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Risk in Sustainability Reporting: Designing a DEMATEL-Based Model for Enhanced Transparency and Accountability

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Abstract: The primary concern of research in the area of fraud risk relevant to sustainability reporting lies in understanding the potential for fraudulent or misleading reporting practices and developing strategies and tools to identify and prevent such behaviors. Taking into consideration that significant research has yet to be conducted on fraud risk models associated with sustainability reporting, this study represents an innovative contribution. It uses a mixed-methods approach to design a fraud risk model based on sustainability reporting. Given its type and approach, this research does not posit any hypotheses involving thematic analysis and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method. This study is exploratory and applied, aiming to design a model through a mixed-methods methodology. Therefore, the research is hypothesis-free and instead utilizes a qualitative sample of experts and academics in the field of accounting from Iran and Denmark. The DEMATEL technique identifies key external and internal factors that significantly impact sustainability reporting, including comprehensive internal controls, strong governance and oversight, training and awareness, the utilization of technology, and data analytics. The influence of stakeholders, third-party audits, and the credibility of sustainability reports emerges as particularly significant in this context, exceeding the impact of other factors. These findings underscore that stakeholders, third-party audits, and report credibility to play a more prominent role in shaping sustainability performance compared to other considerations. This would imply that such variables remain key drivers in the perceptiveness and effectiveness of sustainability performance.

Keywords: fraud risk; sustainability reporting; DEMATEL; International Sustainability Standards Board (ISSB)

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1. Introduction

Sustainability reporting entails the disclosure of an organization's economic, environmental, social, and governance performance. It provides insights into the impact of a company's activities on the economy, the environment, and society. Generally voluntary, this type of reporting enables companies to communicate effectively with stakeholders, including investors, employees, customers, and the public. Sustainability reports are typically published annually and can encompass a wide range of information, including energy consumption, greenhouse gas emissions, and community engagement efforts. With the rising global focus on environmental, social, and governance (ESG) factors, companies are under increasing pressure to showcase their commitment to sustainability and transparency [1].

These reports often showcase a company's commitment to sustainable development and corporate social responsibility [2].

Businesses today face challenges, particularly in the socio-economic domain, compelling them to identify new opportunities and develop strategies to maintain and enhance their competitive advantage [3]. Companies that embrace innovation successfully realize substantial positive outcomes, including profit, growth, and new market opportunities [4]. Risks may arise from internal or external factors, which can impact the sustainability and operational practices of a business environment [5]. Every business is committed to fulfilling specific responsibilities owed to the public [3]. Fraud risk in sustainability reporting refers to the potential for individuals or organizations to engage in deceptive practices related to environmental, social, and governance (ESG) performance. This risk encompasses activities such as greenwashing (misrepresenting environmental efforts), falsifying data on social impacts or labor practices, corruption, bribery, and manipulation of governance-related information. It underscores the importance of accurate and transparent reporting to uphold the credibility of ESG disclosures. The objective of this study is to develop a fraud risk model specifically focused on sustainability reporting.

As ESG (environmental, social, and governance) reporting becomes more prevalent, factors such as investment pressure, compliance complexity, and reputational risk increasingly contribute to the risk of ESG-related fraud [6]. The rising incidence of ESG fraud is a growing concern, making it imperative for organizations to understand and address potential risks associated with ESG reporting to ensure transparency and accountability. Internal auditing plays a crucial role in assessing the effectiveness of ESG fraud risk management and in supporting organizations by providing independent assurance in managing ESG fraud risks. As ESG-related issues progressively feature on the agendas of audit committees, there is a growing need for these committees to broaden their discussions on fraud risk to encompass various ESG-related matters [7].

With the growing global emphasis on environmental, social, and governance (ESG) factors, Iranian companies are experiencing increased pressure to showcase their commitment to sustainability and transparency. The potential for fraudulent or misleading sustainability reports in Iran could have severe implications for investors, regulators, and other stakeholders. Such misconduct could distort a company's performance and perceived value, leading to financial and reputational damage [8]. The primary concern of research in the area of fraud risk based on sustainability reporting is to understand the potential for fraudulent or misleading reporting practices and to develop strategies and tools to detect and prevent such behavior. This involves identifying the factors that contribute to fraud risk in sustainability reporting, assessing the impact of fraudulent reports on stakeholders and the broader economy, and developing best practices and guidelines for companies to ensure the accuracy and transparency of their sustainability reporting processes [7].

Additionally, research in this area seeks to address the regulatory and enforcement challenges related to fraud risk in sustainability reporting, with the aim of promoting greater accountability and integrity. Considering the points raised and acknowledging the limited significant research on fraud risk models focused on sustainability reporting, particularly in the context of current conditions in Iran, there is a clear need to develop a fraud risk model based on sustainability reporting. This model would aim to identify the consequences of fraud risk as well as the factors that contribute to it. By addressing these factors and offering strategies to mitigate the elements contributing to fraud risk, this model could aid organizations in enhancing both productivity and sustainability while reducing negative outcomes. To date, no research has sought to present a fraud risk model based on sustainability reporting, making this endeavor a potential innovation in the field. The current study aims to design a fraud risk model based on sustainability reporting utilizing a

mixed-methods approach. Specifically, this research seeks to address the following question: what constitutes a fraud risk model based on sustainability reporting?

This study advances the understanding of environmental, social, and governance (ESG) transformations influenced by International Sustainability Standards Board (ISSB) standards by creating a fraud risk model rooted in sustainability reporting, with insights drawn from Iran and Denmark. The link between ESG issues and the Sustainable Development Goals (SDGs) is marked by their complementary nature and shared aims. ESG issues correspond to various SDGs, such as environmental concerns aligning with SDG 13 (Climate Action), while social issues relate to goals associated with poverty, health, and education. Corporations frequently utilize the SDGs to organize their sustainability efforts, conducting SDG screenings to evaluate their contributions and impacts. This integration aids firms in aligning their ESG strategies with global sustainability objectives, offering a legitimate framework supported by the United Nations. Additionally, the SDGs guide corporations in their sustainability reporting, ensuring that their activities contribute to broader societal goals and enhancing transparency and accountability in their operations [9].

The criterion for this comparative analysis of Denmark and Iran is founded on their distinct rankings in the Global SDG Index 2024, where Denmark is positioned 3rd and Iran is ranked 86th. This significant disparity highlights the notable differences in sustainability practices and outcomes between the two countries. Denmark is recognized for its high levels of transparency and strong governance frameworks, making it an appropriate benchmark for evaluating sustainability reporting practices in comparison to Iran.

