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The Role of CDOs in Signaling Digital Transformation Endeavors: An Analysis of Firms' External Communication Tools

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Abstract

As part of their digital transformation, firms increasingly appoint Chief Digital Officers (CDOs). Existing research suggests that CDOs are appointed to drive and coordinate digital transformation activities and communicate digital transformation-related topics to stakeholders. However, the specific role of the CDO as a mediator between a firm and its external stakeholders, such as investors, remains unclear. Relying on signaling theory, we investigate whether CDO presence impacts digital transformation-related signaling in firms external communication tools. Indeed, our results show a strong positive association between CDO presence and the volume of digital transformation-related signals. Therefore, it can be assumed that CDO presence has the potential to contribute to reducing digital transformation-related information asymmetries between firms and external stakeholders. However, since our results show that less regulated communication tools are more likely to be used for digital transformation-related signaling than highly regulated ones, the reliability of such signals remains questionable.

Keywords: Digital Transformation, Chief Digital Officer, External Corporate Communication, Signaling Theory, Quantitative Research, Natural Language Processing

Introduction

With rapid advancements in the development and improvement of digital technologies, firms must increasingly address the challenges of digitalization. Thereby, digitalization and associated technological innovations lead to disruptions within industries and markets and to rapidly changing organizational environments (Bharadwaj et al. 2013; Verhoef et al. 2019). To stay competitive in an increasingly digitalized society, firms need to evolve and adapt to the changing business landscape, making digital transformation crucial for firms to survive and remain competitive (Bharadwaj et al. 2013; Vial 2019; Firk et al. 2021). In recent years, an increasing number of firms have recognized the need for digital transformation and its potential opportunities. In that regard, firms increasingly consider digital transformation a critical success factor and invest in new technologies and associated capabilities (Sebastian et al. 2017).

As digital transformation becomes a high-level imperative for firms and their stakeholders, it has turned into a high precedence concern on the leadership level (Hess et al. 2016). The leadership, comprising the board of directors and the rest of the top management team, is vital to a firm's digital transformation. It is responsible for driving and coordinating the strategic direction of an organization, including the decision on how to address digital transformation (Luciano et al. 2020). In addition, the top management team is responsible for communicating digital transformation-related topics with important stakeholders, such as investors (e.g., Singh and Hess 2017). In that regard, an increasing number of firms appoint the position of the Chief Digital Officer (CDO) to the top management team as a centralized digital transformation responsibility with the aim to drive and coordinate digital transformation and to communicate digital transformation-related topics with stakeholders (Grossman and Rich 2012; Péladeau et al. 2017; Singh and Hess 2017; Kunisch et al. 2020; Singh et al. 2020).

Existing research on CDOs writes from different perspectives. In that regard, Kessel and Graf-Vlachy (2021) found that CDO-related research can primarily be distinguished in three different research streams: (1) Antecedents of CDO presence, (2) The CDO in the organization, and (3) Consequences of CDO presence. Whereas research on antecedents of CDO presence and the CDO in the organization is already advanced, research on the consequences of CDO presence is somewhat underrepresented in the existing literature (Kessel and Grad-Vlachy 2021). Thereby, most of the existing research concerning the consequences of CDO presence deals with the impact of CDOs on innovation performance (e.g., Leonhardt et al. 2018; Reck and Fliaster 2018; Reck and Fliaster 2019) or on financial performance (e.g., Zhan and Mu 2016; Drechsler et al. 2019; Berman et al. 2020; Firk et al. 2021). However, although Singh and Hess (2017) found that an appointed CDO is responsible for communicating digital transformation-related topics with stakeholders, the specific role of the CDO as a mediator between a firm and its external stakeholders, such as investors, is still scarcely investigated. In that regard, the reduction of potential information asymmetries between firms and external stakeholders could be a potential side effect of CDO presence. From a signaling perspective, Drechsler et al. (2019) show that firms use the announcement of CDO appointments as a form of strategic signaling to investors. However, since digital transformation activities of firms are bound to risk and uncertainty (e.g., Hess et al. 2016; Sebastian et al. 2017; Moker et al. 2020), related information are highly relevant to evaluate the future prospects of a firm. Therefore, firms need to further send digital transformation-related signals to external stakeholders to reduce potential information asymmetries. Overall, we assume that digital transformation-related signaling does not only include the announcements of CDO appointments.

Research on digital transformation-related signaling is still rare. It especially remains unclear whether those firms appointing a CDO are more likely to conduct digital transformation-related signaling, especially in their external communication tools. If so, it could be assumed that CDO presence can be seen as an indicator for better digital transformation-related signaling and that CDO presence has the potential to reduce digital transformation-related information asymmetries between firms and external stakeholders. Due to the high relevance of digital transformation for the future competitiveness of firms and the resulting high relevance of digital transformation-related information for its stakeholders, especially investors, this research gap should be closed. We approach this research gap by analyzing whether the presence of a CDO can be associated with a higher volume of digital transformation-related signaling in firms' external communication tools. In addition, in order to investigate the reliability of digital transformation-related signaling, we further analyze potential differences between communication tools with different degrees of regulation. Against this background, we formulate the following research questions (*RQs*):

RQ1: How does CDO presence impact the volume of digital transformation-related signals in external communication tools?

RQ2: How does the volume of digital transformation-related signals differ across communication tools with different degrees of regulation?

To answer these research questions, we derive two hypotheses from the literature and analyze the relationship between CDO presence in a firm's top management team and digital transformation-related signaling in external communication tools. Thereby, the volume of these theme-specific signals is measured by the relative frequency of digital transformation-related sentences within the main external communication tools firms use to communicate with external stakeholders and reduce potential information asymmetries. To calculate the frequency of digital transformation-related sentences, we used the dictionary of digital terms developed by Chen and Sinivrasan (2019), which we further extended by

keywords related to digital technologies and digitalization in general. Our study focuses on the constituents of the S&P 500 equity index from 2007 to 2020. Based on insights from existing research on digital transformation and CDOs, we assume that firms appointing a CDO to their top management team pay increased attention to digital transformation activities. In addition, the appointed CDO should further drive digital transformation and digital transformation-related communication and thereby further bring digital transformation to a firm's focus. Overall, this should result in an increase in the volume of digital transformation-related signals. In that regard, we distinguish between highly regulated communication tools (10-K reports) and less regulated communication tools (conference calls). Both communication tools are highly relevant, but they differ significantly in their degree of regulation and subsequently in their reliability, which may impact how firms use them to communicate digital transformation-related information and how relevant they are for external stakeholders, especially investors.

We contribute to the existing literature concerning the consequences of CDO presence in manifold ways. Our study holds important implications for firms deciding whether to appoint a CDO or not and stakeholders deciding which firms are more inclined to signal digital transformation-related activities and where to search for digital transformation-related signals. Our results show that firms with a CDO in their top management team are accompanied by a significantly higher volume of digital transformation-related signals in their external communication. However, we further show that the increase in the volume of digital transformation-related signals in less regulated communication tools is significantly higher than in highly regulated communication tools which questions the reliability of such signals.

To provide sound theoretical foundations and gain valuable insights regarding our research questions, this paper is structured as follows: Starting with the theoretical foundations, we introduce the role of the CDO in the digital transformation journey as well as the role of signaling in corporate communication. Secondly, we introduce the methodological foundation of the conducted study. Thirdly, we present the findings of our analysis. Fourthly, in the context of a discussion, the limitations of our study and implications for future research and practice are presented. Finally, the conclusion summarizes the most important findings.

Theoretical Foundations

The CDO as the Centralized Digital Transformation Responsibility in Firms

The emergence of new digital technologies has a transformational impact on today's society. In a business context, digital technologies can reconfigure the way firms operate their business, communicate with stakeholders (e.g., customers and partners), and compete within markets (Bharadwaj et al. 2013; Hess et al. 2016). The changes that digital technologies bring to a firms' business model, resulting in changed products, the automation of processes, or changed organizational structures, can be described as digital transformation (Hess et al. 2016). Firms need to undergo a digital transformation to stay competitive in an increasingly digitalized market environment and thereby adapt their current business models, organizational structures, strategy, and internal culture (e.g., Matt et al. 2015; Eden et al. 2019; Metzler and Muntermann 2020). For this reason, the process of digital transformation can be seen as one of the most relevant topics on the agenda of executives across industries.

