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Exploring the Impact of Environmental, Social, and Governance Ratings in Investment Decisions During Uncertain Times: A Focus on the Energy Industry

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Abstract

With sustainability awareness on the rise around the world, and as global awareness of sustainability grows, it's inevitable that the financial sector will have to adapt. More than just a numbers-based assessment, modern finance is faced with the integration of environmental, social and governance (ESG) standards. Our research explores how these ESG standards influence investment decisions, especially in uncertain contexts such as global conflicts or pandemics. The growing importance of these considerations is underlined by regulatory developments, which underscore the need for investors, particularly institutional and corporate investors, to factor ESG criteria into their decision-making processes.

Keywords: ESG, Financial Crisis, Investment Decision, Energy Sector, Portfolio Risk

Introduction

"History teaches us that, over the centuries, there has always been something new for every generation. From the industrial revolution a few centuries ago, to aviation in the early 19th century, to the internet (and e-commerce) in the 80s and 90s and, more recently, social media, facilitated by massive access to connectivity and innovation. And now comes the GSE. Like all these great things, they respond to a particular challenge of the time or to anticipated future problems in society (...) Any company or government that wishes to be relevant in the medium or long term cannot ignore [the preferences or opinions of today's millennials and post-millennials, who make up tomorrow's electorate and customers]"[1].

The social and environmental dimension of business is at the heart of new economic and financial guidelines. Faced with the challenges of international regulation, compliance standards linked to international investment directives have been tightened, and governance has become a key indicator for assessing investment compliance and performance. It is against this backdrop that ESG criteria, "developed by the financial community to designate criteria of interest to environmental, social and governance aspects (independence of the board of directors, management structure and presence of an audit committee)", have taken their place as essential elements of extra financial analysis.

Based on the United Nations Framework Conventions and the Sustainable Development Goals (SDGs), ESG criteria are essential indicators. These criteria oblige companies to report on non- financial factors influencing their performance, future cash flows and any associated risks. As a result, 57% of financial advisors believe that adopting these criteria offers an additional dimension of risk management for their client’s investments.

In the current context, the indicators adopted are evolving in parallel with contemporary dynamics. These dynamics, shaped by global issues, require the development of mechanisms that are both anticipatory and forward-looking. These tools must also provide flexible assessments in response to changing concerns. For example, terrorist threats are altering companies' procurement patterns, while meeting contractual obligations to their employees. In addition, the Covid-19 pandemic underlined the imperative of developing effective resilience strategies, demonstrating the need for industries and investors to adjust in the face of potential crises. This reality underscores the importance of government bodies in establishing regulatory frameworks that guarantee the rigorous application of these indicators.

[1] PWC, "ESG - The great next challenge of our generation. Africa cannot afford to be left behind", available at: https://afrique.pwc.com/fr/actualites/decryptages/esg-afrique.html

In this context, the energy sector is an ideal field for analysis. The need for a thorough understanding of the parameters central to this study will guarantee results that are both relevant and adaptive.

- What impact has the recent war had on the implementation of ESG ratings for companies in the energy sector?
- Is it worth sticking to these ratings in times of uncertainty?
- What is the measured impact of including or not including ESG ratings in investment decisions?

To answer these questions, we begin with the context surrounding ESG by exploring the literature on ESG. This will be followed by a discussion of the theoretical underpinnings, before presenting the methodological framework. In particular, we will detail the data studied in relation to the questions posed. The last two points will focus on the analysis of our study and its possible constraints, paving the way for recommendations for future studies.

1. The ESG context: conceptual approach, history and current situation

1.1. The ESG concept

Assessing sustainability poses complex challenges, leading to the emergence of multiple theories and concepts. Sustainable investments, which seek to combine long-term financial returns with positive impacts, are a case in point. As mentioned, the acronym ESG refers to environmental, social and governance criteria, serving as an analytical tool to measure how a company integrates sustainable development and anticipates future challenges.

1.2. ESG and SRI: Continuous or discontinuous concepts?

As understanding of sustainability and ESG issues has evolved, the terminology used has diversified, sometimes creating ambiguities between financial players, fund managers and researchers. Several names, such as "socially responsible investment" (SRI), "impact investment", "green investment" and "ESG investment", refer to this approach (Schueth, 2003).

1.3. The emergence of SRI and ESG and their gradual mainstreaming

The rise of sustainable investment has historical roots in religious convictions, dating back as early as the 18th century. Religious groups, including the Quakers, Methodists, and Muslims, established ethical guidelines for financial investments. In the 21st century, the sustainable investment approach continues to gain momentum.

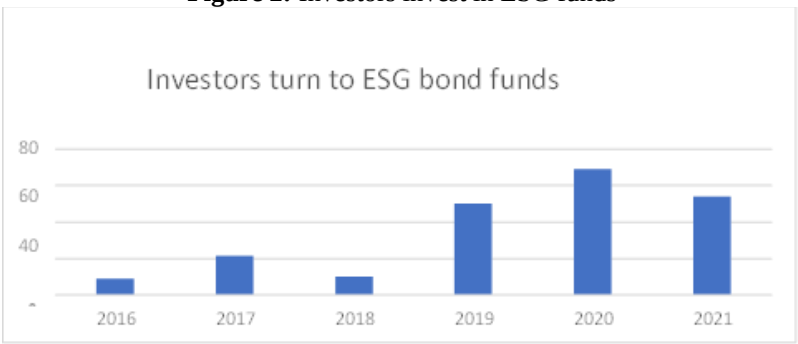
Today, faced with growing demand from investors anxious to combine their social concerns with their financial choices, we are seeing a proliferation of entities offering assessments based on ESG criteria[2].

The field of ESG ratings is vast and diverse, comprising over 600 "products" from 150 organizations offering ESG information (Hawley, 2017). These agencies enjoy considerable flexibility regarding their assessment criteria and methods, given the absence of uniform regulatory standards for the presentation and assessment of this non-financial data (Chatterji et al., 2015). This leads to wide variations in ESG ratings from different sources (Berg et al., 2019), potentially generating uncertainty for investors.

