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Corporate Digital Responsibility: A Board of Directors May Encourage the Environmentally Responsible Use of Digital Technology and Data: Empirical Evidence from Italian Publicly Listed Companies

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Abstract: This paper presents a framework for our hypotheses that the independence of a board of directors and the use of digital technology might influence the way a corporation performs environmentally. For empirical verification of our thesis, we take a sample of 53 publicly listed Italian companies and look at data on their board composition, greenhouse gas emissions, and expenditures for the use of digital technologies of Enterprise Resource Planning (ERP) over a period of five years. What emerges from the test partially supports our predictions. In particular, we find that a higher level of board independence is associated with better environmental performance. There is no direct, statistically significant association between the use of digital technologies and environmental performance, so a greater use of digital technologies is not, in itself, sufficient to improve the environmental performance of a firm. However, our empirical analyses find that environmental performance is positively influenced by the use of digital technologies in firms that include a proportionately high number of independent directors on their boards. This research improves our understanding of antecedents of Corporate Digital Responsibility (CDR), showing how the share of independent directors on a board has a positive impact on CDR, understood here as the set of practices and behaviours that help an organisation use data and digital technologies in ways that are environmentally responsible.

Keywords: board of directors; Corporate Digital Responsibility (CDR); corporate governance; digital transformation; enterprise resource planning (ERP); environmental impacts; information systems

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1. Introduction

The board of directors is a company's main agency of corporate governance and is responsible for protecting the appropriate interests of stakeholders by directing the firm's operations and supporting its decision-making [1]. Independent board directors are individuals whose only business relationship with the firm is their directorship. Anderson and Reeb use the proportion of a board that is composed of independent members as a measure of the board's independence [2]. We adopt a theoretical framework to formulate hypotheses according to which increasing board independence and greater expenditure on ERP digital technologies, evaluated first separately and then together, will result in firms having a better environmental performance.

It was suggested by Jensen and Meckling that, should they have the opportunity, and should egotism and guile be their main drives, then managers might adopt opportunistic behaviour and follow a course of action that does not work in the best interests of external investors [3]. As indicated by Shleifer and Vishny, shareholders might adopt various forms of corporate governance, for example, contractual relations, incentives, and strategies of board monitoring, as a means to combat such opportunism [4]. The agency view of corporate governance assumes that shareholder interests are considered paramount,

and emphasis is placed on economic (financial) efficiency [5]. In terms of its impact on Corporate Social Responsibility (CSR), that is, companies' non-financial results, agency theorists indicate that corporate governance strategies ought to be designed in such a way that CSR practices will only be adopted if they guarantee an increase in efficiency [6].

Here, we look at the board of directors as a governance mechanism that has an impact on the firm's environmental performance. In our empirical analyses, we will use the data on how much greenhouse gas the firm emits as a negative proxy of its green performance. In particular, the environmental performances will be measured as the natural logarithm of the quantity (Kg) of the emissions of CO_{2eq} (CO_2 equivalent) multiplied by -1. Therefore, a good environmental performance will be indicated by higher values of the variable.

According to agency theory, boards attempt to control managers so as to avoid agency conflict. We focus on the degree to which a board of directors may be independent and the impact this has on the firm's environmental performance. From this perspective, it has been said that one consequence of an independent board is that it will reduce conflict of interest within the firm and make sure that management acts in the best interests of the stakeholders [7]. This is also true for stakeholders' environmental demands [8,9]. Those who diminish the role played by independent directors suggest, rather, that independent directors are often appointed on the basis of their financial awareness, and, indeed, some suggest that independent directors do not represent stakeholders as well as they do shareholders [10].

ERP Systems are packaged software solutions that have the function of integrating the complete range of a firm's processes and operations in order to present a holistic view of the business within a single information and IT architecture. This is desired because it paves the way for organisations to have business processes and operations that are environmentally friendly [11,12]. Moreover, an organisation that aims to improve its environmental performance has to be able to evaluate the components on which it depends, so it needs to implement environmental accounting instruments. ERP systems provide functionalities that can be used relatively easily to implement IT-based Environmental Accounting Instruments. Therefore, it may be interesting to study this application of ERP technologies in order to understand the implications that modern digital technologies might have for the relationships between a firm and its stakeholders, with particular attention to their environmental protection expectations. In Section 2, predictions are made regarding governance practices and the use of ERP-type digital technologies that might help improve corporate environmental performance. The empirical research is presented, and the variables, methodology, and data are described in Section 3. A sample of 265 yearly observations of firms is the focus of our research. The results we obtained indicate that the more independent a board is, the better the firm will perform environmentally and that using ERP technologies more intensively does not always correlate with better environmental performance. In particular, we find that greater use of ERP systems only increases the positive effects that the above-mentioned board independence produces on environmental performance. In Section 4, we discuss in detail the results of the empirical analysis and the conclusions that can be drawn.

