



Key CDO functions for successful digital transformation: Insights from a Delphi study

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ABSTRACT

Given that the Chief Digital Office (CDO) is a new business position, it is not yet clear what the key functions they must develop to successfully undertake the company digital transformation process. Although previous literature has tentatively covered this issue, there are still gaps in knowledge about which functions are truly relevant. The aim of this paper is to fill this gap by (1) clarifying the key CDO functions through a Delphi study, validated by a digital dynamic capabilities (DDC) framework (Warner and Wäger 2019), and (2) presenting a measurement instrument useful for assessing the degree of the key CDO functions performance. The findings highlight that key CDO functions are those mainly related to the ability to scan the external environment for unexpected digital trends. In contrast, there is an interesting agreement not to consider CDO responsible for maintaining and advancing the current IT infrastructure and architecture. Our study contributes to understanding the role of a new emergent Csuite position that strategically integrates business and technological knowledge in successfully managing the digital transformation process.

1. Introduction

Digital technologies are disrupting a wide range of industries, transforming current ways of doing things and business models (North et al., 2019) through a process known as digital transformation (DT). DT goes beyond a mere digitalization of resources, as it involves the transformation of operations, products and processes, culminating in revised or entirely new business models (Hess et al., 2016; Singh et al., 2020). Following Vial (2019: 12), DT can be defined as “a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies”. Warner and Wäger (2019: 344) conceive DT as an ongoing process of strategic renewal that uses advances in digital technologies to build capabilities that refresh or replace an organization’s business model, collaborative approach, and culture.

Given the disruptive nature of digitalization, companies must build capabilities that strengthen strategic agility for rapid responses to unexpected opportunities while being skilled at reacting to the disruptions associated with using digital technologies (Hansen et al., 2011; Vial, 2019; Warner and Wäger, 2019). DT involves a wide range of tasks and activities that are complex, cross-functional and interdependent, which

makes it increasingly difficult for one person to assume all of them on their own (Horlacher and Hess, 2016). Consequently, companies need to assign and spread managerial responsibilities adequately across managers to ensure a successful DT. This is because many firms have created a new C-suite leadership role—the chief digital officer (CDO)—to oversee the establishment of digital capabilities in the company (Haffke et al., 2016; Horlacher, 2016). Although several authors agree that the CDO role is critical to ensure the improvement of a company’s competitive position through DT processes (Haffke et al., 2016; Earley, 2017; Tumbas et al., 2017; Singh et al., 2020), it remains unclear what CDO functions are essential to master a successful DT.

As Vial (2019) points out, the CDO role is difficult to define and requires a deep analysis to properly delineate it, since it arises from new requirements that companies demand, and its functions differ from those belonging to other traditional senior leadership levels. Although some positions—chief data officers, also named CDOs, chief information officers (CIOs), chief technology officers (CTOs), and chief analytics officers (CAOs)—are closely related, they do not fully encompass the CDO functions. Empirical evidence has demonstrated that what separates a CDO from other leaders is a strong digital business strategy and leadership orientation to drive the transformation (Kiron et al., 2016). A

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CIO has traditionally been in charge of an organization's digital endeavours, and the literature on information technology (IT) governance and digital business models has emphasized the CIO role throughout strategic alignment. However, the disruptive nature of DT (Vial, 2019) and the consequent complexity of business decisions tend to merit the creation of a separate position that focuses on a wide and strategic perspective. This position indicates, as Bharadwaj et al. (2013:471) conclude, that "the time is right to rethink the role of IT strategy, from that of a functional-level strategy - aligned but essentially always subordinate to business strategy - to one that reflects a fusion between IT strategy and business strategy." Thus, CDOs go beyond IT support and maintenance. A CDO must understand how to incorporate digital technologies into the business model and create a digital business strategy that goes beyond simply implementing a new IT application or infrastructure. CDOs work as boundary spanners to help execute a digital business strategy into a series of specific activities that influence a firm's organizing logic (Sambamurthy and Zmud, 2000) and foster close collaboration between business and IT functions (Vial, 2019).

However, since the CDO role is still very new and not fully consolidated, it implies different things to different organizations. Recently, researchers have discussed the CDO role in business practice (Haffke et al., 2016; Earley, 2017; Tumbas et al., 2017) and listed CDOs' responsibilities and functions in drawing different profiles of them. However, there is a lack of consensus about the key functions they must develop. In view of the literature gap, this research aims to explore and empirically validate the key functions of CDO. To meet this end, we conducted a Delphi study in which 14 specialist professionals participated. For this purpose, we first agree on our conceptual lens of DT, and subsequently, we adopt the digital dynamic capabilities (DDC) framework by Warner and Wäger (2019) to unify the criteria about CDO functions observed in previous literature (Haffke et al., 2016; Earley, 2017; Tumbas et al., 2017; Singh et al., 2020).

