

RESEARCH ARTICLE

The digitalization of sustainability reporting processes: A conceptual framework

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Abstract

Building on the contingency theory, the paper aims to shed light on the contribution provided by technological innovation on sustainability reporting quality. A fuzzy expert system (FES) was developed to evaluate the cumulative effects related to the adoption of digital devices in sustainability reporting practices. The analysis underlined the enabling role covered by Sustainable Enterprise Resources Planning (S-ERP) systems on sustainability reporting processes. In detail, we found that the disclosure of environmental information using technological platforms can lead analysts to a more accurate evaluation.

KEYWORDS

contingency theory, CSRD, fuzzy expert system (FES), sustainability reporting, technological innovation

1 | INTRODUCTION

In recent years, the international scenario has been interested in the proliferation of new forms of regulation to encourage companies to disclose their sustainability information on a mandatory basis (Jackson et al., 2020). This paradigm shift was driven by the increasing consciousness about the pivotal role covered by the private sector, which represents a key actor within the strategies identified by the United Nations in the 2030 Agenda (Bebbington & Unerman, 2020; Pizzi et al., 2021). Furthermore, many companies voluntarily disclose their sustainability information to engage with stakeholders more effectively (Venturelli, Caputo, et al., 2022).

One of the main contributions to the development of accountability practices by large companies has been provided by the European Commission. The European context represents one of the leading jurisdictions affected by this paradigm shift. In particular, the Directive 2014/95/EU introduced specific rules about the disclosure of non-financial information by European public interest entities

(PIEs). However, despite the positive externalities related to the transposition of the law by the member states, the fitness checks performed by the European Commission revealed the existence of many criticisms related to the lack of standardization (European Commission, 2018). This evidence has also been supported by leading organizations in sustainability reporting and accounting scholars, highlighting that many companies overestimated their positive impacts and underestimated the negative externalities (Korca & Costa, 2021; The Alliance for Corporate Transparency, 2020).

Building on this evidence, in 2021, the European Commission launched the proposal for a Corporate Sustainability Reporting Directive (CSRD), which represents the natural prosecution of the Directive 2014/95/EU (Breijer & Orij, 2022). In 2022, the European Commission introduced a set of European Sustainability Reporting Standards (ESRS) released by the EFRAG. Furthermore, following the approach used for financial reporting, the European companies affected by the CSRD will disclose their sustainability information following the European Single Electronic Format (ESEF) (KPMG, 2022). In this

Abbreviations: CSRD, Corporate Sustainability Reporting Directive; FES, Fuzzy expert system; S-ERP, Sustainable Enterprise Resources Planning; XBRL, eXtensible Business Reporting Language.

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sense, the transition from Directive 2014/95/EU to the CSRD will positively impact the overall degree of sustainability accounting standardization in Europe (Baumüller & Sopp, 2022).

The need to standardize sustainability information will favor the development of new reporting tools. As evidenced by the Global Reporting Initiative, many companies started to adopt Sustainable Enterprise Resource Planning (S-ERP) to digitalize their processes (Global Reporting Initiative, 2022). Furthermore, the Sustainability Accounting Standards Board introduced the first XBRL Taxonomy (SASB, 2021). Thus, the following years will be characterized by the wide adoption of these innovative tools, which will enhance the reliability of the sustainability information disclosed on a mandatory or voluntary basis (George & Schillebeeckx, 2022; Pizzi et al., 2022).

Integrating digital tools in sustainability reporting processes should represent an effective way to avoid some of the main issues identified by practitioners and policymakers about the lack of comparability and reliability (Leitner-Hanetseder & Lehner, 2022). However, despite the increasing awareness of the need to digitalize sustainability information, only a few studies have considered the enabling role covered by digital transformation on sustainability reporting practices (Lombardi & Secundo, 2020; Schmitz & Leoni, 2019). In addition, the current scenario is characterized by developing theoretical and critical research based on qualitative methods and literature reviews (Lubin & Esty, 2014; Seele, 2017).

According to this evidence, the paper aims to shed light on the contribution provided by the S-ERP in enhancing sustainability reporting quality. The digitization of sustainability reporting processes represents a new research frontier for academics. Despite many studies highlighting the opportunity to integrate sustainable modules in ERP systems (Alsaid, 2022; Chofreh et al., 2020), only a few studies were developed about the specific impacts caused by the adoption of S-ERP in sustainability reporting processes (Pei & Vasarhelyi, 2020; Seele, 2016). In detail, the main references about S-ERP were developed by academics to explore the interlinkages between sustainable performance and digitalization (Abobakr et al., 2022; Chofreh et al., 2020).