Corporate governance may have a positive effect on promoting environmentally friendly practices [13]. To date, there are still only a few works that investigate the relationships between the characteristics of the structure of boards of directors and firms' environmental performance [8,9,14–16]. This paper aims to extend this area of study by looking at how the relationship between environmental performance and the adoption of digital technologies evolves as the independence of the board of directors changes. Our empirical analysis found that a firm's green performance and control of pollution are influenced by the characteristics of its corporate governance and that greater use of digital technology such as ERP leads to more "green friendly" results when the board's independence is also reinforced.

Boards influence the moral codes and ethical considerations and guide the behaviour of the collectivity and individuals within the organisation. We conclude that the presence

of independent directors on a board has an impact on the organisation's judgement and choices in digital matters. Firms with independent boards use digital technology to attain certain goals that are perceived as socially, economically, and environmentally more responsible. This finding is useful both to practitioners who are looking for the governance mechanisms to implement in a firm that will best meet stakeholders' environmental expectations and to researchers who wish to study the antecedents of CDR.

2. Framework and Hypothesis

Digital technologies increase a firm's productivity and open new horizons while also posing ethical and social problems. The fact that new technologies pose a social risk makes them a subject of study with regard to their social responsibility [17]. Problems arise in situations that clearly involve all of us, given that we are all citizens and consumers. Some examples of this are smart devices that constantly record data or self-driving vehicles that might put people in danger. Many similar ethical problems may emerge in firm contexts, although here, they will sometimes be less obvious. The company ethic is defined as the rules and standards which guide the firm's business judgements and choices [18]. Recent theories based on the general idea of ethics define CDR as the set of specific values and rules which guide the organisation's judgements and choices in digital matters [19–21]. These CDR-related values and choices share some principles and objectives with CSR, that is, the efforts the organisation makes and the responsibility it takes for social and ecological causes in general. Despite this eventual similarity, Lobschat et al. claim that CDR should be considered explicitly and separately from CSR because of the peculiarities of digital technologies [19]. Three characteristics are highlighted, which justify this explicit consideration of digital responsibility as being distinct from the organisation's wider social responsibility. In the first place, technological developments have exponential growth, and innovations multiply and combine in such a way as to offer innumerable alternative uses. For Brynjolfsson and McAfee, it is particularly this growth through the recombining among innovations that require corporations to face up to what digital transformation really means [22]. Examples of such growth include *big data and analytics*, which have been around for years, but today work together with new systems of Artificial Intelligence (AI), Cloud Technologies, and High-Performance Computing. Combining these digital technologies allows greater volumes of already-collected data to be used in ways that could not have been foreseen only a few years ago but that have a great impact on the environment. This is exactly what is happening in the agricultural sector, for example, especially in the context of precision agriculture and livestock farming applications [23]. Secondly, ethical and social preoccupations have to respect the malleability of digital technologies [24,25]. Social media was not created intentionally to spread fake news, but its algorithms, projected to maximise people's involvement, have contributed to this growing tendency [26]. From a firm's perspective, digital responsibility entails a wide, complex, and highly dynamic set of moral challenges that are not all foreseeable at the time a technology is planned or data is acquired but only emerge as they are used over time. Authors who have looked at these problems have shown how, for example, a firm might acquire digital technologies with the best of intentions, but, as a consequence of the extremely "malleable" nature of this technology, there is a high risk of its being exploited in unanticipated ways [24,27]. Thirdly, the arguments that say that specific company rules have to deal with digital responsibility also derive from the pervasive nature of digital technologies. It has become almost impossible to perform daily activities without using digital technology (e.g., apps). These three aspects—the exponential growth of technological development, the malleability of technology and data, and the pervasive nature of technology—lead to specific challenges beyond the generally understood idea of CSR. The assessments and choices that firms make in order to deal with these challenges are conditioned by the system of values and rules that underlie their CDR.

The absence of regulations in industry 4.0 and the unpredictability of the advance of technologies are not a limitation to creating a scenario of corporate digital responsibility. The

development of social responsibility in digital contexts is possible and necessary [17]. For Wagener, CDR is revealed in the voluntary effort to manage digital resources responsibly with reference to the following arguments of interest [28]:

- Conservation of resources in the use and creation of digital services and products;
- Social compatibility and the possibility of creating a "human" work environment in the use of digital technology;
- The "democratisation of digitalisation": assisting access by developing individuals' competence and promoting a generally accessible digital infrastructure;
- Data security and prevention of the abuse of digital power due to acquired "data power".

