Article

The Implications of Triple Transformation on ESG in the Energy Sector: Fuzzy-Set Qualitative Comparative Analysis (fsQCA) and Structural Equation Modeling (SEM) Findings

Theerasak Nitlarp [ID] and Theeraya Mayakul *[ID]

Faculty of Engineering, Mahidol University, Nakorn Pathom 73170, Thailand
* Correspondence: theeraya.may@mahidol.edu

Abstract: Digital transformation has emerged as a key driver of business innovation and growth in the 21st century. As organizations increasingly rely on digital technologies to operate and interact with customers, digital transformation has become an essential strategy for remaining competitive in today's rapidly evolving business landscape. Simultaneously, the relevance of environmental, social, and governance (ESG) issues has increased in the context of consumers, investors, and regulators, as the negative consequences of business activities on the natural environment and society become increasingly evident. In this research article, we examine the relationship between ESG and the triple transformation of business, people, and technology, as well as how organizations can use digital technologies to enhance their ESG performance. Our aim is to identify the principal drivers and mechanisms that shape ESG performance in the context of triple transformation and to investigate the trade-offs and synergies between different ESG dimensions. We used a mixed-methods approach combining fuzzy-set qualitative comparative analysis (fsQCA) and structural equation modeling (SEM) to examine the implications of triple transformation on ESG in the energy sector. The results showed that triple transformation has positive impacts on ESG performance, depending on the specific context and the interaction between different drivers and mechanisms. We suggest that energy companies that are able to effectively navigate the challenges and opportunities of triple transformation are likely to outperform their peers in terms of ESG performance. Our study contributes to the literature on ESG in the energy sector by providing a nuanced and dynamic view of the relationships between triple transformation and ESG performance.

Keywords: ESG; triple transformation; sustainability; business transformation; people transformation; digital transformation

1. Introduction

Environmental, social, and governance (ESG) reporting has experienced dramatic growth over the last couple of decades. Sustainability performance reporting has recently accelerated in the energy industry, including oil and gas businesses, oil refineries, green energy companies, and power companies [1]. However, this has not occurred across the board and by no means equally among companies. According to a 2020 Klynveld Peat Marwick Goerdeler (KPMG) study of the top 100 firms in each of 52 countries, 80 percent report on their sustainability performance, rising to 96 percent among the world's 250 largest corporations [2]. The recovery from COVID-19 provided a significant boost for the world's top firms in terms of sales. In 2021, the overall sales for the Fortune Global 500 reached USD 37.8 trillion, representing the greatest yearly growth rate in the list's history [3]. However, organizations are being pressured to transform the way they conduct business, strategy, and govern themselves. Demands for social, environmental, and climatic responsibility are increasing the pressure on businesses to operate more sustainably [4]. A study of the 100 largest companies worldwide found that 91 percent reported sustainability

information, with 51 percent providing sustainability assurance. There are concerns of greenwashing, with the potential for misleading or deceptive conduct leading to action from regulators, litigants, and class actions. Addressing sustainability issues is increasingly important and companies must be transparent in their ESG performance reporting to meet stakeholder expectations [5]. However, the complexity of ESG reporting and measurements has made it difficult to ensure the credibility of these reports [6,7]. The energy sector has long been a focus of attention due to the fact of its central role in the global economy and its environmental and social impacts [8]. In recent years, the concept of environmental, social, and governance (ESG) has gained increasing prominence as a framework for evaluating the sustainability of energy companies and the energy sector as a whole [9]. ESG encompasses a range of factors that can impact the long-term performance and risk profile of energy companies, including their environmental impact, social responsibility, and corporate governance practices [8,10]. There is growing evidence that ESG performance is closely linked to financial performance and that energy companies that prioritize ESG considerations are more likely to be successful in the long run [11]. This has led to increased pressure on energy companies to improve their ESG performance and to disclose information about their ESG practices.

Digital transformation is emerging as a driver of sweeping change in the world around us. Connectivity has shown the potential to empower millions of people while providing businesses with unparalleled opportunities for value creation and capture. Since the industrial revolution, the oil and gas industry has played a crucial part in global economic change, fueling the global population's desire for heat, light, and transportation [9]. Through digitization, the oil and gas industry now have the ability to redefine its boundaries. After a period of dropping oil prices, repeated budget and schedule overruns, increased expectations for climate change accountability, and difficulty retaining talent, the oil and gas industry is able to provide real answers [9]. The energy sector is undergoing a major transformation, driven by the simultaneous and interconnected processes of decarbonization, decentralization, and digitalization [12–14]. This transformation is likely to have significant implications for the energy sector and the broader economy, as it involves not only technological changes but also business and social transformations [5]. The triple transformation consists of three interconnected dimensions: people transformation [15–18], business transformation [12,19–22], and technology transformation [9,17,23–26]. People transformation refers to the changes in values, attitudes, and behaviors of individuals and communities concerning energy. This includes shifts in the way that people consume and produce energy, as well as their participation in the energy system. Business transformation involves the evolution of business models, strategies, and practices of energy companies in response to the triple transformation. This includes the development of new products and services, as well as the adoption of new technologies and business processes. Technology transformation refers to the development and deployment of new technologies that enable triple transformation, such as renewable energy, energy storage, and smart grids. The triple transformation is likely to have significant implications for ESG in the energy sector. For instance, the transition to low-carbon energy sources may help to reduce environmental impacts, while decentralization and digitalization may enable more participatory and democratic energy systems that are better aligned with social values. However, the triple transformation also presents challenges and risks, such as the potential for technological disruption and social inequality, which may impact ESG performance.

In this study, we aim to explore the implications of the triple transformation for the energy sector, with a particular focus on the people, business, and technology dimensions. The data sample size was 280 ESG reports worldwide. These reports were compiled based on the Standard & Poor's (S&P) Corporate Sustainability Assessment (CSA) [27] and focused on energy companies operating in various countries and regions worldwide. The companies included in the sample were publicly traded and had significant operations in the energy sector, including oil and gas, renewable energy, and electricity. The ESG reports were collected in 2021, and the data were organized in a compatible format. The

characteristics of the energy sector include high levels of regulation and government involvement, large amounts of capital investment required for infrastructure and exploration, and a reliance on natural resources. The sector also tends to be technology intensive, with ongoing advancements in areas such as renewable energy and energy storage. We use a mixed-methods approach combining fuzzy-set qualitative comparative analysis (fsQCA) and structural equation modeling (SEM) to examine the implications. Our objective was to uncover the fundamental drivers and mechanisms that influence ESG performance in the context of triple transformation, as well as the main contributions that follow:

- Exploring the implications of the triple transformation (people, business, and technology) for the energy sector, with a focus on ESG performance;
- Combining fuzzy-set qualitative comparative analysis (fsQCA) and structural equation modeling (SEM) to provide a comprehensive understanding of ESG performance in the context of triple transformation;
- Uncovering the fundamental drivers and mechanisms that influence ESG performance in the energy sector;
- Investigating synergies across various ESG dimensions.

This paper is organized as follows: In Section 1, there is a comprehensive discussion on the triple transformation and ESG in the energy sector, and Section 2 provides an overview of the topics examined by previous works and research and highlights the gap that this study aims to address. In Section 3, we describe the study's dataset which was collected based on the S&P CSA from energy companies worldwide. The methodology adopted fuzzy-set and path analysis. Section 4 outlines the research model and evaluates the extent to which it integrates with the triple transformation and ESG, with a specific focus on the energy industry. Finally, in Section 5, we summarize the main contributions, limitations, and future research suggestions.

2. Literature Review and Hypothesis Development

2.1. Technology Transformation

Technology transformation in the energy sector refers to the process of adopting and integrating new technologies in order to improve the efficiency, reliability, and sustainability of energy production, distribution, and consumption [28,29]. This process often involves the deployment of advanced technologies, such as renewable energy sources, smart grids, and energy storage systems, as well as the integration of digital technologies, such as Internet of Things (IoT) devices and analytics software [30]. To comprehend and lead technology transformation activities in the energy sector, numerous essential theories and frameworks have been created. The technical innovation system (TIS) framework is one such theory, emphasizing the role of numerous actors in the development and diffusion of new technologies, such as corporations, research institutions, and government agencies [28,30]. According to this concept, the ability of various actors to interact and coordinate their efforts in order to overcome hurdles to innovation is critical to the success of technology transformation in the energy sector [31].

The diffusion of innovations idea is another important notion, which posits that the adoption of new technologies follows a predictable pattern over time [32,33]. This theory suggests that the adoption of new technologies is influenced by various factors, such as the perceived benefits and risks of the technology, the availability of resources to support its adoption, and the existence of social norms and networks that support or discourage its use. Furthermore, the notion of sustainability transitions theory has also been used in the energy sector in order to comprehend the drivers and obstacles of the broad adoption of sustainable technology [9,12,15,34,35]. This concept posits that technological change in the energy sector is driven by the interplay of various forces, including economic, social, and political factors [32]. Identifying the complex interconnections between these forces can help policymakers and industry stakeholders determine the most effective ways to promote the adoption of new technologies and facilitate the transition to more sustainable energy systems [32,33].

The technology transformation in the energy sector highlights the importance of considering the various actors and factors that influence the adoption and diffusion of new technologies, as well as the role of sustainability in driving technological change [36–38]. This study, therefore, tests the following hypothesis to determine whether technology transformation is positively related to people transformation and whether technology transformation is positively related to business transformation [39].

Hypothesis 1 (H1). *There is a significant positive relationship between technology transformation and people transformation.*

Hypothesis 2 (H2). *There is a significant positive relationship between technology transformation and business transformation.*

2.2. People Transformation

Digital transformation is strengthening the functions of human resources professional staff [40]. Experts believe that process standardization and automation, together with the improved decision making that results, may greatly increase human resource productivity [41]. According to industry studies, digital transformation has had a substantial influence on the recruiting sector [42]. The social sustainability aspects of digitalization extend beyond the creation of the world's leading industrial employment opportunities. Industry 4.0 and the digitization of the manufacturing sector contribute to a greener and more sustainable business, leading to the creation of millions of sustainable manufacturing employment opportunities. The integration of environmental, social, and governance (ESG) considerations into the energy sector has gained significant attention in recent years [43]. This includes efforts to reduce greenhouse gas emissions, protect natural resources, and promote social and economic development in the communities where energy is produced and consumed [44].

The concept of people transformation in the energy sector refers to the process of shifting from traditional energy practices that prioritize economic growth and profits above all else to a more holistic and sustainable approach that takes into account the needs and well-being of people and the environment [45]. This transformation involves both technical and organizational changes, as well as cultural shifts within the industry and a wide range of activities, including training and development, talent management, succession planning, and employee engagement [16,24]. There is a growing body of research on the economic and social benefits of people transformation and the integration of ESG considerations in the energy sector [46]. The recent findings by Eccles and Serafeim [43] show that companies with strong ESG performance had higher valuations and lower costs of capital compared to those with weaker ESG performance. Similarly, research by the World Bank [44] found that projects with a strong ESG performance had higher returns and were more likely to be successful.

Adoption of people transformation and ESG practices in the energy sector is often driven by a range of stakeholders, including investors, consumers, regulators, and civil society organizations [8,47,48]. These stakeholders are increasingly seeking out companies and projects that prioritize sustainability, and they are willing to allocate capital and other resources toward those that do so. At its core, people transformation is about empowering employees to be more effective and efficient in their roles and enabling them to contribute more fully to the success of the organization. The human capital theory states that an organization's human capital (i.e., its employees) is a valuable asset that can be invested in and grown through time [49]. According to this hypothesis, firms that invest in their human capital are more likely to increase their performance and competitiveness [50].

The integration of ESG considerations into the energy sector is seen as a key way to ensure that the industry can meet the energy needs of societies more sustainably and responsibly. The theoretical background of people transformation highlights the importance of investing in and developing human capital as a strategic asset and emphasizes the

role of learning and knowledge management in driving organizational performance and competitiveness. This study, therefore, tests the following hypothesis to determine whether people transformation is positively related to business transformation

Hypothesis 3 (H3). *There is a significant positive relationship between people transformation and business transformation.*

2.3. Business Transformation

In the energy industry, business transformation relates to the procedure of fundamentally changing the way an organization in the energy sector operates in order to achieve significant and lasting improvements in its performance. This process can involve a wide range of activities, including the adoption of new technologies, the implementation of new business models and strategies, and the redesign of processes and systems [24,51]. Business transformation is often driven by the need to respond to changing market conditions, technological advancements, or shifts in customer preferences [52,53].

