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Integration Among the Socially Responsible Investment, Green, Dirty, and Energy Cryptocurrencies: A Portfolio Diversification Perspective

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ABSTRACT

The paper investigates the association between various green, dirty, energy cryptocurrencies and socially responsible investment markets. **The purpose of the study** is to identify the potential benefits of portfolio diversification for socially responsible investment markets from green, dirty and energy cryptocurrencies using three alternative methodologies for portfolio construction (1) the equally weighted portfolio, (2) the least variance portfolio, and (3) the maximum Sharpe portfolio thus contrasting it with the alternative of home investing. **The research Methodology** used in the study are, correlation analysis, used to investigate short-term association, and subsequently, network analysis, to investigate the long-term connectedness between the socially conscious investment markets and the different green, filthy, and energy cryptocurrencies. **The study is unique** to focus on the interlinkages of socially responsible investment and the green, dirty and energy cryptocurrencies while evaluating the possible portfolio diversification benefits. **The results of the study** suggest that the investors in all other SRI assets, except green bonds, can benefit from the least variance technique. The maximum Sharpe portfolio is beneficial to all investors who make socially conscious investments. **The study has consequences** for asset allocation and investment decisions for investors and portfolio managers.

Keywords: socially responsible investment; green cryptocurrencies; dirty cryptocurrencies; energy cryptocurrencies market integration; portfolio diversification strategies; sharpe ratio

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INTRODUCTION

Stock market integration specifically refers to the degree to which different stock markets move about each other and provide similar risk-adjusted returns. When markets are integrated, movements in one market tend to influence movements in other markets, leading to a more interconnected global financial system. Due to the portfolio diversification benefits and asset allocation, market integration has become important for investors, researchers, and academicians. Researchers like Ibrahim [1] and Patel [2] highlight a key point regarding the benefits of the lack of integration in equity markets, namely, risk diversification. When markets are not fully integrated, investors can achieve greater diversification benefits by allocating their funds across different markets or regions [3]. If markets have a lower correlation, investors have an opportunity to reduce risk with portfolio diversification. If markets have no or weak integration, investors can enjoy risk reduction with portfolio diversification. Weaker integration among markets can offer a portfolio diversification opportunity which will disappear soon with strong integration [4, 5]. Investors are always looking after their wealth in each investment decision [6]. The inherent proven inefficiencies in the markets also make them further vulnerable to be exploited using appropriate strategies [7–9].

Initially, such studies were conducted on developed and emerging countries. However, the studies have not focused on socially responsible investment and green, dirty, and energy cryptocurrencies. The present study focuses on socially responsible investment and green, dirty, and energy cryptocurrency linkages and possible portfolio diversification benefits.

LITERATURE REVIEW

Review of Past Studies

During the initial years of the 1970s, research into financial market integration indicated a reduced correlation between markets. Grubel [10], influenced by the principles of Harry Markowitz [11], elucidated the advantages of diversifying portfolios across international markets. Subsequent studies by Subrahmanyam [12] and Kenen [13] confirmed the presence of financial market integration. Nevertheless, financial markets have progressively witnessed greater integration, with inter-market co-movements on the rise over time [14].

The European markets are closely integrated. As a result, the markets have a high level of systematic risk [15]. According to Bekaert & Urias [16], emerging markets have closed-end funds that can be invested by the investors at a relatively low cost, whereas the IFC investable does not consider the investment costs or restrictions. The effect of the sector increased with the increase in global integration. The investor needs to consider the role of industrial sectors in global strategies [17].