We focus on ERP systems, which make further digital options possible and available to firms, as well as being a good *proxy* for the intensity of the use of digital technologies in general [29]. Over the last three decades, the use of packaged application software for ERP has emerged. Indeed, today it is widely used in large firms and, thanks to the modularity of software solutions, has been adopted by many small and medium enterprises. The ERP industry includes the world's fourth largest software vendor (SAP, a German firm that is the largest producer of ERP software in the world) and several others from the largest software firms (such as Microsoft, IBM, and Oracle which are, respectively, the second, third, and fourth largest vendors of ERP systems). Since ERP systems aim to computerise and integrate core business processes, the implementation by the firm of ERP technological systems precedes or accompanies investments in other digital technologies such as automation, data analytics, artificial intelligence (AI), and machine learning. It is precisely because they are so widely found and able to integrate and combine with other more recent digital technologies that ERP technologies are such a good proxy for the digitalisation of a firm.

2.1. Monitoring and Strategic Functions of the Board

The board participates in the various phases of the strategic decision-making process through interaction with the firm's TMT (Top Management Team) [30–33] and, therefore, is able to direct the use of digital technologies toward goals that stakeholders perceive as socially, economically, and environmentally responsible. Moreover, the board is an internal control mechanism that, depending upon the extent to which it is composed of independent directors, can mitigate moral hazard problems between insiders and stakeholders [34,35]. From this perspective, independent directors represent an effective monitor of the risk that those digital technologies, which were acquired with the best of intentions, might be put to use in unforeseen ways.

Due to the increased attention that environmental issues, and their concomitant strategic opportunities, receive nowadays, managing environmental strategy has become one of the activities which are required of a board of directors [14,15]. Therefore, we look at the aspects of the board that relate to its function as a monitor (i.e., the level of independence it enjoys) as a proxy for how it performs environmentally. Agency theory indicates that strategies are initiated and executed by managers, whereas the process is monitored by the directors [36]. From this viewpoint, the greater independence directors have (i.e., the less financial involvement non-executive directors have with the firm), the more rigorous the monitoring will likely be. There is strong evidence in the literature of the existence of a close relationship between the board's monitoring of managerial behaviour and corporate strategic decisions [36,37]. There is, however, still little understanding of exactly how an active board can influence environmental strategies. Although it is recognised that an appropriate, acceptable level of environmental performance is of importance strategically, it seems that management does not always consider it a priority. Any new environmental initiatives might require a significant degree of investment (in such areas as production processes or new technologies), and the re-coordination of employees from different areas of the production process may be necessary for new strategies [38]. What is more, as it might well take some time for a responsible environmental strategy to produce any

clear benefit [39], there is no great appeal for risk-averse managers in such responsible environmental initiatives [34].

Instead of dealing with issues that offer little to their own personal short-term interests, managers often prefer to follow conventional strategies which provide them with immediate financial and reputational benefit [40,41].

Managers and shareholders have diverse utility functions [42,43]. The increase in effort required to plan and follow innovative environmental strategies diminishes managers' utility, but this is not necessarily the case for shareholders. For example, shareholders will not experience any adverse consequences due to managers' dedicating their valuable time to finding a remedy for the company's high pollution levels through a reorganisation of its internal practices. It has been shown that managers need to make a great extra effort when reorganising their production procedures and obtaining environmental knowledge and experience so as to reduce or avoid producing waste emissions [44]. As a consequence, the firm faces higher costs due to its new procedures and increased managerial effort in its attempt to render its operations more environmentally responsible. As a counterbalance, though, as shareholders might well see that the costs of this increase in effort on the part of managers are justified by the problems involved in the designing and applying of better environmental strategies, it may be assumed that they will accept the higher costs involved. However, the fact that this greater managerial effort is subjective renders its monitoring and verification very difficult [38].

Given that the main activities of the board should include the observation and checking of a firm's operations and the behaviour of its managers, together with evaluating any change in expenditure due to new green practices, the environmental strategies adopted by top management should also be the subject of close scrutiny by the board [15]. Indeed, agency theory-based studies highlight how a higher level of a board's independence within a firm can be linked to a more methodical approach to the performing of its monitoring duties [45]. It is generally accepted that a more independent board of directors will fulfil its role as a monitor of the CEO's activities better because observation and evaluation of the firm's achievements will be carried out with greater objectivity [46,47]. Furthermore, the degree to which a firm practices socially responsible corporate behaviour tends to be more highly valued by independent boards [48]. According to McKendall et al., an independent board of directors is more likely to recognise the potential green investments may have in the long term and, therefore, resist managerial pressure to adopt a different investment strategy [15]. Consequently, there is a greater inclination on the part of independent boards to adopt environmentally-friendly policies, even when they are expensive. Therefore, logic suggests that a more objective application of the board's experience and knowledge to how it monitors the firm's green behaviour will occur if the proportion of independent directors is increased. If independent board members wish to continue in their positions on boards of directors, they have an incentive to safeguard the directors' good reputations, and, to this end, their task will be easier if they work on the boards of firms with a reputation for environmental responsibility. Consequently, we adopt the following as our first hypothesis:

H1. *Board independence has a positive influence on a firm's environmental performance.*

2.2. The Role of ERP Technologies and the Perspective of the CDR

Digital transformation generates both opportunities and threats, and these effects are closely connected with problems dealt with in this paper, including the fact that new technologies can impede as well as enhance energy efficiency and environmental impact [49]. An example of opportunity is that digital transformation can theoretically lead to the inclusion of many disadvantaged societal groups [50], but the COVID-19 pandemic has shown that unequal access to the digital world is already a reality [51]. In synthesis, innovative technology brings with it new social issues and heightened responsibilities, especially for corporations [52]. These new responsibilities have recently been termed CDR [19–21]. In 2021, academics and professionals collaborated in setting out the manifesto on CDR, defining it as "a set of practices and behaviours that help an organisation use

data and digital technologies in ways that are perceived as socially, economically, and environmentally responsible" (https://corporatedigitalresponsibility.net/cdr-manifesto) (accessed on 29 September 2022). CDR will likely become a differentiator for organisations, allowing them to gain and maintain stakeholder trust and competitive advantage, and, therefore, firms will begin to formulate practices for developing and implementing a CDR strategy [53]. The goal of such a strategy should not only be to prevent the potential negative consequences but also to leverage the advantages of information communication technologies (ICTs) for the common good [54,55].

The ERP system is an integrated set of programs that provides support for core organisational activities such as manufacturing and logistics, finance and accounting, sales and marketing, and human resources. An ERP system helps the different parts of the organisation share data and knowledge, reduce costs, and improve the management of business processes [56]. However, the implementation of ERP is not only a technological challenge. It is a socio-technological endeavour that demands the modification of existing applications and the redesigning of critical business processes to facilitate ERP implementation. Research has indicated the necessity of realising effective changes in management strategies so that firms can implement ERP systems successfully [56,57]. The characteristic ability of ERP to redesign, automate, and integrate business processes and operations performs an important role from a CDR perspective, as it paves the way for organisations to have a business process, especially in terms of the supply chain, that is environmentally friendly. Al-Mashari et al. point out that a supply chain system can be re-engineered within, and, indeed, go beyond, the firm's organisational scope by applying the ERP scheme to the existing system [58]. Hervani et al. created a framework for studying, designing, and evaluating a green supply chain [59]. Their studies were based on experience, case studies, and literature reviews. The integration of supply chain management and ERP is illustrated in research work by Koh et al. since these two approaches were known to render one another more complete [60]. This study indicates that a close relationship between suppliers and the centralised system will lead to successful integration. Manufacturers should establish green supply chain systems which are able to document all of the environmental information at each stage of a supply chain. In order to fulfil this objective, an integrated information system is required to track every detail due to the environmental impact of the supply chain system. To achieve this, one possible strategy is the implementation of an ERP system since ERP integrates every aspect of the production system. ERP systems might also be useful as support for environmental accounting instruments, and according to the European Commission ([61], p. 53), environmental management holds a key role within the concept of CSR in the manufacturing sector. Environmental improvement measures have to be identified, analysed, managed, and controlled with respect to financial and environmental effects. New targets have to be set on a regular basis within a management cycle in order to achieve continuous improvement. Within such a management cycle, information from different company units has to be gathered and consolidated. These are typical controlling tasks, but they all focus on environmental data, so they are usually carried out by the environmental management unit. The environmental manager edits environmental information and makes it available to a variety of company officers as a basis for decision-making. New interfaces for environmental information flows emerge, which require systematisation and integration into the organisational structure of the company [62]. A prerequisite to ensure these functions is the availability of relevant information on the environmental performance and environmental aspects of the enterprise. Nowadays, such an information system can be implemented by means of software, and this facilitates the consolidation and aggregation of environmental information such as indicators of resource and energy consumption, waste disposed and emitted wastewater, and air pollution. The literature shows that today's ERP systems provide functionalities that can be used relatively easily to implement IT-based Environmental Accounting Instruments [63,64]. Given that the use of ERP may help a firm to achieve better environmental performance, we hypothesise that:

H2. *Firms generally have better environmental outcomes when they make more use of ERP systems.*

Finally, we consider the combined effects that may derive from a higher quota of independent board members and from simultaneous increased use of ERP systems in the context of the firm. These effects are considered to be added to those already hypothesised because of the characteristics of board independence in itself (as in Hypothesis 1). Therefore, we suppose that:

H3. *The positive effect of board independence on the environmental performance of a firm increases when the use of ERP systems by that firm also increases.*

