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Does It Pay Off to Integrate ESG Performance into Bank Investment Portfolio Selection? Empirical Evidence in the European Energy Sector

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Abstract: There is a growing awareness of the need to integrate non-financial information arising from environmental, social, and governance (ESG) factors into corporate strategies, processes, and credit risk assessment to generate long-term value. Our paper aims to develop, through a Data Envelopment Analysis (DEA)-based approach, a credit risk assessment tool that could be used by banks in constructing an efficient and sustainable investment portfolio, able to maximize banks' probability contemporaneously minimizing corporate inefficiency. This study was carried out on a sample of publicly traded energy companies in Europe, with the energy sector being highly environmentally sensitive. Our portfolio selection model proves to be a valuable tool for building an efficient and sustainable investment portfolio because it leads, within a budget constraint, to selecting both the most efficient companies in absolute terms and those for which ESG scores significantly improve corporate financial efficiency. Additionally, our results show that ESG ratings at high or low levels do not affect overall company efficiency, but at a middle level, they increase it. Findings contribute (and provide suggestions) to policymakers, credit risk managers, and academics.

Keywords: environmental; social and governance (ESG) performance scores; sustainable portfolio; data envelopment analysis (DEA); listed energy firms

Citation: Baldissarro, G.; Bruni, M.E.; Iazzolino, G.; Morea, D.; Veltri, S. Does It Pay Off to Integrate ESG Performance into Bank Investment Portfolio Selection? Empirical Evidence in the European Energy Sector. *Sustainability* **2024**, *16*, 10766. https://doi.org/10.3390/su162310766

Academic Editor: Matteo Rossi

Received: 19 November 2024
Revised: 1 December 2024
Accepted: 6 December 2024
Published: 9 December 2024

1. Introduction

Environmental, social, and governance (ESG) factors are at the forefront of academic debate. In the literature, the terms corporate social responsibility (CSR), sustainability (including environmental and social issues), environmental, social, and governance (ESG) and, more generally, non-financial information (NFI) are often used as synonymous even if ESG can be considered the evolution of the corporate social responsibility (CSR) concept since it specifies three core typologies of stakeholder–firm relationships: environmental, social, and governance [1]. More specifically, ESG and CSR represent distinct approaches to sustainability. ESG emphasizes measurable criteria that investors and stakeholders use to assess a company's performance in environmental, social, and governance areas, as well as the associated risks and opportunities. In contrast, CSR takes a broader, value-driven approach to corporate ethics and societal impact, often expressed through voluntary initiatives and community engagement.

Stakeholders increasingly request companies to disclose non-financial information in their sustainability reports, and a growing number of companies, abandoning the long-held view that shareholders' interests should come first, have voluntarily integrated social and environmental policies into their business model and operations, reporting their environmental and social performance in addition to their financial performance [2]. The

pressure for companies to integrate social issues into their strategic plans and management systems to face stakeholders' expectations led regulators to issue new mandatory legislative frameworks to foster the development of a responsible approach to business, with the aim to enhance transparency between companies and stakeholders, improving the quality of non-financial information disclosed [3]. The reference in Europe is to the Directive 2014/95/UE, also known as Non-Financial Reporting Directive (NFRD) and its evolution in the 2022/2464 Directive, also known as the Corporate Sustainability Reporting Directive (CSRD), issued to overcome some limitations of the NFD and to advance the comparability of the NFI by promoting the adoption of the European Sustainability Reporting Standards (ESRS) in reporting ESG issues [1]. On the market, rating agencies are developing ESG scores measuring firms' ESG performance and exposure to ESG risks to allow stakeholders to compare how much a firm is socially and environmentally responsible [4].

On the other side, institutional investors, such as credit institutions [5], are interested in collecting information on corporate ESG performance beyond the financial one as ESGs, beyond being viewed as a new virtuous approach to business, probably profitable in the near future, could be analyzed in terms of risk [4,6].

ESG factors are thus emerging as crucial in the banking context. Being committed to ESG issues is vital for banks because they not only, as any other firm, are called to pursue ESG performance to enhance their overall corporate performance in addressing stakeholders' expectations [7,8], but they also perform the task of transferring funds, through their lending activity, which has a significant impact on the economic growth [9–11]. This is so relevant that, from a regulatory standpoint, the new European Banking Authority (EBA) guidelines [12] have established a series of principles for credit institutions to adhere to by 30 June 2024 in managing and controlling credit risk that places equal emphasis on ESG factors, as well as qualitative and prospective information, in addition to a firm's financial and capital structure with the aim to promote sustainable lending [13,14].

While the banking system is aware of the strategic importance of ESG issues, their practical introduction into lending processes is still extremely heterogeneous and fragmented. Integrating ESG factors into credit risk assessment is a novel challenge for the financial industry and one of the future research streams [12,15], and ESG risk mitigation is starting to become relevant for investment portfolios [16,17].

Our paper intends to contribute to this literature stream by proposing a credit portfolio optimization tool that includes a firm's ESG performance as adjunctive credit worthiness criteria beyond financial performance. Our tool intends to investigate whether incorporating ESG factors into their loan decisions has led banks to maximize their performance and minimize their risk. In our model, this is accomplished by means of the weighted sum of two different objective functions into a simultaneous DEA model. The first aims to maximize the bank's profitability, which is measured by the number of loans; the second aims to minimize the risk by assigning an inefficiency score to each firm. DEA, a non-parametric approach, is employed to calculate how each company, using the company's input resources efficiently, produces ESG and financial performance.

This paper is original as it proposes a model to optimize the portfolio selection by contemporaneously maximizing the banks' profitability and minimizing the firms' inefficiency, introducing several points of novelty. Firstly, it measures the efficiency of firms by using a DEA-based approach that is able to return an efficiency score, including ESG performance. Second, it concentrates on the energy industry, which has been minimally explored [18]. To our knowledge, there are currently no studies in the existing literature that utilize a DEA approach to examine whether the inclusion of ESG factors enhances the corporate efficiency scores of companies and mitigates risk for banks.

We applied our model for the selection of the most ESG-efficient firms belonging to the energy sector, which is highly environmentally sensitive, where firms are exposed to higher social pressures and public concerns and are more likely to employ greenwashing and impression management strategy to manage their reputational risk [18–20]. Furthermore, a recent article [17] provided evidence that an ESG score cannot yet be considered an

additional and uniformly valid ex ante criterion for selecting assets, as it modifies its sign and significance in different sectors, justifying research focused on a single sector.

Our findings show that our proposed model is a valuable tool for building an efficient and sustainable investment portfolio as, when including ESG as an additional outcome in the DEA model to calculate the firms' efficiency scores, the bank's lending choice is more profitable (i.e., the number of loans increases). In addition, our findings show that high/low levels of ESG scores do not affect companies' efficiency; instead, at a moderate level, ESG scores improve the corporate efficiency score.

Our findings are interesting for practitioners, as they could apply our model to other sectors. As regards managerial implications, our results can help credit risk managers reflect on the opportunity to adopt a sustainable lending policy to achieve competitive advantage. As regards policy implications, our results are in line with the EBA guidelines [12], justifying the current approach of banking authorities to focus more on ESG risks than opportunities [9].

