index

Source: Author's calculation.

The research questions of this study are:

1). Do cryptocurrencies affect the stability and performance of financial markets?

2). How does blockchain influence the transparency and security of financial transactions?

3). Does the impact of cryptocurrencies and blockchain differ between developed and developing countries?

The econometric model of this study is as follows:

$$Bitcoin = \beta_0 + \beta_1 ETH_t + \beta_2 SP500_t + \beta_3 VIX_t + \beta_4 M2_t + \beta_5 INF_t + \beta_6 IR_t + \beta_7 CVI_t + \varepsilon t_{it} \quad (1)$$

Where:

BI *– Bitcoin*

ETH*- Ethereum*

SP500 *- S&P 500 Index*

VIX *- Volatility Index*

M2 *- Money Supply*

INF *– Inflation*

IR *– Interest Rate*

CVI *- Crypto Volatility Index*

4. Results

This section presents and analyzes the results derived from the econometric model, with the aim of evaluating the impact of cryptocurrencies and macroeconomic factors on the development of financial markets. The analysis is based on secondary data for the period 2013–2024 and includes the use of descriptive statistics, correlation analysis, and the GEE model. The results help to understand the relationships between variables such as Bitcoin, Ethereum, SP500, inflation, interest rate, and volatility indicators, offering a clear overview of financial market behavior in the digital era.

Table 3. Descriptive statistics for the variables included in the econometric model.

Variables	Obs.	Mean	Std. Deviation	Minimum	Maximum
Bitcoin	12	3.7875	0.8610049	2.5	54.97
Ethereum	12	2.925833	0.4680415	2.02	3.51
SP500	12	3.51	0.250563	3.1	3.99
VIX	12	16.96417	4.691963	10.26	24.95
M2	12	4.195833	0.1114743	4.04	4.33
Inflation	11	3.081818	1.965105	1.4	7.9
Interest Rate	12	1.684167	1.927973	0.08	5.33
Crypto Volatility Index	12	66.79846	12.35808	57.6468	101.8303

Source: Authors' calculations in Stata (2025).

Table 3 presents descriptive statistics for the variables included in the econometric model, including the number of observations (Obs), the mean, standard deviation, and the minimum and maximum values for each variable. It is evident that the price of Bitcoin has an average of 3.79 and a relatively high standard deviation (0.86), with a maximum value reaching 54.97, reflecting its high volatility. Similarly, the Crypto Volatility Index shows a high average of 66.8 and a wide range from

57.64 to 101.83, indicating significant fluctuations in the cryptocurrency market. The stock market index SP500 appears more stable, with an average of 3.51 and a low variation (0.25). VIX, which measures market uncertainty, also shows noticeable variability, with values ranging from 10.26 to 24.95. The data for inflation are slightly more limited (only 11 observations), but show an average of 3.08%. Overall, the statistics indicate a considerable presence of volatility in financial and macroeconomic markets, which justifies further econometric analysis to identify the relationships between these variables and cryptocurrency prices.

Table 4. Correlation.

Variables	Bitcoin	Ethereum	SP500	VIX	M2	Inflation	Interest Rate	CVI
Bitcoin	1.0000							
Ethereum	0.4606	1.0000						
SP500	0.6451	-0.0516	1.0000					
VIX	0.1987	-0.0839	0.5899	1.0000				
M2	0.9060	0.5852	0.6406	0.3869	1.0000			
Inflation	0.4936	0.4024	0.2916	0.1778	0.6461	1.0000		
Interest Rate	0.4820	0.1614	0.5027	-0.0200	0.5276	0.7877	1.0000	
CVI	0.5340	0.3480	0.2849	0.4013	0.5127	-0.1520	-0.2275	1.0000

Source: Authors' calculations in Stata (2025).

Table 4 presents the correlation analysis between the variables included in the econometric model. The results reveal several interesting relationships between macroeconomic indicators and cryptocurrency prices.