3. Method

3.1. Sample Selection

We analysed data from the Sustainability Reports of all the companies listed on the Italian Stock Market in Milan for the 2014–2018 period. There were 339 companies, but only 83 of them reported detailed environmental data relevant to the subsequent analyses for each of the 5 years. We particularly needed each firm's yearly detailed data on its greenhouse gas emissions. Since 2017, Italian law (254/2016 legislative decree) has made it obligatory for certain types of companies to deposit a non-financial declaration which includes the information that listed companies already communicated in their Sustainability Reports. However, listed companies enjoy wide margins of autonomy when deciding what information and which indicators of non-financial performance to include in their Sustainability Reports, and consequently, disclosure of information on greenhouse gas emissions is still only voluntary. The fact that complete information on emissions of greenhouse gasses for the 2014–2018 period was only available for 83 firms forced us to continue with the empirical analysis for just these firms and exclude other listed firms. These 83 companies mostly belonged to the sectors indicated in the literature as having a great environmental impact (49 cases out of 83, corresponding to 59%) [9]. These sectors include Electricity, Gas, and Waste Water (SIC codes 4900–4999), Iron and Steel Manufacturing (Iron and Steel Manufacturing SIC codes 3300–3399), Chemicals, Pharmaceutical, and Plastics Manufacturing (SIC codes 2800–3099), Coal Mining and Oil and Gas Exploration (SIC codes 1200–1399) and Metal Mining (SIC codes 1000–1099). A short questionnaire was sent to each of the 83 firms identified, asking them to indicate, for each year of the 2013–2017 period, the sum of their expenditure on ERP technologies, both in terms of their acquisition and their implementation within the firm. Only 53 firms returned the completed questionnaires, and therefore, they constituted the final sample of firms we analysed. Most of the firms (37 out of 53) belonged to sectors with great environmental impact, and they showed a greater willingness than the others to compile and return the questionnaire, demonstrating that firms in environmentally sensitive industries disclose more environmental information than others [65–67].

3.2. Dependent Variables

A variety of proxy variables are used in the literature in order to evaluate corporate environmental performance. For instance, some research undertaken in the United States exploits the Environmental Protection Agency (EPA) information on the toxic emissions the companies have to communicate. With regard to this information, certain authors [38,68,69] adopt the emissions of toluene and benzene, both toxic, as a negative indication of a company's environmental performance. On the other hand, authors such as King and Lenox or Kock et al. utilise EPA data to elaborate a calculation of waste on the basis of toxicity [8,48]. This waste is calculated as the number of chemicals (measured in kilogrammes) the firm emits while considering the toxicity coefficient of those chemicals, which is the opposite of the 'reportable quantities' (RQ). EPA uses the idea of RQ to explain how an accidental spill of chemicals has to be reported if it exceeds a set level for that given substance. For instance, a spill of methanol, among the substances considered relatively innocuous, has to be reported if it exceeds 5000 pounds (2268 kg), whereas a spill of as little as a pound (454 g) of the highly dangerous chemical warfare agent Heptachlor has to be reported. The United States has not ratified the Kyoto Protocol,

the international treaty aimed at achieving a reduction in greenhouse gas emissions, whereas Italy has; therefore, Italian businesses are encouraged to disclose their emissions. Consequently, as a negative proxy of a firm's green performance, we used the data on how much greenhouse gas it emits. Indeed, the *environmental performance* variable is measured as the natural logarithm of the quantity (Kg) of the emissions of CO_{2eq} (CO_2 equivalent) multiplied by -1. This means that a good environmental performance will be indicated by higher values of the variable. For instance, in 2018, Enel S.p.A. released a total of 104.29 million tonnes of CO_{2eq} into the atmosphere, meaning that its *environmental performance* was $-25{,}370$ $(= -\ln 104,290,000,000)$. CO_{2eq} levels are often used in environmental studies as an indication of pollution, as well as being a point of reference that our sampled firms had to declare in their annual reports. This level was calculated as the weighted sum of the capacity of six different gases (carbon dioxide, sulphur hexafluoride, nitrous oxide, methane, hydrofluorocarbons, and perfluorocarbons) known to cause climate change according to the Kyoto Protocol (effective since 2005).

3.3. Independent Variables

It is necessary for independent variables to have the capacity to measure the values referred to by the framework predictions. Hypothesis 1 refers to board independence. In studies on Italian listed companies and studies conducted on other stock markets, board independence is measured as the proportion of independent directors on the board [2,70]. Therefore, for the conclusion of every observed year, the number of independent members on each firm's board divided by the sum of people on the board was measured as the variable board independence. The profile of the board members at our sampled firms was evaluated by referring to the companies' internet sites and their 'Relazione sulla corporate governance' (Report on Corporate Governance: something every listed company renders public on its internet site). Hypotheses 2 and 3 refer to the use of ERP digital technology. For this aim, we used the variable proxy ERP spending, which we measured as the expenditure for the use of ERP technologies for every one of our sampled firms at the conclusion of each observed year divided by total assets. This variable was measured as a percentage. Data on expenditures made were obtained by asking each firm in the sample to complete a brief questionnaire regarding their expenditure on the acquisition and implementation of ERP technologies over the years.

