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RESEARCH PAPER

Green Beta: Comparison of Green and Non-Green Stocks Based on Downside Risk

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ABSTRACT

The study offers an innovative technique for diversifying the downside risk by selecting green stocks for investments. Investors fancy green stocks due to their ability of generating sustainable returns. Pursuing such arguments, this study provides a comparative analysis of green and non-green stocks to measure whether green stocks help investors secure their investments during the downward movement of the market, by applying multivariate regression after collecting the data for stocks listed at AIM over the period of 2012 to 2020. The findings of the study prove that green stocks reduce the downside risk as compared to non-green stocks and compensate investors by providing them sustainable returns for holding the stocks with negative returns. However, non-green stocks also have a strong association with downside risk but have less effect on downside risk than green stocks. The study has strong implications for investors who are searching for new exotic asset classes to reduce the risk and improve the returns, particularly during downward recessions of the market.

KEYWORDS Alternative Investment Market, Green Stocks, Non-Green Stocks

Introduction

Capital markets are considered an important part of the financial system and contribute largely to economic development. Portfolio managers predict variations in stock returns in investment markets. Various researchers have studied the different risk metrics to describe security returns. For example (Sharpe, 1963) and (Lintner, 1965) are included in the makers of capital asset pricing theory. This theory explains the relationship among the market risk, quantified as beta to the return anticipation. In 1964, Sharp presented CAPM to quantify the market risk of a stock by employing the beta coefficient as an important risk metric. CAPM measured the direct relationship between systematic risk (beta) and stock returns by assuming that beta is the only variable that can explain asset pricing. There are numerous studies (i.e. Asthana, 2024) that have confirmed the failure of beta to explain security returns navigating the researchers' interest to introduce downside risk.

Initially, the downside risk was debated by (Roy, 1952). According to him investors care more for losses and try to protect themselves from unexpected events. According to his safety-first rule, a portfolio can be created depending on the lower partial moments of portfolio returns, known as the minimum acceptable returns. In this way, an investor lessens the risk of not gaining his investment goals. On the other hand, Markowitz's MV (mean-variance) model and Roy's safety rule both assume the normality of distribution which was denied by many researchers like (Fama, & French. 2004) and (Dobrynskaya, 2024) Therefore, deviations from normality enforced the implementation of any other model as compared to the MV model to assess the estimated utility for an investor (Ergun, 2023).

Hogan and Warren, (1974) presented the concept of the first downside CAPM to judge whether the investors care for downside risks or not. They measured the first downside CAPM by using semi-variance and co-semi variance to handle the asymmetric treatment of risks as well as used mean lower partial moment for measuring downside beta. On the other hand, alarming environmental hazards due to companies' high emission of harmful gases led the literature streams of Finance to introduce the concept of "Green Finance" and green investment. At the start of the 2000s, green investment captured the attention of investors at the global level due to its competency in generating sustainable returns. Green companies that generate their income from renewable sources became fancy investments to investors. Therefore, the issues of Suzlon Energy in India were oversubscribed approximately 25 times, when it issued IPOs in 2005 (Ben Ameur et al., 2024). Traditionally, investors seek a high rate of return by assuming the level of risk linked with their investment.

Currently, environmental concerns are prioritized by investors while making investment decisions. Previous empirical results highlighted that environmentally responsible companies generate positive risk-adjusted returns representing that such investment is good for managing the risk-adjusted wealth of investors. Past literature demonstrated how stock returns are linked with environmental rankings. According to (Arfaoui et al., 2024), companies having poor EC (Environmental Conscientiousness) scores show less than average performance. They reported high positive returns for environmentally friendly companies and negative returns for weak environmentally responsible firms.

This study contributes to the "Finance discourse" by comparing the performance of green and non-green stocks with the underlying objective of determining whether the greenness of stocks plays any role in hedge funds, especially during market slumps or not. The study addresses the gap identified in prior literature by designing a green downside beta to prove how green stocks can compensate investors against losses while investing during market downturns.

