Research Article

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Bitcoin Prices on the Volatility of Environmental, Social and Governance (ESG) Indices

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Abstract

Cryptocurrencies have exploded in popularity since the launch of Bitcoin in 2009 and are collectively worth over $1 trillion. Despite its prevalence, the impact of Bitcoin on traditional financial markets and its influence on other asset classes, such as Environmental, Social, and Governance (ESG) indices, remains unexplored. The current paper focuses on determining the impact of bitcoin prices on the volatility of ESG indices. We use data from the Dow Jones Sustainability Indices family, such as DJSI World (DW), DJSI North America (DNA), DJSI Europe (DE), DJSI Asia Pacific (DAP), and DJSI Emerging Market (DEM). Data was collected for the period from 2012 to 2023. The CBOE market volatility index (VIX) is included to increase the scope of our study. For estimation purposes, Westerlund & Narayan's (2015, 2012) distributed lag model was used to explore the relationship between the realized volatility of ESG index and bitcoin prices. Results indicate that bitcoin prices have no interconnectedness with ESG indices volatility. Further, the correlation between the volatility index (VIX) and ESG indices reveals a negative relationship, strengthening model findings. The bitcoin market is modest; however, ECG indices cover a wide range of industries and sectors, leaving it less vulnerable than the bitcoin market. The findings provide empirical bases to the investors for optimal portfolio allocation.

Keywords: *Bitcoin, volatility, ESG indices, investor behaviour*

1. Introduction

The emergence of cryptocurrencies has caught the interest of investors and the financial world's interest significantly in recent years. Bitcoin is the leading and most generally recognized cryptocurrency among these digital assets. Studies have been conducted to investigate the relationship between bitcoin and stock market volatility; for example, (Bouri et al., 2020, 2022, 2023; Conrad et al., 2018; Hachicha & Hachicha, 2021; Kallinterakis & Wang, 2019; López-Cabarcos et al.,

2021; Nguyen, 2022; Omri, 2023; Uzonwanne, 2021; J. N. Wang et al., 2020). Research on the traditional stock market shows that bitcoin prices significantly impact US stock volatility and stock sector volatility (Bouri et al., 2020, 2022, 2023). In the opposite direction,(Conrad et al., 2018) found that S&P 500 volatility risk premium has a significantly positive effect on long-term bitcoin volatility. López-Cabarcos et al. (2021) argued that the S&P 500 is not the only variable that influences bitcoin prices, but also VIX returns, and sentiment during stable periods. Furthermore,(Hachicha & Hachicha, 2021) suggested that the behaviour of stock market indices is no different from that of cryptocurrency, even though it is traded virtually. Using different class assets, (G. Wang et al., 2019) argued that the gold, monetary, and bond markets all have volatility spillover effects on bitcoin, although bitcoin has solely volatility spillover on gold.

Although bitcoin continues to grow in popularity and influence the traditional financial markets, another critical component of its effect on other asset classes, such as the Environmental, Social, and Governance (ESG) index, has yet to be investigated as we acknowledge that ESG investing has grown in popularity as investors attempt to connect their financial goals with their principles, choosing firms that exhibit ethical practices in environmental management, social inclusion, and robust governance systems.

This paper examines the effect of bitcoin prices on the volatility of ESG indices. Our paper is different from previous studies in the following perspective. We employ ESG indexes included in the Dow Jones Sustainability Index (DJSI) family, such as DJSI World, DJSI North America, DJSI Europe, DJSI Asia Pacific and DJSI Emerging Market, comprising global and regional benchmarks. The study is the first paper investigating the relationship between bitcoin and ESG indices volatility. We also include the volatility index (VIX) in this model. Following (Bouri et al., 2023), we employ Westerlund & Narayan (2015, 2012) method in analyzing the predictive power of the bitcoin on ESG indices.