The contributions of this study are threefold. First, we perform a holistic compilation of CDO functions from previous academic references. Additionally, we proposed the DDC framework (Warner and Wäger, 2019), which is especially suitable for validating CDO functions. Second, through the Delphi method, consensus about key CDO functions was achieved. Previous research contributes significantly to understanding the role of CDOs in business practice, but there is still no clear and concise identification of the key functions of this managerial position that are essential to mastering a successful DT. Finally, a proposed instrument that measures a CDO's key functions is established to be useful both in research and in business practice. To the best of our knowledge, perhaps because of the novelty of the topic, no previous research has validated an appropriate measurement instrument. This has been possible in the current study thanks to the extraordinary internal consistency of the functions that received the highest scores from experts. In practice, this instrument can also be a guide to evaluate CDO performance.

After this introduction, an analysis of the theoretical background is presented. Next, the methodological approach of a Delphi study is described, followed by presenting and discussing the results. Finally, the paper concludes and addresses the practical implications of the study.

2. Background

2.1. Company digital transformation: chief digital officer

Companies in several economic sectors have started to put DT at the top of their strategic agendas (Singh and Hess, 2017). As stated previously, DT goes beyond merely digitalizing resources and engages the transformation of key business operations, products, and processes, ending in revised or completely new business models (Hess et al., 2016). Recent literature has started to clarify what it consists of (Liu et al., 2011; Singh and Hess, 2017; Vial, 2019; North et al., 2019). DT has been

defined "as an organizational transformation that integrates digital technologies and business processes in a digital economy" (Liu et al., 2011: 1730). As Singh and Hess (2017) point out, DT is a transformation rather than merely a change since an organization's DT goes far beyond functional thinking and holistically considers the comprehensiveness of actions that must be taken to exploit the opportunities or avoid the threats that stem from digital technologies.

However, the DT process does not work through inertia; it requires support. In fact, as Earley (2017) shows, many corporate digital goals are not achieved because of a lack of high-level support. Undoubtedly, DT demands digital business leadership (Haffke et al., 2016) with completely new mind and skill sets than previous waves of IT transformation (Fitzgerald et al., 2014). DT requires a leader with abilities to strategize, innovate and drive change that go beyond the abilities of a traditional CIO, who is more operational than strategy-oriented (Singh et al., 2020). CIOs mainly bring IT expertise, while CDOs add their business-related know-how (Horlacher and Hess, 2016). In response, many organizations have introduced the CDO as a new C-suite leadership role (Haffke et al., 2016; Horlacher, 2016). Since the CDO role is still in its nascent stages and not fully defined, it could imply different things to different organizations. Recently, researchers have discussed the CDO role (Haffke et al., 2016; Earley, 2017; Tumbas et al., 2017) or examined how CDOs must be anchored in the organization's structure once this new position has been incorporated (Singh et al., 2020). However, there is still no homogeneous understanding of the scope of the CDO key functions because firms bundle and combine a variety of responsibilities under this position.

Haffke et al. (2016) observe that in business practice, CDO functions depend not only on how the organization perceives the implications of digitalization but also on the orientation of the CIO role. For example, if a company already recognises the importance of digitally transforming itself (and has perhaps already started to transform), then more of the CDO's focus is on ensuring that there is a holistic digital vision and that digitization initiatives are aligned with the digital business strategy rather than exploring digital trends (to be considered). They also found that, in general, a CIO directs the IT function and takes responsibility for the traditional IT strategy and execution, whereas a CDO fulfils a business role that strategically addresses the DT process; however, if the CIO already has a sufficiently ambidextrous profile, then the CDO role will often be reduced in this respect. When the CIO's role encompasses more customer-oriented elements and is more deeply integrated into the strategic management of the company, there is less need to create a new, separate role to the extent that it is considered unnecessary. Similarly, Tumbas et al. (2017) identify different types of CDOs in business practice. Some organizations hold the CDO role to emphasize digital capabilities at a strategic level, while in other organizations, the CDO functions are more tactical and comprise a variety of specific initiatives that digitally assist different units across the organization and its customers. In other firms, the CDO is responsible for supporting product and service innovation, acting as an intersection of different functions, most commonly IT and marketing, as well as product development, technology strategy, communications, and operations. Likewise, Earley (2017) observes that the CDO functions depend on the level of firm maturity with respect to data management and other factors such as the size and business sector. Finally, Singh et al. (2020) shed light on organizational design parameters that help CDOs pursue DT activities. They highlight the importance of integrating CDOs into the organization by anchoring them, centrally or decentrally, depending on whether the company's DT strategy is centralized or decentralized.