Existing research indicates that a firm's leadership team and especially its top management team play an important role in the strategic change processes of firms, such as the digital transformation (Singh et al. 2020). Since digital transformation involves a fundamental transformation of the entire organization, including the need for adapting mindsets and skillsets, leadership is a crucial factor in the process of digital transformation (Westerman et al. 2014). In order to adapt the top management team for the digital era and subsequently drive digital transformation, an increasing number of firms appoint new technology-related C-level roles to the top management team. This, for example, includes the Chief Information Officer, Chief Innovation Officer, Chief Data Officer, Chief Strategy Officer, and the Chief Digital Officer. Chief Information Officers are in charge of IT support and IT deployment, Chief Innovation Officers are in charge of corporate in general without a specific digitalization focus, Chief Data Officers are responsible for the data management and data analytics, and Chief Strategy Officers are responsible for managing and executing strategy processes. Finally, the Chief Digital Officer can be described as the key position of highest responsibility for digital transformation in firms. The CDO is responsible for driving digital transformation activities, digital mobilizing the entire firm, initiating firm-wide collaboration, and communicating digital transformation-related topics with stakeholders (e.g., Singh and Hess 2017).

Not all firms appoint a CDO to the top management team to drive digital transformation. For example, various management boards believe that an already existent CIO is sufficient to fulfill this task. However, in that regard, Singh and Hess (2017) mention that, due to the complexity of digital transformation, it is challenging for a CIO to manage the digital transformation in addition to the original responsibilities of the CIO. Therefore, a CIO might not be the best choice for managing a firm's digital transformation. Other opportunities include, but are not limited to, giving the digital transformation responsibility to the CEO (Hess et al. 2016) or divisional or functional heads (Björkdahl 2020). Overall, existing research does not find a consensus on whether the appointment of a CDO to the top management team is an adequate decision concerning digital transformation issues. Therefore, it remains unclear whether the appointment of a CDO is an essential success factor in the process of digital transformation (e.g., Leonhardt et al. 2018). However, when appointing a CDO to the top management team, it is essential that the CDO and other C-level positions work closely together. For example, the CIO provides the foundation for digital transformation by delivering the necessary agile IT capabilities for more flexibility and digital innovation (Haffke et al. 2016). Furthermore, the CIO is also responsible for implementing the changes in the infrastructure and platforms. Therefore, it is essential that the CIO and the CDO work closely together while the CIO acts as an IT specialist and the CDO as the digital transformation specialist (Haffke et al. 2016; Singh and Hess 2017). Moreover, as the most senior manager, the CEO needs to back the digital transformation and assure that framing the digital transformation successfully supports the CDO in engaging and inspiring the entire organization, especially middle management. Therefore, also the CEO needs to work closely with the CDO and support the digital vision and activities (Westerman et al. 2014).

The decision to appoint a CDO to the top management team depends on various internal and external factors (Kessel and Graf-Vlachy 2021). Most firms appoint a CDO as a response to realizing that the current top management team lacks managers with appropriate skills. In addition, CDOs are most common in firms with a focus on intangible assets. In firms focusing on tangible assets, CDOs are not that frequently presented (Firk et al. 2021; Kessel and Graf-Vlachy 2021). Another common trigger of appointing a CDO is market competition. In markets with highly digital-savvy competitors, firms appoint CDOs as a reaction to their peers (e.g., Haffke et al. 2016; Singh and Hess 2017; Firk et al. 2021; Kessel and Graf-Vlachy 2021).

Exiting research on CDOs has further dealt with the required characteristics and skillsets of CDOs. In that regard, it was found that a good CDO needs a mixture of technology-related skills (e.g., general IT competencies), a digital mindset (e.g., a digital visionary spirit), and more general skills (e.g., change management expertise) (Singh & Hess, 2017). Additionally, existing literature derived various CDO-typologies regarding their specific role within the leadership team. For example, Singh and Hess (2017) proposed three different CDO types: (1) Entrepreneur CDOs, (2) Digital Evangelist CDOs, and (3) Coordinator CDOs. The Entrepreneur CDO mainly focuses on digital innovation, complementing the existing IT infrastructure and drive innovation by developing, exploring, and exploiting digital technology. The Digital Evangelist CDO focuses on spreading the digital strategy throughout the organization to motivate and inspire employees for the digital transformation. Finally, the Coordinator CDO drives high-level coordination and alignment throughout the organization and creates synergies across the firm. However, all CDO-typologies have in common that they agree on the fundamental idea of implementing a CDO: setting up a position in the top management team that drives and coordinates a firm's digital transformation journey (e.g., Singh and Hess 2017; Tumbas et al. 2017).

Appointed to a firm's top management team, a CDO drives and coordinates the digital transformation with the responsibility of formulating an overarching digital transformation strategy and making digital transformation a strategic priority (Westerman et al. 2014; Haffke et al. 2016; Singh and Hess 2017; Singh et al. 2020). This includes introducing new digital technologies, driving a digital culture, and accelerating the digital transformation process (Singh and Hess 2017; Singh et al. 2020). In addition, the CDO is responsible for coordinating digital initiatives and the associated change management within a firm, mediating between different organizational units, working against organizational barriers, and communicating digital transformation-related topics with stakeholders (Singh and Hess 2017; Tumbas et al. 2017; Tumbas et al. 2018). However, it remains unclear whether these actions are also visible and valuable in the communication with external stakeholders, especially investors. In that regard, CDO presence could be associated with a higher volume of digital transformation-related signals that would, at best, reduce potential information asymmetries between a firm and its external stakeholders.

Signaling Theory and the Reduction of Information Asymmetries Through External Corporate Communication

Information asymmetry frequently occurs between a firm's management (possessing more information) and different stakeholder groups, especially investors (possessing less information). In that regard, the principal-agent theory explains contractual relations between parties with mismatched goals in the presence of uncertainty and asymmetric information (Pavlou et al. 2007). The principal (e.g., investor) commissions the agent (e.g., manager) to perform tasks on her or his behalf (e.g., management of the firm). In this case, the agent has more precise information than the principal due to her or his specific role and related activities, making the agent's assessment more difficult. Situations can arise in which the agent does not act in accordance with the principal's utility function but only maximizes her or his own utility. Grossmann and Hard (1984) show that this situation can reduce investor's welfare.

In order to reduce information asymmetry and minimize potential welfare losses, firms capitalize on signaling. The so-called signaling theory primarily addresses situations where two different parties have asymmetric information concerning a specific topic (Spence 2002; Connelly et al. 2011). In his seminar work on job market signaling, Spence (1973) shows how job applicants can reduce information asymmetry to hamper the selection ability of prospective employers (Connelly et al. 2011). Generally, signaling theory explains how the party with more information (e.g., management), the sender, chose signals to communicate that information. The other party (e.g., investor), the receiver, should interpret this signal (Connelly et al. 2011). How useful and effective a signal is for a potential receiver is determined by signal reliability (or signal credibility) (Connelly et al. 2011; Davila et al. 2003), which can be described as the extent to which a signal can be perceived as trustworthy. One of the most common signaling tools for firms are external communication tools, including 10-Q-reports, 10-K-reports, and conference calls. These tools include information about financials as well as information about current strategic topics, including digital transformation. Although all these communication tools are highly relevant, they are characterized by a different degree of regulation and standardization. On the one hand, 10-Q-reports and 10-K-reports are documents required by the SEC quarterly (10-Q) or yearly (10-K). These documents contain financial statements, disclosures, internal controls, and management discussions and analyses (SEC 2021). The management has to report all material information, including qualitative information (Cannon et al. 2020). In addition, the 10-K reports are audited by external auditors (SEC 2021). Overall, it can be concluded that 10-K reports are highly regulated and standardized documents for corporate disclosure. The content in these documents can be classified as highly trustworthy. On the other hand, also other less regulated tools are used to communicate with external stakeholders. For example, conference calls are quarterly telephone-based meetings where firms inform investors and analysts about current topics concerning their business development. These conference calls play a unique role, as they take place in connection with the quarterly earnings announcements and thus provide an essential form of corporate disclosure (Huang et al. 2018). In contrast to 10-K reports, conference calls are not one-sided communication, but company representatives also have to respond spontaneously to questions raised by analysts or others. Thus, compared to highly regulated 10-K reports, conference call transcripts are much less standardized and non-audited documents. The trustworthiness concerning its content, therefore, is not necessarily secured.