The study is essential for several reasons. First, the study can disclose the ESG investors' behaviour based on the performance of cryptocurrency, especially the potential risks related to including the cryptocurrency into the ESG-exclusive portfolio, potentially affecting the ESG investors seeking stable and sustainable returns. Second, the level of market integration or disconnection between the two asset classes is revealed, which leads to a potential volatility spillover from the bitcoin market into an ESG-focused asset. Furthermore, investigating the connectedness between two asset classes will help assess the long-term sustainability of the ESG investment strategies with cooperate cryptocurrency in the portfolio. Finally, the policymakers and regulators can formulate the bylaws and guidelines to prevent the chaotic result of the movements of both assets.

Doing so gives a fresh perspective and improves the body of literature by providing no evidence of connectedness between bitcoin and ESG indices volatility for all regional benchmarks. However, implied volatility has a negative impact on the volatility of ESG indices.

The remainder of the paper is structured as follows. The review of the literature is described in Section 2. Section 3 presents the study's data and procedures. Section 4 elaborates on the discussion and recommendations based on the data analysis. Section 5 contains the conclusion, which emphasizes the relevance of our findings.

2. Material and Methods

The market capitalization of bitcoin stayed below $250 billion from October 2017 to October 2020; however, from November 2020 to February 2021, it increased at an exceptional rate of 321%, briefly crossing the $1,000 billion threshold. Due to this immense response by the market, cryptocurrencies have gained significant attention from academicians, investors and the public. Several studies have investigated the price determination process of Bitcoins (e.g. (Bouri et al., 2022; Brandvold et al., 2015; Ciaian et al., 2016; Georgoula et al., 2015; Panagiotidis et al., 2019).

2.1 Bitcoin Price Formation

A distinctive feature of Bitcoin currency is that circulation is not controlled by a group of people, companies, central banks or government; instead, it is operated by computer software. All transactions are recorded after verification into the public ledger blockchain. After this, participants receive newly minted bitcoins. Hence, the Bitcoin blockchain offers an alternative centralized platform for transactions of goods and services. Therefore, many companies accept bitcoins for payments (Cuthbertson, 2015). Blockchain technology offers privacy and security and a distributed ledger, making them applicable to the internet.

Heavy traffic volumes may result in a brief outage when interacting with Bitcoin. In order to prevent losing their whole wallet in the event of a hard drive failure, serious Bitcoin users keep several wallets spread across various places on the network (Parveen & Alajmi, 2019).

The demand-supply forces, investor sentiment, and media hype determine Bitcoin prices. Interestingly, social media attention towards bitcoin was essential to return predictability (Philippas et al., 2019). Bitcoin prices are correlated with the number of positive comments by users on social media, hence making it an essential source of information for returns forecast. Twitter has been recognized as a significant source of information that influences buying decisions of bitcoins (Abraham et al., 2018). (García-Magariño et al., 2020) have also presented a technique for real-time analysis of online sources that feed from variable information, such as data from IoT sensors in smart cities or cryptocurrency exchange rates. The study demonstrated average advantages from currency exchanges and offered plausible auto-generated reasons for moderate Bitcoin investments in the context of IoT sensor data from smart cities.

Further, (Raza et al., 2022) investigated the relationship between bitcoins and forex markets by examining the quantiles of cryptocurrency values and their influence on the forex market rates. The study found a positive relationship between foreign exchange currencies and cryptocurrencies, particularly Bitcoin, at the low, high, and middle tail quantiles due to changes in economic structure, legal recognition by governments, associated risk, and macroeconomic policy changes that affect cryptocurrency and fiat currency trading.

2.2 ESG Indices

ESG indices are a specific type of stock market index that aims to accurately reflect the performance of companies that demonstrate strong governance practices and positively influence the environment and society. Companies that demonstrate strong performance in social responsibility, environmental sustainability, and ethical business practices are typically included in the indexes. Investors may utilize ESG indices as a benchmark to track the performance of industry front-runners in sustainability and social responsibility. This allows them to identify firms strategically positioned to benefit from the growing emphasis on these factors. ESG investing is becoming increasingly popular as more investors want to align their investments with their ethical values and as businesses recognize the importance of sustainability and social responsibility. The references cited are (Auer & Schuhmacher, 2016; Danila, 2022, 2023; Lins et al., 2017; Piserà & Chiappini, 2022).