There is a very strong positive correlation between Bitcoin and M2 (0.9060), suggesting that the increase in money supply is closely linked to the price of Bitcoin, possibly due to the perception of Bitcoin as a hedge against monetary inflation. Additionally, there is a relatively strong relationship between Bitcoin and the SP500 index (0.6451), indicating a potential connection between stock market performance and cryptocurrency prices.

Table 5. GEE Model.

Bitcoin	Coef.	Std. Err.	z	P>|z|	[95% Cof.	Interval]
Ethereum	-.2371248	.207901	-1.14	0.254	-.6446032	.1703536
SP500	2.620127	.770151	3.40	0.001	1.110658	4.129595
VIX	-.124227	.0260684	-4.77	0.000	-.1753202	-.0731339
M2	2.684945	2.145496	1.25	0.211	-1.520149	6.890039
Inflation	.3104946	.1157808	2.68	0.007	.0835684	.5374208
Interest Rate	-.267897	.0987441	-2.71	0.007	-.461432	-.0743621
CVI	.028139	.0094794	2.97	0.003	.0095596	.0467183
_cons	-16.3434	6.203139	-2.63	0.008	-28.50133	-4.185473

Source: Authors' calculations in Stata (2025).

On the other hand, Ethereum shows weaker correlations with most variables, except for M2 (0.5852) and Bitcoin (0.4606), which is expected since both are cryptocurrencies. The Crypto Volatility Index has a moderate correlation with Bitcoin (0.5340) and M2 (0.5127), reflecting the impact of macroeconomic factors on the volatility of the crypto market.

Meanwhile, the negative correlation between interest rates and crypto volatility (-0.2275) may imply that increasing interest rates reduce investors' sensitivity toward riskier assets like cryptocurrencies. Overall, this analysis highlights meaningful economic linkages between traditional financial factors and the cryptocurrency market, providing a foundation for further investigation through econometric models.

In the tabel 5 The model results show that some independent variables have a statistically significant impact on the price of Bitcoin, while others are not significant at the 95% confidence level.

Variables with statistically significant impact:

SP500 (coef.=6.2013,p=0.000):It has a positive and highly statistically significant effect on the price of Bitcoin. This suggests that an increase in the stock index (S&P 500) is associated with an increase in Bitcoin's price, possibly reflecting overall optimism in financial markets.

VIX (coef.=-0.1242,p=0.000):It has a negative and statistically significant impact. An increase in the VIX (market fear index) is associated with a decrease in Bitcoin's price. This indicates that during times of uncertainty or crisis, investors may withdraw from riskier assets like Bitcoin.

Inflation (coef.=0.3105,p=0.007):Inflation has a positive and significant effect, suggesting that rising inflation is accompanied by an increase in Bitcoin's price possibly as a hedge against the loss of purchasing power in traditional currency.

InterestRate (coef.=-0.2679,p=0.007):Interest rates have a negative and significant effect, consistent with expectations: when interest rates rise, investors tend to shift toward safer investments (such as bonds), reducing demand for cryptocurrencies.

CryptoVolatilityIndex (coef.=0.0281,p=0.003):It has a positive and meaningful effect on Bitcoin's price. This can be explained by the fact that increased trading activity and speculation in the cryptocurrency market influence Bitcoin's price fluctuations, often increasing it.

Variables without statistically significant impact:

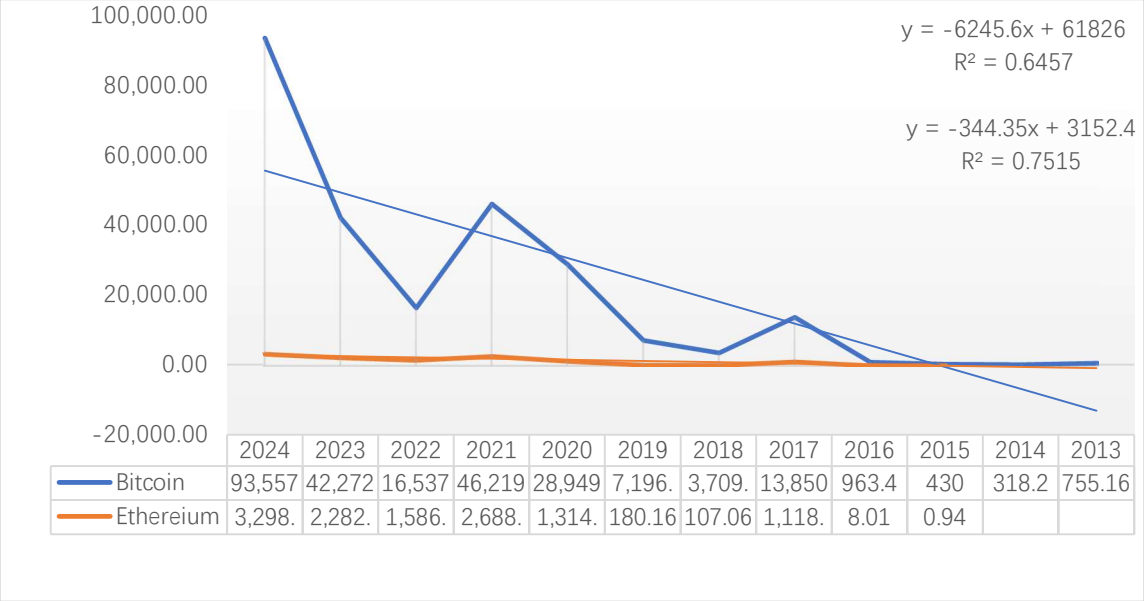
Ethereum ($p = 0.254$): It does not have a significant effect on Bitcoin's price in this model, although both are major cryptocurrencies.

M2 (Money Supply) ($p = 0.211$): It is not statistically significant, possibly due to a delayed effect on cryptocurrency markets or due to lack of large monthly variations in the data.

Figure 2 presents the price trends of Bitcoin and Ethereum over the period 2013–2024, showing an overall downward trajectory for both cryptocurrencies. Bitcoin has experienced greater volatility and a steeper decline, peaking in 2024, while Ethereum has shown more stable behavior. The linear models indicate that Bitcoin has a downward trend of approximately $6,245 per year ($R^2 = 0.645$), whereas Ethereum declines by about $344 per year ($R^2 = 0.751$), suggesting a better model fit for Ethereum. Overall, the data suggest a gradual decrease in the value of both cryptocurrencies, possibly due to macroeconomic factors, regulatory changes, and developments in global financial markets.

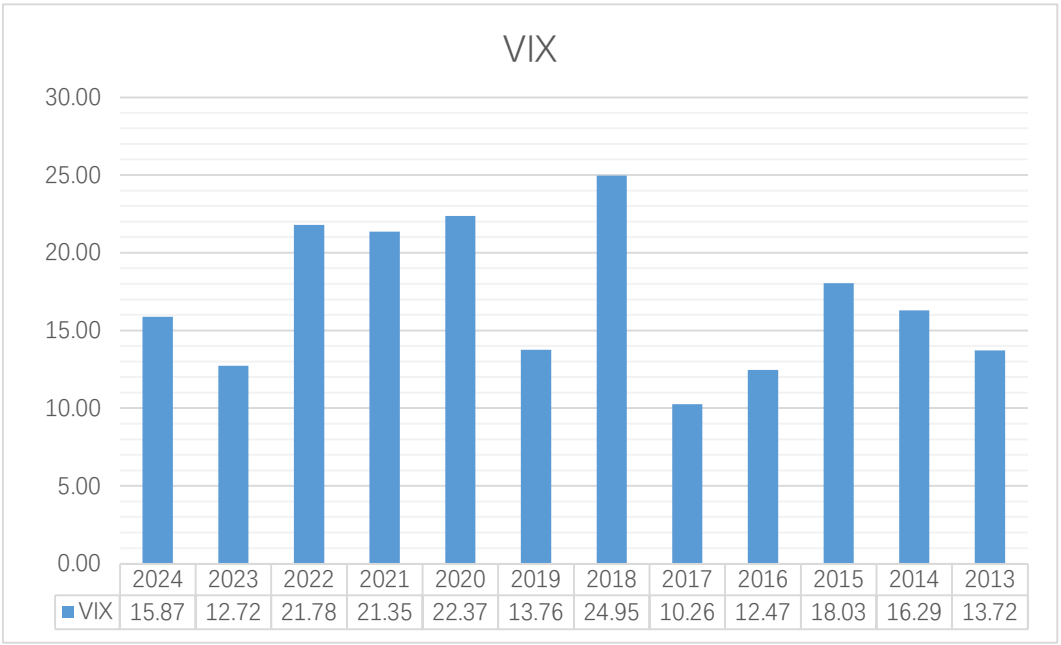
Figure 3 presents the annual movements of the VIX index for the period 2013–2024, which measures market expectations of short-term volatility. The highest value of the index was recorded

