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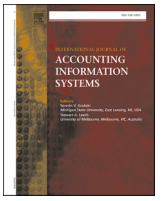

Digital transformation voluntary disclosure: Insights from leading European companies

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ABSTRACT

Purpose: The first goal of this paper is to propose guidelines for digital transformation (DT) voluntary disclosure, using as a starting point the DT voluntary disclosure practices followed by leading European companies. As a second goal, we analyse the factors that may be influencing the DT reporting practices adopted by these companies.
Design/ methodology/ approach: This paper combines qualitative text data mining and panel least squares methodologies to explore current DT disclosure practices followed by leading European companies in their annual reports, and to test our hypotheses identifying the factors that may be influencing the DT reporting practices.
Findings: Our findings show that leading European companies are currently disclosing information about DT on a voluntary basis. However, we find significant differences in their reporting practices, which means that there is still a lack of standardization that can be overcome through DT voluntary disclosure guidelines. Our study contributes to the literature by showing the significant effect of company size, economic sector, the Covid-19 pandemic and CEO gender on DT voluntary disclosure practices.
Originality: We created DT voluntary disclosure guidelines for leading European companies. Having globally harmonised disclosure practices may lead to making meaningful comparisons among companies. Furthermore, results from the panel least squares method significantly contribute to our understanding of the factors that shape the disclosure practices of companies regarding their DT voluntary disclosure initiatives.

1. Introduction

Traditional financial statements are losing relevance for investors (Lev, 2018) because they are becoming obsolete as the world has switched from an industrial to a high-tech, service-based economy (Collins et al., 1997; Core et al., 2003; Brown et al., 1999; Lev and Zarowin, 1999; Rifkin, 2011). It is necessary to overcome these limitations by providing information on the core elements that create value for companies (Pivac et al., 2017). The traditional business reporting model has predominantly emphasised historical and quantifiable financial data, neglecting the importance of qualitative and forward-looking, non-financial information, which has largely gone unnoticed (Beattie et al., 2004). Nonetheless, narrative sections within annual reports enhance the overall quality of corporate reporting and provide stakeholders with additional value (Chatterjee et al., 2011).

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As stakeholders seek a more comprehensive understanding of companies' prospects, the traditional focus on financial metrics is no longer sufficient. Consequently, there is an increasing pressure for companies to voluntarily divulge non-financial details. Managers would voluntarily disclose information about the value creation process of the company to satisfy the growing information demands of shareholders and avoid agency problems (Lueg et al., 2016; Nguyen and Nugyen, 2020). In addition, voluntary disclosure would have further positive effects such as improvements in stock liquidity (Gelb and Zarowin, 2002; Healy et al., 1999), reductions in their cost of capital (Piotroski, 1999; Botosan, 1997), and increases in financial analysts' coverage (Lang and Lundholm, 1993; Healy et al., 1999).

To leverage its benefits, this voluntary disclosure should focus on the key drivers for business growth, which can include a wide set of elements such as new products or services, investment projects, future development strategy, innovation activities, competitive advantage analysis, and industry development trends (Tan et al., 2015). Furthermore, Rezaee and Tuo (2019) consider information about the future focus of technology innovation (and therefore digital transformation −DT) a specific part of the forward-looking, non-financial information that companies should voluntarily disclose to improve their reporting models.

The integration of Information and Communication Technologies (ICT) in business processes has become one of the crucial drivers for future growth in companies, due to their potential to improve business performance significantly (Cuevas-Vargas et al., 2021; Mwantimwa, 2019). Advances in hardware development allow the continuous and exponential increase in data storage and information processing at a lower cost. These hardware advances, coupled with spectacular software developments, enable companies to perform new functions and to increase the effectiveness and efficiency of existing ones (Paletta and Dias, 2008). DT is "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" (Vial, 2019). ICT and DT share a profound connection. ICT serves as the essential technological underpinning and toolkit that empowers organisations to embark on their DT endeavours. In essence, DT encompasses the incorporation of ICT across all facets of an organisation's operations, resulting in a fundamental shift in its operational paradigm and value delivery mechanisms to customers (Alkaraan et al., 2022).

Over the past few years, DT has received increasing attention from academics, leading to a significant number of publications from a business perspective. In this sense, we can find research papers on different topics such as the strategic role of information systems (Bharadwaj et al., 2013), the organisational implications of digitalisation processes (Majchrzak et al., 2016), and the changes in the organisational structure, internal processes, or business culture (Selander and Jarvenpaa, 2016; Carlo et al., 2012; Karimi and Walter, 2015). Nevertheless, there is an area that has not received enough attention so far: how DT enables companies not only to achieve higher levels of effectiveness and efficiency but also to overcome the diminishing relevance of traditional financial statements, through DT voluntary disclosure practices.

Albertini et al. (2021) explored the presence of discretionary narrative disclosures and their findings revealed that companies are actively promoting a four-category approach to intellectual capital (environmental capital, human capital, digital capital, and customer capital) as a key driver of their value creation processes. These authors specifically highlighted the concept of "digital capital" as an emerging theme and they emphasised that digital capital encompasses relatively new activities characterised by high levels of risk and uncertainty, requiring financial and human investments. Furthermore, Albertini et al. (2021) stated that digital capital encompasses an entire narrative on DT. Voluntary disclosure on DT, which may be considered an essential driver for future firm growth in the contemporary economic landscape (Benner and Waldfogel, 2020; Correani et al., 2020), has the potential to enhance the benefits associated with voluntary disclosure.

This study provides three main contributions to the existing literature. First, limited literature is available that provide insights into the types and ways digitalisation-related information is being disclosed in annual reports (Syed Ibrahim et al., 2022). Position papers about new voluntary disclosure practices often arise to reflect changes in business practices, social expectations, and emerging issues. Although there are some studies dealing with DT voluntary disclosure in China (Li et al., 2023), Indonesia (Pratama et al., 2023) and Malasia (Syed Ibrahim et al., 2022), this topic is still in the exploratory stage (Pratama et al., 2023) and further research is required to have a clear diagnostic of the situation of DT voluntary disclosure in leading European companies. With our study, we shed some light on the emerging trend of DT voluntary disclosure.

Second, guidelines for DT voluntary disclosure may play a crucial role due to their ability to help companies communicate information beyond legal requirements. They provide specific recommendations and best practices for implementing DT voluntary disclosure, so that stakeholders can have a more comprehensive view of DT processes. In general terms, the adoption of business reporting standards can provide several benefits, such as greater efficiency, transparency and accuracy. Having DT voluntary disclosure guidelines could help companies to enhance the information they provide on their DT processes. These guidelines may offer a clear direction on the type of DT information to disclose and suggest an approach for companies to follow in doing so. In addition, the development of DT disclosure guidelines may have a stimulating effect on those companies that currently do not provide this kind of information because, as Rouen et al. (2023) found, firms significantly increase their voluntary reporting after the release of voluntary disclosure standards. By following these guidelines, companies are encouraged to update their reporting practices, fostering a culture of continuous improvement in transparency and accountability. For this reason, it is particularly interesting to analyse the information that companies are currently disclosing about their DT processes, which could be considered as the starting point of DT voluntary disclosure guidelines.

Third, little is known about the factors that can enhance DT voluntary disclosure. Information disclosure is regarded as an essential tool for improving transparency in companies. The literature has shown how certain factors are associated with greater voluntary information disclosure such as company size, industry classification, board gender diversity among others (for example, Fernandes and Barbosa, 2022; Gonenc and Krasnikova, 2022; Nguyen and Nguyen, 2020). Considering the non-mandatory nature of disclosure regarding DT, the identification of possible factors influencing DT voluntary disclosure also enriches the research on corporate transparency. Therefore, this study contributes as well to the literature by filling this gap through the analysis of the factors that may be

influencing the DT reporting practices adopted by leading European companies.

This paper has two main goals. The first one is to propose guidelines for DT voluntary disclosure based on a study of practices followed by leading European companies. The second one is to analyse the factors that may be influencing their DT voluntary disclosure practices. We combine qualitative text data mining and panel least squares methodologies. We use a qualitative text data mining approach to explore the current DT disclosure practices of leading European listed companies and to propose DT voluntary disclosure guidelines. After that, we use the panel least squares method to identify the factors that may be influencing them. Our findings show that leading European companies are voluntarily disclosing information on DT although there is a lack of standardisation. Our study also shows the significant effect of company size, economic sector, the Covid-19 pandemic, and CEO gender on DT voluntary disclosure, which is a contribution to the voluntary disclosure literature.

The remainder of this paper is organised as follows. In the next section, we present our literature review and propose our hypotheses. In the third section, we set out the methodology we applied, and results are shown in the fourth section. Discussion is included in the fifth section. Finally, we make our concluding remarks and suggest implications for future research.

2. Literature review

2.1. A primer on digital transformation

DT is "a process where digital technologies create disruptions, triggering strategic responses from organisations that seek to alter their value creation paths while managing the structural changes and organisational barriers that affect the positive and negative outcomes of this process" (Vial, 2019). DT is significantly impacting and challenging companies across the world (Benner and Waldfogel, 2020; Correani et al., 2020) and Covid-19 has accelerated this process (Yallop and Aliasghar, 2020).