We contribute to the existing literature from several perspectives. First, this research focuses on the bank's lending decision and ESG, which is a stream of literature still under research [15]. As a matter of fact, there are few studies in the literature that have incorporated ESG in the creditworthiness evaluation, and there exists a call in the literature to deepen this research line that our paper addresses [4]. Second, we use the DEA methodology to measure firm efficiency. This approach eliminates the issues associated with relying on a single performance metric, whether accounting-based or market-based. It also incorporates ESG performance as an additional measure, providing a more comprehensive view of performance without requiring any assumptions about the functional relationship between financial and ESG metrics. This non-parametric approach addresses difficulties arising from ambiguous, inconclusive, and contradictory results regarding the association between corporate ESG and financial performance, as well as the potential reverse causal relationship between these two variables [21]. Third, it highlights the need for more industry-specific analyses emphasized in the literature [17], with a particular focus on the energy sector. This sector is both controversial and environmentally sensitive, yet it has rarely been examined in empirical studies [20]. Fourth, having been applied to a sample of energy firms, our model allows us to detect the significance of ESG performance in affecting overall firm efficiency in this highly environmentally sensitive sector. Fifth, this paper considers European listed energy companies instead of focusing on USA ones, which is the predominant context analyzed in the empirical research.

The rest of this paper is organized as follows: Section 2 presents the literature review. Section 3 describes the methodology employed, including the data set used and the selected sample. Section 4 presents and discusses the empirical results. Section 5 concludes the paper, highlighting the implications and limitations of this study as well as the future research directions.

2. Literature Review

2.1. Theoretical Framework and Research Questions

Theoretically speaking, different established theories can be used to support a link between bank risk-taking on the one hand and ESG on the other. According to the stakeholder theory [22], a change from shareholder-focused to stakeholder-focused governance will balance the interests of stakeholders who invest and those who do not invest in banks, restraining excessive risk-taking by management and preserving bank value. Considering this, ESG-based governance ought to be inversely correlated with bank risk-taking [23]. Contrarily, the overinvestment hypothesis predicts that ESG will have a negative influence on bank performance because it causes a firm to divert limited resources away from increasing shareholder wealth, which reduces investment and lowers bank value [24]. In addition, the Resource Dependence Theory (RDT) is important for understanding how firms manage their environmental, social, and governance (ESG) dependencies to improve performance. By recognizing their reliance on key resources, organizations can strategically address

ESG factors vital for maintaining reputation and achieving long-term sustainability [25]. Integrating ESG considerations into operations enhances sustainability performance and aligns with economic objectives, as improvements in environmental and social performance are positively linked to economic outcomes [26]. Moreover, effective corporate social responsibility (CSR) initiatives, informed by RDT, can strengthen stakeholder relationships and provide a competitive advantage, reinforcing the connection between ESG factors and overall performance. Thus, RDT emphasizes the importance of managing environmental and social dependencies to achieve superior firm performance in a resource-constrained environment. Consistently with the "stakeholder" view, we formulate our research question:

RQ1: *How do ESG factors affect the financial efficiency of energy companies?*

RQ2: *Is a bank's portfolio selection more efficient (less risky and more profitable) when ESG factors are considered in evaluating a firm's performance?*

2.2. Empirical Studies

The empirical literature on ESG has mainly focused on trying to understand how and whether ESG affects the performance of firms, including financial institutions, with mixed results. Ref. [27], in their meta-analysis of 2200 studies, found that roughly 90% of studies show a non-negative ESG–corporate financial performance (CFP) relation, and the large majority of studies report positive findings, also for banks [23,28,29], even if the effect is found to be weak [30,31], nonlinear [32,33], and mediated by other variables [34].

As we aim to contribute to the ESG literature, deepening how attention to ESG factors can modify the assessment of creditworthiness via internal rating by credit institutions, we are interested in the literature concerning the impact of ESG factors in the portfolio selection process. Lending is one of the main types of banking operations, and the provision of bank loans is a fairly risky activity that banks face when obtaining the necessary (mainly financial) information on the repayment capability of the borrowers. For the bank, the purpose of a credit risk assessment is to make a decision on whether to lend or not, with the aim of maximizing the profit of the credit portfolio. This portfolio selection problem is one of the main financial topics [35]. The essence of the credit portfolio optimization problem is then to select borrowers from a set of firms asking for credit according to one or more decisional criteria. Traditionally, the portfolio selection problem dealt with the trade-off between return and risk, measured using financial performance indicators and credit risk. Nowadays, many investors include ESG as a selection criterion, resulting in institutional investors and banks considering its inclusion in their portfolio selection [35].

The literature on ESG performance and access to loans could be analyzed from the company, investment funds, and banking sides [36].

From the company's perspective, ref. [37] investigated the relationship between corporate social responsibility (CSR) and bank debt. Their study, which analyzed a sample of 3996 loans to U.S. firms, revealed that companies with social responsibility concerns pay between 7 and 18 basis points more in interest than those with better CSR practices. Similarly, ref. [38] examined a sample of publicly listed non-financial firms in Europe over an 8-year period from 2005 to 2012 and found that corporate social performance (CSP) positively impacts the reduction in debt capital costs.

Ref. [39] shows that only a few constituents of CSP matter in creditors' perceptions of firms' risks. Ref. [40], analyzing the effect of ESG disclosure on the cost of debt by a fixed-effects analysis conducted on a sample of 8264 observations revealed a negative effect of ESG disclosure on the cost of debt financing. Ref. [41], focusing on a sample of 3915 unlisted firms from developing economies, found that firms with better environmental performance received higher loans, and the same result was found by [36] for sustainable Italian SMEs. Ref. [42], investigating the association between ESG ratings and the credit default swap (CDS) for European and U.S. firms from 2016 to 2019, found evidence that higher ESG ratings mitigate credit risks according to a nonlinear association. Ref. [43],

investigating S&P500-listed companies between 2002 and 2017, provided evidence of a nonlinear and wholly negative relationship between ESG and a firm's total risk. Ref. [44], exploring the relationship between companies' ESG assessments and their risk (systematic and volatility) exposures for a sample of 222 large-cap companies belonging to the S&P500 stock market index for 2014–2018, found that ESG assessment tends to increase firms' risk exposure and the uncertainty among investors.

From the perspective of investment funds, refs. [45] and [46] found that ESG factors do not impact the financial performance of mutual funds. In contrast, ref. [47] emphasized that differences in return and risk among ESG funds are primarily influenced by fund-specific criteria rather than a uniform ESG factor.

Ref. [48], measuring the impact of portfolio liquidation in a stress scenario on funds with different ESG ratings, found that the relative market value loss of the high ESG-ranked funds is lower than the loss experienced by the low ESG-ranked counterparts in a lower-volatility period, but they do not find differences in the high-volatility period of one class over another. Ref. [49], analyzing Morningstar's ESG ratings and the performance of Norway mutual funds, did not find evidence of rating level effects, but by dividing the sample into ESG quintiles, they found significantly higher returns for the top ESG quintiles. Ref. [17], examining the link between the risk–return performance and the ESG score of different sectoral portfolios entirely composed of ESG assets, found that the average return is positive, but the performance is still heterogeneous among the different sectors, implying that an ESG score cannot yet be considered an additional and uniformly valid ex ante criterion in selecting assets for portfolio managers. Similarly, ref. [16], conducting a multi-sectoral analysis using a sample of companies from different European sectors, found that ESGs impact firm efficiency differently across sectors, as some of them are more sensitive than others to ESG factors.