Literature Review

Downside risk: Theoretical Framework:

Financial economics has long been identified as the involvement of downside risk in stock appraising. In the early 50s, financial economics started to debate about the concept of downside risk. Especially after the idea of safety-first investors who are more concerned with lessening the possibility of negative returns. Then, (Markowitz 1959) clarified that by computing the mean and variance of the expected return an investor may easily calculate the risk and return of an investment. He also explained that variance measures the deviation of the total risk assumed by an investor both above and below the mean. On the other hand, the utility function proposed by (Kahneman, T. 1979) based on prospect theory and later (Libby, R., & Fishburn, P. C. (1977). Behavioral models of risk taking in business decisions: A survey and evaluation. Journal of accounting research, no date)suggested that the variations that are below the mean affect the investors more as compared to the deviations which are above the mean thus presenting an attitude of downside risk aversion. Such utility functions depend on the perception that investors feel losses more deeply than gains. As a result, investors are not risk averse, but they are loss averse. At the start, Markowitz preferred downside risk (semi-variance) to measure investor risk over variance. Later, he preferred variance over downside risk due to the non-availability of proper statistical tools. However, he has realized the significance of downside risk (Zargar et al., 2024).

At the start, CAPM was considered the best model to address risk-return trade-off. CAPM measured the direct relationship between systematic risk (beta) and stock returns by assuming that beta is the only variable that can explain asset pricing. However, later on,

multiple studies confirmed the failure of beta to explain security returns. For example, (Edvall, 2020) observed an insignificant relationship between US stock returns and beta by confirming that beta has weak explanatory power to describe the variations in stock returns. After judging weak empirical support for beta, numerous researchers highlighted the significance of integrating market situations to evaluate beta (Abakah et al., 2024). The academicians took the initiative to focus on explaining time-varying CAPM in which beta is divided into up and down-market betas. Ikadarma, Yandi & Bertuah, (2019) implemented a similar approach and reported that beta can explain stock returns during a bull market, but no such evidence has been found for bear markets. s

First downside CAPM is introduced by using semi-variance and co-semi variance to handle the asymmetric treatment of risks for judging whether the investors care for downside risk or not. The introduction of DCAPM and DR-APT (Glabadanidis, 2014) for overcoming the limitations of CAPM and APT set a debate among the researchers for employing other robust risk metrics to describe the asymmetric distribution of returns. The DCAPM outperforms the standard CAPM and has higher explanatory power as theoretically and contextually as it can measure risk accurately. DCAPM and DR-APT integrate new tactics for computing risk i.e. semi-variance, semi-covariance, and semi-deviations as compared to variance and standard deviation. The introduction of such novel risk measurements strengthens both the empirical and theoretical applications of the model while handling the limitations of the standard factors' frameworks (Naeem et al., 2021).

Relationship between downside risk and non-green stocks

Recently, the association between downside risk and stock returns has been widely debated in literature streams of Finance. Haase and Neuenkirch, (2023) examined how security returns and downside risk are co-related with each other and observed a positive association between security returns and downside risk by focusing on daily equity and market returns. They designed portfolios for measuring volatility and risk and reported that market slumps lead to the generation of highly volatile returns. (Maki, 2024) compared the upside and downside risk by designing an Arrow-Debreu security by focusing on the S&P 500 index of a bearish market. The study concluded that stocks that are highly exposed to bearish market risk earn fewer future returns. He computed the upside and down-tail dependency risk of each stock in the market. The results suggested that stocks having low-tail dependency risk generate high future returns.

Asthana, (2024) explored the association between downside risk and estimated security returns by employing value-at-risk and reported a negative association between value-at-risk and future expected returns. Atilgan et al., (2019) compared the upside and downside beta after measuring the co-skewness in the security market of Australia and concluded that returns of stocks' return, and downside risk are strongly correlated with each other, but downside and upside risk are not linked with each other. Other studies (i.e. Comeig, Holt and Jaramillo-Gutiérrez, 2022) identified that stocks of financial institutions listed in the security market demonstrate a positive and strong risk-return association. They scored downside beta as a better measure to explain the expected returns and risk premiums.

