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When and why technology leadership enters the C-suite: An antecedents perspective on CIO presence

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ABSTRACT

Building on the concept of dynamic managerial capabilities, we set out to advance scholarly understanding of the antecedents of the presence of technology leadership in the form of the chief information officer (CIO) in the top management team. We derive a holistic framework from the literature of dynamic capabilities and introduce into that literature the concept of adaptation pressures. We suggest that external and internal dimensions that pertain to information technology, comprising an environmental, structural, and strategic dimension, intensify the pressure on a firm to adapt. The pressure to adapt increases the likelihood that the firm will add a CIO to its top management team. In turn, the presence of a CIO can direct a firm toward exploration as a way to relieve the adaptation pressure. Results from regression analyses of a longitudinal data set covering 503 large U.S. firms from 2006 to 2017 confirm our hypotheses. This study contributes to the literature of both information systems and strategy by clarifying the antecedents of technology leadership in the C-suite and explicating how environmental, structural, and strategic factors can act as such antecedents. Moreover, this study reinforces the notion that IT leadership can induce strategic change.

Introduction

Researchers in the area of information systems highlight the importance of dynamic capabilities in fostering organizational change (e.g., Roberts et al., 2016; Yeow et al., 2018). Meanwhile, information systems scholars call for a better alignment between information technology (IT) strategy and business strategy (e.g., Renaud et al., 2016). The dynamic capabilities view maintains that dynamic capabilities – a firm's capacity to "purposefully create, extend, or modify its resource base" (Helfat et al., 2007, p. 4) – can systematically improve operational efficiency and alignment with the industry environment (Teece, 2007; Teece et al., 1997). While the dynamic capabilities view is a major theme in strategy research (e.g., Schilke et al., 2018; Wilden et al., 2016), its application to

Abbreviations: BEA, U.S. Bureau of Economic Analysis; CATA, Computer-aided text analysis; CDO, Chief digital officer; CEO, Chief executive officer; CIO, Chief information officer; CRSP, Center for Research in Security Prices; CTO, Chief technology officer; GEE, Generalized estimation equations; GMM, Generalized methods of moments; I/B/E/S, Institutional Broker's Estimate System; IT, Information technology; ITCV, Impact threshold of confounding variable; NAICS, North American Industry Classification System; QIC, Quasi-likelihood of the independence model criterion; SEC, U.S. Securities and Exchange Commission.

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information systems studies is nascent (e.g., Yeow et al., 2018). One way to bridge the gap between information systems and strategy is with the concept of dynamic managerial capabilities, which asserts that dynamic capabilities are embodied in top managers. From a dynamic managerial capabilities perspective, the chief information officer (CIO) can be seen as a source of technology leadership capabilities (Helfat and Martin, 2015).

Researchers using the concept of dynamic managerial capabilities have made great strides in understanding consequential outcomes in strategy research (e.g., Helfat and Martin, 2015). We suggest that it is a good idea to inquire why technology leaders, as sources of dynamic managerial capabilities, become part of top management teams in the first place. The current unclarity on the antecedents of IT leadership in the C-suite impedes information systems and strategy research in two ways. First, scholarly knowledge is scant about the presence of CIOs at the strategy table. One reason for this shortcoming may be the missing theoretical anchoring. We posit that dynamic managerial capabilities can link the dynamic capabilities view with information systems research and develop theory towards a more holistic view of leadership choices. Second, the concept of dynamic managerial capabilities has only infrequently been applied to types of managers. This limitation hinders information systems scholars from effectively using and contributing to the literature on dynamic managerial capabilities – as indicated by a relatively sparse set of information systems studies building on the concept of dynamic managerial capabilities. We believe that giving more theoretical nuance to dynamic managerial capabilities and applying the concept to technology leadership will help information systems literature advance "interest in managerial capabilities" (Wilden et al., 2016, p. 1026) and help to achieve convergence between information systems and strategy research.

In this study, we take an antecedents view of dynamic managerial capabilities. We set out to examine when and why technology leaders like the CIO are added to the top management team as well as the impact of their presence on a firm's orientation towards exploration. Given the ongoing advances in IT, firms and their top management need to adapt, including, sometimes, by shifting the composition of the top management team (e.g., Ceipek et al., 2021). As part of our theorizing on when and why CIOs act as sources of dynamic managerial capabilities, we introduce the concept of *adaptation pressures* into dynamic managerial capabilities theory. Adaptation pressures can arise in the firm's environment and within the firm. We theorize that IT-related external and internal dimensions foster adaptation pressures, which – once a certain threshold is reached – induce the firm to initiate adaptation processes such as appointing a CIO to the C-suite. We theorize that three antecedents, one environmental, one structural, and one strategic, affect the firm's adaptation pressures. Adding technological capabilities by bringing in a figure such as a CIO, firms aim to relieve adaptation pressures and make change a priority, usually by orienting the firm away from the exploitation of its legacy routines and toward the exploration of new ones.

To explore these ideas, we use a longitudinal data set of 4,156 firm-year observations covering 503 large U.S. firms from 2006 to 2017. Regression analyses of panel data support our theorizing by showing that certain environmental, strategic, and structural factors act as antecedents to the presence of CIOs in the top management team. We confirm that CIO presence increases a firm's relative orientation toward exploration, which supports our idea that technology leaders can relieve adaptation pressures by fostering organizational change.

Our study makes at least two critical contributions to information systems research and strategy literature. First, we build upon the concept of dynamic managerial capabilities and its nascent application in information systems literature (e.g., Yeow et al., 2018) and enhance it with a top management perspective. The concept of dynamic managerial capabilities within the dynamic capabilities view is crucial to clarify both the presence of specific individual CIOs and also their impact on organizational change. While considerable work has examined the effects of including CIOs in the top management team (e.g., Benaroch et al., 2017; Zafar et al., 2016), the need remains to assess when and why CIOs have been appointed to firm leadership in the first place. We introduce the mechanism of adaptation pressures to theoretically develop and identify the drivers of CIO presence (e.g., Acharya and Pollock, 2013) and explain how environmental, structural, and strategic factors lead to the adoption of IT executives in the top management team (Banker et al., 2011; Benaroch et al., 2017; Menz, 2012). This perspective integrates prior work on IT leadership into a cohesive theoretical framework and helps to further align the literatures of strategy and information systems.

Second, literature in information systems and strategy has shown that top managers, especially chief executive officers (CEOs), can shape a firm's exploration orientation. In that vein, we echo the idea that "IT is ultimately a change function" (Peppard, 2010, p. 89), with CIOs being "agent[s] of business change" (Banker et al., 2011, p. 488; Thatcher et al., 2011). We anchor these claims conceptually and reinforce the notion that IT leaders can help firms relieve adaption pressures via exploration.

Theory and hypotheses

Dynamic managerial capabilities: relevance for information systems research

Recent information systems research suggests that the dynamic capabilities view is a suitable theoretical lens to examine organizational adaptation and alignment (e.g., Božič and Dimovski, 2019; Yeow et al., 2018), and that it can help firms identify ways to transform digitally (Warner and Wäger, 2019). Dynamic capabilities can be understood as "the processes by which firms reconfigure their resources in order to gain competitive advantage" (Daniel and Wilson, 2003, p. 283). Dynamic capabilities are most valuable in circumstances of change (Schilke, 2014; Teece et al., 1997). Most notably, dynamic capabilities can promote strategic and organizational alignment with the environment (e.g., Fainshmidt et al., 2019), a crucial topic for information systems scholars (e.g., Daniel et al., 2014). Prior studies have shown that IT is both an antecedent and consequence of dynamic capabilities (e.g., Macher and Mowery, 2009; Pavlou and El Sawy, 2010; Roberts et al., 2016).

In this study, we add a top management team perspective to theory on dynamic capabilities in information systems. We wish to understand the antecedents and consequences of IT-specific dynamic managerial capabilities in the firm. *Dynamic managerial*

capabilities depend on "the firm's senior management's perception of opportunities to productively change existing routines or resource configurations, their willingness to undertake such change, and their ability to implement these changes" (Zahra et al., 2006, p. 918). At the center of dynamic managerial capabilities are transformational processes, which, like digital transformation, require management "to recombine and reconfigure assets and organizational structures as the enterprise grows, and as markets and technologies change" (Teece, 2007, p. 1335).

Information systems literature has examined the vital role of technology leadership, especially the CIO, for IT-related change in the organization (e.g., Banker et al., 2011; Peppard, 2010). These studies have established *that* the assessment of technology leadership is warranted. Dynamic managerial capabilities offer the possibility to stress *when* and *why* technology leadership matters for organizational change and alignment. As a form of dynamic capabilities, they are a conceptual bridge between information systems literature on technology leadership and the research that has been done on dynamic capabilities in the strategy literature. Dynamic managerial capabilities reside in a firm's top managers (Helfat and Martin, 2015), such as CIOs, and are concerned with corporate change, renewal, and alignment.

While dynamic managerial capabilities have become an established research stream within the dynamic capabilities view (Helfat and Martin, 2015), research has not yet focused on specific functional roles that are potential sources of them in the top management team. However, dynamic capabilities are frequently portrayed in existing research as readily available in the top management team. This ready availability is questionable, as sources of dynamic managerial capabilities, that is, managers, need to be incorporated into the C-suite first. From the point of view of information systems, it is surprising that the use of IT by any manager is identified as an antecedent of a firm's dynamic managerial capabilities, as information systems literature asserts that a specially qualified agent is required to handle IT (Roberts et al., 2016). We do not have a clear picture of when and why qualified technology leaders such as CIOs enter the top management team, or how their presence shapes the related strategic outcomes. In this study, we set out to investigate antecedents of dynamic managerial capabilities as exemplified by the appointment of a CIO at the apex of the firm.