Since the early 2000s researchers have explored the Integration with other assets. Real estate showed a non-linear correlation with the stock market, but the process of mean reversion between stock and real estate markets is notably gradual, with discrepancies between the two markets potentially enduring for extended periods [5]. According to Gravelle et.al. [18] the markets are integrated and hence the long-term shocks are transferred to other markets. Such shocks cannot be reduced with temporary efforts. Real estate exhibited a non-linear relationship with the stock market, yet the mean reversion process between stock and real estate markets is characterized by a notably slow pace, allowing discrepancies between the two markets to persist for prolonged periods [5]. The opening of the stock market increases the demand for equities and either reduces or unchanged the demand for bonds. The opening up of small and undeveloped markets in emerging economies increases the diversification opportunities across the emerging markets [19]. The onset of war initially disrupts the correlation between oil prices and stock markets, while terrorist attacks have influenced the relationship between oil price returns in France and Germany. The diminished correlation between stock markets and oil suggests significant diversification advantages for investors [20].

Multiple researchers [21–24] have utilized methodologies like correlation-based networks, network structure analysis, and VAR-BEKK frameworks to explore market integration and shifts in market dependence. Initially observing no correlation between oil and stock markets, Ghosh & Kanjilal [25] noted integration between these markets post the global financial crisis. Additionally, Ftiti et al. [26] found that global oil price shocks impact stock markets

Here, past studies have examined the linkage and portfolio diversification among stock markets and other investment alternatives. The domain of socially responsible investment and cryptocurrencies is yet to be explored in detail. Hence, the present study explores the linkages between socially responsible investment and Green, Dirty, Energy cryptocurrencies.

EMPIRICAL FRAMEWORK

The aims of the study are 1) to examine the connectedness between the Socially responsible investment markets and various green, dirty, and energy cryptocurrencies, and 2) to examine the possible portfolio diversification benefits for the Socially responsible investment markets from various green, dirty, and energy cryptocurrencies. For which the study uses Descriptive Statistics and Correction Analysis methods. Market integration is assessed through correlation analysis, while asset interconnection is investigated using network analysis. The study then evaluates portfolio diversification benefits by constructing three distinct portfolios: 1) Equally weighted, 2) Minimum variance, and 3) Maximum Sharpe portfolios, comprising selected assets from March 5, 2018, to October 13, 2023. To ensure the reliability of the findings, the analysis employs daily returns. The study utilizes the following indices for returns

A) Socially Responsible Investment (S&P Kensho Clean Power Index, S&P Global Water Index, S&P Global Clean Energy Index, and S&P Green Bond Index)

B) Green cryptocurrencies (Cardano, Stellar, XRP)

C) Dirty cryptocurrencies (Bitcoin, Ethereum, Ethereum Classic)

D) Energy Cryptos (Powerledger, Energo)

The data for all the indices is collected from the investing.com database and USD is kept as the standard currency for all purposes. As every market experiences public holidays, resulting in missing observations, this absence of data can have adverse effects on the outcomes and implications. Jeon and Von Furstenberg [27] proposed in a study that utilizing data from the previous day could address this issue. Therefore, in line with this recommendation, missing values in the current study are replaced with the previous day's price. To explore the possible advantages of diversifying portfolios, the study employs the Equally Weighted Portfolio, Minimum Variance Portfolio, and Maximum Sharpe Portfolio. In the Equally Weighted Portfolio, the investment amount is divided equally among all the stock markets. The equally weighted portfolio expected return ΣR is calculated using the following formula:

$$\Sigma R = R1W1 + R2W2 \ldots\ldots\ldots RnWn, \qquad (1)$$

where W — weight on investment; R — return of index; n — number of markets.

Those securities that aren't correlated with each other hold the minimum variance portfolio. A minimum variance portfolio is a well-diversified portfolio of risky securities, which are traded in such a way that can result in the lowest possible risk for an expected level of return.