1.5. ESG fund performance and investment growth

ESG funds face a number of challenges. Some investors are prioritizing financial performance over ecology, putting these funds under pressure. Tensions in Ukraine, the impact of technology, inflation and rising interest rates complicate the situation. In 2022, ESG funds fell by 18%, more than non-ESG funds at 15.8%. Only 31% of ESG funds achieved their objectives in the first half of 2022, compared with 41% of non-ESG funds.

Figure 2: Investors invest in ESG funds



Source: Morningstar, 2022

Investor reactions to uncertainty and crises are nuanced and often depend on the type of investor.

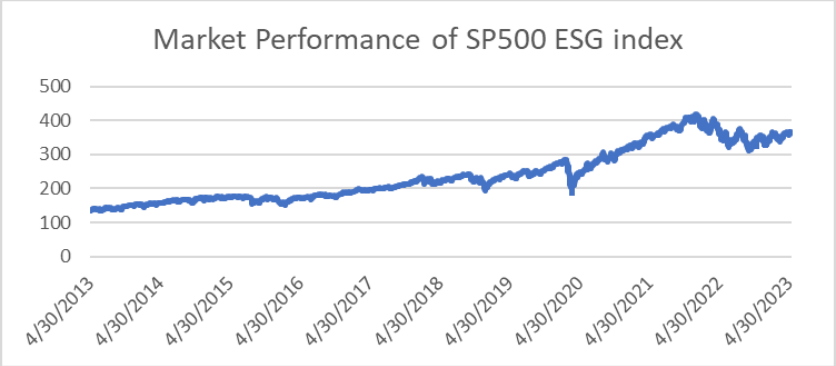
In fact, investor reaction is not uniform. While some seek security, others may see crises as a buying opportunity.

As such, the rise of sustainable finance raises a fundamental question: is it a genuine.commitment based on ethical principles, or simply a reaction to market trends? Recent events, such as the Covid-19 pandemic or the Russian-Ukrainian tensions, offer an opportunity to observe and analyze

[2] By 2027, $16 billion will be invested in ESG and sustainability consulting services, according to an estimate by research firm Verdantix. In 2023, the expansion of this sector is set to continue with the introduction of new legislation.

investor behavior. Will these crises reveal whether sustainable finance is a genuine conviction or simply a "fair-weather strategy"

Figure 3: 10-year performance of the SP 500 ESG index Source: SP 500 Global



2. Literature review

It should be noted that most of the literature on uncertainties focuses on the COVID-19 pandemic, and data on the Russian-Ukrainian war is still limited. For the sake of clarity and organization, we will present the literature article by article.

2.1. ESG investment in times of crisis (in particular COVID 19)

2.1.1. Summary of the study

In our study, we looked at daily data for companies listed on the US stock market between January and April 2020. We used regression models to determine how ESG ratings affected the returns of different sectors during the COVID-19 pandemic. To this end, we incorporated control variables such as Fama-French and an ESG factor, measuring the difference in returns between companies in the top and bottom quartile based on their ESG rating (Díaz, Ibrushi, & Zhao, 2021).

Our analysis highlights the importance of ESG ratings in determining sector returns during the COVID-19 crisis. The ESG factor, based on the difference in ESG performance between companies in the top and bottom quartile, proved significant. When this factor is integrated with the Fama-French variables, it becomes clear that ESG is a key element in sector performance (Díaz, Ibrushi, & Zhao, 2021). Furthermore, we have detailed our study by examining each of the three ESG components individually: environment, social and governance. It appears that the dimensions with the greatest impact on corporate performance are the environmental and social aspects (Díaz, Ibrushi, & Zhao, 2021).

2.1.2. ESG Post-pandemic investment trends

The Covid-19 pandemic has heightened the importance of ESG investment strategies. The major elements identified in the literature indicate that the environmental and social aspects of ESG are dictating the majority of current trends.

During this epidemic, ESG will have played a dominant role in industrial portfolio returns, as Díaz, Ibrushi, & Zhao (2021) point out

Finally, we suggest that investors integrate specific E, S and G ratings, as a complement to general ESG assessments, into their investment strategies. (Díaz, Ibrushi, & Zhao, 2021).

2.2. The role of ESG performance in times of financial crisis: Data from COVID-19 in China

2.2.1. Summary of the study

In our study, we conducted an event-driven analysis using data from companies listed on the CSI300 in China. Our findings indicate that portfolios with higher ESG (Environmental, Social, and Governance) ratings demonstrated greater resilience during crises compared to those with lower ESG ratings. Moreover, amid the COVID-19 pandemic, we identified a positive correlation between ESG performance and short-term cumulative returns. This suggests that companies with favorable ESG ratings may exhibit greater resilience to financial disruptions, potentially influencing future investment decisions for investors.

We also examined the impact of ESG ratings specifically during the financial crisis triggered by the COVID-19 pandemic. Faced with this unprecedented context, our inquiry focused on whether investors perceived ESG scores as indicators of future stock performance or as risk reduction mechanisms. Our analysis revealed that (i) portfolios with high ESG ratings tended to outperform those with low ratings, (ii) a positive ESG rating could contribute to reducing financial risks during times of crisis, and (iii) the influence of ESG ratings was less pronounced in "normal" times, underscoring its heightened importance during crises. We based our study on a recent dataset of Chinese CSI300 members and interpreted these results in the context of ESG investment strategies (Broadstock, Chan, Cheng, & Wang, 2020)."

2.3. The impact of ESG investments on financial returns

Nevertheless, there is some debate about the impact of ESG investments on portfolio performance. On the one hand, studies such as Cortez et al (2009) postulate that ESG integration would limit diversification and lead to opportunity costs. This view is supported by Merton (1987), who

suggests that ESG stocks, being less preferred, will have a lower price, but higher expected returns.

For their part, Pedersen, Fitzgibbons and Pomorski (2020) believe that even though socially performing stocks offer lower returns, investors tolerate them, as these stocks are more socially responsible. Pastor, Stambaugh and Taylor (2019) add that high ESG impact stocks generally have a lower cost of capital and a lower return due to the orientation of investor preferences.

