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Chief Digital Officers: An Analysis of the Presence of a Centralized Digital Transformation Role

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ABSTRACT By appointing a chief digital officer (CDO), firms decide for a central role responsible for their digital transformation. While CDOs have recently appeared in the C-suites of firms across the globe, the current literature lacks insights into the specific antecedents of CDO presence. Grounded in the peculiarities of the digital age, we provide theoretical arguments explaining how the decision to centralize digital transformation responsibilities might be related to transformation urgency and coordination needs. Empirical analyses based on a panel data set of 913 US and European firms support that transformation urgency and coordination needs predict CDO presence. An additional analysis of moderating temporal effects reveals that, over time, the effect of transformation urgency is weakened and the effect of coordination needs on CDO presence is strengthened. We discuss implications for research and practice regarding the antecedents of CDO presence, TMT research more generally, and centralization in the digital age.

Keywords: digital transformation, chief digital officer (CDO), top management team (TMT), centralization

INTRODUCTION

The widespread diffusion of digital technologies across societies renders digital transformation a strategic imperative for an increasing number of firms (Verhoef et al., 2021). Digital transformation can be defined as ‘a process that aims to improve an entity by triggering significant changes to its properties through combinations of information,

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computing, communication, and connectivity technologies [i.e., digital technologies]' (Vial, 2019, p. 118). To cope with this development, firms increasingly decide to add a position to the C-suite: the chief digital officer (CDO) (Kunisch et al., 2020; Singh et al., 2020). For example, McDonalds appointed their first CDO in 2013 (McDonald's, 2013), Nike in 2016 (Nike, 2016), and Novartis in 2018 (Novartis, 2017). However, other firms have refrained from following this trend. This coincides with doubts about whether adding another layer of centralized responsibility to the top management team (TMT) is an appropriate strategic choice for all firms when coping with digital transformation (e.g., Chillingworth, 2014; Mani, 2017; Priestley, 2016). Given this debate, we aim to shed more light on why firms do choose to have a CDO in their TMT.

By approaching digital transformation from a centralization perspective, we identify multiple reasons for why creating a distinct and central role in the TMT to cope with digital transformation could be an appropriate choice. First, digital transformation is associated with a shift in corporate strategy toward differential value creation based on digital resources (Mithas et al., 2013). Firms, therefore, need to adjust their core competencies, which creates substantial strategic challenges. Digital transformation should thus be placed at the top of the management agenda (Love et al., 2002). Second, digital transformation transcends functional and divisional boundaries (Bharadwaj et al., 2013). Accordingly, central coordination might be required to orchestrate the overall endeavour (Joseph et al., 2016). Third, digital transformation creates time pressures due to the market demand for digital products and services and the rise of new forms of competition. Having a central process leader who defines and implements the organizational rules of the game (Foss and Klein, 2014) might help firms to accelerate their digital transformation. However, while these arguments support the idea that creating a central role to respond to the challenges of digital transformation is an appropriate strategic choice, it can also have its downsides. Creating such positions may increase the TMT's complexity (e.g., Menz and Scheef, 2014), reduce flexibility (e.g., Hill et al., 2000), induce power struggles (Tumbas et al., 2018), cause potential losses of hidden knowledge in decentralized units (e.g., Felin and Zenger, 2014), and, finally, it bears direct costs, such as additional salaries or signing fees.

In this study, employing a centralization lens, we predict that the decision to have a CDO should be determined by those conditions under which greater benefits of a central role can be expected. Inspired by initial case-based CDO research (Singh and Hess, 2017; Tumbas et al., 2017a), we classify these benefits as digital transformation acceleration and coordination. We suggest that the accelerating benefits of CDOs, that is, driving and motivating their organizations for digital transformation, increase with internal and external conditions that determine the urgency for digital transformation. Similarly, we suggest that the coordinating benefits of CDOs are mainly determined by internal and external conditions that drive the coordination needs required to succeed in digital transformation. Therefore, we theorize that the decision to have a CDO in the TMT is shaped by (1) the urgency for digital transformation and (2) the coordination needs for initiating and implementing digital transformation.

To test these predictions, we employ panel data regressions on a large longitudinal sample consisting of 7,318 firm years from S&P 500 and MSCI Europe companies from 2010 to 2018. In line with our hypotheses, we find that transformation urgency and

coordination needs are positively associated with CDO presence. This supports our idea that conditions specifically related to the accelerating and coordinating benefits of CDOs explain CDO presence. We further conduct an additional analysis to test whether the identified antecedents evolve over the observed time period. We find that the influence of coordination needs increases over time, whereas the influence of transformation urgency decreases. This finding suggests that accelerating benefits of CDOs might become less important as time goes by and society-level digitalization progresses, while those benefits related to coordination, are likely to increase.

Our study provides three important contributions to the literature. First, our findings extend emerging work on the tasks, roles, and types of CDOs in business practice (Singh et al., 2020; Tumbas et al., 2018). By delivering empirical evidence on the factors driving CDO presence, we complement the initial research on CDO antecedents (Kunisch et al., 2020). We theorize and empirically test novel factors explaining CDO presence. These factors relate to the peculiarities of the digital age, such as the susceptibility of the business model to digital disruption or the entrance of new digital ventures. The results of our additional analysis provide indications for the debate on the durability of CDOs. Second, our work advances perspectives on top management positions more generally (e.g., Guadalupe et al., 2014; Menz, 2012; Roh et al., 2016) by pointing to the relevance of society-level phenomena, such as digitalization (Tilson et al., 2010), as well as external conditions on the country and industry level linked to the need for a specific TMT position. Moreover, we highlight the value of investigating temporal changes in the antecedents of TMT positions, as such dynamics may uncover important nuances and role changes over time. Third, we contribute to the centralization literature (Foss et al., 2015; Menz et al., 2015) by investigating centralizing responsibilities in the context of digital transformation. We extend prior research by indicating how specific internal and external factors drive centralization tendencies and reflect on the extended centralization necessities and opportunities in the digital age.

BACKGROUND

Emergence of a Centralized Responsibility for Digital Transformation

Digitalization, that is, ‘a sociotechnical process of applying digitizing techniques to broader social and institutional contexts that render digital technologies infrastructural’ (Tilson et al., 2010, p. 749) has been altering critical factors for differential value creation in an increasing number of industries (Bharadwaj et al., 2013). Contemporary firms are forced to adapt their business models to leverage digital technologies and defend against the risks associated with this development (Verhoef et al., 2021). The adaptation process (i.e., digital transformation) can be challenging for the affected firms (Henfridsson and Yoo, 2014), as the changes involved transcend the firms’ functional and even organizational boundaries (Bharadwaj et al., 2013).

Given the emerging challenges involved in digital transformation, centralizing digital transformation responsibilities could provide an appropriate mode of control. Centralization can foster vertical information flows (Joseph et al., 2016), avoid

time-consuming negotiations (Egelhoff, 1988), and facilitate overall coordination (Nobel and Birkinshaw, 1998). One particular means of centralization is the creation of a specific TMT position (Aaker, 2008; Guadalupe et al., 2014). For example, creating a chief corporate social responsibility (CSR) officer is highlighted as a means of imposing CSR across the organization (e.g., Strand, 2013), whereas the creation of chief strategy officers (CSOs) is motivated by retaining the central coordination of strategy planning and execution (Menz and Scheef, 2014).

In a similar vein, the introduction of a CDO can be an organizational response to the challenges of digital transformation. TMT positions carry organization-wide responsibility for particular fields of corporate activity (Finkelstein et al., 2009; Mintzberg, 1979; Strand, 2013). In consequence, the CDO is defined as the focal leader responsible for developing and communicating a holistic digital strategy across the firm, advocating for the company's digital initiatives to internal and external stakeholders, and leading the required change efforts (Haffke et al., 2016; Reck and Filaster, 2019; Singh et al., 2020).^[1] In line with this, Novartis, for example, stated that its newly created CDO position should lead the company's digital transformation by being 'responsible for creating and executing a company-wide digital strategy in close collaboration with the Executive Committee of Novartis, working with leadership teams across the business and external partners' (Novartis, 2017).

The Chief Digital Officer (CDO): Types and Characteristics

Initial CDO research has provided insights into the skill sets required for the CDO. Besides more technically related skills, including IT competency (i.e., understanding IT and the underlying infrastructures) and digital pioneering (i.e., the ability to provide a vision for the company's future success in the digital age), more generalist skill sets, such as change management, inspiration, and resilience, also matter (Singh and Hess, 2017). Moreover, prior research has suggested several typologies for CDO roles, each rendering particular configurations of these skills relevant (Tumbas et al., 2017a). Two main benefits of CDOs can be derived from these typologies: (1) accelerating digital transformation and (2) coordinating digital transformation.

First, to accelerate digital transformation, 'CDOs are employed to make digital transformation a strategic priority in their companies' (Singh and Hess, 2017, p. 2). CDOs introduce new digital technologies to TMT colleagues and organize events to inform them about and discuss digital topics (Singh et al., 2020). They further advocate for building capabilities to develop and apply digital technology for corporate success (i.e., digital capabilities [Kindermann et al., forthcoming]), envisioning new digital business models, accelerating a company's digital transformation (Singh and Hess, 2017). In line with this, L'Oréal created a CDO position 'to accelerate L'Oréal's digital transformation regarding consumer experience, serviced-based innovation, customer service and technology platforms' (L'Oréal, 2014).