From the bank's perspective, ref. [50] construct a credit score on sustainability issues, providing evidence that banks that consider sustainability in their lending decisions would have fewer reputational risks. Ref. [24], examining the changes in ESG rating announcements on CDS spreads of European firms, a proxy for credit risks, found evidence that better CSR ratings lead to lower CDS spreads. Ref. [23], examining European banks, found that ESG scores are strongly associated with a reduction in bank risk-taking. Ref. [51], conducting their research on worldwide banks from 2002 to 2018, provided evidence of the risk-reducing benefit of CSR engagement proxied by the ESG score (driven by environmental pillar). Ref. [15] found that ESG scores are strongly and very significantly associated with a reduction in bank credit risk.

A recent systematic literature review provided evidence that there has been no systematization in the way in which ESG risks have been examined in previous ESG portfolio studies and highlighted, as a first, a need for future research to propose and empirically validate novel portfolio selection models that have been proposed over the years. By proposing and testing our novel portfolio selection, we address this research avenue.

3. Methodology

The section illustrates our novel selection portfolio model and the choice of the sample on which to implement the model.

3.1. The Proposed Portfolio Selection Model

In designing our portfolio selection model, we need to consider two distinct dimensions: 1. the ability of the bank manager to increase the value of the loan portfolio, and 2. the ability of the bank manager to maximize profitability and, hence, the number of loans. Value could be measured by market value indicators such as Tobin's Q [52], financial values such as Revenues and Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA), asset values such as the value of Total Assets and the Book value of capital [52]. Indicators such as the EBITDA are widely recognized as crucial from an economic point of view and, together with classical meaning, can be used for different kinds of analysis [53].

Consistently with [31], we decided to employ the DEA to measure the firm's efficiency. DEA was developed by [54], who used a definition of relative efficiency originally proposed by [55]. Using DEA allows us to estimate corporate efficiency by considering several input and output factors. DEA is a non-parametric approach usually used to evaluate the efficiency and inefficiency of a group of companies called decision-making units (DMUs). DEA can also serve as an early-warning index for assessing credit risk [56,57]. In this method, the efficiency measure is obtained from the optimal solution of a mathematical model that considers multiple input–output variables for each company. It does not need to assume linearity between inputs and outputs, and for this reason, it can be fruitfully used to capture the supposed nonlinear relationship between corporate efficiency and ESG scores identified in several articles [32,33,42,43].

DEA has some shortcomings when applied to portfolio selection. To overcome this drawback, we present a novel model of general applicability, providing an integrated framework for loan portfolio selection that considers all the characteristics of the decision problem faced by the banks and is performed into two separate steps.

Table 1 presents the sets, parameters, and decision variables of our novel DEA model.

Table 1. Sets, parameters, and decision variables of the model (source: authors' elaboration).

Sets	J : set of candidate credit applicants indexed by j A : set of inputs indexed by a B : set of outputs indexed by b
Parameters	T maximum risk budget of the bank $p_{aj}, a \in A$ value of the input $o_{bj}, b \in B$ value of the output $\pi_j, j \in J$ probability of default of the firm j $EL_j, j \in J$ insolvency of the firm j
Decision variables	$x_j = \begin{cases} 1 \text{ if the candidate } j \text{ is included into the loan portfolio} \\ 0 \text{ otherwise} \end{cases}$ v_{aj} the a-th input weight assigned to candidate j w_{bj} the b-th input weight assigned to candidate j θ_j the inefficiency score assigned to candidate j

We first present the ordinary DEA model in Table 2 to highlight the differences with our combined DEA model reported in Table 3. The output-oriented DEA model is solved separately for each DMU. For the generic jth DMU, it minimizes the inefficiency θ_j. Moreover, all the DMUs are considered.

Table 2. Objective functions and constraints of the model (source: authors' elaboration).

Objective function	$min : \theta_j,$
Constraints (s.t.)	$\sum_{a \in A} v_{aj} p_{aj} = 1,$ $\sum_{b \in B} w_{bj} o_{bj'} - \sum_{a \in A} v_{aj} p_{aj'} \leq 0, j, j \in J, j' \neq j,$ $\sum_{b \in B} w_{bj} o_{bj} + \theta_j = 1,$ $v_{aj} \geq \varepsilon, a \in A,$ $w_{bj} \geq \varepsilon, b \in B,$ $\theta_j \geq 0$

The original model is then modified according to the simultaneous DEA model presented in [58]. In particular, the inefficiency of all the DMUs is evaluated by solving one comprehensive model instead of a single model for each DMU. Binary variables are also introduced to represent the selection of a specific DMU in the optimal portfolio. In particular, x_j will assume value one if the DMU is selected and zero otherwise. To maximize the

bank's profitability, a second objective function is also considered, which is to maximize the number of loans the bank grants. To limit the insolvency risk, a constraint limits the expected loss of the bank to a maximum value. The total expected loss is evaluated considering the sum of the products between the probability of default of a DMU multiplied by its insolvency.

Table 3. Objective functions and constraints of the model (source: authors' elaboration).

Objective functions	$max: \sum_{j \in J} x_j,$	(1)
	$min: \sum_{j \in J} \theta_j,$	(2)
Constraints (s.t.)	$\sum_{j \in J} EL_j \pi_j \leq T,$	(3)
	$\sum_{a \in A} v_{aj} p_{aj} = x_j, \forall j,$	(4)
	$\sum_{b \in B} w_{bj} o_{bj'} - \sum_{a \in A} v_{aj} p_{aj'} \leq (1 - x_j), j, \acute{j} \in J, j \neq \acute{j},$	(5)
	$\sum_{b \in B} w_{bj} o_{bj} + \theta_j = x_j, \forall j \in J,$	(6)
	$v_{aj} \geq \varepsilon x_j, a \in A, j \in J,$	(7)
	$w_{bj} \geq \varepsilon x_j, b \in B, j \in J,$	(8)
	$w_{bj} o_{bj} \leq x_j, b \in B, j \in J,$	(9)
	$x_j \in \{0, 1\}, \forall j \in J,$	(10)
	$\theta_j \geq 0, \forall j \in J$	(11)

Table 3 illustrates the objective functions and the constraints of the model.

The objective function (1) maximizes the bank's profitability, measured by the number of loans. The objective function (2) minimizes the total inefficiency scores assigned to DMUs. Constraints (3) to (11) outline the limitations of the model. Specifically, constraint (3) restricts the expected loss of the bank, thereby mitigating credit risk. Constraints (4) to (9) relate to the DEA component of the model, which operates as a simultaneous DEA model. Constraint (4) states that the sum of weighted inputs for any selected firm in the portfolio must equal one. Constraint (5) ensures that the assigned weights for each firm in the portfolio are such that no other firm in the portfolio can achieve an efficiency score greater than one using the same weights. It is important to note that these are logical constraints that become active only when a firm is included in the portfolio. Constraint (6) defines the inefficiency variable θ_j as a function of the weighted outputs. Additionally, constraints (7) and (8) ensure that only non-dominated efficient solutions within the DEA model are considered. Constraint (9) requires that the input and output weights for any firm not included in the portfolio be set to zero. Finally, constraints (10) and (11) specify the nature of the decision variables.

Weighting the two objectives with a parameter $\lambda \in (0, 1)$, the bi-objective model can be transformed into a single objective model as follows:

$$max: \lambda \sum_{j \in J} x_j - (1 - \lambda) \sum_{j \in J} \theta_j \quad (12)$$

The proposed model addresses the multi-criteria nature of lending decisions by assessing loan portfolio performance across various dimensions, including both financial and non-financial factors (using ESG criteria). This approach maximizes the efficiency of the loan portfolio while enhancing the profitability of loan operations.