Nevertheless, some authors, such as Pedersen, Fitzgibbons and Pomorski (2020), believe that ESG stocks could outperform if excellent ESG performance is associated with future earnings not yet incorporated by the market. They see this trend particularly in ESG governance, where it predicts an increase in corporate earnings. Mnescu (2011) points out that investors tend to misjudge ESG-related costs, leading to inaccuracies in the valuation of these factors.

Ipso facto, our analysis reveals a divergence of opinion on the impact of ESG investments. Under these conditions, it is crucial for investors to stay informed and adapt their strategies accordingly. (Lina Nassar, 2022).

3. Theoretical approaches

3.1. Modern portfolio theory

Harry Markowitz's conceptualized theory dictates how to select securities to form an optimal portfolio, aiming for the lowest return with the lowest risk, centered on diversification. To illustrate this theory, we focus on financial principles and the associated mathematical equations.

3.1.1. Mean-variance analysis

3.1.1.1. Statement

For investors, portfolio optimization is paramount, as portfolios should not be substituted if another offers the same or better performance with less variation (Fama, MacBeth, 1973). Thus, risk and return are essential in investment decisions. In this respect, Markowitz points out that, on certain occasions, an investor's choices are refocused on two pillars: expected return and the risk associated with the portfolio.

3.1.1.2. Mathematical formulation

$$E\,[Rp\,] \;=\; \sum_{k=0}^{n} W_k \times\; E[R_k\,]$$

Formula 1: Expected portfolio return

Where: W_k is the weight of asset k

$$Var\ [Rp\ ] = \sum_{k=0}^{n} W_k \times Cov\ [R_k R_p]$$

Formula 2: Portfolio variance

Where: W_k is the weight of asset k
$Cov\ [R_k R_p]$is the covariance between the expected return on asset k and the expected return on the portfolio

3.1.1.3. Explaining the theory

There is a positive correlation between risk and return. The more risk an investor is willing to take, the higher the expected return. Conversely, a low level of risk is often associated with lower rewards. This relationship between the two factors is essential.

A rational investor aims to maximize return for a given level of risk, or to minimize risk while achieving a target return.

Diversification plays a central role in portfolio theory, particularly in risk management.

3.2. Portfolio selection

According to Markowitz, an investor should choose a portfolio that maximizes return for a specific level of risk, or minimizes risk for a defined level of return. However, several authors have developed more appropriate mathematical formulas to describe portfolio efficiency. Sharpe's ratio and Treynor's ratio are two important performance measures.

3.2.1. Sharpe ratio

3.2.1.1. Statement

In 1966, William F. Sharpe formulated the Sharpe ratio, which measures the risk-adjusted return on a financial portfolio (Sharpe, 1966). It measures the extra return an investor receives in exchange for the increased volatility incurred by holding riskier assets.

3.2.1.2. Mathematical formulation

$$SR = \frac{E(R_P) - R_f}{\sigma_p}$$

Formula 3: Sharpe ratio

Where $E(R_P)$expected portfolio return
R_f return on assets at risk-free rate
σ_p Portfolio standard deviation

3.2.2. The Treynor Report

3.2.2.1. Statement

The Jack L. Treynor ratio is used to assess risk, by establishing the risk-adjusted value of an investment and analyzing market volatility. This approach evaluates returns above those possible on a risk-free investment, for each unit of market risk. Like the Sharpe ratio, the Treynor ratio assesses the efficiency of the portfolio under review; a higher value indicates that the investor has generated high returns for each level of market risk assumed.

3.2.2.2. Mathematical formulation

$$TR = \frac{E(R_P - R_p)}{B_p}$$

Where
$E(R_P)$: Expected portfolio return
R_p: Return on risk-free assets
B_p: Portfolio beta

3.3. Monte Carlo simulation

Here, we discuss the use of Monte Carlo methods to solve integration problems, while examining sampling techniques, convergence concepts and variance reduction strategies. To improve uniformity, the points of a quasi-random sequence are interconnected. This approach, known as quasi-Monte-Carlo quadrature, has a high convergence rate (Caflisch, 1998).

3.4. Regression method

The aim of simple (resp. multiple) regression is to explain a variable Y using a variable X (resp. several variables X1,..., Xq). The variable Y is called the dependent variable, or variable to be explained, and the variables Xj (j=1,..., q) are called the independent variables, or explanatory variables.

3.4.1. Simple linear regression

In statistics, simple linear regression is a model involving a single explanatory variable. It is represented by the equation $y_i = \beta_0 + \beta_1 x_i + \epsilon_i$, where y is the dependent variable, x is the independent variable, β0 is the intercept, β1 is the slope and ϵi is the error term. It is generally assumed that $E(\epsilon) = 0 \; and \; E(\epsilon x) = 0$.

The value β_1 measures the change in y in response to a one-unit change in x, and can be calculated as Δy/Δx.

The aim is to estimate the values βˆ 0 and βˆ 1 that give the best possible fit to the data. We also wish to test the statistical significance of the parameters, in particular β1, which quantifies the impact of x on y.

A common method for estimating simple linear regression is the least squares approach, which minimizes the sum of squares of the residuals. This translates into the equation min $\beta 0, \beta 1\ \Sigma_i (y_i - \beta_0 - \beta_1 x_i)^2$.

3.4.2. Multiple linear regression

Normally, we can run a multiple linear regression (main variables + control variables) to control for the effect of confounding variables.

$$yi = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_{mxim} + \epsilon_i$$

There are m independent (explanatory) variables. We can also write multiple linear regression in matrix form (more compact and easier for further derivation). $Y = X\beta + \epsilon$

$$Y = X\beta + \epsilon$$

where $Y = [y_1\ y_2\ y_n\ ]_{n\times 1}$, $X = [1\ x_{11}\ x_{12}\ 1 \vdots x_{21} \vdots x_{22} \vdots 1\ x_{n1}\ x_{n2} \ldots \ldots x_{1m} \ldots \vdots \ldots \vdots x_{2m} \vdots \ldots \ldots x_{nm}\ ]_{n\times(m+1)}$

$\beta = [\beta_0\ \beta_1 \vdots \beta_m\ ]_{(m+1)\times 1}$,

$$\epsilon = [\epsilon_1\ \epsilon_2 \vdots \epsilon_n\ ]_{n\times 1} with\ \beta_j = \frac{\partial_y}{\partial_{xj}} \qquad \forall 1 \le j \le m$$

βj measures the change in y in response to a one-unit change in xj after controlling for other confounding factors (i.e. x_1, x_2,..., x_{j-1}, xj+1,..., xm).