Existing research shows that firms use signaling to reduce potential information asymmetries with external stakeholders concerning various topics (e.g., Moker et al. 2020). Since digital transformation activities of firms are bound to risk and uncertainty (e.g., Hess et al. 2016; Sebastian et al. 2017; Moker et al. 2020) and related information highly relevant to evaluate the future prospects of a firm, external stakeholders, such as investors, try to gather a lot of information in order to reduce potential information asymmetries (Moker et al. 2020). Especially a firms' central corporate communication tools are suitable for stakeholders to look out for visible signals of firms (Moker et al. 2020). In that regard, Brown et al. (2004) showed that conference call activity is negatively related to information asymmetry and Fu et al. (2012) show that information asymmetry is reduced when the frequency of financial reporting increases.

Related research shows that the presence of a chief data officer is associated with a higher frequency of big data-related signaling in annual reports (Kralina 2018). Concerning CDOs, Drechsler et al. (2019) found that firms use public announcements of CDO appointments as strategic signaling to investors. However, it remains unclear whether CDO presence is also associated with a higher quantity of digital transformation-related signaling and whether this information is relevant for external stakeholders with regard to potential information asymmetries.

Hypothesis Development

Existing research agrees that digital transformation is a highly relevant topic concerning the future competitiveness of firms (e.g., Westerman et al. 2014). In order to drive and coordinate digital transformation activities, firms increasingly appoint CDOs to their top management team (e.g., Singh and Hess 2017; Tumbas et al. 2017; Singh et al. 2020). In that regard, it can be assumed that those firms appointing a CDO to their top management team pay particularly increased attention to digital transformation activities. A high strategic priority of digital transformation, paired with the fact that digital transformation activities are bound to risk and uncertainty, holds the risk of information asymmetries between a firm and its external stakeholders. In order to reduce potential information asymmetries, these firms can increase their digital transformation-related signaling. Since an appointed CDO is responsible for communicating digital transformation-related topics with external stakeholders, it should further be recognizable that CDOs increase the strategic priority of digital transformation in external communication. Overall, these circumstances should be visible in digital transformation-related signaling in firms' external communication tools. Existing research underscores these assumptions. For example, Kralina (2018) shows that the appointment of a special position (i.e., chief data officer) to the top management team can be associated with increased signaling in the area of responsibility of this person (i.e., big data activities) (e.g., Kralina 2018). Based on these assumptions, we derive the following hypothesis 1 (*H1*):

H1: CDO presence can be associated with a higher volume of digital transformation-related signals in firms external communication tools.

As already discussed in the theoretical background, there exist differences between external communication tools. Whereas highly regulated communication tools (i.e., 10-K reports) mainly contain strictly defined content, less regulated tools (i.e., conference calls) include information on current topics where the specific information needs of analysts and other stakeholders can be addressed. In that regard, signal reliability is an important issue. On the one hand, from the argument of signal reliability, regulated communication tools would be more appropriate if firms want to signal that they really engage in digital transformation. Since such communication tools are more trustworthy and reliable, their signals are more useful for their receivers. Thus, if firms really put much effort into digital transformation activities, which implies that their signals are meaningful and provable, they would choose these more reliable communication tools for digital transformation-related signaling. However, on the other hand, if digital transformation is more of a cheap talk; that is the firms like to talk about it but not do any substantially with digital transformation, firms would primarily rely on less regulated communication tools to talk about digital topics. Overall, both, firms that strongly engage in digital transformation, as well as firms for those digital transformation is more of a cheap talk, can engage in digital transformation-related signaling in less regulated communication tools. However, only those firms really engage in digital transformation can also engage in digital transformation-related signaling in highly regulated communication tools. In the end, it can be assumed that the volume of signals differs across different communication tools. Only those firms really engaging in digital transformation can use digital transformation-related signaling in highly regulated communication tools, and only CDOs in such firms can further accelerate this signaling. Based on these assumptions, we further derive the following hypothesis 2 (*H2*):

H2: The impact of CDO presence on the volume of digital transformation-related signals in non-regulated communication tools is higher than in regulated ones.

To test our hypotheses, we measure the volume of digital transformation-related signals in different external communication tools of the analyzed firms. In that regard, we use the relative amount of digital transformation-related sentences in two of the most important external communication tools: (1) 10-K reports and (2) conference calls.

Since the CDO appointment is an endogenous and not a random event, firms make a conscious decision to make a CDO appointment. This endogeneity problem makes it difficult to make statements about the causal effect of CDO appointments since an unobserved third variable and not the CDO appointment itself could drive the results. We aim to minimize this problem by selecting an appropriate research methodology. The following section describes our methodological approach to test the derived hypothesis and subsequently answer our research questions.

Methodological Approach

To analyze the impact of CDO presence within a firm's top management team on the volume of digital transformation-related signals, we conduct an empirical study comprising several sequential steps. In the first step, we utilize natural language processing techniques to calculate the relative frequency of digital transformation-related sentences (*Digital Ratio*) in a firm's major external communication tools. The sentence-based ratio should prevent the use of numerous topic-specific words in a short section of the text, biasing the results as it could happen with a word-based ratio. However, as part of the validity check, we can confirm that the results of this study do not change when the digital ratio is calculated at the word level. The *Digital Ratio* serves as our proxy to measure the volume of digital transformation-related signals. It is calculated for the selected firms' 10-K reports and conference calls. Indeed, not every digital transformation-related sentence has to be a conscious and deliberate signal in the sense of signaling theory. For example, it may be the case that certain content (especially in 10-K reports) must be reported due to regulatory requirements. Although this kind of communication can reduce information asymmetries, it would lack the conscious decision of the signaler that is at the heart of signaling theory. Since it is hardly possible to decide which sentences were sent conscious and deliberate in the sense of the theory, we cannot make a differentiation and consider all sentences as signals in the sense of the signaling theory.

To determine the relative frequency of digital transformation-related sentences in these documents, we use the dictionary of digital terms developed by Chen and Sinivrasan (2019) and extend it with other important digital technology-related and other digitalization-related word groups and keywords. The existing dictionary comprises a selection of relevant digital technology-related word groups (i.e., the word groups Big Data, Cloud, Artificial Intelligence, and Machine Learning) with a selection of relevant keywords for each word group and a selection of other digitalization-related keywords. Since this sample of word groups and keywords does not represent a sufficient universe of digital transformation-related issues, we extend the existing dictionary by adding word-groups concerning other important digital technologies. Thereby, we primarily focus on SMACIT technologies (Sebastian et al. 2017) and add the word groups "Social Media," "Mobile," and "Internet of Things." Furthermore, we extend the existing word groups with similar and alternative words. The final dictionary of digital terms can be found in the appendix. Researchers are invited to use and extend the existing dictionary for future research projects. A sentence is classified as digital transformation-related if it contains at least one entry (word or n-gram) from the applied dictionary. In that regard, we use a search that is not case-sensitive. If relevant, we also consider different wordings (e.g., virtual agent / virtual agents). In the appendix, the words for which we consider different endings are indicted by the wildcard character "*." We calculate the *Digital Ratio* of a document by dividing the digital transformation-related sentences by the total number of sentences in the document.