Technology leadership as a source of dynamic managerial capabilities

Synthesizing the information systems literature on technology leadership (e.g., Gonzalez et al., 2019; Peppard, 2010; Taylor and Vithayathil, 2018), we argue that technology leadership, and specifically that embodied by the CIO, is vital to build and maintain firm-level dynamic capabilities. The role of functional top management team members (top executives responsible for one or more specific functional areas such as finance, marketing, or IT) is receiving increasing scholarly attention (e.g., Menz, 2012). While there is ongoing interest in IT capabilities – skills and resources that allow a firm to exploit its existing IT assets – information systems research acknowledged early on that to leverage those capabilities, senior executives' *managerial* capabilities are needed (e.g., Johnston and Carrico, 1988). This rationale aligns with the idea that firm-level dynamic capabilities can originate from dynamic managerial capabilities at the top management level (Helfat and Martin, 2015; Teece, 2012).

The most valuable managerial IT capability should be embodied in the role of the CIO, commonly the highest-ranked IT executive in an organization. Although CIOs' exact roles and responsibilities may vary among firms and with the maturity of the organization (e.g., Preston et al., 2008), and may range from assembling IT capabilities to preserving and advancing the vitality of IT activity (Gerth and Peppard, 2014), their core responsibility is to manage the IT function and generate business value from it (Banker et al., 2011). With the rise of digital transformation, the CIO role in many firms has become even more strategic, able to shape the firm's trajectory and initiate change within it (e.g., Chen et al., 2010; Gerth and Peppard, 2016). Notably, the predominant idea that IT is indispensable for organizational change goes hand in hand with the idea that the CIO is in charge of that change (e.g., Banker et al., 2011; Peppard, 2010). The CIO's set of tasks includes many change-oriented activities, such as managing alterations to business processes (Chun and Mooney, 2009), redesigning firm strategy (Banker et al., 2011), and fostering IT-enabled change projects and programs (Peppard, 2010). Hence, the CIOs can be a source of organizational change and adaptation, or, to use the language of the dynamic capabilities perspective, a source of dynamic managerial capabilities.

Many studies have theorized on, and empirically examined, the consequential outcomes of technology leadership in the top management team. Table 1 provides an overview of key studies examining firm top management team executives in the information systems literature since 2010. Please refer to Li et al. (2021) for a general overview of leadership studies in information systems. While several studies assess strategic outcomes of CEO compensation, the CEO-CIO relationship, top management team relationships, CIO presence, and CIO characteristics, our understanding of how technology leadership emerges is still limited.

What brings sources of dynamic managerial capabilities to the C-suite? The concept of adaptation pressures

In developing a theoretical framework, we contribute to the discussion of the reasons why a firm reconfigures its top management team and adds a potential source of dynamic managerial capabilities through appointing a CIO. Prior work indicates that major shifts in technology can create strong "pressures for adaptation" (Benner and Ranganathan, 2012, p. 214). These changes can require firms to develop new capabilities. According to the dynamic capabilities view, dynamic managerial capabilities are "required to adapt to changing customer and technological opportunities" and thus, "much of the traditional literature on organizational adaptation (…) is consistent with dynamic capabilities" (Teece, 2007, p. 1337). In the same vein, the mechanism of adaptation pressures underpins our theoretical framework, in which the build-up of dynamic managerial capabilities through appointing a technology leader to the top management team is triggered once adaptation pressures reach a certain level. Following stimulus-response logic on the development and evolution of change-oriented capabilities, we posit that firms rarely initiate the build-up of such capabilities without reason (e.g., Pierce et al., 2002); stimuli are essential (e.g., Zollo and Winter, 2002). Information systems literature finds that "the persistent

Table 1
Overview of key studies examining firm top management team executives in the information systems literature since 2010.

Authors	Top executive in focus	Type of study	Level of analysis	Independent variable(s)	Dependent variable(s)	Key findings
Banker, Hu, Pavlou, and Luftman (2011)	CIO (reporting to CEO and CFO)	Quantitative with survey and secondary data	Firm	- Strategic positioning (cost leadership vs. differentiation) - Alignment strategic positioning and CIO reporting structure	- CIO reporting structure - Firm performance	- Differentiators are more likely to have CIO report to CEO; cost leaders are more likely to have CIO report to CFO - Alignment between a firm's strategic positioning and its CIO reporting structure increases firm performance
Benaroch et al. (2017)	CIO, CTO	Quantitative with secondary data	Firm	- Cumulative abnormal returns around IT failures - CIO turnover	- Board IT competency	- Firms increase their board IT competency level with an increase in the IT experience of internal directors and CIO board turnover after operational IT failures - CIO turnover likelihood is lower in IT-intensive firms
Benlian and Haffke (2016)	CEO, CIO	Quantitative with survey data	Individual	- CEO's understanding of CIO - CIO's understanding of CEO	- Quality of collaboration - IT contribution	- CEO and CIO opinions are more similar than perceived - CIO's understanding of CEO plays a more pivotal role in predicting quality of CEO–CIO collaboration - Perceived collaboration quality increases presumed IT business value
Chen, Preston and Xia (2010)	CIO	Quantitative with survey data	Firm	- CIO human capital - CIO structural power - Organizational IT support - CIO demand-side leadership - CIO supply-side leadership	- IT contribution to firm efficiency - IT contribution to strategic growth	- CIO supply-side leadership facilitates CIO demand-side leadership - CIO supply-side leadership has a direct influence on IT contribution to efficiency but only indirectly on IT contribution to strategic growth - CIO human capital and organizational support for IT increase CIO supply-side leadership but not CIO demand-side leadership
Chen, Zhang, Xiao, and Xie (2021)	CIO, TMT	Quantitative with survey data	Individual, firm	- CIO strategic authority - CIO/TMT partnership - CIO IT-related strategic knowledge - CIO political savvy	- CIO issue selling effectiveness - Firm digital innovation success	- All four assessed CIO characteristics positively relate to CIO issue selling effectiveness - CIO issue selling perspective is positively associated with a firm's digital innovation success. The relationship is positively moderated by CIO structural power
Choi, Chung, Han, and Pinsonneault (2021)	CEO	Quantitative with secondary data	Firm	- CEO risk-taking incentives - IT-related human capital of CEO (moderator)	- IT patent stock	- CEO risk-taking incentives positively relate to IT patents - CEOs IT education and experience intensify the positive relationship between CEO risk-taking incentives and IT patents
Gonzalez, Ashworth, and McKeen (2019)	CIO	Quantitative with experimental data	Individual	- CIO stereotype - Stereotypic expectations of CIOs	- Selection decisions to strategic committee - Performance reactions	- CIOs are associated with IT stereotypes. CIOs are perceived as technologically knowledgeable and innovative, but also detail-focused - CEO stereotypes bias the perception of CIO's suitability to occupy strategy roles
Karahanna and Preston (2013)	CIO, TMT	Quantitative with survey data	Firm	- Structural social capital - Cognitive social capital - Relational social capital	- IS strategic alignment (mediator) - Firm performance	- CIO-TMT structural social capital increases CIO-TMT cognitive social capital, which in turn increases CIO-TMT relational social capital

(*continued on next page*)

Table 1 (*continued*)

Authors	Top executive in focus	Type of study	Level of analysis	Independent variable(s)	Dependent variable(s)	Key findings
						- CIO-TMT cognitive social capital and CIO-TMT relational social capital increase firm performance via IS strategic alignment
Kulkarni, Robles-Flores, and Popovic (2017)	TMT	Quantitative with survey data	Firm	- TMT championship - User participation (mediator) - Analytical decision-making orientation (mediator)	- Information capability - Business intelligence system capability	- The influence of top management championship on both information capability and business intelligence capability is mediated by user participation and analytical decision-making orientation
Leidner, Preston, and Chen (2010)	CIO, TMT	Quantitative with survey data and qualitative interviews	Firm	- CIO strategic leadership - TMT attitude toward IT - Hospital climate	- Hospital IT innovation - IT impact - Hospital performance	- CIO strategic leadership and the TMT attitude toward IT are positively associated with hospital IT innovation - IT impact positively relates to hospital performance
Li, Li, Wang, and Thatcher (2021)	CIO	Quantitative with secondary data	Firm	- CIO presence - Board educational diversity - Board R&D experience - Board AI experience	- AI orientation	- CIO presence positively relates to AI orientation - Board educational diversity, R&D and AI experience positively moderate the relationship between CIO presence and AI orientation
Liu and Preston (2021)	CIO	Quantitative with secondary data	Firm	- CIO presence - Information uncertainty (moderator)	- Frequency and bias of management earnings forecasts	- CIO presence reduces the bias in management earnings forecasts - Information uncertainty negatively moderates the degree to which CIO presence influence forecasting frequency and bias
Liu, Wang, and Chua (2015)	TMT	Qualitative with case study/natural experiment	Team			- Creating and utilizing social capital via repeated interaction with top managers facilitates top management support for IT project teams
Masli, Richardson, Watson, and Zmud (2016)	CEO, CFO	Quantitative with secondary data	Firm	- Reporting of IT-related weaknesses	- CEO and CFO - turnover	- Weaknesses regarding IT architecture and external IT control are related to CEO turnover - Weaknesses regarding internal IT control are related to CFO turnover
Smith, Bradley, Bichescu, and Tremblay (2013)	CEO, CIO	Quantitative with secondary data	Firm	- CIO reporting to CEO - CIO turnover - IT steering committee	- Sophisticated electronic medical record (EMR) systems adoption - Financial performance	- A CIO reporting to the CEO is negatively associated with EMR sophistication - CIO turnover has a negative association with EMR sophistication
Taylor and Vithayathil (2018)	CMO, CIO	Quantitative with secondary data	Firm	- Marketing leader in TMT - Technology leader in TMT	- Future firm sales	- CIO presence in the TMT positively relates to future firm sales after a one-year, five-year and seven-year period - CMO presence is not associated with future firm sales
Yayla and Hu (2014)	CIO	Quantitative with secondary data	Firm	- IT awareness of the board - IT industry intensity (moderator)	- CIO compensation - Firm performance	- IT awareness of the board positively relates to firm performance but does not relate to CIO compensation - In high IT industry intensity, high IT awareness relates to lower long-term compensation of CIOs

Note: AI = artificial intelligence; IS = information systems; TMT = top management team. Literature analysis focuses on the journals Decision Sciences, Information System Research, Journal of the Association of Information Systems, Journal of Management Information Systems, Journal of Strategic Information Systems, Management Information Systems Quarterly.

evolution of IT presents an ever-changing stimulus" for the development of dynamic managerial capabilities (Wheeler, 2002, p. 129), which we attribute to a result of increased adaptation pressures.

