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**DIGITAL TRANSFORMATION, FINANCIAL PERFORMANCE
AND SUSTAINABILITY: EVIDENCE FOR EUROPEAN UNION
LISTED COMPANIES****Ion Ionașcu^{1*}, Mihaela Ionașcu², Elena Nechita³, Marian Săcărin⁴
and Mihaela Minu⁵**¹⁾²⁾³⁾⁴⁾⁵⁾ *Bucharest University of Economic Studies, Romania***Please cite this article as:**

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Abstract

This paper aims to discuss the digitalization of European listed companies in the context of the European Green Deal. The digital transformation can support companies in the field of corporate social responsibility, particularly in terms of environmental protection. Companies' digitalization may have a beneficial impact by adopting 'smart' technologies that allow for the efficient use of natural resources and the reduction of pollution, enabling the transformation of business models into sustainable ones within the circular and digitized economy. Based on a large sample of companies listed on the main European Union financial markets, this paper aimed at analysing the extent to which digitalization efforts are part of the companies' general tendencies of becoming good corporate citizens, especially in regard to environmental protection. The study also showed that digitalization efforts are rewarded in financial markets, with investors providing more capital to companies that digitize their activities and are more socially responsible.

Keywords: digitalization of companies, digitalization index, Environmental, Social and Governance score, sustainable development, European Green Deal

JEL Classification: L86, M10, M15, M21, M49

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Introduction

Digitalization is a characteristic phenomenon of the contemporary world that affects individuals, organizations, the global economy, and society as a whole. As an ongoing phenomenon, digitalization is perceived as a *megatrend* (Hossnofsky and Junge, 2019; Lichtenthaler, 2021) which influences, with different intensity, companies of all sizes and in all fields of activity. The concept of digitalization of companies is going through a structuring process and there is no commonly accepted definition. For some authors, the terms 'digitalization', 'digitization' and 'digital transformation' are often used interchangeably (Hossnofsky and Junge, 2019). Other authors note that there is a distinction between these terms: digitization is the process of changing from analogue to digital form; digitalization is the use of digital technologies to improve the performance and extend the scope of the business, and digital transformation is the adaptation to the requirements of the digital economy (Rachinger et al., 2018). Other studies (Verhoef et al., 2021) speak of three stages for digital transformation: digitization (e.g., automation of routine activities or conversion of analogue information into digital format), digitalization (e.g., the use of robots in production, the introduction of digital distribution and communication channels) and digital transformation (which consists of the introduction of new business models, such as the delivery of a 'product-as-service', digital platforms etc.). In this case, the digital transformation involves changing the way the company creates and appropriates value, using digital technology, the company's main business model becoming a digital one. From an evolutionary perspective, some authors have associated firms' digitalization with the 'Fourth Industrial Revolution' (or Industry 4.0) which is characterized by a "fusion of technologies that is blurring the lines between the physical, digital and biological spheres" (Schwab, 2016).

These approaches give us a dimension of the complexity of the digital transformation phenomenon that companies are going through, as well as of the difficulty of conceptualizing it. Given the conceptual inconsistency that persists in defining the phenomenon of firms' digitalization, we believe that corporate digital transformation is the phenomenon of change that companies undergo and propagate within the environment in which they operate by adopting digital technologies, with different intensity.

Digital transformation can support companies in the field of corporate social responsibility, in all its forms: responsibility to the environment, to society and to all stakeholders through good corporate governance. In terms of environmental responsibility, companies' digitalization has the potential to have a beneficial impact on the environment by adopting 'smart' technologies that enable the efficient use of natural resources, reduce pollution and other forms of negative environmental impact, enabling the transformation of business models into sustainable ones within the circular and digital economy. In this regard, the European Green Deal (European Commission, 2021) provides for the use of digital technologies to achieve the sustainable development goals in the European area, contributing to the substantial reduction of greenhouse gas emissions by 2030.

In this context, the present study aims to capture the extent to which the digitalization efforts of European listed companies are correlated with their policies in the field of environmental protection. Furthermore, this research intends to capture the degree in which investors reward these efforts by investing more in companies that have a higher level of digitization. The study considers companies included in the main index of the most important stock exchanges of all European Union (EU) countries, providing an overview of the digitalization

phenomenon of large listed European companies and the relationship between digitalization, sustainability, and financial performance at the EU level.