The firm's resource-based perspective, which emphasizes the significance of intangible resources such as human capital in determining an organization's competitive advantage, is another important theory [53]. This theory suggests that firms that are able to effectively manage and leverage their human capital will be better positioned to create and sustain competitive advantages in the market. The concept of organizational learning has also been shown to be an important factor in people transformation efforts [52]. Organizational learning refers to the process by which organizations acquire, create, and share knowledge and learn from their experiences to facilitate and encourage learning at all levels of the organization and are better able to adapt to changing business environments and maintain a competitive edge.

The concept of business model innovation has also been shown to be an important factor in business transformation efforts in the energy sector. Business model innovation refers to the process of developing and implementing new ways of creating, delivering, and capturing value in the market [53]. By innovating their business models, organizations in the energy sector can create new sources of competitive advantage and achieve significant improvements in their performance [33,54]. The conceptualization of sustainability has also become increasingly important in the energy sector, as organizations look to address the social and environmental impacts of their operations and contribute to a more sustainable future [24,33,55]. This has led to the development of various sustainability frameworks, such as the triple bottom line (TBL) [24,56] and corporate social responsibility (CSR) [57,58], which emphasize the importance of balancing economic, social, and environmental goals in driving organizational performance.

Overall, the theoretical background of business transformation in the energy sector highlights the importance of leveraging a company's internal resources and fostering a culture of learning and innovation, as well as considering sustainability, in driving organizational performance and competitiveness. This study, therefore, tests the following hypothesis to determine whether business transformation is positively related to ESG performance.

Hypothesis 4 (H4). *There is a significant positive relationship between business transformation and the level of ESG information disclosure.*

2.4. The Triple Transformation and Social Responsibility of the Energy Sector

The integration of business transformation, people transformation, and technology transformation with social responsibility in the energy sector refers to the process of aligning an organization's operations and strategies with its social and environmental goals while also leveraging new technologies and human capital to drive innovation and competitiveness [57–59]. This process involves a wide range of activities, including the adoption of renewable energy sources, the implementation of sustainable business models, and the development of employee skills and capabilities [57]. In their decision-making

processes, corporations are obligated to consider the interests of all stakeholders, including shareholders, employees, consumers, and the community [52,53]. According to this notion, effectively managing their relationships with stakeholders and addressing their concerns are more likely to achieve long-term sustainability and success [53].

The triple bottom line (TBL) concept [24,56], which highlights the significance of considering social and environmental implications, in addition to financial performance, when evaluating organizational performance is an important argument. The TBL framework suggests that companies that are able to balance the economic, social, and environmental dimensions of their operations will be better positioned to create value for all stakeholders and contribute to a more sustainable future. The concept of corporate social responsibility (CSR) has also been shown to be an important factor in the integration of business transformation, people transformation, and technology transformation in the energy sector [8,48,60,61]. CSR refers to the voluntary actions that organizations take to address the social and environmental impacts of their operations and to contribute to the well-being of their stakeholders and the broader community [8,48,57]. By integrating CSR into their operations, organizations in the energy sector can demonstrate their commitment to sustainability and enhance their reputation and relationships with stakeholders.

The theoretical background of the integration of business transformation, people transformation, and technology transformation with social responsibility in the energy sector (see Appendix A Table A1) highlights the importance of considering the interests of all stakeholders and balancing economic, social, and environmental goals in driving organizational performance and sustainability. This study, therefore, tests the following hypothesis to determine whether the triple transformation is positively related to ESG performance (see Figure 1).
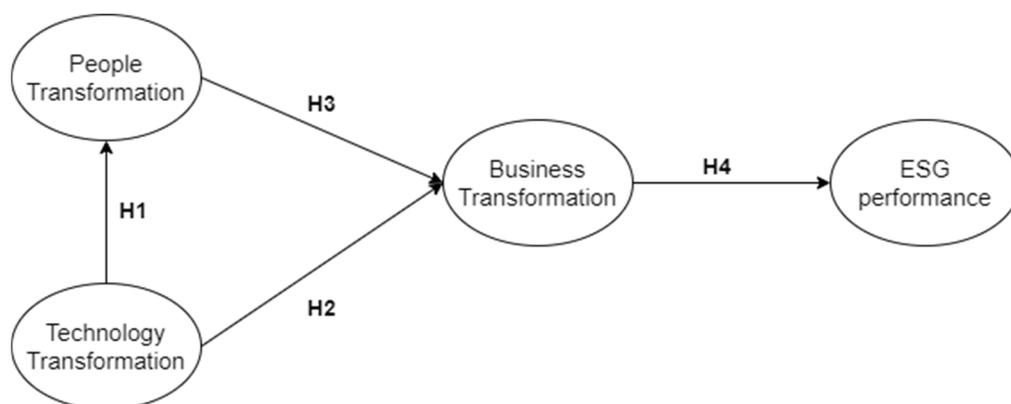

Figure 1. The research hypothesis development.

In this research article, we sought to understand the relationship between triple transformation and ESG using a mixed-methods approach that combines fuzzy-set qualitative comparative analysis (fsQCA) and structural equation modeling (SEM) [62–66]. The fsQCA is useful for identifying complex causal mechanisms and handling multiple causal pathways, while SEM is useful for testing causal relationships between variables and handling more quantitative data [67–72]. Both methods can be used in the analysis of ESG data and can help companies to better understand the relationships between various ESG factors and their impact on their business by examining the factors that influence digital transformation and its impact on ESG outcomes. Understanding the complex interactions between these variables provides insight into the conditions under which business, people, and technology transformation can support improved ESG outcomes and inform the development of strategies and policies that can support the integration of all four in the business world.

3. Materials and Methods

In this study, we aimed to explore the implications of the triple transformation for environmental, social, and governance (ESG) performance in the energy sector. To accomplish this, we gathered information from the ESG reports of 280 global energy companies for the year 2021 [27]. To analyze the data, we used a mixed-methods approach combining fuzzy-set qualitative comparative analysis (fsQCA) and structural equation modeling (SEM) [63,73,74]. The fsQCA is a multivariate and configurational method that allows us to identify and compare the combinations of elements that determine ESG performance in various contexts, whereas SEM is a statistical method that allows us to test hypotheses about the relationships between variables and estimate the strength and direction of these relationships.

Using fsQCA and SEM analyses, we examined the implications of the triple transformation on ESG performance in the energy sector. This methodology enabled us to present a thorough and constructive approach to the triple transformation and its consequences for ESG performance in the energy sector based on high-quality and reliable data from the S&P CSA-listed ESG reports [27], shown in Figure 2.
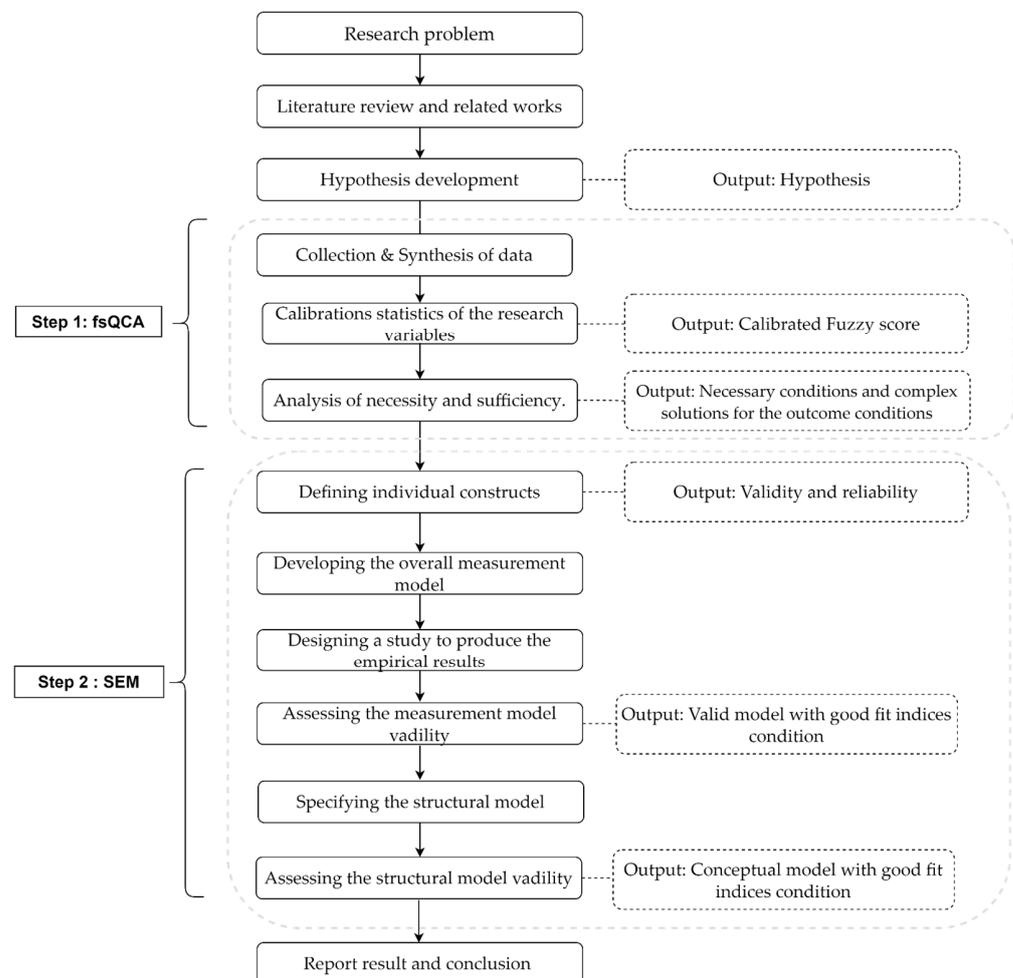
Figure 2. The research methodology.

3.1. Data Collection and Analysis

Data collection: Involved multiple steps. Based on the Standard & Poor's (S&P) Corporate Sustainability Assessment (CSA) [27], we first compiled a list of 472 energy companies operating in various countries and regions worldwide. We focused on firms that are publicly traded and that have significant operations in the energy sector, including oil and gas, renewable energy, and electricity. We then conducted a search for ESG information

published by these companies in 2021. We utilized a range of online databases and search engines, such as company websites, investor relations portals, and ESG rating organizations. To ensure the accuracy and reliability of our data, we only included 280 ESG reports worldwide based on the S&P CSA, which is a major methodology for evaluating the sustainability performance of publicly traded companies and incorporates a broad range of ESG indicators, including environmental, social, and governance aspects. In Figure 3, the color scale used in the world map provides a visual representation of the count of companies. The green is labeled to represent the highest count of companies, which was 75, while the red indicates the lowest count of companies, which was 1. This color scale helps to easily distinguish between different levels of the company counts and to provide a quick visual representation of the data. From Figure 4, it is clear that the United States, Canada, and Australia have the highest quantity of companies in the dataset. Europe also appears to have a high number of companies included in the dataset. These regions are likely the major contributors to the energy sector worldwide and, therefore, have a large representation in the dataset. After finding the relevant ESG reports, we collected and organized the information in a portable document format (PDF)-compatible format.
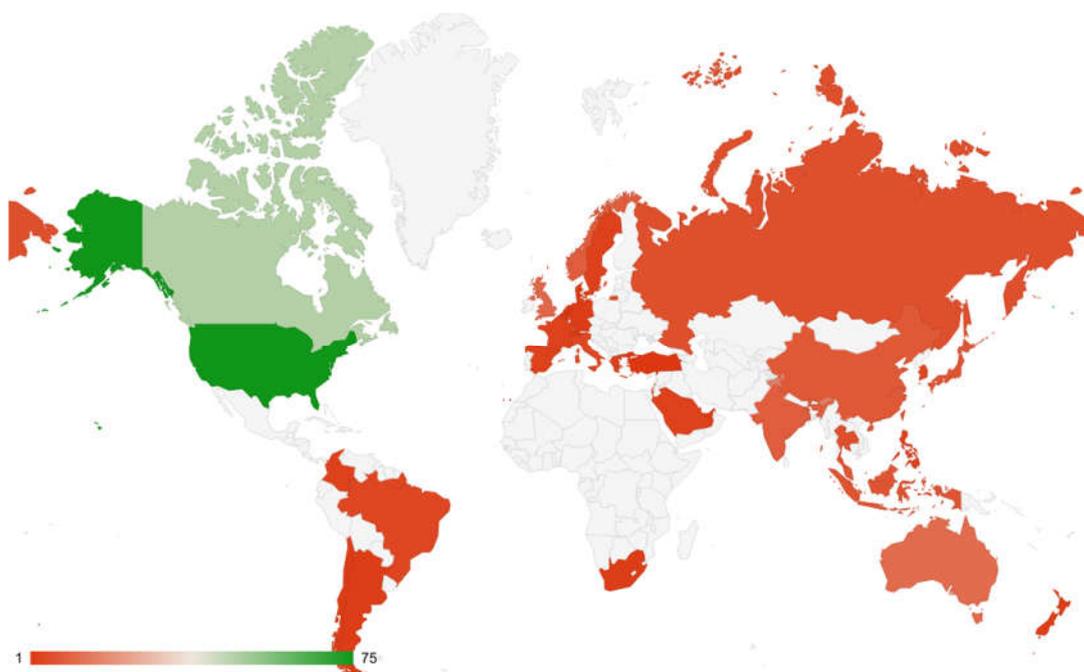
Figure 3. The energy companies worldwide. The color scale ranges from green, which represents the highest count of companies (75), to red, which represents the lowest count of companies (1).