2.3 Financial Contagion & Asset Interdependence

Recently, scholars have conducted research on cryptocurrency interdependence and contagion and showed evidence of significant risk contagion among the price returns of major cryptocurrencies, both in bull and bear markets (Ji et al., 2019; Koutmos, 2018; Tiwari et al., 2020). Moreover, (Ciaian et al., 2018) suggested that the 10-year Treasury constant maturity rate, gold prices, and currency rates (USD/EUR and CNY/USD) all have an impact on Bitcoin values over the short and long terms. Nevertheless, (Corbet et al., 2018, 2019) reported that cryptocurrencies are somewhat isolated from other financial and economic assets, in a similar vein. As a result, cryptocurrencies have a degree of

diversification because they are less sensitive to changes in the value of more established financial assets.

3. Methodology

We utilize the Dow Jones Sustainability Indices family, which includes DJSI Global, DJSI North America, DJSI Europe, DJSI Asia Pacific, and DJSI Emerging Market, as the data samples for our analysis. The DJSI World applies a transparent, rules-based component selection process based on the companies' Total Sustainability Scores resulting from the annual S&P Global Corporate Sustainability Assessment (CSA). Only the top ranked companies within each industry are selected for inclusion in the Dow Jones Sustainability Index family. Our samples cover global, developed, and developing regions. Table 1 shows the details of the data. The global factor – the CBOE market volatility index (VIX) – is included. All data are obtained from Bloomberg Terminal. Table 1 below shows the details of the data.

Table 1. Data and periods

Index	Period
DJSI World (DW)	04/01/2012 – 30/05/2023
DJSI North America (DNA)	04/01/2012 – 30/05/23
DJSI Europe (DE)	04/01/2012 – 30/05/2023
DJSI Asia Pacific (DAP)	04/01/2021 – 26/05/2023
DJSI emerging market (DEM)	02/10/2012 – 30/05/2023

Source: Bloomberg

In terms of estimation, we use (Westerlund & Narayan, 2015, 2012) distributed lag model to investigate the connectedness between the realized volatility of the ESG index and bitcoin prices. The model accounts for endogeneity and persistence effects. The model is as follows:

$$RV_t = \alpha + \beta_1 bc_{t-1} + \beta_2 iv_{t-1} + \beta_3 (bc_t - \gamma bc_{t-1}) + \varepsilon_t \quad (1)$$

Where RV_t is a 20-day annualized realized volatility of corresponding ESG index returns at time t. bc_{t-1} is the log bitcoin price at time t-1. iv_{t-1} is the log implied volatility at time t-1. $(bc_t - \gamma bc_{t-1})$ is a persistence-adjustment term. ε_t is an error term.

An annualized realized volatility is calculated as below:

$$RV = 100 \times \sqrt{\frac{252}{n} \sum_{t=1}^{n} R_t^2} \quad (2)$$

RV is realized volatility; n is the number of days; R is return, calculated as $ln \frac{P_t}{P_{t-1}}$.

4. Results and Discussion

Table 2 reports R_t, bitcoin price, and implied volatility summary statistics. The mean values for all samples of R_t are close to zero, which means that the average of the samples is clustered around zero. Furthermore, the mean values of bitcoin prices for all samples are the highest among the variables. The value of the standard deviation of return and implied volatility variables are slightly different. However, the value is much higher for bitcoin prices. It means that the bitcoin price possesses high variability or the data is more spread out.

Regarding the skewness, all variables indicate deviating from the normal distribution curve, i.e., beyond the range of -0.5 – 0.5. Only in the emerging market does bitcoin price show a relatively symmetrical curve. Moreover, the skewness is negative, meaning the variable's value is more than average. Regarding excess kurtosis, R_t and implied volatility data exhibit leptokurtic distributions,

suggesting that the data have significant outliers. At the same time, the bitcoin price shows the platykurtic distribution, meaning that outliers are at low frequency.