1. Firm digitalization: a megatrend with multiple implications in the context of the European Green Deal

As the speed, magnitude, and effects of companies' digitalization are not comparable to any of the previous technological changes, digitalization is associated with disruptive technologies (Matzler et al., 2018), being a *technological discontinuity* that reshapes companies' functionality both internally, and in relation to the external environment in which they operate. Digitalization transforms the firms' business model (Loebbecke and Picot, 2015; Rachinger et al., 2018) and affects both the companies and those interested in their operations – business partners, capital providers, workforce etc.

Ismail et al. (2017, p. 6) defined corporates' *digital transformation* as “the process through which companies converge multiple new digital technologies, enhanced with ubiquitous connectivity, with the intention of reaching superior performance and sustained competitive advantage”. Therefore, it is estimated that digital technologies offer a high potential in terms of increasing companies' productivity (OECD, 2021) and performance. On the other hand, digitalization can lead to other benefits, such as environmental protection using intelligent machinery and equipment, increased opportunities for the efficient use of resources, waste reduction and sustainable development (Bonilla et al., 2018).

Digitalization is a priority of EU policies, also considering the gaps compared to the United States (USA). In the globalized digital economy, EU companies are less digitalized than those in the US. According to a study (European Investment Bank, 2021) conducted on a sample for 2020, 63% of EU companies had implemented at least one digital technology, in comparison with 73% of US companies. Furthermore, firm digitalization is done with a different intensity in the EU, varying by country. Thus, the most digitalized companies in the EU are companies from Belgium, Denmark, Finland, Ireland, the Netherlands, and Sweden and, at the lower limit, below the EU average, are the entities from the former socialist countries: Bulgaria, Hungary, Latvia, Poland, and Romania (European Commission, 2020; Brodny and Tutak, 2021). The fact that companies in the Scandinavian countries (Denmark, Finland and Sweden) are among the most digitalized in the EU is not surprising, as they have paved the way for digital development (Castells and Himanen, 2002).

EU's strategy is to create a digital single market ('Digital Single Market Strategy'). Through this, the European Commission seeks to boost the economy by eliminating the existing differences between the online and offline environments and removing existing barriers for cross-border online activities, but most of all to reduce the impact on the environment and improve the quality of life (European Commission, 2015). This trend is amplified by the adoption of the European Green Deal (European Commission, 2019) which includes the projection of sustainable development through a digital transformation of industries in the circular economy. The digitalization of industries is considered to be a key factor for attaining the sustainability goals of the European Green Deal, aiming that the use of digital technologies accelerates and maximizes the effects of policies dealing with climate change, environmental protection and optimizing the use of energy and natural resources (European Commission, 2019).

The EU policy of corporate digital transformation aims for 75% of European companies to use cloud computing, Big Data and artificial intelligence (European Commission, 2021) in the digital economy by 2030. Studies by McKinsey & Company (2020) estimate that the introduction of new digital technologies can contribute to a cumulative increase with 14.1% of the GDP in 2030 compared to 2017, representing 2.2 trillion euros (real 2017) at the EU level, an amount that will offset all investments needed for digitalization and will generate a positive return. A recent European Commission document reiterates the idea that the implementation of digital technologies and solutions by companies will ensure the achievement of the European Green Deal targets, contributing to the EU's proposed goal of reducing greenhouse gas emissions with at least 55% by 2030 (European Commission, 2021).

In the current context, European companies are going through a double transformation, in a conditioning relationship: a *digital transformation* that can facilitate another transformation – the adoption of *business models based on the circular economy*, with the aim of a sustainable development.

2. Literature review

Research to provide empirical evidence on the consequences of *digitalization* on firm *financial performance* is scarce and in the exploratory phase, primarily due to difficulties in measuring the phenomenon of digitalization at the companies' level. In addition, the reported findings are mixed. Research conducted by the European Investment Bank (2020) based on a questionnaire applied to 13,400 companies from 28 European countries and the US, having at least five employees, shows that the adoption of digital technologies is positively and significantly associated with firm *productivity*. According to OECD (2021), the gains from digitalization are not evenly distributed among entities. Companies with access to key technical, managerial and organizational skills benefit more than other entities, as they are registering an above average productivity, and digitalization contributes to increase their advantages. High productivity does not automatically translate into increased *performance* because investments in digitization entail high costs, thus having a negative effect on the firm's short-term *financial performance* (Chen and Srinivasan, 2020). Instead, Salvi et al. (2021) showed that the information companies disclose regarding digitalization has an impact on investors' expectations in respect of the estimated future cash flows for companies featuring a higher level of digitalization, the effects of digitalization being expected with a certain delay. Their expectations are justified by the ability of these entities to generate higher cash flows in close correlation with increased revenues and reduced costs. This perception of investors is based on a better understanding of customer needs and a reduction of the response time to requests received from customers among digital companies. At the same time, digitalized companies increase their revenues by using online commerce, and their costs are reduced by applying innovative business models, eliminating manually performed operations and optimizing resources (Salvi et al., 2021).