Data analysis: After collecting the ESG reports, we analyzed the relevant information and focused on a core set of ESG indicators, such as environmental performance, social responsibility, and corporate governance. We also collected data on the triple transformation, including the firms' strategies, initiatives, and investments related to decarbonization, decentralization, and digitalization. To review and score the ESG reports, we used a 9-point Likert scale, with 1 point representing the lowest level of performance and 9 points representing the highest level of performance. We assigned scores to the ESG reports based on the quality and comprehensiveness of the information provided, as well as the alignment with the criteria and variables (see Appendix A Table A2). There were four steps to follow:

1. We first reviewed the ESG reports and identified the relevant information related to each variable listed in Appendix A Table A2.

2. For each variable, we evaluated the level of performance and assigned a score based on the following guidelines:

a. For variables related to environmental performance, we considered factors such as greenhouse gas emissions, energy consumption, and waste management

b. For variables related to social responsibility, we considered factors such as labor practices, human rights, and diversity and inclusion.

c. For variables related to corporate governance, we considered factors such as transparency, accountability, and ethical behavior.

3. We used the 9-point Likert scale to assign scores to the ESG reports based on the level of performance we evaluated for each variable. For example, if a firm performed exceptionally well with regard to a particular variable, we assigned it a score of 9, while if it performed poorly, we assigned it a score of 1.

4. Finally, we aggregated the scores for each variable to arrive at an overall score for each ESG report. The overall score reflected the overall performance of the firm with respect to the sustainability criteria. Our approach is consistent with the CSA methodology and best practices in ESG reporting [27].
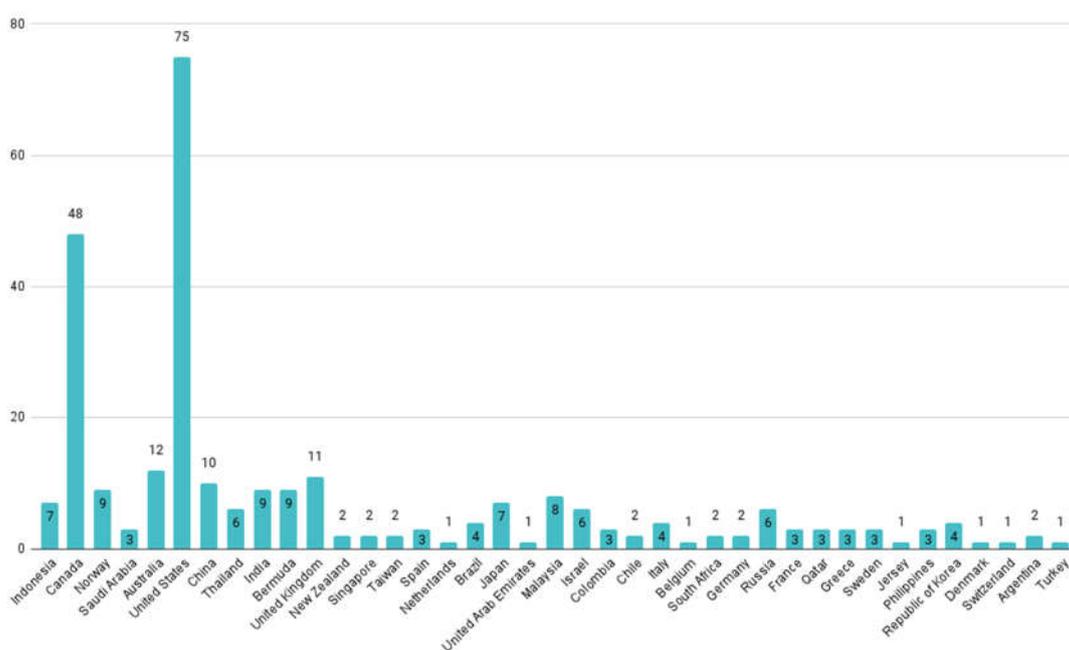
Figure 4. Count by country of energy companies. The United States, Canada, and Australia have the highest number of companies each, while Europe has the largest number of companies included in the dataset.

3.2. Fuzzy-Set Qualitative Comparative Analysis (fsQCA) and Structural Equation Modeling (SEM)

The fuzzy-set qualitative comparative analysis (fsQCA) and structural equation modeling (SEM) approaches [62–66] are two methods that have been widely used in the energy sector to understand and predict the factors that influence the adoption and diffusion of new technologies, as well as the performance and sustainability of organizations in the sector.

According to the fsQCA approach [67,68], causal relationships are defined as combinations of conditions called "inputs" that lead to a specific outcome called the "output". The fsQCA approach allows researchers to identify the necessary and sufficient conditions for an outcome to occur, as well as the potential moderating or mediating effects of other variables. The ability to evaluate complicated and nonlinear interactions, as well as deal with uncertainty and ambiguity in the data, is a fundamental advantage of the fsQCA method [68]. It is particularly useful for examining cases where there are multiple possible pathways to an outcome, or where the relationship between the inputs and outputs is not straightforward.

SEM is a multivariate statistical technique that allows researchers to test hypotheses about relationships between variables [69,70]. SEM is based on the idea that observed variables are influenced by latent (i.e., unobserved) variables and that these relationships can be represented in the form of a structural equation model [71] to estimate the strength and direction of the relationships between variables and to test the fit of the model to the data [69]. SEM's ability to evaluate multiple variables simultaneously and test complex hypotheses regarding variable correlations is a key characteristic [69,72].

Asymmetrical and symmetrical are two methods used in research to analyze and model complex relationships between variables. These methods are used in the social sciences, especially in the field of organization studies, to examine the relationships between independent and dependent variables. Asymmetrical is used to identify and analyze the combinations of conditions that lead to a certain outcome. Fuzzy-set QCA is based on the idea that there is a "fuzzy" boundary between categories, meaning that there can be cases that are partially in one category and partially in another. This method is useful for identifying complex causal mechanisms, as it can handle multiple causal pathways and allow for different degrees of membership in each category. Symmetrical is used to examine the relationships between variables in a more quantitative manner. SEM is a multivariate statistical technique that allows for the testing of causal relationships between variables. It allows for the simultaneous examination of multiple independent and dependent variables and can handle complex relationships between variables, including those that are nonlinear. SEM can also be used to test for mediating and moderating effects, and it can handle missing data and measurement errors.

3.3. Asymmetric Analysis Using the fsQCA Approach

The fsQCA is used to identify the necessary and sufficient conditions for a certain outcome to occur. The method involves applying set theory to comparative research, where sets of cases are compared to identify patterns and relationships. The approach is considered "fuzzy" because it allows for uncertainty and ambiguity in the data, which is often present in real-world situations [67]. In fsQCA, researchers define variables as fuzzy-sets and then use a combination of Boolean logic and mathematical operations to determine the relationships between the variables and the outcome of interest [67]. The steps involved in fsQCA include defining the research question and outcome of interest, defining the independent variables as fuzzy-sets, conducting a truth table analysis, and interpreting the results to identify the necessary and sufficient conditions for the outcome to occur [67].

In order to conduct a fsQCA analysis, it is necessary to first calibrate the dependent and independent variables into fuzzy-sets, the values of which lie from 0 to 1, where 0 = no set membership, 0.5 = crossover point, and 1 = complete set membership [67]. The fsQCA software was responsible for processing variables into calibrated sets. The consequences of this conversion are stated in Table 1 along with other informative details relating to the investigated causative conditions. As a result, the values can be quantified on a continuous scale (0, 1) that reflects the degree of association with the variable under investigation. The fsQCA's compositional structure enables the use of thought experiments in sociological research, as the theoretical matched cases will have unique configurations of the researched causative variables [68]. Before calibrating the variables, the study computed an index for each construct by averaging the related indications. The process of calibrating needs the specification of three anchors: complete membership, complete non-membership, and a crossover point [68]. The second step required a study of necessity. A condition is deemed essential if its consistency score is greater than 0.90 [68]. The proportion of fuzzy-set scores in a condition that is less than or equal to the equivalent scores in the result is shown by necessity analysis [75].

Table 1. Calibrations and Descriptive Statistics of the Research Variables.

Variable [Range]	Fuzzy-Set Calibrations							
	Top Quartile	Median	Bottom Quartile	Mean	SD	Min.	Max.	N-Case
Business (1–9)	7.8	3	1.3	0.49964	0.28846	0.05	0.95	280
People (1–9)	7.7	3	1	0.50675	0.29232	0.05	0.95	280
Technology (1–9)	7.8	3	1	0.49442	0.27922	0.05	0.95	280
ESG (1–9)	9	4	2	0.50557	0.30147	0.05	0.95	280

In the third step of the analysis, the fsQCA truth table technique was used to build a 2k-row truth table, where k is the number of outcomes and each row represents a unique permutation of the causal circumstances [67]. For instance, a truth table between two causal circumstances offers four different logical combinations. In this study, the frequency and consistency values of the truth table were examined. The findings of the fuzzy-set analysis are displayed in a truth table constructed by an algorithm using a two-step logical approach. From the primary data, a truth table worksheet was created to identify the causative and outcome conditions to include in the study. By selecting both consistency and frequency thresholds, the second step prepared the truth table worksheet for examination (see Table 2) [68]. The research then applied a consistency threshold greater than or equal to 0.80 [68], symmetric (SYM), and a proportional reduction in inconsistency (PRI) score threshold greater than or equal to 0.67 to avoid simultaneous subset relations of attribute combinations in both the outcomes and their negations in order to determine which configurations were adequate for achieving the outcomes [76]. In addition, the fsQCA software presented three solutions when these threshold values were applied: intermediate solution, parsimonious solution, and complex solution. This study examined the difficult solutions (see Table 3) for both outcomes, as there were no simplifying assumptions made for these answers. The values for consistency and coverage for any complex solution and its settings exceeded the minimum permitted levels.

Table 2. Fuzz set truth table.

Business	People	Technology	Number	ESG	Raw Consist.	PRI Consist.	SYM Consist.
0	1	0	2	1	0.93995	0.75312	0.75313
0	0	1	4	1	0.94371	0.74011	0.74011
0	1	1	14	1	0.97010	0.89061	0.89619
0	0	0	91	0	0.43158	0.08946	0.09047
1	0	0	2	1	0.94471	0.75081	0.75081
1	1	0	15	1	0.96648	0.88707	0.90223
1	0	1	19	1	0.96748	0.87596	0.88771
1	1	1	65	1	0.94787	0.87651	0.93076

In addition, the set coincidence results demonstrate that coincidence permits an examination of the continuum of complexity and enables researchers to discover intermediate approaches [67,68]. These are the solutions that have the highest complexity, both as subsets of the most parsimonious solution and as supersets of the solution (see Table 4). In the next step of our analysis, we used SEM to further examine and test the relationships between triple transformation and ESG performance.

Table 3. Analysis of necessity and sufficiency.

Condition	Consistency	Coverage
Business	0.852146	0.862259
~Business	0.509678	0.514989
People	0.862319	0.860315
~People	0.502119	0.514662
Technology	0.840279	0.859217
~Technology	0.524159	0.524159
Complex solutions for the outcome conditions		

Model: ESG = f (Business, Technology, People)
Algorithm: Quine–McCluskey
Frequency Cutoff: 2
Consistency Cutoff: 0.939953
Solution Coverage: 0.950763
Solution Consistency: 0.796438

Table 4. Sub/super solution.

