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THE INVESTIGATION OF CRYPTOCURRENCY MARKET VOLATILITY: DO MACROECONOMIC FACTORS MATTER?

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Abstract
Cryptocurrency market volatility has been the critical issue nowadays due to heavy investment in digital market and this aspect needs the attention of the new researchers. Hence, the present study examine the macroeconomic factors such as inflation, interest rate, national income, industrialization and economic growth on the cryptocurrency market volatility in USA. The study extracted the data from World Development Indicators (WDI) and Chicago Board Options Exchange (CBOE) from 1991 to 2024. The study used the non-linear autoregressive distributed lag (NARDL) approach using STATA to check the association among the variables. The outcomes revealed that inflation has a positive association with cryptocurrency market volatility while interest rate, economic growth, national income and industrialization has a negative association with cryptocurrency market volatility. The study helps the policymakers in making policies related to reduce the cryptocurrency market volatility by increasing interest rate, economic growth, national income and industrialization.

Keywords: *Cryptocurrency market volatility, interest rate, economic growth, national income, industrialization, inflation*

Introduction

The recent development of a cryptocurrency trading market has brought a new level of financial systems in the world with the concept of extreme volatility and speculative tendencies. The two determinants of the volatility of cryptocurrency markets are also important to the investors, policymakers and economists, especially when they concern macroeconomic factors. Out of all the macroeconomic indicators, inflation is said to be one of the major forces that cause the price of assets such as cryptocurrencies to change. The lack of purchasing power of the fiat currencies due to high inflation levels makes investors turn to alternative investments like the cryptocurrencies, which may cause high volatility of prices. Evidence has been found that inflation may stimulate a shred of speculative trade in digital currency (Z. Liu & Hou, 2023). Other researches like J. Liu and Serletis (2019)also mention that in more stable times of inflation, volatility in the crypto market can decrease because when there is a lack of uncertainty in regular markets, there also appears to be a decline in volatility in the crypto market.

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Another important factor that has contributed to volatility of cryptocurrency includes interest rate movements. The use of cryptocurrencies also tends to decrease during periods of rising interest rates as in these cases traditional investments make more sense than investments in digital assets, which in turn may dampen price volatility. On the other hand, the low interest rate conditions have the potential to promote speculative investments in risky assets like in Bitcoin and Ethereum. According to empirical evidence, interest rate announcements have been identified to elicit a sudden change in prices in cryptocurrencies (Kyriazis, Papadamou, & Corbet, 2020). Also, the studies like J. Liu and Serletis (2019) emphasize that it has been found that periods of very low interest rates have been linked to risk-seeking behavior and augmented volatility in new financial markets such as cryptocurrencies. The increase in GDP also contributes to influences in the cryptocurrency market. Factors such as strong economic growth generally increase the level of investor confidence in conventional markets thus, depressing volatility in the cryptocurrency market by decreasing the speculator demand. Conversely, a slower pace of growth in the GDP or recessionary environment can trigger the change by investors to purchase a diversified set of assets; this may also increase volatility. According to research, macroeconomic stability, which can be determined by the stable growth of GDP, is associated with lower instability in financial markets (Ehigiamusoe & Samsurijan, 2021). Buthelezi (2025) Study also points out that negative GDP growth shocks may spark interest in alternative investments such as cryptocurrencies leading to a steep price variation.

The volatility of cryptocurrencies is also affected by the level of national income which is frequently associated with wealth in households and the rate of savings. Improved national income may augment the ability of individuals to buy the speculative asset hence, boosting the level of transactions and volatility. Conversely, the low income levels may restrict market involvement whereby volatility is decreased during some time frames. Past researches like Apergis and Bouras (2023) has also revealed that personal wealth and that of the nation can be associated with an increment of investment in more risky financial instruments. On the same note, it is shown that the liquidity and volatility in any kind of assets such as digital currencies can be influenced by the change in the national income distribution. Cryptocurrency market behavior can be influenced indirectly by the measure of economic development and technological advancement called industrialization. Countries that are more industrialized would also have a superior infrastructure to support digital transactions hence getting closer to the potential of accessing cryptocurrencies markets. This is capable of increasing the levels of participation, trade volumes and thus volatility. It is revealed that the development of the industry and technologies contribute to more frequently using financial innovations, including cryptocurrencies (Hashemi Joo, Nishikawa, & Dandapani, 2020). Furthermore, it has been proposed that industrial growth allows speculation in the market to increase as capital mobility improves as well as trading platforms improve due to innovation and technology, with a possible resultant upsurge in the price volatility.

