Chief Digital Officers and Environmental Performance in Complex Settings

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Short Paper

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Abstract

This paper studies the impact of a chief digital officer (CDO) on corporate environmental performance. Drawing on the upper echelons theory and the attention-based view, we examine whether and under what environmental contingencies the presence of a CDO affects a firm's environmental performance. To test our theory, we use a dataset of 514 publicly-traded U.S. firms and analyze their greenhouse gas (GHG) emissions from 2005 to 2021. Our results show that the presence of a CDO is negatively associated with GHG emissions and that environmental complexity moderates this relationship. Thereby, we extend the understanding of the outcomes of new functional top management team members and contribute by bringing the industry environmental level into the analysis. In addition, the results encourage managers to consider corporate environmental performance outcomes and environmental contingencies when deciding whether to implement a CDO role.

Keywords: Chief digital officers, corporate environmental performance, complex environments, upper echelons theory, attention-based view

Introduction

The adoption and deployment of new digital technologies is one of the most critical challenges a company's top management team (TMT) faces today. The TMT's attention to the impact of digitization on its business activities has sharply increased, and this impact has become a fundamental part of corporate strategic considerations. Organizations across all industries face rising expectations and pressure from customers, regulators, and investors to seize the opportunities presented by new digital capabilities (Firk et al., 2021). In this context, stakeholders increasingly question the sufficiency and ability of conventional TMTs to adequately consider emerging digital capabilities in their decision-making. As a result, the CDO has developed into a prominent role within the TMT (Weill & Woerner, 2013). A CDO is primarily responsible for pushing the company toward strategic thinking on digitization and launching digital projects as part of an overarching strategic digitization vision (Kunisch et al., 2022). In practice, a central aspect of a CDO's digitization tasks is their impact on corporate environmental performance through digital innovations. A company's environmental performance refers to the assessment and evaluation of a company's actions, initiatives, and overall environmental impact (Russo & Fouts, 1997). Notably, organizations are increasingly using digital technologies to find innovative ways to hit their environmental performance benchmarks (Bendig et al., 2023; George et al., 2021). A striking real-world example of this trend is Repsol, a Spanish energy multinational, which employs a CDO with the goal of using digital innovations to reduce GHG emissions and drive decarbonization within the energy sector (MIT Technology Review Insights, 2023; Repsol, 2023).

Prior research has paid particular attention to the antecedents, i.e., the factors that explain the presence of a CDO (Firk et al., 2021; Kunisch et al., 2022), and the tasks of a CDO (Kessel & Graf-Vlachy, 2022). Studies to date show that antecedents at the individual level (Firk et al., 2021), the firm level (e.g., company size; Firk et al., 2021), and the industry level (Tumbas et al., 2018) can trigger the presence of a CDO. In addition, much is known about the desired profiles (Singh & Hess, 2017) and the skill set (Firk et al., 2021) of a CDO. However, the field of research has largely overlooked the consequences of CDO presence. Scattered prior investigations suggest an improvement in digital innovation performance (Leonhardt et al., 2018) and a contextual improvement in financial performance (Firk et al., 2021). However, the environmental performance consequences of a CDO presence have not yet been investigated. From a theoretical point of view, these are particularly interesting as they could be used to analyze the broader implications of digital leadership on environmental performance, thereby enriching our understanding of the multifaceted impacts of CDOs (Firk et al., 2021; Hanelt et al., 2021).

In addition, the relevant theoretical approaches suggest that the outcomes of CDO presence may depend on environmental contingencies (Culasso et al., 2023). However, prior research does not provide evidence on how environmental contingencies moderate a CDO's impact (Kessel & Graf-Vlachy, 2022). From a practitioner's perspective, it is crucial to fully understand the implications of CDO presence and its contingencies in order to leverage corporate digitization effectively to tackle major corporate challenges (Culasso et al., 2023; Firk et al., 2021).