Indicators that measure firms' *market performance* incorporate the expectations of financial analysts and investors operating on the capital market regarding the future performance of companies, which are embedded in the share prices (Haslam et al., 2010). In this regard, empirical results show the existence of a positive relationship between the level of companies' *digitalization* and their *market performance* (Nwankpa and Roumani, 2016; Ricci et al., 2020; Salvi et al., 2021).

With respect to the relationship between *digital transformation* and the *sustainable development* of companies, most studies theorize a possible link between them, but empirical evidence is almost non-existent. Thus, a number of studies have questioned the extent to which digitalization can support the sustainable development of companies, given that some digital technologies are energy-intensive, have a high carbon footprint or have limited recycling opportunities (e.g., Kuntsman and Rattle, 2019; Beier et al., 2020). Instead, other authors (e.g., Tjoa and Tjoa, 2016; Vinuesa et al., 2020) consider that digitalization is a prerequisite for sustainable development, in terms of the *environmental* component of sustainability, the arguments being convergent with the goals of the European Green Deal.

In a very recent study, Camodeca and Almici (2021) provide empirical evidence for Italian listed companies, showing that there is a positive relationship between *digitalization* and *sustainable development*.

At the current stage, given the contradictory theoretical approaches in the literature and the lack of empirical results, the relationship between *digitalization* and *sustainable development* is unclear, and research is needed, especially quantitative, to document it. The present study aims to cover a gap in the literature, trying to analyse the extent to which there is a relationship between the digitalization of European listed companies and their sustainability, analysing the protection of the natural environment, considering the goals of the European Green Deal.

3. Research methodology

The sample consists of companies included in the benchmark indexes of the main stock exchanges located within the EU Member States: Austria (ATX), Belgium (BEL20), Bulgaria (SOFIX), Croatia (CROBEX), Cyprus (CSE), Czech Republic (PX), Denmark (OMXC25), Estonia (OMXTGI), Finland (OMXH25), France (CAC40), Germany (DAX), Greece (FTSEAthex20), Hungary (BUX), Ireland (ISEQ 20), Italy (FTSE MIB), Latvia (OMXRGI), Lithuania (OMXVGI), Luxembourg (LuxXIndex), Malta (MSE), the Netherlands (AEX), Poland (WIG), Portugal (PSI20), Romania (BETI), Slovakia (SAX), Slovenia (SBI), Spain (IBEX35), Sweden (OMXS30) and United Kingdom (FTSE100). As this paper aims at analysing the digitalization of listed companies in the context of the European Green Deal goals, out of the total 711 companies (Table no. 1), only companies that have an ESG (Environmental, Social and Corporate Governance) score calculated for the period 2018-2020 have been selected. ESG is a sustainability indicator provided by the Refinitiv Eikon database, which summarizes the behaviour of companies in terms of sustainable development, evaluating the impact of the companies' activities on the natural environment and society, as well as the quality of their corporate governance policies. The environmental pillar of ESG includes three categories: *i) emissions* (of CO₂, waste, biodiversity, environmental management systems); *ii) innovation* (product innovation, 'green' revenues, research and development and capital expenditure) and *iii) resource use* (water, energy, sustainable packaging and the impact of the supply chain on the natural environment).

In order to measure the digitalization of European listed companies, we conducted a quantitative textual analysis of their annual reports published during 2018-2020, using the linguistic software *Linguistic Inquiry Word Count* (LIWC), which identifies specific terms within a given text and calculates their percentage in the total of the words used.

The companies operating in the technology industry were removed from the sample, as, due to the characteristics of the sector, their annual reports feature a significant number of terms pertaining to the digitization realm. For the remaining companies (454 companies), the annual reports in English available in Thomson Eikon were downloaded for each year of the analysed period. Given the diversity of corporate reporting practices on the European markets, for comparability, from the annual reports we have extracted: the letters of the managers to the shareholders/stakeholders, the presentation of the entity, its strategy and its business model, following the methodology used by Chen and Srinivasan (2020) for companies listed on the American stock market, which have a more structured reporting model. The extracts from the annual reports were analysed on the basis of a dictionary of 91 terms describing digitization (shown in Annex no. 1). Out of the total 1,362 annual reports for the three years included in the analysis, after adjusting for cross-listings, a digitalization index (DI) was calculated for only 1,291 reports, as some reports were unavailable in the Thomson Eikon database.