Table 2 – Summary Statistics of ESG Index Returns (R_t), Bitcoin Price, and Volatility Index

Statistics/Variables	DW	DNA	DE	DAP	DEM
Index Return					
Mean	0.12110	0.13580	0.13603	0.13747	0.13773
Std. Dev	0.069861	0.09477	0.07186	0.05781	0.064983
Skewness	4.2658	4.6602	2.9164	2.1477	3.7340
Ex. Kurtosis	29.627	33.736	14.819	9.1263	24.690
Bitcoin Price					
Mean	7.4340	7.4201	7.4287	7.4310	7.8233
Std. Dev	2.5520	2.5629	2.5607	2.5535	2.1595
Skewness	-0.61619	-0.61216	-0.6169	-0.61491	-0.43981
Ex. Kurtosis	-0.46191	-0.47859	-0.47108	-0.46478	-0.67901
Volatility Index					
Mean	2.8281	2.8280	2.8285	2.8280	2.8242
Std. Dev	0.32097	0.32073	0.32095	0.32117	0.32949
Skewness	0.82057	0.82410	0.81699	0.82183	0.83850
Ex. Kurtosis	1.0800	1.1040	1.0795	1.0802	0.96202

Figure 1 – 5 shows the time series plot of RV and bitcoin (a); RV and implied volatility (b) for all samples. We can see from the pattern that there is no correlation between RV and Bitcoin because the movements of the two series are not synchronized. On the other hand, the series of RV and implied volatility reflect the same movements. Therefore, we expect the correlation between the two series to exist for all samples.

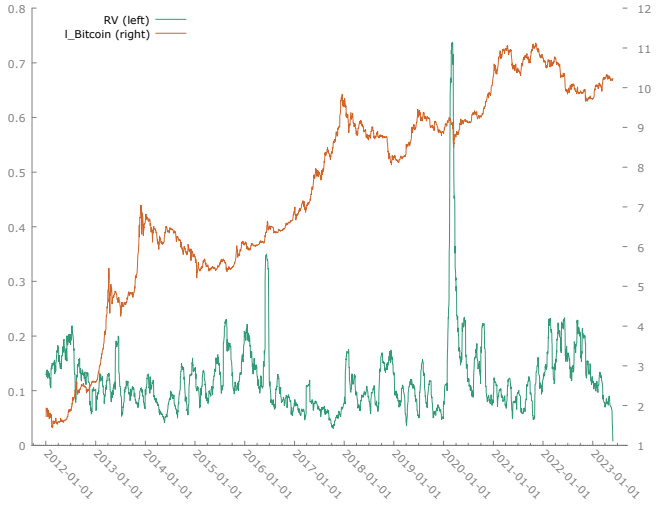

Figure 1a. DJSI World (RV and Bitcoin)

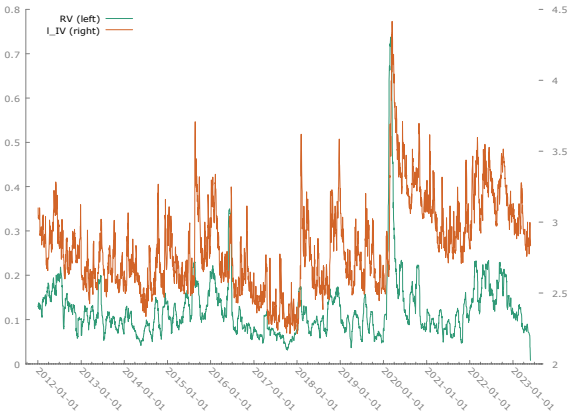

Figure 1b. DJSI World (RV and Implied Volatility)

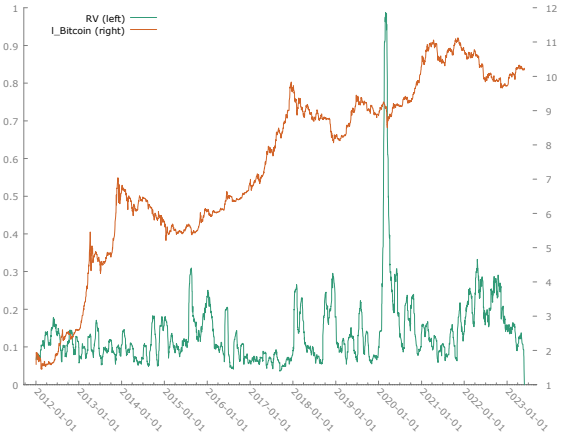

Figure 2 a. DJSI North America RV and Bitcoin)