Our paper addresses the identified research gaps and analyzes the consequences of CDO presence on corporate environmental performance and the environmental contingencies for this linkage. We draw on the upper echelons theory, which suggests that the functional and social background of TMT members affects the firm's strategic decisions and outcomes (Carpenter et al., 2004; Hambrick & Mason, 1984). Furthermore, according to the attention-based view, the appointment of an additional member to the TMT signals recognition of a new functional area and thus increases its relevance within the TMT and the organization at large (Ocasio, 1997). A CDO who is in touch with the other TMT members can raise awareness of digitization concerns and influence strategic corporate outcomes through their leadership role (Garms & Engelen, 2019). Hence, this manuscript aims to answer the questions of whether and under what environmental contingencies the presence of a CDO affects a company's environmental performance. We pose the following research questions:

> RQ1: How does the presence of a CDO influence a company's environmental performance?
>
> RQ2: To what extent do environmental contingencies moderate the relationship between the presence of a CDO and a firm's environmental performance?

We use a panel data set of 514 publicly traded U.S. firms and 2,850 corresponding firm-year observations from 2005 to 2021 to answer the research questions. To identify CDOs, we analyze the BoardEx database. We measure corporate environmental performance using Scope 1 GHG emissions as an objective metric, which we obtain from the Carbon Disclosure Project (CDP). In addition, we collect industry-level data from the Compustat database to calculate our moderating variable of environmental complexity.

Our results contribute to the literature at the intersection of information systems (IS) and strategic management. First, the study adds to the upper echelons theory by enhancing the in-depth knowledge of the role of new TMT members, specifically answering the recent call for research that explores the role of the CDO (Garms & Engelen, 2019). Chief executives with specialized functions can use their distinct knowledge to guide organizations in making decisions that increasingly impact corporate outcomes, such as the CDO for digitization concerns (Cho & Hambrick, 2006). In particular, the presence of a CDO can affect GHG emissions through an attention-based channel. Second, the paper contributes by adding a new, overlooked layer of analysis by unpacking environmental contingencies on the performance outcomes of CDO presence. In doing so, it ties in with previous IS research suggesting that the industry environment is an important factor to consider when looking at organizational digitization outcomes (Bendig et al., 2023; Xue et al., 2012). Notably, the paper reveals that environmental complexity can serve as an important moderating factor. The findings also have important implications for managers, highlighting the strategic impact of appointing a CDO and the contingency of this role depending on the industry environment.

Theory and Hypotheses

CDO Presence and GHG Emissions

The upper echelons theory assumes that a company's strategic decisions and corporate performance are affected by the values, social background, and cognitive characteristics of its top-level executives (Hambrick, 2007; Hambrick & Mason, 1984). The attention-based view proposes that an organization's competitive advantage and performance are determined by its ability to strategically focus and allocate its attention to critical information, opportunities, and challenges in its external environment (Ocasio, 1997, 2011). By integrating these two approaches, this paper examines whether the presence of a CDO affects corporate environmental performance through digital innovations. It is argued that a CDO increases the attention of the TMT to digitization and related innovations for three major considerations, namely the limited field of vision of executive managers, the influential position within the firm, and the specialized knowledge of the CDO (Fu et al., 2020; Hambrick & Mason, 1984; Ocasio, 1997).

First, drawing upon upper echelons theory, executive managers tend to have a limited field of vision (Hambrick & Mason, 1984). Given humans' limited rationality, strategic decisions also entail a significant behavioral aspect (Child, 1972). Consequently, following the attention-based view, it is important to channel the attention of the TMT to digitization-related matters in order to allocate resources effectively to activities that foster digital and environmental innovations (Garms & Engelen, 2019). The IS literature contends that IT capabilities, which should increase when a CDO is present due to increased managerial attention on IT resources (Firk et al., 2021), foster corporate innovation by facilitating innovation development. Some claim that IT capabilities enable a wide range of product development from ideation and conception to product development and manufacturing (Kleis et al., 2012). For example, companies can use R&D activities to join market orientation toward decarbonization and develop innovative, low-GHG emissions products and processes (Narver et al., 2004; Xue et al., 2012).