Terms	Consistency	Coverage	Combined
Business × Technology × People	0.947877	0.734811	0.848596
Business × Technology	0.914713	0.777337	0.868342
Technology × People	0.921854	0.774159	0.866565
Business × People	0.915025	0.787298	0.873887
Technology	0.859217	0.840279	0.874445
Business	0.862259	0.852146	0.885423
People	0.860315	0.862319	0.885839

3.4. Symmetric Analysis Using the SEM Approach

In the following section, we describe the second step in our analysis, which involved conducting a symmetric analysis using SEM to evaluate and test the relationships between triple transformation and ESG performance. SEM is a statistical method that enables us to test hypotheses about the relationships between variables and to estimate the strength and direction of these relationships. It is particularly useful for testing complex and multi-dimensional models and for examining the direct and indirect effects of different variables.

To evaluate the structural equation modeling, we followed several steps. First, we conducted a first-order confirmatory factor analysis to test the reliability and validity of our measurement model. This is expected to evaluate the observed data to the hypothesized correlations between latent variables and observed indicators. Secondly, we conducted a path analysis to examine the structural connections between triple transformation and ESG performance. The aforementioned assessment of the direct and indirect effects of triple transformation on ESG performance, as well as the mediating roles of other variables, such as industry characteristics and corporate governance methods.

To ensure the validity and reliability of our SEM analysis, we used a range of fit indices and goodness-of-fit index (GFI) measures, including the root mean square error of approximation (RMSEA), the standardized root mean square residual (SRMR), Tucker–Lewis index (TLI), and the comparative fit index (CFI). We also used a sensitivity analysis to test the robustness of our results. This experiment's goodness-of-fit result was compatible with the agreed-upon condition based on cutoffs and Hu and Bentler's two-index presentation technique [77]. The RMSEA thresholds were at or below 0.06, SRMR thresholds were at or below 0.09, and TLI and CFI thresholds were at or above 0.96. For the relative chi-square (X^2/df), the cutoffs given by Wheaton et al. range from as high as 5.0 [78] to as low as 2.0 as recommended by Tabachnick and Fidell [79].

3.4.1. Measurement of the Variables and Evaluation of the SEM

Confirmatory factor analysis (CFA) is a powerful statistical method to assess the reliability and validity of a measurement instrument or a set of variables [74]. In CFA, a measurement model is developed to represent the underlying structure of a set of variables, and this model is then tested against the observed data to determine how well it fits the data. The goodness of fit is typically assessed by comparing the observed covariance matrix of the variables to the covariance matrix predicted by the model. In addition, CFA is essential for model validation in route or structural studies, making it a fundamental part of the SEM family [80,81]. In accordance with Dennis et al.'s [80] recommendation, this research included the standard formula for the $\chi2$ value, as well as the degrees of freedom and probability value, which provides a better overall assessment of model fits, to determine the ESG-related implications from the standpoint of triple transformation. The dataset used to evaluate the validity of the correlation dataset is presented in Appendix A Table A3, as well as the standard deviation of the observed variables (see Table 5). IBM SPSS was the software used to conduct the analysis and present the results. To ensure the reliability of the data, the validity of the correlation dataset was assessed using various statistical measures, such as Cronbach's alpha, Kaiser–Meyer–Olkin (KMO), and Bartlett's test, as shown in Table 6 [74,82,83]. Cronbach's alpha is a measure of the internal consistency of a scale, which refers to the extent to which the items in a scale measure the same underlying construct. In this analysis, the value of Cronbach's alpha was 0.947, and the individual Cronbach's alpha, composite reliability (CR), and average variance extraction (AVE) of each criterion are shown in Table 7, indicating that the items in the scale were consistent and reliable. Kaiser–Meyer–Olkin (KMO) is another measure of the internal consistency of a scale, which measures the proportion of variance in the items that can be accounted for by the underlying construct. In this analysis, the KMO value was 0.969, and the Pearson correlation coefficient (Appendix A Table A3) indicated that the items in the scale were suitable for factor analysis. Bartlett's test is a test of the null hypothesis that the correlation matrix is an identity matrix, meaning that there is no correlation among the variables in the scale (Appendix A Table A4). In this analysis, the value of Bartlett's test was 2469.861, with a significance level (Sig.) of 0.000.

Table 5. The observed variables and standard deviations.

Observed	N	Minimum	Maximum	Mean	SD
B1	280	0.05	0.95	0.4914	0.31271
B2	280	0.05	0.95	0.4804	0.30293
B3	280	0.05	0.95	0.4936	0.31583
B4	280	0.05	0.95	0.4916	0.31989
P1	280	0.05	0.95	0.4960	0.31022
P2	280	0.05	0.95	0.4992	0.31541
P3	280	0.05	0.95	0.5130	0.31454
T1	280	0.05	0.95	0.4719	0.29637
T2	280	0.05	0.95	0.5086	0.32224
T3	280	0.05	0.95	0.5113	0.32025
T4	280	0.05	0.95	0.4941	0.30798
Env	280	0.03	0.82	0.3612	0.26829
Soc	280	0.03	0.82	0.3727	0.27465
Gov	280	0.03	0.82	0.3382	0.25660
Valid N (listwise)	280				

It was found to be valid and appropriate [74,82,83], indicating that the SEM analysis was reliable and valid, which are measures of internal consistency and measures of sampling adequacy (MSA) between 0.950 and 0.980 (Appendix A Table A5). This dataset was then utilized to validate the structural equation model in the next stage. This provides strong evidence that the SEM analysis used in our study was able to accurately capture

the relationships between the variables and allowed us to make valid inferences about the impact of triple transformation and ESG on the energy industry.

Table 6. Bartlett's test, validity, and reliability statistics.

Statistics Test		Result
N of Items		14
Cronbach's Alpha		0.947
Cronbach's Alpha Based on Standardized Items		0.947
Kaiser–Meyer–Olkin Measure of Sampling Adequacy		0.969
	Approx. Chi-Square	2469.861
Bartlett's Test of Sphericity	df	91
	Sig.	0.000

Table 7. Reliability Statistics of each criterion.

Main Criteria	Cronbach's Alpha	AVE	CR	N of Items
Overall	0.947	0.593	0.953	14
Business Transformation	0.832	0.594	0.854	4
People Transformation	0.815	0.6142	0.826	3
Technology Transformation	0.847	0.593	0.853	4
ESG	0.793	0.572	0.800	3

3.4.2. First-Order Confirmatory Factor Analysis

A first-order CFA was conducted to examine the fit of the structural equation modeling to the data. In Table 8, there are a total of 14 factors, with 3 relating to people (P), 4 to business (B), and 4 to technology (T), environmental (Env), social (Soc), and governance (Gov). The overall fit of the model was compatible with the agreed-upon condition based on cutoffs. At the *p*-value level, all factor loadings were significant, showing that the items were assessing the targeted latent components.

There were three factors in the people transformation criteria. The results of the structural equation modeling analysis are as follows: people with the relative X^2 = 16.175, *p*-value = 0.000, TLI = 0.843, CFI = 0.948, GFI = 0.964, NFI = 0.945 and RMR = 0.006 had a positive and significant influence on variable P1 (β = 0.626), P2 (β = 0.617), and P3 (β = 1.000).

There were four factors in the business transformation criteria. The results of the structural equation modeling analysis were as follows: business with the relative X^2 = 5.800, *p*-value = 0.055, TLI = 0.972, CFI = 0.991, GFI = 0.989, NFI = 0.986, and RMR = 0.002 had a positive and significant influence on variable B1 (β = 0.991), B2 (β = 1.000), B3 (β = 0.917), and B4 (β = 0.922).

There were four factors in the technology transformation criteria. The results of the structural equation modeling analysis were as follows: technology with the relative X^2 = 1.133, *p*-value = 0.568, GFI = 0.998, NFI = 0.997, RMSEA = 0.000, and RMR = 0.001 had a positive and significant influence on variable T1 (β = 0.868), T2 (β = 0.999), T3 (β = 1.000), and T4 (β = 0.947).

There were three factors in the ESG criteria. The results of the structural equation modeling analysis were as follows: ESG with the relative X^2 = 25.494, *p*-value = 0.000, TLI = 0.704, CFI = 0.901, GFI = 0.945, NFI = 0.899, and RMR = 0.006 had a positive and significant influence on variable Env (β = 1.00), Soc (β = 0.591), and Gov (β = 0.551).

Table 8. The results of the first-order confirmatory factor analysis.

Observed	β	b_i	SE	r^2
	People Relative X^2 = 16.175, *p*-value = 0.000, TLI = 0.843, CFI = 0.948, GFI = 0.964, NFI = 0.945, and RMR = 0.006			
P1	0.626	0.635	0.046	0.403
P2	0.617	0.616	0.047	0.379
P3	1.000	1.000	-	1.000
	Business Relative X^2 = 5.800, *p*-value = 0.055, TLI = 0.972, CFI = 0.991, GFI = 0.989, NFI = 0.986, and RMR = 0.002			
B1	0.991	0.771	0.084	0.594
B2	1.000	0.77	-	0.542
B3	0.917	0.736	0.081	0.593
B4	0.922	0.701	0.085	0.491
	Technology Relative X^2 = 1.133, *p*-value = 0.568, GFI = 0.998, NFI = 0.997, RMSEA = 0.000, and RMR = 0.001			
T1	0.868	0.731	0.074	0.534
T2	0.999	0.773	0.081	0.598
T3	1.000	0.779	-	0.606
T4	0.947	0.767	0.077	0.589
	ESG Relative X^2 = 25.494, *p*-value = 0.000, TLI = 0.704, CFI = 0.901, GFI = 0.945, NFI = 0.899, and RMR = 0.006			
Env	1.000	1.000	-	1.000
Soc	0.591	0.577	0.05	0.333
Gov	0.551	0.577	0.047	0.332

4. Results and Discussion

This section outlines the findings that describe this specific case. Detailed descriptions highlight the implications and applicability of triple transformation and ESG from an energy perspective. The results are presented by two statistical techniques: fuzzy-set qualitative comparative analysis (fsQCA) and structural equation modeling (SEM).

In fsQCA, the study dataset was collected based on CSAs from energy companies worldwide. The approach was used to provide an asymmetric analysis of the data. This method provides a comprehensive examination of the underlying causal mechanisms between the variables of interest and helps to identify key drivers of the triple transformation and ESG. The SEM approach is a statistical technique used to examine the direct and indirect relationships between variables in a study. In SEM, a model is developed that represents the hypothesized relationships between the variables, and the model is tested against the data to determine its fit. The term "goodness of fit" refers to a statistic that determines how well the observed data matches the model. In the case of our study, SEM was used to provide a symmetric analysis of the data and to provide a deeper understanding of the causal relationships between the variables. Following the consideration of each of the principal ESG-related criteria independently, business transformation, people transformation, and technology transformation are examined. Both the fsQCA and SEM approaches were used to analyze the data, with the aim of providing a comprehensive picture of the triple transformation and ESG in the energy sector. The findings of our study provide strong evidence of the importance of incorporating ESG considerations into the energy sector and highlight the key drivers of the triple transformation and ESG in this industry.

4.1. The Implications of Triple Transformation on ESG Performance in the Energy Sector

A path analysis was conducted to assess the relationships between people transformation, business transformation, technology transformation, and ESG performance. In Figure 5, the model included four paths, representing the hypothesized direct and indirect effects between the variables. The overall fit of the model was good, with a goodness-of-fit index of GFI = 0.965, NFI = 0.970, CFI= 0.999, TLI = 0.998, RMSEA = 0.013, and RMR = 0.002. All paths in the model were significant at the 0.368 level, indicating that the results support the hypothesized relationships.
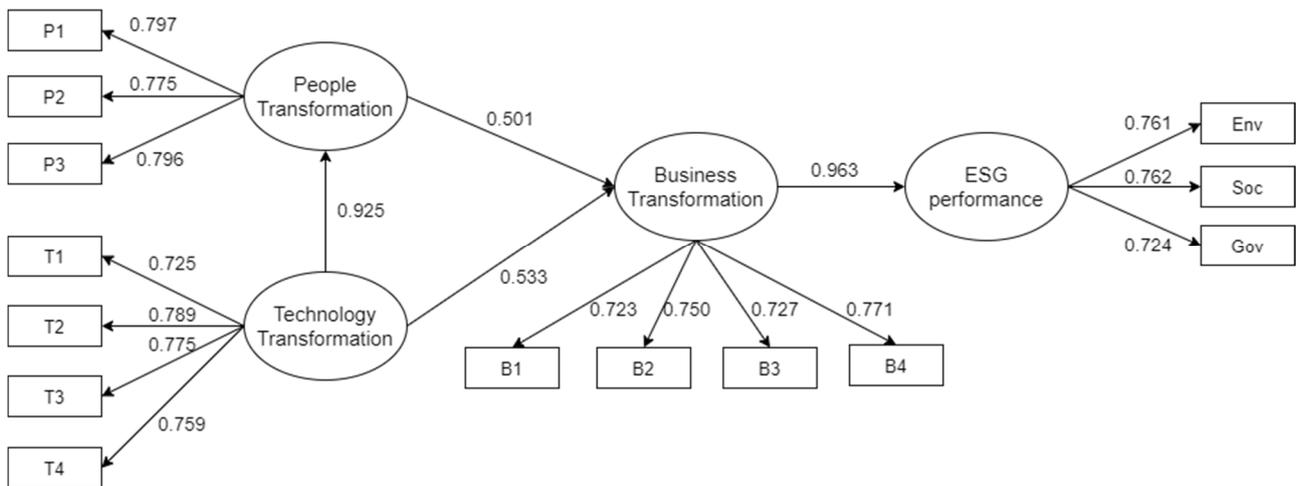

Figure 5. Path analysis result with Chi-square (X^2) = 74.396, degree of freedom (df) = 71, relative chi-square (X^2/df) = 1.048, probability level = 0.368, GFI = 0.965, NFI = 0.970, CFI = 0.999, TLI = 0.998, RMR = 0.002, and RMSEA = 0.013.