Managers should move rapidly even though DT can be viewed as a risky game because it alters established operating models, causing objections from those who stand to gain or lose from the changes or simply because change is needed and people sometimes object to making changes to established approaches. Li (2020) argues that traditional linear approaches are no longer appropriate for leading DT and highlights the need for new and iterative approaches for bridging the strategy–execution gap in the volatile digital economy.

Both academics and professionals suggest that companies should choose the technological alternatives that will enable them to transition into the digital paradigm and benefit from efficiency improvements. Nonetheless, digitalisation is not only a technical process of data conversion, generation, storage, or processing but is also a socio-technical phenomenon that has a substantial influence on societies, businesses, and personal lives (Frenzel et al., 2021). Therefore, organisations face a wide range of challenges when trying to digitally transform their businesses.

Disruptive technologies, such as cloud computing, big data analytics, collaborative robotics, artificial intelligence, machine learning, augmented reality, or the Internet of Things are essential for companies to successfully accomplish their DT (Frank et al., 2019) and improve the customer experience, to optimise their operations or create new commercial models (Alkaraan et al., 2022).

DT is occurring across the value chain, affecting not only the production process, business strategy and organisational culture, but also employees' engagement, training, and skills development (Bhatti et al., 2021; Garzoni et al., 2020; Ghobakhloo and Iranmanesh, 2021; Li, 2020; Rossini et al., 2021). Digital technologies expand beyond the boundaries of specific firms or industries to involve a wider digital ecosystem, which includes suppliers and customers (Hanelt et al., 2021; Keller et al., 2021; Yang et al., 2021). In this sense, Alamäki and Korpela (2021) found that companies are using a more proactive and continuous process where digital value co-creation activities play a significant role. In summary, to achieve an effective DT, companies need to consider their business model, internal structure, human resources, processes, ICT capabilities, their products and services, and the relationships with their stakeholders (Cichosz et al., 2020; Wade, 2015).

2.2. Corporate voluntary disclosure

Since the late 1980s a significant number of studies have stressed the need to improve the traditional business reporting model so that it can reflect companies' true economic value more accurately (ICAS, 1988; ICAEW and ICAS 1990, 1991; CICA, 1988; Rimerman, 1990; Wallman, 1995; IASB, 2017, 2018; FRC, 2019; EFRAG, 2018).

Greater transparency will enable firms to be more resilient and perform better. This will gradually lead to more robust growth and employment rates as well as increased trust among stakeholders (EC, 2017). Therefore, companies need to disclose information about their value drivers as an efficient strategy to decrease information asymmetry and enhance analysts' valuation (Maaloul and Zeghal, 2016; Vanini and Rieg, 2019).

Meek et al. (1995) define voluntary disclosure as "disclosure in excess of requirements that represents free choices on the part of company managements to provide accounting and other information deemed relevant to the decision needs of users of their annual reports". Since firms are expected to comply with mandatory disclosure requirements, they are not rewarded for such compliance. However, voluntary disclosure practices are rewarded by investors. Consequently, the market valuation of the firm is likely to be more related with voluntary disclosure than mandatory disclosure (Cheung et al., 2010).

Voluntary disclosure can certainly be considered as one of the foundations of good corporate governance, due to its ability to increase shareholderś and potential investorś confidence (Saha and Kabra, 2018). Firms that provide greater information disclosure are fostering increased investor confidence (Michelon et al., 2015). According to Mohammadi and Nezhad (2015), heightened financial disclosure stands as a pivotal factor attracting investors and other stakeholders, boosting confidence. Even when revealing

unfavourable information, enhancing transparency about such data elevates the management's credibility, thus bolstering investor confidence, especially in the short term (Haslem, 2015; Miller and Skinner, 2015). In brief, increased voluntary disclosure of information to external parties positively impacts firm value as outsiders place greater confidence in the company (Boone and White, 2015; García-Sánchez and Noguera-Gámez, 2017; Honggowati et al., 2017; Martínez-Ferrero et al., 2016).

The motivations that may lead firms to voluntary disclose information as well as the nature and extension of such disclosure has been analysed using different theoretical frameworks. According to Rouf and Siddique (2023), these theoretical frameworks can be classified into two different groups: (i) economics-based theories, such as agency theory, signaling theory, resource dependence theory, and impression management theory, and (ii) socio-political theories, including stakeholder theory, political economy theory, legitimacy theory, institutional theory, and neo-institutional theory. After a systematic and comprehensive review of the existing literature on corporate voluntary disclosure, several authors concluded that agency theory, legitimacy theory, stakeholder theory, institutional theory, and signalling theory are the most used theoretical frameworks to discuss the drivers of voluntary disclosure (Al Amosh and Khatib, 2022; Rouf and Siddique, 2023; Shehata, 2014; Zamil et al., 2023).

Agency theory is based on the idea that the disclosure of additional information on a voluntary basis may mitigate the agency problem derived from ownership-management separation by reducing the agency cost, and assuring the external users that managers are acting in the best possible way (Barako et al., 2006; Healy and Palepu, 2001). Thus, Bertomeu et al. (2020) explored how voluntary disclosure mitigates information asymmetry in capital markets and facilitates the acquisition of cost-effective financing. Their research demonstrates a positive correlation between voluntary disclosure and a firm's cost of capital.

Legitimacy and stakeholder theories consider that companies are part of a wider social structure and operate under the rules and limits of the societies in which they exist. According to legitimacy theory, businesses must ensure that their actions are consistent with, or perceived to be consistent with, societal norms and values to avoid breaking the social contract that exists between the organisation and society (O'Donovan, 2002; Lightstone and Driscoll, 2008). Based on legitimacy theory, the disclosure process is a mechanism that firms can use to legitimate themselves by showing the society that they are operating according to its norms and values (Ullah et al., 2019; Giannarakis et al., 2017). Stakeholder theory focuses on certain groups in society, the stakeholders, and evaluates the potential impact of the various stakeholders within the community on the corporatiońs disclosure practices. Managers would report on specific types of information to attract and maintain groups of stakeholders and therefore, guarantee their companies' future survival (Reverte, 2009; Waheed and Yang, 2019).

Institutional theory emphasises the value of organisation compliance with the practices, procedures, rules, and norms of the institutional environment. Therefore, voluntary disclosure is a consequence of these institutional and external pressures that may help companies achieve internal legitimacy and compliance with formally institutionalised processes (Akbar and Deegan, 2021; Biswas et al. 2019). In accordance with signalling theory, businesses would voluntarily disclose information to show their superiority to rival companies in the market to draw in investors and establish a good reputation (Campbell et al., 2001; Ross, 1977; Verrecchia, 1983; Arena, et al., 2020). These theoretical frameworks can also be used to analyse DT disclosure practices.

Companies are facing increasing pressure to expand their voluntary disclosure practices to encompass non-financial information, particularly with a focus on providing insights into future growth potential (Rezaee and Tuo, 2017). One specific area of interest within this trend is innovation activities (Tan et al., 2015) and information regarding the future focus of technology innovation, including DT, can enhance voluntary disclosure practices (Rezaee and Tuo, 2019).

However, research on DT voluntary disclosure practices is still in an early stage. Li et al. (2023) assessed the level of digitalisation among Chinese listed firms over a span of twelve years (2007–2018), drawing from 548 observations across firm-years. They employed the total frequency of five key words (artificial intelligence, big data, blockchain, cloud computing, digital technology) as a proxy for measuring the extent of enterprise digitalisation. The descriptive statistics of this variable indicated a very limited presence of these five terms in the annual reports throughout this period. Canestrino et al. (2020) employed content analysis to ascertain the extent of digitalisation mentioned in the environmental statements of a sample comprising sixty Italian and Polish organisations. They found that only 43 % of the environmental statements referred to digitalisation. Pratama et al. (2023) explored the extent of digitalisation disclosure among fifty-two Indonesian companies over a span of three years. They utilised eight dummy variables to track the presence of specific keywords (intelligenisation, digitisation, automation, artificial intelligence, machine learning, cloud computing, big data, blockchain) in their annual reports. Their findings indicate that almost 40 % of the sampled companies had no mention of digitalisation, and those that did refer to it sparingly used keywords such as artificial intelligence, big data, blockchain, and cloud computing. Syed Ibrahim et al. (2022) assessed how and how much forty-nine Malaysian public listed companies disclose digitalisation-related information in their 2020 annual reports using a qualitative approach. They identified and counted sentences or paragraphs of texts containing the terms 'digital and/or digitalisation' and categorised them into eight main categories (marketing, product offered, business operations, governance, risk management, customer relations, organisational structure, and strategic management). Their findings showed that approximately 65 % of the sample only reported a few sentences for each occurrence of "digital" or "digitalisation" and that disclosures related to digitalisation were primarily at a basic level. In this regard, there is still a lack of knowledge regarding DT voluntary disclosure by leading European companies.

DT is also gaining prominence as a crucial driver for future firm growth in today's macro-economic scenario (Correani et al., 2020; Yallop and Aliasghar, 2020) and DT voluntary disclosures have the potential to amplify the advantages associated with extensive voluntary reporting practices. For example, Salvi et al. (2023) conducted manual content analysis on a sample of 122 listed companies worldwide to assess the extent of transparency in digitalisation choices and examine how this transparency impacts the cost of equity capital. They measured transparency in digitalisation choices as the information related to digitalisation that companies present on their websites. Their findings indicate that broad transparency enables companies to enjoy reduced costs of equity.