Furthermore, both countries acknowledge the critical importance of sustainability reporting among corporations, particularly in light of International Sustainability Standards Board (ISSB) guidelines. This shared commitment to sustainability reporting strengthens the rationale for this comparative study, as it allows for a more nuanced exploration of how differing contextual factors can shape reporting practices and outcomes. Utilizing the DEMATEL method, the analysis identifies key factors such as stakeholder engagement, third-party audits, and report credibility that significantly impact sustainability performance. The comparative examination of Iran and Denmark highlights how varying regulatory environments influence the implementation of ISSB standards, offering valuable insights into global ESG reporting and strategies for fraud risk prevention.

2. Theoretical Foundations and Research Background

Fraudulent sustainability reports can lead to severe reputational damage, a loss of investor trust, and potential legal and regulatory repercussions. Therefore, it is crucial for companies to establish robust internal controls and verification processes to ensure the accuracy and transparency of their sustainability reports. Moreover, stakeholders must remain vigilant and exercise due diligence when evaluating these reports to mitigate the risk of fraud. The potential for fraud in sustainability reporting has become increasingly significant due to the heightened focus on environmental, social, and governance (ESG) factors of investors, regulators, and other stakeholders. As companies face growing pressure to demonstrate their commitment to sustainability, the risk of producing fraudulent or misleading reports in this area increases.

Fraud in sustainability reporting can significantly impact investors by distorting a company's performance and perceived value. It can also harm a company's reputation, erode shareholder trust, and result in legal and financial repercussions. Given these potential impacts, it is crucial for companies to assess and mitigate their risk of fraud in sustainability reporting. This necessitates implementing strong internal controls, conducting comprehensive risk assessments, and ensuring the accuracy and transparency of their sustainability reporting processes.

As sustainability reporting becomes more integrated into mainstream financial reporting, regulators are increasingly focusing on the accuracy and reliability of ESG disclosures. In summary, addressing the risk of fraud in sustainability reporting is of paramount importance. Companies must prioritize the integrity of their ESG disclosures to maintain stakeholder trust, comply with regulations, and safeguard their reputation and financial performance.

The risk of fraud in sustainability reporting poses a significant concern for businesses, especially small and medium-sized enterprises (SMEs). These companies often encounter unique challenges in establishing comprehensive fraud risk management strategies due to their limited resources. Consequently, it is essential for SMEs to develop and maintain robust internal controls and transparent reporting practices to mitigate these risks effectively.

2.1. The History of Sustainability Reporting

Corporate sustainability reporting has become widespread and largely institutionalized in recent years. This evolution indicates not only that such reporting has become relatively common, but also that established and accepted reporting approaches have been developed. However, this does not imply that the field is static; rather, it constantly develops and evolves. The practices and performance metrics of sustainability reporting have evolved rapidly over the past few decades. Contemporary reporting practices differ significantly from those used in earlier reports, reflecting a growing recognition of the importance of sustainability and accountability [10].

A significant milestone in the history of sustainability reporting was reached in the year 2000 with the publication of the first version of the Global Reporting Initiative (GRI) guidelines. Since that time, the GRI has emerged as the foremost framework for sustainability reporting. Prior to this development, corporate disclosures primarily focused on environmental issues; however, they have progressively broadened to include social and economic dimensions. The introduction of the GRI guidelines, which integrated these three aspects, played a crucial role in the evolution of sustainability reporting. The initial version of the GRI, released in 2000, marked a pioneering effort to create a comprehensive framework for corporate information disclosure. Despite this progress, there remains significant variation in reports and in how information is presented. Even today, reports are often published under various titles, such as Corporate Citizenship Reports, Social Responsibility Reports, and Sustainability Reports, each sharing a common characteristic: an expanded scope of issues addressed. Since the Global Reporting Initiative (GRI) was launched, its guidelines have undergone several developments and continue to hold considerable influence. Consequently, discussions about the GRI remain pertinent and are ongoing throughout this field [11].

2.1.1. Early Practices

While the prevalence of corporate social and environmental reports increased significantly in the 1990s, the academic literature suggests that some organizations had been disclosing information beyond financial data for a much longer time. Historical analyses indicate that certain companies began publishing social information as early as the early 20th century, with a primary focus on employee-related issues, housing projects, and other social initiatives [12]. The 1970s witnessed a notable rise in the number of companies reporting on social issues. In the United States, annual corporate reports from this period included disclosures in topics such as human resources, community involvement, and fair business practices [13,14]. Similar practices were also observed in Europe. In the United Kingdom, for instance, companies began publishing value-added reports that illustrated the value

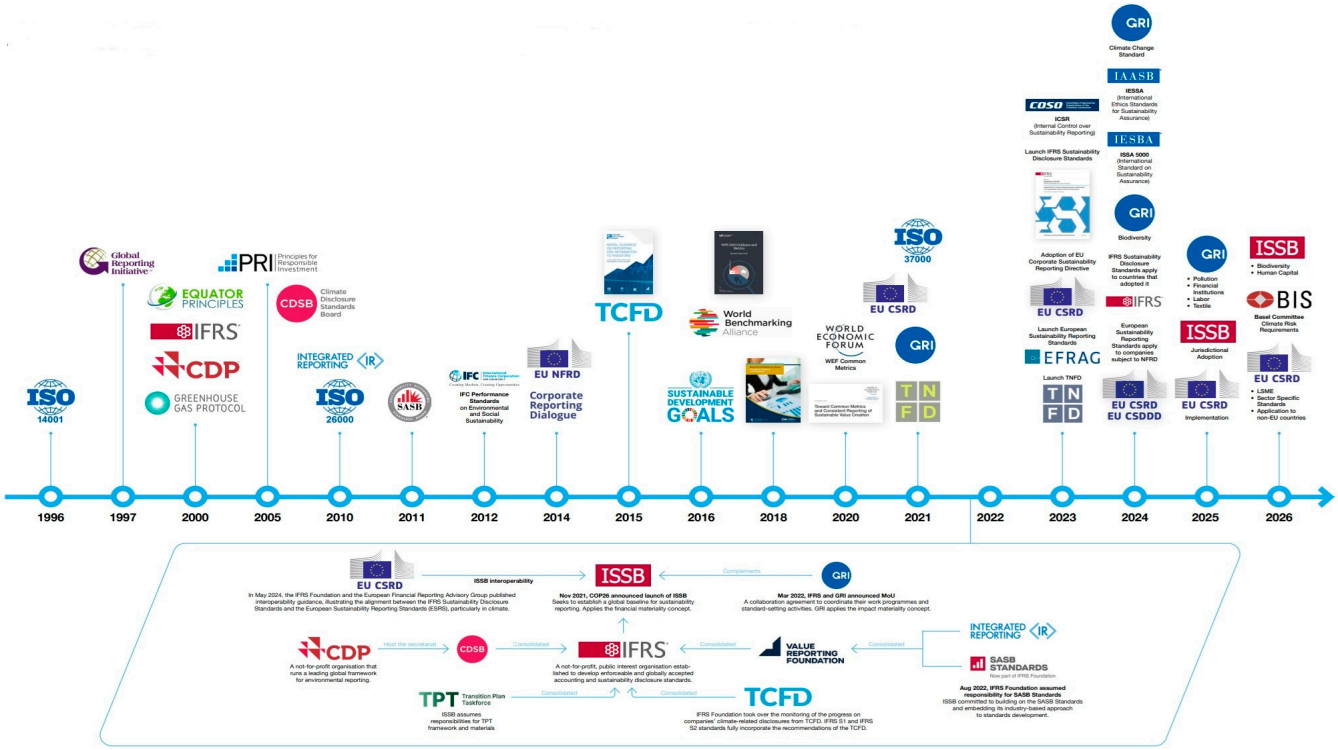
generated by their corporate activities for society at large. These reports demonstrated that companies create value not only for investors but also for other stakeholder groups and the broader community [15]. However, the trend toward disclosing social information declined in the late 1970s and early 1980s due to broader political trends in Anglo-American societies at that time.