The model explicitly addresses the uncertainty associated with providing bank loans, which is an inherent aspect of the lending process, as outlined in constraint 3. This consideration aligns with the well-known risk–return relationship. Several measures of the risk are the z-score [59], the CDS spread [24], and the ratio of "banks' nonperforming loans to total loans" [60]. In our model, risk pertains to the potential losses a bank may incur from a specific credit portfolio if a borrower defaults on their obligations. We evaluate the

expected portfolio loss as the product of the probability of default (probability of default) and the value of assets at risk at the time of default (credit exposure), which we have set at 20% of total corporate debt. Additionally, we impose a constraint that limits expected portfolio loss to remain below an upper bound, referred to as budget risk, which we have established at €5 million.

3.2. Sample and Data

We decided to address our research question in an environmentally sensitive sector—namely, the energy industry—where firms are exposed to higher social pressures and public concern. Consistently with [18,19], we believe that it is interesting to research the energy sector from a sustainable angle as it is under stronger pressure and at risk of losing its legitimacy. Despite the significant environmental impacts of the energy industry—including coal, oil, and gas, renewable energy, and uranium—existing research on sustainability accounting in this sector is limited. The International Energy Agency reports that energy-related carbon dioxide (CO_2) emissions constitute most of the global greenhouse gas (GHG) emissions. Specifically, oil and gas are the largest contributors to fuel combustion emissions, accounting for approximately 53% of global energy-related CO_2 emissions. Sustainability has long been a vital concern for companies in the energy sector. Their sustainability strategies revolve around compliance with health, safety, and environmental regulations, as well as enhancing their contributions to the communities in which they operate, all aimed at creating long-term value. These firms are now striving to achieve both cost-efficient and environmentally friendly operations. The environmental impact of energy activities has particularly shaped the perceptions of the younger generation, leading to a negative view of industry. Beyond managing their reputations, energy companies have additional incentives to prioritize sustainability, including compliance with environmental regulations, pressure from stakeholders, and a commitment to contributing to a sustainable future for the planet [20].

In detail, we focused our research on European listed energy companies. The extensive regulatory process of the European Union (EU), which has begun to institutionalize ESG disclosure inside corporate reporting procedures, served as the driving force behind the decision to concentrate on Europe in our research [18,61]. The EU released Directive No. 95/2014 on 22 October 2014 as a component of its CSR strategy for 2011–2014. This directive established a "reporting cut-off point" between the European region and the other geographical contexts by imposing specific non-financial disclosure requirements on all public interest entities with more than 500 employees [62]. In 2021, the EU Commission launched a proposal for a Corporate Sustainability Reporting Directive [63], issued in 2022, to expand the scope and reporting requirements of Directive No. 95/2014. At the same time, specific sustainability reporting standards have been under development by the European Financial Reporting Advisory Group (EFRAG) to increase the comparability and reliability of non-financial reports [64]. The data provided by these organizations can be considered reliable as they provide an independent evaluation and follow a rigorous process. We are conscious that the disagreement between ESG ratings is far larger than between credit ratings [65] and that ESG ratings evaluated by different providers are not homogeneous [66]. This could create confusion for investors [67] and scarce comparability of information [17], mainly due to a divergence of measurement [66]. In detail, the financial and sustainability data, i.e., ESG scores, will be collected from Refinitiv Eikon Asset4, a database widely used in the financial industry [17,44,68]. Refinitiv ESG, a significant provider of ESG ratings, is regarded as one of the most meticulous and reliable providers of ESG data [69]. In 2017, Thomson Reuters made significant changes in Asset4's rating process and rebranded Asset4 as Thomson Reuters Environmental, Social, and Governance (ESG) scores. Although Asset4's methodology partially changed in 2017, its overall structure remains intact. The Refinitiv database constructs its ratings at four levels: At the first level, there are many data points; at the second level, the data points are combined into indicators; at the third level, these indicators are synthesized into different categories (e.g., 18 categories in 2014); and at

the fourth level, the various categories are composed of few pillars. Before 2017, Asset4 comprised four pillars: (1) environmental pillar, (2) social pillar, (3) corporate governance pillar, and (4) economic pillar. In 2017, the economic pillar was removed, leaving three pillars (the environmental pillar, social pillar, and corporate governance pillar). A new pillar was introduced, namely, ESG controversy, which comprises 23 controversy indicators. After 2017, the overall rating (i.e., ESG score) is the equal-weighted average of indicators of the environmental (E) pillar, social (S) pillar, and corporate governance (G) pillar [70]. The Refinitiv ESG scores seem to be particularly suitable for our purpose thanks to their highly informative power and widespread application in the financial industry.

In our sample, we concentrate on 2020 since Refinitiv restated its data in April 2020 in a way that made it historically more highly linked with returns [69]. The final sample, constituted by European listed energy companies with all financial and ESG data available on Refinitiv, is made up of 50 companies. For these companies, we draw two input variables (Total Assets and Total Equity), three output variables (EBITDA, Revenues, and ESG scores), the total debt (as constraint 3 of our DEA model says that the default probability times the 20% of the total debt should be lower than or equal to an expected loss of 5 MLN€), and two measures of financial reliability, the probability of default and the credit ratings, useful to verify whether the efficient (with ESG score) companies are related with a lower default probability. Whilst the inputs and outputs have been defined based on the existing literature (ref. [71] used assets as input variables and [31] used revenues as output variables), the inclusion of ESG performance is a novelty of our model. In the literature, there are other attempts to include the ESG factor to measure firm efficiency. Ref. [21] proposes an energy-adjusted firm efficiency which includes energy inputs and energy outputs in the DEA model. Ref. [35] applied a fuzzy multi-criteria portfolio selection model that includes in the decision process, beyond the usual criteria of profitability and risk, the ESG behavior of the companies to create investment portfolios with 28 companies included in the Dow Jones Index Average (DJIA) stock over the period 2008–2019. All the variables have been extracted from Refinitiv. Table 4 presents the data of our DEA model and furthermore the credit ratings.

Table 4. Data (source: authors' elaboration).