Inspired by the literature on competitive dynamics (e.g., Chen and Miller, 2012) and on organizational change (e.g., Gulati et al., 2005; Strebel, 1994), we define *adaptation pressure* as the latent strain either within a firm or between a firm and its environment that requires the firm to respond. Adaptation pressures can threaten a firm in several ways, including with operational inefficiencies (e.g., Foray, 1997), coordination costs through misfit (Rai et al., 2015), and foregone sales (Winter, 2000). Information systems literature suggests that not addressing adaptation pressures can be harmful. Adaptation pressures require relief through organizational action, which both information systems and management literatures say can be done through an adaptation process and/or through the exercise of actions that aim at "alignment" or "fit" (e.g., Cragg et al., 2002; Fainshmidt et al., 2019).

Building on prior work (e.g., Helfat et al., 2007; Wilden et al., 2016), we suggest two conceptual dimensions: external adaptation pressure and internal adaptation pressure. *External* adaptation pressure is the strain between a firm and its surroundings. Studies have shown that the accumulation of dynamic managerial capabilities is triggered by external forces, such as market dynamism and uncertainty (Schilke et al., 2018). In the context of technological change and digital transformation, information systems research stresses that external dimensions fuel adaptation pressures (Vial, 2019). *Internal* adaptation pressure is the strain between multiple internal constituents of a firm. Schilke et al. (2018) also indicate that the accumulation of dynamic capabilities is triggered by internal forces such as organizational structure, culture, and IT. Hanelt et al. (2021) argue that digital transformation can fuel internal adaptation pressures.

We theorize that once external and internal adaptation pressures accumulate and increase, there is a tipping point at which adaptation pressures require a firm to take action, such as by building up dynamic managerial capabilities. To do that, firms need the "skills and knowledge of one or a few executives" (Teece, 2012, p. 1395) in the top management team. That knowledge can be considered the key to enabling new technology adoption in an organization (e.g., Liang et al., 2007). We regard adding CIOs as a deliberate act to equip the organization with IT-related dynamic managerial capabilities. Technology leadership in the C-suite can help foster change, alleviate adaptation pressure, and ultimately achieve alignment with the environment. We propose that external and internal factors increase or decrease pressures on a firm to adapt, thereby influencing the likelihood that CIOs will be embedded in the top management team. Following prior literature, we probe three specific sources of external and internal adaptation pressures that can serve as antecedents to the presence of a CIO: the firm's *environment*, i.e., the intensity of the use of IT in its industry; the firm's *structure*, i.e., the IT-related experience of the members of the top management team; and the firm's *strategy*, i.e., its strategic shift toward greater use of IT (e.g., Wilden et al., 2013). Subsequently, we expand our analyses by probing an outcome of CIO presence, the firm's relative exploration orientation, an important strategy-related concept among information systems and strategy scholars (e.g., Božič and Dimovski, 2019; O'Reilly and Tushman, 2008). Our research model is depicted in Fig. 1.

Antecedents of CIO presence

We theorize that the *environment*, and particularly competition, is a vital source of adaptation pressures. Prior management studies show that external factors influence the presence of individual top management team members (Hambrick and Cannella, 2004; Menz and Scheef, 2014). Thus, the environment can influence the presence of CIOs in the C-suite. We propose that competitors' activities in IT are pertinent. The more the external environment transitions to IT-based competition, the more the environment becomes a so-called digital business ecosystem, a transformed setting that can "never be expected to revert to any kind of 'equilibrium' after disruptions change things" (El Sawy and Pereira, 2013, p. 2). Technological advances and digital transformation are said to create strong pressures for a firm to adapt (Benner and Ranganathan, 2012), demanding a "response from the part of the organization" (Vial, 2019, p. 124). Not surprisingly, firms in computers and software, prototypical IT-intensive industries, have been found to change continuously (e.g., Brown and Eisenhardt, 1997). In the age of digital transformation, "many digital technologies cannot be restricted to the boundaries of specific firms or industries" (Hanelt et al., 2021, p. 2); change is no longer infrequent and does not end in a phase of

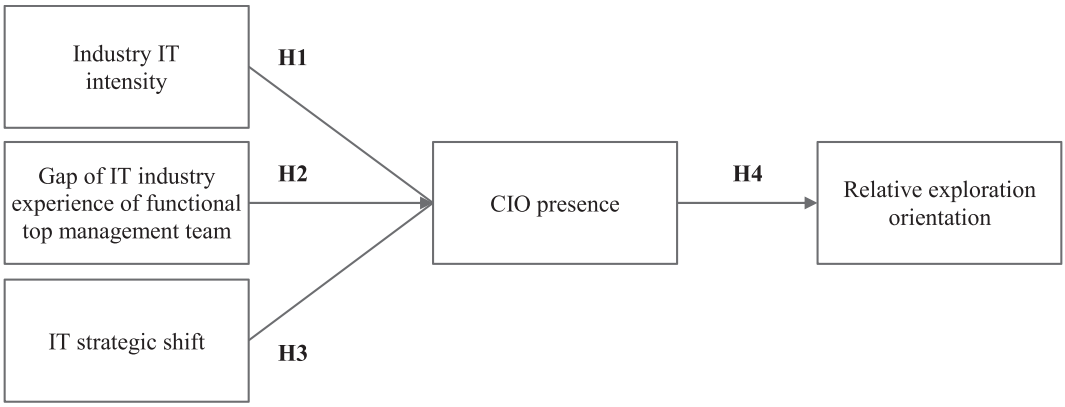

Fig. 1. Research model in focus.

stability. To relieve adaptation pressures, a firm must alter its capabilities in accordance with opportunities and threats that dynamically emerge and dissolve (Hanelt et al., 2021). We hypothesize that IT intensity among a firm's competitors can increase the likelihood of CIO presence in its top management team for two main reasons.

First, in competing with firms that exhibit high IT intensity or are increasing their activities in IT, a firm is pressured to keep up with its rivals. In such circumstances, a firm can reduce adaptation pressures through differentiation based on IT. Because competitive activity and firm capabilities are "often inseparable from IT" (Pavlou and El Sawy, 2010, p. 456), IT is critical for differentiation in an industry that increasingly shifts towards IT (Peppard et al., 2011). Within the competitive dynamics induced by IT, as it strives to differentiate itself, a firm must cope with the market-wide convergence of physical products and digital services by creating an omnichannel customer environment (e.g., Brynjolfsson et al., 2013). For firms to adapt and keep pace with their competitors' differentiation, research shows that effective leveraging of IT is indispensable (Chi et al., 2007). In a changing environment, particularly one with competition shifting towards IT, the role of IT-leveraging capability in dynamic managerial capabilities is more pronounced than it would be in a stable environment (Pavlou and El Sawy, 2010). Fleeting growth opportunities associated with increased industry IT intensity and uncertain customer demand need to be grasped (Sabherwal et al., 2019). A CIO can foster differentiation through data-driven operations, swift transformations, and speedy releases of products or services (Hanelt et al., 2021), reducing external adaptation pressures.

Second, firms in industries with high IT intensity become more exposed to IT risks and threats. On the one hand, increasing firm activity in IT can bring up IT-related risks, such as compliance risks (Tanriverdi and Du, 2009) and operational IT failures (Benaroch et al., 2017). On the other hand, increased IT risks that put firms under external adaptation pressures can also be attributed to the competition in an increasingly IT-intensive environment. As firms compete on IT, the nature of competitive threats changes as rivals can use IT to build barriers of entry, instill switching costs, or "to completely change the basis of competition" (McFarlane, 1984, p. 98), exacerbating external adaptation pressures. Technology leaders such as CIOs can provide the capabilities to cope with emerging IT risks such as cyberattacks, IT failures, and data security vulnerability that naturally emerge when competing on IT (e.g., Dang-Pham et al., 2017). They can also help make qualified decisions on countering IT-related competitive moves and orchestrating dedicated activities in IT. As IT-related managerial capabilities have become an adaptive factor vis-à-vis a firm's competitors with increasing industry IT intensity, the value of CIOs to the firm has increased, as they can reduce adaptation pressures (e.g., Chatterjee et al., 2001). Hence, we propose that:

Hypothesis 1. Industry IT intensity positively relates to CIO presence in a firm's top management team.