Conversely, not every company perceives the need to create a new independent CDO position. The necessity depends on the different factors that influence DT processes. For example, as observed by Haffke et al. (2016), when the digitalisation pressure in the business industry is less intense, the need for a CDO to drive digital issues is lower. Therefore, when the business culture is more innovation-oriented and the cross-functional teams or committees are more effective, there is less

indication that a CDO is required (a possible argument would be that DT is part of the responsibilities of all executives who effectively share a CDO's functions among them). Additionally, when the digitalisation in the operational area of a company is more intense (and less intense in sales, marketing, customer service, etc.), there is less need for a CDO, as in these cases, the CIO can often perform much of the CDO's functions.

2.2. Digital dynamic capabilities and the CDO functions

There is an interesting fit between DDC theory as a conceptual foundation (Annarelli et al., 2021; Linde et al., 2021) and the CDO's functions as a phenomenon of interest. Dynamic capabilities are the abilities with which companies build, integrate, and reconfigure their resources and competences (Adner and Helfat, 2003; Kokshagina, 2021; Teece, 2007). Warner and Wäger (2019) develop a theoretical model that specifies the digitally based dynamic capabilities that are necessary to complete a DT process. Firms need to build strong DDC to rapidly create, implement, and transform business models to remain relevant in the emergent digital economy. These DDCs reside in skills, processes, procedures, organizational structures, decision rules and distinct disciplines that motivate and promote detection (*digital sensing*) and capture opportunities (*digital seizing*) to reconfigure organizations' capabilities (*digital transforming*).

Firms require *digital sensing* capabilities to scan the external environment for unexpected digital trends that could disrupt the organization (Warner and Wäger, 2019). Sensing new opportunities (and threats) is very much a scanning, creation, learning, and interpretative activity to analyse diverse information about trends in the digital business ecosystem. To sense digitally enabled growth opportunities, companies need to seek out and understand external information to identify new trends and interpret future digital scenarios. Digitally enabled innovation and growth opportunities arise from understanding digital customer needs and from identifying digital technology-driven opportunities.

In addition, a firm has to develop an understanding of how digital opportunities can help to achieve the firm's objectives and to review its business strategy. To address opportunities or neutralize threats, firms require *digital seizing* capabilities that safeguard leaders, avoid bias and allow firms to experiment with digital platforms and new business models (Teece, 2007). *Digital seizing* is an experimental capability that involves action and commitment by using techniques such as rapid prototyping and real options logic to effectively balance risk and reward (Warner and Wäger, 2019). Setting up digitalization initiatives is crucial to seizing perceived opportunities and anchoring pilot initiatives in an overall picture of digitalization (North et al., 2019) to quickly exploit technological and market opportunities. *Digital seizing* implies exploiting identified opportunities and mitigating threats of digitalization, revising business strategies and deciding whether to adapt current business models or develop new ones that balance external and internal options.

Finally, managing resources for DT is a prerequisite to achieve a mature DT (North et al., 2019). Transforming an organization requires, according to Teece (2007), the continuous alignment and realignment of specific tangible and intangible assets. Apart from financial resources, these assets are composed of knowledge of people and technologies embedded in processes. Once organizations have captured (*digital seizing*), opportunities are crucial to reconfigure (*digital transforming*) their capabilities (Warner and Wäger, 2019). This implies raising the awareness of the owners, managers, and employees of organizations regarding the required capabilities, as well as opportunities and threats; creating a shared understanding of what digitally enabled growth means for the firm; developing and communicating the digital strategy; and defining learning objectives (North et al., 2019). The core purpose of *digital transforming* capabilities is to manage a wide range of tensions that relate to balancing internal and external collaboration, redesigning flexible and manageable governance structures, and improving the digital maturity of an externally recruited and internally promoted

workforce.

Warner and Wäger's (2019) DDC framework is especially suitable for setting the limits of the CDO functions. CDOs are responsible for driving organizations' DT process; therefore, we consider that a CDO is responsible for developing DDC throughout the company. Accordingly, CDOs should foster *digital sensing*, *digital seizing* and *digital transforming*. As DDCs are composed of nine subcapabilities, in order to obtain an integrated view of the CDO position, we have paired them (see first two columns in Table 1) with each of the functions identified in the literature (see columns 3 to 6 in Table 1) that represents the CDO activities, roles and tasks observed in practice (Haffke et al., 2016; Earley, 2017; Tumbas et al., 2017; Singh et al., 2020). These links make the theoretical framework proposed especially appropriate to support the validation of the CDO functions and subfunctions.

Based on Warner and Wäger's (2019) framework and concerning *digital sensing* capability, the CDO first set of functions ensures DT success by actively developing *digital scouting*, *digital scenario planning* and *digital mindset crafting* subcapabilities. We found evidence supporting that CDOs foster *digital sensing*. Examples include *scouting digital trends* by assessing upcoming digital opportunities and threats; *planning digital scenarios* by strongly focusing on strategy and making digitalization a large component of a company's strategy (Tumbas et al., 2017); aggregating existing digital initiatives originating in different business units (Haffke et al., 2016); and *crafting a digital mindset* by sensitizing executives across the company so that they understand the opportunities and threats of digitalization trends in their respective markets (Haffke et al., 2016), i.e., being a key evangelist in organizations to promote a general entrepreneurial mindset (Earley, 2017; Tumbas et al., 2017).