Second, the CDO can be an influential member of the company's structure. As CDOs hold executive positions at the top management level, they can contribute to digitization through their actions (Firk et al., 2021). When seen as legitimate leaders, and given the fact that they have a unique perspective on corporate digitization, CDOs can initiate processes to set up digital innovation roadmaps (Tumbas et al., 2018) and thus bring digitization to the attention of the other TMT members and the entire company (Ocasio, 1997, 2011). By having a top management representative for digitization-related aspects, companies with a CDO are more likely to engage with digital innovations (Tumbas et al., 2018), which has proven to be a key lever in reducing corporate GHG emissions (MIT Technology Review Insights, 2023).

Third, CDOs bring their specialized knowledge to the TMT and thus broaden its range of skills and spheres of expertise. Following upper echelons theory, this improves the TMT's decision-making capabilities in complex contexts (Cannella Jr. et al., 2008; Hambrick, 2007). Digitization issues can generally be complex, as they commonly involve a variety of conflicting sets of stakeholder pressures, including shareholders, vendors, consumers, legislators, and the wider community (Firk et al., 2021). Therefore, appointing a top executive with specialized knowledge and skills can be crucial for managing complex tasks (Menz & Scheef, 2014). Moreover, it is assumed that CDOs are chosen for their digitization-related professional record and skills (Hambrick & Mason, 1984).

In this context, a CDO should be somewhat driven and intrinsically motivated to promote digital innovations. Recent findings in the relevant literature show that companies can improve their energy use through digital innovations, resulting in energy reductions and, thus, a decrease in GHG emissions (Jin et al., 2023; Liang et al., 2022). In addition, digital innovations have the potential to reduce production costs (Genc & De Giovanni, 2020), which leads to an increased organizational willingness to invest in low-carbon production processes (Jin et al., 2023). From this, we infer that digital innovations initiated by a CDO are a catalyst for reducing GHG emissions and thus improve a company's environmental performance. These arguments lead to the first hypothesis:

H1: A positive relationship exists between CDO presence and corporate environmental performance.

The Moderating Role of Environmental Complexity

Next, previous IS research suggests that the industry environment is a key contingency factor to consider when looking at organizational outcomes of corporate digitization (Nadkarni & Chen, 2014; Xue et al., 2012). The question arises whether environmental contingencies moderate the effect of CDO presence on GHG emissions. According to the models of Aldrich (1979) and Dess and Beard (1984), the most essential environmental dimensions are environmental dynamics, turbulence, uncertainty, munificence, and complexity. Studies have shown that the relationship between IT infrastructure and organizational performance outcomes (Soh & Setia, 2022), as well as the relationship between software innovation and organizational performance outcomes (Chung et al., 2019), are moderated by environmental dynamism. Other important contingency factors are environmental turbulence, for instance, the effect of a company's digital orientation on environmental performance (Bendig et al., 2023); environmental uncertainty, for example, concerning the effects of a strategic alignment of IT strategy on corporate performance (Yayla & Hu, 2012); and environmental munificence, such as the efficiency effects of IT portfolios (Xue et al., 2012).

Our study focuses on environmental complexity because it is considered the most salient aspect of an environment (Aldrich, 1979; Dess & Beard, 1984), particularly in the IS context (Xue et al., 2012), where environmental complexity is defined as the "heterogeneity and concentration of environmental elements" (Keats & Hitt, 1988, p. 573). Accordingly, the complexity of the environment results from the number and variation of external parties with which a company interacts (Xue et al., 2012). Following Porter (1980), the key indicator of complexity is the concentration of competition within an industry. If a few companies dominate the industry and the concentration of competition is lower, the industry can be considered less complex because a few companies act as the industry's driving force (Porter, 1980). On the other hand, an industry with high competitive concentration is considered more complex because there is some uncertainty about competitive interactions and new companies with new digital capabilities or resources can emerge more readily (Thomas, 1996).