Second, to coordinate the digital transformation, CDOs focus on organizational change management and on mediating between different units, functions, and external partners involved in digital initiatives (Singh and Hess, 2017). Thus, CDOs foster collaboration among the different units and functions involved in the endeavour (Singh

and Hess, 2017). By developing an aggregated view of all ongoing digital initiatives and connecting them to the strategic-level vision, they identify and work against organizational barriers, such as functional silos that inhibit the progress of digital transformation (Tumbas et al., 2017a). In line with this, Henkel highlighted they appointed a CDO ‘to steer and coordinate the digital activities across all business units’ (Henkel, 2017).

These two major benefits of CDOs reveal how the CDO role differs from other TMT roles. For instance, while chief information officers (CIOs) or chief technology officers (CTOs) might focus on the strategic use of (information) technologies (Garms and Engelen, 2018), CDOs emphasize digital business models by not only attending to technological opportunities, but also by catering to the customer and ecosystem perspective to achieve value creation and capture. Through this distinction, CDOs complement rather than substitute CIOs (Kunisch et al., 2020; Tumbas et al., 2017b) and even advocate for the CIO and the IT unit (Singh and Hess, 2017). Furthermore, while CSOs (Menz and Scheef, 2014) can be viewed as corporate strategists who focus on the corporate strategy process and content in general, CDOs are digital transformation specialists who focus on the specific organizational change required to arrive at digital business models (Singh and Hess, 2017). These distinct CDO responsibilities are advantageous, since not only CIOs, CTOs, and CSOs may feel responsible for the digital transformation, but also finance, marketing, and operations officers in the C-suite could feel the urge to lead the digital transformation. The CDO as a central role, which is specifically developed for digital transformation, can therefore coordinate between these existing functions. Thus, CDOs complement existing TMT roles by building on the rationale that the challenges of digital transformation require more than an existing ‘senior executive to manage them in addition to his or her original responsibilities’ (Singh and Hess, 2017, p. 2). CDOs focus emerging tasks at the top of a firm’s strategic agenda and activate key stakeholders for their execution (Singh et al., 2020).

While installing a CDO in the TMT may be an adequate response to the challenges of digital transformation, initial works have pointed out that CDOs can but do not have to be part of successful organizing for success in digital transformations (Leonhardt et al., 2018). Case studies illustrate multiple alternative pathways, such as putting functional or divisional heads in charge of digital transformation (Björkdahl, 2020), or framing it as a particular responsibility of the CEO (Hess et al., 2016). Indeed, case-based evidence shows that some firms may be sensitive to the negative implications of having a CDO. Specifically, aside from direct costs, such as signing fees or an additional salary, creating a CDO position may be viewed sceptically, as centralizing the digital responsibility can exacerbate the complexity of the TMT. It may induce power struggles involving fights for legitimacy between the new and existing executive roles (Tumbas et al., 2018), or create the perception that digital transformation is shouldered by one person alone – a dangerous view given the organization-wide impact of the phenomenon (Bharadwaj et al., 2013). The actual gestalt of digital transformation for particular firms might be very different (Hinings et al., 2018) and the magnitude of the challenges to be managed by a potential CDO can vary substantially (Singh and Hess, 2017). Hence, the decision to have a CDO may be influenced by specific contextual factors and the ongoing changes associated with digital transformation.

THEORY AND HYPOTHESES

Antecedents of CDO Presence from a Centralization Perspective

Centralization reflects the concentration of authority and decision-making at the corporate level (Jansen et al., 2006). Prior literature suggests that centralization emphasizes vertical communication and thereby resolves time-consuming political behaviour (Baum and Wally, 2003; Egelhoff, 1988, 1991), handles large levels of information well (Nobel and Birkinshaw, 1998), facilitates coordination (Joseph et al., 2016), helps in realizing synergies (Hill et al., 1992), and accelerates strategic change (Foss and Klein, 2014). Since centralization can also be associated with costs, such as harming explorative activities (Love et al., 2002) and deciders being further away from customers and other stakeholders (Foss et al., 2015), firms will base centralization decisions on conditions that make the benefits particularly valuable. This also holds for the decision to centralize digital transformation responsibilities in the CDO position. In particular, we expect this centralization decision to depend on specific internal and external conditions expressing (1) how urgently firms need to transform to digital business models and (2) how much coordination is needed to initiate and execute such a digital transformation.

Transformation urgency. Digital transformation varies in its disruptiveness (Singh and Hess, 2017) and thus in its urgency from the perspective of particular firms. Firms experiencing such urgency need fast responses, rendering the accelerating benefits of the CDO particularly relevant. We argue that digital transformation urgency depends on two factors: (1) the inherent characteristics of the respective business model that make it susceptible to substantial alterations in value creation and capture due to the advent of digital technology (i.e., digital disruption [Skog et al., 2018]), and (2) threats in the external environment in the form of new actors who may attack established market positions.

First, information-based business models can be subject to digitization, involving the encoding of analogue information into digital formats (Tilson et al., 2010; Yoo et al., 2010), and they are, therefore, susceptible to being replaced by digital substitutes that are comparably easier to produce and scale up by a larger range of potential competitors (Yoo et al., 2012). Similarly, knowledge-based business models are increasingly susceptible to digital disruption due to the penetration of artificial intelligence that might challenge and eventually substitute the value-creating knowledge processes of human agents (Loebbecke and Picot, 2015). Digitalization – spreading digitization across all sectors of society (Tilson et al., 2010) – therefore threatens the survival of firms whose business models rely heavily on information and knowledge, such as media or service companies (Karimi and Walter, 2015). For others, such as manufacturing firms, to date, digital transformation has been rather moderate, partly because of the ‘inherent bounds and durability granted by physical underpinnings’ (Kallinikos et al., 2013, p. 364). Here, simply put, physical materiality represents core elements of the established business model that cannot be easily digitized, thus preventing incumbents from outright digital disruption, yet also challenging them in their digital transformations (Piccinini et al., 2015; Svahn et al., 2017; Vanini, 2018). To cope with these threats imposed by digitalization, firms

need to be aware of the necessity of departing from the status quo (Hanelt et al., 2020). Hence, firms with business models susceptible to digital disruption could particularly benefit from CDOs accelerating digital transformation in their companies (Singh and Hess, 2017). Drawing on their digital pioneering skills, CDOs might anticipate the susceptibility of the established business models and advocate for envisioning new digital business models as well as building the needed digital capabilities.

Second, the emergence of digital ventures (Tumbas et al., 2017b) is an important facet of digital transformation urgency. New and agile ventures that can skilfully and rapidly leverage digital technologies (Huang et al., 2017) increasingly enter established contexts of competition or create new ones that render previously dominant ones irrelevant (Skog et al., 2018). These digital ventures experiment with new business models at ease and quickly scale up successful designs globally (Kelestyn et al., 2017). This development, as can be seen in the photography and media industries, can have disruptive consequences (Lucas and Goh, 2009). In the automotive industry, even though digitizing is more difficult, new players such as Uber and Lyft are putting traditional players under severe pressure by building digital platforms to offer mobility as a service (Svahn et al., 2017). Hence, firms need the capacity to identify potential disruptions and initiate countermeasures (Hanelt et al., 2020). Here, they could particularly profit from the CDOs' accelerating benefits. Drawing on their digital pioneering skills, CDOs might anticipate the disruptive threats posed by emergent digital ventures and be of specific value for raising awareness regarding such threats (Singh et al., 2020).

In sum, we contend that pressure from both the peculiarities of the business model depending on information and knowledge and the threats exerted by digital entrants renders the accelerating benefits a CDO can potentially deliver particularly relevant. Therefore, we propose the following hypothesis:

Hypothesis 1: Transformation urgency – represented by (a) the dependency of the business model on information and knowledge and (b) a high number of new digital entrants in the industry – is positively associated with the likelihood of CDO presence in the TMT.

Coordination needs. To advance in digital transformation, firms need to orchestrate multiple digital initiatives and connect existing capabilities with new digital capabilities (Tumbas et al., 2018). However, digital transformation could create political tensions among organizational players, provoking isolated initiatives. It also requires negotiation and cooperation with external players who might deliver complementary offerings or important digital infrastructures to build upon (Yoo et al., 2012). Based on the understanding of coordination as the 'process of interaction that integrates a collective set of interdependent tasks' (Okhuysen and Bechky, 2009, p. 463), we claim that the need for internal and external coordination emphasizes the benefits of CDOs in centrally coordinating digital transformation. These internal and external coordination needs might not be equally present for all firms but are driven by internal and external conditions.