The Maximum Sharpe Portfolio is chosen based on the following formula:

$$\max SR = \frac{wE(r) - R_f}{\sqrt{wVw}}, \qquad (2)$$

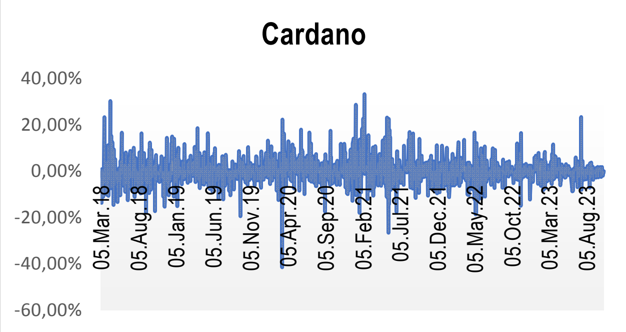
where w — portfolio weights; $E(r)$ — expected return on each stock market; R_f — the risk-free rate.

Based on the formula, the data is examined and the results of various tests are reported in the empirical findings section.

DATA ANALYSIS

Return on Selected Investments

Figure shows the Return trend for the selected socially responsible investment indexes and the green, dirty, energy cryptocurrencies. All the selected investment shows a fluctuating trend during the COVID-19 period. The returns of all the securities show varied returns and high ups-down during the breakout of the COVID-19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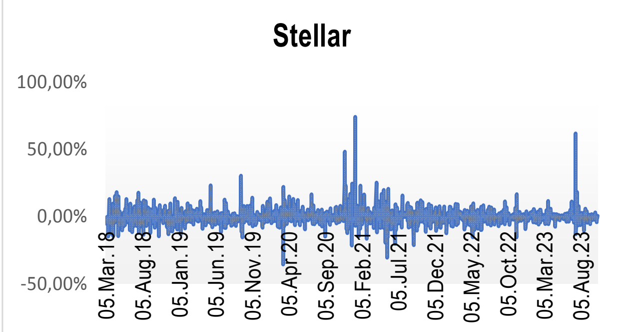
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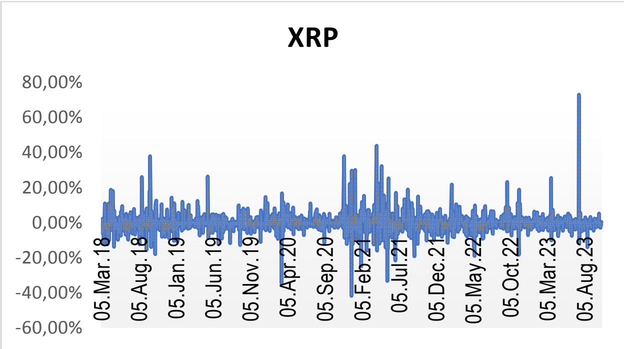
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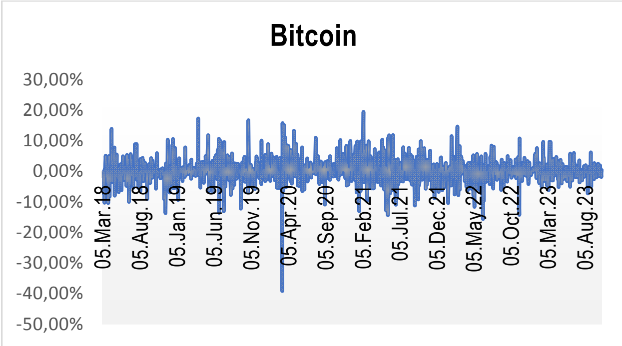
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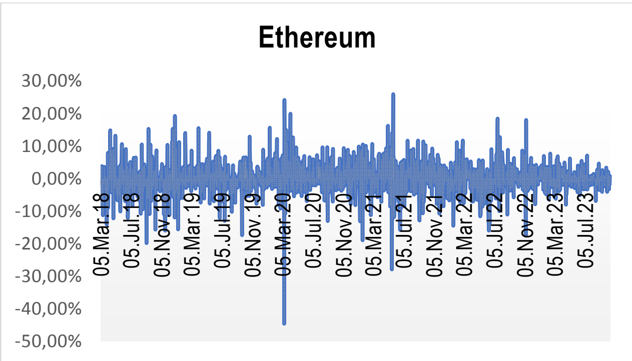