3.4. Control Variables

In order to check for a range of factors that might have an impact on a firm's environmental performance, a series of variables at the firm level were looked at. In particular, by using the AIDA databases (Bureau van Dijk) and Datastream databases (Thomson Financial), we obtained the financial and market data we needed to be able to control for:

- ***Firm size***. Calculated as the natural log of total assets. Clarkson et al. hypothesised that larger firms would have a greater propensity to prioritise the effective management of environmental issues [71];
- ***Firm age***. Calculated as the number of years from the foundation of the firm up until the last fiscal year for which we have data. According to Berrone et al., older firms will quite possibly have sunk costs in the shape of more primitive, older, and more polluting plants and equipment, which they will, therefore, find expedient to continue using [68];
- ***Financial performance***. Evaluated by referring to returns on assets (ROA). McKendall et al. suggest that firms that are profitable will probably have a better green performance because of their ability to deal with the high costs of certain green strategies [15];
- ***Tobin's Q***. Calculated by using the price-to-book relationship. It has been found that usually, the better a firm's performance is in the market, the better it will perform environmentally [8,14];

- ***Leverage***. Calculated as total debt divided by total assets. Those firms which enjoy higher leverage tend to perform better environmentally [71];
- ***Polluting industry***. The way a firm performs environmentally may be influenced by the industrial sector to which it belongs [68]. In particular, firms in environmentally sensitive industries are likely to manage their environmental impacts more effectively [65–67]. A dummy variable is used to control whether a firm belongs to those sectors which are considered to have a great impact on the environment: Electricity, Gas, and Waste Water (SIC codes 4900–4999), Iron and Steel Manufacturing (Iron and Steel Manufacturing SIC codes 3300–3399), Chemicals, Pharmaceutical, and Plastics Manufacturing (SIC codes 2800–3099), Paper and Pulp Mills (SIC codes 2600–2699), Coal Mining and Oil and Gas Exploration (SIC codes 1200–1399), Metal Mining (SIC codes 1000–1099), and Forestry (SIC codes 800-899). Therefore, this variable has a value of "1" whenever the firm belongs to one or another of the above-listed sectors and a value of "0" otherwise.

4. Results

In our study, the values of the dependent variable were measured a year after those of the independent variables. Consequently, our dependent variable (environmental performance) was measured from 2014 to 2018, while the control and independent variables were measured from 2013 to 2017. This time-lapse of one year between when the dependent and independent variables were measured served to reduce the risks which derive from inverse causality. In fact, strategic change sometimes leads to better green performance. Pettigrew and Whipp suggest that such a time lapse between the disclosure of independent and dependent variables would seem appropriate because the positive consequences of changes in strategy may not become evident for some time [72]. The five years of measuring variables resulted in data for a panel with 265 different combinations of the values of our variables (*environmental performance*$_t$, *board independence*$_{t-1}$, *erp spending* $_{t-1}$, *financial performance*$_{t-1}$, *firm size*$_{t-1}$, *firm age*$_{t-1}$, *Leverage*$_{t-1}$, *Tobin's Q*$_{t-1}$, *polluting industry*$_{t-1}$, where *t* is the conclusion of a generic year from between 2014 and 2018), a combination for each of the firm-year observations that make up the sample (5 years × 53 firms). The standard deviations, the average values and the values of the Pearson correlation coefficient relative to the variables used in our analysis are presented in Table 1, which also shows some meaningful correlations between the variables when considered as pairs.

Table 1. Mean averages, standard deviations, and correlation matrix.

		Means	Standard Deviations	*8*	*7*	*6*	*5*	*4*	*3*	*2*	*1*
1.	***Environmental performance***	−14.001	21.009								1
2.	***Board independence***	0.503	0.104							1	0.178 **
3.	***ERP spending***	0.2154	0.2971						1	0.112	0.091
4.	***Firm size***	19.998	5.303					1	0.121 *	0.063	0.159 **
5.	***Firm age***	63.167	29.171				1	0.183 **	0.109	0.393 **	−0.061
6.	***Financial performance***	6.113	7.131			1	0.129 *	0.129 *	0.099	0.031	0.023
7.	***Tobin's Q***	3.974	9.982		1	0.171 **	−0.009	−0.031	0.081	−0.029	0.047
8.	***Leverage***	0.557	0.156	1	−0.183 **	−0.165 **	0.041	0.183 **	0.043	0.081	0.131 *
9.	***Polluting industry***	0.698	0.454	−0.159 **	−0.055	−0.035	0.179 **	0.145 *	0.057	0.171 **	−0.601 **

N = 265; 1-tailed: * $p < 0.05$; ** $p < 0.01$.