First, internal coordination needs for the digital transformation should be particularly relevant in highly diversified firms. Diversified firms organized in multiple subsidiaries to address different geographic and/or product markets are vulnerable to creating business silos that engage in decoupled initiatives to bring about digital innovation (Tumbas et al., 2018). CDOs could bring such decentralized digital activities under a single umbrella to coordinate all digital transformation efforts, guided by a strategic-level vision (Tumbas et al., 2017a). As to the organization-wide scope of digital transformation (Bharadwaj et al., 2013), firms with strong internal compartmentalization may seek the help of a centralized responsibility, as ‘CDOs initiate and design the controlled organizational shift from decoupled silo functions to cross-functional cooperation’ (Singh and Hess, 2017, p. 11). Moreover, compared to other technologies or assets, digital technologies are context-agnostic and adaptable (Hanelt et al., 2021; Kallinikos et al., 2013). Capabilities based on digital technologies (e.g., data-driven customer analytics) developed in one geographic and/or product segment may therefore be applied and recombined comparatively easily across other, even unrelated, segments. Having a CDO may thus allow diversified firms to better identify and realize synergies in developing and applying digital technologies across product or geographic divisions. Finally, as digital transformation could reshuffle organizational power structures in diversified firms (Leonhardt and Hanelt, 2018), some actors might hamper negotiations and progress. The coordination of such political tensions might also require a CDO who can identify and work against such barriers to transformation (Tumbas et al., 2017a).

Second, external coordination needs for digital transformation should be particularly strong when the regional environment lags behind in terms of digital infrastructures (Tilson et al., 2010). Such infrastructures include both technical and regulatory conditions. Regarding the former, driving digital transformation in a particular region depends on existing technical foundations, such as the speed and coverage of broadband internet access. Lagging behind in such infrastructures may hinder firms in introducing digital innovations – such as those building upon the Internet-of-Things – to the respective markets and, therefore, constrain progress in digital transformation (Yoo, 2010). Furthermore, the regulatory conditions could either ease digital transformation by adapting regulatory frames to digital innovation or hamper its progress by creating additional barriers. Firms confronted with a lagging digital infrastructure face the challenge of costly translocation activities to more digitally advanced regions (e.g., due to unfavourable European legislation, many European car manufacturers mainly began their autonomous driving activities in California). CDOs may identify such shortages and approach potential partners to arrange collaborations as countermeasures (Singh and Hess, 2017). In addition to initiating and coordinating such collaborations with external partners, CDOs may be particularly helpful in engaging in external communications (Tumbas et al., 2017a) with relevant stakeholders to emphasize the resulting problems and to negotiate and improve the surrounding infrastructure.

In sum, we expect that coordination needs stemming from a firm’s diversification and lagging national digital infrastructures renders the coordination benefits a CDO can potentially deliver particularly relevant. Hence, we propose the following:

Hypothesis 2: Internal and external coordination needs for digital transformation – represented by (a) increased firm diversification and (b) a lagging national digital infrastructure – are positively associated with the presence of CDOs in the TMT.

Figure 1 summarizes our line of reasoning by organizing CDO antecedents into four quadrants based on internal and external dimensions of transformation urgency and coordination needs. The upper left quadrant relates transformation urgency to the business model of the firm to present the dependency of the business model on information and knowledge as an important internal antecedent. The lower left quadrant focuses on the external environment’s influence on transformation urgency by pointing to a high number of digital entrants in the industry as a threat that could drive CDO presence. The upper right quadrant points to firm diversification, an important internal trait, and relates it to coordination needs. Finally, the lower right quadrant relates coordination needs to the conditions of technological and regulatory environments to present lagging national digital infrastructure as an important external antecedent. Beneath the quadrants, the figure outlines the benefits that a CDO could supply in the respective situation (i.e., accelerating or coordinating benefits).

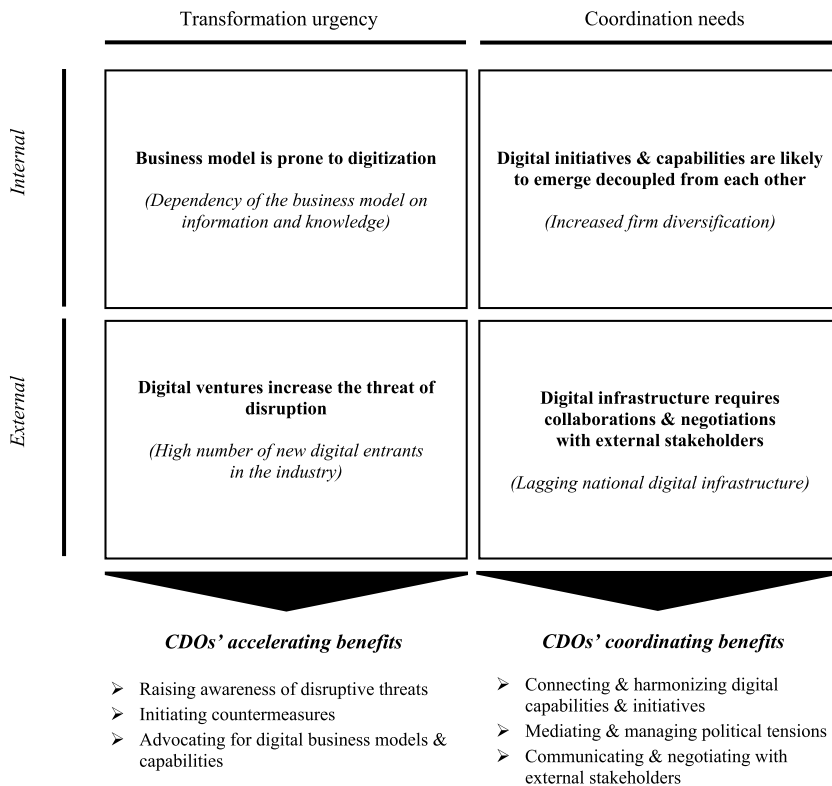


Figure 1. Antecedents of CDO presence

METHODOLOGY

Sample Selection

We focus on a longitudinal and international sample of firms listed in the S&P 500 and the MSCI Europe Indices. The S&P 500 consists of large listed US firms and the MSCI Europe of large listed firms from 16 Western European countries. To cover the CDO diffusion process, we decided to investigate the years from 2010 to 2018. While we hand-collected data on CDOs, financial data were obtained from Datastream, the board, CEO, and TMT data from BoardEx, ownership data from Thomson One Banker and data on digital ventures from the Crunchbase database. From the potential 8,577 firm years, we excluded double listings and firm years without available data for our regressions, resulting in a final sample of 7,318 firm years for 913 firms (477 S&P 500 and 436 MSCI Europe firms).

Variables

CDO presence. The variable *CDO presence* indicates whether a firm has installed a CDO position in its TMT. We considered a CDO as a part of the TMT if the CDO had an organization-wide responsibility for developing a holistic digital strategy and leading the required change efforts related to its execution (Haffke et al., 2016; Reck and Filaster, 2019; Singh et al., 2020). Similar to previous CxO research (e.g., Shi et al., 2018; Wiengarten et al., 2017), we used multiple sources to collect information on the presence of CDOs.

We first ran a search algorithm including the term ‘chief digital officer’ and the relevant company name on a search engine site. In addition, we ran the search algorithm on LinkedIn and LexisNexis and checked the company websites for press releases and/or TMT information. If a potential CDO was identified, we searched for any news on that CDO and for the executive biographies in Bloomberg, Business Week, Relationship Science, and LinkedIn to verify the CDO’s responsibilities and tenure. In particular, we searched for role descriptions to indicate whether the CDO had an overall responsibility for the digital strategy and the lead for the required change efforts. If the description indicated that the responsibility was confined to a specific business unit or a subset of the digital strategy, we considered the position as not central enough for the TMT. Second, as with other CxOs (e.g., Menz and Scheef, 2014; Wiengarten et al., 2017), we noticed different title terms standing for a CDO position and reran our initial search with CDO synonyms.^[2] If we found a position with a potential CDO synonym, we again searched for additional information on the responsibility and tenure to verify the position. However, in about 75 per cent of cases, the title contained the term ‘chief digital officer’. Third, as firms may revisit the decision to have a CDO or change the individual CDO, we carefully checked whether we identified the entire historical CDO presence via a final check in the LexisNexis database for press releases or media articles mentioning such changes. Our final *CDO presence* variable was then created as an indicator variable taking the value of one if a firm had a CDO position with a central responsibility and zero otherwise.

Transformation urgency. We suggest that the degree to which firms base their business models on information and knowledge and the level of new digital ventures entering the industry drive the urgency for digital transformation.

First, we suggest that firms that rank high in intangible assets on their balance sheet (e.g., licensing agreements or other copyright-protected content) regularly base their business models on information and knowledge (Alimov and Officer, 2017; Chang et al., 2013; Zhang et al., 2014).^[3] In contrast to firms relying on tangible assets, such as machinery, the business model of such firms can more easily be digitized (Vanini, 2018; Zmud et al., 2010). We expect that these conditions call for urgent digital transformation. However, intangible assets on the balance sheet may not only be an indicator for the reliance of a business model on information and knowledge, but also for a firm's general acquisition activities. Specifically, intangible assets include goodwill, which accounts for the excess purchase price of an acquired company (Fich and Nguyen, 2020). So as not to confound our results by the goodwill included in intangible assets, we subtracted the amount of goodwill from the intangible assets. We then used intangible assets excluding goodwill and divided them by a firm's net sales (Antia et al., 2010) to specify our variable *intangible assets*.^[4]

Second, as we aimed to capture the degree of pressure that digital start-ups placed on incumbent firms, we defined *new digital entrants* as new digital entrants per industry incumbent. Therefore, we extracted all start-ups in the Crunchbase database (e.g., Kanze et al., 2018; Parks et al., 2017; Spiegel et al., 2016) founded between 2009 and 2017, amounting to more than 250,000 start-ups. Based on the industry description provided by Crunchbase, we then classified each start-up's industry affiliation. Next, to specify the start-up pressure as digital, we evaluated whether each start-up was indeed a digital venture by evaluating all the different categories and short descriptions of the start-ups. Finally, to construct our *new digital entrants'* variable, we counted the number of new digital start-ups in each industry and year and divided this number by the number of industry incumbents. We considered all firms as industry incumbents that had been listed for more than 3 years in the Datastream database.