Company Name	Country	DMU	Total Assets	Total Equity	EBITDA	Revenue	ESG	Total Debt	PD	Rating
Akastor ASA	Norway	dm1	1074.94	442.35	50.71	544.58	56.91	43.15	1.687%	6.00
Aker Solutions ASA	Norway	dm2	2560.76	751.23	118.36	2805.98	72.03	685.23	0.512%	3.00
BP PLC	U.K.	dm3	219,155.10	58,339.50	9144.36	86,746.95	85.53	13,416.20	0.280%	11.00
CGG SA	France	dm4	2765.50	916.81	285.43	726.03	76.49	225.45	1.333%	3.00
Dno ASA	Norway	dm5	2217.88	692.38	490.38	503.48	25.26	155.88	0.208%	10.00
Enagas SA	Spain	dm6	9008.92	2990.03	768.12	1053.60	83.46	970.44	0.714%	11.00
Eni SpA	Italy	dm7	109,648.00	37,415.00	9240.00	43,987.00	81.20	6340.80	0.311%	10.00
EnQuest PLC	U.K.	dm8	3162.70	74.69	349.71	707.32	43.55	351.29	0.415%	2.00
Equinor ASA	Norway	dm9	102,193.61	27,735.21	10,763.13	37,462.56	81.39	6241.71	0.212%	6.00
Etablissements M.P	France	dm10	1368.02	441.87	42.13	270.00	52.99	101.9	0.290%	5.00
Euronav NV	Belgium	dm11	3019.11	1892.89	680.71	991.03	55.82	208.53	1.912%	6.00
Fugro NV	Netherlands	dm12	1701.04	702.07	146.04	1386.30	73.77	95.85	0.265%	8.00
Galp Energia SGPS	Portugal	dm13	12,492.00	3160.00	1091.00	11,568.00	76.78	966.4	0.396%	9.00
Gazprom Neft' PAO	Russia	dm14	47,261.30	23,131.88	4076.00	22,188.49	62.28	1951.97	0.344%	2.00
Gazprom PAO	Russia	dm15	259,124.12	157,989.26	15,546.36	70,146.26	59.61	11,452.67	0.226%	6.00
Genel Energy PLC	U.K.	dm16	1269.63	761.32	63.29	130.76	56.95	57.04	0.335%	14.00
Grupa Lotos SA	Poland	dm17	4801.59	2542.61	187.02	4593.37	40.11	178.98	0.179%	11.00
Harbour Energy PLC	U.K.	dm18	7764.27	873.91	1433.64	1976.26	58.27	380.37	0.631%	8.00
Hunting PLC	U.K.	dm19	911.73	789.65	15.56	512.57	44.44	7.43	0.500%	14.00
John Wood Group	U.K.	dm20	8043.07	3414.40	467.21	6193.65	56.61	352.61	2.374%	6.00
Koninklijke Vopak	Netherlands	dm21	6498.60	2961.40	612.00	1190.00	67.21	531.54	0.250%	10.00
MOL Magyar Olaje Gazip	Hungary	dm22	15,257.49	6105.96	1413.97	11,066.57	64.78	630.6	0.207%	11.00
Motor Oil H.C.R SA	Greece	dm23	3408.73	1005.10	102.17	6120.44	68.33	301.66	1.186%	9.00
Neste Oyj	Finland	dm24	9815.00	5925.00	2357.00	11,751.00	70.77	261.4	0.118%	15.00

Table 4. *Cont.*

Company Name	Country	DMU	Total Assets	Total Equity	EBITDA	Revenue	ESG	Total Debt	PD	Rating
NK Lukoil PAO	Russia	dm25	66,484.68	45,750.43	7826.14	62,576.79	79.21	1464.08	0.302%	7.00
NK Rosneft' PAO	Russia	dm26	170,329.04	52,219.44	11,684.46	63,881.71	77.21	9747.04	1.367%	3.00
Novatek PAO	Russia	dm27	22,849.37	17,975.69	1730.58	7898.52	64.36	516.22	0.082%	11.00
OMV AG	Austria	dm28	49,271.00	13,740.00	4455.00	16,550.00	81.09	2387.20	0.241%	11.00
Petrofac Ltd.	Jersey	dm29	3415.21	329.98	162.94	3341.52	69.81	182.26	1.046%	12.00
PGS ASA	Norway	dm30	1714.40	324.57	203.31	387.46	61.56	214.36	2.970%	5.00
Pharos Energy PLC	U.K.	dm31	449.52	240.48	55.68	116.27	48.64	8.86	0.321%	7.00
Orlen SA	Poland	dm32	18,464.36	9138.15	982.45	18,932.73	61.93	860.04	0.422%	11.00
Polskie Gornictwo N.	Poland	dm33	13,812.02	9693.96	1882.95	8611.12	49.23	183.84	0.185%	15.00
Repsol SA	Spain	dm34	49,302.00	20,295.00	3263.00	33,282.00	82.45	3111.80	0.169%	10.00
Rubis SCA	France	dm35	4928.62	2501.05	506.40	3902.00	70.20	286.1	0.503%	14.00
Saipem SpA	Italy	dm36	11,262.00	2923.00	605.00	7399.00	89.35	691.2	2.540%	8.00
SBM Offshore NV	Netherlands	dm37	9076.40	2093.67	885.12	2862.52	69.33	920.66	0.453%	9.00
Scorpio Tankers Inc	Monaco	dm38	4223.88	1691.45	415.95	749.93	47.40	499.11	0.914%	8.00
Shell PLC	U.K.	dm39	310,544.64	127,167.83	24,169.34	147,828.61	88.52	17,688.37	0.255%	11.00
Siemens G.R.E SA	Spain	dm40	16,341.51	4934.09	348.62	9483.21	68.50	334.08	2.991%	7.00
Snam SpA	Italy	dm41	25,675.00	6469.00	2165.00	2770.00	88.84	3187.40	0.306%	12.00
Surgutneftegaz PAO	Russia	dm42	75,893.86	64,097.06	6957.59	22,631.40	75.93	41.37	0.237%	5.00
Tatneft' PAO	Russia	dm43	14,019.59	9184.14	2029.72	9031.33	46.49	139.91	0.318%	13.00
Tenaris SA	Luxembourg	dm44	11,230.82	9222.05	522.51	4214.15	67.48	143.51	0.604%	8.00
TGS ASA	Norway	dm45	1644.82	1038.78	219.50	294.77	68.30	9.89	0.178%	9.00
Torm PLC	U.K.	dm46	1636.49	833.10	241.63	611.94	61.67	137.95	0.725%	9.00
TotalEnergies SE	France	dm47	217,908.88	84,911.20	16,014.91	98,013.64	90.07	12,394.50	0.203%	10.00
Transneft' PAO	Russia	dm48	47,967.68	30,641.40	7084.92	15,326.44	47.25	1896.38	0.186%	9.00
Transocean Ltd.	Switzerland	dm49	17,853.12	9360.52	1061.16	2580.86	54.48	1351.18	1.374%	3.00
Vestas W.S. A/S	Denmark	dm50	18,160.00	4654.00	1391.00	14,819	79.24	270.8	0.268%	15.00

4. Empirical Results and Discussion

The first set of experiments was carried out with the aim of testing the correlation between ESG and financial reliability. In particular, we calculated the correlation between (i) efficiency (with ESG scores) and credit rating and (ii) efficiency (with ESG scores) and probability of default. Our results do not show the existence of a relationship between ESG scores and financial reliability. The correlation coefficient between efficiency values, calculated considering ESG scores, and credit ratings and PD, is around values very close to zero (0.0026 and 0.0725). This is in line with recent studies on the impact between ESG activities and corporate performance, which emphasized that an investment strategy linked to ESG factors does not significantly affect the profitability or value of the company in the energy sector [19] or even found negative association between ESG performance and corporate financial performance in the oil and gas industry [20]. More generally, this trend is also confirmed in other sectors: [72], conducting a panel study on Malaysian companies not belonging to the energy sector found no significant relationship between individual and combined factors of ESG and firm profitability (e.g., Return On Equity—ROE) as well as firm value (e.g., Tobin's Q). Even in the utilities sector, the study by [73] did not find a significant relationship between ESGs and financial performance.

Table 5 shows the ESG value for each DMU and the efficiency results with and without ESG.

In addition, Figure 1 shows through a histogram the differences in the efficiency values calculated with and without ESG as the output of the model.

As we can observe, for those companies with high ESG scores (ESG score > 80), the efficiency score remains the same regardless of whether ESG factors are considered or excluded from the efficiency evaluation. Furthermore, of 10 companies in the sample with higher ESG scores and low efficiency, 8 of them are characterized by having higher debts than their peers despite having similar equity values. This is expressive of an unbalanced financial structure, which could have been caused by an overinvestment in ESG, consistent with the overinvestment theory [23,33]. These companies could be perceived as riskier by investors [44]. For those companies with high ESG scores (ESG score > 80) and good financial efficiency scores, the combined efficiency score remains the same regardless of whether the ESG factors are considered or excluded from the efficiency score. The results of the first phase do not provide evidence of the significance of ESG factors in affecting firms' efficiency. In detail, our results, consistent with the findings of [31], show that high/low ESG scores do not affect the company efficiency, which is the same with or without ESG

scores; instead, at a moderate level (going from 44.44 to 77.21, Table 2), ESG scores improve the corporate efficiency. In other words, ESG factors have a positive effect on a firm's corporate efficiency only at a medium level. In a similar vein, other studies highlighted a weak link between ESG and corporate performance/risk [23,30,31]. Theoretically speaking, our results are in line with the overinvestment theory, according to which ESG may have detracted from companies' value by diverting scarce resources out of investment.