In essence, the growing emphasis on DT voluntary disclosure aligns with more expansive trends in corporate reporting, where

companies are expected to reveal non-financial aspects that can impact their future performance and innovation strategies.

2.3. Objectives and hypotheses development

The first goal of this paper is to propose guidelines for DT voluntary disclosure using as a starting point the practices followed by leading European companies. A standard DT disclosure model could help external stakeholders make more meaningful analyses and comparisons of the information provided by companies about their DT processes. Guidelines can be useful for the standardisation of DT voluntary disclosure by leading companies. They can enhance transparency by ensuring that relevant and comparable information is disclosed consistently across companies. This would benefit investors, analysts, and other stakeholders in making informed decisions and assessing the performance and risks of companies. Standardised disclosure allows easier comparisons of performance and practices among companies within the same industry or across industries, facilitating benchmarking, and can promote healthy competition and best practices. Additionally, standardisation can streamline the reporting process for companies and can also improve efficiency in data collection, analysis, and interpretation for users of annual reports. Moreover, guidelines could enhance DT voluntary disclosure practices (Rouen et al., 2023).

Our second goal is to analyse the factors that may be influencing the DT reporting practices adopted by leading European companies. Since disclosure on DT is not compulsory, the selection of potential determinants of DT reporting practices draws upon determinants taken from the voluntary disclosure literature. In this paper, three company characteristics (firm size, industry, and CEO gender) are selected as potential factors that may lead companies to voluntarily disclose information on their DT processes. In addition, since the Covid-19 marked a turning point in the way companies approach digital technologies, we considered it interesting to analyse whether there are differences in the DT reporting practices of corporations before and after the pandemic.

The literature acknowledges that firm size is considered one of the factors influencing voluntary disclosure. Voluntary disclosure is frequently used by companies as a mechanism to mitigate agency costs, and the advantages of voluntary disclosure are likely to increase with the size of the firm (Melati et al., 2022; Abdi et al., 2018).

Cooke (1991) argued that "larger firms are likely to be entities of economic significance so that there may be greater demands on them to provide information for customers, suppliers and analysts, and governments as well as the general public". The suggested impact of firm size on the amount of corporate voluntary reporting is positive, as larger companies tend to attract greater public attention, which in turn increases their concern for maintaining legitimacy based on societal expectations (Zamil et al., 2023). Hence, they are driven to share voluntary information with stakeholders in order to establish the legitimacy of their actions (Fernandes and Barbosa, 2022). Larger companies have greater public visibility, making them more concerned with transparency and reputation (Murcia et al., 2008).

Research has traditionally focused on the significant relationship between business size and voluntary disclosure (Buzby, 1975; Firth, 1979; Chow and Wong-Borne, 1987; Cooke, 1991). Barac et al. (2014) examined the level and extent of voluntary disclosure practices in Croatia. They found that firm size has a significant and positive impact on the level and extent of voluntary disclosure in annual reports. Alsaeed (2006) noted a strong correlation between firm size and the amount of disclosure after performing a study on the relationship between firm-specific traits and the disclosure practices of Saudi Arabian companies. Hossain and Hammami (2009) examined the factors that affected voluntary disclosure in the annual reports of listed companies on Qatar's Doha Securities Market. Their results showed that business size played a major role.

On the other hand, Aljifri (2008) and Shams Koloukhi et al. (2018) did not find a significant relationship between firm size and voluntary disclosure in annual reports. Therefore, the following hypothesis is formulated:

Hypothesis 1. The size of firm influences DT voluntary disclosure in leading European companies.

Companies from different industry sectors may have industry-specific features and, therefore, different reporting practices (Aljifri et al., 2014; Fernandes and Barbosa, 2022). For this reason, the "industry type" is one of the factors traditionally considered when analysing voluntary disclosure practices. Studies about the relationship between voluntary disclosure and the industry sector have been performed on different companies, periods, and countries, revealing significant associations (Melati et al., 2022).

Patten (1991) concluded that voluntary disclosures are more frequent and comprehensive in some industries than others because proprietary costs vary across industries. Dolinsek and Lutar-Skerbinjek (2018) established a connection between the industry sector and the amount of voluntary disclosure based on legitimacy and signalling theories. These authors argued that companies in industries with advanced IT technology need to respond faster to potential changes. Technology-intensive industries provide a significantly greater amount of voluntary information about their research and development activities in their annual reports (Almagtome et al., 2017; Bilic, 2016).

Alfraih and Almutawa (2014) concluded that manufacturing and service companies exhibit a higher degree of voluntary disclosure. Consistent with this conclusion, Jinfeng and Huifeng (2009) found that the industry type, among other factors such as size and audit firm type, positively affects the voluntary reporting practices in Chinese manufacturing companies. Similarly, Boshnak (2022) confirmed that manufacturing corporations tend to engage in greater corporate social and environmental voluntary disclosure due to their higher environmental impact and political exposure. Voluntary disclosure could be seen by these companies as a strategy to reduce political costs and pressure from social activists (Hackston and Milne, 1996). Alotaibi (2020) stated that the industry type is an important driver of environmental sustainability voluntary disclosure because, according to legitimacy theory, companies in the same sector are competitively seeking to provide additional information to guarantee their survival and meet the communitýs expectations.

However, contrary to these findings, other studies showed that the industry does not play a role in explaining voluntary disclosure practices (Lai et al., 2016; Naser et al., 2002; Ricardo et al., 2017; Wallace et al., 1994).

Table 1
Companies included in the sample (alphabetical order).

Adidas	Bayer	ENEL	Intesa	Sanofi
Adyen	BBVA	ENI	Kering	Santander
Ahold	BMW	EssilorLuxottica	Linde	SAP
Air Liquide	BNP	Flutter	LOREAL	Schneider
Airbus	CRH	Hermes	LVMH	Siemens
Allianz	Daimler	Iberdrola	MunichRe	TotalEnergies
Amadeus	Danone	InBev	Nokia	Vinci
ASML	Deutsche Borse	Inditex	Nordea	Vivendi
AXA	Deutsche Post	Infineon	Pernod Ricard	Volkswagen
BASF	Deutsche Telekom	ING	Safran	Vonovia

To investigate whether the industry sector has an impact on DT voluntary disclosure, we propose our second hypothesis:

Hypothesis 2. The industry sector influences DT voluntary disclosure in leading European companies.

Lewis (2001) discussed the devastating effects of epidemics on the economy and society while Bloom et al. (2018) warned of the necessity to be prepared for the fatal consequences that global pandemics could bring. Indeed, the Covid-19 pandemic was a real shock to the whole global community, causing not only a significant increase in mortality rates, but also a growth in social distancing and a decrease in investments, production levels, and economic development (Nicola et al., 2020; Nusratullin et al., 2021).

The Covid-19 crisis greatly intensified consciousness of the threats posed by structural issues and existential risks to the stability of the social and economic systems (Adams and Abhayawansa, 2022). Many of the affected countries decided to close their borders and ban the free movement of their citizens, to reduce the transmission of the virus among their residents (Chakraborty and Maity, 2020). During these times of distress, companies had no choice but to rethink their processes. While, before the pandemic, DT was considered by many firms as an option, the Covid-19 made it a staple, an essential element to improve their productivity and adapt to the changing business needs of the hyper-connected digital economy. In this sense, Yallop and Aliasghar (2020) concluded that organisations from different industry sectors around the world experienced major disruptive changes because of the Covid-19 pandemic that accelerated the adoption and integration of emergent information and communication technologies.

Due to the key role that DT plays in ensuring the future survival of companies, especially after the Covid-19 crisis, we consider it appropriate to study if there are significant differences between the amount of information on DT disclosed by leading European companies before and after the pandemic.

Based on this justification, we present the following hypothesis:

Hypothesis 3. The Covid-19 pandemic influences DT voluntary disclosure in leading European companies.

The CEO gender serves as a cross-cutting variable that could have a significant impact on various aspects of organisations such as firm value (Agyemang-Mintah and Schadewitz, 2019), firm performance (Adams and Ferreira, 2009) or financial reporting decision making (Francis et al., 2015). Some studies have shown that board gender diversity does have an influence on management decisions and practices because of added diversity in skills, experiences, and ethical values (Francis et al., 2015; Khaoula and Ali, 2012). Oyenike et al. (2016) concluded that female managers show higher ethical values than their male peers because they pay more attention to the firḿs ethical, environmental, and social responsibilities.

These organisational issues also include voluntary disclosure practices. CEO gender may have an impact on the level of companieś transparency and the extent of the information they willingly provide. According to Bueno et al. (2018) and Nalikka (2009), companies with female CFOs have greater voluntary disclosure rates in their annual reports. This idea is also supported by Saha and Kabra (2022), who showed the positive impact of gender diversity on regulation compliance and transparency through voluntary disclosure.