In less complex environments, firms may improve their products and processes through digital innovations that have an exploratory character (Jansen et al., 2006). Unlike in highly complex environments, the margin pressure in low-complexity environments is not as pronounced, and there is more organizational slack (Zahra, 1996). Consequently, the CDO has more resources for R&D, which they can dedicate to exploratory digital innovations. The related literature reveals that for low-complexity environments, the effectiveness of exploratory innovations is higher (Jansen et al., 2006), which positively encourages the pioneering of new solutions, especially in the environmental sphere, with the potential to improve corporate environmental performance.

Furthermore, previous IS research demonstrates that in corporate environments characterized by lower complexity, IT resources can engender greater corporate efficiency than in more complex environments (Xue et al., 2012). Digital innovations initiated by a CDO can optimize products and processes (Xue et al., 2012), especially their environmental performance, e.g., through the substitution or atomization of labor as well as by reducing waste and GHG emissions. Therefore, with lower environmental complexity, the impact of CDO presence on GHG emissions should be more substantial. Based on this theoretical reasoning, the second hypothesis is derived:

> H2: The positive relationship between CDO presence and corporate environmental performance is stronger for lower levels of environmental complexity.

Data and Methods

Sample

The hypotheses are tested using data from 2005 to 2021 on a sample of publicly traded U.S. firms retrieved from several databases. Initially, TMT data were extracted from the BoardEx database. To identify CDOs, the study follows the common approach of previous academic research and evaluates the role descriptions of the managers (Firk et al., 2021; Fu et al., 2020). Those managers whose role description contains one of the words "CDO," "Chief Digital Officer," "Digitalization," "Digital," or "President of Digital" are identified as CDOs (Kunisch et al., 2022). In addition, GHG emissions data are obtained from the Carbon Disclosure Project (CDP). Through a questionnaire, it gathers emissions data from publicly traded firms. This

manuscript uses gross global Scope 1 emissions, which include direct emissions from owned or controlled sources, reported in metric tons (Homroy, 2023). For the moderating variable environmental complexity, industry-level data are obtained from the Compustat database. Further, firm-specific financial control data are also taken from the Compustat database and board-specific controls are obtained from the BoardEx database. As a result, the final sample includes 514 distinct firms and 2,850 firm-year observations.

Empirical Approach

To address the identified research gaps, this paper adopts a quantitative approach that uses firm-year observations as units of analysis. The outcome variable in this study is GHG emissions under Scope 1 in metric tons, which is log-transformed. The main explanatory variable indicates the presence of a CDO, which is set to 1 if the respective company has a CDO in that year and to 0 if not. The moderating variable is environmental complexity, which indicates the concentration of competition within an industry. We measure this using the Herfindahl–Hirschman Index (Finkelstein & Boyd, 1998; Xue et al., 2012)—the higher the value of the index, the lower the degree of environmental complexity.

Further, the study includes a comprehensive set of control variables at the firm and board levels. These are firm size, the return on assets (ROA), the leverage ratio, Tobin's Q, the number of board members, the average time on the board, and the average age of the board members. All variables are winsorized to the two-sided 1% quantile. To examine the effect of CDO presence on GHG emissions, the paper follows related studies and analyzes the dataset using a panel data model with firm fixed effects and robust standard errors (e.g., Fu et al., 2020).

The mean value of CDO presence shows that 7.8% of the firms in our sample have a CDO. The summary statistics of the company- and board-level controls are all comparable to the values of related studies and consequently can be considered reasonable (Fu et al., 2020). Further, a breakdown by industries shows that a large majority of enterprises operate in the manufacturing sector (i.e., first digit SIC codes of 2 and 3) and in the services sector (i.e., first digit SIC code of 7).

Arguably, a company's decision on whether to hire a CDO may be endogenous (Garms & Engelen, 2019). As outlined in the hypothesis development, a CDO may increase the priority of digitization-related projects within an organization. However, the extent to which companies invest resources in digitization and environmental innovation efforts is also a driver of the priority and value placed on environmental performance within an organization. To ensure that potential endogeneity and causal inference concerns are adequately addressed, this study adopts an instrumental variable (IV) regression approach to mitigate potential effects on the reported findings. Previous studies suggest that the industry average of the explanatory variable may be a suitable instrument (e.g., Fu et al., 2020). Consequently, this paper adopts the industry average as an instrument for CDO presence. The results of the first stage show that the industry propensity to establish a CDO position significantly predicts the probability of CDO presence in the focal firm. Also, the corresponding F-statistic is well above the typical threshold for a powerful instrument. In addition, a series of identification tests are conducted to confirm the validity of the instrument.