Another study by (Ergun, 2023), evaluated the significance of a negative beta ratio after observing the average security returns and portfolio performance. He performed a study to evaluate the downside risk based on the efficiency of investment portfolios after focusing on the dynamics of the Kuala Lumpur stock market. The results reported that the downside risk metric is a highly effective measure of risk as compared to the conventional mean-variance method. (Dobrynskaya, 2024) measured the performance of the Asian stock market after evaluating the association between the downside risk and average stock returns. They split the whole sample into two sub-groups for addressing the analysis in the downward and upward market situations and found that the value of downside risk is

significantly high during the downward movements of the market. A study by (Deng and Wu, 2023) identified that investors care for losses more than gains in the light of prospect theory after evaluating how representativeness heuristics and conservatism influence investors' reaction towards the downside risk. The study concluded that investors' high concern for losses leads the investment towards abnormal returns due to mis-reaction of prior downside risk, affecting stocks' pricing. ((Naeem et al., 2023) proposed an innovative metric of downside risk, called ES-employed beta which improves the prediction of stocks' returns. This new technique addresses the loopholes of current downside risk metrics and determines a strong association with security returns. According to (Delle Monache, De Polis and Petrella, 2024), the security returns of the UK demonstrate that downside risk has a strong association with contemporary returns but negatively influences future returns. This association is particularly addressed during financial crises, indicating the time robustness of downside risk in the UK market. Other multiple studies (i.e.Nugraha, Lantang and Yudhanegara, 2024) showed that stocks that are highly responsive to market deteriorations demand a premium for holding such stocks. This premium is not complete compensation for robust market beta but demonstrates additional risk linked with the downside fluctuations.

All the above studies recommend that downside risk plays an important role in predicting diverse distributions of stocks' returns affected by investor perceptions, novel risk metrics, and market scenarios. This association determines the significance of using downside risk in evaluating the accurate risk and returns distributions.

H1:Non-green stocks have high downside risk than green stocks.

Green investment: Theoretical framework

Climate change due to carbon emissions has captured large attention at the international level. In 2015, the Paris Agreement within the United Nations Framework Conventions for Climate Change (UNFCCC) developed a common consensus to address this issue. All member countries agreed to invest a significant amount and work cooperatively to handle the serious issue of greenhouse gas emissions (GHG) (Xidonas and Essner, 2024). According to "International Energy Agency" IEA (2014), almost $53 trillion is required to maintain the 2°C temperature threshold of the Paris Agreement by 2035. In 2010, 194 countries established a GCF (Green Climate Fund) to aid developing countries in controlling GHC emissions and adapting to climate change. Since then, the concept of green finance has been frequently discussed at international forums (IFC, 2017).

To control the discharge of harmful gases and save ecological sustainability, companies are focusing highly on greening their products. Like all other business domains, financial management is also paying attention to greening their investment and generating sustainable returns.

In this field, green finance is a novel financial technique that integrates ecological security and the growth of profit. Green stocks generate a high proportion of green income (Akhtaruzzaman et al., 2023). The concept of green stocks is enlightened by prior studies based on companies' social or environmental concerns which can be explained in the light of stakeholder theory by (Freeman, 2002). Companies are highly responsive towards the demands of primary and secondary stakeholders while making investment and other strategic decisions. A company's strategic pursuits and decision-making depend on the stakeholders' expectations. Currently, stakeholders' expectations depend highly on emerging global issues i.e. climate shifts, natural disasters, escalating sea levels, and high discharge of greenhouse gasses. Stakeholders like the government, customers, workers, and investors demand strict adaptation of green laws, green products, and green portfolios. Green companies can improve the investors' allegiance by offering them green stocks as a

hedging tool for diversifying risk and reducing financial costs (Abate, Basile and Ferrari, 2024).

Relationship between downside risk and green stocks:

Green finance is a comparatively new field of finance. It is a subset of socially responsible investing (SRI). SRI measures an investment approach that determines investors' preferences to invest in those portfolios that are socially and environmentally responsible. SRI investment has gained popularity since 1990 among investors (Giannikos et al., 2024). In the USA alone, it crossed $2.71 trillion out of total investment of net worth of $25.1 trillion. SRI stocks have had better performance previously by generating sustainable returns than traditional stocks as SRI stocks combine environmental and social concerns (Basher and Sadorsky, 2024). Moreover, considering different financial scandals, investors search to invest in more secure stocks, so they prefer green or environmentally sustainable stocks, especially after the alarming environmental concerns at the global level. Green stocks have less risk, and they can save investors from corporate greed (Borg et al., 2022).