In order to determine the extent to which CDO presence affects the volume of digital transformation-related signals, we estimate equation (1), representing a panel regression in which the firms are observed several times during the observation period. This panel structure is particularly suitable for investigating an event's effect (in this case, first-time CDO appointments) on the dependent variable (Wooldridge 2016).

$$\begin{aligned} &Digital\ Ratio[CC;\ 10-K]_{t,i} \\ &\quad = \alpha_0 + \alpha_1 CDO_{t-1,i} + \alpha_2 Intangibles_{t-1,i} + \alpha_3 MTB_{t-1,i} \\ &\quad + \alpha_4 ln(Total\ Assets)_{t-1,i} + \alpha_5 ROA_{t-1,i} + \alpha_6 Leverage_{t-1,i} + \alpha_7 Return_{t-1,i} \\ &\quad + \alpha_8 ln(1 + Digital\ M\&A)_{t-1,i} + \alpha_9 Related\ CxO_{t-1,i} + \alpha_i + \alpha_t + \varepsilon_{t,i} \end{aligned} \tag{1}$$

The dependent variable *Digital Ratio* is calculated separately with respect to the conference calls $[CC]$ and the annual reports $[10-K]$ on a firm (i) year (t) level. In order to answer RQ2, the digital Ratios will be examined separately for each document type. The main variable of interest is the binary variable CDO which is set to 1 for all firm-year combinations with an acting CDO in the respective year and firm and 0 in all other cases. We further incorporate common control variables into the equation that could influence the volume of digital transformation-related signals. We follow Firk et al. (2021) and use intangible assets (excluding goodwill and scaled by net sales) to assess whether the business model is more focused on knowledge (intangible assets) or on tangible assets (e.g., production of raw materials). We use the market-to-book ratio (MTB) to account for the firm's valuation, the natural logarithm of total assets to account for firm size, return on assets (ROA) to account for profitability, the leverage ratio ($Leverage$) to account for the capital structure and the annual stock return ($Return$) to account for current stock market performance.

In addition, we use the variable *Digital M&A* to account for the acquisition of digital knowledge through inorganic growth (Hanelt et al. 2020). The variable is calculated by the number of digital M&A transactions the company has conducted as an acquirer during the respective year. We define an M&A transaction as digital if the target's business description or the purpose text of the deal contains at least one entry of the dictionary that is also used for the *Digital Ratio*. Since it is not only the CDO who could potentially engage in digital-transformation-related signaling, we also consider the board's composition with respect to other technology-related C-level roles as discussed in the theoretical background (section 2.1). The variable *Related CxO* is 1 in all firm-years where the board has a chief information/technology/innovation/data or strategy officer and 0 in all other cases. We further utilize firm fixed effects (α_i) to control for all time-invariant firm characteristics (e.g., industry) (Wooldridge 2016) and year fixed effects (α_t) to account for period-specific characteristics (e.g., increased awareness of the relevance of digitalization activities over time). This comprehensive set of controls reduces the problem of endogeneity of a CDO appointment in our research design. Finally, we use lagged independent variables (lagged by one year) to mitigate the potential problem of reversed causality.

Datasets and Descriptive Statistics

To get a basic understanding of the main variables used in this study and to present first interesting insights concerning our data, we present our different datasets and descriptive statistics. As a sample, we use all firms that were part of the U.S. equity index S&P 500 at any time during the period from January 1, 2007 to December 31, 2020. The selection of the S&P 500 allows a relatively broad sample and also good data availability. Since the trend towards appointing CDOs started around 15 years ago (Singh and Hess 2017), the period under review covers the main phase of CDO appointments in firms. The resulting sample includes a total number of 810 firms and thus theoretically 11,340 firm-year observations (810 firms * 14 years). Not all 810 firms existed during the whole period (e.g., due to liquidations and mergers). This reduces the number of observations we consider for our analysis.

For our research approach, we use three distinct datasets. The first dataset comprises information about board positions. Our main variable (*CDO*), as well as the control variable *Related CxO*, is drawn from this dataset. The process of gathering the CDO data comprises several sequential steps. In the first step, we combine the data of the three databases (1) Boardex, (2) Amadeus, and (3) Crunchbase and extracted all current and former senior executives for those firms included in our sample. Afterward, we identify relevant CDO positions. In that regard, we build on recommendations of existing research (e.g., Kunisch et al. 2020). Therefore, we classify all senior executives with the term "digital" in their role title as potential CDOs. According to Kunisch (2020), this procedure ensures considering those CDOs with similar roles but different role titles. In the next step, we check all resulting potential CDOs and eliminate clear non-CDOs. This, among others, include divisional CDOs, subsidiary CDOs, Chief Data Officers, and CIOs. Finally, to extend our dataset, we also browsed professional websites, online-based executive platforms, firm websites, and press releases with regard to those firms included in our sample. The final sample of CDOs solely contains top management positions responsible for the digital transformation activities within their specific firm. Our approach identifies 213 CDOs across 152 firms of the total 810 firms included in our sample. For the control variable *Related CxO*, we used the role titles from the Boardex and Amadeus databases.

The second dataset includes the textual data used to explore the scope of digital transformation-related content in firms' external communication tools. This dataset includes 10-K reports and transcriptions of conference calls for those firms included in our sample. We extract 10-K reports from the SEC Edgar database, and the conference calls stem from the Refinitiv Thomson ONE database. We choose these data types as they represent highly relevant external communication tools that give insights into ongoing and completed strategic issues. Both data types aim to reduce potential information asymmetries and therefore contain a vast amount of information that enables a deeper insight into the firms' corporate strategy and, therefore, are suitable for our study (e.g., Bowman 1984; Kloptchenko et al. 2004; Lee and Hong 2014). Whereas 10-K reports are highly standardized annual reports whose publication is legally prescribed, conference calls are carried out several times a year (usually each quarter) to inform investors and analysts about a firm's business development. In contrast to other annual reports, 10-K reports are generally more detailed but lack graphical elements. From the 10-K reports, we extract the text passages for further analysis. We remove any tables and figures. From the conference calls transcripts, we separated the content from the metadata. For the subsequent analysis, we use the conference calls' presentations as well as the

Q&A sessions. We remove extremely short sentences of less than 20 characters, as a manual review of the text sections has shown that these are mostly very short statements from conference call participants without meaningful content (e.g., "Ok, thank you."). We use the extracted textual data from both sources to calculate the *Digital Ratio* as described in the methodology section.

To obtain a first understanding of the data used, we combined both datasets (i.e., CDO information and text in external communication tools) to show how the *CDO Ratio* and the *Digital Ratio* evolved over time.

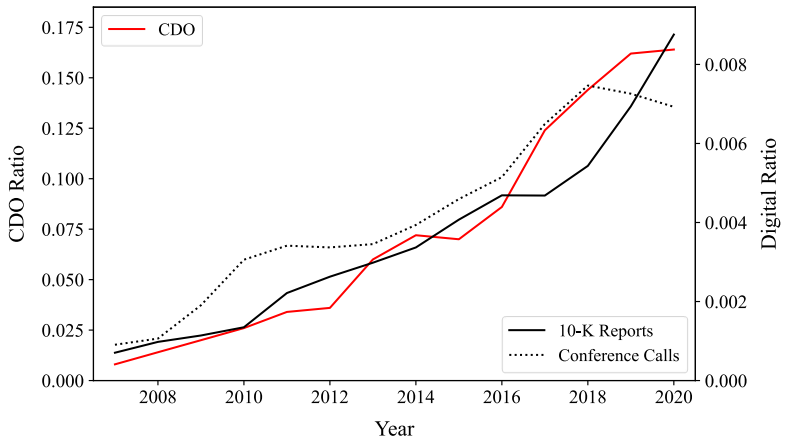

Figure 1. CDO Presence and Digital Transformation Activities Within S&P 500 Over Time

As illustrated in Figure 1, the CDO presence across the considered firms has increased strongly during the observation period. In line with existing literature, we can observe that before 2010, CDOs were only very sporadically present in our sample. However, at the end of our observation period, in 2020, a CDO is present in about one-fifth of the analyzed firms. In addition, also the *Digital Ratio* across the 10-K reports and conference calls has increased strongly over time. In that regard, our data indicates that the average *Digital Ratio* of the conference calls is significantly higher than the average *Digital Ratio* of the 10-K reports. Since existing research indicates industrial differences in the frequency of CDO appointments, we also investigate the *CDO Ratio* and the *Digital Ratio* per industry. The relevant information is shown in Figure 2. The chart on the left-hand side illustrates the *CDO Ratio* per industry and its development over the years 2007, 2014, and 2020. The chart on the right-hand side illustrates the average *Digital Ratio* over the entire study period per industry and communication tool (10-K reports vs. conference calls).