The second set of CDO functions includes developing the *digital seizing* dynamic capability, which includes the ability to support *rapid prototyping*, the skill to *balance digital portfolios* and the competence of developing *strategic agility*. From the literature review, we observe that CDOs often experience with entrepreneurial methods to build *rapid prototyping* through brainstorming and idea-generation processes for innovation activities (Haffke et al., 2016; Singh et al., 2020). CDOs develop data analysis to gain insights from both internal and external data sources (Earley, 2017) and digital technologies that can enhance products, customer relationships and competitive positions (Tumbas et al., 2017), helping to properly *balance digital portfolios*. Finally, CDOs also respond with *strategic agility* to unexpected opportunities by formulating short decision-making paths and rapid digital implementation (Singh et al., 2020).

Finally, the third set of functions involves helping to understand and explain how DT is maintained in practice, i.e., to consolidate *digital transforming* capability by fostering *navigating innovation ecosystems*, *redesigning internal structures* and *improving digital maturity* subcapabilities. Some evidence from the literature supports that the CDO is often a member of the C-suite (Earley, 2017), i.e., that the CDO has a hierarchical position of senior executive, giving him or her enough power and resources to lead the DT process (Singh et al., 2020). From this position, CDOs often are in charge of designing cross-functional teams to implement changes in *redesigning internal structures*. As Singh et al. (2020) and Tumbas et al. (2017) observe, this function involves being responsible for implementing the DT strategy with commitment from everyone, coordinating employees who work on DT activities in different units and leading the required change management efforts (Haffke et al., 2016), i.e., *improving digital maturity* by expanding the digital knowledge base in their organizations to facilitate adaptation.

3. Study one: Delphi for an exploratory analysis

An online Delphi survey was the exploratory method applied to this study. It allows both the collection of reliable data for scientific purposes (Aengenheyster et al., 2017; Flostrand et al., 2020; Gnatzky et al., 2011) and facilitates expert debate and consensus (Gordon et al., 2020; Kavoura and Andersson, 2016). The Delphi survey method establishes

Table 1
Theoretical framework based on DDC and links with the CDO functions identified in previous literature.

Digital Dynamic Capabilities/Subcapabilities		Links with the CDO functions identified from the literature			
		Haffke et al. (2016)	Earley (2017)	Tumbas et al. (2017)	Singh et al. (2020).
Sensing <i>Detect digitally enabled growth potential</i>	Digital scouting <i>Scanning for digital trends/ Screening of digital competitors/ Sensing customer-centric trends</i>	Exploring digital trends.	Facilitating rapid digital experimentation.	Sensing the environment for emerging digital technologies.	Dealing with digital and technological challenges and opportunities.
		Assessing upcoming digital opportunities and threats.		Evaluating customer centeredness using a variety of data to gain insights.	Updating on digital advances across markets and industries generally.
		Sensing emerging online competitors.			Identifying what digital technologies customers value most.
	Digital scenario planning <i>Analysing scouted signals/ Interpreting digital future scenarios/Formulating digital strategies</i>	Understanding the industry-specific aspects of digitalization.	Leveraging dispersed initiatives to benefit multiple departments.	Leading the efforts to analyse data for new insights.	Discussing the digital initiatives and refining them depending on the outcomes of discussions.
		Aligning various digitization initiatives, originated in different business units.	Having one guided approach to digital strategy.	Needing extensive knowledge of digital technologies.	Discussing DT steps with fellow board members. Providing insights firm's DT strategy.
		Determining the implications of DT for the company.		Aggregating the disparate digital efforts distributed across the organization into a single unit and coordinate them.	Supporting DT activities in line with the firm's strategy.
		Developing and refine of an overarching digital strategy for the company.			
	Digital mindset crafting <i>Establishing a long-term digital vision/Enabling an entrepreneurial mindset/ Promoting a digital mindset</i>	Ensuring a common digital vision.	Being an evangelist about the importance of data.	Leading organization-wide DT.	Spreading information on the strategy to employees to develop a shared vision across units.
		Fostering a more innovative mindset.	Being able to effect process and cultural change.	Being the key evangelist in organizations for a general entrepreneurial mindset.	Supporting product managers to not only understand new digital products but also properly market them.
		Fostering cultural change across the company.		Reconciling existing organizational values with digital innovations.	Managing the cultural shift. Inspiring people in the organization about digital topics.
Seizing <i>Leverage digitally enabled growth potential</i>	Rapid prototyping <i>Creating minimal viable products. Methodology/Considering a lean start-up/Using a digital innovation lab</i>	Creating prototyping of digital innovations.	Connecting abstract digital concepts with tangible business outcomes.	Facilitating continual experimentation with minimal viable products of digital innovations.	Brainstorming and idea-generation processes for innovation activities.
		Experimenting with innovative digital-end customer services.	Taking an agile approach to innovation and continually drive experimentation and iteration.	Focusing on experimenting with new capabilities in novel areas.	Scanning the start-up market for ideas that can be transferred to the organization.
		Establishing digital innovation labs.			Creating start-up workspaces to serve as a breeding ground for new ideas.
	Creating a hub for experimentation.	Getting a rapid digital experimentation.	Experimenting intensely with a variety of digital technologies.	Testing many new digital tools and technologies.	
	Balancing digital portfolios <i>Balancing internal and external options/Scaling up innovative business models/ Setting an appropriate speed of execution</i>	Introducing digital collaboration tools.	Developing data analysis to gain insights from both internal and external data sources.	Creating connections between existing and new digital capabilities.	Bringing innovation into the company via the use of new digital technologies.
		Responding rapidly to evolving digital trends.		Developing digital technologies that can enhance products, customer	