Switching to the internal drivers of adaptation pressures, we zoom in on aspects of organizational *structure*, particularly the composition of the top management team. When IT and digital technologies enter firms, they interfere with managerial and organizational behavior (Hanelt et al., 2021). Keeping in mind that dynamic managerial capabilities are useful in fostering systematic change, and must be rooted in a firm's top management team, we suggest that the likelihood of the presence of a CIO is related to the absence of comparable skills in the other members of the top management team. In Hypothesis 2, we propose that a shortage of IT experience in the top management team creates an internal, structural adaptation pressure to add a CIO to the team. Peppard et al. (2011) note that if there is no designated IT expert in the C-suite, other management team executives need to make IT a part of their task domains, creating pressure on them to learn. Hence, specific individuals need to be able to apply dynamic managerial capabilities to support, build, and maintain a firm's ability to make decisions that can lead to competitive advantage (Matarazzo et al., 2021). While firm-specific experience is said to be unnecessary for top management team appointments (e.g., Menz, 2012), industry experience does matter (e.g., Nielsen, 2009).

The IT industry itself is substantially different from other industries, especially in its transitory opportunities and trends. Unless they have worked in the IT industry, other functional managers in the top management team are unlikely to possess the IT experience that, for example, a CIO brings to the table. To act upon and fully benefit from IT in any industry, at a time when every industry is touched by IT, industry experience in IT is essential. This experience is needed not only to recognize opportunities and threats (e.g., Kor, 2003), but also to take action and react to them, which includes overcoming potential adoption barriers of IT adoption within the top management team (e.g., Lederer and Mendelow, 1988; Nielsen, 2009). Such experience fosters, for instance, IT-aligning activities (Vial, 2019), such as reconciling long-term and short-term objectives (Yeow et al., 2018), learning through knowledge sharing between IT units (Leonhardt et al., 2017), and decision-making with evidence-based data analytics (Watson, 2017).

If the top management team lacks sufficient IT industry experience, it may fail to respond quickly to opportunities and threats (e.g., Haffke et al., 2016). Failures, especially those that are technology-related and relevant for dynamic managerial capabilities, "alter the attention directed toward closing a capability gap" (Wilden and Gudergan, 2015, p. 186). Hence, such adaptation pressures from a lack of required capabilities may be reduced by appointing a CIO who can enhance the existing top management team with IT-specific experience. Thus, we propose that:

Hypothesis 2. A gap in the IT industry experience of the functional top management team positively relates to CIO presence in a firm's top management team.

Changes in a firm's *strategy* can give rise to adaptation pressures. As has been noted in information systems and strategy research (e.g., Fainshmidt et al., 2019; Gerow et al., 2015), misfit between the firm and its environment can either stem from a changing environment or from an IT strategy that is disconnected from a firm's general business strategy. Strategic change from within puts firms under pressure to adapt, especially given the severe risks for firms' operational performance during the period of strategic change (e.g., Kaplan, 2006). As firms integrate IT in their product portfolios and attempt to increase market share in related industries via strategic change processes (Nambisan, 2003), they move towards becoming IT-driven. Not surprisingly, "the dynamic managerial capabilities

concept provides a singular focus on managerial impact on strategic change" (Helfat and Martin, 2015, p. 1282). Dynamic managerial capabilities can guide and foster systematic strategic changes, relieving internal adaptation pressures. Hypothesis 3 posits that a strategic shift towards IT can create the need for dynamic managerial capabilities in the form of a CIO for two major reasons.

First, IT strategy differs from general business strategy in that the former focuses on technology opportunities instead of providing an overall strategic plan, as the latter does (e.g., Baets, 1992). Thus, the two types of strategy need to be deliberately aligned to reduce friction (Cragg et al., 2002). The more IT strategy changes, the more it is likely to become a guiding part of a firm's business strategy, such that the boundary between the two becomes blurred, and they eventually merge into one. CIOs can act as a source of dynamic managerial capabilities to assist strategic changes to minimize "alignment gaps" between IT strategy and business strategy (Rathnam et al., 2004, p. 1). On the one hand, CIOs are designated agents in the top management who formulate and refine IT strategy and ultimately effectuate compatibility between IT and business strategy (e.g., Johnson and Lederer, 2010). As IT strategy tends to follow IT's fleeting trends on the market, a technology leader such as the CIO can systematically update a firm's IT strategy (e.g., Chun and Mooney, 2009). On the other hand, a strategic shift towards IT requires the focal firm to adapt its operations. Given the bridging role of CIOs for IT strategy formulation and implementation, they are indispensable when a focal firm strategically shifts towards IT.

Second, information systems literature tells us that establishing a CIO in the top management team is often a milestone of a firm's agenda to transition towards being a digitalization-driven company, with the announcement of a CIO in the top management team being a signal of the progress of IT-driven transformation (Chatterjee et al., 2001). Initially, modest strategic shifts towards IT may signal experimentation with IT, and associated activities may initially be handled by existing non-IT top managers (e.g., Doll, 1985). Typically, a firm only gradually recognizes that such change needs to be driven by specific human actors (e.g., Hsiao and Ormerod, 1998), so that a CIO at the apex of the firm may not initially be wished for. However, the more advanced and mature a firm's strategic shift towards IT becomes, the more pressured the firm becomes to make a CIO part of the C-suite to materialize IT strategy in the top management team. Arguing that IT strategy shifts can guide top management composition, we suggest that strategic shifts towards IT affect CIO presence in the top management team. Thus, we propose that:

Hypothesis 3. IT strategic shift positively relates to CIO presence in a firm's top management team.

CIO presence and a firm's relative exploration orientation

We argue that firms engage CIOs to boost their dynamic managerial capabilities to gain competitive advantage. Research has shown that CIOs can drive firm performance (e.g., Richardson et al., 2018). This insight raises the question of *how* CIOs do this. Chen et al. (2010, p. 231) find that CIOs are "increasingly expected to play not only the traditional supply-side leadership role that focuses on exploiting existing IT competencies to support known business needs but also the demand-side leadership role that focuses on exploring new IT-enabled business opportunities that result in competitive advantage." March (1991) suggests that organizational learning can be achieved by the exploitation of existing knowledge or by the exploration of novel knowledge pools and that a balance between both activities maximizes firm performance. Uotila et al. (2009) empirically confirm this notion and derive from it the notion of a firm's "relative exploration orientation" – that is, the relative emphasis on exploration versus exploitation in firm strategy. Given that a firm's relative exploration orientation is a major strategic trajectory that has to be anchored in a firm's strategic orientation and that relates to competitive advantage, we inquire if CIOs seek to increase or diminish it. Hypothesis 4 proposes that CIOs are likely to drive the pursuit of novel knowledge domains, and that, accordingly, their presence in the top management team enhances their firm's relative exploration orientation.

Information systems literature increasingly accepts the idea that by "[a]cting as an *entrepreneur*, the CIO is a change agent who plans and initiates change" (Thatcher et al., 2011, p. 21). This idea aligns with the notion that dynamic managerial capabilities can rest "on entrepreneurial competences" (Teece, 2012, p. 1396) and can lead to strategic change. The tension between exploration and exploitation orientations can be fruitful for an organization if harnessed adequately (Andriopoulos and Lewis, 2009). Top managers engage in "sensing and seizing opportunities as markets evolve" (O'Reilly and Tushman, 2008, p. 189), including in the realm of IT. Appointing a CIO to the top management team, a company may, as part of an IT-driven path, revisit its status quo and decide to "explore more, and engage in a mode of exploring tied to a strong experimental mindset" (Tschang and Almirall, 2020, p. 3). Given their role in exploring IT-enabled ways of doing business, technology leaders such as CIOs are active participants in formulating a firm's strategy and are responsible for continually aligning IT and business (Chen et al., 2010). A CIO brings dynamic managerial capabilities to the firm to manage the conflicting goals between exploiting existing IT within the firm, exploring new IT, and changing the technological orientation accordingly (Haffke et al., 2016; Li et al., 2021). We believe that CIO presence in the top management team shifts a firm's strategic trajectory from old, analog, exploitative ways of doing business towards new, digital, exploratory ways of doing business. Thus, we propose that:

Hypothesis 4. CIO presence in the top management team positively relates to a firm's relative exploration orientation.

Methods and results

The study's sample consists of all U.S. firms included in the S&P 500 index in the twelve years between 2006 and 2017 for at least three consecutive years. To create our data set, we combine data from several sources. First, we collect data on top management team members regarding their roles and prior industry experience from firms' annual Form-10 K submissions, proxy statements, annual reports, and other publicly available sources such as executives' biographies and professional social media profiles (e.g., Nath and Bharadwaj, 2020). Second, we collect data on firms' financials from S&P Compustat North America, the Center for Research in Security

Prices (CRSP), and Institutional Broker's Estimate System (I/B/E/S). Third, we obtain industry capital spending data compiled by the U.S. Bureau of Economic Analysis (BEA) (e.g., Benaroch et al., 2017). Fourth, to capture relative exploration orientation, we hand-collect and analyze firms' annual letters to shareholders made available via the annual report and firm websites (e.g., Gamache et al., 2020). Following prior research (e.g., Menz and Scheef, 2014), we exclude observations from three-digit North American Industry Classification System (NAICS) industry groups with fewer than three firms. Our sample construction resulted in an unbalanced panel data set of 503 U.S. firms comprising 4,156 firm-year observations. Since letters to shareholders are not available for all firm years, the sample is reduced to 426 firms and 3,274 firm-year observations in models testing Hypothesis 4.