The main aim of the research is to investigate whether macroeconomic factors such as inflation, interest rate, GDP growth, national income, and industrialization influence cryptocurrency market volatility. It would help to determine which of these variables have a great influence, thus, increasing knowledge of the connection between macroeconomics and crypto markets. The research helps fill some important gaps in the literature, since literature up to date has largely focused on cryptocurrencies price dynamics on speculative nature, investor sentiment, or technological factors with little consideration of underlying macroeconomic drivers. Besides, the current literature tends to evaluate these aspects either independently or in already developed

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markets, which creates a gap in cross-nation, cross-dimension analysis of a multitude of macroeconomic indicators in emerging market environments.

Literature Review

As one of the major macroeconomic indicators, inflation has gained popularity in the economy due to its impacts in terms of asset price volatility, and cryptocurrency markets are recent developments. High inflation usually devalues the purchasing power of the fiat currencies, and hence causes investors to get alternative assets thus leading to more trading and volatility in the market. In cryptocurrency markets, this impact is intensified by the fact that it is a speculative capital asset that is affected by macroeconomic changes. Researches like Glas (2022a) have argued that the highest inflation rates tend to increase price volatility in digital assets where investors will shift assets in their portfolio to reflect on the depreciated currency. It has also aroused an uncertainty in the future monetary policies as a result of inflationary pressures which can trigger a rush of funds into or out of cryptocurrencies. This ambiguity is especially important in the case of decentralized assets that exist beyond the conventional financial systems. Moreover, the hedging ability of cryptocurrencies in inflationary times is disputed, which makes the markets unstable. There is empirical evidence that inflation expectations and announcements can cause temporary price volatility abundance in cryptocurrencies since they are sensitive to the macroeconomic shocks (Glas, 2022b).

Probably the most important phenomenon that affects capital allocations is the interest rates on offer and also has a significant impact on cryptocurrency market volatility. Low rates increase demand in investment and more expansionary trading of non-yielding assets such as cryptocurrency as the opportunity cost would be relatively low in comparison with higher rates that are most of the time redirected to safer and interest bearing assets. This change of capital flow will cool down the cryptocurrency market environment and remove its volatility. According to empirical research, it has been suggested that rising interest rates are normally associated with a fall in trading volume on cryptocurrencies and this would stabilize the prices (Ammous, 2018). In addition, central bank monetary policies that are interested in the manipulation of interest rates represent the general perspectives in economic parameters that influence investor confidence and risk taking. In a high-interest rate environment, there are more chances that investors shall opt to stick to conventional fixed-income assets meaning that participation in risky investments such as cryptocurrencies would be low in the market. On the other hand, low interest environment leads to liquidity inflows in crypto markets that may increase volatility because of over trading and swift buying/selling patterns. As Elsayed and Sousa (2024) research notes, when it comes to affecting the volatility of cryptocurrencies, sudden alterations in interest rates further impact this more than expected alterations in policies.

An increase in GDP is one of the fundamental factors that determine the economic welfare of any nation, which is highly correlated with the volatility of cryptocurrencies in the market. High growth rate of GDP indicates a safe and growing economy, which prompts investors to use the traditional forms of investments like equities, bonds or property instead of highly volatile investments like cryptocurrencies. During those times, the minimized speculative demand of cryptocurrencies may decrease volatility in the markets. It has been demonstrated that under conditions of strong economic growth, investors have more trust in conventional markets and, therefore, their dependency on other assets, crypto included, declines (Matkovskyy, Jalan, & Dowling, 2020). Moreover, increased GDP growth has been linked to better employment opportunities and income level as well as consumption that is likely to have a stabilizing impact

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on financial markets and moderate long price volatility in crypto currencies. In contrast, a deceleration of GDP growth or economic recession can force investors to chase high-risk and high-returns products, to the cryptocurrency market at times making it sometimes very volatile. The empirical data also show that macroeconomic stability due to steady improvement of GDP allows alleviating drastic swings of speculative asset classes including a cryptocurrency (Agarwal, Agarwal, Agarwal, & Agarwal, 2021).