Companies with a higher proportion of women on their boards are inclined to participate in a greater number of environmental, social, and governance (ESG) initiatives and are more likely to report on these activities in their annual reports (Arayssi et al., 2020). In this context, gender diversity has a positive significant influence on voluntary ESG disclosures (Anazonwu et al., 2018; Ben-Amar et al., 2017; Boulouta, 2013; Gonenc and Krasnikova, 2022; Gurol and Lagasio, 2023; Suttipun, 2021; Tingbani et al., 2020).

Nadeem (2019) also revealed a positive association between boardroom gender diversity and the voluntary disclosure of intellectual capital. Board gender diversity is considered an additional corporate governance mechanism that exerts a positive impact on the voluntary disclosure of intellectual capital (Loulou-Baklouti, 2023). However, other studies indicated that there is no significant relationship between board gender and the disclosure practices of firms (Masoud and Vij, 2021; Suarez-Rico et al., 2018). Therefore, it seems appropriate to consider CEO gender as a factor that can drive improvement in the level of DT voluntary disclosure and, consequently, we formulated our hypothesis:

Hypothesis 4. The CEO gender influences DT voluntary disclosure in leading European companies.

3. Methodology

3.1. Sample and text data mining methodology

The first objective of this paper is to propose guidelines for DT voluntary disclosure using as a starting point the practices followed by leading European companies in their annual reports, employing a qualitative text data mining approach (Gaikwad et al., 2014). Due to its extensive set of powerful tools for advanced coding, retrieval, transcription, and visualisation, we decided to utilise Maxqda, a qualitative data analysis software program.

Our sample includes the 50 companies listed in the EuroStoxx50 Index on May 11st, 2023 (Table 1). The EuroStoxx50 is derived from the EuroStoxx index and represents the performance of the 50 largest companies in terms of free-float market capitalisation in the Eurozone. Our focus on European companies is driven by the likelihood that these companies may be more influenced by harmonised accounting and reporting standards, such as those issued by the European Securities and Markets Authority (ESMA), which could lead to a more standardised approach to disclosure, or by the EFRAG (European Financial Reporting Advisory Group), which serves the European public interest by developing and promoting European views in the field of corporate reporting. European companies are often subject to specific directives and regulations that impact their disclosure practices, such as the Non-Financial Reporting Directive, which requires large companies to disclose non-financial information on a clear path toward greater business transparency and accountability. The implementation of reporting requirements may provide companies with incentives to satisfy investorś demand for improved information (Tan et al., 2011). Since 2017, firms from the European Union (EU) must report nonfinancial information according to the EU Directive 2014/95 and this has pioneered a standardised approach to report drafting, aiming not only for comprehensive reporting but also for comparability and performance measurement based on qualitative data (Cicchiello et al., 2023). Christensen et al. (2022) state that the passing of the EÚs directive could diminish information asymmetry and allow stakeholders to control companieś nonfinancial disclosures more efficiently because the primary aim of reporting regulations is to enhance disclosure quality (Christensen et al., 2021). Furthermore, the EU's directives on corporate reporting can offer both a requirement and motivation for companies to meet investors' expectations for higher-quality disclosures (DeFond et al., 2011). For example, Rezaee et al. (2023) conclude that the implementation of rules and disclosure guidelines is linked to the enhancement of reporting practices. After comparing the level of disclosures by EU companies and US firms the authors confirm that EU firms have greater levels of ESG disclosure compared to US firms. Cicchiello et al. (2023) additionally highlight the impact of EU disclosure regulations on the ESG scores of firms. Through analysing samples of both EU and US firms, they discover that EU regulatory initiatives aimed at enhancing transparency regarding the social and environmental impacts of companies' operations are successful in improving both the commitment to disclosure and its effectiveness, and they find that EU companies subject to the disclosure regulation demonstrate higher ESG rating scores than US companies, confirming the efficacy of the Non-Financial Reporting Directive.

It is important to recognise that these generalisations may not uniformly apply to all European companies. Individual firms may adopt diverse disclosure practices based on their specific circumstances or industry dynamics. This variability underscores the significance of this study, which aims to identify the factors influencing voluntary corporate disclosure practices related to DT in leading European companies. The objective is to propose guidelines that encourage companies to disclose DT information, providing investors and other stakeholders with a more comprehensive understanding of their development, performance, and position, all aligned with harmonised standards.

To identify current DT disclosure practices of leading European companies, we analysed their annual reports, collected from their official websites. We decided to use annual reports because they are perceived as the most important, frequent, and major source of information to many users in developed and developing countries (Abu-Nassar and Rutherford, 1996; Alattar and Al-Khater, 2007; Chau and Gray, 2010).

The information provided on DT was analysed over a period of 5 years, from 2018 to 2022, both inclusive. To transform all the relevant information extracted from companies' annual reports into structured formats, we performed a process comprised of several phases. The first step was to create a code system that would be later used to categorise and analyse the information disclosed by companies.

A code is a character string that can consist of one or more words. A code dictionary or code system in qualitative research compiles a roster of codes employed in qualitative data analysis. This system may be crafted via either inductive or deductive coding techniques. Deductive coding, a top-down method, entails constructing a codebook based on the preexisting literature. Conversely, inductive coding, a bottom-up approach, derives codes directly from the data. Inductive coding proves particularly valuable when exploring novel subjects, as it refrains from imposing predefined notions on code selection, allowing codes to organically emerge from the raw data (Cohen et al., 2017). Because of the lack of previous research on DT voluntary disclosure, in this paper the code system was developed using inductive coding that covered all the annual reports.

We performed the inductive coding process and the identification of the codes relating to DT with the help of the interactive word tree technique (Wattenberg and Viégas, 2008). As Wattenberg and Viégas (2008) state: "a word tree places a tree structure onto the words that follow a particular search term, and uses that structure to arrange those words spatially. Simple interaction techniques allow the viewer to examine the ways that a particular word or phrase is used in a text, seeing broad patterns, and drilling down into details". Therefore, this technique allows us to explore and analyse interactively, with the support of visual tools, the word or word combinations in their respective contexts. Using this technique, we navigated through the different "tree branches" to visualise key words in the context of DT and we verified these words were properly used in the context of DT.

Specifically, the following methodology was followed. First, we loaded all the annual reports into Maxqda software to utilise the interactive word tree technique. We analysed a total of 250 annual reports (50 companies during a 5-year period each) which amounts

to a total of 48,313,429 words. Then, we navigated through various 'tree branches' to visualise information about DT across all the annual reports, aiming to identify key words in the context of DT. Upon identifying key words, we also identified consecutive word pairs or 'bigrams' using the interactive word tree. The size of each word in the interactive word tree reflects its frequency in the annual reports. All identified words and bigrams were incorporated into the code system. Once this inductive coding method was finished, the final 'dictionary' comprised 32 codes, capturing a wide range of DT disclosure practices (Table 2). Throughout the entire process, we employed the investigator triangulation method, which involved the active participation of all three authors in the code identification process. Codes were amalgamated based on a consensus among the authors (Thurmond, 2001). This approach to triangulation serves to validate our findings and introduce diverse perspectives, enriching our understanding of the phenomenon of interest (Denzin, 1978). The advantages of investigator triangulation include the establishment of cross-investigator confirmation, the reduction of inherent investigator biases, the enhancement of validity and reliability, and, ultimately, the fortification of the robustness of our findings (Denzin, 1978).

Fig. 1 illustrates an example of the inductive coding process when the word 'digital' was searched in the word tree. The interactive word tree identifies all the words that have been used in combinations with the word 'digital' and classifies them based on their frequency. With this information, bigrams such as 'digital transformation' and 'digital solutions,' among others, were added to the code system. The process continues by clicking on those words or bigrams that are more frequent to identify additional words or bigrams related to voluntary DT disclosure. For example, from Fig. 1 we clicked on all the bigrams containing the word 'digital,' as well as those words indicated by the system as relevant, such as 'e-commerce,' to navigate through all annual reports in search of these codes.

After creating the dictionary of codes, we continued our text-mining analysis by automatically coding the 250 annual reports. This process involves two main steps: segment coding and code mapping.

Segment coding implies the identification and labelling of specific segments (sentences) within the annual reports that contain relevant information related to the predefined codes in the code system. Basically, segment coding consists of automatically identifying those sentences where the codes are present and counting the frequency of each of the 32 codes in the 250 annual reports. Throughout this process, we carefully checked all the sentences to ensure the proper usage of these codes in the context of DT.

Code mapping in Maxqda is a powerful feature that allows the creation of visual representations of code relationships within documents. By analysing coded segments and identifying patterns, co-occurrences, and connections between codes, the user can have a comprehensive understanding of the code system. Code mapping examines factors such as the proximity of coded segments in the document and the frequency of code co-occurrences, among others. The result is a visually informative map that helps identify overarching patterns and clusters within coded data, as well as the relationships between specific codes.

3.2. Variables and panel data analysis method

The second goal of this study is to examine the potential influence of the factors previously defined on the DT reporting techniques used by leading European companies. We applied the panel least squares method using the Eviews12 software.

A balanced panel data collection of leading European companies was used in the study, including 250 company-year observations. The dataset provides a thorough representation of many industries and sectors, offering a solid basis for analysing trends and patterns followed by leading European companies. The panel design guarantees that each organisation is tracked consistently over the course of the study, allowing for a thorough examination of the dynamic shifts and performance indicators covering the five-year period. A thorough and trustworthy examination of the companies' performance is made possible by the extensive dataset, which also enables us to reach insightful conclusions.