Coordination needs. To account for the coordination needs regarding digital transformation, we expect that internal coordination is driven by the firm's level of diversification and external coordination by the prevalent digital infrastructure in the respective area.

First, to measure *diversification*, we considered both product market diversification (e.g., Roh et al., 2016) and geographic diversification (e.g., Kunisch et al., 2019). Firms may diversify in either product segments, geographic segments, or both. By focusing on a composite measure of both product and geographic diversification, we are thus able to capture a firm's coordination needs more comprehensively. We calculated a Herfindahl Index (e.g., Roh et al., 2016) accounting for the sales distribution across (related and unrelated) product segments as well as a Herfindahl Index accounting for the sales distribution across geographic segments. We then reversed these two Herfindahl Indices to obtain measures that increase with the degree of diversification. Finally, we used the average of product and geographic diversification to account for *diversification*.

Second, following previous corporate governance and management literature (e.g., Aguilera et al., 2008; Oehmichen et al., 2017), we consider the country of the firm's

headquarters to account for the level of the surrounding (digital) infrastructure. We used information from the global technology report from the World Economic Forum. The report evaluates several country indicators on whether they enable firms to exploit the opportunities offered by information and communication technologies (ICTs), and it has been published on a yearly basis since 2003. Sussan and Acs (2017) highlight how this report allows for insights to be made regarding the digital infrastructure at the country level. The digital infrastructure relates to both technical (e.g., speed of broadband internet) and regulatory conditions (e.g., laws facilitating the use of ICTs) (Tilson et al., 2010). Hence, for all our countries in each year, we extracted their rank in the political and regulatory environment indicator and the technical infrastructure indicator from the global technology report. We use the average rank to proxy for the national digital infrastructure. As a higher rank implies a weaker infrastructure, we label the variable *lagging national digital infrastructure*. Finally, we log transformed the rank to account for skewedness and some outliers.^[5]

Control variables. First, we selected control variables on the board, CEO, and ownership level to capture the parties potentially involved in the decision to appoint a CDO. We included *board size*, as a larger board with increasing networks could better help in finding potential CDO candidates. We specified board size as the absolute number of non-executive directors (e.g., Oehmichen et al., 2017). We controlled for *CEO age*, as older CEOs could particularly struggle with digital transformation and thus tend to appoint a CDO. We further included the level of *institutional ownership* and *ownership concentration*. As institutional investors typically possess profound market expertise (e.g., McCahery et al., 2016), they could be particularly sensitive to digital transformation and propose the appointments of CDOs. More concentrated ownership should provide owners with better control of digital transformation, potentially alleviating the need for a CDO. We calculated institutional ownership as the sum of fractional holdings by institutional investors with at least a 1 percent stake and ownership concentration as the sum of closely held shares (stakes exceeding 3%).

Second, we controlled for the current TMT structure. Therefore, we included three control variables for specific CxO positions. Specifically, we captured whether a firm employs a *CIO*, *CSO*, and *CTO*. We considered these roles as we expect that they will complement a CDO and thus increase the likelihood of CDO presence. However, we acknowledge that one might argue that these roles could overlap to some extent and substitute each other. We constructed the variables based on the role names of senior managers and executives in BoardEx (e.g., Kunisch et al., 2020) and classified all positions including the label ‘Chief Information’ or ‘CIO’ as CIOs, with the label ‘Chief Strateg*’, ‘CSO’, or ‘Strateg’ as CSOs, and with the label ‘Chief Techn*’, ‘CTO’, or ‘Technology’ as CTOs. In addition, we captured the proportion of functional executives in the TMT. Therefore, we counted all the prior CxOs and further considered senior managers and executives with role names containing the word ‘Chief*’ but not ‘Chief Executive Officer’ or ‘C*O’ but not ‘CEO’. We divided the number of CxOs by all TMT members (i.e., divisional CEOs, CxOs, and managers being at least a vice president) to create a measure for *functional executives*.

Third, we controlled for industry conditions. We considered CDO adoptions by industry peers because mimetic motives may also play a role in the decision to appoint a certain TMT member (Hambrick and Cannella, 2004; Shi et al., 2018). We calculated *peer CDO adoptions* as the percentage of new CDO appointments within the firm's industry peers (excluding the focal firm). We further included a measure for *industry concentration*, as lower levels of competition could alleviate the need for a CDO. Industry concentration is measured by a Herfindahl–Hirschman Index, which considers the firms' shares of total market sales in the relevant industry (e.g., Luo et al., 2015) based on our sample firms. In addition, we included a measure for *industry dynamism*, as a dynamic environment is typically associated with higher external task demands calling for additional TMT members (Hambrick and Cannella, 2004). To measure industry dynamism, industry sales values for each industry over the previous 5 years were regressed over time. We used the standard error of the regression coefficient related to a time dummy variable and divided it by the average value of the industry's sales (Dess and Beard, 1984; Nadkarni and Chen, 2014). Moreover, we included a control for the average market-to-book value in the industry, capturing the industry's growth opportunities (*industry MTB*). For all these industry measures, we used the Fama and French 48 classification (Fama and French, 1997). Finally, we included a dummy variable (*financial industry*) that captures whether the firm is operating in the financial industry.

Fourth, we included several financial variables to control for confounding effects. We included *firm size*, as larger firms are more likely to adopt new functional TMT positions. Firm size is measured as the natural logarithm of net sales. Similarly, a better economic situation at the firm is often associated with the appointment of a new functional TMT member. Hence, we included return on assets (*ROA*) measured as earnings before interest and taxes divided by total assets, the firm's *liquidity* calculated as cash and short-term investments divided by total assets, the firm's *leverage* measured as total debt in relation to total assets, and the firm's *sales growth* measured as the yearly average growth in net sales over the last 3 years. In addition, we included a control variable accounting for *firm risk* measured as the 3-year standard deviation (SD) of return on equity.

Empirical Strategy

By focusing on a panel dataset, we follow prior research in assuming that firms may implicitly revisit the decision to have a CDO annually (e.g., Hambrick and Cannella, 2004). Similar to other CxO research (e.g., Menz and Scheef, 2014; Nath and Mahajan, 2008), we ran a general estimating equations (GEE) regression model with a logit link function. We decided on the GEE model, as it enables us to consider the binary nature as well as the non-normal distribution of our dependent variable while accounting for both within- and between-firm variance to calculate robust estimates (Ballinger, 2004; Liang and Zeger, 1986). Given these benefits, the GEE model is frequently highlighted for adequately tackling the issue of unobserved heterogeneity when binary-dependent variables are used in panel datasets (e.g., Firk et al., 2019; Guldiken et al., 2019; Gupta and Misangyi, 2018). Given our binary-dependent variable, we specified a logit link function of the binomial family. We selected an autoregressive correlation structure to account for serial correlation within our panel. We also specified the robust option in the *xtgee*

considering the Huber–White standard error correction. Moreover, we lagged all our independent and control variables to tackle reverse causality issues and included year fixed effects.

RESULTS

Descriptive Results

Table I provides a broad overview of the development of the CDO position by year, industry, country, and index. First, the results indicate the rapid diffusion of CDOs in recent years. While in our starting year of 2010 less than 1 per cent of the firms had a CDO position, 23 per cent employed a CDO in 2018. Second, the results support the idea that external pressures are relevant drivers of CDO appointments, as we find considerable differences among countries and industries. For example, CDO diffusion in Germany and France exceeded 40 per cent in 2018, whereas companies in the US (17 per cent) or the Netherlands (12 per cent) showed much lower diffusion rates. Similar to the differences among countries, the results for industries indicate that CDOs are widely diffused in some industries (e.g., the retail trade) while they are rather rare in others (e.g., mining). Moreover, the results not only show differences in diffusion but also in the development of diffusion. While, for example, the retail industry already showed high levels of CDO diffusion in 2014 (21 per cent), other industries, such as the finance and insurance or manufacturing industries, have only just started to catch up in recent years (2017–18). Finally, when looking at a more clustered level, we see that CDOs are more widely diffused in MSCI Europe firms than in S&P 500 firms.

In Table II, we provide the pairwise correlations and descriptive statistics of all our regression variables. The means and SDs of our control variables are in line with prior empirical studies. For example, the presence of other CxOs, such as CIOs (59 per cent), CTOs (46 per cent), and CSOs (54 per cent), is comparable to prior work on CxOs (Garms and Engelen, 2018; Kunisch et al., 2020; Menz and Scheef, 2014). In addition, we also checked variance inflation factors (VIFs) for all variables, including our interaction terms and year fixed effects. As the highest individual VIFs were below 5, the analysis further alleviated multicollinearity concerns.