This paper aims to advance the scientific knowledge about sustainability reporting quality by using a fuzzy expert system (FES). The choice to adopt an FES instead of alternative quantitative approaches has been driven by the opportunity to evaluate the moderating role covered by digitalization on the traditional items considered by accounting scholars in their research. In particular, we developed an FES based on evaluating the main interlinkages between organizational factors and adopting digital tools to support sustainability reporting processes. In this regard, the FES will estimate the potential benefits of providing more strict requirements by the CSRD about data digitalization.

The analysis was built considering a sample of Italian PIEs interested in transitioning from Directive 2014/95/EU to the CSRD. The choice to consider a sample of large PIEs has been driven by the necessity to consider a sample characterized by an adequate degree of homogeneity. Regarding the choice to consider the Italian

context, our choice has been driven by the opportunity to evaluate an institutional context characterized by an adequate degree of standardization. In fact, despite the opportunity to comply with Legislative Decree 254/2016 using alternative reporting standards, all the Italian PIEs disclosed their sustainability information according to the GRI Standards (Deloitte, 2019).

The contribution of the research is twofold. The first implication is related to the opportunity to extend the scientific knowledge about social and environmental accounting by identifying new insights about the enabling role covered by digital technologies (Mancini et al., 2021). In detail, we answered the following research question:

RQ1: What is the contribution of the S-ERP to sustainability reporting?

The second contribution consists of identifying new technological implications related to adopting S-ERP in accounting. Despite many companies adopting S-ERP during the last few years, only a few insights have been collected about using the tools in reporting processes (Pei & Vasarhelyi, 2020; Seele, 2016). Therefore, we will also fill the following research gap:

RQ2: What is the state of the art of digital sustainability reporting in Italy?

2 | LITERATURE REVIEW

2.1 | Sustainability reporting and digitalization

The introduction of new requirements for sustainability reporting digitalization by the European Commission represents a relevant innovation within the debate about social and environmental accounting (Alles et al., 2021; Atkins et al., 2023). In this regard, despite recent data released by leading consulting firms highlighting that many international companies adopted new accountability tools on a mandatory or voluntary basis, only a few pieces of evidence have been collected about the adoption of digital devices in sustainability reporting (EY, 2022; KPMG, 2020). Furthermore, the need to consider the effects related to the introduction of digital requirements is also supported by the recent initiatives launched by the IFRS Foundations and the SEC (Haji et al., 2022).

The main factors that have driven the choice made by the European Commission to include mandatory requirements for digital reporting are represented by the need to develop more reliable and verifiable information. During the final public consultations launched in 2021, stakeholders highlighted the lack of informativity on the data included in the non-financial declarations prepared according to Directive 2014/95/EU. In particular, the main issues were identified by investors, which underlined the opportunity to consider more strict requirements in the CSRD (European Commission, 2021). In this regard, the European Commission chose to extend the scope of the ESEF regulation to the CSRD.

Following the methodological approach used for financial reporting processes, the European Commission requires the EFRAG to develop an XBRL-based taxonomy to digitalize sustainability reports' contents (EFRAG, 2022). The direct involvement of international experts with specific backgrounds in digitalization and XBRL has supported the activities conducted by the EFRAG. The first wave of activities performed by the EFRAG finished in June 2022 with the release of an ESRS E1 Proof-of-Concept (PoC) XBRL taxonomy. The disclosure considered in the first PoC is represented by the information about climate change, which are the first set of information released by the EFRAG.

The extensible business reporting language (XBRL) is the international digital business reporting standard managed by a global not-for-profit consortium (XBRL International, 2022a). In the last few years, XBRL evolved into inline XBRL (iXBRL), a standard that allows both human-readable and structured, machine-readable data to be provided in a single document (XBRL International, 2021). The XBRL language is an extensive markup language (XML) used by worldwide companies to digitalize their financial reports on a mandatory or voluntary basis. Even without specific legal requirements, many companies started to disclose their information using XBRL to enhance their transparency (Boritz & No, 2008).