The variables in the panel least squares method are divided into two groups. The first category consists of the dependent variable, which is the number of coded segments in each company-year observation. The second category comprises the explanatory variables, including company size, economic sector, Covid pandemic effects and CEO gender. We considered these variables because, as we previously stated in the literature review section, they have the potential to influence the voluntary disclosure practices of the company.

The number of coded segments for each company-year observation was obtained by identifying the presence of the codes in the 250 annual reports using the Maxqda software. Company size was measured by the log of total assets (Barac et al., 2014) and CEO gender was defined as a qualitative variable with to two possible values (Female or Male).

In order to test the impact of the Covid-19 pandemic on the DT disclosure practices we split the 5-year period to create a new variable with two possible values (Pre-Covid or Post-Covid). The Pre-Covid period includes the 2018 and 2019 annual reports while the

Table 2
Dictionary of codes or code system (alphabetical order).

artificial intelligence	digital culture	digital platforms	digital tools
big data	digital data	digital process	digital training
blockchain	digital ecosystem	digital product/service	digital transformation
cloud computing	digital ethic	digital risk	digitaliz(s)ation
digital agility	digital evolution	digital skill	digitaliz(s)e
digital capabilities	digital innovation	digital solution	e-business
digital communication	digital learning	digital strategy	e-commerce
digital content	digital marketing	digital technology	omnichannel

Fig. 1. An Interactive word tree example.

Post-Covid period comprises the 2020, 2021 and 2022 annual reports. We chose the year 2020 as the inflection point because there is evidence that DT was accelerated during the onset of Covid-19 to tackle the negative effects of the coronavirus pandemic (Rinker et al., 2021). Yallop and Aliasghar (2020) argued that companies, in order to counteract the undesirable economic impact of the Covid-19 pandemic, implemented disruptive changes in their companies, by intensely employing ICT for the purpose of maintaining "business as usual". Therefore, we could expect to find a substantial increase in information about this topic. For this reason, according to Sharma et al. (2021), we considered the year 2020 as a potential breaking point to test whether or not the Covid-19 pandemic changed the DT voluntary disclosure practices.

Regarding the economic sector, companies in the sample were classified into the following sectors according to the FTSE global classification system: (00) Resources, (10) Basic Industries, (20) General Industrials, (30) Cyclical Consumer Goods, (40) Non-Cyclical

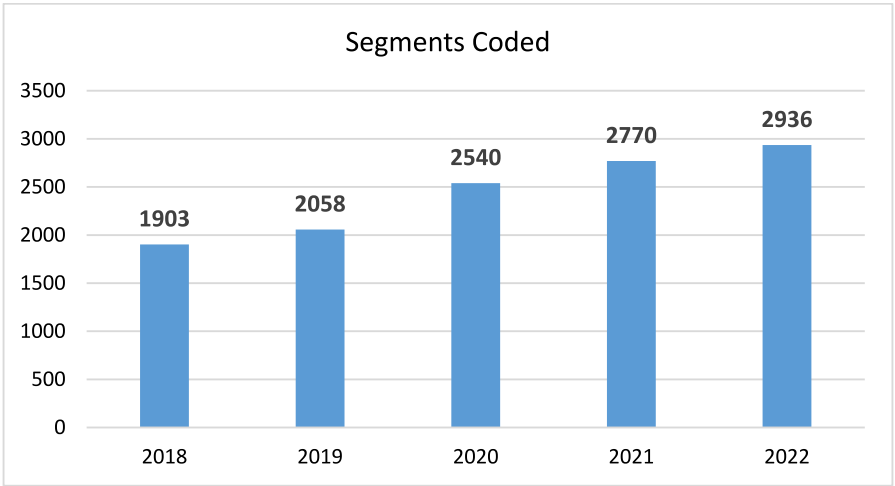

Fig. 2. Number of segments coded.

Consumer Goods, (50) Cyclical Services, (60) Non-Cyclical Services, (70) Utilities, (80) Financials and (90) Information Technology.

Lastly, we considered the number of words, a proxy for the length of the annual report, as a control variable. This control variable is important to isolate the effect of the length of the annual report from the rest of the independent variables. The coefficient of this control variable was expected to be positive.

4. Results

4.1. Results of qualitative text data mining analysis

Fig. 2 illustrates the evolution of the number of coded segments over the 5-year period. We can observe how the amount of DT voluntary disclosures increased from 1,903 segments in 2018 to 2,936 segments in 2022 (54 % growth).

Table 3 shows the results of the coding process over the 5-year period, where a total of 12,207 segments were coded. This table shows the total and relative frequency of each code on a yearly basis.

Finally, Table 4 presents the number of companies (up to 50) that use each code to disclose information about DT in their annual reports, on a yearly basis.

Tables 3 and 4 show that the most frequent code we found in the annual reports published by leading European companies listed in the EuroStoxx50 Index is "digitaliz(s)ation", which is used by almost all the companies, followed by "e-commerce", "digital transformation" and "artificial intelligence". We also found that some codes, such as "digital tools", "digitaliz(s)e", "big data", "digital platforms" or "blockchain" are used by a great number of companies although their total frequency is lower. These tables also suggest the interest of companies in specific topics such as "artificial intelligence," whose frequency is higher compared to other emergent trends such as "blockchain.".

Fig. 3 represents the codes cloud using the total number of annual reports in our sample. Codes clouds are particularly useful because they help us visualise the most common codes in a text, giving us an instant and clear idea of the DT disclosure practices of the companies in our sample. The size of the code is proportional to its frequency so that the higher the frequency of a code, the larger it is.

In addition, we identified groups of codes and represented them on a map using the code mapping tool (Fig. 4).

This tool proves valuable for uncovering underlying factors or categories that elucidate correlations among a set of codes. The code map allows us to identify if the codes related to the previous issues are presented in the annual reports and their relationship. The

Table 3
Frequency table for code variables.

Codes	2018		2019		2020		2021		2022	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
artificial intelligence	149	7.8 %	168	8.2 %	185	7.3 %	205	7.4 %	265	9.0 %
big data	69	3.6 %	70	3.4 %	63	2.5 %	60	2.2 %	38	1.3 %
blockchain	89	4.7 %	77	3.7 %	50	2.0 %	41	1.5 %	31	1.1 %
cloud computing	26	1.4 %	20	1.0 %	22	0.9 %	31	1.1 %	28	1.0 %
digital agility	0	0.0 %	0	0.0 %	1	0.0 %	0	0.0 %	1	0.0 %
digital capabilities	17	0.9 %	15	0.7 %	28	1.1 %	25	0.9 %	27	0.9 %
digital communication	10	0.5 %	15	0.7 %	16	0.6 %	15	0.5 %	16	0.5 %
digital content	8	0.4 %	4	0.2 %	8	0.3 %	10	0.4 %	4	0.1 %
digital culture	7	0.4 %	11	0.5 %	8	0.3 %	9	0.3 %	8	0.3 %
digital data	7	0.4 %	7	0.3 %	10	0.4 %	7	0.3 %	5	0.2 %
digital ecosystem	17	0.9 %	17	0.8 %	15	0.6 %	13	0.5 %	20	0.7 %
digital ethic	0	0.0 %	4	0.2 %	7	0.3 %	8	0.3 %	10	0.3 %
digital evolution	3	0.2 %	6	0.3 %	4	0.2 %	7	0.3 %	6	0.2 %
digital innovation	16	0.8 %	19	0.9 %	14	0.6 %	16	0.6 %	20	0.7 %
digital learning	23	1.2 %	22	1.1 %	28	1.1 %	40	1.4 %	32	1.1 %
digital marketing	17	0.9 %	13	0.6 %	22	0.9 %	16	0.6 %	16	0.5 %
digital platforms	81	4.3 %	90	4.4 %	120	4.7 %	107	3.9 %	92	3.1 %
digital process	4	0.2 %	3	0.1 %	5	0.2 %	8	0.3 %	9	0.3 %
digital product/service	83	4.4 %	102	5.0 %	104	4.1 %	96	3.5 %	108	3.7 %
digital risk	1	0.1 %	6	0.3 %	11	0.4 %	8	0.3 %	12	0.4 %
digital skill	8	0.4 %	19	0.9 %	26	1.0 %	33	1.2 %	53	1.8 %
digital solution	61	3.2 %	91	4.4 %	110	4.3 %	119	4.3 %	113	3.8 %
digital strategy	23	1.2 %	26	1.3 %	37	1.5 %	36	1.3 %	39	1.3 %
digital technology	89	4.7 %	78	3.8 %	90	3.5 %	83	3.0 %	89	3.0 %
digital tools	39	2.0 %	40	1.9 %	63	2.5 %	98	3.5 %	65	2.2 %
digital training	15	0.8 %	12	0.6 %	26	1.0 %	21	0.8 %	15	0.5 %
digital transformation	244	12.8 %	266	12.9 %	291	11.5 %	329	11.9 %	448	15.3 %
digitaliz(s)ation	414	21.8 %	420	20.4 %	569	22.4 %	661	23.9 %	621	21.2 %
digitaliz(s)e	19	1.0 %	51	2.5 %	73	2.9 %	82	3.0 %	60	2.0 %
e-business	2	0.1 %	9	0.4 %	15	0.6 %	9	0.3 %	14	0.5 %
e-commerce	329	17.3 %	322	15.6 %	417	16.4 %	397	14.3 %	511	17.4 %
omnichannel	33	1.7 %	55	2.7 %	102	4.0 %	180	6.5 %	160	5.4 %
	1,903	100 %	2,058	100 %	2,540	100 %	2,770	100 %	2,936	100 %

Table 4
Number of companies that use each code.