Green investment is now an important part of socially responsible investment focusing on companies or projects devoted towards the saving of natural resources. The basic goal of green investment is to maximize environmental safety while generating positive returns. Investors have now realized that being environmentally aware can also be financially advantageous (Zhou, Zhang & Polochova, 2021). Numerous studies have been performed so far to measure the true performance of green stocks and their role in handling risk-return trade-offs. For example, (Manurung et al., 2024) observed the performance of green stocks in Indonesia after assessing the performance of green funds by computing their returns. They reported that green funds generated lesser risk adjusted returns as compared to market benchmark and non-green funds.

Investors' appetite for sustainable stocks has grown quickly. According to (Lei, Chen and Zhang, 2024) investors have realized that eco-friendly commitments are now treated as new investment choices that demand high attention. Many investors particularly those in the carbon-intensive sectors have now become very sensitive to handling environmental-relevant skills i.e. carbon control and sequestration. More significantly, most investors now focus on incorporating environmental-based risk evaluation before investing (Cui et al., 2024).

Liu, Liu and Chen, (2024) analyzed the risk-return relationship of companies after categorizing them based on environmental and social ratings. They documented that the companies having high ES ratings provide sustainable returns as compared to those that have lower ES scores. The study proved that emerging stock markets are more vulnerable to downward fluctuations than developed markets and sustainable financial growth contributes strongly to managing risk. Other studies like (Pham et al., 2023) and (Ma et al., 2024) proved that companies with strong environmental commitments compensate investors with green investments while holding stocks with less risk. They reported a negative relationship between corporate environmental commitments and risk by claiming high risk and return trade-offs.

H2: Green stocks have lower downside risk than non-green stocks.

Material and Methods

Sample Size

The study's population involves all companies that are listed on AIM (Alternative investment market). AIM is a famous secondary market of the UK which provides an

attractive platform for companies to list themselves with meager regulations. The market has now created a unique worldwide image by distinguishing itself as a green market. The revenue generation capacity of companies listed at AIM has exceeded 50% by making huge investments in eco-friendly products and services. Green economy marks accredited AIM as a major contributor in driving the growth of green economy. The UK is now renowned as the world's best sustainable finance ecosystem. So, the companies of AIM are selected for computing the greenness level where approximately every second firm is offering green stocks due to their eco-friendly products and services.

Sampling Technique

The sample size selected for this study involves 118 firms which are selected out of the 1186 firms listed from 2012 to 2020. Depending on the population scale over the timeframe of 2012 to 2020, 118 firms are selected by using the stratified proportionate sampling technique. By using this technique, a 10% sample from the 1186 companies has been selected by picking every 10th number. 118 firms as 10% *1186=118 are selected based on the data availability about the gasses' release. These companies are selected after excluding service, financial, and IT-based firms because of their lowest involvement in discharging GHGs. All 118 firms are locally listed in the UK.

Variables' Description

Downside risk

Ratio of co-variance to variance is used to measure downside risk. The formula has been used by Bawa and Lindenberg (1977) and ACX (2006).

$$\text{Betadown}^{i}_{t} = \frac{\text{cov}_{t-250,t-1}\left(r^{i},\ r^{m} \middle| r^{m} < \mu^{m}\right)}{\text{Var}_{t-250,t-1}\left(r^{m} \middle| r^{m} < \mu^{m}\right)}$$

Whereas $r^{i}$and r^{m} signifies the stock i's and the market's excess return and μm is the average market excess returns over the past 250 trading days. The risk-free rate is used to compute excess returns i.e. T-bills rate. The results will be annualized by multiplying them by 365.

Green and Non-Green Stocks

The greenness index is designed to compute a company's greenness level. Formula for measuring the greenness index is given below, same formula is used by (Mumtaz, & Yoshino, 2021).

Greenness Index= -[-{proportion of a emission of a sector * weight of CO_2 in overall emission}

= - {proportion of emission of a sector*weight of CH_4in overall emission}

= - {proportion of emission of a sector*weight of N_2O in overall emission}]

CO_2, CH_4, and N_2O determine the discharge volume of carbon dioxide, methane, and nitrogen oxide. A firm with high emissions of CO_2, CH_4 and N_2O is categorized as a polluting firm and identified as a non-greenness level. The negative sign indicates the low weight of CO_2, CH_4 and N_2O released by a sector. The high value of the Greenness index (x) indicates a low degree of greenness while the low value represents a high degree of greenness. The index value recommends the firms' involvement in polluting

the environments. The sample is divided into green and non-green stocks by using the Greenness index.