Results

The regression results examining the link between CDO presence and GHG emissions are presented in models (1) and (2) in Table 1. They provide evidence in support of H1. Model (2) reveals a negative and statistically significant effect of CDO presence on GHG emissions (β = -0.243; SE = 0.085, p = 0.005). Thus, the findings show that the presence of a CDO is associated with lower Scope 1 GHG emissions. Regarding the economic magnitude of the effect, the estimated coefficient in model (2) implies a reduction in Scope 1 GHG emissions of 24.30% on average, resulting from the presence of a CDO.

Model (3) depicts the results of the IV approach. The industry average in the same four-digit SIC code industry as the focal firm is used as an instrument for CDO presence. Using a two-stage least squares (2SLS) approach to address potential endogeneity issues, the study likewise finds that CDO presence has a significant negative effect on GHG emissions (β = -0.326; SE = 0.113, p = 0.004).

	(1)	(2)	(3)	(4)
	Linear Model	**Linear Model**	**Linear Model with IV**	**Interaction Model**
CDO	-0.120** (-2.455)	-0.243*** (-2.847)	-0.326*** (-2.892)	-0.226*** (-2.651)
Herfindahl Index				0.032 (0.949)
CDO x Herfindahl Index				-0.209*** (-2.870)
Financial Controls	Included	Included	Included	Included
Board Controls	Not Included	Included	Included	Included
Firm and Year FE	Yes	Yes	Yes	Yes
IV Approach	No	No	Yes	No
Observations	2,850	1,172	1,172	1,172
Adjusted R-squared	0.091	0.118	0.117	0.123
F	123.82***	77.68***	77.53***	78.06***
Notes: * p< 0.1; ** p< 0.05; *** p< 0.01. Robust t-statistics in parentheses.				

Table 1. Regression Results

The regression results regarding the moderating impact of the Herfindahl Index on the main effect of CDO presence on GHG emissions are provided in model (4). The estimations for the effect of CDO presence (β = -0.226; SE = 0.085, p = 0.008) as well as the interaction term of CDO presence and the Herfindahl Index (β = -0.209; SE = 0.073, p = 0.004) are significantly negative. Hence, the findings show support for H2. Figure 1 depicts the marginal effects of the interaction for which we rescaled the original log transformed variable GHG emissions. Remarkably, there is only a minor difference in GHG emissions between firms with and without CDOs when the Herfindahl Index is close to zero. However, as hypothesized, the impact of CDO presence on GHG emission reductions increases significantly with the Herfindahl Index.

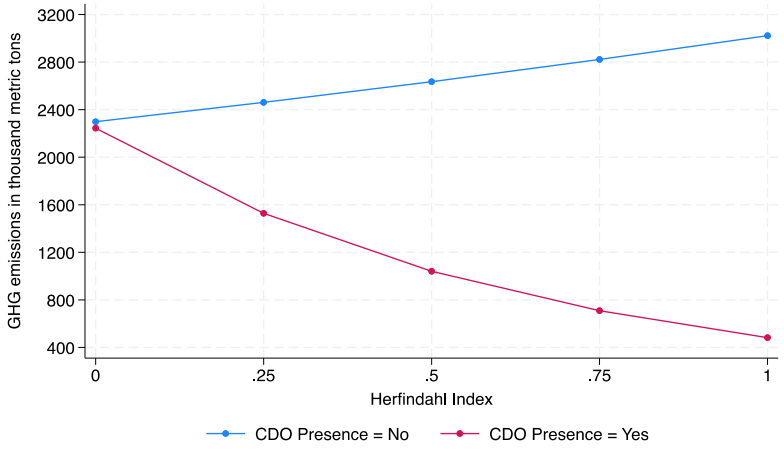

Figure 1. Interaction Plot

Robustness Tests

We created a matched sample based on the firm size and re-ran our regression models. Further, we time-shifted the outcome variable to period t+1 in order to enhance the validity of our results. Additionally, we included a control for environmental policies in our study, as they may play an important role in influencing GHG emissions (Yan et al., 2021). Moreover, we created industry subsamples and tested whether the results were sensitive to specific industries. Our results hold throughout all robustness tests.