To ensure comparability, financial data have been extracted from consolidated financial statements, which have the same basis for preparation. Missing financial data in Thomson Eikon further reduced the analysed sample to a total of 986 firm-year observations. The remaining sample contains 93.81% of companies listed on the EU developed markets, which is due to the importance of these markets in the total European stock exchanges, but also to the fact that the ESG indicator, relatively recently introduced, primarily considers large companies, likely to produce a significant impact on society, the environment and on all stakeholders. The structure of the sample by industry is shown in Table no. 1.

Table no. 1. Sample structure

Companies included in the main European Stock Market indexes	711
Less companies missing ESG score	(224)
Less companies operating in the technology industry	(33)
Total companies	454
Firm-year observations (2018-2020)	1,362
Less missing management reports and cross-listings	(59)
Total firm-year observations with digitalization index	1,291
Less missing financial data	(305)
Total firm-year observations	986
Industry ^{a)}	%
Basic Materials	11.46
Consumer Discretionary	17.55
Consumer Staples	8.62
Energy	6.80
Financials	5.78
Health Care	9.63
Industrials	23.02
Real Estate	5.38
Telecommunications	6.69
Utilities	5.07
Markets ^{b)}	%
Developed Markets	93.81
Emerging and Frontier Markets	6.19

Note: ^{a)} Industry Classification Benchmark (ICB) developed by FTSE Russel and Dow Jones;

^{b)} Classification by FTSE Russel.

The objective of this study is twofold. (1) On the one hand, this study aims at analysing the extent to which companies' digitalization efforts are in line with their general tendencies of being good corporate citizens, measured by their responsibility towards the environment, the society and all their stakeholders. (2) On the other hand, the purpose of this paper is to determine the extent to which companies' digitalization efforts are rewarded by financial markets, with investors providing more capital to companies that digitize their activities.

Objective 1: Investigation of the link between digitalization and social responsibility.

Within this objective, based on the theoretical arguments advanced in the literature and the goals of the European Green Deal, we formulate the following hypothesis:

H₁: Digitalization efforts are more intense for more socially responsible companies.

As indicated earlier, digitalization efforts are measured based on a digitalization index (DI) and corporate social responsibility is operationalized through the ESG score. Other control variables, which are likely to influence the digitization phenomenon, are also included in the model. Companies' digital transformation can be favoured by higher performance (ROA) or by the size of the companies (Size), as better performing or larger companies have the necessary resources for conducting these processes. On the other hand, digitalization efforts can be driven by financial distress, such as the lack of liquidity (Liquidity) or indebtedness (Leverage), as companies can construe automation and digitization as means to improve financial performance (e.g., implementing software for managing receivables, switch to online sales, etc.). Furthermore, companies with greater growth potential (Growth) can increase digitalization efforts to boost performance. Digitalization can also be determined by the industry in which companies operate, some industries being more suitable for these processes, or benefiting to a greater extent from this transformation. In addition, the digitalization efforts can also be amplified by the context generated by the COVID-19 pandemic, which is covered by the analysed period.

Accordingly, the first hypothesis is tested on the basis of the following regression model:

$$DI_{ij} = \alpha_0 + \alpha_1 \times ESG_{ij} + \alpha_2 \times ROA_{ij} + \alpha_3 \times Size_{ij} + \alpha_4 \times Growth_{ij} + \alpha_5 \times Liquidity_{ij} + \alpha_6 \times Leverage_{ij} + \alpha_7 \times IndustryDummy_{ij} + \alpha_8 \times YearDummy_{ij} + \alpha_9 \times CountryDummy_{ij} + \varepsilon_{ij} \quad (1)$$

Where:

DI_{ij} – Digitalization index of company *i* in year *j* calculated as a percentage of digitalization related terms in the total words used in the selected sections of the annual report describing the company's activity to its stakeholders.

ESG_{ij} – Environment, Social and Governance score of company *i* in year *j*.