Table 5. Efficiency scores with and without ESG (source: authors' elaboration).

DMU	ESG	Efficiency without ESG	Efficiency with ESG	GAP	PD
dm1	56.91	0.358	0.709	0.3518	1.687%
dm2	72.03	0.707	0.824	0.1171	0.512%
dm3	85.53	0.353	0.353	0.0000	0.280%
dm4	76.49	0.483	0.626	0.1431	1.333%
dm5	25.26	1.000	1.000	0.0000	0.208%
dm6	83.46	0.384	0.384	0.0291	0.714%
dm7	81.20	0.459	0.459	0.0000	0.311%
dm8	43.55	1.000	1.000	0.0000	0.415%
dm9	81.39	0.559	0.559	0.0000	0.212%
dm10	52.99	0.196	0.569	0.3726	0.290%
dm11	55.82	0.939	0.993	0.0543	1.912%
dm12	73.77	0.604	0.823	0.2188	0.265%
dm13	76.78	0.805	0.805	0.0000	0.396%
dm14	62.28	0.419	0.419	0.0000	0.344%
dm15	59.61	0.250	0.250	0.0000	0.226%
dm16	56.95	0.208	0.415	0.2067	0.335%
dm17	40.11	0.568	0.568	0.0000	0.179%
dm18	58.27	1.000	1.000	0.0000	0.631%
dm19	44.44	0.325	0.658	0.3335	0.500%
dm20	56.61	0.497	0.497	0.0000	2.374%
dm21	67.21	0.409	0.439	0.0303	0.250%
dm22	64.78	0.594	0.594	0.0000	0.207%
dm23	68.33	1.000	1.000	0.0000	1.186%
dm24	70.77	1.000	1.000	0.0000	0.118%
dm25	79.21	0.679	0.679	0.0000	0.302%
dm26	77.21	0.414	0.414	0.0000	1.367%
dm27	64.36	0.315	0.318	0.0025	0.082%
dm28	81.09	0.486	0.486	0.0000	0.241%
dm29	69.81	1.000	1.000	0.0000	1.046%
dm30	61.56	0.610	0.913	0.3025	2.970%
dm31	48.64	0.526	1.000	0.4744	0.321%
dm32	61.93	0.626	0.626	0.0000	0.422%
dm33	49.23	0.568	0.568	0.0000	0.185%
dm34	82.45	0.486	0.486	0.0000	0.169%
dm35	70.20	0.580	0.626	0.0460	0.503%
dm36	89.35	0.537	0.537	0.0003	2.540%
dm37	69.33	0.535	0.559	0.0231	0.453%
dm38	47.40	0.434	0.466	0.0320	0.914%
dm39	88.52	0.436	0.436	0.0000	0.255%
dm40	68.50	0.359	0.359	0.0000	2.991%
dm41	88.84	0.403	0.403	0.0000	0.306%
dm42	75.93	0.382	0.382	0.0000	0.237%
dm43	46.49	0.603	0.603	0.0000	0.318%
dm44	67.48	0.270	0.288	0.0183	0.604%
dm45	68.30	0.556	0.730	0.1739	0.178%
dm46	61.67	0.631	0.779	0.1482	0.725%
dm47	90.07	0.421	0.421	0.0000	0.203%
dm48	47.25	0.615	0.615	0.0000	0.186%
dm49	54.48	0.253	0.257	0.0043	1.374%
dm50	79.24	0.705	0.705	0.0000	0.268%

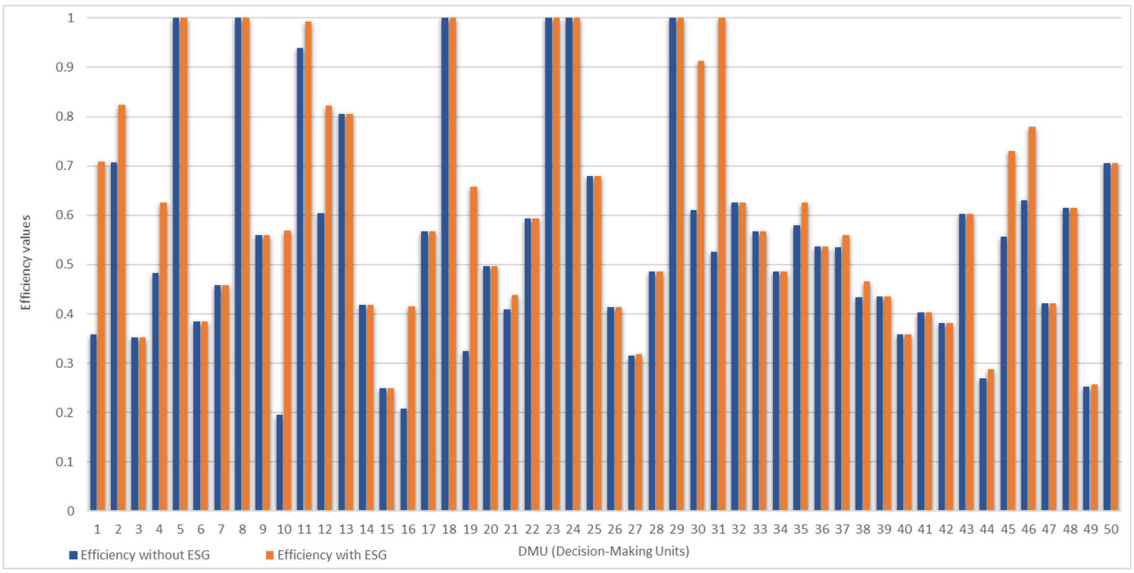

Figure 1. Histogram of efficiency values with and without ESG (source: authors' elaboration).

The second set of experiments is devoted to the bank's optimal lending decisions. As can be seen from Table 6, 10 out of 50 companies are selected, which saturates the budget risk of the bank. They represent those companies that have maximized both the efficiency of the loan portfolio (with ESG) and the bank profitability (number of loans) by choosing a threshold of 0.7.

Figure 2 compares, for the 10 selected companies, the combined efficiency with ESG with the combined efficiency without ESG.