A hierarchical regression model was run so that our hypothesis could be tested, and the results are presented in Table 2. Initially, the variance inflation factor (VIF) for every one of the independent variables within the regression models was calculated in order to

guarantee that no potential multicollinearity problems existed with the variables. However, as the VIF values all lay within a range of between 1.1 and 1.7, it was clear that they had no influence on the validity of our three models [73].

Table 2. Hierarchical regression analysis of environmental performance (N = 265).

	Model A		Model B		Model C	
Variable	**Parameter Estimate**	***p* Value**	**Parameter Estimate**	***p* Value**	**Parameter Estimate**	***p* Value**
Intercept	−39.3	0.21	−31.1	0.04 *	−32.5	0.02 *
Controls						
Firm size	0.15	0.002 **	0.09	0.001 **	0.08	0.021 *
Firm age	−0.07	0.031 *	0.08	0.029 *	0.09	0.033 *
Financial performance	0.05	0.049 *	0.04	0.035 *	0.01	0.009 **
Tobin's Q	0.13	0.171	0.43	0.231	0.22	0.319
Leverage	0.74	0.217	0.65	0.094 †	0.70	0.047 †
Polluting industry	−1.19	0.009 **	−1.23	0.004 **	-0.92	0.002 **
Main effect						
Board independence			1.23	0.008 **	0.829	0.004 **
ERP spending			0.961	0.239	3.641	0.549
Interaction						
Board independence x erp spending					0.141	0.009 **
ANOVA						
F sign	7.921 **		6.573 **		6.723 **	
R2	0.156		0.170		0.192	
Adj R2	0.136		0.144		0.163	
ΔR2	0.156		0.015		0.021	
F change	7921 **		3415 **		4211 **	

N = 265; 1-tailed: † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$.

We hypothesised that variables for board independence and ERP spending were, on the one hand, individually capable of producing positive effects on corporate environmental performances (H1 and H2) and, on the other, able to improve these positive effects further together (H3). Therefore, we started by placing only the Model A control variables in Table 2. We then carried out ordinary least squares (OLS) regression analysis and presented the results in the first two columns of Table 2. Next, we also added the independent variables from the testing of our hypotheses to the control variables so as to carry out another ordinary least squares (OLS) regression analysis in Model B, the results of which are reported in the third and fourth columns of Table 2. The results for the variable of board independence show that a firm's green performance is positively influenced by its having a large proportion of its board constituted by independent directors. This is a statistically significant result ($\beta = 1.23$, $p = 0.008$) and is in line with Hypothesis 1, which was formulated according to agency theory predictions. Hypothesis 2 focuses on how ERP technologies are put to use, and the prediction was that they would affect the way our sampled firms perform environmentally. However, this hypothesis is not supported by our results ($\beta = 0.961$, $p = 0.239$). Finally, in columns 5 and 6 of Table 2, the results of the addition of the term for the interaction between the use of ERP technologies and the share

of independent directors on boards are reported. The interaction is statistically significant (β = 0.141, p = 0.009). The addition of this interaction term to Model 3 gives an explanatory contribution above and beyond effects-only Model 2. Explained variance increases by 2.1%, and this increase is statistically significant (Fchange = 4.211, $p < 0.01$). Therefore, this empirical analysis provides support for Hypothesis 3. The results found in the three steps (Model A, Model B, and Model C) are significant and robust. As is evident from Table 2, all models are significant (at $p < 0.01$), with R^2 ranging from 0.156 for the base model to 0.192 for the full model. In particular, the full model (Model C) is fit and explains about 19.2% of the variance, with Fsign = 6.723 and significance at the 0.01 level.

Robustness Checks

The Breusch and Pagan heteroscedasticity test was applied to the outcome of the multiple OLS regression analysis (Models A, B, and C, Table 2) so as to test whether our model is robust [74]. Table 3 presents the results from an auxiliary regression of the Breusch–Pagan test.

Table 3. Heteroskedasticity Test.

	Model A	**Model B**	**Model C**
F-statistic	3.344	3.001	2.991
Prob. *F*	0.003	0.003	0.002
N*R-squared	18.550	21.995	24.115
Prob. *Chi-Square*	0.005	0.005	0.004

Note: N = 265.

5. Discussion and Conclusions

The aim of this paper was to establish whether the corporate governance structure and digital technologies a firm adopted could have an impact on its environmental performance. We began our analysis by looking at the composition of the board of directors. From an agency point of view, the more independent the members of a board of directors are, the more effectively the board will perform its internal control function of offsetting any agency problems the firm might have. Consequently, we formulated Hypothesis 1 because we expected greater involvement of independent directors in the board's activities to increase the firm's likelihood of achieving good environmental performance. ERP-type digital technologies provide functionalities that can be used relatively easily to implement practices and provide functionalities that can help manufacturers to establish their green supply chain. ERP systems might also be useful as support for environmental accounting instruments. Consequently, we formulated Hypothesis 2, according to which increased use of ERP systems can bring about better environmental performance. Finally, we formulated Hypothesis 3 to check the environmental effects of board independence and ERP technologies considered in combination and no longer individually.