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Table 1 (continued)

Digital Dynamic Capabilities/Subcapabilities		Links with the CDO functions identified from the literature			
		Haffke et al. (2016)	Earley (2017)	Tumbas et al. (2017)	Singh et al. (2020).
				relationships and competitive position.	
				Reducing the cycle time required for different areas to consider and incorporate digital innovations.	
	Strategic agility <i>Rapid reallocating resources/ Accepting redirection and change/Pacing strategic responses</i>	Leading the required change efforts. Quickly realizing the strategic implications of digital trends.	Guiding digital marketing efforts with an emphasis on customer intimacy. Focusing on process change.	Focusing on maintaining and advancing the current IT infrastructure and architecture. Adapt data policies to the digital evolution in the organization. Adapting data policies to the digital evolution in the organization.	Making short decision-making paths and rapid digital implementation.
Transforming <i>Transform capabilities to realize the full potential of digital strategic change</i>	Navigating innovation ecosystems <i>Joining a digital ecosystem/ Interacting with multiple external partners/Exploiting new ecosystem capabilities</i> Redesigning internal structures <i>Hiring a CDO/ Digitalization of business models/Designing team-based structures</i>	Not identified ^a Being a new C-suite member. Leading key transformational digital initiatives into organization. Designing cross-functional teams to implement changes.	Not identified ^a Becoming directly involved in governance, acting more as ambassadors and liaisons rather than taking on this operational aspect of the role.	Not identified ^a Being a new C-suite member. Helping to successfully use various classes of digital technologies to generate value. Establishing digital channels to the customer and mobile solutions. Emphasizing governance and the need for transparency in digital projects.	Not identified ^a Being a new C-suite member. Spreading digitalization throughout the organization. Coordinating between employees who work on DT activities in different units and at different hierarchical levels. Handling organizational interdependencies and to link intra-organizational key stakeholders during DT activities.
	Improving digital maturity <i>Identifying digital workforce maturity/External recruiting of digital natives/Leveraging digital knowledge inside firm</i>	Recruiting digital talent.	Helping to acquire data analytics capabilities. Helping different managers to understand how the quality of data impacts their business objectives. Working in different functional areas with managers who are trying to achieve business objectives.	Focusing on data quality issues. Being different from that of IT executives in their organizations. Understanding data analytics techniques. Being facilitators of enterprise-wide change associated with digital transformation. Building up their organizations' digital capabilities.	Helping to acquire data analytics capabilities. Training for all employees on specific digital topics. Facilitating cooperation about DT activities across functions, executives and employees. Expanding the digital knowledge base in their organizations to facilitate adaptation.

^a This digital dynamic subcapability was not detected in the literature review.

multiple discussion rounds of the same set of theses to feedback an aggregated group opinion to the participants, leading them to a convergence – or divergence – of opinions. The Delphi methodology produces more accurate results than traditional opinion-polling techniques (Beiderbeck et al., 2021a).

The Roßmann et al. (2018) approach was applied to guarantee the quality and validity of our Delphi results (see Fig. 1). First, we collected a long list of CDO functions (88 ideas) (see Table 1) based on interviews with executives conducted in previous research (Haffke et al., 2016;

Earley, 2017; Tumbas et al., 2017; Singh et al., 2020). After several reviews and working meetings between the members of our team, we extracted 43 CDO function-related statements. Second, we selected a homogeneous set of experts to participate in our study, with recognized expertise in the topic. Third, we conducted the Delphi survey and asked participants to assess each of the statements concerning CDO functions on the basis of their level of agreement. Fourth, we explained the descriptive statistics applied. Fifth, we analysed the results of consensus. Finally, we conducted a dissent analysis.