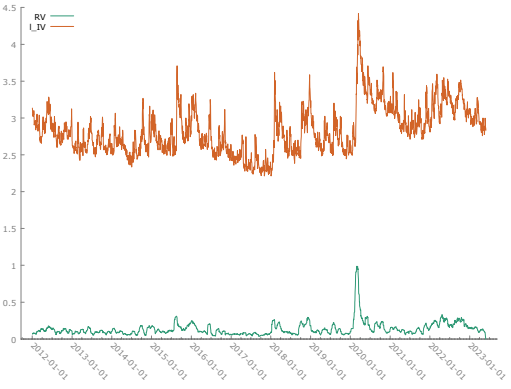

Figure 2b. DJSI North America RV and Bitcoin)

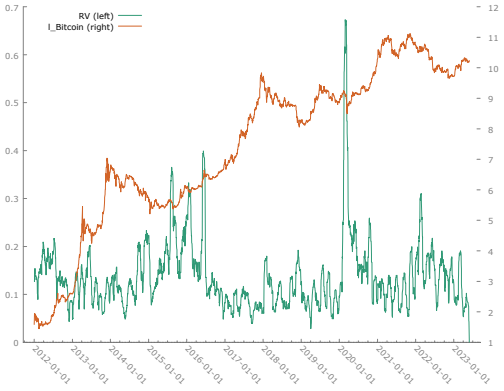

Figure 3a. DJSI Europe (RV and Bitcoin)

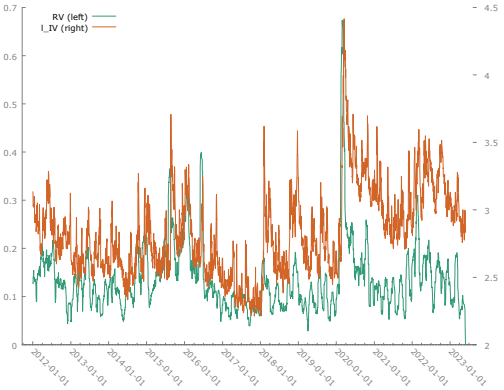

Figure 3b. DJSI Europe (RV and Implied Volatility)

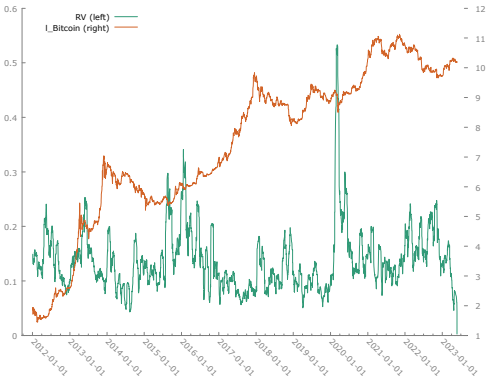

Figure 4a. DJSI Asia Pacific (RV and Bitcoin)

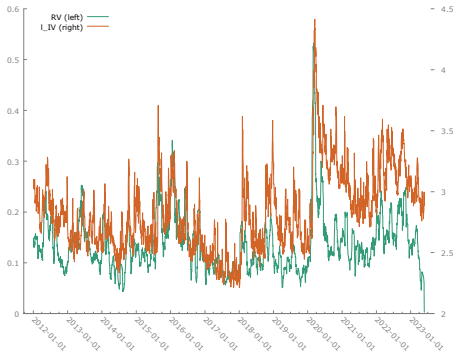

Figure 4b. DJSI Asia Pacific (RV and Implied Volatility)

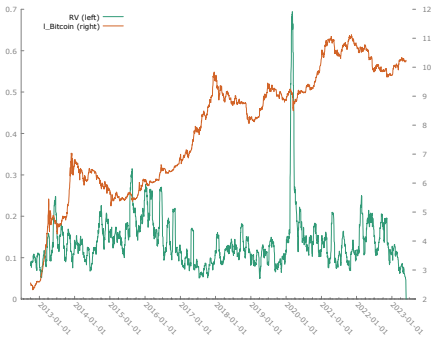

Figure 5a. DJSI Emerging Market (RV and Bitcoin)