Control variables:

ROA_{ij} – Return on assets of company *i* in year *j*, calculated as net profit divided by total assets;

Size_{ij} – Natural logarithm of the market capitalization of company *i* in year *j*;

Growth_{ij} – The increase in sales of company *i* in year *j* calculated as the ratio of the increase in revenues of the current year compared to the previous year divided by the previous year's revenues;

Liquidity_{ij} – Current ratio of company *i* in year *j* calculated as the ratio of current assets and current liabilities;

Leverage_{ij} – The degree of indebtedness of company *i* in year *j* calculated as debt to total assets;

YearsDummy_i, *CountryDummy_i*, *IndustryDummy_i* are dummy variables used to control for fixed effects (FE) related to time, country, and industry. To avoid multicollinearity, countries are grouped into two categories according to the level of market development (developed markets and emerging and frontier markets).

Objective 2: Investigation of the relation between the financial performance, digitalization, and corporate social responsibility.

Based on the results reported so far in the literature (e.g., Chen and Srinivasan, 2020; Ricci et al., 2020), we posit that:

H₂: Financial performance is higher for European listed companies that are making greater digitalization efforts.

To measure financial performance, we use two market variables: i.e., *Tobin's Q*, and *Market to Book*. Accounting variables measuring performance have not been selected, as they depict companies' current performance (Haslam et al., 2010), and the literature shows that positive effects of digitalization are expected with a certain delay (Chen and Srinivasan, 2020). In contrast, market variables incorporate investors' expectations regarding companies' future performance, which are included in share prices (Haslam et al., 2010).

To capture the effect of digitalization on financial performance, other factors that can affect corporate performance are considered, such as the ESG score, as the markets tend to appreciate firms that are more socially responsible. The model also includes a number of financial indicators likely to be correlated with market performance, which control for growth, company size, leverage and company liquidity (e.g., Vafaei et al., 2015).

Consequently, for testing *H₂*, we formulate the following regression model:

$$\begin{aligned} Performance_{ij} = & \alpha_0 + \alpha_1 \times DI_{ij} + \alpha_2 \times ESG_{ij} + \alpha_3 \times ROA_{ij} + \alpha_4 \times Size_{ij} + \alpha_5 \times Growth_{ij} + \\ & \alpha_6 \times Liquidity_{ij} + \alpha_7 \times Leverage_{ij} + \alpha_8 \times IndustryDummy_{ij} + \alpha_9 \times YearDummy_{ij} + \\ & \alpha_{10} \times CountryDummy_{ij} + \varepsilon_{ij} \end{aligned} \quad (2)$$

Where:

Performance_{ij} – represents one of the market performance variables: *TQ_{ij}* or *MTB_{ij}*.

TQ_{ij} – *Tobin's Q* calculated as the sum of the market value of equity and the carrying amount of debt of company *i* in year *j* divided by the sum of their equity and debt carrying amount;

MTB_{ij} – *Market to Book* value represents the ratio between the market value of equity and its carrying amount calculated for company *i* in year *j*.

4. Research results

The research results showed, in a first phase, an overview of the digitization phenomenon of large listed European companies. The digitalization index, calculated based on the quantitative analysis of 1,291 annual reports, depicts an important gap between the

companies listed on developed markets and those listed on emerging or frontier markets (Figure no. 1). Furthermore, an increase in the digitalization efforts can be observed in 2020, the year in which companies' activities have been severely affected by the COVID-19 pandemic, especially in the case of less developed markets, which, in an attempt to adapt to the new pandemic context, are bridging the gap to their more advanced counterparts.

Detailed results on the averages of the digitalization index by country, year and industry are presented in Table no. 2. High scores are recorded in the Northern countries (Finland, Sweden), but also in France, Spain, United Kingdom, the Netherlands, Belgium and Luxembourg, while in the less developed markets, the Czech Republic stands out. These scores are comparable to the EU reported results on companies' digitalization computed at a national level (European Commission, 2020), which supports the validity of the DI index.