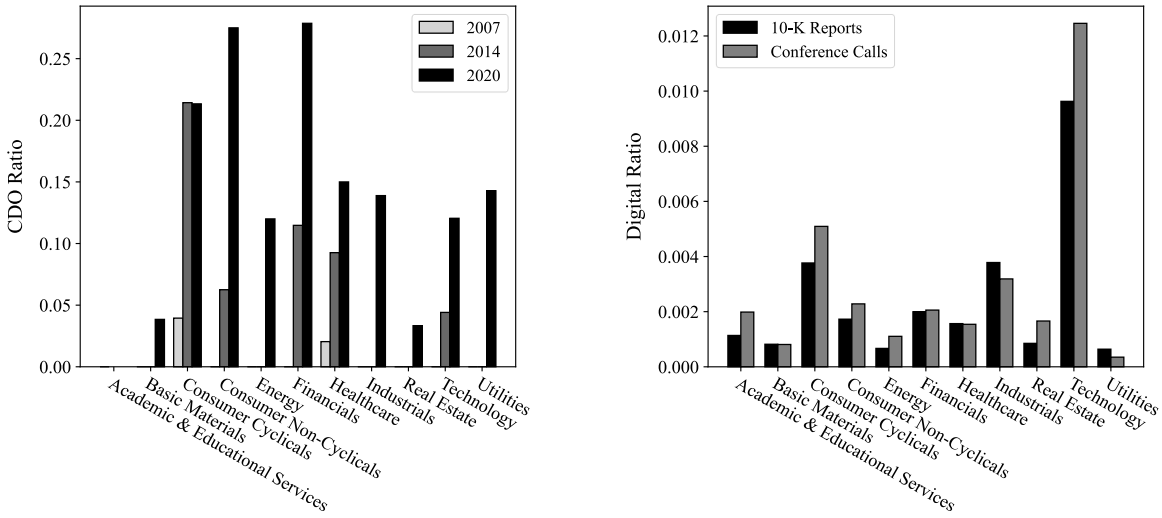

Figure 2. CDO Ratio and Digital Ratio Across Industries and Communication Tools

In line with existing literature (e.g., Firk et al. 2021; Kessel and Graf-Vlachy 2021), our data shows that the proportion of firms with a CDO in their top management team in firms with a high focus on intangible assets (e.g., Financials) is higher than in firms with a high focus on tangible assets (e.g., Basic Materials). The *Digital Ratio* measured in 10-K reports and conference calls also varies considerably among different industries. It is not surprising that the *Digital Ratio* of firms within the technology sector is the highest of all industries. This can be justified because these firms focus on developing and selling technology-based products and services. As a result, they have a high technology focus in their reporting. Consumer cyclical firms and industrial firms have a relatively high *Digital Ratio* as well. Firms of the basic materials industry and the utility industry have the lowest average *Digital Ratio*. Finally, another interesting finding in this dataset is that the average *Digital Ratio* in conference calls is higher than in 10-K reports. This might be due to the fact that 10-K reports only allow little flexibility, whereas conference calls also include a larger share of more spontaneous content. Further, since the content conference call documents is not highly regulated, this could indicate that digital transformation is more of a cheap talk for many firms.

The third dataset includes the control variables gathered from Refinitiv Datastream (accounting and price data) and SDC (M&A data). Table 1 shows the descriptive statistics for all variables. We only include a firm-year observation in our analysis if all variables from equation (1) are available (10-K report, conference calls transcripts, and control variables). We further drop singleton observations (firms with only one observation during the observation period) as they do not add within-firm variation to our analysis. This reduces the total number of firm-year observations for the subsequent analysis to 6,456.

	N	Mean	SD	P(0.01)	P(0.99)
Digital Ratio [CC]	6,456	0.0047	0.0100	0.0000	1.0507
Digital Ratio [10-K]	6,456	0.0039	0.0078	0.0000	1.0415
CDO	6,456	0.0649	0.2464	0.0000	1.0000
Intangibles Ratio	6,456	0.1667	0.4313	0.0000	1.783
Market to Book	6,456	2.6742	59.7569	-40.2000	45.9900
Total Assets (M)	6,456	41,267	142,956	475.685	731,781
Return on Assets	6,456	0.0697	0.0867	-0.2299	0.2990
Leverage Ratio	6,456	0.6177	18.1205	-12.7548	17.1008
Stock Return	6,456	0.1545	0.4173	-0.6859	1.4572
Digital M&A	6,456	0.0694	0.3500	0.0000	2.0000
Related CxO	6,456	0.7103	0.4536	0.0000	1.0000

Table 1. Descriptive Statistics

To better understand how the utilized variables are interrelated, we calculate the pairwise correlations (Pearson correlation). The results can be obtained from Table 2.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Digital Ratio [CC]	1										
(2) Digital Ratio [10-K]	0.68*	1									
(3) CDO	0.14*	0.11*	1								
(4) Intangibles Ratio	0.02*	0.04*	0.02*	1							
(5) Market to Book	0.01	0.02	0.01	0.01	1						
(6) Total Assets (M)	-0.01	0.01	0.06*	-0.01	-0.01	1					
(7) Return on Assets	0.10*	0.10*	-0.02	-0.09*	0.01	-0.09*	1				
(8) Leverage	0.01	0.01	0.01	-0.01	0.48*	-0.02*	-0.01	1			
(9) Stock Return	0.05*	0.04*	-0.01	-0.01	0.03*	0.04*	0.10*	-0.01	1		
(10) Digital M&A	0.33*	0.29*	0.04*	0.01	0.01	0.03*	0.06*	0.01	0.01	1	
(11) Related CxO	0.06*	0.08*	0.08*	-0.01	0.01	0.02*	0.04*	0.01	-0.01	0.07*	1
* significance at the 0.05 level											

Table 2. Correlation Matrix

A significant positive correlation between CDO presence and *Digital Ratio* can be observed, which could indicate a positive relation between CDO presence and the volume of digital transformation-related signals in external corporate communication. The correlation matrix also shows that a higher *Digital Ratio* is associated with a higher return on assets and higher stock returns. This could be interpreted as

communication about digital transformation measures that positively impact profitability (if increased communication is associated with increased digital transformation activities) and investors' assessment. The reversed direction could also be possible, so that particularly profitable firms invest their resources, especially in such activities, and communicate it to the capital market. There is also a positive correlation between firm size and CDO presence which is also as expected because larger firms typically have a larger board (Eisenberg et al. 1998) and are therefore more likely to implement more specific positions such as that of a CDO. Finally, we see higher Digital Ratios for firms that engage in *Digital M&As* and that have *Related CxOs* in their top management team.

Empirical Results

In order to evaluate the impact of CDO presence on the volume of digital transformation-related signals, we make use of the underlying data's panel structure. The analysis is divided into two parts. In the first part, we consider only first-time CDO appointments, while in the second part, the entire set of observations is utilized by the panel regression. First, we only look at the cases of first-time CDO appointments for which we can observe the two years before and the two years after the appointment. For this, the firm must exist for the entire five years, and data on CDO presence, conference call transcripts, and 10-K reports must be available for each year. This results in a total of 81 first-time appointments we can utilize. Thereby, our analysis focuses on the transition from a firm without CDO presence to a firm with CDO presence. The results of this analysis can be obtained from Figure 3.