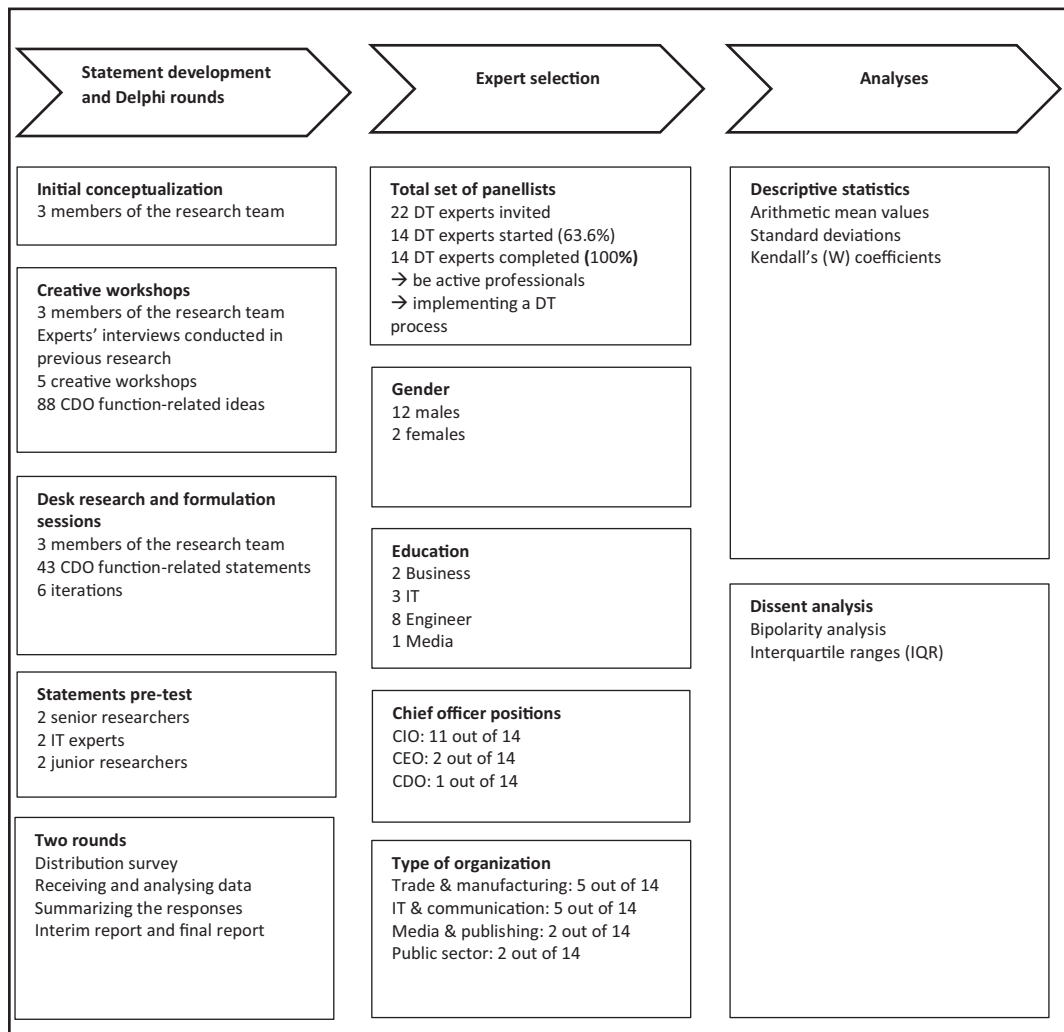


Fig. 1. Statement development, expert selection, and analyses (adapted from Roßmann et al., 2018).

3.1. Development of Delphi statements

To study the key functions of CDO, we aimed to create a specialized picture of the potential functions of a CDO. We conducted an initial conceptualization phase to define a comprehensive structure for a versatile set of potential functions of a CDO. We held five creative workshops with members of the research team to prepare a full list of potential functions related to a CDO. In these sessions, we collected 88 ideas from previous research based on interviews with executives and/or CDOs from various sectors (Haffke et al., 2016; Earley, 2017; Tumbas et al., 2017; Singh et al., 2020) (see Table 2).

After these creative workshops, members of the research team conducted formulation and review sessions (6 iterations in total) to analyse the findings. The goal was to decide the final set of Delphi statements. We obtained a set of 43 CDO functions. This high number of single-question statements is appropriate in topics where qualitative feedback is not the core of the research (Beiderbeck et al., 2021a).