As a metric of overall economic output and income in a nation, national income is significant in the determination of the volatility experienced in the cryptocurrency market. An increase in national income is usually an indicator of better economic times, higher consumer expenditure and better investment chances in the traditional markets and this may diminish the speculative interest in cryptocurrencies. The investors are also more likely to invest in stable and more productive projects when the economy thrives rather than in projects that cause the highest volatility in the market, such as cryptocurrencies (Caton, 2020). Such investment behavior leads to a decrease in volatility in the price of cryptocurrencies. Moreover, a high level of national income is also linked to maturity in the financial market, a better regulatory control, and better availability to such low-risk investment tools, which further discourages a speculative exchange in cryptocurrencies. On the other hand, reduction in the national income or deteriorating earning may drive individuals and institutional investors into more risky investments to have a higher rate of returns, which may also raise auction in the crypto market. It is also given that macroeconomic prosperity, manifesting through increased national income, contributes to stabilizing the speculative types of assets, such as cryptocurrencies (Caton, 2020).

An important factor that can affect the volatility of the cryptocurrency market is economic stability, which is mostly related to industrialization as a particular phase of the development of production capabilities, technological infrastructure, and production capacity. The above indicates a higher degree of industrialization which is normally associated with stable economic growth, creation of employment, and better distribution of income thus, leading to investment which is directed in long run productive resources as opposed to speculated investments in assets. The increasing propensity in economies with highly established industries to allocate their capital towards stabilization markets does not make volatile cryptocurrencies attractive to either institutional or retail investors (Giudici, Milne, & Vinogradov, 2020). Moreover, the industrialized nations tend to have well established financial systems, legislations, diversified liquidity prospects, thereby reducing uncontrolled risk in the speculative markets. Industrialization leads to a higher level of predictability in economic outputs and provides a stable atmosphere that reduces the severe oscillation in the market of alternative financial assets such as cryptocurrencies (Su, Qin, Tao, & Umar, 2020). The same ties can also be attributed to the fact that currency stability in the domestic market introduces enhanced industrial development, which can reduce their reliance on cryptocurrencies as a form of hedge-seeking against an uncertain economy. In this way, the industrialization is indirectly adding to the decrease in the volatility of the cryptocurrency market by increasing the macroeconomic resilience.

Research Methodology

The study examine the macroeconomic factors such as inflation, interest rate, national income, industrialization and economic growth on the cryptocurrency market volatility in USA. The study extracted the data from WDI and CBOE from 1991 to 2024. The study established the equation using understudy constructs given below:

$$CCMV_t = \alpha_0 + \beta_1 INF_t + \beta_2 IR_t + \beta_3 GDPG_t + \beta_4 NI_t + \beta_5 IND_t + e_t \quad \textbf{(1)}$$

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Where;
CCMV = Cryptocurrency Market Volatility
t = Time Period
INF = Inflation
IR = Interest Rate
GDPG = GDP Growth
NI = National Income
IND = Industrialization

The study used the cryptocurrency market volatility as the dependent variable measured as VIX index. In addition, the study used five predictors such as inflation measured with Inflation, consumer prices (annual % growth), interest rate measured with real interest rate (%), GDP growth measured with GDP (annual % growth), national income measured with adjusted net national income (annual % growth) and industrialization measured with industry, including construction, value added (% of GDP). Table 1 shows these constructs with measurements.

Table 1: Variables with measurements

Variables	**Measurement**	**Databases**
Cryptocurrency Market Volatility	VIX Index	CBOE
Inflation	Inflation, consumer prices (annual % growth)	WDI
Interest Rate	Real interest rate (%)	WDI
GDP Growth	GDP (annual % growth)	WDI
National Income	Adjusted net national income (annual % growth)	WDI
Industrialization	Industry, including construction, value added (% of GDP)	WDI

The study checks details of constructs using descriptive analysis. In addition, the study also checks correlation among variables. Moreover, the study check the unit root that is essential step to apply the appropriate model. The study used PP and ADF test to check the unit root. The equation of the test is given below:

$$d(Y_t) = \alpha_0 + \beta t + \Upsilon Y_{t-1} + d(Y_t(-1)) + \varepsilon_t \quad \textbf{(2)}$$