Measures

To identify CIOs in the top management team, we follow a two-step approach. First, we define the firm's top management as those senior executives listed in the firm's annual 10-K, or definitive proxy (DEF 14A), statement filed with the U.S. Securities and Exchange Commission (SEC). This definition is consistent with prior research on functional top management team members (Benaroch et al., 2017; Menz and Scheef, 2014; Nath and Mahajan, 2008), and it offers at least three benefits (Nath and Bharadwaj, 2020). First, as firms are required to publish annual reports and proxy statements, the list of top management team members is consistently available over time and across firms. Second, this set of top management team members is more inclusive than other approaches to measuring these members relying on the list of only the few executives for whom annual compensation is reported. In our sample, firms list up to 38 senior executives in their proxy statements, usually including the CEO, several functional top managers such as the CIO, as well as divisional and regional heads. Third, this definition relies on the board of directors' classification of who is a strategically important, "policy-making" executive in their firm (Nath and Bharadwaj, 2020, p. 679). In sum, this top management team definition has been explicitly recommended by previous researchers (Nath and Bharadwaj, 2020). Using the refined conceptualization of the top management and constructing a measure accordingly, the mean top management team size in our sample of firms is 10.43, with a standard deviation of 4.29. These values align with prior research (Menz and Scheef, 2014; Nath and Mahajan, 2008).

Second, we search the executives' titles for specific keywords proposed in prior research, such as "Chief Information Officer" and "Chief Software Technology Officer" (Menz, 2012). Since Banker et al. (2011) note that up to 40 percent of senior IT executives do not explicitly carry the "CIO" title, the titles were manually examined for other keywords such as "Information Technology," "Information Management," "Technology Systems," "Information Systems," and "Digital." We further analyzed executives' role descriptions in other sources to determine executives' specific responsibilities where the titles were ambiguous. We also include chief digital officers (CDOs) in our definition of the CIO, since prior research finds that the CDO role is functionally broadly equivalent to that of the CIO (Haffke et al., 2016). However, we explicitly distinguish CIOs from chief technology officers (CTOs), who do not necessarily deal with IT but focus on research, development, and innovation in the broader sense (Garms and Engelen, 2019). We further check and ensure that divisional executives with titles resembling a CIO's were not falsely considered as such. We improve and align our coding scheme in several iterations to ensure reliability and consistency in our approach across raters. Table 2 presents the frequency of clustered titles identified as CIOs in this study. The resulting binary variable *CIO presence* indicates whether the focal firm has a CIO in the top management team in the relevant firm-year. On average, 20 percent of firm-year observations show a CIO in the top management in our sample.

In constructing *industry IT intensity* as our first explanatory variable, we follow an established approach to identifying IT-related investment categories in industry capital spending data compiled by the BEA (Benaroch et al., 2017; Yayla and Hu, 2014). We measure industry IT intensity, as a proxy of competitors' engagement in IT activities, through the proportion of annual capital spending in IT-related investment categories of the total annual capital spending per three-digit NAICS industry group. To measure our second explanatory variable, we follow Yayla and Hu (2014) in measuring the *gap in IT industry experience of functional top management team* as the proportion of functional top management team members who have previously held executive positions in IT-related industries as identified by the respective firms' industry codes (standard industrial classification codes 357, 366, 367, 48, and 737). Executives' prior work history has been commonly used in literature as a proxy for topic expertise (e.g., Kor and Misangyi, 2008). We exclude the CIO of the focal firm in calculating this measure. To facilitate interpretation, we invert this measure by multiplying it by negative one, such that a higher score indicates a higher gap in IT industry experience of the functional top management team. To measure our third explanatory variable, *IT strategic shift*, we determine the share of business segment revenue in Compustat Segments linked to IT-related industries. We identify these industries in coherence with the industry codes we also used to measure functional top management members' IT industry experience. We calculate the standardized change in the share of IT-related revenue from one year

Table 2
Relative frequency of clustered titles identified.

Clustered titles	Relative frequency
Chief Information Officer (CIO)	78.6%
Head of Information Technology (IT)	10.2%
Head of Information Systems (IS)	3.8%
Head of Digital Strategy	2.3%
Chief Digital Officer (CDO)	1.7%
Head of Data & Information Security	0.4%
Other	3.0%

Note: Associated abbreviations in brackets.

to the next to capture IT strategic shift (similar to Crossland et al., 2014; see also Rahmati et al., 2021).

To probe the effect of CIO presence on *relative exploration orientation*, we use content analysis techniques applied to firms' annual letters to shareholders. These letters inform shareholders of the top management's interpretation of the firm's strategic trajectories and environmental conditions (Short et al., 2010). Analyzing letters to the shareholders is a non-intrusive way to measure a strategic orientation. This approach also allows researchers to overcome many of the limitations of surveys and interviews in longitudinal research. First, letters to shareholders reflect the top management's cognition when they were published, therefore avoiding recall bias (Moss et al., 2014). Second, they are published annually by a majority of firms, allowing researchers to consistently examine the top management's priorities over time and across firms (McKenny et al., 2018). Third, letters to shareholders are written with the management team's direct involvement and signed by the CEO (Cho and Hambrick, 2006; Gamache et al., 2020). As letters to shareholders do not have to follow rigid regulatory requirements regarding style, length, or content, they tend to reveal the managerial strategic priorities (Cho and Hambrick, 2006). To measure exploration and exploitation orientation, McKenny et al. (2018) propose a dictionary and provide software to perform computer-aided text analysis (CATA). We employ these resources to identify words associated with exploration, such as "experiment," "creative," "innovation," and "launch" in firms' letters to shareholders. Following prior research, we consider exploration and exploitation as two ends of a continuum (Uotila et al., 2009). To measure relative exploration orientation, we divide the number of explorative words in the letters to shareholders by the total number of exploitative and explorative words. The resulting ratio is between zero and one (Uotila et al., 2009).

In line with prior research on contingencies affecting functional top management team member presence, we control for a rigorous set of firm-, management-, and industry-specific factors. First, we account for *firm performance*, measured as the firm's EBIT return on assets (Benaroch et al., 2017; Menz and Scheef, 2014), since prior research has argued that changes in the top management team may be adaptation mechanisms responding to past low firm performance (Finkelstein and Hambrick, 1996). Second, we control for *firm size*, measured as the natural logarithm of the firm's total assets (Nath and Mahajan, 2008), to account for the notion that size increases organizational complexity, which requires task division and specialization (Donaldson, 2001). Third, following prior research (Nath and Mahajan, 2008), we account for *firm R&D intensity*, computed as the firm's annual research and development (R&D) stock divided by sales. R&D intensity reflects a firm's focus on innovation and differentiation and therefore captures a core element of a firm's strategic positioning (Nath and Mahajan, 2008). Following Hall (1990), we calculate R&D stock K as $K_t = K_{t\text{-}1}\ (1 - \delta) + R_t$, where R_t is the R&D expenditure in year t, and the depreciation rate δ is 0.15. Firm years with missing R&D expenditure are assigned a zero value (Guadalupe et al., 2014). Fourth, we control for *CEO role tenure*, since top management team structure is related to a CEO's role tenure (Hambrick and Fukutomi, 1991). Fifth, we capture top management team (TMT) structure using *TMT size*, i.e., the total number of all executives listed in the Form 10-K of the focal firm, excluding the CIO (Nath and Mahajan, 2008).

Table 3
Variable definitions and data sources.

Variable	Description	Data source
CIO presence	Binary variable indicating CIO presence among the senior executive officers named in the firm's proxy statements, i.e., the top management team (following Benaroch et al., 2017)	SEC proxy filings
Industry IT intensity	Proportion of annual capital spending in IT-related investment categories of the total annual capital spending per three-digit NAICS industry group (following Benaroch et al., 2017; Yayla & Hu, 2014)	BEA
Gap in IT industry experience of functional TMT	Proportion of functional top management team (TMT) members who have previously held executive positions in digital technology industries (SIC codes 357, 366, 367, 48, and 737) (following Yayla & Hu, 2014). We exclude the CIO of the focal firm in calculating this measure. To facilitate interpretation, we invert this measure by multiplying it by (-1)	Biographies and public profiles
IT strategic shift	Standardized year-on-year change in the share of business segment revenue in Compustat Segments linked to IT-related industries (SIC codes 357, 366, 367, 48, and 737) (based on Crossland et al., 2014)	Compustat Segments
Relative exploration orientation	Ratio expressing the number of explorative words used in letters to shareholders divided by the total number of exploitative and explorative words used (following Uotila et al., 2009)	Annual letters to shareholders
Firm performance	EBIT return on assets (following Benaroch et al., 2017; Menz & Scheef, 2014)	Compustat
Firm size	Natural logarithm of total assets (following Nath & Mahajan, 2008)	Compustat
Firm R&D intensity	Accumulated R&D stock divided by sales; R&D stock K in year t is defined as $K_t = K_{t\text{-}1}\ (1 - \delta) + R_t$ where R_t is the R&D expenditure, and the depreciation rate δ is 0.15; firm-year observations with missing R&D expenditure are assigned a zero value (following Hall, 1990; Guadalupe et al., 2014)	Compustat
CEO role tenure	Number of years since a CEO was appointed to their current role at the current firm (following Hambrick & Fukutomi, 1991)	Biographies and public profiles
TMT size	Top management team (TMT) size: Total number of senior executives mentioned in the firm's proxy statements (DEF 14A) (following Nath & Mahajan, 2008)	SEC proxy filings
Corporate opacity	Index indicating the level of transparency in a firm's reporting policy (following Anderson et al., 2009). Determined based on four indicators: trading volume, bid-ask spread, analyst following, and analyst forecast errors. The four indicators are ranked into deciles, summed, and scale to the range between zero and one	CRSP, I/B/E/S
Industry performance	Average market-to-book value of firms in the same three-digit NAICS industry group (following Menz & Scheef, 2014)	Compustat
Industry concentration	Herfindahl-Hirschman index of sales of all firms in the same three-digit NAICS industry group (following Wiedeck & Engelen, 2018)	Compustat

Note: SEC = U.S. Securities and Exchange Commission; BEA = U.S. Bureau of Economic Analysis;
CRSP = Center for Research in Security Prices; I/B/E/S = Institutional Brokers' Estimate System

Table 4
Descriptive sample statistics and bivariate correlation coefficients.