2.1.2. Environmental Reporting and Reporting Initiatives

Environmental issues gained prominence in the late 1980s due to a series of significant international events, including the Chernobyl nuclear disaster (1986), the Exxon Valdez oil spill in Alaska (1989), the Montreal Protocol (1987), and the Brundtland Report (1987). In conjunction with these important developments, pioneering companies started publishing environmental information in their annual reports, often presenting it in standalone documents. These early reporting entities primarily included companies operating in environmentally sensitive and impactful industries, such as oil and gas, mining, pulp and paper, and chemicals, as well as companies like The Body Shop, which aimed to highlight their environmental and social values. Since there were no regulations or standards governing the publication of these early reports, they were issued voluntarily. Nevertheless, various initiatives began to promote environmental reporting. Notable among these were the reporting award schemes conducted by the Association of Chartered Certified Accountants, which started in the United Kingdom in 1991. Similarly, the Eco-Management and Audit Scheme (EMAS), introduced in 1993 along with its reporting requirements, served as a significant driver of environmental disclosure, especially in German-speaking countries in Europe [16]. By the late 1990s, approximately one-third of the world's 250 largest companies were voluntarily disclosing environmental information [16,17].

2.1.3. The Mainstreaming of Sustainability Reporting

In the 2000s, sustainability reporting rapidly became a routine activity for most large companies. Today, the majority of major corporations in industrialized nations disclose sustainability information in their reports. By the 2010s, this practice had become standardized in Asia as well as in some of the larger economies in Latin America and Africa. Many large companies across various countries began providing sustainability reports to their stakeholders. However, it is evident that in most cases, there is a threshold for the level of disclosure, as external reporting in such environments is not as prevalent among smaller companies. Despite the significant academic and public attention given to large multinational corporations, a wide range of other organizations also engage in sustainability reporting. These include universities, utility companies, and other public sector organizations, and non-governmental organizations (NGOs), as well as cities and regions, which often publish sustainability reports on an annual or biennial basis [10]. Scheme 1 illustrates the key milestones that have characterized the evolution of sustainability disclosure and its integration into mainstream practice over the past three decades.



Scheme 1. Key milestones in sustainability disclosure [18–23]. Source: IFC, 2024 [24].

2.2. Fraud Risk

Fraud encompasses a wide range of legal concepts but is generally defined as an intentional act aimed at obtaining unfair and illegal advantages. In this context, misconduct refers to unethical behavior that involves violating laws, regulations, or internal organizational procedures or neglecting market expectations for ethical business conduct. According to Statement on Auditing Standards o. 99 (SAS 99) [25], fraud is defined as an intentional act that leads to a material misstatement or a significant distortion in the financial statements being audited [26].

According to the Australian Standard AS 8001-2008 [27] on Fraud and Corruption Control, fraud is defined as a dishonest activity that either results in or has the potential to result in financial loss to any individual or organization. Examples of fraud include the theft of money or property and situations in which employees, external parties, or both engage in fraudulent activities to secure personal benefits. Additionally, fraud encompasses deliberate misrepresentations, concealment, the intentional destruction of documents, the misuse of incorrect documents, and the inappropriate use of information and positions.

Corruption, in contrast, is defined as dishonest activities conducted by management, executives, employees, or contractors that are contrary to the interests of the business or involve the misuse of others' trust to gain personal benefits. In Section 1.1 of this standard, fraud and corruption are categorized into three main areas:

1. Fraud involving asset misappropriation;
2. The manipulation of financial reporting (either internal or external);
3. Corruption, which includes the improper use of one's position for personal gain.

This standard applies to publicly listed companies, large private enterprises, public sector entities, and governmental institutions.

Fraud Risk Management

The adoption of a mandatory approach alone cannot resolve all recent issues related to fraud and misconduct. The role of a company and its management in establishing an

organizational culture—one that encourages responsible behavior and holds individuals accountable for misconduct— is crucial. One of the tools that management employs to mitigate risks associated with fraud or misconduct is fraud risk management. This approach has gained attention from various institutions and organizations, including the U.S. Securities and Exchange Commission (SEC) and the European Union, and professional bodies such as the International Federation of Accountants (IFAC) and the Association of Certified Fraud Examiners (ACFE).

The costs associated with fraud and misconduct extend beyond financial aspects; the broader public implications of fraud must be taken seriously. One significant consequence of fraud is the erosion of public trust in capital markets, which can subsequently lead to a decrease in investment and in the attraction of capital—elements essential for the vitality and growth of any economy. Therefore, fraud risk management is crucial not only for protecting financial interests but also for maintaining public confidence in economic institutions and capital markets.

3. Research Methodology

The research methodology of this study is based on a mixed-methods approach, integrating both qualitative and quantitative methods within the pragmatic (practical) paradigm. Initially, the study employs a qualitative method to identify the research model through the thematic analysis of data obtained from interviews. In the subsequent step, the DEMATEL (Decision-Making Trial and Evaluation Laboratory) technique is utilized for analysis.

The present study is exploratory in nature regarding its objectives. In terms of practical implications, it is applied research, and in terms of the implementation process, it follows a mixed-methods approach. Mixed-methods research refers to a methodology that combines, analyzes, and integrates both quantitative and qualitative methods within a single study or a series of studies, leading to a deeper understanding of the research problem and questions.