Results and Discussion

Descriptive Statistics

Table 1
Descriptive Statistics

Category	N	Carbon emission	Mean	Standard Deviations	Minimum	Maximum
Green stocks	60	= < 1146.788	-0.925	.282	-1.762	0.602
Non-Green Stocks	58	> 62811.335	-1.157	0.943	-1.633	1.519
Downside risk			-0.018	1.091	-1.515	6.972
Total sample	118					

Above table indicates that average return value for green stocks is -0.925 and average non-green return value is -1.157. The standard deviation value for green stocks is .282 and for non-green stocks it has dispersion around 0.943. Average downside risk is -0.018 and its standard deviation is 1.091.

Correlation Analysis

Coefficient values provided in the table of correlation analysis are used to report the problem of multicollinearity between variables. Results in Table 2 indicates that data has no multicollenearity problems due to less coefficient values between explanatory factors.

Table 2
Correlation matrix

	Green stocks	Non-green stocks	Downside risk
Green stocks	1		
Non-green stocks	0.60	1	
Downside risk	-0.07*	0.06*	1

Based on overall sample, the coefficient values in the above table represents that Green stocks are negatively associated with the downside risk having the coefficient values (-0.07). The negative association between green stocks and downside risk represents that greenness of stocks reduces downside risk. Non-green stocks are positively correlated with the downside risk with the coefficient value (0.06).

Multivariate Analysis

For investigating the effect of the greenness on downside risk, the stocks are divided into two groups i.e. green and non-green stocks. Table 3 displays the results for the comparison of green and non-green stocks based on downside risk.

Table 3
Comparison of Green and Non-green stocks based on downside risk

Predictors	Downside risk Coefficient	T-statistics
Green stocks	-0.052	1.97**
Non-green stocks	0.043	2.01**
R^2	0.22	
N	118	

The above table indicates that green stocks have a significant but negative impact on downside risk having the (β =-0.052, $p < 0.05$). The negative value indicates that the greenness of stocks reduces downside risk, leading towards the acceptance of H2. The coefficient value (β =0.043, $p < 0.05$) against non-green stocks indicates that non-green

stocks have a positive and significant effect on downside risk. The positive value represents that non-green stocks do not participate highly in reducing downside risk, leading towards the acceptance of H1. The coefficient results and significant values lead to the approval of the following assumptions.

H1: Non-green stocks have high downside risk than green stocks

H2: Green stocks have a lower downside risk than non-green stocks.

The comparative analysis of green and non-green stocks indicates that green stocks act as a premium for investors, especially when they hold stocks with high negative returns. Environmental commitments of companies' fancy investors and they select green stocks to compensate themselves against losses that may happen due to the downward deviations of the market.