Variables	Min	Mean	Max	S.D.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) CIO presence	0.00	0.20	1.00	0.40												
(2) Industry IT intensity	0.01	0.23	0.80	0.23	0.10											
(3) Gap in IT industry experience of functional TMT	0.00	−0.24	−1.00	0.37	0.12	−0.26										
(4) IT strategic shift	−0.04	−0.01	1.00	0.02	0.06	0.01	0.01									
(5) Relative exploration orientation[a]	0.00	0.54	1.00	0.26	0.01	0.07	−0.11	0.04								
(6) Firm performance	−1.38	0.11	0.40	0.09	−0.00	−0.06	−0.05	0.01	0.18							
(7) Firm size[b]	1,457.20	39,003.71	923,225.00	102,010.10	0.09	0.18	0.10	−0.03	−0.01	−0.31						
(8) Firm R&D intensity	0.00	0.04	1.47	0.08	−0.12	−0.10	−0.41	−0.01	0.28	0.04	−0.18					
(9) CEO role tenure	1.00	6.88	54.00	6.02	−0.04	0.01	−0.01	0.01	0.05	0.06	−0.06	0.01				
(10) TMT size	3.00	10.43	38.00	4.29	0.18	−0.01	0.11	−0.00	0.00	−0.00	0.27	−0.06	−0.04			
(11) Corporate opacity	0.05	0.24	0.78	0.11	−0.07	−0.02	0.03	−0.01	−0.10	−0.25	−0.16	0.01	−0.03	−0.12		
(12) Industry performance	0.60	2.96	20.05	1.60	−0.02	−0.17	−0.11	0.02	0.13	0.30	−0.24	0.18	0.09	−0.02	−0.18	
(13) Industry concentration	0.04	0.20	1.00	0.15	0.10	0.06	−0.04	−0.00	−0.14	0.08	−0.13	−0.16	0.06	−0.08	0.02	0.19

Note: Variables (2) to (4) and (6) to (13) are lagged by one year. All continuous variables are winsorized at the 1% and 99% levels. All values greater than |0.03| are statistically significant at $p < 0.05$. S.D. stands for standard deviation.
$n = 4{,}156$
[a] $n = 3{,}274$
[b] Figures in US$ millions.

Sixth, since we rely on firms' self-reported data, our measure of CIO presence might be partly distorted by a firm's lack of transparency in its reporting policy. To account for a firm's level of reporting transparency, we control for *corporate opacity,* which is an index developed by Anderson et al. (2009) based on financial data disclosure. The index determines four indicators for firm-level opacity: trading volume, bid-ask spread, analyst following, and analyst forecast errors. These four indicators are then ranked into deciles, summed, and scaled to the range from zero to one. If the measure of corporate opacity is high, it is difficult for outsiders to gain relevant information about a firm's activities (Deb et al., 2017). Seventh, we control for *industry performance* to account for differences in profitability between industries, measured as the average market-to-book value of firms in the same three-digit NAICS industry group (Menz and Scheef, 2014). Eighth, we control for *industry concentration* to capture the firm's competitive environment, computed as the Herfindahl-Hirschman index of sales of all firms in the same three-digit NAICS industry group (Wiedeck and Engelen, 2018). Ninth and last, we include year effects to control for time trends and macroeconomic movements. Table 3 summarizes all variable definitions and data sources used in this study.

Analytical procedures

We test Hypotheses 1 to 3 using generalized estimation equations (GEE). This approach extends generalized linear models by applying quasi-likelihood estimation to panel data (Shah et al., 2017). It allows researchers to control for serial correlation within firms' manager appointments and can account for the distribution of our binary dependent variable (Ballinger, 2004; Liang and Zeger, 1986). GEEs are valid and robust (Agresti, 2013: Section 4.7) and are an established statistical method to analyze the presence of other functional top management members (Hambrick and Cannella, 2004; Menz and Scheef, 2014; Nath and Mahajan, 2008). Following these studies, we use a binomial distribution, since our dependent variable, *CIO presence*, is binary. Based on analyses using the quasi-likelihood of the independence model criterion (QIC) for model selection in GEEs (Cui, 2007), we further specify a logit link function, an exchangeable correlation structure, and robust standard errors. To empirically address concerns regarding reverse causality, we lag all explanatory and control variables by one year. We winsorize all continuous variables at the 1% and 99% levels to rule out bias from outliers.

We specify our empirical models to test Hypotheses 1 to 3 as follows (Anand et al., 2020):

$$CIO_{it} = \beta_1 + \beta_2 IITI_{it-1} + \beta_3 GITE_{it-1} + \beta_4 ITSS_{it-1} + C_{it-1} + \lambda_t + \varepsilon_{it} \quad (1)$$

where CIO_{it} is the presence of CIOs in their firms' top management team for the *i*th firm at time *t*. $IITI_{it-1}$ refers to industry IT intensity, $GITE_{it-1}$ refers to the gap in IT industry experience of the functional top management team, and $ITSS_{it-1}$ refers to IT strategic shift. C_{it-1} is the vector of control variables. To control for time trends, we include year fixed effects (λ_t). We do not include industry fixed effects because the *industry IT intensity* variable (Hypothesis 1) is defined on an industry level. Our explanatory variable, *industry IT intensity*, as well as the controls, *industry performance* and *industry concentration*, already capture the most relevant industry characteristics. Still, we find that including industry fixed effects in unreported models re-testing Hypotheses 2 and 3 does not affect the statistical significance or the direction of our results.

We test Hypothesis 4 using both a fractional logit regression and a fixed effects regression. Our dependent variable, *relative exploration orientation*, is a fraction defined only on the unit interval, i.e., $0 \leq y \leq 1$. In a recent methodological review, Villadsen and Wulff (2021) argue that fractional regression models "should be the preferred choice" for this type of outcome variable (p. 314). Linear models are not appropriate for estimating fractional response variables because the boundary conditions require a nonlinear effect of the regressors, and the linear model does not restrict the predicted values to the unit interval. Frequently used alternatives such as log-odds transformation or Tobit models may also be severely biased (Villadsen and Wulff, 2021). By contrast, fractional regression models take into account the characteristics of the fractional response variable and are robust and efficient (Papke and Wooldridge, 1996). We use robust standard errors to account for heteroskedasticity. Our empirical specification for Hypothesis 4 is as follows:

$$REO_{it} = \beta_1 + \beta_2 CIO_{it-1} + \beta_3 IITI_{it-1} + \beta_4 GITE_{it-1} + \beta_5 ITSS_{it-1} + C_{it-1} + \gamma_i + \lambda_t + \varepsilon_{it} \quad (2)$$

where REO_{it} is the relative exploration orientation for the *i*th firm at time *t*. The independent variables are specified as for Equation (1), above. To control for time trends and industry-specific characteristics, we include industry fixed effects (γ_i) and year fixed effects (λ_t).

Since fractional logit regressions cannot include firm fixed effects (Hochberg et al., 2010), we also estimate a fixed effects model with year fixed effects and robust standard errors as a robustness check. Our alternative empirical specification for Hypothesis 4 is as follows:

$$REO_{it} = \beta_1 + \beta_2 CIO_{it-1} + \beta_3 IITI_{it-1} + \beta_4 GITE_{it-1} + \beta_5 ITSS_{it-1} + C_{it-1} + \alpha_i + \lambda_t + \varepsilon_{it} \quad (3)$$

The specifications follow Equation (2) above. To control for firm-specific characteristics that are stable over time, we include firm fixed effects (α_i).

Results

Table 4 presents descriptive statistics and bivariate correlation coefficients. None of the pairwise correlation coefficients exceed |0.41| and none of the computed variance inflation factors exceed 1.45, placing them all well below critical thresholds. Since recent research has called into question the exclusive reliance on variance inflation factors to mitigate concerns about multicollinearity, we follow a suggestion by Kalnins (2018) and introduce the hypothesized variables successively in isolated regressions. Our model results

show that these variables do not display statistically significant beta coefficients of the opposite sign. Given this result and our large sample size, we infer that multicollinearity is not likely to be an issue.

Table 5 reports the GEE regression results of our analyses of Hypotheses 1 to 3, with CIO presence as the dependent variable. Model 1 includes the controls only, Models 2 to 4 successively introduce the hypothesized variables theorized to be antecedents of CIO presence, and Model 5 presents the full model including all variables simultaneously. Each model addition improves the model fit (see Chi^2 in Table 5). TMT size ($\beta = 0.07$, $p < .001$), corporate opacity ($\beta = -1.19$, $p < .05$), and industry concentration ($\beta = 1.32$, $p < .05$) are statistically significantly associated with CIO presence in Model 5.