To achieve the primary objective of designing a fraud risk model based on sustainability reporting, a qualitative approach will be employed. For the secondary objective, which involves the quantitative analysis of relationships, the DEMATEL technique will be utilized. Furthermore, from a temporal perspective, this research is considered cross-sectional.

3.1. Qualitative Phase

The qualitative phase of research involved accounting and auditing professors and experts. To clarify the selection process for academics in this phase, we refined our methodology to focus on identifying individuals with expertise in both fraud and sustainability. This was accomplished by thoroughly reviewing their professional profiles, research interests, and published or ongoing work. This careful selection process ensured that participants possessed the necessary knowledge and experience to provide valuable insights for the study. The sampling was conducted purposefully using the snowball technique, resulting in 11 participants. The principle of theoretical saturation guided the determination of the sample size. Theoretical saturation is achieved when no additional themes or insights emerge from the data collection, and all conceptual categories have been explored, identified, and completed [28]. This means that after interviews were conducted with the ninth and tenth participants, no new themes or factors were identified, leading to the conclusion of the interview process with the eleventh participant. The interviews were conducted in a semi-structured format. Following the interviews, thematic analysis and coding were utilized to identify the key factors influencing sustainability reporting. To ensure the accuracy of the coding process and the validity of the themes derived from the interviews, the

identified codes were re-evaluated with the participants to confirm that they accurately reflected their views. The main objective was to capture the core ideas conveyed by the interviewees.

Thematic Analysis Technique

Thematic analysis is a technique used to identify, analyze, and report patterns themes, concepts, and recurring patterns in qualitative data. It serves as a method for analyzing textual information, transforming diverse and scattered data into rich and meaningful insights. This technique is commonly employed in various qualitative research methods. Thematic analysis is an iterative process, involving continuous back-and-forth movement between the different stages of analysis [29]. It allows researchers to extract meaningful insights from qualitative information, enhancing the understanding of underlying trends and issues.

In other words, this type of analysis can be applied independently or as part of other procedures and involves the researcher or analyst carefully identifying, examining, recording, classifying, and interpreting themes or patterns that are significant in describing the phenomenon under investigation or are relevant to the research questions. The ultimate goal is to identify and report one or more clear and meaningful patterns. Thus, thematic analysis transcends the mere identification and counting of phrases or words within a text; it aims to uncover both explicit and implicit beliefs within the data and to derive thematic patterns through coding and classification. Therefore, coding is a prerequisite for the formation and extraction of themes from the text [30].

The results derived from data analysis using the qualitative thematic analysis approach are presented as main themes, sub-themes, and concepts. This study employed the DEMATEL method to analyze the factors influencing the fraud risk model.

In line with the approach outlined by Braun and Clarke, thematic analysis in this study was conducted in six phases: familiarization with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and finally, reporting the findings [29]. Additionally, thematic analysis is a process carried out over time. Braun and Clarke proposed six stages for performing thematic analysis, which are illustrated in Figure 1.

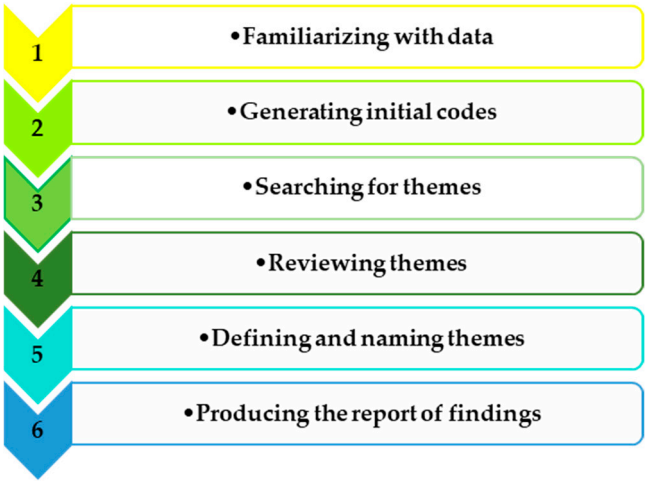


Figure 1. Steps of thematic analysis—Braun and Clarke's 6-phase thematic analysis framework.

3.2. Quantitative Phase

In the quantitative phase, the statistical population comprised experts and auditors. Using non-probability convenience sampling, we initially selected 57 experts, with 33

ultimately participating in the study. From the pool of 57 auditors, a total of 33 male participants were chosen. Among these participants, 5 held bachelor's degrees, while 28 held master's degrees, and all were certified accountants. The DEMATEL (Decision-Making Trial and Evaluation Laboratory) method was employed for data analysis. This method is particularly valuable for confirming the relationships among variables and for identifying the interconnections that are characteristic of a specific system [31]. The DEMATEL approach also facilitates the assessment of subjective perceptions, effectively integrating personal insights into complex issues [32]. The DEMATEL method was specifically developed to address complex problems. It provides an effective solution for resolving issues that involve interconnected subjects, indicators, or groups of factors by creating an appropriate hierarchical network system. DEMATEL offers a clear understanding of the interactions among different factors and establishes a structured network for researchers. This method aids in solving complex problems by gathering group opinions and identifying causal relationships among the factors involved [33].

The output of the DEMATEL process is a graphical representation that enables users to make informed decisions and prioritize factors or categories accordingly. This technique serves as a comprehensive approach for constructing and analyzing a structural model of causal relationships among multiple complex factors [34]. This method was first utilized by the Battelle Memorial Institute in Geneva between 1972 and 1976 to study and address a set of complex and interrelated issues [32,35].

4. Research Findings

4.1. The Findings of the Qualitative Section

The semi-structured interviews conducted in the qualitative section facilitated the identification of factors influencing fraud risk within the framework of sustainability reporting, using thematic analysis and coding methods. Thematic analysis, as proposed by Clarke and Braun, is a method used to recognize, analyze, and report patterns within qualitative data, transforming diverse information into rich insights. This approach is applied to comprehend textual data, derive meaningful interpretations, and convert qualitative findings into quantitative insights.

In the first step, recorded audio and written statements from the interviewees were categorized. Following this, initial codes were generated after careful analysis and organization. In the third phase, different codes were organized into themes, which focused on higher-level analysis. The next step involved refining these themes by grouping similar ones into cohesive clusters, ultimately resulting in a network of main themes and sub-themes.

Consequently, the interview texts were reviewed, and the influencing factors were identified using thematic analysis through MaxQDA2024 software. The interviews, which comprised five main questions, were conducted after necessary explanations were provided to the participants. The text from the completed interviews was then analyzed. To ensure the accuracy of coding and concept extraction, the codes derived from the interviews were returned to the participants for confirmation of the extracted codes.