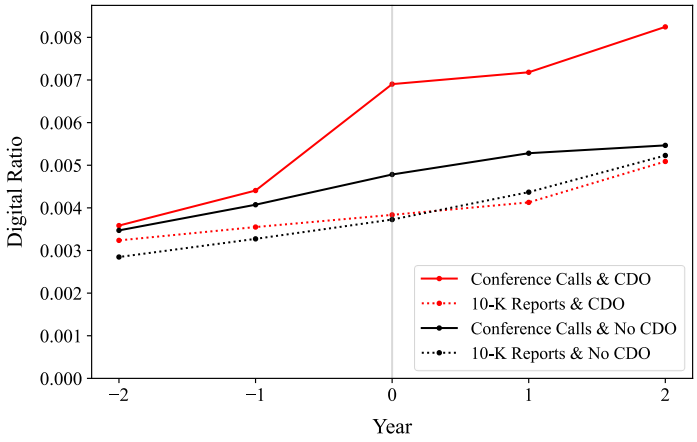

Figure 3. Digital Transformation Activities Around CDO Appointments

The red lines in Figure 3 show how the *Digital Ratio* changes over time relative to the first-time CDO appointment. The year 0 marks the year in which the CDO is appointed. The black lines serve as references and show how the *Digital Ratio* developed in the conference calls and the 10-K reports among those firms that did not appoint a CDO during the entire observation period. The temporal structure of the CDO groups and the reference groups are matched. For the conference calls (solid line), we observe an almost identical *Digital Ratio* in the two years before the appointment. However, in the year of the CDO appointment, the *Digital Ratio* rises sharply, while the reference firms only follow the overall trend. In the two years after the CDO appointment, the *Digital Ratios* are again relatively parallel, but those of the firms with a CDO are on a much higher overall level. This suggests that the CDO has triggered an increase in the volume of digital transformation-related signals in conference calls. Based on 10-K reports (dotted line), no such effect can be observed. The two graphs are thus relatively similar over the entire period under consideration. Again, this could indicate that digital transformation is more of a cheap talk for many firms. Firms indeed increase their digital transformation-related signaling after CDO appointments, however, mostly in less regulated communication tools with lower signal reliability. Further, in 10-K reports firms have only little flexibility, whereas conference calls also include a larger share of spontaneous content and Q&A sessions.

The findings derived from Figure 3 provide a first indication that H1 and H2 can be confirmed. Thereby, the confirmation of H1 is mainly driven by the conference calls. To provide statistical evidence, we make

use of a research approach in which all 6,456 firm-year combinations are utilized and not only the limited time periods surrounding first-time CDO appointments as in the previous analysis. Due to the larger number of observations and the numerous control variables, this analysis allows more precise statements about the effects of CDOs on digital transformation-related signaling. The results are shown in Table 3.

	[1] Digital Ratio [CC]	[2] Digital Ratio [10-K]	[3] Digital Ratio [CC]	[4] Digital Ratio [10-K]
CDO	0.0053***	0.0035***	0.0031**	0.0009*
	(10.51)	(9.05)	(2.54)	(1.80)
Intangibles Ratio			-0.0016**	-0.0011**
			(-2.12)	(-2.19)
Market to Book			0.000001	0.000001
			(1.15)	(1.51)
ln(Total Assets)			0.0014**	0.0013***
			(2.10)	(2.96)
Return on Assets			0.0010	0.00004
			(0.43)	(0.02)
Leverage Ratio			-0.000002	-0.000003
			(-0.48)	(-1.08)
Stock Return			0.0003	0.0002
			(0.69)	(1.29)
ln(1+Digital M&A)			0.0030***	0.0025**
			(3.22)	(2.43)
Related CxO			-0.0003	-0.0007*
			(-0.32)	(-1.72)
Intercept	0.0043***	0.0037***	-0.0085	-0.0075*
	(33.90)	(37.12)	(-1.43)	(-1.93)
N	6,456	6,456	6,456	6,456
Fixed Effects	No	No	Firm & Year	Firm & Year
Clustering	No	No	Firm	Firm
Adj. R^2	0.017	0.012	0.628	0.718
* p<0.1, ** p<0.05, *** p<0.01; t statistics in parentheses				

Table 3. Panel Regression

Models [1] and [2] are standard OLS regressions. Thus, they do not consider the panel structure of the underlying data. However, they show that CDO presence has a positive effect on the *Digital Ratio*. Models [3] and [4] correspond to equation (1) specified in the methodology section. Also, based on these regression models, it can be seen that CDO appointments have a significant positive effect on the *Digital Ratio* in the conference calls (p=0.010). The effect with respect to the 10-K reports is almost significant (p=0.072) but with less than a third of the magnitude compared to the effect on conference calls. Thus, H1 and H2 can be confirmed. Both models account for multiple control variables, firm fixed effects, and year fixed effects. Furthermore, we use heteroskedasticity-robust standard errors that are clustered on the firm dimension. The regression coefficient of 0.0031 for the conference calls also shows an economically significant effect size, considering that the mean value across all years and firms is only 0.0047 and that even if only the firms that introduce a CDO later in the observation period are considered, the mean *Digital Ratio* is only 0.0055 in the year before the CDO is appointed. The CDO effect thus corresponds to an increase of 56.36% in the *Digital Ratio* of conference calls. The results clearly confirm that CDO presence is associated with an increase in the volume of digital transformation-related signals and that this signaling primarily takes place via less regulated communication tools (i.e., conference calls). Interestingly, we do not see a significant effect of *Related CxO* positions on digital transformation-related signaling, which emphasizes the specific role of CDOs concerning digital transformation.

Discussion

Theoretical and Practical Implications

This paper enhances existing literature in the research stream "Consequences of CDO presence" in manifold ways. Our analysis shows that CDO presence is continuously increasing across S&P500 firms which underlines the high relevance of CDOs for firms. Further, it underlines the strategic importance of dealing with the decision on appointing a CDO or not. Our data indicates that CDO presence and digital transformation-related signaling in external communication tools vary across industries. In line with existing literature, we show that CDO presence in firms focusing on intangible assets is higher than in firms with tangible assets (e.g., Firk et al. 2021; Kessel and Graf-Vlachy 2021).

Consistent with existing studies, we show that the appointment of a particular position in the top management team can be associated with increased signaling in the area of responsibility of this person (e.g., Kralina 2018). In our case, we show that CDO presence leads to a higher volume of digital transformation-related signals within firms' main external communication tools (i.e., firm's 10-K reports and conference calls). Thus, CDO presence is associated with a higher volume of digital transformation-related signals in a firm's corporate communication tools. In addition, our results indicate significant differences between the volume of digital transformation-related signals in highly regulated communication tools (i.e., 10-K reports) and less regulated ones (i.e., conference calls). Conference calls contain a relatively higher amount of such signals. Concerning signal reliability, it can be assumed that digital transformation is more of a cheap talk for many firms. These firms like to talk about it but do not substantially engage in digital transformation activities. In that regard, CDO presence indeed reinforces digital transformation-related signaling. However, mostly associated with relatively low signal reliability. Overall, it remains questionable if the increased signaling through CDO presence is suitable for reducing potential information asymmetries. Another potential reason for the predominant use of non-regulated communication tools, is that 10-K reports are highly standardized documents in which firms have only little flexibility. This makes it more difficult for firms to address current issues as quickly as possible. Second, conference calls also include a large share of spontaneous content. In such conference calls, firms have the possibility to present and discuss current issues. In addition, in conference calls, external analysts and other persons can ask questions that can increasingly be related to digitalization activities. Therefore, it can be assumed that digital transformation-related signaling works easier through less regulated communication tools. However, again, this bears the risk that such less regulated communication tools are not as trustworthy as more regulated communication tools. Consistent with these results, we also found considerable variation among the different document types concerning the increase of the scope in digital transformation-related content as a direct reaction to the first-time appointment of a CDO. Whereas we can observe a sharp increase in digital transformation-related content in conference calls as a reaction to CDO appointments, the increase in 10-K reports does not exceed the overall trend. This also might be due to the highly regulated and standardized nature of 10-K reports. Overall, these results indicate that less regulated communication tools (i.e., conference calls) are more likely to be used to address digital transformation-related topics. Investors searching for information concerning firms' digital transformation activities, therefore, are more likely to find such information in less-regulated communication tools. However, at the same time, these communication tools are accompanied by lower signal reliability. Thus, it could be that firms rather just referencing digital technologies and digital transformation in order to, say, impress the investors instead of implementing these technologies.