Regression Results

The impact of transformation urgency and coordination needs on CDO presence. Table III displays GEE logit regressions estimating the influence between our dependent variable *CDO presence* and our independent variables for transformation urgency and coordination needs separately and together.^[6] The non-linearity of logit models complicates the interpretation of the effect sizes of our results. Hence, for our transformation urgency and coordination needs' variables, we follow Hoetker (2007) by calculating the average effect over all observations for a 1SD change as well as the effect at meaningful values

Table I. CDO diffusion by industry, country, index, and year

<i>Industry Classification</i>	<i>Obs.</i>	<i>Firms</i>	2010	2011	2012	2013	2014	2015	2016	2017	2018	<i>Total</i>
Panel A: CDO diffusion by industry and year												
Manufacturing	2848	356	1%	2%	3%	4%	6%	10%	18%	23%	21%	9%
Finance & Insurance	1301	167	0%	2%	3%	3%	4%	4%	11%	22%	24%	8%
Transport& Utilities	1175	147	1%	1%	2%	3%	6%	9%	17%	20%	25%	9%
Services	791	97	1%	2%	3%	5%	6%	15%	18%	22%	24%	10%
Retail Trade	540	67	0%	1%	8%	17%	21%	25%	35%	31%	26%	17%
Mining	411	49	0%	0%	0%	2%	2%	4%	9%	11%	14%	4%
Construction	132	16	0%	0%	0%	0%	8%	14%	33%	33%	38%	14%
Wholesale Trade	120	14	0%	0%	0%	0%	0%	0%	14%	23%	22%	6%
<i>Country</i>	<i>Obs.</i>	<i>Firms</i>	2010	2011	2012	2013	2014	2015	2016	2017	2018	<i>Total</i>
Panel B: CDO diffusion by country and year												
USA	3,906	477	0%	2%	3%	5%	6%	7%	12%	16%	17%	7%
United Kingdom	822	105	0%	1%	2%	6%	11%	15%	23%	26%	24%	11%
France	632	75	1%	4%	5%	8%	14%	25%	36%	45%	46%	20%
Germany	331	47	0%	3%	5%	8%	6%	19%	31%	48%	50%	19%
Sweden	242	30	0%	0%	0%	4%	4%	12%	17%	20%	28%	9%
Switzerland	226	31	0%	0%	0%	0%	0%	11%	31%	41%	38%	13%
Spain	221	27	0%	0%	0%	0%	0%	0%	4%	8%	14%	3%
Italy	200	26	0%	0%	4%	4%	4%	4%	8%	13%	17%	6%
Netherlands	139	19	0%	0%	0%	0%	0%	0%	11%	11%	12%	4%
Finland	125	15	0%	7%	7%	7%	7%	15%	46%	54%	45%	19%
Belgium	106	14	0%	0%	8%	8%	9%	10%	15%	8%	11%	8%
Denmark	78	10	0%	0%	10%	0%	0%	17%	10%	20%	13%	8%

(Continues)

Table I. (Continued)

<i>Industry Classification</i>	<i>Obs.</i>	<i>Firms</i>	2010	2011	2012	2013	2014	2015	2016	2017	2018	<i>Total</i>
Norway	72	8	0%	0%	0%	0%	0%	13%	25%	25%	25%	10%
Austria	68	8	0%	0%	0%	0%	0%	13%	13%	13%	25%	7%
Portugal	68	9	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Greece	45	7	0%	0%	0%	0%	0%	0%	20%	14%	20%	7%
Ireland	37	5	0%	0%	0%	0%	33%	33%	33%	25%	25%	14%
<i>Index</i>	<i>Obs.</i>	<i>Firms</i>	2010	2011	2012	2013	2014	2015	2016	2017	2018	<i>Total</i>
Panel C: CDO diffusion by index and year												
S&P 500	3906	436	0%	2%	3%	5%	6%	7%	12%	16%	17%	7%
MSCI Europe	3412	477	0%	1%	3%	5%	7%	14%	23%	29%	30%	12%
Panel D: Total CDO diffusion by year	<i>Obs.</i>	<i>Firms</i>	2010	2011	2012	2013	2014	2015	2016	2017	2018	<i>Total</i>
<i>Total</i>	7318	913	0%	2%	3%	5%	6%	10%	18%	22%	23%	9%

Notes: The industry classification follows the Standard Industrial Classification (SIC) industry divisions.

Table II. Correlation matrix of all regression variables

<i>N_a</i>	<i>Variables</i>	<i>mean</i>	<i>SD</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)		
(1)	CDO	0.09	0.29	0.00	1.00																								
(2)	Intangible assets ^a	0.08	0.10	0.01	0.12	0.08	1.00																						
(3)	New digital entrants ^a	0.75	1.33	0.06	0.63	0.12	0.11	1.00																					
(4)	Diversification	0.55	0.20	0.36	0.75	0.04	0.10	-0.02	1.00																				
(5)	Lagging national digital infrastructure ^b	1.99	0.74	1.43	2.55	0.05	0.07	-0.05	0.17	1.00																			
(6)	Board size	9.42	2.67	8.00	11.00	0.03	0.06	-0.10	0.04	0.12	1.00																		
(7)	GEO age ^a	56.32	6.19	52.00	60.00	0.02	-0.03	-0.07	0.00	-0.05	0.11	1.00																	
(8)	Institutional ownership	0.32	0.13	0.23	0.40	-0.01	0.00	0.13	-0.07	-0.02	-0.21	-0.06	1.00																
(9)	Ownership concentration	0.34	0.17	0.22	0.44	-0.03	0.01	0.02	-0.05	0.22	-0.07	-0.03	0.19	1.00															
(10)	Functional executives	0.17	0.20	0.07	0.20	0.09	0.03	0.02	0.04	0.15	-0.05	-0.02	0.02	0.07	1.00														
(11)	CIO	0.59	0.49	0.00	1.00	0.03	0.01	0.05	0.03	-0.26	0.10	0.03	-0.06	-0.14	0.03	1.00													
(12)	CTO	0.46	0.50	0.00	1.00	0.08	0.09	0.08	0.18	-0.07	0.03	-0.04	-0.03	-0.10	0.06	0.20	1.00												
(13)	CDO	0.54	0.50	0.00	1.00	0.09	0.14	0.05	0.15	0.03	0.11	-0.03	-0.06	-0.10	0.17	0.21	0.23	1.00											
(14)	Financial industry	0.18	0.38	0.00	0.00	-0.04	-0.24	-0.18	-0.15	0.07	0.19	0.04	0.00	-0.02	-0.02	-0.03	-0.11	-0.05	1.00										
(15)	Peer CDO adoptions	0.02	0.04	0.00	0.04	0.34	0.10	0.12	0.05	0.03	-0.02	0.06	0.00	0.00	0.07	0.03	0.03	0.06	-0.05	1.00									
(16)	Industry concentration	0.09	0.10	0.03	0.11	-0.11	0.02	-0.05	0.06	-0.01	-0.04	-0.01	0.03	0.03	-0.04	-0.02	-0.01	-0.02	-0.16	-0.28	1.00								
(17)	Industry dynamism	0.02	0.01	0.02	0.02	0.01	-0.02	-0.07	0.00	-0.04	-0.01	0.03	0.02	0.01	0.00	-0.03	-0.01	-0.05	0.05	0.15	0.07	1.00							
(18)	Industry MTP ^a	3.12	1.46	1.95	3.96	0.16	0.34	0.35	0.10	-0.12	-0.18	-0.02	0.04	-0.04	0.01	0.06	0.10	0.08	-0.49	0.32	0.07	-0.01	1.00						
(19)	Size ^b	15.83	1.47	14.97	16.68	0.14	-0.02	-0.08	0.22	0.01	0.31	0.09	-0.34	-0.21	0.00	0.24	0.15	0.25	0.00	0.14	-0.10	0.00	-0.01	1.00					
(20)	Liquidity ^a	0.09	0.07	0.05	0.13	-0.02	0.09	0.16	-0.09	-0.17	-0.22	-0.05	-0.04	-0.02	-0.04	0.03	0.11	-0.03	-0.43	0.03	0.09	-0.06	0.36	-0.10	1.00				
(21)	Leverage ^a	0.27	0.17	0.15	0.38	-0.02	0.13	-0.05	-0.06	0.03	0.07	-0.02	0.07	0.04	0.01	-0.02	-0.10	-0.02	-0.08	0.03	-0.05	0.00	0.04	-0.03	-0.05	1.00			
(22)	Firm risk ^a	0.07	0.08	0.02	0.09	-0.03	0.01	0.02	-0.02	-0.03	-0.09	-0.09	0.07	0.01	0.01	-0.01	0.01	-0.03	-0.10	-0.03	0.04	-0.01	0.07	-0.12	0.10	0.22	1.00		
(23)	Sales growth ^a	0.05	0.14	-0.02	0.11	-0.03	0.14	0.06	-0.09	-0.13	-0.05	0.00	-0.03	-0.02	-0.03	0.01	0.01	-0.01	-0.08	-0.01	0.04	0.09	0.13	0.09	0.08	-0.06	-0.08	1.00	
(24)	ROA ^a	0.09	0.09	0.03	0.14	-0.02	0.11	0.15	-0.08	-0.19	-0.16	-0.03	-0.10	-0.04	-0.07	0.00	0.04	-0.04	-0.29	0.00	0.11	-0.04	0.39	-0.04	0.61	-0.07	0.06	0.30	1.00

Notes: Observations = 7318; Number of firms = 913; a = winsorized at the 1st and 99th percentiles; b = measured as natural logarithm; correlations greater than the absolute value of 0.02 are significant at the 95% confidence interval.