Codes	2018		2019		2020		2021		2022	
	Companies	%	Companies	%	Companies	%	Companies	%	Companies	%
artificial intelligence	34	68 %	37	74 %	37	74 %	38	76 %	38	76 %
big data	28	56 %	23	46 %	22	44 %	21	42 %	19	38 %
blockchain	20	40 %	19	38 %	18	36 %	20	40 %	18	36 %
cloud computing	13	26 %	13	26 %	11	22 %	17	34 %	16	32 %
digital agility	0	0 %	0	0 %	1	2 %	0	0 %	1	2 %
digital capabilities	9	18 %	10	20 %	13	26 %	8	16 %	13	26 %
digital communication	6	12 %	11	22 %	11	22 %	10	20 %	10	20 %
digital content	3	6 %	2	4 %	6	12 %	8	16 %	4	8 %
digital culture	4	8 %	6	12 %	7	14 %	6	12 %	6	12 %
digital data	6	12 %	6	12 %	9	18 %	6	12 %	5	10 %
digital ecosystem	10	20 %	11	22 %	10	20 %	8	16 %	10	20 %
digital ethic	0	0 %	2	4 %	2	4 %	2	4 %	3	6 %
digital evolution	3	6 %	5	10 %	3	6 %	4	8 %	6	12 %
digital innovation	14	28 %	11	22 %	11	22 %	12	24 %	15	30 %
digital learning	11	22 %	9	18 %	12	24 %	17	34 %	13	26 %
digital marketing	11	22 %	7	14 %	7	14 %	11	22 %	10	20 %
digital platforms	31	62 %	30	60 %	29	58 %	32	64 %	30	60 %
digital process	3	6 %	3	6 %	5	10 %	6	12 %	5	10 %
digital product/service	24	48 %	26	52 %	30	60 %	29	58 %	31	62 %
digital risk	1	2 %	1	2 %	4	8 %	3	6 %	4	8 %
digital skill	7	14 %	12	24 %	13	26 %	19	38 %	14	28 %
digital solution	19	38 %	28	56 %	30	60 %	30	60 %	32	64 %
digital strategy	9	18 %	11	22 %	16	32 %	15	30 %	13	26 %
digital technology	25	50 %	26	52 %	30	60 %	28	56 %	27	54 %
digital tools	19	38 %	22	44 %	25	50 %	27	54 %	23	46 %
digital training	9	18 %	10	20 %	17	34 %	16	32 %	13	26 %
digital transformation	39	78 %	39	78 %	44	88 %	43	86 %	43	86 %
digitaliz(s)ation	34	68 %	39	78 %	44	88 %	45	90 %	45	90 %
digitaliz(s)e	9	18 %	20	40 %	23	46 %	26	52 %	24	48 %
e-business	2	4 %	4	8 %	6	12 %	5	10 %	5	10 %
e-commerce	27	54 %	29	58 %	28	56 %	33	66 %	33	66 %
omnichannel	7	14 %	10	20 %	12	24 %	17	34 %	17	34 %

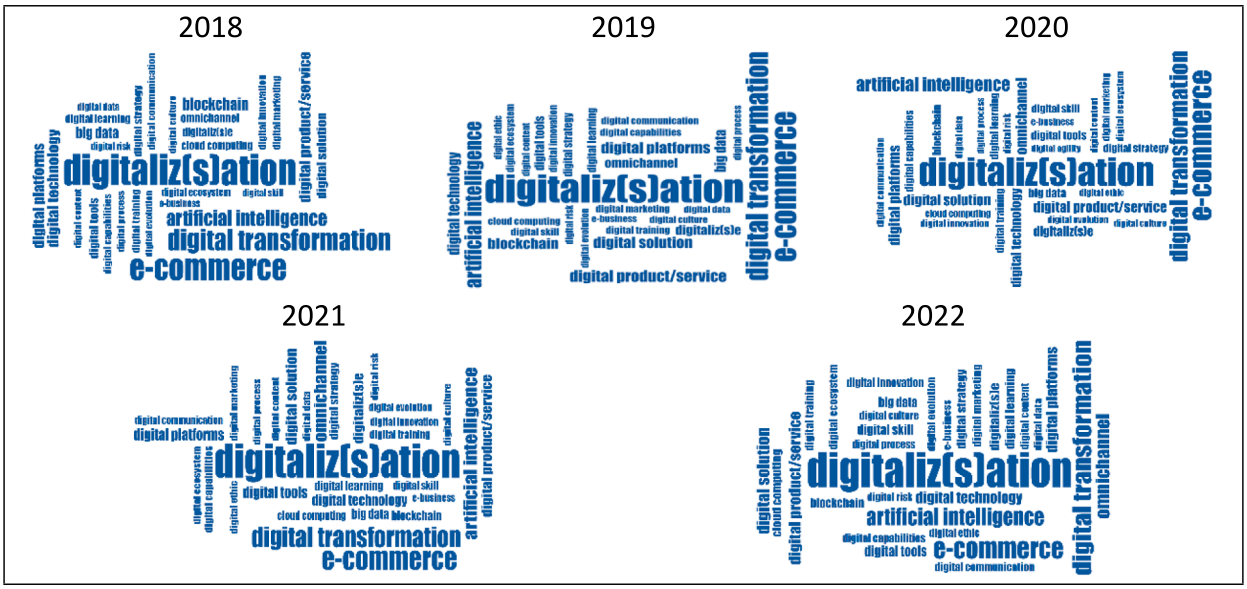

Fig. 3. Codes Cloud.

positions of the codes on the map play a crucial role in identifying these factors or categories. In the code map, all the codes are visually represented as points on a map, and the distances between these codes reflect the degree of similarity in their application within the annual reports. The closer the two codes are on the map, the more frequently they co-occur in annual reports, indicating a higher level

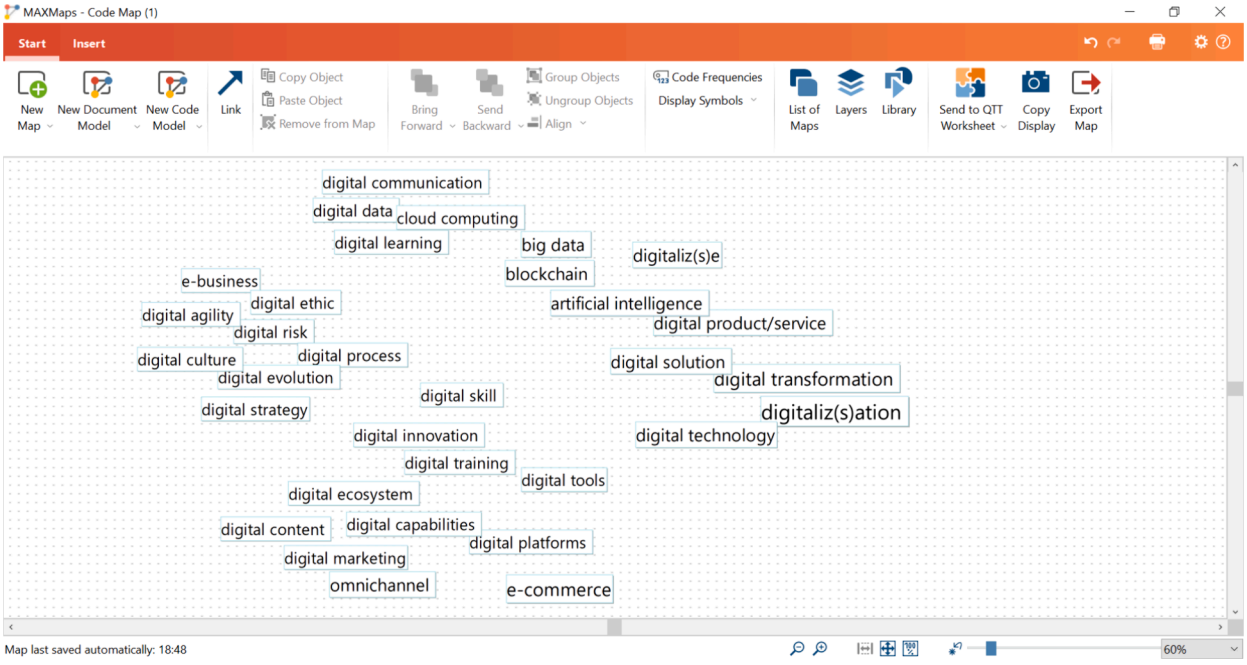

Fig. 4. Codes Map.

of similarity in their usage. Specifically, a distance of 0 implies that two codes always occur together and never independently. On the other hand, the maximum distance signifies that these codes never appear together.