For firms, our study can support the decision-making process when facing the question of appointing a CDO to the top management team or not. Our study suggests that appointing a CDO to the top management team is an excellent option for firms that are at least interested in improving their digital perception with regard to external stakeholders. Nevertheless, our study does not replace a systematic decision-making process. Firms should also consider their specific requirements and determine their individual needs.

Finally, although our results confirm hypothesis 2, that the impact of CDO presence on the quantity of digital transformation-related content in less regulated communication tools is different than in highly regulated communication tools, these results are questionable from a regulatory point of view. On the one hand, firms have to report all material information, including qualitative information, in a 10-K report. Indeed, digital transformation-related topics are material information as the degree of digitalization

impacts the future competitiveness of firms. However, on the other hand, digital transformation-related topics play a rather subordinate role in 10-K reports.

Limitations and Future Research

Besides the careful design of our research approach, this study is subject to some limitations. First, our study only considers S&P500 firms. Therefore, our results can only be generalized to large US-based firms. Future research could build on this by verifying whether our results can be confirmed in other countries and for small and medium-sized enterprises (SMEs). In addition, we only assessed two specific communication tools (i.e., conference calls and 10-K reports). These are the very important communication tools of firms to get in touch with investors and other stakeholders. However, these sources still only represent a selection of relevant communication tools of firms. Future research could adopt this methodology and could, for example, also analyze firms' websites and other publicly available sources.

The volume of digital transformation-related signals in documents is measured based on a dictionary, which allows a high degree of transparency and replicability for future research. However, machine learning techniques may extract such content with a higher degree of accuracy (Huang et al. 2014). Further, although we already extended the existing dictionary of digital words, future research could extend it even further, e.g., by adding more digital technology-related word-groups.

One of the most ubiquitous problems in research on firm's management teams concerns endogeneity. Decisions on the structure of the top management team are typically made consciously and in particular based on strategic considerations. As a result, our results may not be causally driven by the CDO. Our results (increased relevance of digital transformation activities) and the appointment of the CDO could also be driven simultaneously by a third variable that is not considered. At the same time, the CDO presence could have no causal impact on the scope of digital transformation-related communication. For this reason, our results can only indicate an association between the presence of a CDO and the relevance of digital transformation activities in firms. While we control for numerous possible factors through the use of firm and year fixed effects as well as control variables that could drive our results, we cannot derive flawless causality based on our study design. This leads to the possibility that the results could be affected by the phenomenon that firms with a higher strategic focus on digital transformation naturally engage more in digital transformation activities (independent of the presence of a CDO). Future research is encouraged to further improve this approach in order to minimize endogeneity issues further.

Our study indicates that CDO presence is associated with a higher volume of digital transformation-related signals quantitatively. Future research could build on this by verifying whether there also is a causal effect between these variables. Further, our study assumes that this higher quantity of digital transformation-related signaling, i.e., higher information quantity, goes along with higher information quality, reducing potential information asymmetries. However, it remains unclear whether the presence of a CDO really has a positive impact on the quality of digital transformation-related signaling and thereby has the power to reduce potential information asymmetries. Future research could build on this by qualitatively analyzing the content of digital transformation-related signaling of firms with a CDO vs. firms without a CDO. Finally, future research could also investigate whether a higher quantity of digital transformation-related signaling has an impact on specific information asymmetry proxies (e.g., bid-ask spreads), financial performance, and capital market parameters.

Conclusion

Existing CDO-related research indicates that firms appoint CDOs to the top management team intending to drive and coordinate digital transformation activities and communicate digital transformation-related topics with stakeholders (e.g., Singh and Hess 2017; Grossman and Rich 2012). However, until now, it remained unclear whether those firms appointing a CDO are more likely to conduct digital transformation-related signaling, especially in their external communication tools, and whether a CDO appointment is an appropriate instrument to increase a firm's external visibility and to handle investor relations concerning digital transformation. With this study, we approached this research gap by analyzing the impact of CDO presence on the volume of digital transformation-related signals in firms' external communication tools.

Our empirical results indicate that CDO presence leads to an increase in the discussion of digital transformation-related topics in firms' external communication tools. This increase in the volume of digital transformation-related signals can be observed directly after a CDO appointment. In addition, we show that this effect is mainly driven by the impact on less regulated communication tools (i.e., conference calls). Overall, our results highlight that the presence of a CDO in the top management team can be associated with a higher volume of digital transformation-related signals in a firms' external communication tools. Therefore, it can be concluded that a CDO is an appropriate instrument to increase a firms' external visibility and to handle investor relations concerning digital transformation. However, concerning signal reliability, investors and other external stakeholders need to evaluate whether a firm actually engages in digital transformation or if it is more of a cheap talk.

References

Berman, S., Baird, C., Eagan, K., and Marshall, A. 2020. "What Makes a Chief Digital Officer Successful?," *Strategic Leadership* (48:1), pp. 32-38.

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., and Venkatraman, N. 2013. "Digital Business Strategy: Toward a Next Generation of Insights," *MIS Quarterly* (37:2), pp. 471-482.

Björkdahl, J. 2020. "Strategies for Digitalization in Manufacturing Firms," *California Management Review* (62:1), pp. 17-36.

Bowman, E. H. 1984. "Content Analysis of Annual Reports for Corporate Strategy and Risk Analyzing The," *Strategic Management Journal* (14:1), pp. 61–71.

Brown,S., Hillegeist, S. A., and Lo, K. 2004. "Conference Calls and Information Asymmetry," *Journal of Accounting and Economic*s (37:3), pp. 343-366.

Cannon, J. N., Ling, Z., Wang, Q., and Watanabe, O. V. 2020. "10-K Disclosure of Corporate Social Responsibility and Firms' Competitive Advantages," *European Accounting Review* (29:1), pp. 85-113.

Chen, W., and Srinivasan, S. 2019. "Going Digital: Implications for Firm Value and Performance," *Working Paper*.

Connelly, B. L., Certo, S. T., Ireland, R. D., and Reutzel, C. R. 2011. "Signaling Theory: A Review and Assessment," *Journal of Management* (37:1), pp. 39-67.

Drechsler, K., Wagner, H.-T., and Reibenspiess, V. 2019. "Risk and Return of Chief Digital Officers' Appointment – An Event Study," in *Proceedings of the 40th International Conference on Information Systems*, Munich, Germany.

Eden, R., Burton Jones, A., Casey, V., and Draheim, M. 2019. "Digital Transformation Requires Workforce Transformation," MIS Quarterly Executive (18:1), Article 4.

Eisenberg, T., Sundgren, S., and Wells, M.T. 1998. "Larger Board Size and Decreasing Firm Value in Small Firms," *Journal of Financial Economics* (48:1), pp. 35-54.

Firk, S., Hanelt, A., Oehmichen, J., and Wolff, M. 2021. "Chief Digital Officers: An Analysis of the Presence of a Centralized Digital Transformation Role," *Journal of Management Studies*, doi: 10.1111/joms.12718.

Fu, R., Kraft, A., and Zhang, H. 2012. "Financial Reporting Frequency, Information Asymmetry, and the Cost of Equity," *Journal of Accounting and Economics* (54:2-3), pp. 132-149.