The diffusion of the XBRL has been favored by regulators, which included in their jurisdiction's specific rules about financial reporting and digitalization. Many regulators adopted XBRL because it represents an effective way to enhance financial markets transparency due to the identification of a common language to disclose financial information (Troshani & Rowbottom, 2022). Financial and non-financial reports prepared according to XBRL are characterized by desirable features, such as accessibility, availability, administrative burden reduction, and usefulness (Bartolacci et al., 2021). XBRL adoption has also been supported by investors' increasing demand for information, which adopted digital platforms to analyze and select their investments portfolio (Blankespoor et al., 2014). Furthermore, the wide diffusion of XBRL-based reports favored the interaction between companies and non-professional and foreign investors (Wang & Seng, 2014).

The firsts attempt to conceptualize XBRL taxonomies about sustainability reporting is represented by the proposals made by international standard setters during the last few years (EFRAG, 2022; SASB, 2021; XBRL International, 2022b). Before that period, a first attempt was made by the Global Reporting Initiative (Roohani et al., 2009), but scarce adoption by companies and practitioners characterized the project. In this regard, the scientific debate about sustainability reporting and XBRL is fragmented due to the lack of evidence-based research. However, despite the absence of taxonomy about sustainability reporting, the last few years have been characterized by preliminary research about the main constraints and opportunities related to the disclosure of sustainability information using XBRL.

One of the first studies was published by Knebel and Seele (2015), which argued that introducing XBRL as the corporate reporting language for CSR and sustainability content should enhance the reliability of the evaluation made by academics and investors.

Furthermore, the authors suggested the use of comparable data points as already used in XBRL-based financial reporting. In this regard, the authors theorized the effects of the projects launched by the European Commission in 2022. At the same time, Seele (2016) researched the opportunity to bridge the gap between sustainability reporting and management control using XBRL.

Another far-sighted research was conducted by Efimova et al. (2020). The authors tried to identify potential interlinkages between financial and non-financial information in their research. Interestingly, the authors adopted a critical approach to identify the main benefits and barriers to adopting XBRL in sustainability reporting. First, they confirmed that a common taxonomy could favor implementing a more effective management control system. However, at the same time, they underlined the need to consider companies' infrastructures, which represents essential items to consider in developing an XBRL-based report. Finally, Helbig et al. (2021) shed light on the opportunity to develop a data repository to exchange ESG data with stakeholders. Using an alternative lens of analysis, the authors highlighted the advantages related to the systematic collection of ESG data. In detail, the authors identified the opportunity to publish corporate sustainability open data (CSOD) to engage more effectively with stakeholders.

3 | THEORETICAL FRAMEWORK

The last decades have been characterized by increasing attention paid by academics to technological innovation. In particular, understanding the contribution of digitalization on business processes represents a critical task for researchers interested to evaluate the main implications related to adopting new technologies by companies (Lucas & Goh, 2009; Trabucchi et al., 2019). In this regard, many studies underlined the pivotal role covered by digitalization in management research (Caputo et al., 2021).

Accounting research represents one of the main fields interested in this trend. The wide adoption of digital features and the rapid growth of new accounting technologies have contributed to the development of studies about adopting emerging technologies in accounting and auditing processes (Troshani et al., 2019). In particular, many studies were developed about financial reporting, as evidenced by the proliferation of studies about research topics such as ERP systems, XBRL, and blockchain (Alles et al., 2021; Mancini et al., 2021; Vasarhelyi & Romero, 2014). However, as evidenced below, only a few studies were developed about non-financial reporting because of the field's novelty. In this regard, many research agendas have been launched by accounting scholars to fill this research gap through novel and original insights about the interlinkages between digitalization and sustainability reporting (Pizzi et al., 2022; Seele, 2017; Watson & Wray, 2022).

Although the topic's novelty, the need to explore the effects related to integrating new features in accounting processes was first discussed by Otley (1980). In its pioneer contribution, the author underlined the need to consider the external circumstances that can

impact traditional accounting systems. The author argued that “the adoption of appropriate accounting system will depend upon the specific circumstances in which an organization finds itself” (Otley, 1980, p. 413). Building on this preliminary reflection, the author introduced within the management accounting debate the contingency theory, which represents one of the main theoretical frameworks adopted by accounting scholars to evaluate the moderating role covered by technological innovation on accounting processes (Otley, 2016). Furthermore, the theoretical framework proposed by Otley has also been explored by other leading scholars during the last few years, such as Donaldson (2001) and Drazin et al. (1985).