Table 9 presents the findings of a path analysis, which describe the direct and indirect relationship between the observed variables and latent variables. Consequently, Table 10 shows that technology transformation had a significant direct effect on people transformation (β = 0.925) and business transformation (β = 0.533) while an indirect effect on business transformation (β = 0.463) and ESG performance (β = 0.949). People transformation was also found to have a significant direct effect on business transformation (β = 0.501) through its relationship. These results indicate that business transformation has a crucial role in the association between ESG performance (β = 0.963) and other variables. This description provides an overview of the variables included in the path analysis model, the fit of the model to the data, and the significance and strength of the direct and indirect relationships between the variables.

Table 9. The results of the path analysis.

Latent	Technology			People			Business			ESG			
Observed	Total Effect	Direct Effect	Indirect Effect	Total Effect	Direct Effect	Indirect Effect	Total Effect	Direct Effect	Indirect Effect	Total Effect	Direct Effect	Indirect Effect	r^2
T1	0.725	0.725											0.525
T2	0.789	0.789											0.623
T3	0.775	0.775											0.600
T4	0.759	0.759											0.577
P1	0.737		0.737	0.797	0.797								0.635
P2	0.717		0.717	0.775	0.775								0.601
P3	0.736		0.736	0.796	0.796								0.633
B1	0.72		0.72	0.362	0.362		0.723	0.723					0.522
B2	0.747		0.747	0.375	0.375		0.75	0.75					0.562
B3	0.724		0.724	0.364	0.364		0.727	0.727					0.529
B4	0.768		0.768	0.386	0.386		0.771	0.771					0.594
Env	0.73		0.73	0.367		0.367	0.733		0.733	0.761	0.761		0.579
Soc	0.731		0.731	0.367		0.367	0.734		0.734	0.762	0.762		0.581
Gov	0.735		0.694	0.349		0.349	0.697		0.697	0.724	0.724		0.524

Table 10. The result of the path analysis of the direct and indirect effect.

Latent	Technology			People			Business			R^2
Effect	Total Effect	Direct Effect	Indirect Effect	Total Effect	Direct Effect	Indirect Effect	Total Effect	Direct Effect	Indirect Effect	
Business	0.996	0.533	0.463	0.501	0.501					0.981
ESG	0.959		0.959	0.482		0.482	0.963	0.963		0.927
People	0.925	0.925								0.855

4.2. Business Transformation and ESG

Changes in a company's operations and supply chain might influence the environment as a result of business transformation. A corporation that transitions to a more digital business model, for illustration, may consume less energy and resources, yet a company that embraces new technology may generate new waste streams [12,47]. Businesses should evaluate the environmental consequences of their transformation initiatives and establish solutions to prevent any negative consequences [9,44,46]. Additionally, business transformation can have social implications, such as adjustments to the workforce and local communities [43,47]. A corporation that automates some operations, for instance, may replace workers, but a company that enters a new market may disrupt the local economy. It is essential for enterprises to examine the social impacts of their transformation efforts and to collaborate with stakeholders to mitigate any negative effects and produce positive results [43,46]. Furthermore, business transformation can also impact a company's governance practices, including its decision-making processes, leadership, and management [46]. A corporation that undergoes a significant reorganization, for instance, may need to modify its governance structures and processes to suit the new business model. It is important for businesses to consider the governance implications of their transformation efforts and to ensure that they have strong, transparent, and accountable governance practices in place. For instance, supply chain transparency or visibility is important to ensure that companies are held accountable for their ESG impact, because it provides stakeholders with valuable information about the environmental and social practices of companies, helps to ensure that companies are engaging in responsible practices throughout their entire supply chain, and provides an opportunity for companies to identify and address any negative ESG impacts for which they may be responsible. It is important for businesses to consider the potential ESG impacts of their transformation efforts and to take a holistic and proactive approach to manage these impacts [47]. This can help businesses to create positive outcomes for their stakeholders and to build long-term value and sustainability.

4.3. People Transformation and ESG

People transformation, or the process of changing an organization's culture, values, and behaviors, can have a significant impact on a company's environmental, social, and governance (ESG) performance. People transformation efforts that focus on improving employee engagement, such as through training and development programs, can lead to increased employee satisfaction and retention [63]. This can have a positive impact on a company's ESG performance, as engaged employees are more likely to be motivated to work towards the company's ESG goals and to act responsibly and ethically [43]. Moreover, people transformation activities that encourage diversity and inclusion can result in a more varied and inclusive workplace culture, which can have a beneficial effect on the ESG performance of a company [20,84]. A diverse and inclusive workplace can lead to improved decision making, better innovation, and stronger relationships with customers, suppliers, and other stakeholders [16,43]. Additionally, corporate social responsibility (CSR)-focused activities to transform the workforce can help to instill a culture of social responsibility throughout a firm [8,62]. This can lead to a stronger focus on social and environmental issues and a greater commitment to acting responsibly and sustainably. In principle, people

transformation can have a beneficial effect on a company's ESG performance by fostering a culture of participation, diversity, inclusion, and social responsibility [43].

Employee engagement is a critical aspect of organizational success and can be influenced by a variety of factors. While "transformation office", "culture of innovation", and "workforce development" are often identified as important drivers of employee engagement, there are other factors that may have a significant impact as well. One such factor is income inequality. In recent years, income inequality within companies has increased dramatically. This trend is driven by various factors, including globalization, technology advancements, and changing labor market conditions. For example, the rise of automation has led to a decline in middle-skilled jobs, which can be routinized, and has resulted in a reduction in salaries for many workers. This can be demotivating for personnel and can negatively impact their engagement with their work and their employer. Therefore, it is important to consider the impact of income inequality on employee engagement when developing strategies to increase engagement and improve organizational performance. This may involve implementing policies and programs that address income inequality, such as fair and transparent compensation practices, and addressing any systemic biases that may contribute to unequal pay. Additionally, companies may consider providing opportunities for professional development and career advancement, which can help employees feel valued and motivated to contribute to the organization's success.

4.4. Technology Transformation and ESG

Technology transformation, or the integration of digital technology into every aspect of a business, can have a substantial effect on the environmental, social, and governance (ESG) performance of a corporation. It could also lead to significant changes in a firm's functions and business operations that have environmental consequences [12]. The use of more efficient technology, for instance, can minimize energy and resource consumption, while the usage of digital platforms can lessen the need for physical transit and storage [17,85]. It is important for businesses to consider the environmental impacts of their technology transformation efforts and to implement strategies to mitigate any negative impacts [17]. Technology transformation can also have social impacts, including changes to the workforce and local communities. For instance, the adoption of automation technologies may displace certain types of workers, while the expansion of digital platforms may create new job opportunities [17,85,86]. It is important for businesses to consider the social impacts of their technology transformation efforts and to work with stakeholders to address any negative impacts and create positive outcomes [14,20]. Moreover, it can also impact a company's governance practices, including its decision-making processes, leadership, and management. For example, the adoption of new technologies may require changes to the way in which the business uses data and analytics and may require new governance structures and processes to support these changes [17,19]. It is important for businesses to consider the governance implications of their technology transformation efforts and to ensure that they have strong, transparent, and accountable governance practices in place.

5. Conclusions

In this study, we explored the implications of the triple transformation for environmental, social, and governance (ESG) performance in the energy sector. The triple transformation refers to the interrelationship of people transformation, business transformation, and technology transformation, all of which are anticipated to have significant effects on the energy sector and the broader economy. Using fuzzy-set qualitative comparative analysis (fQCA) and structural equation modeling (SEM), we assessed the underlying drivers and mechanisms that determine ESG performance in the context of triple transformation. The use of fsQCA and SEM in research can reduce bias by providing a more comprehensive and flexible approach to analyze the relationships between variables, as well as allowing researchers to consider a wider range of possible causal pathways and combinations of variables. The findings indicate that triple transformation has positive impacts on ESG

performance in the energy sector, depending on the specific context and the interaction between different drivers and mechanisms. This research makes a significant contribution to the literature on ESG in the energy sector by offering a nuanced and dynamic viewpoint on the connections between triple transformation and ESG performance. This research points to substantial implications for energy businesses, investors, governments, and other stakeholders since it sheds light on the situation and opportunities for triple transformation and its effects on ESG performance in the energy industry.

This study found that depending on the specific context and the interaction of different drivers and mechanisms, triple transformation has had a positive impact on ESG performance in the energy sector. While the results of this study provide valuable insights into the relationship between triple transformation and ESG performance, there are some limitations and criticisms to consider. One criticism of the study is that it focused merely on internal parameters, such as the interrelationships of people, business, and technology transformations, as drivers of ESG performance. While these internal factors are important, external factors, such as regulatory frameworks and stakeholder engagement, may also play a significant role in shaping ESG performance. Another criticism of the study is that it does not fully address the concerns of ESG investors. For example, investors may be concerned about the long-term viability of ESG performance in the energy sector. They may also be concerned about the accuracy and transparency of ESG reporting, as well as the alignment of ESG goals with financial performance. It is, however, relevant to people-led, sustainable transformation. Future research on triple transformation and ESG performance in the energy sector should take these concerns into consideration.

5.1. Limitations

There are some limitations to our study that should be considered when interpreting the results. First, our sample was limited to publicly traded energy firms that published ESG reports based on the S&P Corporate Sustainability Assessment (CSA) methodology. This means that our findings may not be representative of the entire energy sector or of firms that do not report on ESG. Our analysis was based on a snapshot of ESG performance in 2021, and it did not capture the long-term or dynamic impacts of triple transformation on ESG performance.

5.2. Future Research

Our study provides a preliminary exploration of the implications of triple transformation for environmental, social, and governance (ESG) performance in the energy sector, and it highlights the need for further research in this area. Future research could build on our findings in several ways. First, future research could extend our analysis to cover a wider range of energy firms and countries and include firms that do not report on ESG. This would enable us to provide a more comprehensive and global perspective on the impacts of triple transformation on ESG performance in the energy sector. Second, future research could deepen our understanding of the drivers and mechanisms that shape ESG performance in the context of triple transformation. For instance, researchers could examine the roles of industry characteristics, corporate governance practices, regulatory frameworks, and stakeholder engagement in shaping ESG performance in the energy sector. Overall, future research on triple transformation and ESG performance in the energy sector has the potential to provide valuable insights for energy firms, investors, policymakers, and other stakeholders, as they seek to navigate the challenges and opportunities of triple transformation and enhance their ESG performance.

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

Appendix A

Table A1. Summary of the literature review.