Graphical comparison of green and non-green stocks

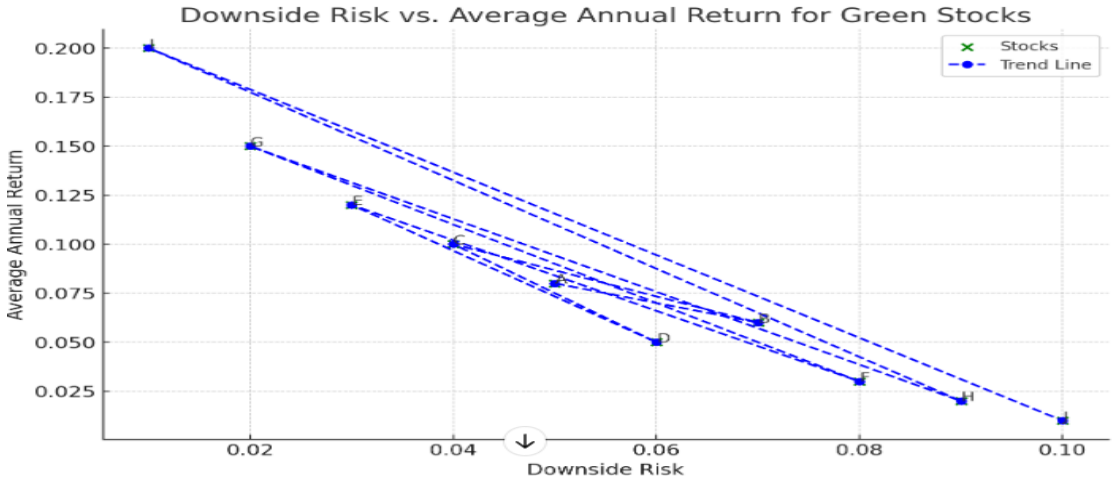

Fig 1: Downside risk and Green stocks

Note: In downward market conditions, different highlighted points indicated investment in diverse green stocks. These points represent lower stocks volatility and stable returns, achieved by holding the stocks with negative returns, timed with downward market phase at the point of purchase.

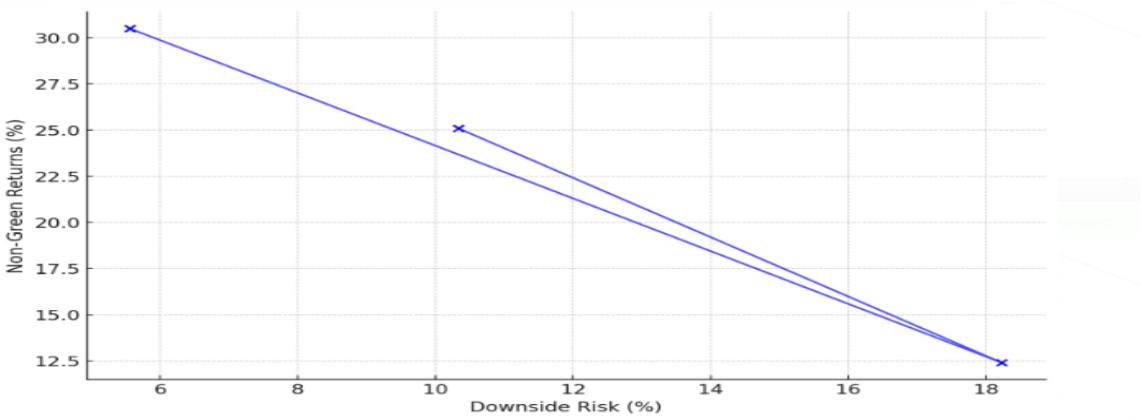

Fig 2: Downside risk and non-green stocks

Note: In downward market conditions, two lines indicated investment in diverse stocks. These points represent higher stocks volatility and unstable returns, achieved by

holding the stocks with negative returns, timed with downward market phase at the point of purchase

Conclusion

This study provides an in-depth analysis for measuring the effect of downside risk on security returns after comparing the performance of green and non-green stocks. Downside risk and green investment have long been renowned as the major concerns of investors and strongly affect security returns. However, due to multiple limitations, involving the scarcity of investing in green stocks as hedging strategies against downside risk, this study proves that investors can shelter their investment with extreme downside risk by holding green stocks.

In this study, the greenness effect on downside risk is assessed by breaking down stocks into two categories green and non-green stocks, depending upon the daily data set over the periods of 2012 to 2020 listed at AIM. AIM is a secondary market that has created a distinct image after winning the title of the green market by "Green Mark Economy" at the global level. In the current highly risky and volatile environment, green stocks act as a haven, particularly when downside risk elevates in the market due to the downward movements. The findings of the study reported that green assets have strong diversifying attributes and have reduced downside risk significantly. On the other hand, non-green stocks do not reveal any strong involvement in reducing downside risk proving that green stocks act as a premium for investors and generate sustainable returns even during the downward situation of a market.

Recommendations

Investors can diversify their investment by paying strong attention on adding green stocks as the study has proved that green stocks help investors to mitigate the risk. Downside risk lead investors to protect their investment with high negative returns. Greens stocks can protect investment by providing sustainable returns and provide premium for compensating investors for making investment during downward market conditions, guiding investors to pay huge attention on greening their portfolios even during the downward movement of markets. In future, a study needs to be conducted by comparing the performance of green and non-green portfolios to measure whether addition of green stocks can help to diversify portfolios or not.

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