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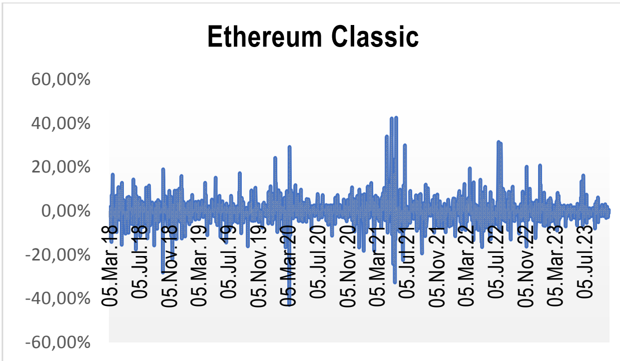
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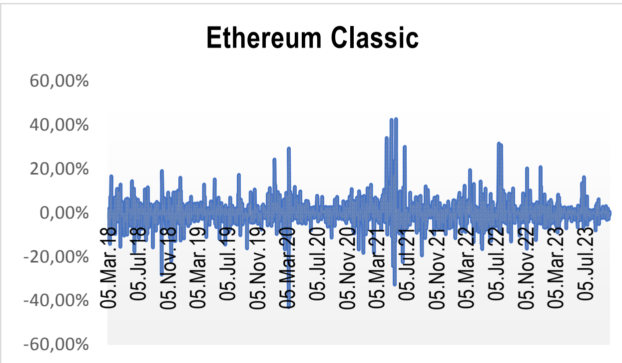
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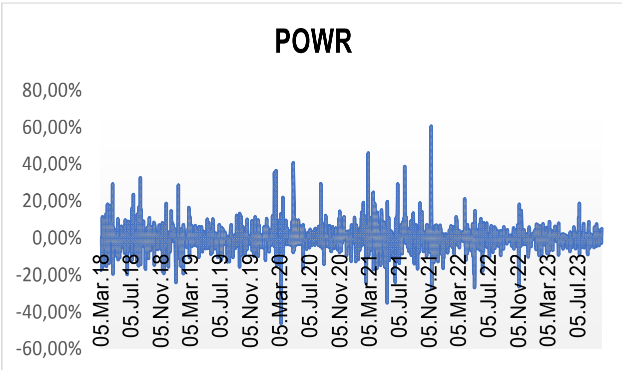
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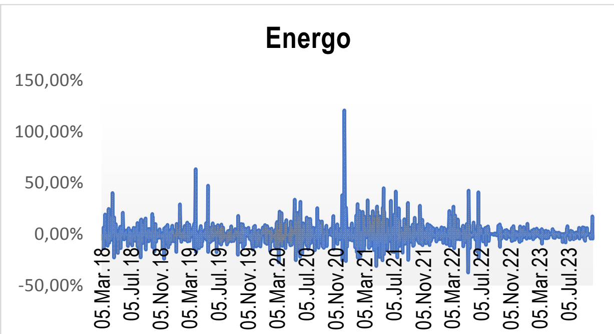
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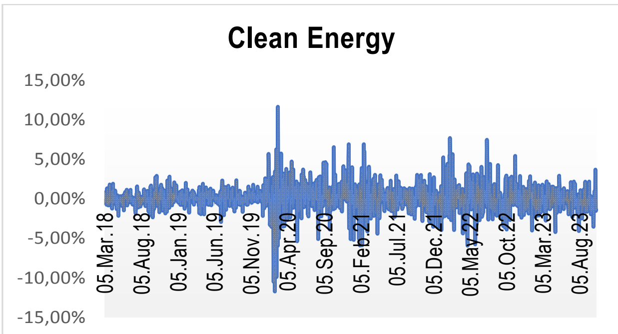
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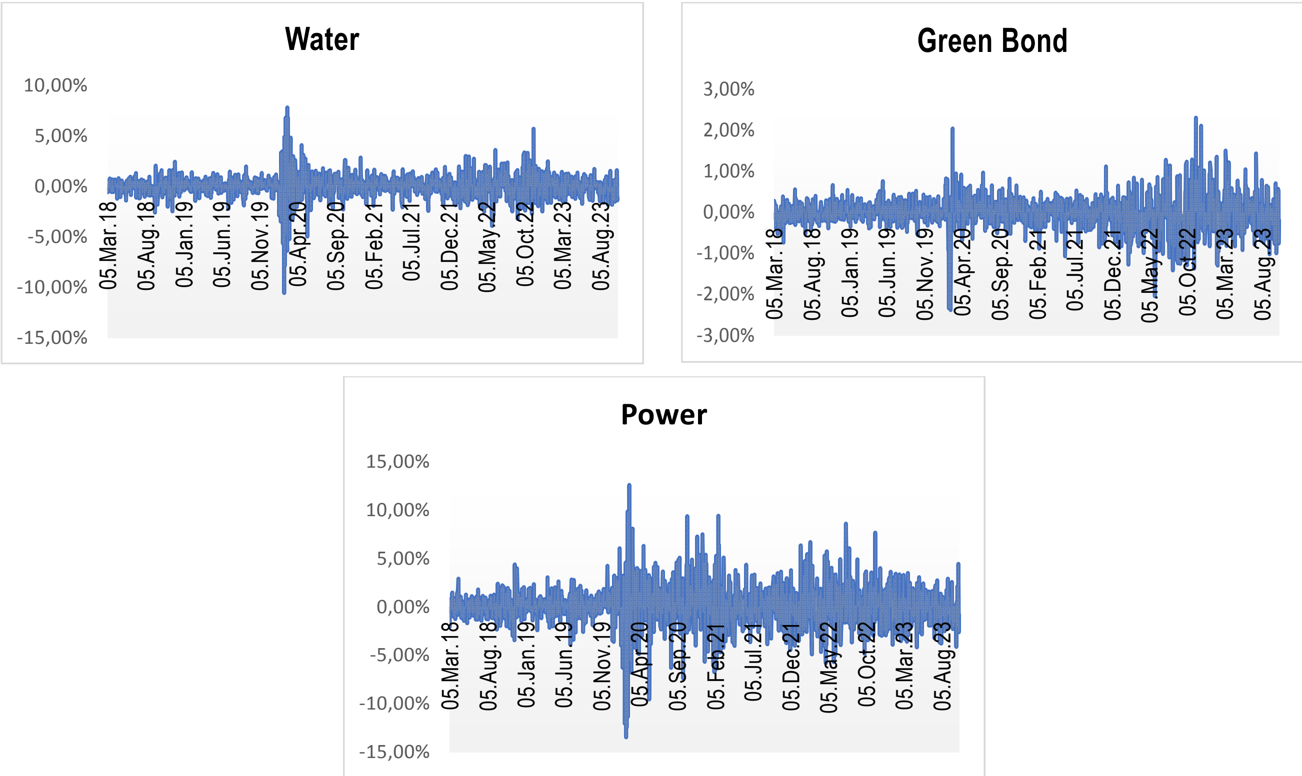