Source	Title	Key Finding	Area of Study				
			Environmental	Social	Governance	Energy Sector	Digital/Industry 4.0
AG Frank et al. (2019) [87]	Industry 4.0 Technologies: Implementation Patterns in Manufacturing Companies	Structure of Industry 4.0 technology layers	X				X
R Morrar et al. (2017) [60]	The Fourth Industrial Revolution (Industry 4.0): A Social Innovation Perspective	Framework		X			X
JM Müller et al. (2018) [88]	What Drives the Implementation of Industry 4.0? The Role of Opportunities and Challenges in the Context of Sustainability	Hypothesized model	X	X			X
D Kiel et al. (2018) [89]	Sustainable Industrial Value Creation: Benefits and Challenges of Industry 4.0	Comprehensive and structured picture			X		X
KC Lin et al. (2017) [23]	A Cross-Strait Comparison of Innovation Policy under Industry 4.0 and Sustainability Development Transition	Framework	X		X		X
AM Braccini and EG Margherita (2019) [57]	Exploring Organizational Sustainability of Industry 4.0 under the Triple Bottom Line: The Case of a Manufacturing Company	Identifying two trajectories	X	X	X		X
S Bag et al. (2021) [90]	Industry 4.0 Adoption and 10R Advance Manufacturing Capabilities for Sustainable Development	Hypothesized model	X	X			X
J Oláh et al. (2020) [14]	Impact of Industry 4.0 on Environmental Sustainability	Framework	X				X
FE. García-Muiña et al. (2020) [24]	Sustainability Transition in Industry 4.0 and Smart Manufacturing with the Triple-Layered Business Model Canvas	Illustrate diagram	X	X	X		X
M Sony et al. (2020) [91]	Industry 4.0 Integration with Socio-Technical Systems Theory: A Systematic Review and Proposed Theoretical Model	Designing architecture		X			X
M Chen et al. (2021) [92]	Impact of Technological Innovation on Energy Efficiency in Industry 4.0 Era: Moderation of Shadow Economy in Sustainable Development	Impact factor			X	X	X
J Vrchota et al. (2020) [93]	Sustainability Outcomes of Green Processes in Relation to Industry 4.0 in Manufacturing: Systematic Review	Conceptual Model	X				X
AK Feroz et al. (2021) [94]	Digital Transformation and Environmental Sustainability: A Review and Research Agenda	Framework	X				X
M Nasiri et al. (2020) [95]	Shaping Digital Innovation via Digital-Related Capabilities	Framework		X			X
YJ Fan et al. (2021) [96]	Corporate sustainability: Impact Factors on organizational innovation in the industrial area	Impact factor			X		X
M Baran et al. (2022) [84]	Does ESG Reporting Relate to Corporate Financial Performance in the Context of the Energy Sector Transformation? Evidence from Poland	Impact factor			X	X	
N Valaei et al. (2017) [66]	Examining Learning Strategies, Creativity, and Innovation at SMEs Using Fuzzy-Set Qualitative Comparative Analysis and PLS Path Modeling	Finding factors using fsQCA and PLS-SEM					X

Table A2. The main criteria and variables are key components that help to identify and evaluate the relationships between different factors or phenomena being studied.

Main Criteria	Acronym	Variable	Description	Literature
Business	B1	Digitization of the supply chain	The extent of digitization of the supply chain	[97–99]
	B2	Senior executives	Make digital a priority for senior executives	[11,44,46,47]
	B3	Regulations	Create clear regulatory frameworks	[11,44,46,47]
	B4	Collaboration	Identify opportunities to deepen collaboration and understanding of sharing-economy platforms.	[11,44,46,47]
People	P1	Transformation office	Enterprise-wide transformation office in place with the bankable plan and quarterly targets to drive 4IR implementation across the company	[9,11,100–102]
	P2	Culture of innovation	Drive a culture of innovation and technology adoption	[9,11,100–102]
	P3	Workforce development	Invest in human capital and development Programs that promote new, digital thinking	[9,11,100–102]
Technology	T1	The Industrial Internet of Things stack	Pilot of IIoT architecture designed for advanced use cases development (e.g., requiring latency, streaming, and security capabilities) and scale-up	[11,17,19,26,34,103]
	T2	Reform the company's data architecture	This includes decisions about whether to build or buy capabilities and a program-management approach to scale-up the technology and digital platforms	[11,17,19,26,34,103]
	T3	Develop global data standards	This includes policies related to data sharing and security and encouraging transparency in operations	[11,17,19,26,34,103]
	T4	Foster an ecosystem for innovation.	Policymakers, governments, and wider society have an important role in driving future prosperity	[11,17,19,26,34,103]
ESG	Env	Environment	Reviving and transforming the enabling environment	[3,9,11,13,46]
	Soc	Social	Rethink labor laws and social protection for the new economy and the new needs of the workforce	[11,17,48,104]
	Gov	Governance	Increase incentives to direct financial resources toward long-term investments, strengthen stability, and expand inclusion	[11,62,97–99,105,106]

Table A3. The correlation matrix is a table showing the correlations between multiple variables.

	B1	B2	B3	B4	P1	P2	P3	T1	T2	T3	T4	Env	Soc	Gov
B1	1.000	0.549	0.623	0.521	0.596	0.528	0.583	0.515	0.580	0.530	0.558	0.537	0.523	0.552
B2	0.549	1.000	0.551	0.563	0.573	0.561	0.618	0.553	0.568	0.589	0.588	0.530	0.590	0.524
B3	0.623	0.551	1.000	0.518	0.589	0.549	0.529	0.531	0.558	0.589	0.577	0.548	0.540	0.547
B4	0.521	0.563	0.518	1.000	0.643	0.567	0.592	0.569	0.643	0.586	0.593	0.547	0.571	0.552
P1	0.596	0.573	0.589	0.643	1.000	0.535	0.635	0.521	0.583	0.538	0.578	0.589	0.557	0.515
P2	0.528	0.561	0.549	0.567	0.535	1.000	0.616	0.514	0.550	0.554	0.534	0.580	0.631	0.570
P3	0.583	0.618	0.529	0.592	0.635	0.616	1.000	0.547	0.623	0.587	0.553	0.597	0.542	0.567
T1	0.515	0.553	0.531	0.569	0.521	0.514	0.547	1.000	0.568	0.554	0.574	0.533	0.529	0.449
T2	0.580	0.568	0.558	0.643	0.583	0.550	0.623	0.568	1.000	0.613	0.580	0.597	0.554	0.548
T3	0.530	0.589	0.589	0.586	0.538	0.554	0.587	0.554	0.613	1.000	0.600	0.540	0.594	0.538
T4	0.558	0.588	0.577	0.593	0.578	0.534	0.553	0.574	0.580	0.600	1.000	0.481	0.553	0.504
Env	0.537	0.530	0.548	0.547	0.589	0.580	0.597	0.533	0.597	0.540	0.481	1.000	0.577	0.577
Soc	0.523	0.590	0.540	0.571	0.557	0.631	0.542	0.529	0.554	0.594	0.553	0.577	1.000	0.530
Gov	0.552	0.524	0.547	0.552	0.515	0.570	0.567	0.449	0.548	0.538	0.504	0.577	0.530	1.000

Table A4. The validity statistics with the correlation significance at the 0.01 level (2-tailed).

Variables	Factor Loading	B1	B2	B3	B4	P1	P2	P3	T1	T2	T3	T4	Env	Soc	GoV
B1	0.759														
B2	0.775	0.549													
B3	0.764	0.623	0.551												
B4	0.786	0.521	0.563	0.518											
P1	0.785	0.596	0.573	0.589	0.643										
P2	0.768	0.528	0.561	0.549	0.567	0.535									
P3	0.798	0.583	0.618	0.529	0.592	0.635	0.616								
T1	0.736	0.515	0.553	0.531	0.569	0.521	0.514	0.547							
T2	0.796	0.58	0.568	0.558	0.643	0.583	0.55	0.623	0.568						
T3	0.78	0.53	0.589	0.589	0.586	0.538	0.554	0.587	0.554	0.613					
T4	0.767	0.558	0.588	0.577	0.593	0.578	0.534	0.553	0.574	0.58	0.6				
Env	0.763	0.537	0.53	0.548	0.547	0.589	0.58	0.597	0.533	0.597	0.54	0.481			
Soc	0.769	0.523	0.59	0.54	0.571	0.557	0.631	0.542	0.529	0.554	0.594	0.553	0.577		
GoV	0.737	0.552	0.524	0.547	0.552	0.515	0.57	0.567	0.449	0.548	0.538	0.504	0.577	0.53	

Table A5. Anti-image matrices are particularly common in factor analysis, where they are used to isolate and extract specific components or factors from complex datasets.

	B1	B2	B3	B4	P1	P2	P3	T1	T2	T3	T4	Env	Soc	Gov
Anti-Image Covariance														
B1	0.458	−0.024	−0.103	0.017	−0.061	−0.009	−0.043	−0.025	−0.047	0.005	−0.038	−0.012	−0.012	−0.059
B2	−0.024	0.449	−0.023	−0.012	−0.027	−0.021	−0.070	−0.045	−0.013	−0.043	−0.055	−0.001	−0.064	−0.021
B3	−0.103	−0.023	0.446	0.024	−0.063	−0.037	0.029	−0.037	−0.016	−0.066	−0.050	−0.031	−0.010	−0.049
B4	0.017	−0.012	0.024	0.409	−0.102	−0.034	−0.012	−0.057	−0.085	−0.035	−0.048	0.002	−0.029	−0.052
P1	−0.061	−0.027	−0.063	−0.102	0.409	0.014	−0.078	0.007	−0.005	0.017	−0.041	−0.062	−0.027	0.016
P2	−0.009	−0.021	−0.037	−0.034	0.014	0.442	−0.077	−0.014	0.001	−0.009	−0.017	−0.048	−0.108	−0.059
P3	−0.043	−0.070	0.029	−0.012	−0.078	−0.077	0.396	−0.027	−0.051	−0.039	−0.004	−0.043	0.023	−0.040
T1	−0.025	−0.045	−0.037	−0.057	0.007	−0.014	−0.027	0.503	−0.039	−0.034	−0.071	−0.052	−0.025	0.036
T2	−0.047	−0.013	−0.016	−0.085	−0.005	0.001	−0.051	−0.039	0.410	−0.057	−0.032	−0.061	−0.007	−0.019
T3	0.005	−0.043	−0.066	−0.035	0.017	−0.009	−0.039	−0.034	−0.057	0.435	−0.061	−0.011	−0.062	−0.029
T4	−0.038	−0.055	−0.050	−0.048	−0.041	−0.017	−0.004	−0.071	−0.032	−0.061	0.449	0.040	−0.026	−0.013
Env	−0.012	−0.001	−0.031	0.002	−0.062	−0.048	−0.043	−0.052	−0.061	−0.011	0.040	0.452	−0.057	−0.079
Soc	−0.012	−0.064	−0.010	−0.029	−0.027	−0.108	0.023	−0.025	−0.007	−0.062	−0.026	−0.057	0.444	−0.019
GoV	−0.059	−0.021	−0.049	−0.052	0.016	−0.059	−0.040	0.036	−0.019	−0.029	−0.013	−0.079	−0.019	0.495
Anti-Image Correlate														
B1	0.970	−0.052	−0.229	0.039	−0.140	−0.019	−0.101	−0.052	−0.109	0.011	−0.084	−0.026	−0.027	−0.125
B2	−0.052	0.977	−0.050	−0.028	−0.062	−0.047	−0.166	−0.095	−0.030	−0.097	−0.122	−0.002	−0.142	−0.044
B3	−0.229	−0.050	0.964	0.056	−0.147	−0.084	0.068	−0.078	−0.037	−0.151	−0.112	−0.068	−0.023	−0.103
B4	0.039	−0.028	0.056	0.962	−0.248	−0.081	−0.031	−0.126	−0.206	−0.082	−0.113	0.005	−0.067	−0.116
P1	−0.140	−0.062	−0.147	−0.248	0.959	0.033	−0.193	0.016	−0.011	0.041	−0.096	−0.143	−0.064	0.035
P2	−0.019	−0.047	−0.084	−0.081	0.033	0.967	−0.184	−0.029	0.002	−0.020	−0.038	−0.108	−0.244	−0.127
P3	−0.101	−0.166	0.068	−0.031	−0.193	−0.184	0.964	−0.062	−0.127	−0.095	−0.009	−0.103	0.055	−0.090
T1	−0.052	−0.095	−0.078	−0.126	0.016	−0.029	−0.062	0.976	−0.085	−0.073	−0.150	−0.109	−0.053	0.073
T2	−0.109	−0.030	−0.037	−0.206	−0.011	0.002	−0.127	−0.085	0.972	−0.134	−0.074	−0.142	−0.017	−0.041
T3	0.011	−0.097	−0.151	−0.082	0.041	−0.020	−0.095	−0.073	−0.134	0.973	−0.138	−0.024	−0.141	−0.062
T4	−0.084	−0.122	−0.112	−0.113	−0.096	−0.038	−0.009	−0.150	−0.074	−0.138	0.972	0.089	−0.059	−0.028
Env	−0.026	−0.002	−0.068	0.005	−0.143	−0.108	−0.103	−0.109	−0.142	−0.024	0.089	0.968	−0.128	−0.168
Soc	−0.027	−0.142	−0.023	−0.067	−0.064	−0.244	0.055	−0.053	−0.017	−0.141	−0.059	−0.128	0.968	−0.040
Gov	−0.125	−0.044	−0.103	−0.116	0.035	−0.127	−0.090	0.073	−0.041	−0.062	−0.028	−0.168	−0.040	0.972