We can also estimate the β matrix by minimizing the sum of squared errors. The minimization program is as follows.

$$\epsilon = Y - X\beta$$
$$min_\beta \epsilon^T \epsilon = (Y - X\beta)^T (Y - X\beta)$$
$$= (Y^T - \beta^T X^T)(Y - X\beta)$$
$$= (Y^T Y - Y^T X\beta - \beta^T X^T Y + \beta^T X^T X\beta)$$
$$= (Y^T Y - 2Y^T X\beta + \beta^T X^T X\beta)$$

The last step is because $(Y^T X\beta)^T = \beta^T X^T Y$ and they are both 1×1 matrix (a scalar). Therefore $Y^T X\beta = \beta^T X^T Y$

3.4.3. Logistic regression

In logistic regression, the dependent variable (outcome variable) is binary (i.e. 1/0). In real life, many outcomes are binary, such as whether or not to invest, or whether the price will rise (or fall). In our case, we can analyze whether the company will have a high environmental risk or not.

$$E\ (Y\ |X\ =\ x)\ =\ X\beta$$
$$E\ (Y\ |X\ =\ x)\ =\ P\ (Y\ =\ 1|X\ =\ x)$$

However, this linear probability model (LPM) has certain drawbacks.
The predicted probability $P\ (Y\ =\ 1|X\ =\ x)$ may be < 0 or > 1 if the new x is not in the estimation (learning) sample.
Impossible to model "diminishing returns - changing the probability p by the same proportion requires a greater change in x when p is already large (or small) than when p is close to ½.
Let Y* be a continuous latent (unobserved) variable $Y^*\ =\ X\,\beta\ +\ \epsilon$

4. Methodology

4.1. Selection of the database used in the study

For our first analysis, we've collected data from the SP500 global index, which provides daily returns on SP500 variants, allows for simple visualization and comparative analysis; the date range is between 2011 and 2022; this will provide smoother regression and consistent model plots. We use the Energy and ESG indices as variants. The study of these two indices compared to the standard SP500 will give us an empirical buffer to consider or not the SP500 ESG index as an ESG variant respecting the characteristics of a benchmark index.

Validation of the first data provides us with a solid framework to begin the second. In fact, the first Monte-Carlo simulation uses companies from the energy sector (including the major industry players in Europe and the USA). We calculate adjusted returns for each component of our portfolios, as well as the associated risk measure; here, the Sharpe ratio, with the addition of 10-year Treasuries, is crucial, as it is considered the risk-free benchmark for the continuity of the study. The second Monte Carlo simulation uses Sustainalytics ratings to select ranges of companies with different ESG risk scores, ranging from low, medium, high and severe.

4.2. Descriptive statistics

Table 1: Descriptive statistics for all variables used

	FRU, TO	TPZ, TO	VNOM	^TNX	CNQ	REP, HM	TTE, PA	BP	CVX	SHELL, AS	2222, SR	NOG	XOM	SP500ESG	SP500ENERGY
Count	328	328	328	328	328	328	328	328	328	328	328	328	328	328	328
Mean	10,26045	16,80419	20,69809	2,072996	39,180714	10,392207	40,057164	25,730948	119,76381	19,5234	29,217036	18,164906	60,489902	356,74728	472,25368
Std	3,793967	3,506181	7,391409	0,955217	13,857280	2,2472194	8,2680678	4,6134227	33,56717	4,9831107	3,1369264	7,29985	17,53190	29,800887	133,25457
Min	3,196 019	11,45	5,853 909	0,801	13,434	4,566 266	21,240	13,35	61,042	9,318 99	25,348	3,251 82	27,480	280,11	216,41
25 %	6,932 923	13,244	14,96	1,369 25	27,197	9,069 70	33,299	22,628	93,423	15,137	27,083	12,163	50,782	332,725	369,945
50 %	10,554	16,498	20,227	1,639	37,80	10,187	39,637	25,711	107,602	18,571	27,472	18,560	57,175	356,36	433,405
75 %	13,649	20,048	27,478	2,886 249	52,439	12,001	46,459	29,255	153 212	24,531	31,829	23,614	76,034	379,52	588,8
Max	16,775	23,595	33,016	4,234	63,085	15,278	58,192	35,167	182 474	27,950	36,710	34,923	101,09	418,01	720,16

4.2.1. Data summary

Table 2: Summary of selected data

Data	Source	Sampling (Dates°)	Specifications
SP500	SP500 GLOBAL	2011-2022	-
INDICE SP500ESG	SP500 GLOBAL	2011-2022	-
SP500 ENERGYIND EX	SP500 GLOBAL	2011-2022	-
SHARE DATA	YAHOO FINANCE	2020-2022	USE DATA SCRAPPING IN PYTHON
ESG ratings	Sustainable development		Only companies in the energy sector are concerned by ESG risk.

In our study, we will use multiple linear regressions and simple linear regressions to check the persistence of the statistical model, as well as logistic regression (binary output of 0 or 1) to see the direct impact of the ESG score on return on equity as a measure of performance. We will opt for quantitative research to carry out our research. When researchers attempt to quantify social phenomena and the links between them, they generally adopt a quantitative research methodology. (Bell, Bryman and Harley, 2019). In our case, the tools used are the Python spider, a tool dedicated to data analysis, as well as Excel analysis tools.