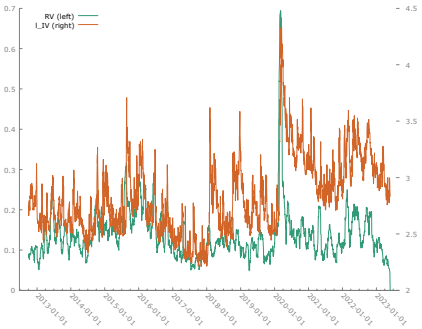

Figure 5b. DJSI Emerging Market (RV and Implied Volatility)

Table 3 – Estimation of model – GARCH (1,1)

$RV_t = \alpha + \beta_1 bc_{t-1} + \beta_2 iv_{t-1} + \beta_3 (bc_t - \gamma bc_{t-1}) + \varepsilon_t \; \sigma^2 = \omega + \theta_1 \varepsilon_{t-1}^2 + \theta_2 \sigma_{t-1}^2$						
Variables	α	β_1	β_2	β_3	θ_1(ARCH)	θ_2 (GARCH)
DW	0.0087	0.0001	-0.0033	0.9939	0.0603	0.9283

$RV_t = \alpha + \beta_1 bc_{t-1} + \beta_2 iv_{t-1} + \beta_3(bc_t - \gamma bc_{t-1}) + \varepsilon_t\ \sigma^2 = \omega + \theta_1 \varepsilon_{t-1}^2 + \theta_2 \sigma_{t-1}^2$						
Variables	α	β_1	β_2	β_3	θ_1(ARCH)	θ_2 (GARCH)
	(0.0000)***	(0.2831)	(0.0000)***	(0.0000)***	(0.0095)***	(0.0000)***
DNA	0.0168 (0.0000)***	9.050e-05 (0.2137)	-0.0060 (0.0000)***	1.0086 (0.0000)***	0.0385 (0.0004)***	0.9419 (0.0000)
DE	0.0106 (0.0000)***	7.586e-05 (0.3912)	-0.0037 (0.0000)***	0.9908 (0.0000)***	0.0405 (0.0030)**	0.9448 (0.0000)***
DAP	0.0060 (0.0052)***	4.961e-05 (0.4715)	-0.0017 (0.0906)*	0.9869 (0.0000)***	0.2159 (0.0080)***	1.323e-12 (1.0000)
DEM	0.0077 (0.0000)***	3.1113e-05 (0.6934)	-0.0023 (0.0003)	0.9869 (0.0000)***	0.0339 (0.0072)***	0.9429 (0.0000)***

p-values are in parentheses. *** indicates significant at 1% of significant level; * indicates significant at 10% of significant level.

Source: prepared by the authors.

We test the ARCH effect in our regression model. The results show that the ARCH effect of up to 5-lag is present for all samples. Therefore, we run GARCH (1,1) for our model to cooperate with the ARCH effect. We used QML (White) covariance matrix robust standard errors and covariance. ARCH and GARCH effects are significant at 1% of significant level (only DAP has no GARCH effect). Therefore, the GARCH (1,1) is the model's appropriate method instead of the OLS method.

Table 3 reports that β_1 is not significant for all samples, meaning that bitcoin price does not affect the ESG indices volatility. The result is contradictory to the existing studies, e.g., (Bouri et al., 2020, 2022, 2023; Conrad et al., 2018; Nguyen, 2022; G. Wang et al., 2019), who suggested that the correlation between bitcoin and stock return exist. However, β_2 is significant with negative values for all samples; in other words, the relationship between ESG indices volatility and implied volatility is in the opposite direction (negative). The finding is supported by (Chandra & Thenmozhi, 2015; Emna & Myriam, 2017; Sarwar, 2012; Vergili & Celik, 2023; Y.-C. Wang et al., 2014), who suggested that implied volatility has a negative impact on stock market volatility.