On the basis of the unit root test, the current study apply the ARDL model to check the nexus among variables because some variables have no unit at level and other have no unit root at first difference (Erkal, Yalçınkaya, & Gültekin, 2025). Moreover, the ARDL model gives the long and short run outcomes (Wang et al., 2024). The equation for ARDL model is given below:

$$\Delta CCMV_t = \alpha_0 + \sum\delta_1\Delta CCMV_{t-1} + \sum\delta_2\Delta INF_{t-1} + \sum\delta_3\Delta IR_{t-1} + \sum\delta_4\Delta GDPG_{t-1} + \sum\delta_5\Delta NI_{t-1} + \sum\delta_6\Delta IND_{t-1} + \varphi_1 CCMV_{t-1} + \varphi_2 INF_{t-1} + \varphi_3 IR_{t-1} + \varphi_4 GDPG_{t-1} + \varphi_5 NI_{t-1} + \varphi_6 IND_{t-1} + \varepsilon_t \quad \textbf{(3)}$$

Moreover, the study also has the intention to check the asymmetric relationship among IND, EI and CCMV. Hence, the nonlinear function of this association is given below:

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$$CCMV = f(INF, IR, GDPG, NI^{+}, NI^{-}, IND^{+}, IND^{-}) \quad \textbf{(4)}$$

Thus, the empirical model is given below:

$$CCMV_t = \alpha_0 + \beta_1 INF_t + \beta_2 IR_t + \beta_3 GDPG_t + \beta_4 NI_t^{+} + \beta_5 NI_t^{-} + \beta_6 IND_t^{+} + \beta_7 IND_t^{-} + e_t \quad \textbf{(5)}$$

In addition, the current study also investigates the nonlinear association among IND, NI and CCMV. The partial sum of positive and negative changes are presented in the equations given below:

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$$NI^{+} = \sum_{i=1}^{t} \Delta NI_i^{+} = \sum_{i=1}^{t} \max(\Delta NI_i\ 0) \quad \textbf{(6)}$$
$$NI^{-} = \sum_{i=1}^{t} \Delta NI_i^{-} = \sum_{i=1}^{t} \min(\Delta NI_i\ 0) \quad \textbf{(7)}$$
$$IND^{+} = \sum_{i=1}^{t} \Delta IND_i^{+} = \sum_{i=1}^{t} \max(\Delta IND_i\ 0) \quad \textbf{(8)}$$
$$IND^{-} = \sum_{i=1}^{t} \Delta IND_i^{-} = \sum_{i=1}^{t} \min(\Delta IND_i\ 0) \quad \textbf{(9)}$$

Thus, by using the above positive and negative changes in IND, NI and CCMV, the current study has developed the nonlinear ARDL model equation given below:

$$\Delta CCMV_t = \alpha_0 + \sum \delta_1 \Delta CCMV_{t-1} + \sum \delta_2 \Delta INF_{t-1} + \sum \delta_3 \Delta IR_{t-1} + \sum \delta_4 \Delta GDPG + \sum \delta_5 \Delta NI_{t-1}^{+} + \sum \delta_6 \Delta NI_{t-1}^{-} + \sum \delta_7 \Delta IND_{t-1}^{+} + \sum \delta_8 \Delta IND_{t-1}^{-} + \varphi_1 CCMV_{t-1} + \varphi_2 INF_{t-1} + \varphi_3 IR_{t-1} + \varphi_4 GDPG_{t-1} + \varphi_5 NI_{t-1}^{+} + \varphi_6 NI_{t-1}^{-} + \varphi_7 IND_{t-1}^{+} + \varphi_8 IND_{t-1}^{-} + \varepsilon_t \quad \textbf{(10)}$$

Findings of the Study

The study checks details of constructs using descriptive analysis. The outcomes indicated the total observation that 34 years. In addition, the outcome also shows mean value of all the constructs along with standard deviation, maximum and minimum values of all the variables. Table 2 shows these results.