4.3. Econometric model

First model: Multiple linear regression model Addition $Y = aX + bX_L + cX_N + ... + nX_n + e$

Multiple regressions are run to study the relevance of ESG data and to extract possible relationships between variables. The first regression uses SP500 variant analysis:

- Y is the standard SP500; this variable is used because of its importance on the stock market, as it gives an idea of the market trend. The SP500 is widely used as a benchmark for equity investments. It is therefore relevant to use it as the dependent variable.
- X1: The SP500 offers the possibility of filtering its components. For this reason, there are many variants of the SP500, the most important in our study being the SP00 ESG index; this variant is derived from a negative filtering method[3] by filtering the standard SP500 and retaining only the "good stocks".
- X2: following the same logic of filtering the overall SP500, and as our study focuses more on the energy sector, we'll take the SP500 Energy index as the second variable for our model.

Note that the data is filtered using Power Query, and the regression is run as a first test in Excel, using the full set of analysis tools. The data runs from 2011 to 2022, the idea being to take account of crises that have caused market collapses, in particular the avian flu pandemic and the war between Russia and Ukraine.

[3] Negative and positive screening: Companies from "controversial" sectors such as oil and gas could be screened favorably if they can demonstrate that they have made significant ESG commitments and are in a position to improve.

Discussion of results

Table 3: Regression statistics[4]

Regression statistics	
Coefficient of multiple determination	0,999 074 472
Coefficient of determination R^ 2	0,998 149 801
Coefficient of determination R^ 2	0,998 148 335
Standard error	37,635 140 77
Comments	2528

The results of this tables emphasis on the strong relationship between variables, the R squared is almost one which implies that the model is strong and the two variables explain statistically the dependent variable Y.

Table 4: ANOVA[5] test

	Degree of freedom	Sum of squares	Average square	F	Critical value of F
Regression	2	1 929 415 359	964 707 680	681 096,496	0
Residues	2525	3 576 419,65	1416,403 82		
Total	2527	1 932 991 779			

This table satisfies the normality hypothesis. If all the variables in the model are normally distributed, we can accept H0 (the null hypothesis), because if we reject the normality test, the study will not be significant. Thus, the P-value is 0, perfectly respecting the null hypothesis.

Table 5: Regression model coefficients

	Coefficients	*Standard error*	*Statistics t*	*Probability*
Constant	269,672 334 4	4,805 673 48	56,115 409 4	0
Variable X 1	11,079 470 88	0,009 968 96	1111,397 22	0
Variable X 2	-0,182 026 567	0,006 870 29	-26,494 728 3	1,078E-136

In Table 5, we summarize the regression equation. Writing it as a mathematical formula, we obtain: $Y = 11.079X_1 - 0.182\,X_L + 269{,}672$ Interpretation: The impact of the ESG variant is very clear and positive. Indeed, 1 additional unit of the ESG variant brings approximately 16 units to the SP500 standard. We also conclude that SP500 Energy has a negative impact on the model, but the ESG variant is still more significant.

[4] The results in this table highlight the strong relationship between the variables, with the R-squared almost equal to one, implying that the model is strong and that both variables statistically explain the dependent variable Y.

[5] ANOVA is a statistical analysis technique that divides systematic components from random factors to account for the overall variability observed within a data set.

4.4. Monte Carlo simulation: calculating the efficient frontier

4.4.1. Monte Carlo simulation

In this simulation, we calculate the efficient frontier of different portfolios. The aim is to determine the impact of different ESG variants on the investment decision; the risk/return trade-off being the one that first and last determines an investment decision. For this reason, calculating the efficient frontier of each portfolio is crucial to determining the real impact that could affect investors' decision-making.

4.4.2. The efficient frontier

First, we calculate the efficient frontier for random energy companies in the stock market. To do this, we use the standard SP500 index as a benchmark. By calculating the risk/return trade-off, we aim to assess the impact of introducing the SP500 ESG index as a benchmark in place of the standard index. We then use Sustainalytics' ESG ratings in the energy sector to create different stock portfolios with different ESG ratings, and examine the impact of these ratings on the investment decision, in particular on the risk/return trade-off.

5. Results and analysis

- **Results obtained from the econometric model**

Statement:

This econometric model provides a statistically robust basis for analyzing ESG variants in the stock market. The SP500 ESG index reflects market trends well, as it is positively correlated with the standard SP500. Even during periods of market turbulence, particularly in the energy sector, it is relevant and statistically significant.

If we write it as a mathematical formula, the regression equation will be:

$$Y = 11.079X_1 - 0.182\,X_L + 269{,}672$$

Interpretation

The impact of the ESG variant is very clear and positive. In fact, 1 additional unit of the ESG variant adds approximately 16 units to the SP500,

This result confirms the literature studying this relationship, particularly in areas related to ESG investment, such as the relevance of ESG data to the stock market.

Monte Carlo simulation results

Simulation 1

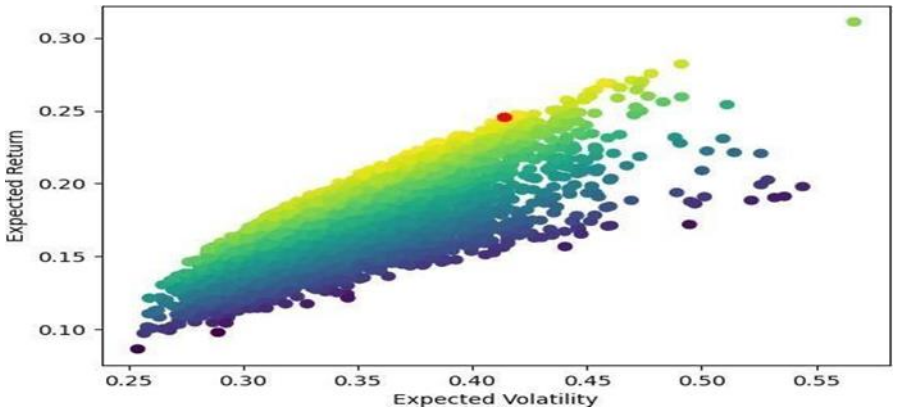


Chart 1: Efficient frontier without ESG variant

This graph shows the risk and return parameters for a portfolio of energy stocks. The optimal portfolio is represented by a red dot with an approximate volatility measure of 0.40 and an expected return of 0.25. If we take into account the number of returns per unit of risk9 (simple division of risk and return), we obtain approximately 1.6.