However, integrating new technologies in management accounting processes can lead to different scenarios because of the existence of different impacts on organizational structures. As evidenced by Chenhall and Chapman (2017), a practical evaluation of the impacts of external contingencies on managerial accounting systems requires the analysis of the following items: (1) the characteristics of the system, (2) the identification of the organizational performance, and (3) the analysis of the contingency factor. In this regard, the authors underlined the need to consider contingency factors as external resources accountants adopt to integrate their management accounting systems. In fact, the comparative analysis between scenarios characterized respectively by the adoption and absence of contingency factors can lead researchers to evaluate the phenomenon effectively.

4 | METHODS AND DATA

4.1 | The FES

The analysis was built using a methodological approach based on fuzzy logic, “a cognitive framework that adequately replicates the natural way human beings cognize the world and think about problems and situations” (Magni et al., 2006). Developing a FES enables researchers to overcome some of the main criticisms related to adopting a Boolean logic to evaluate complex phenomena. FES can convert unstructured concepts into structured information using fuzzy data, fuzzy rules, and fuzzy inference usable to merge the capabilities of an expert system to simulate the decision-making process with the vagueness typical of human reasoning (Magni et al., 2001). In this regard, it represents a methodological approach particularly suitable for researchers interested in evaluating complex dynamics related to companies' implementation of business strategies (Arias-Aranda et al., 2010; Veltri et al., 2015).

FES also represents a methodological approach particularly suitable for management research based on contingency theory (Chenhall & Chapman, 2017). In particular, FES have found applications in various accounting and financial management areas. For example, they can be used in financial risk assessment, investment portfolio optimization, credit risk evaluation, and performance evaluation of financial instruments. By incorporating fuzzy logic, these systems can better handle the imprecision and uncertainty often encountered in financial data.

Therefore, the adoption of FES in management research can enhance decision-making processes, especially in situations where uncertainty and imprecision are prevalent. By capturing expert knowledge and handling complex systems, FES contributes to a more comprehensive understanding of management problems and supports better informed decisions in accounting and other management-related domains. Thus, the FES model has been used to obtain information about the main effects of adopting digital features to collect and report environmental data within the non-financial declarations prepared on a mandatory basis by Italian PIEs. For our purposes, we developed a research protocol based on the following phases:

1. focus group with experts to define the inputs and conditions for aggregating intermediate variables and output. In particular, we involved accounting academics with a strong professional background in sustainability reporting practices.
2. layout of the model (modular decision tree).
3. definition of linguistic attribute (fuzzy value) for each variable, range of variables and blocks of fuzzy rules.
4. trial processing and optimization.
5. analysis of the final output.

4.2 | The model

Model design is one of the most relevant phases of empirical research based on fuzzy logic. Developing a practical evaluation requires the involvement of a panel of experts with specific knowledge about the research field. In this regard, the analysis was built through the involvement of a research team composed of an expert in fuzzy logic and three scholars with specific expertise in sustainability reporting and digitalization fields. From a mathematical point of view, the connection between the set of the n input variables and the output can be represented by a function f of n independent variables x_i ($i = 1, 2, \dots, n$) affecting the dependent variable y (intermediate variable), so that

$$y = f(x_1, x_2, \dots, x_n).$$

The model was built considering the theoretical approach proposed by Chenhall and Chapman (2017). In particular, technological innovation was considered a contingency factor independent of the organizational structure. This choice has been driven by the opportunity to collect information about the main variations related to companies' adoption of technological innovation. From a technical perspective, the FES consists of 10 input variables, 5 output variables, 5 rule blocks, 581 rules, and 65 membership functions (Figure 1).

Considering previous review studies about sustainability reporting quality (Hahn & Kühnen, 2013; Turzo et al., 2022), researchers conceptualized a company's organization factors considering three of the main components accounting scholars consider in their empirical research. The three blocks aim to summarize the following