Due to the specific adaptation to the digital transformation context, we opted for the DDC framework by Warner and Wäger (2019), which is especially appropriate to validate CDO functions (see Section 2.2). Based on this framework, the 43 statements were grouped according to their link to different digital capabilities and subcapabilities (see Appendix 1). The research team reviewed these links individually and then discussed the results, reaching an agreement where each digital subcapability was represented with at least one statement, except in *Navigating innovation*

Table 2
Interviewee's overview.

Previous research	Interviewed	Companies/Location
Haffke et al. (2016)	19 CIOs or CDOs	Companies with least 250 employees, annual revenues of 50 million Euros or more, and a history of at least 15 years with an established IT function
Earley (2017)	Several CDOs and CEOs that attended the MIT Chief Data Officers Symposium (www.mit.cdoiq.org)	From various types of companies
Tumbas et al. (2017)	35 CDOs	From various types of companies
Singh et al. (2020)	4 CDOs and their colleagues	Companies with various sizes engaged in DT activities and that had a CDO

ecosystems subcapability.

Regarding question format, we used a fixed (end-state) statement type (Beiderbeck et al., 2021a). To assess each statement, participants expressed their level of agreement using a traditional five-point Likert scale ranging from very low (1) to very high (5). To formulate the Delphi statements, we first translated them into Spanish and then iteratively reviewed the wording. As an introduction to the online questionnaire,

we also discussed relevant information associated with our statements and emphasized to the participants the meaning of DT and subsequently, the importance of distinguishing the role of a CDO from that of other managerial positions. This information provided a common basis to all experts and motivated participants to think of both supporting and opposing arguments, which is a way to mitigate framing, anchoring, or desirability biases (Winkler and Moser, 2016; Bonaccorsi et al., 2020).

In the last step, to guarantee high reliability (Beiderbeck et al., 2021a), two senior researchers checked the 43 statements proposed for all relevant quality criteria. Two IT experts and two junior researchers checked comprehensibility and clarity (Hasson and Keeney, 2011; Markmann et al., 2020). Based on these pre-tests, we slightly adjusted our final wording.

3.2. Expert selection

A proper selection of participants is essential for the validity of a Delphi study (Hasson et al., 2000). We aimed to recruit a homogeneous small set of experts, i.e., participants with similar levels of knowledge in the objective of research. To achieve this homogeneity, we selected participants considering, first, that they should be active professionals and, second, that their organizations were implementing a DT process. When the panel's criterion selection is homogeneous, a sample size of between 10 and 15 people can yield sufficient results and assure validity (Skulmoski et al., 2007). Moreover, scholars have shown that, for specialized topics, a condensed set of experts is suitable (Beiderbeck et al., 2021a). In recruiting such panel members, we applied the snowball sampling method to identify and select the panel members (Etikan and Bala, 2017; Rezaei et al., 2021). First, we used the professional experience of one member of our research team to contact relevant individuals, and later, we asked each of them to recommend colleagues who were actively involved in DT in other companies and who were willing to be interviewed. At last, 22 experts were eventually invited. Once they were identified, each participant was formally contacted by phone or email invitation. To maintain methodological rigor, we contacted all experts individually and specifically asked them not to share the survey link without research team permission (Beiderbeck et al., 2021b). The overall response rate was thus 63.6%, i.e., 14 experts agreed to participate, and all of them finished the entire Delphi study that consisted of two rounds (see Fig. 1). The sample size reached is typical in scientific studies using the Delphi technique that require the participation of highly specialized experts (Hilbert et al., 2009). All of them were high-level workers in competitive companies from different economic sectors and were responsible for IT, managers and/or were in charge of DT. Participant anonymity was maintained throughout the entire process and guaranteed from the first contact to avoid biases produced by perceived authority, persuasion, or bandwagon effects (Osborne et al., 2003).

Regarding the characterization of our panel of experts, all of them were Spanish. Their professional profile was in most cases linked to technological environments (eight engineers and three computer scientists), two of them from business education and one from media. The gender distribution was twelve men and two women. Regarding their chief officer positions, eleven were CIOs, two CEOs and one CDO. In terms of the type of organization, five belonged to the retail and manufacturing sector, five to IT and communication, two to media and publishing and two to the public sector.

3.3. Delphi survey conduction

From a technical perspective, the *Alchemer* platform, a professional software tool suitable for Delphi research (Aengenheyster et al., 2017), supported the links to the online Delphi questionnaire. A personalized link to the questionnaire was created for each of the participants to identify the responses individually to carry out the subsequent Delphi round.

To ensure a clear understanding of the procedure, we provided an introduction to all participants about the Delphi technique. Following the introduction, experts were asked to assess all 43 statements quantitatively. The quantitative evaluation was focused on their "level of agreement".