References

1. Shaaban, M.; Scheffran, J. Selection of sustainable development indicators for the assessment of electricity production in Egypt. *Sustain. Energy Technol. Assess.* **2017**, *22*, 65–73. [CrossRef]
2. KPMG Impact The Time Has Come: The KPMG Survey of Sustainability Reporting 2020. 2020. Available online: https://assets.kpmg.com/content/dam/kpmg/be/pdf/2020/12/The_Time_Has_Come_KPMG_Survey_of_Sustainability_Reporting_2020.pdf (accessed on 19 December 2022).
3. Fortune Fortune Global 500. 2022. Available online: www.fortune.com/global500/ (accessed on 12 November 2022).
4. World Economic Forum and Boston Consulting Group. *Net-Zero Challenge: The Supply Chain Opportunity*; World Economic Forum: Colony, Switzerland, 2021.
5. Nitlarp, T.; Kiattisin, S. The Impact Factors of Industry 4.0 on ESG in the Energy Sector. *Sustainability* **2022**, *14*, 9198. [CrossRef]
6. Lokuwaduge, C.S.d.S.; De Silva, K.M. ESG Risk Disclosure and the Risk of Green Washing. *Australas. Account. Bus. Financ. J.* **2022**, *16*, 146–159. [CrossRef]

7. Choi, M.; Hong, S. Another Form of Greenwashing: The Effects of Chaebol Firms' Corporate Governance Performance on the Donations. *Sustainability* **2022**, *14*, 3373. [CrossRef]

8. Gillan, S.L.; Koch, A.; Starks, L.T. Firms and social responsibility: A review of ESG and CSR research in corporate finance. *J. Corp. Financ.* **2021**, *66*, 101889. [CrossRef]

9. *World Economic Forum and Accenture Digital Transformation Initiative Oil and Gas Industry In Collaboration with Accenture*; World Economic Forum: Colony, Switzerland, 2017.

10. dos Santos, M.C.; Pereira, F.H. ESG performance scoring method to support responsible investments in port operations. *Case Stud. Transp. Policy* **2022**, *10*, 664–673. [CrossRef]

11. Schwab, K.; Zahidi, S. How Countries Are Performing on the Road to Recovery. *Glob. Compet. Rep.* **2020**, *95*.

12. Busu, M.; Nedelcu, A.C. Sustainability and Economic Performance of the Companies in the Renewable Energy Sector in Romania. *Sustainability* **2017**, *10*, 8. [CrossRef]

13. Orenstein, M.; Millington, D.; Cooke, B. *ESG and the Canadian Energy Sector*; Canada West Foundation: Calgary, AB, Canada, 2021.

14. Oláh, J.; Aburumman, N.; Popp, J.; Khan, M.A.; Haddad, H.; Kitukutha, N. Impact of Industry 4.0 on Environmental Sustainability. *Sustainability* **2020**, *12*, 4674. [CrossRef]

15. Kazancoglu, Y.; Sezer, M.D.; Ozkan-Ozen, Y.D.; Mangla, S.K.; Kumar, A. Industry 4.0 impacts on responsible environmental and societal management in the family business. *Technol. Forecast. Soc. Chang.* **2021**, *173*, 121108. [CrossRef]

16. Schröder, M. The performance of socially responsible investments: Investment funds and indices. *Financ. Mark. Portf. Manag.* **2004**, *18*, 122–142. [CrossRef]

17. Alkaraan, F.; Albitar, K.; Hussainey, K.; Venkatesh, V. Corporate transformation toward Industry 4.0 and financial performance: The influence of environmental, social, and governance (ESG). *Technol. Forecast. Soc. Chang.* **2021**, *175*, 121423. [CrossRef]

18. Statman, M.; Glushkov, D. The Wages of Social Responsibility. *Financ. Anal. J.* **2009**, *65*, 33–46. [CrossRef]

19. Benitez, G.B.; Ayala, N.F.; Frank, A.G. Industry 4.0 innovation ecosystems: An evolutionary perspective on value cocreation. *Int. J. Prod. Econ.* **2020**, *228*, 107735. [CrossRef]

20. Yang, Q.; Du, Q.; Razzaq, A.; Shang, Y. How volatility in green financing, clean energy, and green economic practices derive sustainable performance through ESG indicators? A sectoral study of G7 countries. *Resour. Policy* **2021**, *75*, 102526. [CrossRef]

21. Cormier, D.; Magnan, M. The revisited contribution of environmental reporting to investors' valuation of a firm's earnings: An international perspective. *Ecol. Econ.* **2007**, *62*, 613–626. [CrossRef]

22. Dainienė, R.; Dagilienė, L. A TBL Approach Based Theoretical Framework for Measuring Social Innovations. *Procedia Soc. Behav. Sci.* **2015**, *213*, 275–280. [CrossRef]

23. Lin, K.C.; Shyu, J.Z.; Ding, K. A Cross-Strait Comparison of Innovation Policy under Industry 4.0 and Sustainability Development Transition. *Sustainability* **2017**, *9*, 786. [CrossRef]

24. García-Muiña, F.E.; Medina-Salgado, M.S.; Ferrari, A.M.; Cucchi, M. Sustainability transition in Industry 4.0 and Smart Manufacturing with the triple-layered business model canvas. *Sustainability* **2020**, *12*, 2364. [CrossRef]

25. Kraus, S.; Schiavone, F.; Pluzhnikova, A.; Invernizzi, A.C. Digital transformation in healthcare: Analyzing the current state-of-research. *J. Bus. Res.* **2020**, *123*, 557–567. [CrossRef]

26. Frank, A.G.; Mendes, G.H.S.; Ayala, N.F.; Ghezzi, A. Servitization and Industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective. *Technol. Forecast. Soc. Chang.* **2019**, *141*, 341–351. [CrossRef]

27. CSA Invited Companies. Available online: https://www.spglobal.com/esg/csa/invited-companies (accessed on 27 May 2022).

28. Kagermann, H.; Helbig, J.; Hellinger, A.; Wahlster, W. *Recommendations for Implementing the Strategic Initiative INDUSTRIE 4.0: Securing the Future of German Manufacturing Industry*; Final Report of the Industrie 4.0 Working Group; Forschungsunion: Berlin, Germany, 2013.

29. Hermann, M.; Pentek, T.; Otto, B. Design Principles for Industrie 4.0 Scenarios. In Proceedings of the Annual Hawaii International Conference on System Sciences, Koloa, HI, USA, 7 March 2016; pp. 3928–3937.

30. Wollschlaeger, M.; Sauter, T.; Jasperneite, J. The Future of Industrial Communication: Automation Networks in the Era of the Internet of Things and Industry 4.0. *IEEE Ind. Electron. Mag.* **2017**, *11*, 17–27. [CrossRef]

31. Vial, G. Understanding digital transformation: A review and a research agenda. *J. Strateg. Inf. Syst.* **2019**, *28*, 118–144. [CrossRef]

32. Hinings, B.; Gegenhuber, T.; Greenwood, R. Digital innovation and transformation: An institutional perspective. *Inf. Organ.* **2018**, *28*, 52–61. [CrossRef]

33. Schallmo, D.; Williams, C.A.; Boardman, L. Digital Transformation of Business Models-Best Practice, Enablers, and Roadmap. *Int. J. Innov. Manag.* **2017**, *21*. [CrossRef]

34. Yu, W.; Gu, Y.; Dai, J. Industry 4.0-Enabled ESG Reporting: A Case from a Chinese Energy Company. *J. Emerg. Technol. Account.* **2022**. Available online: www.ssrn.com/abstract=4063071 (accessed on 15 April 2022). [CrossRef]

35. Bonilla, S.H.; Silva, H.R.O.; Terra da Silva, M.; Gonçalves, R.F.; Sacomano, J.B. Industry 4.0 and Sustainability Implications: A Scenario-Based Analysis of the Impacts and Challenges. *Sustainability* **2018**, *10*, 3740. [CrossRef]

36. Scott Burger Future of Energy. Available online: https://intelligence.weforum.org/topics/a1Gb00000038oN6EAI?tab=publications (accessed on 31 March 2021).

37. Kettunen, P.; Mäkitalo, N. Future smart energy software houses. *Eur. J. Futur. Res.* **2019**, *7*, 1–25. [CrossRef]

38. Sohag, K.; Begum, R.A.; Abdullah, S.M.S.; Jaafar, M. Dynamics of energy use, technological innovation, economic growth and trade openness in Malaysia. *Energy* **2015**, *90*, 1497–1507. [CrossRef]

39. Aflaki, S.; Basher, S.A.; Masini, A. Technology-push, demand-pull and endogenous drivers of innovation in the renewable energy industry. *Clean Technol. Environ. Policy* **2021**, *23*, 1563–1580. [CrossRef]

40. Longo, F.; Nicoletti, L.; Padovano, A. Smart operators in industry 4.0: A human-centered approach to enhance operators' capabilities and competencies within the new smart factory context. *Comput. Ind. Eng.* **2017**, *113*, 144–159. [CrossRef]

41. Sivathanu, B.; Pillai, R. Smart HR 4.0—How Industry 4.0 Is Disrupting HR. *Hum. Resour. Manag. Int. Dig.* **2018**, *26*, 7–11. [CrossRef]

42. Brougham, D.; Haar, J. Smart Technology, Artificial Intelligence, Robotics, and Algorithms (STARA): Employees' perceptions of our future workplace. *J. Manag. Organ.* **2017**, *24*, 239–257. [CrossRef]

43. Eccles, R.G.; Ioannou, I.; Serafeim, G. The Impact of Corporate Sustainability on Organizational Processes and Performance. *Manag. Sci.* **2014**, *60*, 2835–2857. [CrossRef]

44. World Bank. Sustainability Review 2021. 2021. Available online: www.openknowledge.worldbank.org/handle/10986/36352 (accessed on 19 December 2022).

45. Cretchley, J.; Gallois, C.; Chenery, H.; Smith, A. Conversations Between Carers and People With Schizophrenia: A Qualitative Analysis Using Leximancer. *Qual. Health Res.* **2010**, *20*, 1611–1628. [CrossRef] [PubMed]

46. KPMG. The Business Case for Climate Action. 2020. Available online: https://assets.kpmg/content/dam/kpmg/ie/pdf/2020/01/ie-the-business-case-for-climate-action.pdf (accessed on 19 December 2022).

47. Bonini, S.; Görner, S. The Business of Sustainability: Putting It into Practice. *McKinsey Glob. Surv. Results* **2011**. Available online: www.mckinsey.com/~/media/mckinsey/dotcom/client_service/sustainability/pdfs/putting_it_into_practice.pdf (accessed on 19 December 2022).

48. Lock, I.; Seele, P. The credibility of CSR (corporate social responsibility) reports in Europe. Evidence from a quantitative content analysis in 11 countries. *J. Clean. Prod.* **2016**, *122*, 186–200. [CrossRef]

49. Rooney, D. Knowledge, economy, technology and society: The politics of discourse. *Telematics Informatics* **2005**, *22*, 405–422. [CrossRef]

50. Westerman, G.; Bonnet, D.; Mcafee, A. The Nine Elements of Digital Transformation Opinion & Analysis. *MITSloan Manag. Rev.* **2014**, *55*, 1–6.

51. *World Economic Forum Seeking Return on ESG Advancing the Reporting Ecosystem to Unlock Impact for Business and Society Produced in Collaboration with Allianz SE and Boston Consulting Group*; World Economic Forum: Colony, Switzerland, 2019.

52. World Economic Forum. Two Degrees of Transformation Businesses Are Coming Together to Lead on Climate Change. 2018. Available online: https://www.weforum.org/reports/two-degrees-of-transformation-businesses-are-coming-together-to-lead-on-climate-change-will-you-join-them (accessed on 1 May 2021).