4.2. The Reliability and Validity of the Model and the Theoretical Saturation of Findings (Codes)

In qualitative research, the concept of validity encompasses elements such as the defensibility, credibility, confirmability, and reflexivity of the research findings. This indicates that if another researcher were to replicate the study, the results would be consistent with those obtained in the current study. A key indicator of reliability in qualitative research involves comparing two or more documents to ensure that they consistently reference a specific indicator. MaxQDA software supports this process by offering the capacity to

assess validity through the "two-case model" test. By selecting two groups, this software automatically identifies and reports common and unique codes between these groups. In the current study, two groups were selected, consisting of 156 and 116 items, respectively, and the corresponding two-case model analysis is presented in Figure 2.

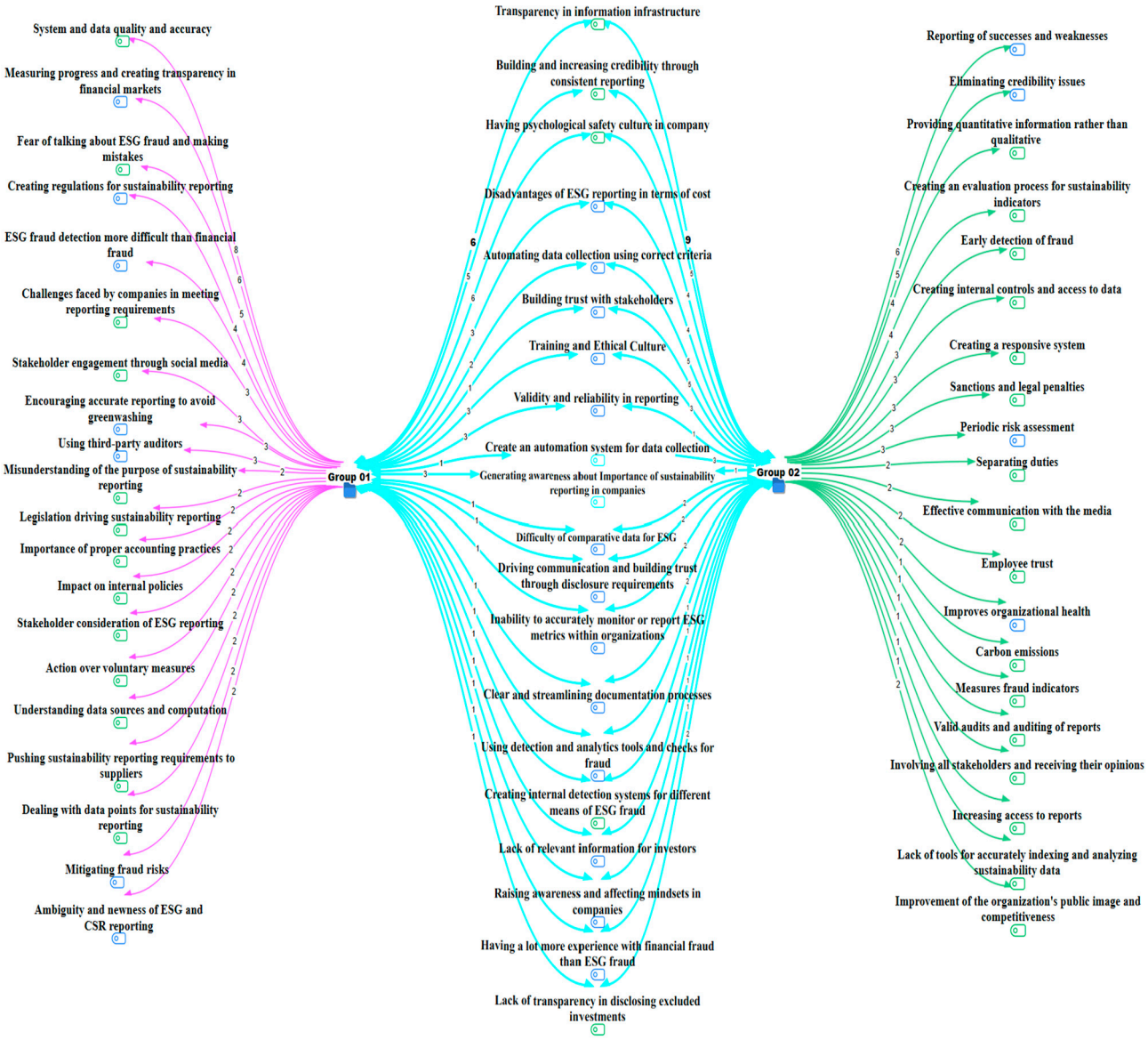


Figure 2. Two-case model.

The two-case model diagram was drawn for the first and second groups. In the diagram above, the codes that are in the middle are the ones that are common between the two groups, with each of them referring to these codes. According to the figure above, on each arrow, a number in the form of frequency is reported, indicating how many times that group referred to that code. For example, the topic "Transparency in Information Structure" is reported to have been repeated 15 times. Also, on the arrow of the first group, a frequency of six repetitions is reported, and for the second group, a frequency of nine repetitions is reported. These numbers mean that in total, in the coded sections for the two groups, the frequency of the code "Transparency in Information Structure" is equal to 15, with this code mentioned 6 times by individuals in the first group and 9 times by individuals in the second group.

The aim was to capture the main ideas of the interviewees. Based on the analysis of the interviews, seven concepts were extracted.

Following the interviews, thematic analysis and coding were employed to identify the key factors influencing sustainability reporting. To ensure the accuracy of the coding process and the validity of the themes derived from the interviews, the identified codes were re-evaluated with the participants to confirm that they accurately reflected their views.

4.3. Research Design

In this section, we focus on designing a paradigmatic research model aimed at developing and presenting a conceptual design model and explaining the fraud risk model based on the sustainability reporting of identified factors.

Quantitative Findings

As noted in Section 4.2, the comparison diagram in Figure 3 and the primary seven factors presented in Table 1 serve as the basis for our application of the DEMATEL method. This approach allows us to integrate both methodologies, thereby clarifying and elucidating the causal relationships among the factors.