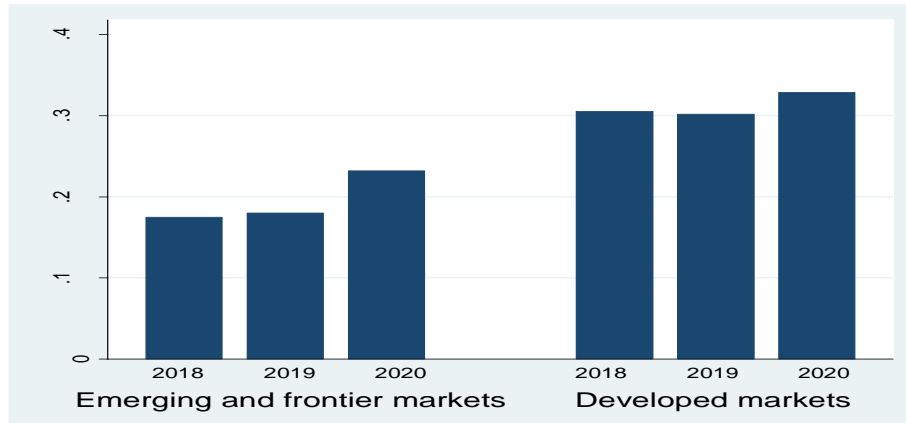


Figure no. 1. Evolution in European listed companies' digitalization

The averages computed for the two types of markets analysed, illustrate the gap between developed markets, with an average of the digitization index of 0.32 and a maximum of 2.09, and emerging and frontier markets, with an average of 0.2 and a maximum of 1.07. The annual averages per total sample confirm the increase in the digitization efforts in 2020 (0.32) compared to 2019 and 2018 (0.29).

Table no. 2. Digitalization index across country, time and industry

Countries	Obs	Mean	Min	Max	Years	Obs	Mean	Min	Max
Developed markets					2020	432	0.32	0	1.88
Austria	51	0.18	0	0.81	2019	431	0.29	0	2.09
Belgium	48	0.3	0	1.67	2018	428	0.29	0	2.05
Denmark	64	0.25	0	1.07	Industries				
Finland	63	0.47	0	2.09	Basic Materials	113	0.14	0	0.73
France	101	0.42	0	1.75	Consumer	184	0.4	0	1.41
Germany	79	0.26	0.01	1.38	Discretionary	102	0.31	0	1.55
Ireland	39	0.2	0	0.77	Consumer	102	0.31	0	1.55
Italy	115	0.24	0	0.98	Staples	72	0.12	0	0.84
Luxembourg	6	0.57	0.08	1.22	Energy	72	0.12	0	0.84
Netherlands	73	0.34	0	1.28	Financials	264	0.3	0	1.09
Poland	46	0.3	0	1.01	Health Care	98	0.2	0	1.03
Portugal	45	0.18	0	0.64	Industrials	235	0.35	0	1.75
Spain	83	0.33	0	1.74	Real Estate	56	0.13	0	0.79

Countries	Obs	Mean	Min	Max	Years	Obs	Mean	Min	Max
Sweden	78	0.47	0.02	1.55	Telecom Sector Utilities	69	0.8	0	2.09
United Kingdom	295	0.3	0	1.6					
Total	1186	0.32	0	2.09					
Emerging and frontier markets									
Cyprus	3	0.12	0.04	0.21					
Czech Republic	12	0.42	0.02	0.9					
Greece	63	0.16	0	1.07					
Hungary	15	0.14	0	0.37					
Romania	9	0.27	0.03	0.54					
Slovenia	3	0.09	0.08	0.11					
Total	105	0.2	0	1.07					

Within industries, the telecommunications sector scores the highest value (0.8), as this industry is more prone to incorporating digital technologies, followed by non-essential consumer goods industry, i.e., consumer discretionary sector, (0.4), which also includes domains which are more likely to rely on digitization (production of electronic devices or cars, etc.), and have an important component of digitalization in the field of e-commerce.

Table no. 3 presents descriptive statistics for all variables, including financial ones, after eliminating missing data and winsorizing outliers. The companies included in the sample are large, with an average market capitalization (MK) of 14,400 mil. EUR and an average of total assets (TA) of 20,500 mil. EUR. The average ESG score is relatively high (67.28) and the mean digitalization index on the total sample is 0.29. The best-performing European listed companies have an average return on assets of 5%, an average annual growth of 3%, based on their annual turnover, and a relatively good liquidity with an average of 1.4. They also have a low indebtedness level with an average of 28% of total assets.

Table no. 3. Descriptive statistics

Variables	Obs	Mean	Standard deviation	Min	Max
DI	986	0.29	0.29	0.00	1.10
ESG	986	67.28	17.40	5.97	94.23
TQ	986	1.70	0.94	0.41	4.11
MTB	986	3.00	2.58	0.09	9.76
ROA	986	0.05	0.06	-0.10	0.19
Liquidity	986	1.40	0.77	0.00	3.30
Growth	986	0.03	0.16	-0.36	0.41
Leverage	986	0.28	0.16	0.00	0.88
MK (mil. EUR)	986	14,400.00	15,400.00	125,99	51,600.00
TA (mil. EUR)	986	20,500.00	24,300.00	70.87	81,000.00

The results of the first regression model, which analyses the relationship between the digitization of European listed companies and their corporate social behaviour, are presented in Table no. 4. They confirm the first hypothesis of the paper (H_1), i.e., the results indicate a significant positive correlation between digitalization efforts and corporate social responsibility, operationalized by the ESG score.