in 2018 (24.95), reflecting increased uncertainty in financial markets during that year. Additionally, the period from 2020 to 2022 also shows high VIX values, linked to the global crisis caused by the COVID-19 pandemic. In 2023 and 2024, a noticeable decline in the index is observed, with the lowest value occurring in 2023 (12.72), suggesting a more stable environment and less fear in financial markets compared to previous years. Overall, the data indicate that the VIX responds sensitively to global events that affect investor confidence.



	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
Bitcoin	93,557	42,272	16,537	46,219	28,949	7,196.	3,709.	13,850	963.4	430	318.2	755.16
Ethereum	3,298.	2,282.	1,586.	2,688.	1,314.	180.16	107.06	1,118.	8.01	0.94		

Figure 2. Bitcoin and Ethereum.



	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013
VIX	15.87	12.72	21.78	21.35	22.37	13.76	24.95	10.26	12.47	18.03	16.29	13.72

Figure 3. Volatility Index.

5. Discussion

The empirical findings of this study underscore the growing entanglement between cryptocurrencies and traditional macroeconomic forces. The statistical significance of variables such

as the S&P 500, VIX, inflation, interest rates, and the Crypto Volatility Index in explaining Bitcoin's price movements suggests that the cryptocurrency market is far from operating in isolation. Rather, Bitcoin often promoted as a hedge or alternative to traditional assets appears increasingly responsive to broader financial conditions and market sentiment.

The positive correlation between the S&P 500 and Bitcoin indicates a convergence of investor behavior across both markets, possibly driven by institutional involvement and portfolio diversification strategies that incorporate crypto assets. Conversely, the impact of the VIX (Volatility Index) on Bitcoin prices may reflect the asset's dual nature: both a risk-on speculative tool and a perceived safe haven during uncertainty. This complexity reinforces the notion that Bitcoin is evolving beyond its original decentralized ethos and becoming embedded in the psychology of global financial markets.

Inflation and interest rates were also found to have a significant relationship with Bitcoin prices, aligning with economic theory that suggests cryptocurrencies may act as a store of value during periods of monetary expansion or fiat currency depreciation. However, the strength and direction of these effects could vary depending on regional policy environments, investor sentiment, and adoption levels factors not fully captured in the current model but worthy of future exploration.

Interestingly, Ethereum and M2 money supply did not show significant effects in the GEE model. This may point to differences in use cases (e.g., Ethereum's utility in decentralized finance and smart contracts vs. Bitcoin's store-of-value perception) or a possible time lag between monetary expansion and its transmission into crypto markets. The lack of impact from M2 also raises questions about the direct monetary channel between liquidity and crypto valuation, suggesting the need for more granular, region-specific studies.