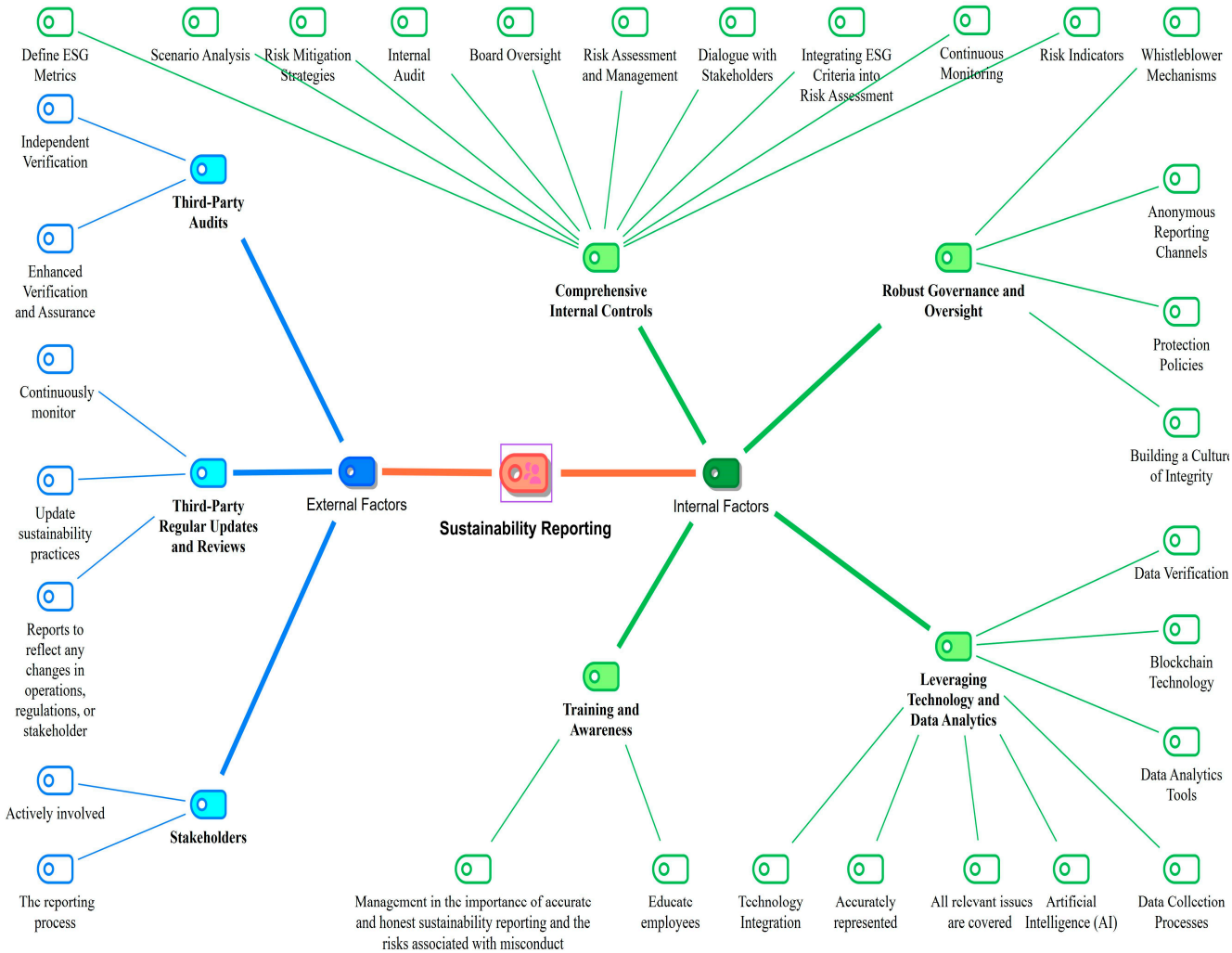


Figure 3. Model of fraud risk factors in the context of sustainability reporting.

Table 1. Categorization of core subjects.

Main Themes	Axial Themes
Training and Awareness	Educate employees
	Management in the importance of accurate and honest sustainability reporting and the risks associated with misconduct
Comprehensive Internal Controls	Integrating ESG criteria into risk assessment
	Define ESG metrics
	Risk indicators
	Continuous monitoring
	Internal audit functions
	Risk assessment and management
	Risk mitigation strategies
	Scenario analysis
	Dialogue with stakeholders
	Board oversight
Robust Governance and Oversight	Building a culture of integrity
	Whistleblower mechanisms
	Anonymous reporting channels
	Protection policies
Leveraging Technology and Data Analytics	Data analytics tools
	Artificial Intelligence (AI)
	Blockchain technology
	Data collection processes
	Data verification
	Technology integration
	All relevant issues are covered
	Accurately represented
Third-Party Regular Updates and Reviews	Continuously monitor
	Reports to reflect any changes in operations, regulations, or stakeholder expectations
	Update sustainability practices
Third-Party Audits	Enhanced verification and assurance
	Independent verification
Stakeholders	Actively involved
	The reporting process

4.4. Calculation Algorithm

This section examines the influence and impact of the seven research factors, which are introduced below, using the DEMATEL method:

1. Third-Party Regular Updates and Reviews (F1);
2. Third-Party Audits (F2);
3. Stakeholders (actively involved) (F3);

4. Training and Awareness (F4);
5. Comprehensive Internal Controls (F5);
6. Robust Governance and Oversight (F6);
7. Leveraging Technology and Data Analytics (F7).

The direct relationships between the indicators under consideration were evaluated using a scoring scale ranging from 0 to 4, known as the Fontel and Gabus scale. This scale is defined as follows: 0 indicates no direct impact, 1 represents low impact, 2 denotes medium impact, 3 signifies high impact, and 4 reflects a very high impact. The assessment was conducted in pairs, by experts who were asked to indicate the direct influence of factor F_i on factor F_j, to enhance objectivity in the evaluation process. The outcome of making pairwise comparisons between these factors is a matrix of direct relations, denoted as M (refer to Table 2). The matrix of direct relations, M, is a square matrix where the diagonal elements are set to 0, reflecting the principle that an indicator cannot influence itself within the framework of the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method. The element m_{ij} in matrix M represents the direct influence exerted by factor i on factor j, following the Fontel and Gabus point scale.

Table 2. The matrix of direct relations, M.

M	F1	F2	F3	F4	F5	F6	F7
F1	0	4	2	1	1	3.8	1
F2	1.3	0	4	1	3	1.5	1
F3	1.3	3	0	1.1	4	3.9	1.3
F4	1.2	4	4	0	4	3.9	3.9
F5	1.4	4	4	4	0	3.8	3.7
F6	1.6	3.9	3.9	3.8	4	0	3.9
F7	1.2	3.7	3.8	3.9	3.7	3.8	0

The assessments of m experts are arranged in the direct matrix Dk = $[d_{ij}^k]$, where Dk is the $n \times n$ matrix, and d_{ij}^k indicates the assessment of expert k in relation to the direct influence of factor i on factor j. Dk is an asymmetric matrix as the influence of factor i on factor j is not necessarily equal to the influence of factor j on factor i. The group direct matrix $D = [d_{ij}]$ is an average of matrices Dk, where its factors d_{ij} are the arithmetic means of the factors d_{ij}^k, $k = 1, \ldots, h$.