As was previously stated, DT is having a significant impact across the entire value chain of companies, affecting not only their production process, but also their strategy, organisational culture, and relationships with different groups of stakeholders, such as customers, employees, government, and society. If firms want to communicate an accurate picture of their business, they should disclose information about these dimensions of DT in their annual reports.

DT is based on understanding both the direct and indirect effects of applying ICT within organisations (Pousttchi et al., 2019) and is directly associated with the investment in technological tools to significantly enhance the business performance (Zhang et al., 2023). Driven by technological advancements and evolving customer demands, DT is fostering the adoption of digital marketing (Peter and Vecchia, 2021), with organisations recognizing digital marketing as a pivotal aspect in their broader DT endeavours (Hofacker et al., 2020).

The job market has experienced significant changes in recent years, primarily driven by technological advancements that have prompted industries to seek new requirements for skilled professionals (Goulart et al., 2022). Technological skills have become one of the key pillars supporting digital transformation processes. Hence, the development of digital skills is crucial for the effective utilisation of human resources in the emerging digital era, enabling workers to adapt to evolving work environments and processes (Kelchevskaya and Shirinkina, 2019). Merely implementing digital technologies is not enough for digital transformation, as organisational and cultural changes must also take place (Sebastian et al., 2017). The concept that digital transformation necessitates the integration of business strategy and IT is emphasised (Bharadwaj et al., 2013; Matt et al., 2015).

These factors are considered by the companies as critical success factors that will enable them to carry out these DT processes

Table 5
Results of panel data analysis.

Independent Variables	Coefficient	Std. Error	t-Statistic	Prob.	Hypotheses
LOG(ASSETS_MILLIONS)	5.016	2.256	2.223	0.027(**)	H1 Supported
ECONOMIC_GROUPS="Information Technology"	15.369	8.268	1.859	0.064(*)	H2 Supported
ECONOMIC_GROUPS="Financials"	−24.374	7.274	−3.351	0.001(***)	H2 Supported
COVID-19="POST-COVID-19"	11.047	3.913	2.823	0.005(***)	H3 Supported
CEO_GENDER="Female"	26.962	11.576	2.329	0.021(**)	H4 Supported
WORDS_PDF	0.001	2.20E-05	6.412	0.000(***)	Control Variable
C	−42.112	26.694	−1.578	0.116	
R-squared: 0.253		F-statistic: 13.719			
Adjusted R-squared: 0.235		Prob(F-statistic): 0.000			
S.E. of regression: 31.669		White diagonal standard errors & covariance (d.f. corrected)			

(*) $p < 0.10$; (**) $p < 0.05$; (***) $p < 0.01$.

successfully and should be included in their annual reports. Based on Fig. 4, five main informative categories or groups of codes can be identified:

- Codes related to technology and tools are displayed at the top of the figure (i.e., big data, blockchain, artificial intelligence…)
- Codes about digital marketing appear at the bottom of the figure (i.e., digital marketing, digital platforms, e-commerce…)
- The right side of the figure shows generic codes about the DT process (i.e., digital transformation, digitaliz(s)ation, digital technology…)
- The left side presents codes related to organisational and culture issues (i.e., digital strategy, digital culture, digital process…)
- Finally, codes about the skills and technological competences can be found in the centre of the figure (i.e., digital skills, digital training…)

4.2. Results of panel least squares analysis

Table 5 shows the overall results of the panel least squares method with reference to the proposed hypotheses, using as the dependent variable the number of segments coded for a five-year period and 50 cross-sections included. It means a total panel (balanced) of 250 observations.

The results suggest that company size and DT voluntary disclosure are significantly positively associated, confirming our first hypothesis, which implies that larger companies tend to engage in more extensive disclosure practices regarding their DT. Larger companies are motivated to communicate their DT initiatives to stakeholders and show their capabilities and commitment to innovation. These results highlight the importance of company size as a determinant of DT voluntary disclosure, stressing the role of financial capacity and resource availability in driving transparency and accountability in the digital era.

Regarding our second hypothesis, the results obtained using the panel least squares method provide insight into the relationship between the economic sector of a company and its DT voluntary disclosure. We observe that the economic sector significantly affects the level of DT disclosure, and this relationship holds true for both “Information Technology” and “Financials” companies.

In the case of “Information Technology” companies, the effect of the industry on the volume of disclosures about DT was positively significant. This result suggests that companies operating in the “Information Technology” sector tend to exhibit a higher level of DT disclosure in their annual reports. These companies may have a stronger incentive to show their digital capabilities and emphasise their commitment to technological innovation due to the nature of their business and value creation process.

Conversely, among “Financials” companies, the relationship between the industry and DT disclosure was negatively significant. This implies that companies in the “Financials” sector may be inclined to disclose less information about DT in their annual reports.

Based on these findings, it becomes evident that there are different levels of DT disclosure across the different economic sectors. The “Information Technology” industry appears to be more proactive in providing information about DT, whereas the “Financials” industry demonstrates a lower level of DT disclosure. These sector-specific trends highlight the importance of considering industry dynamics and characteristics when assessing the voluntary disclosure practices of companies regarding their digital initiatives.

Our third hypothesis suggests a significant influence of the Covid-19 pandemic on DT voluntary corporate disclosure because the amount of DT voluntary information in Post-Covid annual reports is significantly higher than the amount of DT voluntary information in Pre-Covid annual reports (Fig. 2). The results in Table 5 confirm this relationship showing that the Covid-19 pandemic prompted a paradigm shift in the perception and adoption of DT by companies worldwide. The crisis acted as a catalyst, compelling organisations to embrace DT as a vital component to improve corporate productivity and adapt to the rapidly evolving business landscape in the hyper-connected digital economy. Before the pandemic, DT was often viewed as an optional investment for companies, with some firms hesitating to fully embrace its potential. However, the global health crisis has proven that DT is not a passing fad; it is an integral part of the present and future of businesses.

The findings from panel data analysis reveal a significant correlation between CEO gender and the extent of voluntary disclosure about DT in annual reports. According to our research, leading European companies with female CEOs display higher levels of DT voluntary disclosure. These findings show the proactive approach adopted by female CEOs in embracing and sharing their firms’ DT initiatives and shed light on the gender-based differences in corporate reporting practices. This empirical data emphasises how crucial it is to have a diverse leadership team to encourage transparency and increase DT disclosure.

Finally, as expected, the control variable shows that organisations tend to disclose more thorough and precise information about their DT in their longer annual reports. This result supports the idea that a larger report gives businesses more room to elaborate on their DT initiatives and provide more specific information about their strategy, investments, and technology breakthroughs. A longer annual report may also signify greater responsibility and transparency, as it implies that the corporation is prepared to disclose detailed information to enable stakeholders to make well-informed decisions. This can contribute to building trust and fostering positive relationships between the company and its stakeholders.

5. Discussion

5.1. DT voluntary disclosure guidelines

Previous research on DT has predominantly focused on various aspects of digital technologies, strategic responses and structural changes within organisations in response to DT, or how companies modify their value creation pathways due to the influence of DT (Vial, 2019). Companies are voluntarily disclosing non-financial information, particularly future growth insights. DT is a crucial driver

for future growth and DT disclosure can improve the benefits of voluntary reporting, aligning with broader corporate reporting trends. This paper explores the current DT disclosure practices of leading European companies by analysing their annual reports.

Our first objective was to create DT voluntary disclosure guidelines. We created a code system with 32 codes that allows organisations to disclose information about a wide variety of topics. After analysing the similarities between the codes (Fig. 4), we proposed five categories or code groups that can be used to classify the information provided by leading European companies.

The first category, *DT General Codes*, includes generic codes about the DT process such as "digital transformation", "digitaliz(s)ation", "digital technology" or "digital solutions". This is a prominent category because, as Table 3 shows, many of the annual reports we analysed include this kind of information. Besides, these codes can be used to build a significant number of coded segments.

In addition to this first category, used by companies to disclose general and broad information about their DT process, we identified a considerable number of codes that enable the disclosure of more specific information. The second code group, *DT Toolset Codes*, encompasses a variety of codes related to technologies and tools used by firms to appropriately tackle their DT process, such as "big data", "blockchain", "artificial intelligence", and "cloud computing".

However, as Wade (2015) states, to achieve an effective DT, companies need, in addition to the right ICT resources, the appropriate business model, internal structure, human resources, processes, products and services, and relational capital. To successfully develop and implement cutting-edge technologies, companies need to make profound changes in their organisations. Only by reengineering their existing structures and processes, will firms be able to adjust their operations to the new technologies, optimise their workflows and unleash the power of DT tools.

Therefore, flexibility in the way businesses operate is essential, and adaptability and agility are increasingly becoming key attributes in this competitive economic environment. Bureaucratic organisations are formal and highly organised and, consequently, show greater resistance to changes in their internal processes. This resistance may act to the detriment of the effective implementation of new technologies. On the other hand, flexible companies can adapt and respond relatively quickly to changes in their external environment by incorporating new technologies and reengineering their internal processes.