These findings contribute to the growing body of literature that challenges the assumption of cryptocurrencies as detached or immune from traditional financial systems. Instead, the evidence suggests that cryptocurrencies are becoming increasingly sensitive to macro-financial variables an important consideration for policymakers and regulators. As Central Bank Digital Currencies (CBDCs) gain momentum globally, understanding these interdependencies becomes even more crucial for designing resilient monetary systems that can coexist with or counterbalance the influence of decentralized digital assets.

From a methodological standpoint, the use of the GEE model allowed for robust estimation across unbalanced panel data and autocorrelation within time-series clusters. However, limitations remain, including potential endogeneity, the influence of unobserved country-level factors, and the need to account for structural breaks in the crypto market post-2020.

In sum, this study illustrates that while cryptocurrencies and blockchain technologies emerged as disruptive forces, they are now increasingly influenced if not shaped by the very systems they once aimed to bypass. Future research should expand the scope of analysis to include behavioral finance variables, real-time regulatory shocks, and cross-chain developments that could further illuminate the evolving financial ecosystem.

An important limitation of this study is the relatively small number of observations for some key variables, which may affect the statistical power of the analysis. Certain variables, particularly those related to the use of cryptocurrencies and the development of blockchain technology in specific financial markets, have a limited amount of available data for certain time periods or specific countries. This factor may influence the ability to draw generalized conclusions and indicates that

more comprehensive data are needed to strengthen the accuracy of future analyses. Although the dataset used provides a useful overview of global trends, the limitations in data quantity for some variables should be taken into account when interpreting the results.

6. Conclusions

This study econometrically examined the impact of cryptocurrencies and blockchain technology on the development of the global financial landscape, using secondary data for the period 2013–2024. Statistical analyses and the GEE model revealed that several macroeconomic factors such as the S&P 500 index, inflation, interest rates, and volatility indices (VIX and Crypto Volatility Index) have a significant influence on the price of Bitcoin. This suggests that cryptocurrency markets, although decentralized, are sensitive to developments in traditional financial markets and global monetary policy. The findings confirm that Bitcoin may serve as an alternative asset during periods of inflation but remains highly influenced by risk and volatility factors, raising questions about its role as a long-term store of value. On the other hand, Ethereum and other variables like the money supply (M2) did not show statistically significant effects in this model, which may imply that their impact is more conditional and dependent on specific market dynamics or shorter-term analyses.

Furthermore, the study highlights that blockchain technology through applications like DeFi and smart contracts is contributing to a transformation in how financial transactions are conducted and financial services are mediated. Likewise, the growing interest in Central Bank Digital Currencies (CBDCs) shows that governments are seeking ways to harness the benefits of digital technologies without losing control over the monetary system. Overall, this paper concludes that cryptocurrencies and related technologies have the potential to reshape the global financial system but require careful and balanced approaches due to the risks they carry. Therefore, collaboration between technological innovation and policymaking is essential to ensure the sustainable and inclusive development of modern financial markets. Based on these results, we will provide some recommendations regarding this research.

Regulatory policies – It is recommended that regulatory authorities develop balanced legal frameworks that preserve innovation in crypto markets while simultaneously ensuring financial stability and investor protection.

Investment in financial education – As cryptocurrencies and DeFi gain wider adoption, there is a growing need to enhance public financial literacy regarding the benefits and risks associated with these technologies.

Development of CBDCs – Both developing and developed countries should continue testing and implementing Central Bank Digital Currencies (CBDCs) as a way to increase financial inclusion and improve the efficiency of the monetary system.

Monitoring of crypto markets – International financial institutions should develop mechanisms for the regular monitoring of cryptocurrency markets in order to identify potential systemic risks in a timely manner.

Contributions: Berisha A.: Introduction, literature review, discussion, and conclusion and recommendation; and Kilaj D.: Structural equation model, methodology, formal analysis, and results. Both authors reviewed the manuscript structural.

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