Step 1: Calculating the Mean Matrix (M)

The mean matrix, denoted as M, represents the aggregated matrix of experts' responses. The elements of this matrix are calculated according to Equation (1), where H denotes the number of experts, and $\boldsymbol{X}_{ij}$ represents the values assigned by the Kth expert that can be formed, where all principal diagonal elements are equal to zero, and X_{ij}^k represents the judgment of the decision maker on the degree to which factor $\boldsymbol{F}_i$ affects factor $\boldsymbol{F}_j$.

$$a_{ij} = \frac{1}{H} \times \sum_{k=1}^{H} X_{ij}^k \quad (1)$$

In Table 2, F1 to F7 represent the seven factors extracted from the interviews, which are detailed in Table 1.

Step 2: Calculation of the Normalized Direct Relations Matrix (D)

Matrix A is converted into the initial normalized direct relations matrix, referred to as matrix D (Table 3) through Equations (2) and (3).

$$D = m \times A \tag{2}$$

$$m = min\left[\frac{1}{max\sum_{i=1}^{n}|a_{ij}|}, \frac{1}{max\sum_{j=1}^{n}|a_{ij}|}\right] \tag{3}$$

Table 3. A standardized direct relationship matrix, D.

D	F1	F2	F3	F4	F5	F6	F7
F1	0	0.177	0.088	0.044	0.044	0.168	0.044
F2	0.058	0	0.177	0.044	0.133	0.066	0.044
F3	0.058	0.133	0	0.049	0.177	0.173	0.058
F4	0.053	0.177	0.177	0	0.177	0.173	0.173
F5	0.062	0.177	0.177	0.177	0	0.168	0.164
F6	0.071	0.173	0.173	0.168	0.177	0	0.173
F7	0.053	0.164	0.168	0.173	0.164	0.168	0

The sum of each row j in matrix A represents the total direct influence that factor *i* exerts on other factors. Therefore, this value indicates the factor with the greatest impact on others. Similarly, the sum of each column i in matrix A represents the total direct influence that factor *i* receives from other factors, indicating the factor most influenced by others.

The scalar matrix m is defined as the upper bound, taking the minimum value of these two sums. The normalized direct relations matrix *D* is obtained by dividing all elements of matrix A by the scalar matrix m. It is important to note that each element d_{ij} of matrix *D* will have a value between zero and one. In other words, all elements in matrix *D* are followed with $0 \leq d_{ij} < 1$.

Step 3: Calculation of the Indirect Influence Matrix (ID)

The indirect influence matrix, denoted as ID, as indicated in Table 4, is obtained using the following Equation (4):

$$ID = D(I - D)^{-1} \tag{4}$$

where *I* represents the identity matrix, and *D* is the normalized direct relations matrix. This calculation allows us to determine the indirect relationships or influences between factors, complementing the direct relationships identified earlier.

Table 4. Total effect matrix, ID.

T	F1	F2	F3	F4	F5	F6	F7
F1	1.14035	0.503377	0.435075	0.28735	0.373932	0.461138	0.2881405
F2	0.187653	1.333977	0.489701	0.278457	0.432849	0.372283	0.2786579
F3	0.22244	0.538669	1.426544	0.351625	0.548963	0.532535	0.358186
F4	0.282902	0.736192	0.745062	1.419351	0.707191	0.684132	0.5667199
F5	0.288293	0.73191	0.74015	0.565619	1.551874	0.676837	0.5561907
F6	0.2975	0.733946	0.741586	0.563125	0.706462	1.537927	0.5665274
F7	0.274713	0.70597	0.717574	0.552187	0.677914	0.662433	1.4052578

Step 4: Generation of the Influential Relation Matrix and Map (Summing the Rows and Columns and Construct the Causal Diagram)

To construct the causal diagram, as illustrated in Table 5, we calculate the sum of the rows (S) and the sum of the columns (R) of the overall relationship matrix. Then, we calculate S + R and S − R.

Table 5. The values of the significance indicator (S) and the relation indicator (R).

The Key Factors Influencing Sustainability Reporting	S	R	S + R	S − R	The Position in Cause and Effect
F1	2.489	1.694	4.183	0.796	cause
F2	2.374	4.284	6.658	−1.910	effect
F3	2.979	4.296	7.275	−1.317	effect
F4	4.142	3.018	7.159	1.124	cause
F5	4.111	3.999	8.110	0.112	cause
F6	4.147	3.927	8.074	0.220	cause
F7	3.996	3.020	7.016	0.976	cause

Source: author's work.

4.5. Cause-And-Effect Relations

The calculations presented in Table 5 and illustrated in Figure 4 elucidate the cause-and-effect relationships among the identified factors. The S index reflects the influence of these factors; the higher the S value for a given factor, the more influential it is within the system. This analysis identifies Robust Governance and Oversight (F6) as the most influential factor.

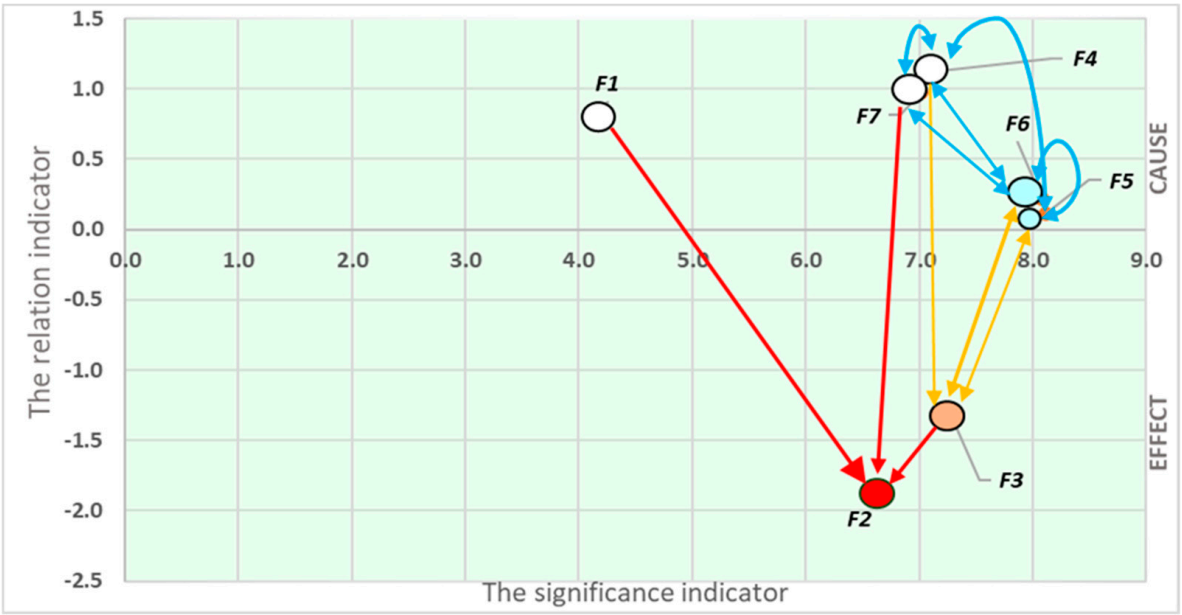


Figure 4. Cause–effect chain diagram of factors (impact–relation map) illustrating cause-and-effect relationships among factors. The circles' colors are used to differentiate the factors, indicating their level of influence and their connection to other factors. The arrows' colors highlight the nature and direction of these relationships, with red representing a stronger influence in the direction of the arrow.