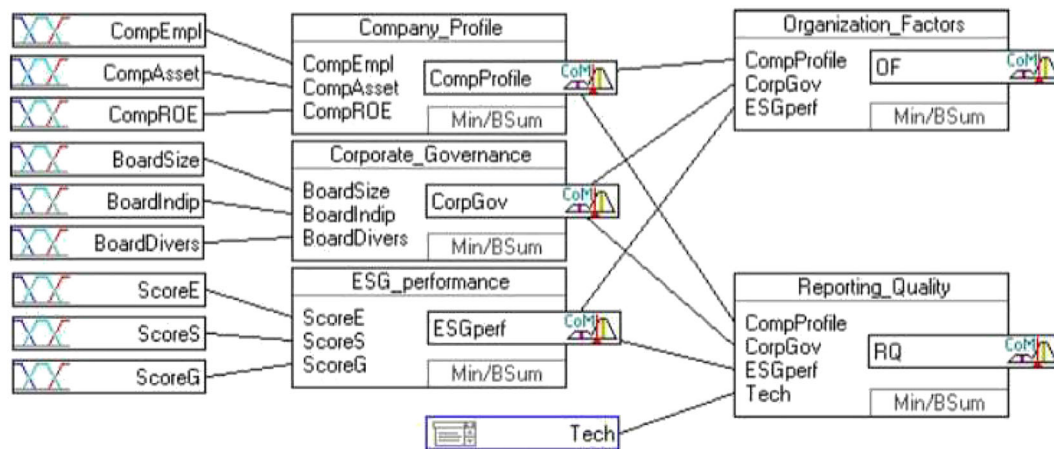


FIGURE 1 Overview of the FES.

components: company profile (Company_profile), corporate governance (Corporate_governance), and ESG performance (ESG_performance).

The block titled “Company_profile” consists of the following three input variables: number of employees (CompEmpl), total assets (CompAsset), and ROE (CompROE). Regarding the block titled “Corporate_governance,” it considers the effects caused by the following three input variables: the number of directors involved in the board (BoardSize), the percentage of independent directors (BoardInd), and the percentage of women directors (BoardDivers). Finally, the block “ESG_performance” considers three input variables that summarize the main sustainability dimensions considered by financial analysts, which are the environmental (ScoreE), the social (ScoreS), and the governance (ScoreG). The variables were selected using external sources.

The interaction between the three blocks will contribute to evaluating the output variables titled “Organizational_factors,” which will estimate the sustainability reporting quality of the observed companies. However, as evidenced in the previous sections, the research aims to evaluate the enabling role covered by digitalization on sustainability reporting quality. In this regard, we integrated our FES with one additional variable titled TECH, which will contribute to developing the Reporting_Quality index.

The variable TECH is equal to 0 if preparers do not disclose information about the methodological approach used for data collection, 1 if preparers adopt traditional methods (e.g., hand-collected data), and 2 if preparers adopt digital features such as ERP systems and RPA. Including the variable TECH will provide specific details about the effects related to the adoption of more sophisticated reporting tools by preparers (Mancini et al., 2021; Troshani & Rowbottom, 2022). The variable TECH was identified considering the freely available information disclosed by companies in their non-financial declarations.

According to this evidence, the comparison between the two outputs will shed light on the cumulative effects related to the adoption of digital devices in sustainability reporting. In Table 1, we report the

information about the secondary data used to measure the input variables considered in the FES.

4.3 | The sample

As evidenced in previous studies about sustainability reporting and XBRL, ESG data digitalization requires the implementation of S-ERPs. In this regard, we will contribute to the debate by evaluating the adoption level of digital reporting systems by Italian PIEs. For our purposes, we considered the 40 Italian companies included in the FTSE Mib, representing Milano Stock Exchange's 80% of the total capitalization and almost 90% of the turnover. From the initial sample, we excluded one company exempted from the scope of the legislative decree 254/2016. Thus, the final sample consists of 39 companies that have disclosed their ESG information on mandatory basis during the fiscal year 2021.

The choice to consider a subsample of the Italian companies interested in the effects of the legislative decree 254/2016 was driven by two motivations. First, using FTSE Mib favors identifying comparable companies with a consolidated experience in digital reporting. Companies included in the FTSE MIB disclose their financial information using XBRL. Furthermore, the second motivation consists of the explorative character of the research. In this regard, using a limited sample favors the collection of qualitative and quantitative insights about a complex and not yet explored phenomenon.

5 | FINDINGS

5.1 | Main statistics

The FES output provides interesting insights into sustainability reporting quality in Italy. In detail, the analysis (Table 2) reveals the existence of an average score equal to 75.47, which has been driven by the positive performance in terms of ESGperf and CorpGov. This evidence is

TABLE 1 Variables' description.











#	Var. name	Type	Unit	Min	Max	Default	Term names
1	BoardDivers		Percent	0	100	0	low medium high
2	BoardIndip		Percent	0	100	0	low medium high
3	BoardSize		Units	0	15	0	low medium high
4	CompAsset		Mld	0	15	0	low medium high
5	CompEmpl		Units	0	13000	0	low medium high
6	CompROE		Percent	-5	5	0	low medium high
7	ScoreE		Units	0	50	0	low medium high
8	ScoreG		Units	0	50	0	low medium high
9	ScoreS		Units	0	50	0	low medium high
10	Tech		-	0	2	0	000 none 001 traditional 002 digital

TABLE 2 FES's results (Focus on OF).