Fig. **Return Trends**

Source: Author's Calculation based on the closing price data downloaded from investing.com.

period. This reveals that the COVID-19 breakout has affected all the investment indexes negatively with the increase in the risk level.

MARKET INTEGRATION ANALYSIS

Here, in *Table 1,* except for Green Bond and Energo, all the markets show positive returns during the entire period. The markets' average daily returns were 0.0002%, 0.0005%, 0.0016%, 0.0010%, 0.0008%, 0.0012%, 0.0008%, 0.0004%, 0.0005%, and 0.0009% respectively for Cardano, Stellar, XRP, Bitcoin, Ethereum, Ethereum Classic, Power, Water, Clean Energy, and POWR. Among all the investments, Energo has the highest standard deviation whereas Green Bond has the lowest standard deviation. The present results do not support the theory of finance which says the higher the risk, the higher the return. The difference between minimum and maximum is also significant indicating the return on the investment is highly fluctuating. The skewness and kurtosis reveal that the data are fit to perform further tests.

Table 2 shows the correlation between Socially responsible investment and green, dirty, energy cryptocurrencies. It is observed that Clean Power, Global Water, Global Clean Energy, and Green Bond have a low positive correlation with Cardano, Stellar, XRP, Bitcoin, Ethereum, Ethereum Classic, POWR, and Energo. The lack of significant correlation among the selected securities indicates weak integration. Due to weak integration, these securities offer portfolio diversification opportunities to investors. The opportunities to diversify this investment are examined using three different diversification strategies: 1) Equally weighted portfolio, 2) Minimum variance portfolio, and 3) Maximum Sharpe portfolio.

PORTFOLIO DIVERSIFICATION ANALYSIS

Table 3 presents the diversification advantages for socially responsible investors derived from green, dirty, and energy-related cryptocurrencies. Each investment portfolio is created using daily return data (converted to annual returns) spanning from March 5, 2018, to October 13, 2023. Utilizing the correlation findings, potential diversification opportunities for investors are identified. Subsequently, portfolios are constructed for both non-diversified (home market) and diversified approaches (such as Equal Weighted Portfolio

Table 1

Descriptive Statistics

Investment Asset	Mean	Standard Deviation	Kurtosis	Skewness	Minimum	Maximum	Count
Cardano	0.0002	0.0590	4.6701	0.3528	−0.4149	0.3323	1389
Stellar	0.0005	0.0625	25.4083	2.3783	−0.3562	0.7395	1389
XRP	0.0016	0.0626	21.3393	1.7862	−0.4178	0.7301	1389
Bitcoin	0.0010	0.0393	9.3453	−0.4601	−0.3918	0.1941	1389
Ethereum	0.0008	0.0504	6.9729	−0.4177	−0.4455	0.2596	1389
Ethereum Classic	0.0012	0.0623	9.6063	0.8120	−0.4296	0.4264	1389
POWR	0.0009	0.0720	9.3877	0.8059	−0.4603	0.6037	1389
Energo	−0.0008	0.0909	27.0082	2.5530	−0.3747	1.2074	1389
Clean Energy	0.0005	0.0176	6.4432	−0.1744	−0.1175	0.1166	1389
Water	0.0004	0.0116	11.7861	−0.4886	−0.1054	0.0781	1389
Green Bond	−0.0001	0.0041	4.6563	−0.1501	−0.0238	0.0229	1389
Power	0.0008	0.0220	4.8613	−0.1623	−0.1348	0.1260	1389

Source: Author's calculation.

Table 2

Correlation

Investment Asset	Cardano	Stellar	XRP	Bitcoin	Ethereum	Ethereum Classic	POWR	Energo	Clean Energy	Water	Green Bond	Power
Cardano	1.000											
Stellar	0.764	1.000										
XRP	0.674	0.762	1.000									
Bitcoin	0.717	0.640	0.617	1.000								
Ethereum	0.785	0.690	0.683	0.847	1.000							
Ethereum Classic	0.680	0.615	0.589	0.665	0.742	1.000						
POWR	0.543	0.484	0.458	0.539	0.560	0.486	1.000					
Energo	0.259	0.207	0.244	0.210	0.244	0.248	0.243	1.000				
Clean Energy	−0.028	−0.003	0.012	0.053	0.022	0.042	−0.008	0.018	1.000			
Water	−0.028	−0.005	−0.002	0.010	−0.009	0.016	0.008	0.030	0.671	1.000		
Green Bond	−0.023	−0.017	−0.024	−0.012	−0.018	0.002	−0.002	0.009	0.287	0.393	1.000	
Power	−0.011	0.003	−0.001	0.061	0.029	0.029	−0.010	0.005	0.898	0.660	0.187	1.000

Source: Author's calculation.