The R index represents the effectiveness of each factor. The higher the R value for a given factor, the more effective it is within the system. Based on this analysis, Stakeholders (actively involved) (F3) are identified as the most effective factor.

Using the S + R and S − R values from Table 5, it can be determined that the factors located above the X-axis have a positive D-R value, indicating that they function as causes, where their influence on other factors is greater than the influence they receive. These factors include F1, F4, F5, F6, and F7.

Conversely, the factors located below the X-axis have a negative S-R value, indicating that they function as effects in the study, receiving a greater degree of influence from other factors. These factors include F2 and F3.

5. Discussion

This study makes a significant contribution to the literature on sustainability reporting by exploring the critical yet under-researched area of fraud risk. The mixed-methods approach, which integrates qualitative data from expert interviews with quantitative DEMATEL analysis, offers a nuanced understanding of the complex factors influencing fraud risk. By identifying key influential factors—such as stakeholder engagement, third-party audits, report credibility, comprehensive internal controls, robust governance, and the effective use of technology—this research provides valuable insights for both practitioners and regulators. The comparative analysis between Iran and Denmark highlights the influence of differing regulatory environments on the application of sustainability reporting standards and the effectiveness of fraud prevention measures. This study does not seek to detect fraudulent or misleading practices but rather to identify risks and propose preventive measures related to fraud in sustainability reporting. The comparison of Denmark and Iran provides an illustrative contrast between a developed and developing economy, highlighting potential vulnerabilities and best practices. The DEMATEL analysis, particularly, successfully illuminates the complex interdependencies between these factors, creating a more holistic understanding of the fraud risk landscape. The findings directly support the increasing emphasis on transparency, accountability, and robust internal controls within sustainability reporting frameworks, suggesting areas requiring further attention and improved regulatory oversight. The causal relationships identified underscore the crucial role of independent assurance mechanisms and the importance of fostering a culture of ethical behavior within organizations.

Our findings highlight the critical role of stakeholder engagement, internal controls, and strong governance frameworks in effective fraud risk management within sustainability reporting. This aligns with M.K. Shad et al. (2019) [7], who demonstrate that robust sustainability reporting practices can moderate the relationship between enterprise risk management (ERM) and business performance, ultimately enhancing organizational integrity and competitiveness. While our research focuses on mitigating fraud risk, their findings further substantiate that effective sustainability reporting not only promotes transparency and accountability but also reduces information asymmetry among stakeholders. Therefore, these insights underscore the interconnectedness of risk management and sustainability reporting as essential elements in driving organizational success and maintaining ethical practices.

Also, our research was supported by an examination of risk factors associated with the fraud triangle presented by Y.-I. Lou and M.-L. Wang (2009) [18], who indicate that conditions such as financial pressure on firms, complex transactions, and questionable managerial integrity significantly correlate with fraudulent financial reporting. Using a logistic regression model, their analysis of fraud and non-fraud cases reveals that these risk factors can reliably estimate the likelihood of fraudulent behavior. While our research focuses on enhancing sustainability reporting practices to mitigate fraud risk, identifying specific proxy variables in the fraud triangle underscores the necessity for vigilance against these risks. Together, our insights indicate that addressing the fundamental compo-

nents of the fraud triangle in conjunction with robust sustainability reporting can provide organizations with a comprehensive framework to prevent fraud and promote ethical practices effectively.

The study's findings have important implications for businesses seeking to enhance their sustainability reporting practices. The identified factors can serve as a guide for the development of comprehensive fraud risk management strategies. Similarly, regulators can utilize these findings to inform the development of more effective policies and standards to promote transparency and deter fraudulent reporting. The use of a mixed-methods approach allowed for the validation of key factors identified through qualitative data analysis, strengthening the reliability and generalizability of the findings. However, the study's limitations, discussed below, should be considered when interpreting the results and developing future research agendas. The model, while effective, may need further refinement to account for the dynamic nature of fraud risk and the potential for new challenges to emerge within the field of sustainability reporting.

6. Conclusions

The comparative analysis of two countries—Denmark and Iran—was designed to explore both theoretical and practical insights that reflect distinct approaches to sustainability reporting within differing socio-economic, regulatory, and cultural contexts. By leveraging insights gathered from interviews with academic experts and industry professionals, we identified significant factors that influence sustainability reporting practices in these regions. These factors were contextualized against the broader framework of the Global SDG Index to establish a baseline for understanding how national-level priorities shape corporate-level reporting dynamics. This research successfully developed a fraud risk model within the context of sustainability reporting, utilizing a robust mixed-methods approach. The study's findings provide valuable insights into key factors influencing fraud risk, highlighting the significance of stakeholder engagement, third-party audits, report credibility, and robust internal controls. The comparative analysis between regulatory environments in Iran and Denmark offers valuable context and underscores the importance of strong governance frameworks. The DEMATEL method effectively captures the intricate interdependencies between factors. These findings have significant implications for both organizations seeking to enhance their sustainability reporting and policymakers aiming to improve regulatory frameworks. The results underscore the need for improved transparency, accountability, and ethical practices in sustainability reporting to mitigate the risk of fraud and maintain the integrity of this critical area of corporate reporting.

However, several limitations warrant consideration. The purposive sampling method, while appropriate for exploratory research, may limit the generalizability of the findings to other contexts. The relatively small sample size, particularly in the qualitative phase, could also affect the extent to which the conclusions can be generalized to a broader population. Furthermore, the cross-sectional nature of the study prevents the analysis of the dynamic relationships between the identified factors over time. Future research could address these limitations by using larger and more diverse samples, employing longitudinal research designs, and exploring the effectiveness of specific interventions aimed at mitigating fraud risk. Finally, the qualitative data analysis might benefit from even more rigorous thematic analysis to strengthen the reliability of the findings.

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