Simulation 2

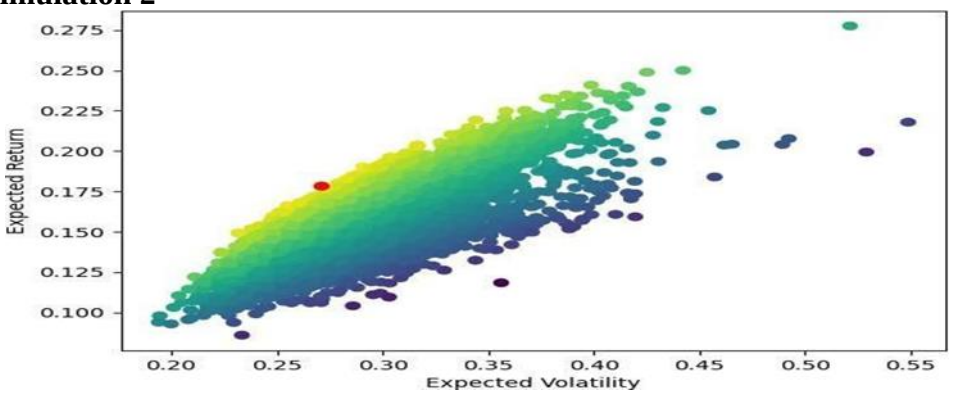


Chart 2: Efficient frontier with ESG variant

Interpretation:

For each additional unit of yield, there is 1.6 units of volatility.

The ESG variant is important for hedging risk, but does not clearly affect returns.

This graph shows the risk and return parameters for a portfolio of energy stocks. The optimal portfolio is represented by a red dot with an approximate volatility measure of 0.27 and an expected return of 0.18

Simulation 3

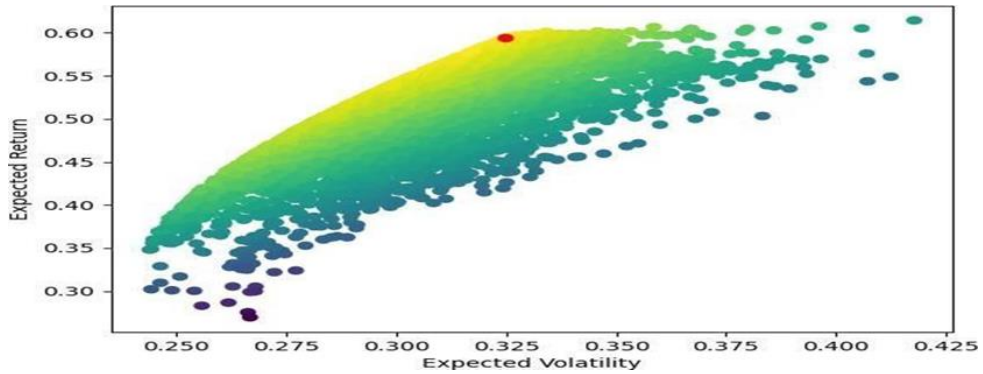


Chart 3: Efficient frontier with low ESG risk

This chart displays the risk and return parameters for a portfolio of energy stocks. The red dot represents the optimal portfolio, with an approximate volatility measure of 0.23 and an expected return of 0.45. If we take into account the returns per unit of risk (simply dividing risk by return) or calculate the maximum Sharpe ratio using Python code, we obtain a Sharpe ratio of 1.829.

Simulation 4

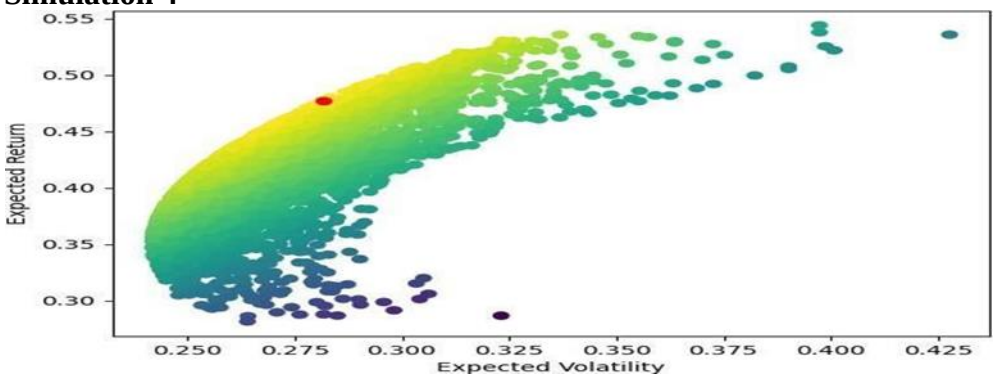


Figure 4: Efficient frontier with average ESG risk

The portfolio consists of stocks from the energy sector, including companies like TotalEnergies and the Canadian National Energy Company, all with an average ESG score. Considering the returns per unit of risk. the Sharpe ratio is calculated to be 1.695.

Simulation 5

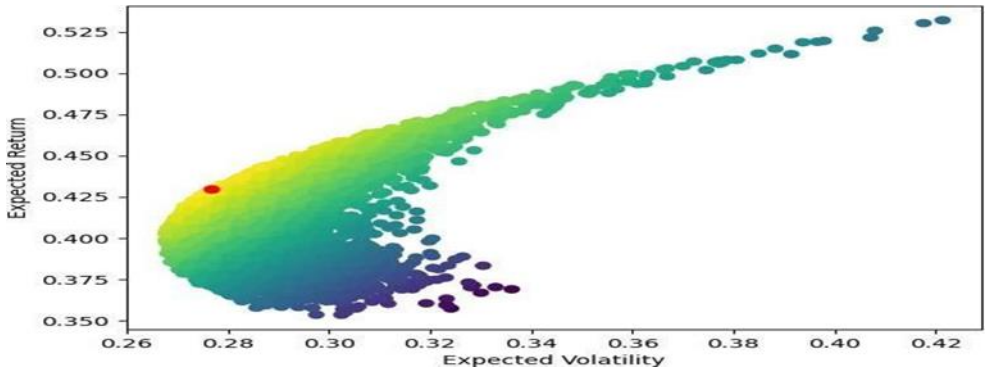


Chart 5: Efficient frontier with high ESG risk

This graph shows the risk and return parameters of a portfolio of shares in the energy sector, for companies with a high ESG risk, i.e. a poor ESG rating according to Sustainalytics. The optimal portfolio is represented by a red dot; the shape of this graph is more precise, as it containslarge-cap companies.