In order to understand the extent to which the digitization efforts are consistent with the corporate policies related to environmental protection, we focus on the environmental pillar

within the ESG score, and its constituents: *i) emissions; ii) innovation and iii) resource use*. Model 1.1 shows that digitalization is in line with the policies adopted by European listed companies in the field of environmental protection, as there is a significant direct relationship between the environmental component of ESG (E Pillar score) and the digitalization index.

A more detailed analysis (Models 1.2, 1.3 and 1.4 in Table no. 4) shows that two of the constituent categories of the environmental pillar (Emissions and Resource use) are significantly and positively correlated with the digitalization of companies, which suggests that digitalization is a prerequisite for reducing emissions and making better use of natural resources, in line with the goals of the European Green Deal.

Among the control variables, liquidity is negatively correlated with digitalization efforts, which confirms the initial assumptions, namely the fact that digitization efforts may be driven by financial difficulties, as companies may perceive digitalization as a means of increasing their performance. Within the same rationale, the digitization processes have increased significantly in 2020, as digitalization allowed companies to adapt to the new pandemic context (through e-commerce, teleworking, etc.).

Regression analysis confirms initial data showing that the digitalization index is significantly higher for companies operating in the telecommunications and consumer discretionary industries. Companies listed on developed EU markets also have a significant lead in the digitalization of their activities.

Tabel no. 4. Regression results

Variables	Dependent:						
	DI					TQ	MTB
	Model 1	Model 1.1	Model 1.2	Model 1.3	Model 1.4	Model 2.1	Model 2.2
DI						0.194* [2.05]	0.607* [2.20]
ESG	0.002*** [4.30]					0.004* [2.46]	0.018*** [3.81]
E Pillar:		0.001** [3.16]					
<i>Emissions</i>			0.002*** [5.22]				
<i>Innovation</i>				0.000 [0.25]			
<i>Resource use</i>					0.001*** [4.02]		
ROA	0.062 [0.48]	0.062 [0.47]	0.030 [0.23]	0.116 [0.87]	0.035 [0.26]	6.753*** [9.42]	16.677*** [9.28]
Size	0.001 [0.09]	0.006 [0.92]	0.004 [0.63]	0.014* [2.24]	0.006 [1.07]	-0.221*** [-9.70]	-0.707*** [-11.27]
Growth	0.060 [1.28]	0.054 [1.15]	0.063 [1.34]	0.027 [0.57]	0.057 [1.22]	0.306 [1.56]	0.654 [1.32]
Liquidity	-0.041*** [-3.75]	-0.041*** [-3.73]	-0.039*** [-3.51]	-0.045*** [-4.06]	-0.039*** [-3.52]	0.099* [2.35]	-0.091 [-0.81]
Leverage	-0.084 [-1.39]	-0.073 [-1.18]	-0.083 [-1.35]	-0.062 [-1.00]	-0.083 [-1.36]	-0.006 [-0.03]	1.861*** [3.55]
Non-essential goods	0.070* [2.34]	0.068* [2.25]	0.069* [2.31]	0.059 [1.92]	0.070* [2.35]		

Variables	Dependent:						
	DI					TQ	MTB
Independent:	Model 1	Model 1.1	Model 1.2	Model 1.3	Model 1.4	Model 2.1	Model 2.2
Telecom sector	0.401*** [10.04]	0.402*** [10.14]	0.414*** [10.56]	0.391*** [9.80]	0.407*** [10.32]		
COVID-19	0.047* [2.47]	0.048* [2.52]	0.046* [2.42]	0.048* [2.52]	0.048* [2.52]		
Developed markets	0.120*** [3.94]	0.121*** [3.92]	0.114*** [3.71]	0.134*** [4.34]	0.114*** [3.69]		
Intercept	0.114 [1.19]	0.109 [1.12]	0.100 [1.06]	0.058 [0.61]	0.091 [0.95]	3.529*** [11.33]	9.273*** [10.81]
Obs	986	986	986	986	986	986	986
F statistic	31.67***	30.96***	31.28***	29.66***	31.04***	49.50	39.12***
Adjusted R ²	0.332	0.326	0.336	0.320	0.343	0.476	0.415
FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: significance levels: ***0.01, **0.05, *0.1. Dummy variables for years, industry and markets are included in the models to control for fixed effects. Only those with relevant economic significance are reported.