Items	Avg.	Median	Min.	Max.
CompProfile	51.20	57.28	0.00	100.00
CorpGov	71.32	82.92	0.00	100.00
ESGperf	95.63	100.00	84.06	100.00
OF	75.47	77.45	37.91	100.00

consistent with previous studies that have underlined the increasing attention to ESG dynamics by listed firms. Furthermore, the positive score related to the CorpGov confirms that Italian companies have started to enhance their corporate governance mechanisms through the involvement of independent and women directors. However, the score related to CompProfile is of little relevance, confirming that disclosing ESG information represents a strategic driver for listed companies. In this regard, considering the presence of the largest Italian listed companies in the FTSE Mib, this result underlines that the dimensional factor appears to be less and less relevant within the European financial markets because of the proliferation of sustainability reports prepared according to the national laws that have transposed the Directive 2014/95/EU.

TABLE 3 FES's results (Focus on RQ).

Items	0 = None	1 = Traditional	2 = Digital
CompProfile	49.38	69.29	45.33
CorpGov	61.41	84.59	82.03
ESGperf	96.92	92.89	94.75
RQ	52.32	74.95	81.74

Regarding the enabling role covered by digitalization, the FES provides interesting insights about its moderating role. In particular, Table 3 highlights that the reports prepared using digital devices are more informative than reports prepared using traditional methods. Although previous accounting research agreed about the enabling role covered by digitalization in fostering reporting quality (Vasarhelyi et al., 2015), this result is fascinating because of its novelty. As evidenced in previous studies about sustainability reporting and digitalization, the scientific debate is characterized by the lack of empirical evidence about this relationship (Lombardi & Secundo, 2020; Seele, 2016).

The analysis also provides interesting insights about the role covered by the other items considered in the FES. In particular, the

analysis highlighted that adopting digital devices can moderate the effects related to ESG performance and corporate governance. Although a more high RQ score, the variables CorpGov and ESGperf are smaller for digital adopters than companies that adopt traditional reporting methods. In this sense, providing digital infrastructure could compensate for the deficit related to the lack of best practices in terms of corporate governance mechanisms and ESG performance. This evidence is particularly relevant because of the choice made by the European Commission to extend the scope of the CSRD, including small listed firms and large unlisted companies (Venturelli, Fasan, & Pizzi, 2022). In this regard, late adopters interested in the CSRD should benefit from adopting a mandatory basis of technological infrastructure to digitalize their ESG information.

5.2 | Embedding digitalization in sustainability reporting evaluations: some reflections

The previously illustrated analyses have highlighted that evaluating the adoption of digital devices by preparers could support the evaluation made by financial analysts. In the current scenario, many investors have started considering sustainability reporting quality as a potential proxy of profitability. In this regard, previous empirical research about sustainability reporting underlined a positive relationship between the quality of the information disclosed on a voluntary or mandatory basis and firms' profitability. Thus, it is necessary to evaluate the value-added provided by identifying the methodological approach adopted by preparers to support analysts in their evaluation.

According to this evidence, we evaluated the difference between OF and RQ to collect valuable insights about the signaling effects related to analyzing the reporting approaches adopted by preparers.

Interestingly, the analysis reveals that the value of the RQ is more significant than OF for digital adopters. In this regard, the risks related to an inexact evaluation made by analysts of a company that disclose its ESG information using digital devices are limited. Thus, in an institutional context characterized by companies interested in disclosing high-quality information, it is necessary to consider the enabling role covered by digital devices.

However, the analysis of the reports prepared both by companies that do not disclose information about their reporting approaches and both by companies that adopt traditional methods can lead to inexact evaluation. As evidenced in Figure 2, for many of those companies, the value of the OF is greater than RQ. Thus, an evaluation made by analysts without considering reporting methods could generate an overall estimation of the quality of the information reported by observed companies. In this sense, achieving a higher degree of comparability between reports could benefit from the development of more strict requirements about adopting digital devices to support and validate accountability processes.

5.3 | Model validation

Finally, we performed an empirical assessment to validate our FES model. The output variable "Reporting_Quality" is a continuous variable that can take a value between 0 (Very Low Quality) and 100 (Very High Quality). The variable was measured using a methodological approach based on content analysis (Krippendorff, 2018), an empirically grounded method widely used by accounting scholars (Dumay & Cai, 2014). The protocol used in the content analysis consists of the following steps: (a) units' identification, (b) taxonomy's identification, and (c) units' analysis.