(EWP), Minimum Variance Portfolio (MVP), and Maximum Sharpe Portfolio (MSP). This analysis aims to assess the presence of diversification benefits.

It is observed that Clean Power, Global Water, and Global Clean Energy do not benefit the portfolio diversification as per the equally weighted portfolio. Green Bond, on the contrary,

Table 3

Portfolio Diversification with Different Strategies

Security	Investment in respective security only				Equally Weighted Portfolio			
	Return (%)	SD (%)	Sharpe Ratio	Asset Allocation (%)	Return (%)	SD (%)	Sharpe Ratio	Asset Allocation (%)
Clean Power	28.60	8.03	3.56	Clean Power – 100	25.11	15.21	1.65	11.11% in each security – Clean Power, Cardano, Stellar, XRP, Bitcoin, Ethereum, Ethereum Classic, POWR and Energo
Global Water	13.10	4.23	3.10	Global Water – 100	23.40	15.18	1.54	11.11% in each security – Global Water, Cardano, Stellar, XRP, Bitcoin, Ethereum, Ethereum Classic, POWR and Energo
Global Clean Energy	17.96	6.41	2.80	Global Clean Energy – 100	23.93	15.20	1.57	11.11% in each security – Global Clean Energy, Cardano, Stellar, XRP, Bitcoin, Ethereum, Ethereum Classic, POWR and Energo
Green Bond	–3.58	1.48	–2.42	Green Bond – 100	21.54	15.17	1.42	11.11% in each security – Green Bond, Cardano, Stellar, XRP, Bitcoin, Ethereum, Ethereum Classic, POWR and Energo
Security	**Minimum Variance Portfolio**				**Maximum Sharpe Portfolio**			
	Return (%)	SD (%)	Sharpe Ratio	Asset Allocation (%)	Return (%)	SD (%)	Sharpe Ratio	Asset Allocation (%)
Clean Power	29.34	7.12	4.12	76.68% in Clean Power, 18.92% in Bitcoin, 2.44% in Energo, 1.11% in XRP, 0.83% in POWR, 0.02% in Stellar, 0% Cardano, Ethereum & Ethereum Classic	33.70	7.46	4.52	71.56% in Clean Power, 16.43% in Bitcoin, 12.01% in XRP, 0% in Cardano, Stellar, Ethereum, Ethereum Classic, POWR & Energo
Global Water	14.60	4.06	3.59	92.08% in Global Water, 6.86% in Bitcoin, 0.64% in Cardano, 0.42% in Energo, 0% in Stellar, XRP, Ethereum, Ethereum Classic and POWR	19.57	4.63	4.23	79.80% in Global Water, 13.08% in Bitcoin, 7.12% in XRP, 0% in Cardano, Stellar, Ethereum, Ethereum Classic, POWR & Energo
Global Clean Energy	19.67	5.93	3.31	84.25% in Global Clean Energy 12.20% in Bitcoin, 1.45% in Cardano, 1.43% in Energo, 0.53% in POWR, 0.14% in Stellar, 0% in XRP, Ethereum, Ethereum Classic	26.15	6.61	3.95	70.45% in Global Clean Energy, 18.34% in Bitcoin, 11.22% in XRP, 0% in Cardano, Stellar, Ethereum, Ethereum Classic, POWR & Energo
Green Bond	–3.06	1.47	–2.08	98.83% in Green Bond, 1.03% in Bitcoin, 0.13% in XRP, 0% in Cardano, Stellar, Ethereum, Ethereum Classic, POWR, Energo	44.87	15.51	2.89	66.17% in Bitcoin, 33.83% in XRP, and 0% in Green Bond, Cardano, Stellar, Ethereum, Ethereum Classic, POWR, and Energo

Source: Author's calculation.