(Continues)

Table III. Antecedents of CDO presence

<i>Model</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>
<i>DV</i>	<i>CDO</i>	<i>CDO</i>	<i>CDO</i>	<i>CDO</i>
<i>Transformation urgency (H1)</i>				
Intangible assets		1.345 (0.025)*		1.236 (0.043)*
New digital entrants		0.197 (0.001)**		0.204 (0.001)***
<i>Coordination needs (H2)</i>				
Diversification			0.757 (0.034)*	0.722 (0.040)*
Lagging national digital infrastructure			0.234 (0.029)*	0.217 (0.043)*
<i>Control variables</i>				
Board size	0.003 (0.905)	0.002 (0.943)	0.001 (0.963)	0.000 (0.998)
CEO age	0.001 (0.887)	0.002 (0.797)	0.002 (0.861)	0.002 (0.772)
Institutional ownership	-0.025 (0.957)	-0.037 (0.935)	-0.061 (0.893)	-0.082 (0.855)
Ownership concentration	0.136 (0.704)	0.075 (0.836)	0.100 (0.769)	0.057 (0.869)
Functional executives	0.247 (0.195)	0.256 (0.203)	0.217 (0.233)	0.225 (0.240)
CIO	0.037 (0.799)	0.034 (0.816)	0.110 (0.476)	0.102 (0.517)
CTO	0.146 (0.249)	0.100 (0.433)	0.156 (0.231)	0.117 (0.371)
CSO	0.249 (0.042)*	0.233 (0.060)†	0.224 (0.082)†	0.217 (0.092)†
Financial industry	-0.267 (0.296)	-0.123 (0.645)	-0.174 (0.512)	-0.041 (0.884)
Industry CDO adoptions	3.100 (0.003)**	3.387 (0.001)***	2.938 (0.006)**	3.223 (0.002)**
Industry concentration	-0.144 (0.723)	-0.104 (0.809)	-0.144 (0.713)	-0.108 (0.796)
Industry dynamism	7.201 (0.720)	17.293 (0.375)	8.712 (0.667)	19.281 (0.328)
Industry MTB	0.019 (0.642)	-0.027 (0.529)	0.019 (0.638)	-0.027 (0.530)
Size	0.388 (0.000)***	0.418 (0.000)***	0.358 (0.000)***	0.389 (0.000)***
Liquidity	-0.513 (0.523)	-0.353 (0.671)	-0.175 (0.832)	-0.048 (0.955)
Leverage	-0.946 (0.034)*	-1.010 (0.027)*	-0.835 (0.067)†	-0.896 (0.053)†
Firm risk	-1.421 (0.035)*	-1.379 (0.038)*	-1.382 (0.040)*	-1.344 (0.043)*
Sales growth	-0.988 (0.002)**	-1.129 (0.001)***	-0.887 (0.008)**	-1.024 (0.003)**
ROA	0.556 (0.312)	0.431 (0.432)	0.695 (0.220)	0.576 (0.305)
Year fixed effects	yes	Yes	yes	Yes
Wald-chi square	247.098	289.067	251.206	292.427
Observations	7318	7318	7318	7318
Number of firms	913	913	913	913

Notes: ***, **, * and † indicate significance at the 0.1%, 1%, 5%, and 10% level (two-tailed), respectively. p-values are provided in parentheses. Intercept is included but not separately reported. All models are estimated with GEE logit regressions using a first-order autoregressive correlation structure. Unstandardized coefficients are reported representing the change in log odds of CDO presence.

of these variables. Here, we focus on a 1SD increase from the mean of the independent variable while holding all other variables constant at their means.^[7]

In line with our predictions, we observe a positive and significant effect of *intangible assets* ($p < 0.05$) on CDO presence in Model 2. The positive and significant impact remains stable ($p < 0.05$) when including all independent variables in Model 4. Based on Model 4, we further interpret the effect size. The results indicate that a 1SD increase from the mean in *intangible assets* leads to a 13 per cent increase in the predicted probability for CDO presence. Moreover, the average marginal effect for a 1SD change relates to a 10 per cent change in the predicted probability of CDO presence. Regarding *new digital entrants*, we find a positive and significant coefficient ($p < 0.01$) in Model 2 and again a positive and significant impact ($p < 0.001$) when considering all independent variables in Model 4. Model 4 suggests that the probability of CDO presence is 29 per cent greater in firms confronted with a high level of *new digital entrants* (mean + 1SD) compared to firms confronted with the average level of *new digital entrants*. The average marginal effect for a 1SD change in new digital entrants relates to a 21 per cent change in the predicted probability of CDO presence. In sum, these results support our first hypothesis, suggesting that transformation urgency is positively associated with CDO presence.

In Model 3, we observe a positive and significant influence ($p < 0.05$) of firm *diversification* on CDO presence. The effect of *diversification* is still positive and significant ($p < 0.05$) when we include all independent variables in Model 4. Model 4 suggests that a 1SD increase in firm *diversification* from the mean leads to a 15 per cent increase in the predicted probability for CDO presence. The average marginal effect for a 1SD change in firm diversification relates to a 11 per cent change in the predicted probability of CDO presence. Regarding *lagging national digital infrastructure*, we find a positive and significant impact ($p < 0.05$) in Model 3. When including all independent variables in Model 4, our results again indicate a positive and significant coefficient ($p < 0.05$). Model 4 suggests that the probability of CDO presence is 16 per cent greater for firms in a country ranking high in terms of *lagging national digital infrastructure* (mean + 1SD) compared to firms from an average country. The average marginal effect for a 1SD change in *lagging national digital infrastructure* relates to a 12 per cent change in the predicted probability of CDO presence. Hence, the results support our second hypothesis, suggesting that higher internal and external coordination needs increase the likelihood of CDO presence.

Robustness of Results

We conducted several robustness tests to validate our results. First, we checked several alternative definitions of our CDO variable to verify that our results were not restricted to CDOs as TMT members when they had an organization-wide responsibility for the digital strategy and the associated organizational changes. Specifically, we reran our regressions with CDOs that only had the title of ‘chief digital officer’, with CDOs who were included in the BoardEx database, and with CDOs who directly report to the CEO, another board member, or another CxO. All these robustness checks yielded

similar results. Second, we tested several alternative variables for each of our independent variables, leading to consistent empirical results. Third, we considered alternative regression models. For example, we tested a discrete time-event history regression analysis (i.e., complementary log-log). Our results supported all our hypotheses. Fourth, we examined whether the predominance of US firms may have driven our results. Here, we reduced the US firms to only S&P 100 firms to gain a more balanced sample and found statistical support for the predicted relationships. Fifth, we included the economic wealth of a country (i.e., GDP per capita) as an additional control variable and found consistent results. In sum, the various tests supported the robustness of our results. The results for these robustness tests are not reported but are available from the authors on request.

Additional Analysis

Despite the robustness of our results it is important to note that the diffusion of CDOs is embedded in society-level digitalization, which evolves over time, ultimately penetrating every sphere of life, industry context, and corporate activity (Tilson et al., 2010). The ongoing digitalization of societies could also render different benefits – and thus antecedents – of the CDO more or less relevant. For example, as digitalization progresses, the need to raise awareness of digital technologies could decrease, while the need to coordinate digital capabilities and activities could increase or at least stay relevant. Hence, it may be interesting to explore whether our antecedents are stable or evolve over time.

To investigate potential temporal effects, we decided to interact our independent variables for transformation urgency and coordination needs with a continuous time variable (i.e., year). This allows us to test the influence of transformation urgency and coordination needs depending on the time. In Table IV, we report results of GEE logit regressions including the interaction terms between our independent variables and the time variable. As several studies highlight that the statistical significance of the coefficient of interaction terms cannot be simply interpreted in a logit model (Hoetker, 2007; Zelner, 2009), we decided to further follow a graphical analysis of the interaction effects using the simulation approach developed by Zelner (2009). The idea is to graphically illustrate the change in the predicted probability of the dependent variable for an increase in the independent variable given different values of the moderator variable. By including a confidence interval, the illustration allows us to identify at which levels of the moderator variable the effect is statistically different from zero. Figures 2 to 3 show such a graphical analysis for each of our independent variables. The figures are based on a full model that includes all interaction terms.^[8]

Figure 2 illustrates the marginal effect of the transformation urgency variables on CDO presence over time while holding all other variables at their means. The 90 per cent confidence interval indicates that the effect of an increase in intangibles and also new digital entrants on CDO presence is statistically different from zero for the early and mid-years; the influence decreases after 2014 and is not statistically different from zero for the later years of our time period. Figure 3 illustrate the marginal effect of the coordination needs' variables on CDO presence over time while holding all other variables