Table no. 4 reports regression results for the second model, which captures the impact of European companies' digitalization on their market performance. The regression analysis confirms the second hypothesis of the paper (H_2), both variables selected (TQ and MTB), which measure market performance, are significantly correlated with the variable DI, which measures digitization efforts. This shows that investors on the capital market appreciate the measures taken towards digitalization, which lead to more sustainable business models and have the potential to increase future performance of European listed companies. The digitalization index is significantly correlated with market variables, even when controlling for corporate social responsibility (operationalized through ESG).

Among the control variables, performance measured in terms of profitability (i.e., ROA) is positively and significantly correlated with market variables in both models, confirming previous results obtained in multiple markets characterized by different levels of development (Barth et al., 2011, Ionaşcu et al., 2018), the information on the companies' profitability being relevant for the capital market and incorporated into the share prices. The size of the firm is negatively correlated with market performance which confirms previous results reported for some developed markets (e.g., Vafaei et al., 2015). In general, in emerging markets, larger companies perform better (e.g., Ionaşcu and Ionaşcu, 2018), but given the sample structure of this study, with a vast majority of companies listed on developed markets, the results are to be expected.

Conclusions

This study aimed to analyse the digitalization efforts of companies listed on the main EU stock exchanges considering the European Green Deal's objectives, which proposes very ambitious targets in terms of environmental protection. The EU sees digitalization as a way to achieve its goals in the field of fighting pollution and climate change and promoting circular business models for resource efficiency and sustainable development.

In this context, this research aimed to analyse the extent to which digitization processes are consistent with the measures taken by companies in the area of corporate social responsibility and, especially, in the field of environmental protection. The study also observed whether financial markets appreciate digitalization efforts by rewarding companies that are more advanced in the digital transformation process.

Based on a computerized quantitative analysis of 1,291 annual reports of European listed companies published during 2018-2020, a digitalization index was calculated, which allowed observing the evolution in the degree of companies' digitization in different European financial markets and industries. Using regression analysis, the research has shown that digitalization processes are more advanced for more socially responsible companies, which confirms certain theoretical presuppositions (e.g., Tjoa and Tjoa, 2016; Vinuesa et al., 2020), but also some preliminary results reported in the literature (Camodeca and Almici, 2021). In terms of the objectives of the European Green Deal, the digitalization index is directly correlated with environmental indicators that measure corporate responsibility for harmful emissions and the use of natural resources. The study also confirmed previous results (e.g., Ricci et al., 2020; Chen and Srinivasan, 2020; Salvi et al., 2021), showing that the information on companies' digitalization presented in their annual reports is relevant for investors and analysts operating on the capital markets, with market values being higher for companies with more advanced digitization processes.

The research results are relevant for the EU regulatory bodies, which can implement policies to stimulate digitalization, with beneficial effects on the natural environment by promoting sustainable business models. The results also confirm management strategies of large European listed companies, based on digitalization and sustainable development, which can be extended to other types of entities.

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Annex no. 1. Digitalization dictionary

App	Data lake	Emobility	Newsfeed
Artificial intelligence	Data mining	E-mobility	NLP
Artificial reality	Data monetisation	Eprocurement	Online
Augmented reality	Data monetization	E-procurement	Open source
Automation	Data processing system	Epublishing	Platform
Autonomous technology	Data science	E-publishing	Proprietary
Big data	Deep learning	Eservice	algorithm
Biometric	Devops	E-service	Robotics
Biometrics	Digital	Etravel	Robots
Bitcoin	Digitalisation	E-travel	Selfdriving car
Blockchain	Digitalization	Fintech	Sentiment analysis
Bots	Digitally	Hightech	Sharing economy
Business intelligence	Digitisation	High-tech	Smart content
Click through rate	Digitization	Image recognition	Smart devices
Cloud	Ebusiness	Industry 4.0	Smart factory
Cognitive computing	E-business	Influencer	Smart home
Connected car	Ecatalogue	Intelligent systems	Smartphone
Connectivity	E-catalogue	Internet	Social media
Cryptocurrency	Ecommerce	IoT	Software
Data analytics	E-commerce	Machine learning	Speech recognition
Data architecture	Edge computing	Natural language processing	Trade in data
Data capturing	Elearning	Neural network	Virtual reality
Data integration	E-learning	New economy	Web based

Source: Adaptation based on Chen and Srinivasan (2020) and Hossnofsky and Junge (2019)