Based on the importance of these ideas, we identified a third group of codes, *DT Mindset Codes*, which refer to the organisation climate. This category contains terms, such as "digital strategy", "digital culture", "digital ethic", "digital innovation", and "digital process", which help describe collaborative innovation strategies that can act as a catalyst for the DT of the entire company.

The role of human resources is crucial for companies undergoing DT. Employees should have the right skills and technological competences to face the challenges of digitally transformed companies. In an ideal scenario, workers should be able to take full advantage of the opportunities offered by technologies. However, if they are not equipped with the right skills, they may prevent the company from achieving an effective DT.

The first issue a company should address is the adequacy between its employeeś skills and the demands of the specific technology to implement. Undoubtedly, those companies that do not have properly trained staff cannot perform any kind of DT process. Even so, having properly trained personnel is a necessary but not sufficient condition. In addition, workers should have a proactive attitude and high abstract thinking skills so that the DT adoption process reaches its highest potential. Another key element is the work environment, which should be open, collaborative, dynamic, and flexible. These concepts are contained in the fourth category, *DT Skillset Codes*, which includes codes such as "digital skill", "digital capabilities", and "digital training".

The DT process affects the digital structures of both the back office and the front office. The front office incorporates those aspects of the DT process directly related to consumers or clients, while the back office is the portion of the company concerned with running and supporting the business and does not deal directly with the public. Since the digital structure of the front office is used by companies to communicate with its clients, companies are disclosing specific information about this topic. Therefore, we created a fifth category, *DT*

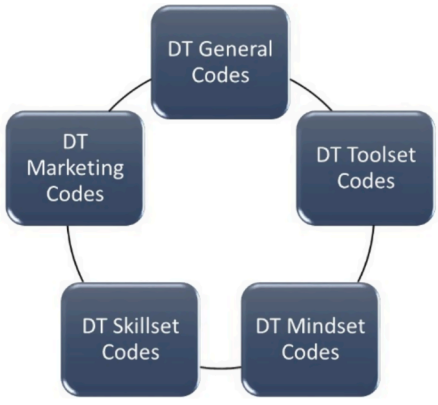

Fig. 5. DT Voluntary Disclosure Guidelines.

Marketing Codes, which includes codes such as "digital marketing", "digital platforms", and "omnichannel".

As a conclusion, the five groups of codes previously identified from the codes map results (Fig. 4) can be used as the starting point to propose DT voluntary disclosure guidelines that may be used by leading European companies to disclose information on their DT processes (Fig. 5).

5.2. Factors influencing DT voluntary disclosure

Regarding our second objective, four hypotheses were tested to identify the factors that may be influencing the DT reporting practices adopted by leading European companies. Larger companies demonstrate a greater inclination towards comprehensive disclosure practices concerning their DT initiatives. Sometimes, company size can also play a key role in enabling organisations to achieve a high level of DT, which, in turn, facilitates their ability to disclose this transformation. Conversely, smaller companies with limited resources may find it challenging to engage in extensive DT initiatives, resulting in restricted disclosure capabilities.

Our study also revealed that the economic sector exerts a substantial influence on the extent of DT disclosure among companies. Specifically, companies operating within the "Information Technology" sector have a high level of DT disclosure, showing a strong support of innovation. These companies are more sensitive to environmental influences and are particularly exposed to DT (Dolinsek and Lutar-Skerbinjek, 2018), having more incentives to voluntary disclosure about their DT processes. In contrast, companies in the "Financials" sector tend to disclose less information about their DT initiatives. Sometimes, the financial sector exhibits conservative behaviours when disclosing information (Hamdan et al., 2011; Manganaris et al., 2010). This could lead companies in this sector to not be pioneers in DT voluntary disclosure, adopting a laggard role. The underlying reasons for this disparity warrant further investigation, as they may vary based on industry-specific factors and considerations.

Our findings strongly support the notion that the Covid-19 pandemic acted as a catalyst, prompting companies to acknowledge the crucial need for embracing the DT to boost productivity and adapt to the constantly changing business environment. DT exceeded its previous status as an optional investment, solidifying its position as an essential force that is shaping the present and future of businesses across various sectors.

Furthermore, our study highlighted a noteworthy trend regarding the influence of CEO gender on DT disclosure. Female-led companies demonstrated greater levels of DT voluntary disclosure compared to their male-led companies. This finding highlights the proactive stance adopted by female executives in embracing and effectively communicating their organisations' DT endeavours. It underscores the importance of having a diverse leadership to promote transparency of DT strategies across companies. This is also consistent with previous research about the effects of gender in voluntary disclosure. Numerous studies support the significative relationship between board gender diversity and voluntary information disclosure about intellectual capital, greenhouse gas, carbon emissions, or environmental, social, and governance activities (Arayssi et al., 2020; Gonenc and Krasnikova, 2022; Loulou-Baklouti, 2023; Nadeem, 2019; Tingbani et al., 2020).

6. Concluding remarks

The analysis of the information disclosed by companies on a voluntary basis has received increased research attention over recent years. Voluntary disclosure practices have the potential to improve companies' reputation and stakeholders' confidence (Lightstone and Driscoll, 2008; Saha and Kabra, 2018).

This is the first study to examine, through the analysis of annual reports, the current DT disclosure practices of leading European firms. Our results show that these companies are disclosing information about DT on a voluntary basis. However, there is still a lack of standardisation on this subject because the amount of information supplied varies greatly among businesses. After our analysis, we propose DT voluntary disclosure guidelines that could be used by leading European companies as the foundation to enhance the information they provide about their value-creation processes and, therefore, reduce the asymmetry of information between managers and stakeholders, mitigating agency problems.

The study also uncovers the significant impact of the company size, the economic sector, the Covid-19 pandemic, and CEO gender on DT voluntary disclosure. These findings significantly contribute to our understanding of the factors that shape the disclosure practices of companies regarding their DT initiatives. The conclusions derived from the hypothesis testing can help practitioners, regulators, and stakeholders understand the factors that may influence the disclosure practices of companies when reporting information about their DT. This research adds to the body of knowledge by offering new insights into the potential impact of the company size, the economic sector, the Covid-19 pandemic, and CEO gender on the DT reporting strategies.

Regarding the company size, our findings support the theory that larger firms, due to their higher economic significance, may face greater information demands from stakeholders and, with the goal of maintaining their legitimacy, they provide more information about their DT (Cooke, 1991; Zamil et al., 2023). When analysing whether the economic sector has a material impact on DT reporting practices, our results show that "Information Technology" companies, whose value proposition heavily relies on ICT, do report a significantly higher amount of information on their DT. Conversely, "Financial" institutions, which are subject to increasingly strict reporting rules to ensure the safety and soundness of the financial system, tend to disclose less information about their DT processes on a voluntary basis.

Based on the results of our third hypothesis, we may conclude that the Covid-19 pandemic had a crucial effect on the reporting practices followed by companies. The digitalisation of organisations and the use of digital tools by employees dramatically accelerated trends that were unfolding at a much slower pace before the crisis. To ensure their survival, companies had to speed up changes in the way they were engaging with their stakeholders, as well as in their daily work routines and internal communication processes. The

Covid-19 outbreak represented a major step toward the digitalisation of the economy and society that may have prompted companies to enhance their DT reporting practices to show their stakeholders that they are properly equipped to face this challenging environment. Our fourth hypothesis provides empirical evidence of the positive effect that female CEOs may have on the reporting practices about the DT processes developed by companies. This finding may be used to support and encourage the efforts that governments, administrators, and societies are doing to promote gender equality and diversity initiatives in the workplace.

These proposed DT voluntary disclosure guidelines also have practical applications, serving as a starting point to create a more comprehensive framework for DT voluntary disclosure. This paper puts forward the guidelines about structure and codes for DT voluntary disclosure in the hope of helping leading companies to complete and organise the information they are providing about their DT processes. This research offers opportunities for policymakers and regulators to implement changes in voluntary disclosure practices through reform initiatives. From the European institutional perspective, European institutions could focus on proposing a global common framework for organisations to report information about their DT processes due to its increasing relevance as an essential driver for future firm growth.

DT voluntary disclosure guidelines can also help companies demonstrate their commitment to global best practices and facilitate cross-border comparisons. Such guidelines provide a standardised structure for reporting, ensuring that companies disclose information consistently. This consistency facilitates easier comparisons among companies within the same industry or sector, as clear reporting is essential for effective communication. In this line, this paper identifies five main categories of DT voluntary disclosure that can be used by companies in their annual reports: DT general information, DT marketing information, DT toolset information, DT skillset information, and DT mindset information.

However, our research has certain limitations that may affect the universal applicability of the results. Firstly, the generalisation would be limited to leading European companies listed in the Eurostoxx50 index rather than encompassing all companies worldwide. Secondly, it is necessary to conduct further analysis in subsequent years to verify the validity of the results obtained during the period of 2018–2022. We hope these findings will stimulate future research on the nature and extent of voluntary DT disclosure practices. Future studies could fruitfully explore this issue further by expanding this kind of research to different countries/ economic areas and industries as an important area for further voluntary disclosure research. It would also be interesting to analyse the possible correlation between the number of segments coded and Google word searches for each year to identify whether it represents a leading, lagging, or contemporaneous measure.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.accinf.2024.100711.

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