Our predictions were tested by taking a sample of 53 firms that were quoted on the Italian stock exchange in Milan and looking at their end-of-year reports (Sustainability Reports/non-financial declaration) for a period of 5 years, for a total of 265 firm-year observations. Sampled firms were also asked for data on the costs they faced in implementing ERP digital technologies. The results of our analysis:

- Support Hypothesis 1, meaning that firms that increase the independence of their boards present a better environmental performance;
- Do not support Hypothesis 2, meaning no direct and positive relationship exists between the use of ERP systems and the firm's green performance;
- Support Hypothesis 3, according to which the growing use of ERP systems is only linked to an improvement in environmental performance in those firms where the presence of independent directors on the board is also growing. This improvement in

environmental performance is in addition to the impact brought about by the board's greater independence (considered alone as in for the verification of Hypothesis 1).

The verification of Hypothesis 1 and the non-verification of Hypothesis 2 may be considered due to the differing behaviour that independent directors and managers have toward the pursuit of green strategies. Hill and Jones point out that managerial behaviour is influenced by particular utility functions, which means that the managers might not consider it convenient to invest a lot of their high-quality time in redesigning the company's internal procedures simply to reduce the causes of the firm's polluting in the future [42]. This circumstance may negatively influence results which, from an environmental point of view, might be achieved by a firm's implementation of an ERP system. For such a system to be successful, the aims and expected results of its implementation should first be clearly defined and shared within the organisation, and then the efforts necessary to change management and reproject the firm's processes and operations should be undertaken [56,57]. Managers' utility functions, which are in contrast with the attribution of pollution control aims to ERP systems, could provide an explanation for the failure to test Hypothesis 2. Nevertheless, from an Agency Theory point of view, the powers that managers have to control firm activity are counterbalanced by board independence. Through the board, independent directors compensate for the behaviour of managers who are only interested in short-term interests by forcing them to consider the long-term interests of shareholders and stakeholders [34,35]. Literature on agency theory indicates how an independent board of directors is more likely to recognise the potential that green investments may have in the long term and, therefore, resist managerial pressure to adopt a different investment strategy. Consequently, there is a greater inclination on the part of independent boards to adopt environmentally-friendly policies, even where they are expensive [15]. These aspects might provide an explanatory verification of Hypothesis 1. Today, many stakeholders require disclosures of corporate responsibility and environmental performance in particular [14,75]. Society expects firms to take greater environmental responsibility for their activities. These expectations correspond to, on the one hand, new opportunities that are emerging for those firms which are most attentive to environmental performance and, on the other, more severe sanctions and fines for those firms that commit environmental crimes [76]. The Exxon Valdez and BP oil spills (of 1989 and 2010, respectively) are two examples of how environmental disasters may lead to harsh financial consequences for a firm that does not pay attention to environmental problems. Adopting environmentally responsible business practices ought to be a primary consideration for a firm's board of directors and owners. One explanation for the verification of Hypothesis 3 is that reinforcing a board's independence releases the potential that ERP digital technology has to improve environmental performance. A more independent board of directors will be more effective in blocking and overcoming management resistance to making the efforts necessary to redesign company processes and adequately configure ERP systems so as to obtain maximum advantage for the environment, too. Some boards know how to shape behaviour that helps an organisation use data and digital technologies in ways that are perceived as socially, economically, and environmentally responsible. In this sense, a board may constitute an antecedent with respect to CDR.

Our study is not without its limitations. We opted for a sample and a hierarchical regression model that were capable of explaining a part of the complexity of the entire phenomenon. However, a firm's green performance and control of pollution are complex phenomena, while governance mechanisms and ERP digital technology only represent a limited part of the variables affecting a firm's environmental achievements. Finally, the data for this study were gathered in Italy. Therefore, special attention should be given when generalising with regard to other national contexts on the basis of these discoveries. In Italy, firm ownership is generally rather concentrated, and family firms make up the most sizeable set of blockholders on the stock market, while the next largest set consists of the state or other public bodies [76].

Our conceptualisation paves the way for further future research, especially regarding antecedents to CDR and their relationship to corporate governance. It would also be advantageous to extend the empirical research to include other countries, and analysis should be made of further possible relationships between CDR and other characteristics of board composition, such as CEO duality or interlocking directorates. Further food for thought might emerge from the drawing up of environment, social, and governance (ESG) parameters that take account of CDR problems. With regard to these, particular attention ought to be given to the malleability of the technology and data, which, as this paper has shown, may be positively influenced by effective governance mechanisms.

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