Several reasons why the bitcoin price does not have connectedness with the ESG indices volatility are as follows. Bitcoin and ESG indices are different asset classes driven by different factors. Market sentiment, adoption rate, and technology advancement might drive the bitcoin price fluctuation, while ESG indices fluctuation is driven by the included companies' financial performance and sustainability compliance. Furthermore, investing in Bitcoin attracts groups of investors such as individuals, speculators, and institutional investors. In contrast, most investors concerned with environmental, social, and governance issues may have limited exposure to Bitcoin. Finally, bitcoin's market value is significant but still modest compared to the larger financial markets. ESG indexes, on the contrary, often consist of a broader range of corporations from various industries and sectors. ESG indexes are less vulnerable to the price changes of a particular asset like Bitcoin because of their broader market size and diversification. Volatility in ESG indexes is more likely to be impacted by variables particular to the firms, including more significant market movements and macroeconomic situations.

Moving on to the correlation between the volatility index (VIX) and ESG indices, the result reveals a negative relationship. Some of the arguments are mentioned here. The VIX is vulnerable to shifts in investor attitude. When investors are concerned about the future direction of the ESG stock indices, they tend to buy options for protection, raising the demand for and price of these options and, as a result, increasing the implied volatility. The VIX, on the other hand, tends to fall at times of market optimism and confidence. In addition, the rising popularity of ESG investing has generated demand for ESG-related products such as ESG index funds. This demand can lead to more consistent and predictable trading patterns, lowering the VIX associated with these products. At last, investors may seek safe-haven assets such as government bonds and precious metals during market stress and increasing anxiety, resulting in a drop in demand for riskier assets such as ESG stocks. As a result, the stock market may fall, while the VIX increases owing to increased market uncertainty.

5. Conclusion

In this study, we look at how bitcoin prices affect the volatility of ESG indexes. For the study, we utilize data samples from the Dow Jones Sustainability Indices family - DJSI Global, DJSI North America, DJSI Europe, DJSI Asia Pacific, and DJSI emerging market. The worldwide element is the CBOE market volatility index (VIX). For the period 2012-2023, all statistics were gathered from Bloomberg. The distributed lag model investigated the association between ESG index realized volatility and bitcoin prices.

It was discovered that the mean values of bitcoin prices for all samples were the highest among the variables. The standard deviation of return and implied volatility variables have somewhat different values, but the figure for bitcoin price is substantially more significant. It suggests that the bitcoin price is highly volatile, according to the statistics. Furthermore, the skewness is negative, indicating that the variable's value is more significant than average, implying that the data contains substantial outliers. However, the frequency level is low based on the kurtosis distribution.

Additional findings showed that the volatility of the ESG indexes is unaffected by the bitcoin price. This is because ESG indicators based on financial performance, market sentiment, adoption rate, and technological innovation influence the value of Bitcoin. Furthermore, although the market value of Bitcoin is substantial, more is needed about the more established financial markets. ESG indices are influenced mainly by factors specific to the businesses, such as more prominent market movements and macroeconomic conditions. They are less susceptible to price fluctuations of a particular asset. However, market size and diversification have a significant impact on Bitcoin.

Furthermore, since there are variations in investors' attitudes, there is a negative association between the volatility index (VIX) and ESG indices, which is also confirmed by the research. Investors typically purchase options as a safeguard when they are worried about the future course of the ESG stock indexes; conversely, during market confidence and optimism periods, the volatility index typically declines.

The studies' implications are as follows: Investors can optimize their portfolios by leveraging the low correlation between Bitcoin and ESG indices, potentially enhancing risk-adjusted returns. Moreover, investors can adopt distinct investment strategies for Bitcoin and ESG indices. Investors, for example, may use Bitcoin for speculative gains or as a hedge against inflation and incorporate ESG indices due to their potential for long-term growth and alignment with ethical investing principles. Lastly, financial institutions may come up with new products that take advantage of the fact that VIX-linked instruments (like options) and ESG indices are negatively correlated. These products could include ESG-based low-volatility funds or derivatives that combine VIX-linked instruments with ESG exposure.

6. Acknowledgment

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7. Data Availability Statement

The data that support the findings of this study are available from Bloomberg Terminal. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the authors upon request with the permission of Bloomberg.

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