53. de Man, J.C.; Strandhagen, J.O. An Industry 4.0 Research Agenda for Sustainable Business Models. *Procedia CIRP* **2017**, *63*, 721–726. [CrossRef]

54. Müller, J.M.; Buliga, O.; Voigt, K.-I. Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technol. Forecast. Soc. Chang.* **2018**, *132*, 2–17. [CrossRef]

55. Butt, J. A Conceptual Framework to Support Digital Transformation in Manufacturing using an Integrated Business Process Management Approach. *Designs* **2020**, *4*, 17. [CrossRef]

56. Braccini, A.M.; Margherita, E.G. Exploring Organizational Sustainability of Industry 4.0 under the Triple Bottom Line: The Case of a Manufacturing Company. *Sustainability* **2019**, *11*, 36. [CrossRef]

57. Bouten, L.; Everaert, P.; Van Liedekerke, L.; De Moor, L.; Christiaens, J. Corporate social responsibility reporting: A comprehensive picture? *Account. Forum* **2011**, *35*, 187–204. [CrossRef]

58. Burritt, R.; Christ, K. Industry 4.0 and environmental accounting: A new revolution? *Asian J. Sustain. Soc. Responsib.* **2016**, *1*, 23–38. [CrossRef]

59. Rabeh Morrar, H.A.M. The Fourth Industrial Revolution (Industry 4.0): A Social Innovation Perspective. *Technol. Innov. Manag. Rev.* **2017**, *7*, 12–20. [CrossRef]

60. Garcia-Sanchez, I.-M.; Gómez-Miranda, M.-E.; David, F.; Rodríguez-Ariza, L. The explanatory effect of CSR committee and assurance services on the adoption of the IFC performance standards, as a means of enhancing corporate transparency. *Sustain. Accounting, Manag. Policy J.* **2019**, *10*, 773–797. [CrossRef]

61. Waworuntu, S.R.; Wantah, M.D.; Rusmanto, T. CSR and Financial Performance Analysis: Evidence from Top ASEAN Listed Companies. *Procedia Soc. Behav. Sci.* **2014**, *164*, 493–500. [CrossRef]

62. Zhang, J.; Long, J.; von Schaewen, A.M.E. How Does Digital Transformation Improve Organizational Resilience?—Findings from PLS-SEM and fsQCA. *Sustainability* **2021**, *13*, 11487. [CrossRef]

63. Kaya, B.; Abubakar, A.M.; Behravesh, E.; Yildiz, H.; Mert, I.S. Antecedents of innovative performance: Findings from PLS-SEM and fuzzy sets (fsQCA). *J. Bus. Res.* **2020**, *114*, 278–289. [CrossRef]

64. Mikalef, P.; Pateli, A. Information technology-enabled dynamic capabilities and their indirect effect on competitive performance: Findings from PLS-SEM and fsQCA. *J. Bus. Res.* **2017**, *70*, 1–16. [CrossRef]

65. Valaei, N.; Rezaei, S.; Ismail, W.K.W. Examining learning strategies, creativity, and innovation at SMEs using fuzzy set Qualitative Comparative Analysis and PLS path modeling. *J. Bus. Res.* **2017**, *70*, 224–233. [CrossRef]

66. Afonso, C.; Silva, G.M.; Gonçalves, H.M.; Duarte, M. The role of motivations and involvement in wine tourists' intention to return: SEM and fsQCA findings. *J. Bus. Res.* **2018**, *89*, 313–321. [CrossRef]

67. Ragin, C.C.; Sonnett, J. Between Complexity and Parsimony: Limited Diversity, Counterfactual Cases, and Comparative Analysis. In *Redesigning Social Inquiry*; Ragin, C.C., Ed.; University of Chicago Press: Chicago, IL, USA, 2004; pp. 180–197. [CrossRef]

68. Charles, C. *Ragin Redesigning Social Inquiry: Fuzzy Sets and Beyond*; University of Chicago Press: Chicago, IL, USA, 2008.

69. Hair, J.F.; Ringle, C.M.; Sarstedt, M. PLS-SEM: Indeed a Silver Bullet. *J. Mark. Theory Pract.* **2011**, *19*, 139–152. [CrossRef]

70. Rigdon, E.E.; Sarstedt, M.; Ringle, C.M. On Comparing Results from CB-SEM and PLS-SEM on JSTOR. *J. Res. Manag.* **2017**, *39*, 4–16.

71. Astrachan, C.B.; Patel, V.K.; Wanzenried, G. A comparative study of CB-SEM and PLS-SEM for theory development in family firm research. *J. Fam. Bus. Strat.* **2014**, *5*, 116–128. [CrossRef]

72. Hair, J.F.; Risher, J.J.; Sarstedt, M.; Ringle, C.M. When to use and how to report the results of PLS-SEM. *Eur. Bus. Rev.* **2019**, *31*, 2–24. [CrossRef]

73. Salem, I.E.; Elbaz, A.M.; Al-Alawi, A.; Alkathiri, N.A.; Rashwan, K.A. Investigating the Role of Green Hotel Sustainable Strategies to Improve Customer Cognitive and Affective Image: Evidence from PLS-SEM and fsQCA. *Sustainability* **2022**, *14*, 3545. [CrossRef]

74. Hair, J.F. *Multivariate Data Analysis: A Global Perspective*, 7th ed.; Prentice Hall: Hoboken, NJ, USA, 2009.

75. Llanos-Contreras, O.; Alonso-Dos-Santos, M.; Ribeiro-Soriano, D. Entrepreneurship and risk-taking in a post-disaster scenario. *Int. Entrep. Manag. J.* **2019**, *16*, 221–237. [CrossRef]

76. Schneider, C.Q.; Wagemann, C. *Set-Theoretic Methods for the Social Sciences: A Guide to Qualitative Comparative Analysis*; Cambridge University Press: Cambridge, UK, 2012.

77. Hu, L.T.; Bentler, P.M. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Struct. Equ. Model. Multidiscip. J.* **1999**, *6*, 1–55. [CrossRef]

78. Wheaton, B.; Muthén, B.; Alwin, D.F.; Summers, G.F. Assessing Reliability and Stability in Panel Models. In *Sociological Methodology*; Heise, D.R., Ed.; Jossey Bass: San Francisco, CA, USA, 1977; pp. 84–136.

79. Tabachnick, B.G.; Fidell, L.S. Using Multivariate Statistics Title: Using Multivariate Statistics. 2019. Available online: https://scirp.org/reference/referencespapers.aspx?referenceid=3132273 (accessed on 19 December 2022).

80. Jackson, D.L.; Gillaspy, J.A., Jr.; Purc-Stephenson, R. Reporting practices in confirmatory factor analysis: An overview and some recommendations. *Psychol. Methods* **2009**, *14*, 6–23. [CrossRef]

81. Timothy, A. *Brown Confirmatory Factor Analysis for Applied Research*, 2nd ed.; Pearson: Boston, MA, USA, 2006.

82. Williams, B.; Onsman, A.; Brown, T. Exploratory factor analysis: A five-step guide for novices. *Australas. J. Paramed.* **2010**, *8*, 1–13. [CrossRef]

83. Almanasreh, E.; Moles, R.; Chen, T.F. Evaluation of methods used for estimating content validity. *Res. Soc. Adm. Pharm.* **2019**, *15*, 214–221. [CrossRef] [PubMed]

84. Baran, M.; Kuźniarska, A.; Makieła, Z.J.; Sławik, A.; Stuss, M.M. Does ESG Reporting Relate to Corporate Financial Performance in the Context of the Energy Sector Transformation? Evidence from Poland. *Energies* **2022**, *15*, 477. [CrossRef]

85. Awan, U.; Arnold, M.G.; Gölgeci, I. Enhancing green product and process innovation: Towards an integrative framework of knowledge acquisition and environmental investment. *Bus. Strateg. Environ.* **2021**, *30*, 1283–1295. [CrossRef]

86. Fatemi, A.; Glaum, M.; Kaiser, S. ESG performance and firm value: The moderating role of disclosure. *Glob. Finance J.* **2018**, *38*, 45–64. [CrossRef]

87. Frank, A.G.; Dalenogare, L.S.; Ayala, N.F. Industry 4.0 technologies: Implementation patterns in manufacturing companies. *Int. J. Prod. Econ.* **2019**, *210*, 15–26. [CrossRef]

88. Müller, J.M.; Kiel, D.; Voigt, K.-I. What Drives the Implementation of Industry 4.0? The Role of Opportunities and Challenges in the Context of Sustainability. *Sustainability* **2018**, *10*, 247. [CrossRef]

89. Kiel, D.; Müller, J.M.; Arnold, C.; Voigt, K.I. Sustainable industrial value creation: Benefits and challenges of Industry 4.0. *Int. J. Innov. Manag.* **2017**, *21*, 1740015. [CrossRef]

90. Bag, S.; Gupta, S.; Kumar, S. Industry 4.0 adoption and 10R advance manufacturing capabilities for sustainable development. *Int. J. Prod. Econ.* **2020**, *231*, 107844. [CrossRef]

91. Sony, M.; Naik, S. Industry 4.0 integration with socio-technical systems theory: A systematic review and proposed theoretical model. *Technol. Soc.* **2020**, *61*, 101248. [CrossRef]

92. Chen, M.; Sinha, A.; Hu, K.; Shah, M.I. Impact of technological innovation on energy efficiency in industry 4.0 era: Moderation of shadow economy in sustainable development. *Technol. Forecast. Soc. Chang.* **2020**, *164*, 120521. [CrossRef]

93. Vrchota, J.; Pech, M.; Rolínek, L.; Bednář, J. Sustainability Outcomes of Green Processes in Relation to Industry 4.0 in Manufacturing: Systematic Review. *Sustainability* **2020**, *12*, 5968. [CrossRef]

94. Feroz, A.K.; Zo, H.; Chiravuri, A. Digital Transformation and Environmental Sustainability: A Review and Research Agenda. *Sustainability* **2021**, *13*, 1530. [CrossRef]

95. Nasiri, M.; Saunila, M.; Ukko, J.; Rantala, T.; Rantanen, H. Shaping Digital Innovation Via Digital-related Capabilities. *Inf. Syst. Front.* **2020**, 1–18. [CrossRef]

96. Fan, Y.-J.; Liu, S.-F.; Luh, D.-B.; Teng, P.-S. Corporate Sustainability: Impact Factors on Organizational Innovation in the Industrial Area. *Sustainability* **2021**, *13*, 1979. [CrossRef]

97. Oprean-Stan, C.; Oncioiu, I.; Iuga, I.C.; Stan, S. Impact of Sustainability Reporting and Inadequate Management of ESG Factors on Corporate Performance and Sustainable Growth. *Sustainability* **2020**, *12*, 8536. [CrossRef]

98. López, M.V.; Garcia, A.; Rodriguez, L. Sustainable Development and Corporate Performance: A Study Based on the Dow Jones Sustainability Index. *J. Bus. Ethic-* **2007**, *75*, 285–300. [CrossRef]
99. Raucci, D.; Tarquinio, L. Sustainability Performance Indicators and Non-Financial Information Reporting. Evidence from the Italian Case. *Adm. Sci.* **2020**, *10*, 13. [CrossRef]
100. Xie, C.L. Institutional Investors, Shareholder Activism, and ESG in the Institutional Investors, Shareholder Activism, and ESG in the Energy Sector Energy Sector. *Whart. Res. Sch.* **2020**, *196*. Available online: https://repository.upenn.edu/wharton_research_scholars/196 (accessed on 19 December 2022).
101. Khan, M. Corporate Governance, ESG, and Stock Returns around the World. *Financ. Anal. J.* **2019**, *75*, 103–123. [CrossRef]
102. Amel-Zadeh, A.; Serafeim, G. Why and How Investors Use ESG Information: Evidence from a Global Survey. *Financ. Anal. J.* **2018**, *74*, 87–103. [CrossRef]
103. Osterrieder, P.; Budde, L.; Friedli, T. The smart factory as a key construct of industry 4.0: A systematic literature review. *Int. J. Prod. Econ.* **2020**, *221*, 107476. [CrossRef]
104. Camilleri, M.A. Environmental, social and governance disclosures in Europe. *Sustain. Account. Manag. Policy J.* **2015**, *6*, 224–242. [CrossRef]
105. Schreck, P. Reviewing the Business Case for Corporate Social Responsibility: New Evidence and Analysis. *J. Bus. Ethic-* **2011**, *103*, 167–188. [CrossRef]
106. Landau, A.; Rochell, J.; Klein, C.; Zwergel, B. Integrated reporting of environmental, social, and governance and financial data: Does the market value integrated reports? *Bus. Strat. Environ.* **2020**, *29*, 1750–1763. [CrossRef]