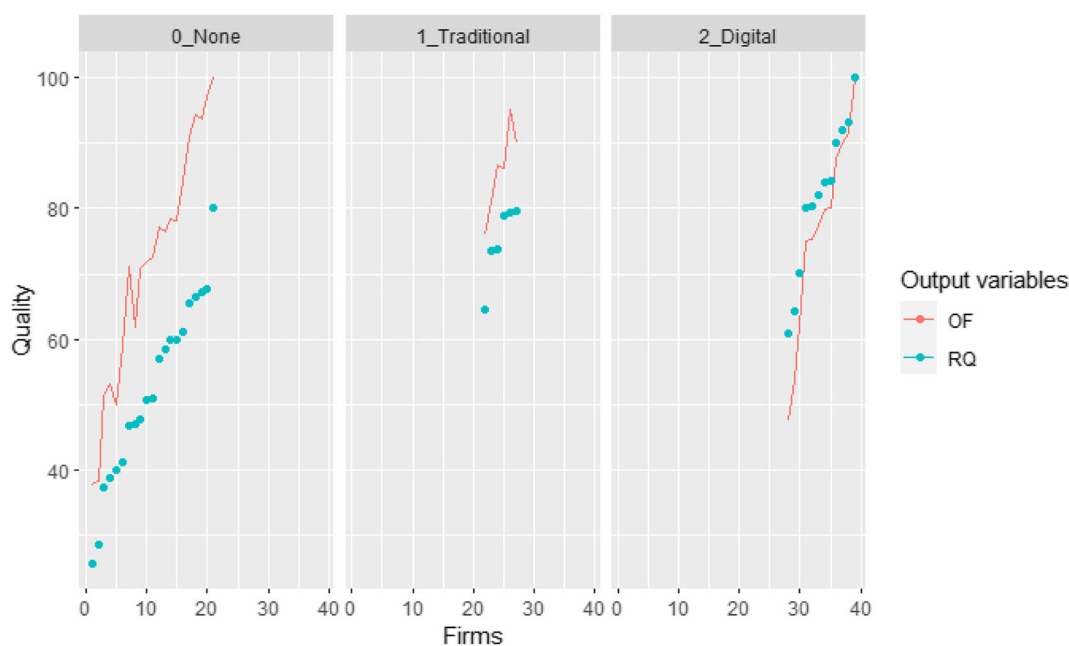


FIGURE 2 Cluster analysis.

The units' identification was conducted using the information disclosed by the 39 companies on their website. We considered only sustainability information disclosed in 2021 to comply with Legislative Decree 254/2016 explicitly. Thus, we excluded all documents prepared voluntarily (e.g., infra-annual reports and sustainability reports not compliant with the legislative decree 254/2016).

The second step is identifying a reliable coding structure to analyze the non-financial declarations. Considering the recent initiatives conducted by the EFRAG and the IFRS Foundation, we chose to analyze the environmental information disclosed by the 39 companies. Using the GRI content indexes as data sources, we extracted all the information about the 32 indicators included in the Environmental Series released by the GRI (Global Reporting Initiative, 2016). The variable (RQ) can take values between 0 (low quality) and 100 (high quality).

$$\text{ENV_DISC} = \frac{\text{n}^\circ \text{ of indicators disclosed}}{32} \%$$

The GRI disclosure analysis (Table 4) reveals that the primary information disclosed by Italian PIEs is represented by GRI 307 (Environmental compliance), GRI 306 (Waste), and GRI 305 (Emissions). As regards the less disclosed information, the data revealed a lack of information about GRI 304 (Biodiversity) and GRI 301 (Materials). The results are consistent with previous Directive 2014/95/EU studies. In particular, the broad adoption of information about environmental

TABLE 4 GRI disclosure analysis.

GRI disclosure	GRI indicators	GRI disclosure score
301: Materials	3	32.50%
302: Energy	5	57.90%
303: Water and effluents	5	52.80%
304: Biodiversity	4	25.00%
305: Emissions	7	72.50%
306: Waste	5	74.90%
307: Environmental compliance	1	82.10%
308: Supplier environmental assessment	2	44.90%
Final score	32	56.41%

TABLE 5 T-test analysis.