Simulation 6

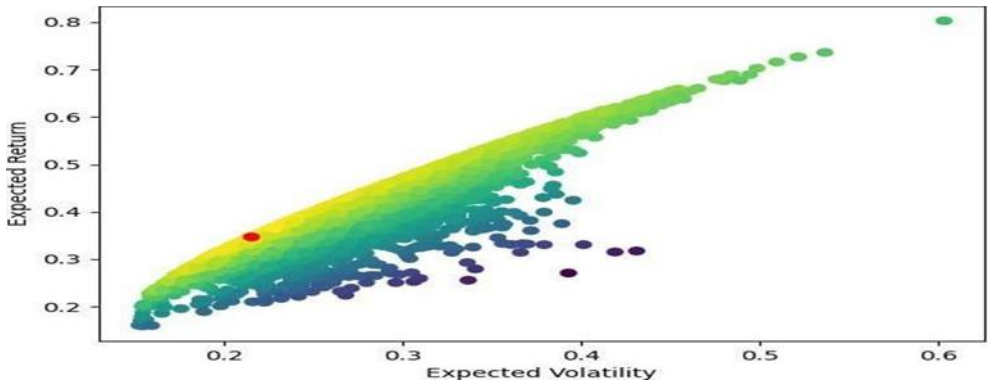


Chart 6: Efficient frontier with high ESG risk

This graph illustrates the risk and return parameters for a portfolio of stocks within the energy sector. The red dot represents the optimal portfolio, which, in the worst-case scenario, comprises solely companies with a high ESG risk and consequently a very low ESG rating. By considering the returns per unit of risk (calculated through a simple division of risk and return).

Simulation 7

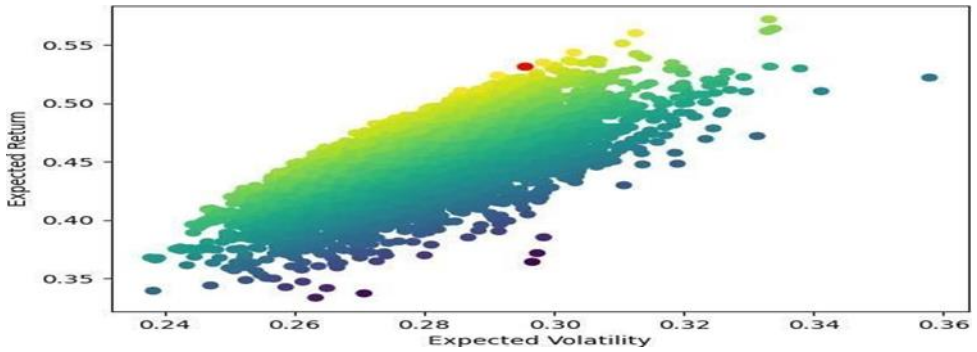


Figure 7: Efficient boundary of the envelope scenario

This chart shows the risk and return parameters of a portfolio of equities in the energy sector. This is an envelope scenario, subsequently developed in the form of proposals. The optimal portfolio is represented by a red dot and includes companies with high ESG risk and companies with low ESG risk. Taking into account the number of returns per unit of risk (simple division of risk and return), the Sharpe ratio for this portfolio is 1.799.

6. Analysis of results/data

ESG investing consists of proposing portfolios that meet certain ethical investment standards. As such, rating agencies provide ratings to facilitate the selection of portfolios for "responsible" investors. If we see ourselves as investors who are aware of this investment scheme, we will look directly at the risk and return provided by these portfolios.

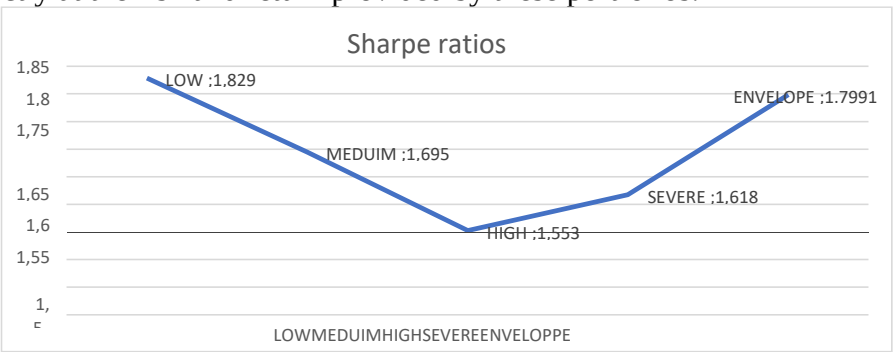


Figure 8: Sharpe ratios for the different portfolios used - Visualization of results

- In general, a higher Sharpe ratio is preferable, as it indicates a greater return in relation to the risk assumed. Remember that the Sharpe ratio is not the only factor to consider when choosing an investment. Factors such as investment objectives, time horizons and personal risk tolerance should also be taken into account.

- The low-risk portfolio has the highest Sharpe ratio (1.829); it "is the best portfolio in our investment decision schema. Finally, the medium-risk portfolio lies between the low- and high-risk portfolios, with a Sharpe ratio of 1.695, while the high-risk portfolio has a Sharpe ratio of 1.553.
- The problem in the order lies with the severe portfolio, which is an outlier with a better risk/return trade-off compared to the high-risk portfolio; descriptively, both are bad portfolios with little difference when Sharpe ratios are compared.
- In fact, ESG ratings are dissociated from any financial criteria and therefore do not directly influence risk and return. As a result, ESG investment is more in keeping with an ethical approach than a purely financial one. What's more, the "7 sisters", historically major oil companies, also receive unfavorable assessments.