Table IV. Temporal change of the antecedents of CDO presence

<i>Model</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
<i>DV</i>	<i>CDO</i>	<i>CDO</i>	<i>CDO</i>
<i>Independent variables</i>			
Intangible assets	2.822 (0.000)***		2.789 (0.000)***
New digital entrants	0.303 (0.000)***		0.307 (0.000)***
Diversification		-0.044 (0.916)	-0.211 (0.598)
Lagging national digital infrastructure		0.155 (0.441)	0.155 (0.252)
<i>Moderator variable</i>			
Time	0.408 (0.000)***	0.373 (0.000)***	0.406 (0.000)***
<i>Interaction terms (temporal change)</i>			
Intangible assets * Time	-0.621 (0.001)**		-0.653 (0.001)***
New digital entrants * Time	-0.058 (0.000)***		-0.054 (0.000)***
Diversification * Time		0.332 (0.002)**	0.365 (0.001)***
Lagging national digital infrastructure * Time		0.059 (0.078)†	0.054 (0.112)
<i>Control variables</i>			
Board size	-0.010 (0.701)	-0.008 (0.757)	-0.010 (0.697)
CEO age	0.002 (0.814)	0.003 (0.775)	0.003 (0.724)
Institutional ownership	-0.054 (0.905)	-0.021 (0.963)	-0.050 (0.909)
Ownership concentration	0.116 (0.755)	0.137 (0.697)	0.094 (0.794)
Functional executives	0.203 (0.352)	0.148 (0.460)	0.180 (0.388)
CIO	-0.011 (0.943)	0.091 (0.559)	0.072 (0.647)
CTO	0.086 (0.494)	0.164 (0.206)	0.106 (0.412)
CSO	0.253 (0.040)*	0.239 (0.063)†	0.234 (0.068)†
Financial industry	-0.161 (0.524)	-0.179 (0.476)	-0.078 (0.769)
Industry CDO adoptions	1.996 (0.062)†	2.240 (0.045)*	1.679 (0.118)
Industry concentration	0.546 (0.128)	0.731 (0.026)*	0.625 (0.072)†
Industry dynamism	9.734 (0.407)	10.952 (0.307)	11.443 (0.325)
Industry MTB	-0.007 (0.870)	-0.003 (0.939)	-0.007 (0.859)
Size	0.435 (0.000)***	0.371 (0.000)***	0.420 (0.000)***
Liquidity	0.022 (0.980)	0.241 (0.774)	0.315 (0.723)
Leverage	-0.793 (0.087)†	-0.576 (0.228)	-0.610 (0.198)
Firm risk	-1.632 (0.012)*	-1.517 (0.024)*	-1.517 (0.019)*

(Continues)

Table IV. (Continued)

<i>Model</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
<i>DV</i>	<i>CDO</i>	<i>CDO</i>	<i>CDO</i>
Sales growth	-0.350 (0.239)	-0.179 (0.534)	-0.253 (0.404)
ROA	0.011 (0.984)	0.406 (0.475)	0.139 (0.800)
Wald-chi square	373.161	384.089	394.259
Observations	7318	7318	7318
Number of firms	913	913	913

Notes: ***, **, * and † indicate significance at the 0.1%, 1%, 5%, and 10% level (two-tailed), respectively. p-values are provided in parentheses. Intercept is included but not separately reported. All models are estimated with GEE logit regressions using a first-order autoregressive correlation structure. Unstandardized coefficients are reported representing the change in log odds of CDO presence. The independent variables and moderator variable included in the interaction terms are centred on their means.



Figure 2. The association between transformation urgency and CDO presence over time

Notes: The graphs are based on the `intgph` logit command in Stata 14. The graph indicates the impact of a 1SD increase in *intangibles assets/new digital entrants* for different levels of *time*. The Y-axis presents the change in the predicted CDO presence probability. The X-axis indicates the level of *time*. Confidence intervals are two-tailed, at 90% confidence level.

at their means. The figures show the opposite trend. The 90 per cent confidence interval indicates that the effect of an increase in the diversification and the lagging national digital infrastructure variables on CDO presence is statistically not greater than zero for the early to mid-years. However, the influence of both variables increases and is statistically different from zero for the later years of our time period. In sum, the test indicates that the antecedents of CDO presence evolve over time. In recent years, the influence of transformation urgency on CDO presence has decreased in its relevance, while the influence of coordination needs on CDO presence has gained relevance. We elaborate on the reasons for these results in the discussion and conclusion section.

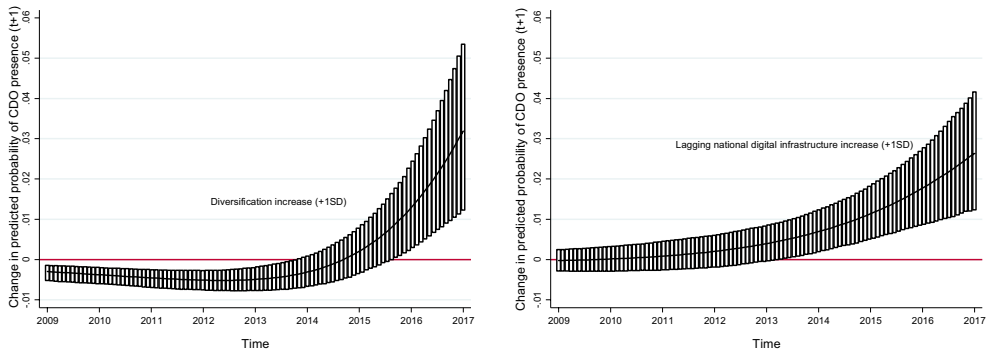


Figure 3. The association between coordination needs and CDO presence over time

Notes: The graphs are based on the `intgph` logit command in Stata 14. The graph indicates the impact of a 1SD increase in *diversification*/*lagging national digital infrastructure* for different levels of *time*. The Y-axis presents the change in the predicted CDO presence probability. The X-axis indicates the level of *time*. Confidence intervals are two-tailed, at 90% confidence level.

DISCUSSION AND CONCLUSION

In this study, following a centralization lens, we propose digital transformation acceleration and coordination as the main benefits of CDOs. Based on a panel data set of 913 US and European firms, we find that internal and external conditions (see Figure 1) that are specifically related to the accelerating and coordinating benefits of CDOs explain CDO presence. First, our results indicate that transformation urgency – in the form of the dependency of the business model on information and knowledge and pressure from digital start-ups entering the industry – increases the likelihood of CDO presence. Second, our results show that coordination needs – in the form of high firm diversification and a lagging national digital infrastructure – increase the likelihood of CDO presence. These findings suggest that, in the context of digital transformation, firms anticipate and aim to leverage the benefits of a central authority in identifying and managing strategic change as well as overall coordination.

In additional tests, we find that the influence of transformation urgency on CDO presence decreases over time, while the influence of coordination needs on CDO presence increases. The benefits of CDOs help to explain this temporal change. First, this finding suggests that when digitalization increasingly penetrates diverse industry contexts and corporate activities, the need to coordinate between different initiatives and units across the organization increases. External coordination to drive changes in the national digital infrastructure or to find alternatives also becomes more pressing when a lagging national infrastructure contrasts with high levels of society-level digitalization. Given the progression of digitalization over recent years, the rising importance of coordinating benefits could explain the increased relevance of coordination needs for CDO presence. Second, the accelerating benefits of CDOs relate to the lack of awareness among organizational members, for example, due to a relatively low level of societal digitalization (Tilson et al., 2010). As digitalization progresses, ideas and knowledge are more widely distributed and are increasingly taken for granted, thus acting as role models and new realities (Gregory

et al., 2018; Hinings et al., 2018). The need for change and potential pathways for digital transformation become more obvious. This provides an explanation for the decreasing emphasis on the accelerating benefits of the CDO and the relevance of transformation urgency for CDO presence.

Contributions to the Literature

This study makes three important contributions to management research. First, we contribute to the emerging research on CDOs (e.g., Kunisch et al., 2020; Singh et al., 2020) by adding more variation to the antecedents of CDO presence (see Figure 1). We argue and find that conditions explicitly catering to the nature of digital transformation, such as the susceptibility of the business model to digital disruption, the condition of digital infrastructures, and emergent digital ventures, are important antecedents for CDO presence. These aspects are of specific importance to understanding the decision to appoint a CDO and might be less relevant for the presence of other TMT positions. In particular, accounting for external antecedents that extend beyond conventional industry measures is important given the society-level digitalization in which a firm's digital transformation is embedded (Tilson et al., 2010) and given that firms, through their digital transformation, move toward interacting within complex digital business ecosystems (Hanelt et al., 2020). While prior research has placed particular emphasis on the interaction of CDOs with intra-organizational stakeholders (Singh et al., 2020; Tumbas et al., 2018), our analysis points to the importance of coordination efforts involving external parties in order to successfully manage the digital transformation. Finally, prior research has questioned the durability of the CDO role (Singh and Hess, 2017). Our additional analysis of the moderating temporal effects indicates a nuanced development. While certain benefits of the CDO, those related to acceleration, might become less important as time goes by, others, those related to coordination, are likely to increase.