benefited and gained significantly on the Sharpe ratio. The Minimum variance portfolio (MVP) helps to reduce the portfolio risk for Clean Power, Global Water, and Global Clean Energy. Clean Power can have a standard deviation of 7.12% with an asset allocation of 76.68% in Clean Power, 18.92% in Bitcoin, 2.44% in Energo, and 1.11% in XRP. Global Water can have the lowest risk of 4.06 with MVP with the asset allocation of 92.08% in Global Water, 0.42% in

Table 4

Gains from Portfolio Diversifications

Market	Equally Weighted Portfolio		Minimum Variance Portfolio		Maximum Sharpe Portfolio	
	Δ SR	Δ SR%	Δ SR	Δ SR%	Δ SR	Δ SR%
Clean Power	−1.91	−54	0.96	27	0.56	16
Global Water	−1.56	−50	1.13	36	0.49	16
Global Clean Energy	−1.10	−39	1.15	41	0.51	18
Green Bond	3.84	159	5.31	219	0.34	−14

Source: Author's calculation.
Note: The Δ in Sharpe Ratio (SR) and the Δ% in Sharpe ratio (SR) indicate changes relative to the home portfolio.

Energo, 6.86% in Bitcoin, and 0.64% in Cardano. As per MVP, Global Clean Energy has the lowest standard deviation of 5.93% with asset allocation of 84.25% in Global Clean Energy, 12.20% in Bitcoin, 1.43% in Energo, 0.301.45% in Cardano 0.53% in POER. Green bonds can have the lowest risk with MVP but it generated a negative Sharpe ratio due to negative return.

The Maximum Sharpe Portfolio (MSP) strategy gives the maximum Sharpe for the investment. The Clean Power can have a Maximum Sharpe of 4.52 with the asset allocation of 71.56% in Clean Power, 16.43% in Bitcoin, and 12.01% in XRP. Global Water can make the asset allocation of 79.80% in Global Water, 13.08% in Bitcoin, and 7.12% in XRP to have the Maximum Sharpe ratio of 4.23. Global Clean Energy can have a Maximum Sharpe of 3.95 with an asset allocation of 70.45% in Global Clean Energy, 18.34% in Bitcoin, and 11.22% in XRP. The green bond can have a Sharpe ratio of 2.89 with an asset allocation of 66.17% in Bitcoin and 33.83% in XRP. *Table 4* illustrates the advantages of portfolio diversification for investors. It compares the Sharpe ratios of the equally weighted portfolio, minimum variance portfolio, and maximum Sharpe portfolio with those of the home market to evaluate the degree of gains. Importantly, investors in Green Bonds and other Socially Responsible Investments (SRI) do not find benefits from the Equally Weighted Portfolio. Similarly, Global Water investors do not see gains from the minimum variance portfolio. Conversely, Clean Power, Global Water, Global Clean Energy, and Green Bond investors can potentially achieve gains of 16%, 16%, 18%, and −14%, respectively, by adopting the maximum Sharpe ratio strategy. Among all the strategies, the maximum Sharpe ratio strategy proves to be the most advantageous for investors.

CONCLUSION

The current study aims to attain two objectives: (1) to assess the interconnectivity among Socially Responsible Investment markets and various cryptocurrencies categorized as green, dirty, and energy-related; and secondly, to evaluate the potential portfolio diversification benefits for SRI markets derived from these cryptocurrencies. Correlation analysis indicates an insignificant integration among the markets, suggesting a diversification possibility for investors. Investors in Clean Power, Global Water, and Global Clean Energy stand to benefit from the minimum variance portfolio, offering the lowest risk. However, green bond investors may not reap advantages from the MVP strategy. Conversely, all SRI investors can potentially benefit from the maximum Sharpe portfolio, leading to significant gains in the Sharpe ratio, reduced investment risk, and increased portfolio returns. Green, dirty, and energy cryptocurrencies present a promising avenue for Socially Responsible investors seeking diversification.

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H.P. Singh — contributed to the conceptualisation of the study and the development of the introduction and background sections of the manuscript.
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M. Patel — carried out the interpretation of results, data collection, and the literature review to support the research.

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