7. Limits and proposals

7.1. Statement of limits

Nevertheless, our study has intrinsic limitations related to the methodology adopted and the availability of data:

The model we use is based on a positive/negative selection approach specific to responsible investment. Despite its often "naïve" critics, this methodology is still widely used in investment decision-making.

7.2. Formulating proposals

We suggest a more rigorous selection of countries to enhance the relevance of our study. However, this improvement is highly dependent on data availability.

We observe that small-cap stocks, perceived as riskier, present interesting opportunities. Indeed, they are often considered more volatile than large-cap stocks. This is because the latter, often held by well-established firms, do not generally aspire to rapid growth, as Investopedia points out.

In our study, the size factor[6] plays a central role. By considering this factor, we could provide significant additional information. Separate research on the size factor would be particularly beneficial and would enrich the literature on the subject. As part of our approach, we conducted a test to evaluate this hypothesis.

[6] The concept of size factor is essential for investment management. The performance of small-cap versus large- cap companies is examined. The difference in performance between small-cap and large-cap companies is, in other words, the size factor.

By applying the positive/negative selection methodology to our study and evaluating efficient frontiers, then comparing Sharpe ratios, we arrived at specific results.

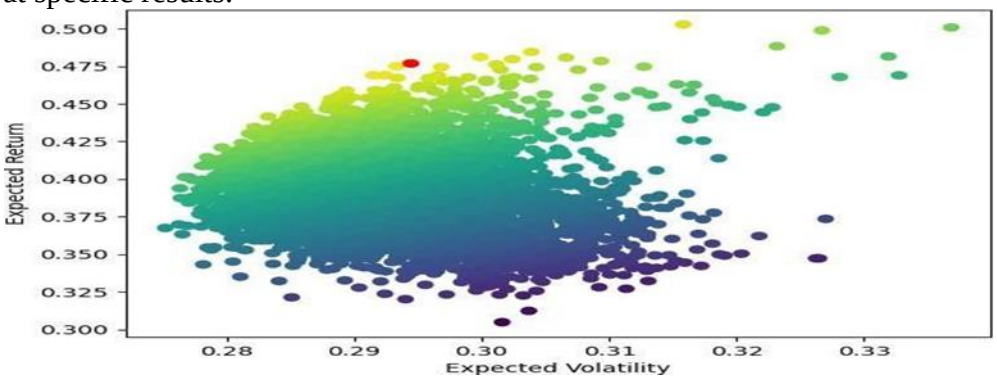


Figure 9: Efficient frontier for the 5 companies with the worst ESG ratings

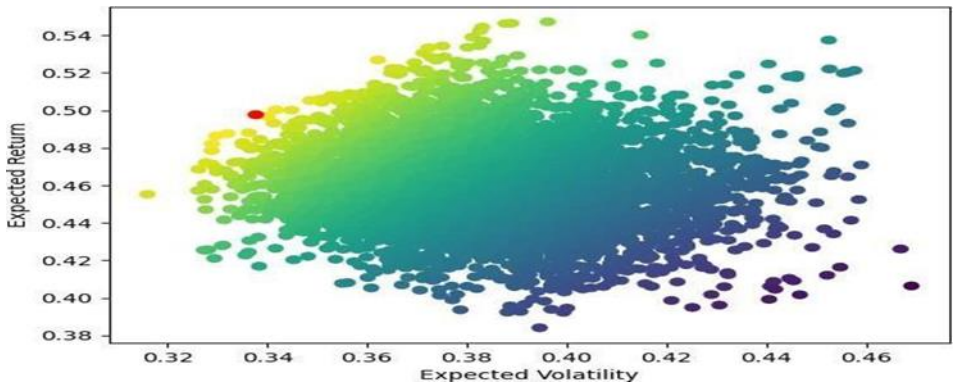


Figure 10: Efficient frontier for the top 5 ESG-rated companies

- In analyzing the efficient frontiers and associated metrics, we observe a notable gap between the Sharpe ratios of the highest-ranked and lowest-ranked companies. The top-ranked companies, mainly small- and mid-caps, have a Sharpe ratio of 1.474, while the bottom-ranked companies, largely large-caps, have a ratio of 1.623. This difference underlines the need to examine this feature in greater detail.
- In addition, a sharper focus on the energy sector could provide a better understanding of the disparities observed. We could consider using industry sub- codes to refine the model, and specifically target those branches of the sector most impacted by ESG investment decisions. It should be noted that our research focuses primarily on companies in the oil and gas sector. In the future, an exploration of the renewable energies sector could prove promising for our research.

Conclusion

In this scientific article, we explore the relevance of ESG ratings in the investment decision- making process, particularly in the face of uncertainties in the energy sector. There's no denying that, when it comes to investing, the risk/return trade-off is at the heart of investors' concerns. The first reflex is often to review the various portfolios available and assess their respective risks and returns.

Our research was based on data from the global SP500 index. The aim of our econometric model was to assess the usefulness of the SP500 ESG index as a benchmark. The results show a strong correlation and statistical convergence between these two indices. What's more, integrating ESG data into a portfolio by substituting the SP500 with the ESG SP500 index generates a significant reduction in risk and a higher Sharpe ratio.

In addition, our risk/return analysis, carried out by calculating the efficient frontier for various equity portfolios based on ESG scores, confirms the relevance of the scoring method.

Specifically, we found a more favorable Sharpe ratio for low ESG risk portfolios than for high ESG risk portfolios.

However, our conclusions must be tempered by the intrinsic limitations of this study, notably those associated with data availability and the constraints of the model employed. We have suggested improvements to make this study even more relevant, including a more rigorous selection of countries and a more thorough consideration of the size factor.

An "envelope scenario" has also been established to further explore this ESG investment opportunity. With the limitations identified and improvements suggested, we are convinced that there is still much to discover and learn in the vast field of ESG investing.

Conflict of Interest: The authors reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

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