We find statistically significant relationships for all three antecedents. First, Hypothesis 1 is supported, stating that the likelihood of CIO presence positively relates to higher industry IT intensity. Industry IT intensity has a positive relationship with CIO presence both in Model 2 ($\beta = 0.87$, $p < .05$) and in the full model ($\beta = 1.55$, $p < .001$). Following prior studies (Menz and Scheef, 2014; Wiedeck and Engelen, 2018), Table 6 reports the estimated likelihood of CIO presence at low, mean, and high levels of the explanatory variables in the full model. All values are statistically significant ($p < .01$). For firms in an industry with an IT intensity of one standard deviation above the mean, the predicted likelihood of CIO presence increases by 5.9 percentage points, highlighting the economic significance of our findings (Mohajeri et al., 2020). Second, Hypothesis 2 is supported, stating that CIO presence positively relates to a greater lack of IT industry experience among functional top managers. IT industry experience of the functional top managers has a positive effect on CIO presence both in Model 3 ($\beta = 1.66$, $p < .001$) and in the full model ($\beta = 1.88$, $p < .001$). For firms with a larger gap in functional top management members with IT industry experience of one standard deviation above the mean, the predicted likelihood of CIO presence increases by 12.2 percentage points compared to the mean of the moderator variable. Third, Hypothesis 3 is supported, stating that CIO presence positively relates to IT strategic shift. IT strategic shift has a positive relationship with CIO presence both in Model 4 ($\beta = 5.59$, $p < .001$) and in the full model ($\beta = 5.38$, $p < .01$). For firms with an IT strategic shift of one standard deviation above the mean, the predicted likelihood of CIO presence increases by 1.5 percentage points. In sum, we find support for Hypotheses 1, 2, and 3.

Hypothesis 4 suggests that CIO presence positively relates to firms' relative exploration orientation. Table 7 reports the fractional logit regression analysis results, with relative exploration orientation as the dependent variable. We show the model first only with controls (Model 6) and then including the variable of interest, CIO presence (Model 7). The fractional logit model specification shows a significantly positive effect of CIO presence on relative exploration orientation ($\beta = 0.11$, $p < .01$). In an alternative specification, we also estimate a fixed effects model to test Hypothesis 4 as reported in Models 8 and 9. We again find a significantly positive effect of CIO

Table 5
Results of regression models using GEE with CIO presence as the dependent variable.

Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
Independent variables										
Industry IT intensity			0.87	*					1.55	***
			(0.40)						(0.44)	
Gap in IT industry experience of functional TMT					1.66	***			1.88	***
					(0.40)				(0.39)	
IT strategic shift							5.59	**	5.38	**
							(1.92)		(2.08)	
Controls										
Firm performance	−0.19		−0.19		−0.12		−0.18		−0.12	
	(0.38)		(0.40)		(0.36)		(0.38)		(0.40)	
Firm size	0.00		−0.03		0.00		0.00		−0.05	
	(0.10)		(0.09)		(0.10)		(0.10)		(0.10)	
Firm R&D intensity	−1.29		−1.15		0.27		−1.25		0.64	
	(1.61)		(1.61)		(0.87)		(1.59)		(0.84)	
CEO role tenure	0.00		0.00		0.00		0.00		0.00	
	(0.01)		(0.01)		(0.01)		(0.01)		(0.01)	
TMT size	0.07	***	0.07	***	0.07	***	0.07	***	0.07	***
	(0.02)		(0.02)		(0.02)		(0.02)		(0.02)	
Corporate opacity	−1.05	*	−1.07	*	−1.13	*	−1.05	*	−1.19	*
	(0.53)		(0.53)		(0.50)		(0.53)		(0.51)	
Industry performance	−0.01		−0.01		−0.01		−0.01		0.00	
	(0.03)		(0.03)		(0.03)		(0.03)		(0.03)	
Industry concentration	1.12	†	1.12	†	1.24	*	1.13	†	1.32	*
	(0.63)		(0.64)		(0.61)		(0.63)		(0.62)	
Constant	−2.16	*	−2.18	*	−1.85	†	−2.18	*	−1.78	†
	(0.96)		(0.95)		(0.97)		(0.96)		(0.95)	
Fixed effects	Year		Year		Year		Year		Year	
Observations	4,156		4,156		4,156		4,156		4,156	
Number of firms	503		503		503		503		503	
Chi^2	37.64	***	40.27	***	53.96	***	43.90	***	65.14	***
QIC	4,374		4,359		4,386		4,042		4,003	

Note: All explanatory and control variables are lagged by one year. All continuous variables are winsorized at the 1% and 99% levels. Firm size is log-transformed. Standard errors in parentheses.
† $p < .1$; * $p < .05$; ** $p < .01$.; *** $p < .001$.

Table 6
Estimated likelihood of CIO presence at different levels of the explanatory variables.

	Likelihood of CIO presence		
Explanatory variables	Low EV[a]	Mean EV	High EV[a]
H1: Industry IT intensity	15.3%	20.1%	26.0%
H2: Gap in IT industry experience of functional TMT	10.6%	18.7%	30.9%
H3: IT strategic shift	18.6%	20.1%	21.6%

Note: All values are statistically significant at the 1% level. Marginal effects calculation based on the full model (#5). EV stands for explanatory variable.
[a] Low (and high) values of the explanatory variables are calculated as the mean minus (plus) one standard deviation.

Table 7
Results of fractional logit, fixed effects, and system GMM models with relative exploration orientation as the dependent variable.

Variables	Fractional logit models		Fixed effects models		System GMM	
	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11
Independent variable						
CIO presence		0.11 **		0.03 †		0.04 *
		(0.04)		(0.02)		(0.02)
Controls						
Industry IT intensity	0.61 ***	0.64 ***	0.03	0.03	0.13	0.08
	(0.18)	(0.18)	(0.17)	(0.17)	(0.10)	(0.10)
Gap in IT industry experience of functional TMT	0.19 **	0.19 **	0.06	0.05	0.01	0.02
	(0.07)	(0.07)	(0.06)	(0.06)	(0.04)	(0.04)
IT strategic shift	2.37	2.17	0.33	0.31	0.26	0.01
	(1.76)	(1.69)	(0.21)	(0.22)	(0.54)	(0.44)
Firm performance	1.85 ***	1.86 ***	0.15 **	0.15 **	0.21 ***	0.22 ***
	(0.31)	(0.31)	(0.05)	(0.05)	(0.07)	(0.07)
Firm size	0.08 ***	0.08 ***	0.00	0.00	0.01	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Firm R&D intensity	4.50 ***	4.56 ***	0.00	−0.01	0.70 ***	0.65 ***
	(0.41)	(0.41)	(0.13)	(0.12)	(0.17)	(0.15)
CEO role tenure	0.01 *	0.01 *	0.00 *	0.00 *	0.00 †	0.00 †
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
TMT size	−0.01 †	−0.01 *	−0.00 *	−0.01 *	−0.00	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Corporate opacity	−0.32	−0.29	−0.03	−0.02	−0.04	−0.03
	(0.21)	(0.21)	(0.06)	(0.06)	(0.06)	(0.06)
Industry performance	0.00	0.00	0.00	0.00	−0.01	−0.01
	(0.02)	(0.02)	(0.00)	(0.00)	(0.01)	(0.01)
Industry concentration	−0.48 **	−0.48 **	0.09	0.08	−0.10	−0.13
	(0.18)	(0.18)	(0.07)	(0.08)	(0.07)	(0.09)
Relative exploration orientation (1-year lag)					0.21 ***	0.20 ***
					(0.03)	(0.03)
Constant	−1.60 ***	−1.61 ***	0.52 **	0.51 **	0.13	0.12
	(0.24)	(0.24)	(0.18)	(0.18)	(0.09)	(0.09)
Fixed effects	Year, industry	Year, industry	Year, firm	Year, firm	Year, industry	Year, industry
Observations	3,274	3,274	3,274	3,274	3,120	3,120
Number of firms	426	426	426	426	410	410
Chi^2	932.01 ***	935.13 ***			739.75 ***	708.03 ***
R^2			0.03 ***	0.03 ***		
Arellano-Bond test for AR(1)					−8.32 ***	−8.32 ***
Arellano-Bond test for AR(2)					1.23	1.21
Hansen test of overidentifying restrictions					371.01	373.60

Note: All independent and control variables are lagged by one year, except for the three antecedents from Hypotheses 1–3, which are lagged by two years. All continuous variables are winsorized at the 1% and 99% levels. Firm size is log-transformed. Standard errors are shown in parentheses.
† $p < .1$; * $p < .05$; ** $p < .01$.; *** $p < .001$.

presence on relative exploration orientation, though with a weaker statistical significance ($\beta = 0.03$, $p < .1$). Thus, we find support for Hypothesis 4.

Validity threats and robustness

Despite our rigorous selection of control variables, we can never fully rule out that other omitted variables may impact our results. Hence, we performed additional tests. Following approaches in recent studies (e.g., Quigley et al., 2020), we determined the impact threshold of confounding variable (ITCV) for each direct effect of the antecedents on CIO presence and for the direct effect of CIO presence on relative exploration orientation (Frank, 2000). Applied to our baseline models, as shown in Table 5, and exemplified for Model 3, an analysis using two-tailed tests yielded 53.33% as the invalidation threshold. This result indicates that to invalidate our findings, 2,216 firm-year observations would need to be replaced with observations for which the direct effect of the gap in functional top management members on CIO presence is zero. The results further show an ITCV of 0.0338, showing that partial correlations between the direct effect of the gap in functional top management members and CIO presence with a confounding omitted variable would have to be about 0.1838 (the square root of 0.0338) to overturn our results, and that to overturn our results, a correlated omitted variable would need to be 25 percent stronger than the current strongest predictor in the model. Given our selection of control variables based on prior work, this analysis suggests that our findings are not likely to be driven by omitted variables. Analyses for the other regression models lead to similar results.