Grossman, S. J. and Hart, O. D. 1983. "An Analysis of the Principal-Agent Problem," *Econometrica* (51:1), pp. 7-46.

Grossman, R., Rich, J., 2012. *The Rise of the Chief Digital Officer*, Russell Reynolds Associates: New York, NY.

Haffke, I., Kalgovas, B., and Benlian, A. 2016. "The Role of the CIO and the CDO in an Organization's Digital Transformation," in *Proceedings of the 37th International Conference on Information Systems*, Dublin, Ireland.

Hanelt, A., Firk, S., Hildebrandt, B., and Kolbe, L. M. 2020. "Digital M&A, Digital Innovation, and Firm Performance: An Empirical Investigation," *European Journal of Information Systems* (30:1), 3-26.

Huang, A. H., Zang, A. Y., and Zheng, R. 2014. "Evidence on the Information Content of Text in Analyst Reports," *The Accounting Review* (89:6), pp. 2151-2180.

Hess, T., Matt, C., Benlian, A., and Wiesböck, F. 2016. "Options for Formulating a Digital Transformation Strategy," *MIS Quarterly Executive* (15:2), pp. 123-139.

Huang, A. H., Lehavy, R., Zang, A. Y., and Zheng, R. 2018. "Analyst Information Discovery and Interpretation Roles: A Topic Modeling Approach," *Management Science* (64:6), pp. 2833-2855.

Kessel, L. and Fraf-Vlachy, L. 2021. "Chief Digital Officers – Review and Research Agenda," in *Proceedings of the 16th International Conference on Wirtschaftsinformatik*, Essen, Germany.

Kloptchenko, A., Eklund, T., Karlsson, J., Back, B., Vanharanta, H., and Visa, A. 2004. "Combining Data and Text Mining Techniques for Analysing Financial Reports," *Intelligent Systems in Accounting, Finance & Management* (12:1), pp. 29-41.

Kralina, L. 2018. "Big Data Signaling in Annual Reports: Does the Presence of a Chief Data Officer (CDO) Signal Big Data Initiatives in Annual Financial Reports?," Journal of Business & Financial Affairs (7:2), pp. 1-3.

Kunisch, S., Menz, M., and Langan, R. 2020. "Chief Digital Officers: An Exploratory Analysis of Their Emergence, Nature, and Determinants," *Long Range Planning* (101999), pp. 1-17.

Lee, J., and Hong, Y. S. 2014. "Business Model Mining: Analyzing a Firm's Business Model with Text Mining of Annual Report," *Industrial Engineering and Management Systems* (13:4), pp. 432–441.

Leonhardt, D., Hanelt, A., Huang, P., and Mithas, S. 2018. "Does One Size Fit All? Theorizing Governance Configurations for Digital Innovation," in *Proceedings of the 39th International Conference on Information Systems*, San Francisco, CA.

Luciano, M. M., Nahrgang, J. D., and Shropshire, C. 2020. "Strategic Leadership Systems: Viewing Top Management Teams and Boards of Directors from a Multiteam Systems Perspective," *Academy of Management Review* (45:3), pp. 675-701.

Matt, C., Hess, T., and Benliam, A. 2015. "Digital Transformation Strategies," *Business Information Systems Engineering* (57:5), pp. 339-343.

Metzler, D.R. and Muntermann, J. 2020. "The Impact of Digital Transformation of Incumbent Firms: An Analysis of Changes, Challenges, and Responses at the Business Model Level," in *Proceedings of the 41st International Conference on Information Systems*, Hyderabad, India.

Moker, A., Brosi, P., and Welpe, I. M. 2020. "It Depends on the Size: How Firm Strategic Emphasis on Digital Transformation Predicts Market Capitalization," in *Proceedings of the 53rd Hawaii International Conference on System Sciences*.

Pavlou, P., Liang, H., and Xue Yajiong. 2007. "Understanding and Mitigating Uncertainty in Online Exchange Relationships: A Principal-Agent Perspective," *MIS Quarterly* (31:1), pp. 105-136.

Péladeau, P., Herzog, M., & Acker, O. (2017). "The New Class of Digital Leaders," *Strategy + Business* (88:1), pp. 1-5.

Reck, F. and Fliaster, A. 2018. "How to Drive Digital Transformation? – A Configurational Analysis on the Impact of CDOs," in *Proceedings of the 2018th Proceedings of the Academy of Management*.

Reck, F. and Fliaster, A. 2019. "Four profiles of successful digital executives," *MIT Sloan Management Review*, pp. 1-8.

Sebastian, I. M., Ross, J. W., Beath, C., Mocker, M., Moloney, K., and Fonstad, N. O. 2017. "How Big Old Firms Navigate Digital Transformation," *MIS Quarterly Executive* (16:3), pp. 197-213.

SEC 2021. "Form 10-K," U.S. *Securities and Exchange Commission (SEC)*. (https://www.investor.gov/introduction-investing/investing-basics/glossary/form-10-k/, accessed April 28th, 2021).

Singh, A., and Hess, T. 2017. "How Chief Digital Officers Promote the Digital Transformation of Their Firms," *MIS Quarterly Executive* (16:1), pp. 1-17.

Singh, A., Klarner, P., and Hess, T. 2020. "How do Chief Digital Officers Pursue Digital Transformation Activities? The Role of Organization Design Parameters," *Long Range Planning* (53:3), (101890).

Spence, M. 1973. "Job Market Signaling," *Quarterly Journal of Economics* (87:3), pp. 355-374.

Spence, M. 2002. "Signaling in Retrospect and the Informational Structure of Markets," *American Economic Review* (92:3), pp. 434-459.

Tumbas, S., Berente, N., and vom Brocke, J. 2017. "Three Types of Chief Digital Officers and the Reasons Organizations Adopt the Role," *MIS Quarterly Executive* (16:1), pp. 121-134.

Tumbas, S., Berente, N., and vom Brocke, J. 2018. "Digital Innovation and Institutional Entrepreneurship: Chief Digital Officer Perspectives of their Emerging Role," *Journal of Information Technology* (33:1), pp. 188-202.

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., and Haenlein, M. 2019. "Digital Transformation: A Multidisciplinary Reflection and Research Agenda," *Journal of Business Research* (122:1), pp. 889-901.

Vial, G. 2019. "Understanding Digital Transformation: A Review and a Research Agenda," *The Journal of Strategic Information Systems* (28:2), pp. 118-144.

Westerman, G., Bonnet, D., and McAfee, A. 2014. *Leading Digital: Turning Technology into Business Transformation*, Harvard Business Review Press: Harvard, UK.
Wooldridge, J. 2016. *Introductory Econometrics: A Modern Approach,* Boston, MA: Cengage Learning.Zhan, X. and Mu, Y. 2016. "Examining the Shareholder Value Effects of Announcements of CDO Position," in *Proceedings of the 13th International Conference on Service Systems and Service Management*, Kunming, China.

Appendix

Word Groups	Relevant Key Words	
Social Media	social media web 3.0	web 2.0
Mobile	smart mobility app mobility smartphone* self driving	ewallet* / e-wallet* epayment* / e-payment* electronic wallet* electronic payment* wearable*
Analytics	analytics big data smart data	data scien* data mining business intelligence
Cloud	cloud platform* cloud based cloud computing	cloud deployment* distributed cloud*
Internet of Things	internet of things iot internet of everything enterprise 4.0	industry 4.0 smart manufacturing smart production
Artificial Intelligence	artificial intelligence ai ai related autonomous tech* intelligent system* computer vision neural network* virtual machine* virtual realit*	virtual agent* virtual assistant* chatbot* augmented realit* extended realit* smart device* robotic process automation rpa
Machine Learning	biometric deep learning machine learning natural language processing nlp	image recognition facial recognition speech recognition voice recognition sentiment analysis
Blockchain	blockchain	cryptocurrency*
Digitalization	digiti* digitali* digital transform* digital revolution digital strateg*	digital marketing digital business* digital platform* agile

Table 4: Dictionary of Digital Words