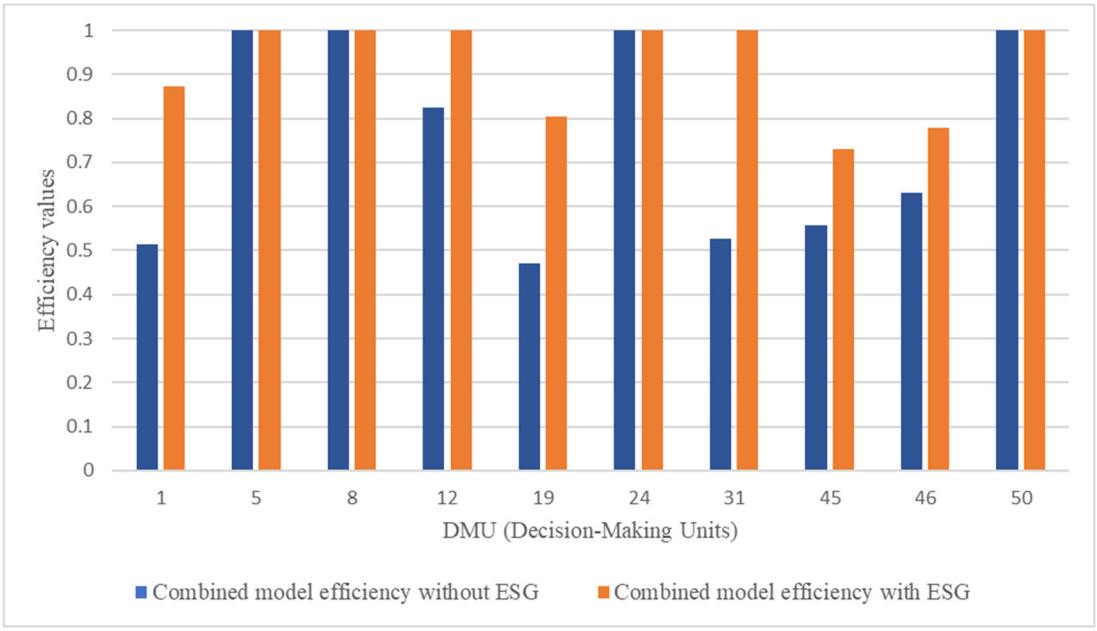

Figure 2. Efficiency with and without ESG of selected companies (source: authors' elaboration).

Table 6. Selected efficient companies (source: authors' elaboration).

DMU	ESG	Combined Model Efficiency without ESG	Combined Model Efficiency with ESG
dm1	56.91	0.514	0.873
dm2	72.03		
dm3	85.53		
dm4	76.49		
dm5	25.26	1.000	1.000
dm6	83.46		
dm7	81.20		
dm8	43.55	1.000	1.000
dm9	81.39		
dm10	52.99		
dm11	55.82		
dm12	73.77	0.825	1.000
dm13	76.78		
dm14	62.28		
dm15	59.61		
dm16	56.95		
dm17	40.11		
dm18	58.27		
dm19	44.44	0.470	0.803
dm20	56.61		
dm21	67.21		
dm22	64.78		
dm23	68.33		
dm24	70.77	1.000	1.000
dm25	79.21		
dm26	77.21		
dm27	64.36		
dm28	81.09		
dm29	69.81		
dm30	61.56		
dm31	48.64	0.526	1.000
dm32	61.93		
dm33	49.23		
dm34	82.45		
dm35	70.20		
dm36	89.35		
dm37	69.33		
dm38	47.40		
dm39	88.52		
dm40	68.50		
dm41	88.84		
dm42	75.93		
dm43	46.49		
dm44	67.48		
dm45	68.30	0.556	0.730
dm46	61.67	0.631	0.779
dm47	90.07		
dm48	47.25		
dm49	54.48		
dm50	79.24	1.000	1.000

Among these 10 companies, 4 maintain high-efficiency scores both with and without ESG, meaning that if a company is already financially efficient, the ESG does not impact the overall efficiency. In addition, we can notice that the ESG score of the six remaining selected companies does not have a very high value; instead, they record a moderate ESG value. The results of the second phase, i.e., the application of the asset allocation optimization model, show that our proposed model is a valuable tool for building an efficient and sustainable

investment portfolio because both the most efficient companies in absolute terms and those for which ESG scores significantly improve corporate financial efficiency are selected.

5. Conclusions

ESG issues are the subject of increasing interest from stakeholders, companies, and national and international regulators. Within the banking sector, ESG awareness is even more crucial, as credit institutions are not only expected by stakeholders to integrate ESG factors into strategies, business models, and reporting processes as any other company, but European banks also face increasing pressure from financial regulators to integrate sustainability factors into their lending decision-making process with the ultimate aim to encourage banks to promote sustainable lending.

Banks have started to recognize that their lending and investment operations could affect the health of the planet and are taking action to decrease the financing of projects that damage the environment, also considering the reputational risks associated with continuing to fund unsustainable companies [74] and benefits to lend to sustainable companies for generating long-term value [75–78].

However, ESG is still not a deciding factor in risk models by commercial banks, especially when they adopt a short-term vision [9,50].

Our paper contributes to the literature stream by focusing on how banks incorporate ESG criteria into their lending process by proposing a new portfolio selection model. This two-step approach employs a DEA model to obtain an assessment of the financial and ESG efficiency of companies while minimizing the total inefficiency score, combined with an asset allocation optimization model that aims to maximize the bank profitability expressed in terms of bank loans.

We implemented our model to a sample of European listed energy firms, focusing on a specific sector as recent research provided evidence that it is not possible to assess a unique intensity and direction of the relationship between ESG and the firm's performance/risk for all sectors [17]. However, we think that one of our three results is valid in all sectors and industries. We found that an unbalanced investment in ESG factors does not yield financial benefits and instead leads to economic inefficiency for companies, particularly in the short term.

We decided to focus on the energy sector as it is an environmentally sensitive one, and companies belonging to this industry (coal, oil, and gas, renewable energy, and uranium) are subjected to intense social and environmental scrutiny because of the nature of their activities [6]. Focusing on the energy sector from a banking creditworthiness point of view seems important, as lending to carbon-intensive energy industries has always entailed significant operational, credit, and political risks, and banks must consider financial and reputational risks associated with continuing to invest in carbon-intensive energy technologies [74,79].

Our portfolio selection model reveals to be a valuable tool for building an efficient and sustainable investment portfolio because it considers a budget constraint and respects the criterion of low default probability (or high credit rating) to select both the most efficient companies in absolute terms and those for which ESG scores significantly improve corporate financial efficiency. Our results are in line with other empirical studies [15,50], not in line with other studies [35], but they are consistent with stakeholder theory.

Additionally, our results provide evidence that ESG performance affects firms' overall efficiency only at a moderate level, highlighting a weak positive association with financial performance, as underlined by other studies [17,30]. This result highlights that the most significant variables in guiding overall performance are financial variables [80]. This could be explained by considering that ESG may have a short-term impact on profits, but the implementation of ESG is beneficial for the long-term development of the company, which is consistent with stakeholder theory [9,21].

5.1. Limitations of This Study and Future Research Directions

The results obtained are largely due to the model being applied to the measurement of variables included in the model, the sample of companies selected, and the period analyzed. Further research is needed to validate the results stemming from preliminary evidence concerning the application of our multi-criteria portfolio optimization model to a sample of listed energy firms [35]. Future research directions should thus consider refining the methodology to apply it to other industries and a larger number of companies for many years to obtain a general validation of the results [4].

Our portfolio selection model is influenced by the input–output DEA model, the budget constraint, the maximum expected loss, the fixed threshold value, and the chosen measures of financial value, ESG performance, and credit risk. The DEA methodology is well-regarded for its ability to assess relative efficiency without requiring explicit weightings; however, it carries inherent assumptions and constraints that merit discussion. Firstly, the DEA approach presupposes that all decision-making units (DMUs) operate under similar conditions and have access to comparable resources. This assumption may not hold true in diverse ESG contexts, where companies face varying regulatory, cultural, and operational landscapes. Additionally, the deterministic nature of DEA renders it sensitive to outliers and noise in the data, which can distort efficiency scores if inaccuracies or anomalies are present. The dataset further complicates matters, as the variability and lack of standardization among ESG scoring systems introduce additional challenges. ESG ratings often reflect differing methodologies, weightings, and underlying metrics across providers. For instance, one scoring system might prioritize environmental factors, while another emphasizes governance, leading to inconsistencies in company evaluations. This misalignment can affect the choice of inputs and outputs for DEA, potentially introducing bias and diminishing the comparability of results. Moreover, ESG data is frequently self-reported, raising concerns about data reliability and the risk of greenwashing. Variability in data quality and availability across industries or regions could undermine the robustness of the DEA model's conclusions. To address these limitations, future research could investigate the integration of probabilistic or stochastic DEA models to account for uncertainty and variability in ESG data. Additionally, developing a standardized framework for ESG metrics could enhance comparability across different scoring systems.