Lastly, to mitigate potential concerns regarding endogeneity as well as autocorrelation in the residuals when modeling the relationship between CIO presence and relative exploration orientation, we introduce a robust two-step system generalized methods of moments (GMM) estimator with Windmeijer corrected standard errors (Arellano and Bond, 1991; Blundell and Bond, 1998). The system GMM approach allows lagged values of the dependent variable to be included as controls. As reported in Table 7 (Model 11), we find that the relationship between CIO presence and relative exploration orientation still holds ($\beta = 0.04$, $p < .05$). Our results show that autocorrelation of the residuals is unlikely to weaken the instruments since the AR-1 test is significant ($z = -8.32$, $p < 0.001$), while AR-2 is non-significant ($z = 1.21$, $p > 0.1$) (Shaikh et al., 2018). Furthermore, the Hansen-J test of overidentifying restrictions is non-significant ($Chi^2 = 373.60$, $p > 0.1$), indicating that our choice of instruments is exogenous.

Discussion

In this study, we develop an antecedents view of dynamic managerial capabilities in the top management team rooted in information systems and apply it to CIOs as a potential source of dynamic managerial capabilities. At the center of our theorizing, we suggest that external and internal factors can create adaptation pressures. Increasing adaptation pressures require the focal firm to act, including by appointing CIOs to the top management team. Once appointed, CIOs can foster the necessary change to reduce adaptation pressures, typically by strengthening the relative exploration orientation of the focal firm. Our regression analyses of a panel data set support our hypotheses that external tensions, here *industry IT intensity*, and internal tensions, here *gap in IT industry experience* of *the functional top management team* and *IT strategic shift*, increase the likelihood that a CIO will be on the top management team. Furthermore, our analyses support our contention that CIO presence increases the relative exploration orientation of the firm.

Contributions to Theory. This study offers several theoretical contributions to information systems and strategy research. First, while prior work has examined the consequential effects of including technology leadership within the top management team, there was little understanding of when and why CIOs got to the C-suite in the first place. Building on the concept of dynamic capabilities, and acknowledging that there is "an opportunity for IS to contribute to the literature on dynamic capabilities" (Vial, 2019, p. 134), we theoretically develop the drivers of IT leadership presence in the C-suite. Thus, we advance the theoretical anchoring of the antecedents of dynamic managerial capabilities in information systems. Our theoretical framework clarifies the drivers of CIO presence regarding environmental, structural, and strategic factors leading to the adoption of technology leadership in the top management team. This perspective integrates prior work on technology leadership into a cohesive theoretical framework and helps bridge the gap between information systems literature and strategy literature applying the concept of dynamic managerial capabilities (e.g., Helfat and Martin, 2015; Yeow et al., 2018).

Second, we inform strategy literature on the potential of CIOs to induce firm strategic change, exemplified by relative exploration orientation, as a way to relieve adaptation pressures. We show that the presence of a CIO, an "agent of business change" (Banker et al., 2011, p. 488; Thatcher et al., 2011), fosters a firm's relative exploration orientation. Our findings also support our contention that firms often do attempt to relieve adaptation pressures by employing a CIO. In turn, knowledge about the strategizing activity at the top is indispensable to understand better the consequences of CIO presence in the C-suite (e.g., Besson and Rowe, 2012). We provide an example of how dynamic managerial capabilities can be represented by a specific functional leadership role, which increases our understanding of how individuals at the strategy table can sense, seize, and transform firm resources.

Third, in exploring these phenomena at the intersection of antecedents of CIO presence and its consequential outcomes on a firm's strategy, we identify what can trigger an organization to adopt IT more broadly. Our analyses show that firms require certain stimuli via adaptation pressures to act upon opportunities that arise with IT; in the case of the present study, the response to the stimuli is to hire a CIO or a comparable figure with a different title. When examining the presence of IT in any form within an organization, researchers may detect an underlying rationale of action and response patterns that create tension – comparable to the dyadic competitive action and response pattern in competitive dynamics literature (e.g., Chen et al., 2007). On a meta-level, we reason that while prior studies on CIOs assess the consequential outcomes, the drivers of such presence are at risk of being overlooked. Hence, this study contributes by raising awareness among scholars that an antecedent perspective of IT phenomena may be warranted. When

asking what the outcomes of digital transformation for a company are, it is useful to examine what has brought a firm to engage in such activities in the first place and to continue to clarify the contextual conditions (e.g., Hanelt et al., 2021).

Fourth, our theoretical framework and related empirical methods provide a blueprint for scholars to assess the broader presence of IT-related managers in the C-suite. Information systems researchers have devoted much attention to studying how IT effectuates organizational performance and can contribute to organizational alignment (e.g., Renaud et al., 2016). Yet before the present study, models on assessing the presence of technology leadership in the first place were scarce. Our work may also help align the emerging empirical CDO literature (e.g., Kunisch et al., forthcoming) with the established CIO literature. Beyond its applicability to an information systems context, we believe that our versatile theoretical framework and antecedents perspective of dynamic managerial capabilities can be important for other IT leaders beyond the top management.

Implications for Practice. We suggest that adaptation pressures require the focal firm to act and appoint a change agent, such as a CIO. We show three factors that lead to the appointment of a technology leader, and we advise managers to monitor them: an IT-intensive industry, a shortage of IT industry experience within the top management team, and a strategic shift towards IT. These factors can guide corporate decision-makers in deciding whether to embed a CIO or not. A technology leader such as a CIO has the potential to tilt the organization towards a more explorative orientation. Addressing practitioners from the perspective of strategy, our study's results strengthen the idea that reconfigurations of the top management team help the firm cope with adaptation pressures, mainly as the C-suite is a source of managerial change capabilities that can foster changes in organizational behavior. The need to resolve adaptation pressures is a good reason to bring in a CIO, and that fact can be readily communicated to shareholders. Further, prior research has shown that CIOs need to clearly understand why they have been hired (e.g., Gerth and Peppard, 2016). According to our findings, there may be much to be gained by making organizational realignment an explicit priority, and management who hires CIOs should tell them that their purpose is to realign the organization, rather than hinting at the exact purpose. A CIO's presence tends to be a consequence of heightened adaptation pressure that emerged before their appointment – pressure that can potentially be relieved through increasing the firm's relative exploration orientation. Suppose a firm needs a CIO who can act as a change agent and be a source of change-oriented dynamic managerial capabilities. In that case, it should assess candidates' related experience in effectuating organizational change instead of experience in increasing the efficiency of IT – a task area that is fundamentally different from what may be needed.

Limitations and Future Research. This study has several limitations that can serve as avenues for future research. First, by relating CIO presence to theory on the antecedents of dynamic managerial capabilities, we support the infusion of information systems theorizing into the literature of strategy, especially that on dynamic capabilities (e.g., Li and Chan, 2019; Yeow et al., 2018). The fact that technology leaders are pivotal figures for gearing systematic change activities causes information systems literature to have more to say on the origins. We encourage information systems scholars to further contribute to the dynamic capabilities view. Future researchers may want to continue to elucidate the sources of dynamic managerial capabilities (Schilke et al., 2018), which are specific top managers such as the CIO. Related studies could address the combined impact of technology leaders, such as the CIO and CDO, with the latter intended to help the CIO effectuate change and undertake transformation (e.g., Vial, 2019).

Second, the concept of adaptation pressures serves as a key notion in this study to develop theory on when and why firms appoint CIOs to their top management team. While we theorize on why adaptation pressures are a crucial latent mechanism that connects our set of antecedents with the presence of a CIO, future researchers could seek to disaggregate the monolithic concept of adaptation pressure. They could develop different archetypes of adaptation pressures beyond our conceptual distinction between external versus internal ones.

Third, while a direct measure of adaptation pressures is not applied, we believe that with future methodological advances, scholars will be able to directly probe the effects of our suggested antecedents on adaptation pressures, and through a mediator logic, examine the suggested effects of adaptation pressures on CIO presence. Relatedly, we probe the initial three hypotheses and the fourth hypothesis as two mostly unrelated regression models. An even more sophisticated approach would be to model the effects of the antecedents on relative exploration orientation, with CIO presence serving as a mediator. However, mediation analyses applied to panel data are methodologically underdeveloped, especially when accounting for fixed effects in model specification. Following Bentley and Kehoe (2020), future work can yield methodological blueprints that follow a mediation logic.

Fourth, embodying certain dynamic managerial capabilities, a CIO is likely to have a set of effects on firm outcomes (e.g., Schilke, 2014). Future research is warranted to further disentangle the effects of CIO presence from a dynamic capabilities perspective. Assuming the trend towards appointing a CDO alongside the CIO to the top management team continues, examining these particular roles and the combination thereof also promises to be an exciting endeavor for research. Furthermore, relying only on top managers as sources of dynamic managerial capabilities may obscure the importance of middle and lower-level managers, and a broader perspective could be taken. Likewise, while prior work identified the board of directors as another force driving technology (Choi et al., 2021; Yayla and Hu, 2014), its role as a source or trigger of dynamic managerial capabilities remains to be explored.

Conclusion

Building on the concept of dynamic managerial capabilities, we advance scholarly understanding of the antecedents and outcomes of CIO presence in the top management. We theorize that external and internal dimensions pertaining to IT can foster adaptation pressures, increasing the likelihood that technology leadership will be added to the firm leadership team. In turn, the presence of a CIO can lead the firm to orient itself more toward relative exploration to relieve these adaptation pressures through organizational change. The present study contributes a holistic theoretical framework for when and why environmental, structural, and strategic factors lead to CIO adoption in the top management team and strengthens the anchoring of an antecedents view of dynamic managerial capabilities

in information systems research.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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