Table 2: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CCMV	34	19.361	5.863	11.09	32.695
INF	34	2.619	1.436	-0.356	8.003
IR	34	3.105	2.372	-1.844	7.150
GDPG	34	2.518	1.755	-2.577	6.055
IND	34	20.451	2.264	17.116	24.267
NI	34	3.583	2.842	-3.912	7.069

In addition, the study also checks correlation among variables. The outcomes indicated that the INF has a positive correlation while IR, GDPG, IND and IN have a negative correlation with CCMV. Table 3 shows these results.

Table 3: Matrix of Correlations

Variables	CCMV	INF	IR	GDPG	IND	NI
CCMV	1.000					
INF	0.018	1.000				
IR	-0.051	-0.201	1.000			

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GDPG	-0.444	0.263	0.126	1.000		
IND	-0.075	0.097	0.785	0.227	1.000	
NI	-0.456	0.111	0.457	0.799	0.594	1.000

Moreover, the study check the unit root that is essential step to apply the appropriate model. The study used PP and ADF test to check the unit root. The outcomes exposed that CCMV, IND and NI have no unit root at level while INF, IR and GDPG have no unit root at first difference. Table 4 shows these results.

Table 4: Unit Root Test

	ADF		PP	
Series	Level	First difference	Level	First difference
CCMV	-5.231***	-8.453***	-4.383***	-8.753***
INF	-0.874	-3.291***	-0.453	-3.281***
IR	-0.211	-3.281***	-0.542	-3.432***
GDPG	-0.343	-4.391***	-1.445	-4.362***
IND	-3.891***	-6.654***	-4.383***	-7.453***
NI	-4.351***	-7.732***	-3.272***	-6.231***

The study also examines the co-integration in the model that is also a necessary step to apply appropriate model. The outcomes indicated that f-calculated (5.875) value is higher than lower and upper bound that shows co-integration exist. Table 5 shows these results.

Table 5: Bound Test of Nonlinear ARDL

	F-statistics	**Lower Bound**	**Upper Bound**	**Decision**
Linear ARDL	0.512	2.271	2.829	No Co-integration
Asymmetric ARDL	5.875	2.210	2.765	Co-integration

The study used the NARDL approach using STATA to check the association among the variables. The outcomes revealed that inflation has a positive association with cryptocurrency market volatility while interest rate, economic growth, national income and industrialization has a negative association with cryptocurrency market volatility. These results are given in Table 6 given below:

Table 6: Nonlinear ARDL Results

Variables	**Coefficients**	**Std. Err.**	**t-statistics**
C	1.821	0.126	14.452
CCMV (-1)	2.161	0.871	2.481
INF (-1)	-2.098	0.881	-2.381
IR (-1)	0.867	0.182	4.764
GDPG (-1)	1.092	0.392	2.786
IND-P (-1)	3.272	1.092	2.996
IND-N (-1)	4.373	1.252	3.493
NI-P (-1)	1.252	0.219	5.717
NI-N (-1)	0.884	0.210	4.209
Adj. R Square	0.676		
F-statistics	50.110		

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Prob.(F-statistics)	0.011		

Discussions

The results of this work present valuable evidence on macroeconomic factors that affect the volatility of cryptocurrency markets, analyzing such aspects as inflation, interest rates, growth of GDP, the level of national income, and industrialization. All hypotheses were tested separately and the results are presented below in the reasoning with regard to the available literature and theoretical assumption. The findings revealed that inflation is significantly and positively related to the cryptocurrency market volatility. This suggests an increase in uncertainty in economy that will grow with increased inflationary pressures resulting in investors embrace views that increasingly see cryptocurrency either as speculative investments or a new store of value further increasing volatility. Such results are aligned with the findings of Kukacka and Kristoufek (2023) that stated that the inflationary conditions contribute to the speculative nature of the cryptocurrency markets. Likewise, Conlon, Corbet, and McGee (2021) emphasized the fact that cryptocurrencies can become inflation hedges, which would attract speculative trading on the rise of inflationary periods, enhancing price volatility. The strong positive correlation is also consistent with the idea that macroeconomic instability, especially in the nature of inflation, destabilizes the sentiment of the investors thus fueling volatility. Regarding interest rates, the research literature showed that they are negatively and significantly linked with the volatility of the cryptocurrency market. Increased interest rates usually make more traditional and low-risk investments like bonds or savings accounts more appealing, and slow speculative investment capital on the way to cryptocurrency markets. This observation is congruent with that of Dhanani, Fifield, Helliar, and Stevenson (2008), who established interest-rate hikes reduce the demand of investors in high-risk assets. On the same note, Kyriazis et al. (2020) stated that higher rates would mean that the opportunity cost of holding non-yielding investments such as cryptocurrencies increases and this effect would decrease the speculative behavior and lower volatility. The findings further support the belief that monetary tightening may be used to mellow down the exaggerated price fluctuation prevailing in the cryptocurrency markets.