In our model, both the input model and output variables (except for ESG) are accounting-based variables. Future research could consider including energy-based input and output into the DEA model [21], measures of financial performance beyond accounting-based ones (e.g., market-based, cash-flow based), and other ESG measures beyond Thomson Reuters, given that ESG scores vary greatly from one rating agency to another [35,81,82]. Furthermore, while our model focuses on the overall ESG score, future research could examine how each of the three ESG pillars individually affects the relationship between ESG and financial performance in the utilities sector. Special attention could be given to the environmental factor [31,80,83]. Future research could also consider incorporating other real-world constraints [35], using different budget risk levels for the constraint and different values of threshold to measure credit risk differently [24,35]. Future research could explore the ways in which lending activities contribute to the development of sustainable financial systems or how banks can implement more efficient risk management strategies. This could be accomplished using various quantitative methodologies, such as panel data regression or panel generalized method of moments (GMM) [84–86].

We applied our model to European listed companies from the energy sector, which are mainly large firms, especially in the coal, oil, and gas subsectors, and our results are based on a small sample of companies that publish non-financial statements connected with ESG. Further research can distinguish between heterogeneous subsectors in the energy industry, which have subsamples different in their attitude towards sustainability (e.g., coal towards renewable energy subsector) [80]. Future research could also be conducted in other industrial (controversial) settings by distinguishing the results according to the size of the companies (large, medium, and small). Furthermore, as our data are

drawn for 2020, future research could widen the time span beyond 2020, also considering whether the ESG–financial performance relationship has been affected by the COVID-19 pandemic [68,80,87–90] or how the pandemic has affected the process of estimating and managing market risk in financial markets [91]. Future research could be carried out by using other market-based indicators, such as Tobin's Q, EV/EBITDA, or P/E. With respect to ESG criteria, international guidelines, which are widely used in corporate settings for reporting and measuring ESG performance, could be used, such as SASB (Sustainability Accounting Standards Board) or CDP (Carbon Disclosure Project).

Moreover, future research to increase the reliability of information could take into consideration not only the ESG good performance but also the ESG bad performance, such as environmental pollution and social conflicts, by measuring ESG scores combining ESG performance and the ESG controversy score, a measure of ESG risk [74,92]. Including ESG controversies in the model could also allow for control of the practices of "greenwashing", the well-known phenomenon of disseminating information that is false or incomplete about environmental, social, and governance factors [17], as ESG controversies are not controlled by firms and, hence, represent an effective indicator to express the market perception of firms' real compliance with ESG criteria [6].

Finally, further research could refer to modifying traditional models for credit risk analysis by including hypotheses related to different scenarios and conditions. Previous works tried to introduce modified models as well [93]. In our case, including sustainability-related elements could mean considering a different framework.

5.2. Implications for the Theory, Practices, and Policymaking

Our findings have useful implications for academic researchers, investors, bank managers, firms' managers, and regulators. Academic researchers could apply the tool we developed to different sectors and time spans, testing the validity of other measures of financial and ESG performance. Potential investors could use our tool to select sustainable yet efficient companies to invest in. Bank managers could consider selecting sustainable companies in their lending process to maximize their profitability. As our results provide evidence that moderate ESG performance improves the overall firm performance, firms' managers can incentivize ESG engagement (at least until a threshold point). In doing so, both banks and firms would achieve significant positive externalities for the environment in which the firm is embedded.

As for the policy implications, the consideration that the weak link between ESG scores and firm performance could be linked to an increasing amount of extra non-univocal financial information on the markets (i.e., the lack of standardization of sustainability reports and the divergence of ESG ratings), poses a fundamental issue in terms of regulation. New and effective regulations for ESG reporting and ESG metrics are needed, aimed at making non-financial communications more transparent for investors and also providing companies with standardized and unambiguous indications for measuring and reporting ESG indicators [4,82,94]. The establishment of a standardized framework for ESG reporting could enhance transparency and facilitate comparability across different firms and sectors. By adopting such frameworks, stakeholders would be better equipped to assess the true impact of ESG initiatives on financial performance, addressing the inconsistencies noted in previous studies regarding the ESG–financial performance relationship [95]. Moreover, standardization can help mitigate the risks associated with greenwashing, where firms may exaggerate their sustainability efforts without delivering genuine benefits. As banks increasingly integrate ESG considerations into their risk management practices, they must prioritize ongoing dialogue with regulatory bodies to ensure that evolving standards reflect both market realities and stakeholder expectations. Ultimately, fostering a collaborative environment among regulators, firms, and investors will be essential for driving meaningful progress towards sustainable economic growth while maintaining robust financial performance. This collaborative approach not only enhances transparency but also encourages innovation in sustainable practices, enabling companies to create long-term value for their

stakeholders while addressing pressing environmental and social challenges. Finally, this study's findings regarding the relationship between ESG factors and financial reliability can be understood within the context of the European Union's Corporate Sustainability Reporting Directive (CSRD), which marks a significant policy shift in sustainability reporting. Our results indicate that moderate ESG engagement—defined as ESG scores between 44.44 and 77.21—correlates with increased corporate efficiency, suggesting an optimal level for sustainability efforts. This implies that when ESG factors are appropriately calibrated, they can improve operational performance without negatively impacting financial outcomes. The CSRD advocates for double materiality, necessitating that companies disclose both the effects of sustainability issues on their financial status and their impacts on society and the environment. Promoting moderate ESG integration is consistent with the CSRD's goal of balancing sustainable practices with financial viability, allowing firms to illustrate and report on the tangible benefits of their ESG initiatives. The findings of this study offer practical insights for firms as they navigate the CSRD and similar regulatory frameworks. By highlighting the importance of strategic ESG investments—especially at moderate levels—this study provides a roadmap for achieving compliance while sustaining financial and operational efficiency. Additionally, it emphasizes the potential of standardized ESG reporting, as mandated by the CSRD, to enhance transparency and optimize resource allocation in support of sustainability objectives.

Author Contributions: Conceptualization: G.B., M.E.B., G.I., D.M. and S.V.; methodology: G.B., M.E.B., G.I., D.M. and S.V.; validation: G.B., M.E.B., G.I., D.M. and S.V.; formal analysis: G.B., M.E.B., G.I., D.M. and S.V.; investigation: G.B., M.E.B., G.I., D.M. and S.V.; resources: G.B., M.E.B., G.I., D.M. and S.V.; data curation: G.B., M.E.B., G.I., D.M. and S.V.; writing—original draft preparation: G.B., M.E.B., G.I., D.M. and S.V.; writing—review and editing: G.B., M.E.B., G.I., D.M. and S.V.; visualization: G.B., M.E.B., G.I., D.M. and S.V.; supervision: G.B., M.E.B., G.I., D.M. and S.V.; project administration: G.B., M.E.B., G.I., D.M. and S.V. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data is contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

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