Stats	RQ	ENV_DISC	Δ
Mean	64.85	56.49	8.37
St.Dev	2.95	3.34	-0.39
Median	65.63	56.00	9.63
Min.	25.63	19.00	6.63
Max.	100.00	100.00	0.00
t-test	0.055		

compliance is explained by the direct connection with the legal requirements identified by Legislative Decree 254/2016. As evidenced in previous studies about Directive 2014/95/EU, many Italian companies included in the scope of the legislative decree 254/2016 were just aligned with those requirements (Doni et al., 2019; Venturelli et al., 2019). As regards the lack of information about biodiversity, this evidence is confirmed by policymakers and academics about the need to enhance biodiversity reporting, which remains a residual topic for many international companies (Schaltegger et al., 2022).

Finally, a T-test (Watson & Stock, 2015) was conducted to evaluate the robustness of the insights collected using the FES. The T-test reveals that there was no significant difference, $t(2) = 8.365$, $p = .55$, despite RQ ($M = 64.85$, $SD = 2.95$) is greater than ENV_DISC ($M = 53$, $SD = 7.8$). In this sense, despite the misalignment between the two scores, the absence of statistically significant differences confirms the robustness of the FES developed by the researchers (Table 5).

6 | DISCUSSIONS AND CONCLUDING REMARKS

The next few years will be characterized by the wide adoption of digital devices in accounting and accountability. Introducing new requirements for sustainability reporting will generate disruptive impacts on financial markets because of the increase in the overall degree of transparency of ESG information. In this regard, the intense activities conducted by the EFRAG will support this virtuous process by introducing new guidelines to support the transition toward the new XBRL taxonomy.

Within this scenario, a central role will be covered by implementing new accountability mechanisms to support disclosing unconventional and complex information. As evidenced by the primary surveys published by leading organizations, many reports prepared in accordance with Directive 2014/95/EU were affected by criticisms related to the lack of transparency in their reporting processes. At the same time, investors' increasing demand for sustainability information will foster this process. Thus, the following years will be characterized by a relevant paradigm shift related to the transition toward the "Reporting 4.0" era (Alles et al., 2021).

The analysis reveals that digitalization can foster the transition of European companies toward more sophisticated and reliable accountability approaches. In this regard, the contingency factor's effects on adopting digital features are positive. Furthermore, our insights are particularly relevant for companies without experience in sustainability reporting processes that will be affected by the new legal requirements introduced by the CSRD. Adopting digital features will mitigate the adverse effects of late adopters' lack of expertise.

According to this evidence, the research provides preliminary insights into an emerging topic. The lack of scientific knowledge about the relationship between sustainability reporting and digitalization will favor the development of a new research stream for accounting scholars. Similarly to the first wave of research about XBRL and

financial reporting, qualitative and quantitative research can be relevant for comprehending a scientific topic characterized by a high degree of multidisciplinary.

The research contributes to the debate through novel insights about the need to reconsider sustainability reporting practices. The transition from the NFRD to the CSRD will generate substantial impacts because of the introduction of more strict reporting standards and digitalization requirements. This could lead to a “tick-box” approach to reporting rather than fostering genuine sustainability efforts. However, the implementation costs associated with digitization could deter some companies from fully embracing sustainability reporting. Organizations might view the compliance expenses as burdensome and may attempt to minimize the scope of reporting, potentially limiting the disclosure of crucial ESG information.

The analysis also sheds light on the state of the art of digital sustainability reporting in Italy. The scarcity of digital instruments for mandatory ESG information disclosure by preparers poses significant challenges regarding data transparency, comparability, and standardization. The absence of such tools may lead to manual errors and data inconsistencies, undermining the credibility of reported information and hindering stakeholder decision-making. Moreover, the lack of standardized platforms makes performance comparisons difficult, impeding assessments of a company's ESG performance compared to peers. This limited adoption places an extra burden on preparers, diverting resources from core business activities. The absence of integrated reporting systems also hinders comprehensive evaluations of sustainability performance. Additionally, it may impede the establishment of globally accepted ESG reporting standards, contributing to a fragmented reporting landscape.

However, the analysis requires a more in-depth evaluation of the effects of integrating ESG tools in accounting information systems. In this regard, the comprehension of the actual effects caused by digitalization on sustainability reporting requires further study based on more sophisticated methodological approaches. In particular, quantitative analysis can favor the comprehension of the main interlinkages between ERP systems and sustainability reporting quality. Furthermore, qualitative research can provide more detailed explanations about the main factors that have impacted Italian companies' early adoption of these tools.

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