Second, our investigation of the CDO role contributes to the literature on TMT positions more generally (e.g., Guadalupe et al., 2014; Menz and Scheef, 2014; Roh et al., 2016). We theorized and empirically validated a framework of antecedents that caters to the digital transformation of firms and thereby relates to the society-level phenomenon of digitalization (Tilson et al., 2010). In the future, the presence of further TMT positions might be influenced by society-level phenomena. For instance, societal themes, such as sustainability or diversity, are gaining increasing relevance for business success (Herring, 2017; Ioannou and Serafeim, 2015). Furthermore, our findings on the antecedents for CDO presence also stand out from prior TMT research by indicating that external factors explain the need for a TMT position. Our study is among the first to examine and find that country characteristics shape the presence of TMT positions, addressing the call for exploring TMT differences across country settings (Menz, 2012). Moreover, while prior TMT research found fewer indications for the relevance of industry-level factors (Hambrick and Cannella, 2004; Nath and Mahajan, 2008), we highlight the relevance of specific industry conditions in unlocking the benefits of a specific TMT position and thus explaining its presence. Finally, our additional analysis reveals the value of investigating the temporal robustness of the antecedents of TMT positions, as such dynamics may uncover important nuances and role changes over time.

Third, our findings inform the debate about centralized versus decentralized responsibilities (e.g., Foss et al., 2015), which is proliferating, especially in the context of digital transformation (Nell et al., 2021; Schmitt et al., 2019). While the creation of a central role in the TMT is one option that firms can select when coping with digital transformation, decentralized units may also drive digital initiatives and gain power (e.g., Tumbas et al., 2018). A substantial part of past work has pointed to decentralization when environmental turbulence rises to better account for divisional specifics (e.g., Brown, 1997; Siggelkow and Rivkin, 2005) and to centralization when related segments offer the potential to exploit synergies (e.g., Hill et al., 1992). Our findings extend the literature by indicating that the peculiarities of the digital age increase the necessity of and opportunities for centralization. On the one hand, our findings suggest that the magnitude of digital transformation for the organization as a whole favour central responsibilities in turbulent contexts where firms are challenged by new digital entrants. Thus, digital transformation may drive the *necessity* to centralize. On the other hand, the *opportunity* to centralize for firms with high coordination needs is on the rise in the digital age. Centrally developed digital technologies and capabilities, due to their context-agnostic and flexible nature (Kallinikos et al., 2013), become more adaptable to various functional and divisional requirements (Hanelt et al., 2021; Yoo et al., 2012), increasing the potential to identify and realize synergies, even between unrelated divisions. In addition, in accelerating and coordinating digital transformation, CDOs engage in measures that transcend functional separation and organizational silos (Bharadwaj et al., 2013). In contrast to several other TMT positions that may represent functions or divisions and thereby reinforce organizational compartmentalization, this ‘trans-functional’ nature of the CDO role (i.e., transcending functional separation and encompassing all functions and processes) might pave the way for a trend toward higher levels of centralization in the digital age.

Managerial Implications

Besides the aforementioned theoretical contributions, our study has important implications for managerial practice. First, managers may reflect on how to organize for digital transformation. Our study can enrich their thinking as to which external and internal conditions are seen as favouring centralization measures when organizing the digital transformation. Thus, managers concerned with organizational design and structure may learn from our study how centralization tendencies within their firm relate to internal as well as external factors. Second, managers concerned with driving digital transformations may reflect on supporting measures, such as restructuring, change management, and training addressing and reprioritizing acceleration and coordination tasks over time. Third and finally, our findings suggest that the CDO’s tasks involving the necessary skill set may evolve over time, with the coordination tasks of CDOs gaining more relevance. Therefore, firms reflecting on a CDO appointment or re-appointment should carefully assess the respective contextual conditions and then decide upon a CDO role with an emphasis on acceleration or coordination. Figure 1 supports this assessment by illustrating the internal and external conditions that require emphasis on acceleration or coordination. Depending on the emphasis selected, firm should also search for a candidate with either more pioneering or more general management skills.

Limitations and Future Research

Our study is not exempt from limitations, many of which offer fruitful avenues for future research. First, we selected a particular theoretical framing focused on centralization arguments. However, we admit that there might be additional and alternative arguments, for instance, from an institutional perspective about why firms decide for a CDO (e.g., fashion or bandwagon pressures). Recent research has indeed provided evidence for isomorphic pressures in the context of digital transformation and the respective firm reactions (Leonhardt and Hanelt, 2018). Our additional analysis of the moderating role of temporal effects, can be seen as the first indication of the evolution of the institutional environment in times of society-level digitalization, which might substantially interact with the antecedents of CDO appointments we identified in this study. Extending our framework with additional institutional theorizing might hence enable future research to further tease out the motives of firms when appointing CDOs.

Second, similar to other studies on emerging TMT roles (e.g., Roh et al., 2016; Shi et al., 2018), we focused on whether firms created a CDO position or not. Our arguments suggest that particular contextual conditions may create a need for certain human capital-related attributes, such as IT vs. management competencies, as well as career paths, such as internal vs. external. For example, our finding that, over time, the coordinating role of the CDO becomes particularly relevant might also increase the need for CDOs with more general management skills. Future research could build upon our findings by investigating the preference of firms for specific CDOs (e.g., with respect to their human capital-related dimensions) and how such CDO facets affect their effectiveness. Furthermore, in our theoretical framework, we focused on the benefits associated with the CDO role, yet downsides surely exist. Future research may complement our work by selecting a stronger emphasis on the potential disadvantages of CDO presence.

Third, a relevant extension of our work would be to link CDO presence to particular firm-level consequences. There are several outcome variables that could be of interest. For instance, in addition to financial performance, it would be valuable to investigate whether CDO presence is associated with specific indications for progress in digital transformation, such as organizational reconfiguration and digital innovation (Hanelt et al., 2020). When examining the consequences of CDO presence, it might also be interesting to disentangle the interfaces between the CDO and other executives, such as the CIO, CSO, and the CEO. While we argue that CDOs tend to complement other TMT roles, power struggles could also emerge that prevent progress during digital transformations. With respect to such CDO interfaces, it might be interesting to follow a role-taking and role-multiplicity perspective (Georgakakis et al., 2019) in order to learn more about the linkages and interactions between CDOs and other managers.

Conclusion

Contemporary organizations are challenged to drive digital transformation and may decide to do so by creating a dedicated, central role – the CDO. Our study reveals that transformation urgency and coordination needs drive CDO presence. On the basis of our findings, we discussed implications for TMT, CDO, and centralization research as well as managerial practice. Our study encourages future research to build on our

insights and further advance our knowledge of the new challenges and opportunities that the digital age is creating for strategy, corporate governance, and leadership research.

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NOTES

- [1] Sometimes firms may decide for a decentral CDO with a responsibility confined to a specific business unit (Singh et al., 2020). Such decentral CDOs are, however, rather uncommon (Kunisch et al., 2020).
- [2] Specifically, we included the following titles as potentially referring to a CDO: chief digital evangelist, digital director, digital officer, digital transformation officer, group digital director, head of digital, head of digitalization, and SVP/VP digital. Moreover, in some cases, the title not only referred to the term 'digital' but to 'digital strategy', 'digital transformation', 'digital business', 'digital development', 'digital growth', or 'corporate digital'.
- [3] We acknowledge that the actual value of intangible assets is hard to capture and thus the value of intangibles in the balance sheet might deviate to some extent (Zhang et al., 2014). Still, we believe that the level of intangible assets (excluding goodwill) is able to differentiate between firms with business models that rely more on information and knowledge and those that rely more on material assets, such as machinery. Nevertheless, we also conducted a robustness test where we used the level of tangible assets (e.g., equipment such as machinery) as a variable for firms that focus their business model more on material assets than on immaterial assets such as information and knowledge. The results indicate that firms with more tangible assets are less likely to have a CDO. Hence, we also found support with this alternative variable.
- [4] We used net sales as a denominator instead of total assets because we also included the finance and insurance industry. Banks, for example, typically have very large balance sheets, which might bias the results when using total assets as the denominator. However, we also tested this by dividing intangible assets by total assets and by property, plant, and equipment, which yielded similar results.
- [5] We also ran the analysis with the pure variable and obtained similar results. However, given that there were some outliers (e.g., ranks between 1 and 108), we were confident of obtaining more valid results with the log transformation.
- [6] In Models 2 and 3, we ran regressions with either both variables for transformation urgency or both variables for coordination needs. We also tested each variable separately and found consistent results.
- [7] The reported coefficients (i.e., log-odds) in Table III also allow us to calculate odds ratios by exponentiating the coefficients. For example, the coefficient of 0.204 for new digital entrants in Model 4 corresponds to an odds ratio of 1.226. This odds ratio indicates a 22.6 increase in the odds of CDO presence for a one-unit increase in the new digital entrants' variable.
- [8] In addition to focusing on time as a moderator variable, we also run two alternative tests to examine a temporal change in our antecedents. First, we interacted the antecedents' variables with dummy variables for each year allowing us to compare the coefficient of each interaction term. This test again showed decreasing size and significance of the coefficients for the interaction with the transformation urgency variables and increasing size and significance of the coefficients for the interactions with the coordination needs variables. Second, similar to Ioannou and Serafeim (2015), we ran several regression where we subsequently added a year of our timeframe. Again we found that the coefficients for the transformation urgency variables decreased in size and significance, whereas the coefficients for our coordination needs' variables increased in size and significance.

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