Discussion

IS research actively discusses the governance required to establish digital capabilities and innovation. Including a CDO in the TMT plays an important role (Firk et al., 2021). Our study shifts the focus of prior research on the antecedents (Firk et al., 2021; Tumbas et al., 2018) and role profiles (Singh & Hess, 2017) toward the previously overlooked consequences of having a CDO. These consequences are theoretically important for understanding the multifaceted impact of CDOs and the wider effect of digital leadership on environmental performance (Firk et al., 2021).

Consistent with our first hypothesis, the presence of a CDO is negatively associated with GHG emissions. This finding is in line with the upper echelons theory and the attention-based view, suggesting that the presence of a CDO directs the TMT's attention toward digitization-related matters. Consistent with this attention-based mechanism, resources are effectively allocated to activities that promote digital and environmental innovation (Garms & Engelen, 2019). Moreover, previous IS literature finds that the environment is a significant factor to consider when looking at the organizational outcomes of IT-related activities (Nadkarni & Chen, 2014). Following our second hypothesis, we find that environmental complexity moderates the direct effect of CDO presence on GHG emissions. Thus, we reveal an important contextual factor for the relationship between CDO presence and corporate environmental performance.

The present study makes two key contributions to the IS literature and management research. First, it contributes to upper echelons theory by deepening our understanding of the outcomes of new functional TMT members. In doing so, the work addresses a recent call for research to examine the CDO's function in upper echelons theory (Garms & Engelen, 2019). As with the CDO for digitization-related issues, chief executives with specialized roles can use their unique skills to steer organizations toward decisions that increasingly affect company outcomes (Cho & Hambrick, 2006). More specifically, a CDO may influence GHG emissions through an attention-based pathway. Second, by analyzing how contextual contingencies affect the performance results of CDO presence, the article adds a current level of analysis. By doing so, it contributes to earlier IS research that argues that the industry environment should be considered when analyzing the organizational effects of corporate digitization (Bendig et al., 2023; Nadkarni & Chen, 2014; Xue et al., 2012).

The results have important managerial implications. First, we show the environmental performance consequences of appointing a CDO, which firms should consider when designing their TMT. Second, the results show how this relationship depends on the industry environment. Therefore, firms considering appointing a CDO should carefully review the industry environment when deciding on the CDO role.

Our study also has limitations that may provide fruitful avenues for future research. First, our analysis is limited to public U.S. firms. Future research could use an international sample to augment the analysis of moderating industry environments and, for example, look at country-level environments. Second, an interesting path might be to examine the antecedents of CDOs at the firm level, such as firm size or firm age, more thoroughly (Firk et al., 2021). Third, establishing a CDO function could broadly improve a company's performance. Therefore, it seems advantageous to investigate how the presence of a CDO affects environmental and financial performance along with the resulting tensions and spillover effects. Fourth, we rely on secondary data from external databases. It might be a promising avenue to extend the study with additional research methodologies, such as interviews or surveys, to substantiate the findings.

Conclusion

Organizations today face a significant demand to accelerate the adoption and deployment of new digital technologies. In this situation, companies have increasingly decided to create a unique, central role in the

TMT—the CDO, an executive who is expected to introduce strategic thinking on digitization and launch innovative digital technologies to meet companies' environmental performance benchmarks. The results of our study disentangle the impact of CDO presence on corporate environmental performance. We show that the presence of a CDO has a favorable impact on corporate environmental performance, contingent on environmental complexity. Our study contributes to both the IS literature and management research. In addition, the results encourage managers to consider potential environmental performance outcomes and environmental contingencies when deciding whether to appoint a CDO.

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