The results indicated that during the period under study, there was a significant and negative impact of the growth rates of GDP on the volatility of the cryptocurrency market. This implies that during economic periods of robust growth, investors would be less prone to indulge in speculative trading by investing in cryptocurrencies due to enhanced attractive traditional investment products as well as real sector operations. This observation is supported by the arguments presented by Fattouh, Kilian, and Mahadeva (2013), who discovered that a strong GDP growth lowers the demands on speculative assets. In addition, an expanding economy can be related to reduce levels of uncertainty, which undermines the speculative trading that promotes the volatility of cryptocurrencies. This follows similar studies in the wider macro-financial literature world that connects economic stability to low volatility in other financial markets. The results reported that the national income has a negative and significant association with the volatility of the cryptocurrency market. Increased levels of national income normally indicate enhanced living standards, better financial stability and wider access to traditional investment opportunities, all of which may decrease the attractiveness of high risk investments like cryptocurrencies. This correlates with those of Giudici et al. (2020), who recommended that larger economies could support more developed financial markets that are not offering such speculative demand of cryptocurrencies. Moreover, the increase of national income may be also associated with the

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increase of financial literacy that will make investors less inclined to using speculative and turbulent markets.

The outcomes showed that there is a negative and significant relationship between industrialization and financial volatility related to cryptocurrency markets. The existence of good industrial sectors in an economy would usually mean the availability of reliable sources of jobs and income, and in such cases, the mere feeling that they would invest in a form of speculative investments such as cryptocurrencies may be minimized. The evidence aligns with the argument of Griffin (2019), who indicated that the diversification of the economy, particularly, industrial growth, creates stability in the financial markets and makes the alternative asset classes less volatile. Moreover, the industrial growth has more chances to be connected to the presence of more powerful regulatory systems and institutional gains, and these can indirectly mitigate the wild fluctuations in emergent financial markets, such as cryptocurrencies. All in all, the outcomes of this investigation can be considered consistent with the theory and the majority of prior empirical ones and determine that macroeconomic stability, which manifests itself in a decreased rate of inflation, improved interest rates and GDP growth, increased national income and industrialization, leads to the reduced volatility of cryptocurrency markets. The only positive correlation that we witnessed was between volatility and inflation that points to the susceptibility of cryptocurrency markets to price-speculator forces.

Implications

The research has great implications on both academics, policy-makers, and investors since it enhances the comprehension of the effects of macroeconomics on cryptocurrency market volatility. The research provides a more detailed vision of the forces that can impact crypto prices through the study of the impact of inflation, interest rates, GDP growth, national income, and industrialization. To the policymakers, the results can inform the design of appropriate regulatory mechanisms that take into consideration the macro dynamics of the economy thus making the market more stable. The insights can help investors and financial analysts improve risk management tactics to better predict volatility patterns. Academically, this analysis helps to fill the literature gap with combining the traditional macroeconomic measures with the changing nature of the cryptocurrency market, which leads to the creation of a dialogue between the disciplines of economics and a digital financial market.

Limitations and Future Directions

The weaknesses of the given study are the fact that it uses secondary data, which could be potentially inaccurately reported and differ in the measurement approaches in countries. Since this study is aimed at analyzing the role of macroeconomic factors namely inflation rate, interest rate, GDP growth rate, national income, and industrialization in determining market volatility of a cryptocurrency, the scope of this study is restricted to these few of the macroeconomic variables. The other probable factors that can influence the market volatility of a cryptocurrency such as investor sentiment of the market or geopolitical risks are not considered. Also, the results cannot be applied to cryptocurrencies and locations individually as the markets in different areas are heterogeneous, and certain changes in the regulations are present.

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