3.4. Descriptive statistics

For quantitative analysis, we asked for the level of agreement per statement and expert. Respondents were asked to indicate on a five-point Likert scale from 1 "strongly disagree" to 5 "totally agree" the extent to which they agreed with each statement. We effectively generated 602 statement-related numeric assessments. We then assessed the panel consensus. Responses were grouped into two categories, one considering Likert scores of 1 and 2 (disagree) and the other incorporating scores of 4 and 5 (agree). Regarding consensus criteria, we considered the agreement threshold to be achieved when at least 75% of the experts "agreed" or "disagreed" on each specific proposed statement, as Giannarou and Zervas (2014) and Christie and Barela (2005) recommended.

Moreover, the rounds of the Delphi method are recommended to be repeated until either sufficient stability is reached. Concerning stability measurement, we applied Kendall's (*W*) as a finishing criterion (Beiderbeck et al., 2021a; Rezaei et al., 2021). Kendall's (*W*) value levelled off after two successive rounds. The two-round process to reach consensus is in line with Mullen's (2003) suggestion that states when the sample is small, no more than two rounds may be needed.

Afterwards, to gain insights into potential reasons for diverging expert opinions, we conducted a dissent analysis following our descriptive statistics (Warth et al., 2013). To do so, we checked for bimodal distributions and visually inspected histograms of the level of dissent for statements that had not obtained consensus. Additionally, interquartile range (IQR) analysis was considered. A threshold value of the IQR higher than 1.25 was defined as a level of dissent. Such a dissent measure is also in line with earlier Delphi research (Warth et al., 2013).

3.5. Descriptive statistics-results

To ensure reliable data quality for further processing, all expert inputs were checked for errors before analysis (Häder, 2002). SPSS 26.0.0 software was used for the analysis. The arithmetic means and standard deviations (SD) values of the ratings for each statement (grouped by DDC) and in each round of the Delphi survey were calculated (see Table 3).

3.5.1. 1st round

The first round lasted 25 days (from February 23 to March 19, 2021). Consensus of agreement was reached on 27 statements (see Appendix 2), i.e., 75% of our experts agreed 27 out of 43 statements. No consensus of disagreement was obtained (see Appendix 3).

Kendall's *W* was calculated ($W = 0.27$, $X^2 = 161.31$ y $p < 0.00$). Given that the value of $p = 0.00 < 0.05$, the result allows us to reject the null hypothesis that there is no agreement between the experts. However, the consensus level was weak ($W = 0.27$). Therefore, we decided to carry out another round in which the 16 statements without consensus were re-evaluated.

3.5.2. 2nd round

In the second round, the respondents were informed about the other panel members' responses in the first round. Participants received feedback from the group's mean responses to the 16 statements without consensus and were invited to review their own response and amend their rating using the same Likert scale. Again, the questionnaires were personalized for each participant. Studies have shown that this method improves the decision quality of the Delphi method (Gordon and Pease, 2006).

Table 3
Descriptive statistics results of the first and second Delphi rounds (N = 14).

Statements		Round 1				Round 2				
		Min.	Max.	Average	SD	Min.	Max.	Average	SD	
Digital sensing	S12	4.00	5.00	4,79	0.42582	4.00	5.00	4,79	0.42582	
	S23	3.00	5.00	4,64	0.63332	3.00	5.00	4,64	0.63332	
	S24	4.00	5.00	4,93	0.26726	4.00	5.00	4,93	0.26726	
	S25	1.00	5.00	3,79	0,11,883	1.00	5.00	3,64	0.92878	
	S36	1.00	5.00	4,00	117,670	1.00	5.00	4,00	117,670	
	Digital scenario planning	S37	1.00	5.00	4,14	109,945	1.00	5.00	4,14	109,945
		S1	3.00	5.00	4,36	0.74495	3.00	5.00	4,36	0.74495
		S4	1.00	5.00	4,00	124,035	1.00	5.00	4,00	124,035
	S9	1.00	5.00	3,50	109,193	2.00	5.00	3,64	0.74495	
	Digital scouting	S34	1.00	5.00	4,43	108,941	1.00	5.00	4,43	108,941
	Digital mindset crafting	S22	1.00	5.00	4,14	129,241	1.00	5.00	4,14	129,241
	S35	4.00	5.00	4,64	0.49725	4.00	5.00	4,64	0.49725	
	Digital seizing	S3	1.00	5.00	4,50	109,193	1.00	5.00	4,50	109,193
		S7	3.00	5.00	4,21	0.69929	3.00	5.00	4,21	0.69929
		S8	1.00	5.00	4,43	108,941	1.00	5.00	4,43	108,941
S10		1.00	5.00	4,07	107,161	1.00	5.00	4,07	107,161	
S33		1.00	5.00	3,86	116,732	1.00	5.00	3,86	116,732	
Balancing digital portfolios		S41	1.00	5.00	3,50	155,662	1.00	5.00	3,79	125,137
		S17	1.00	5.00	4,07	114,114	1.00	5.00	4,07	114,114
		S32	1.00	5.00	3,36	127,745	1.00	5.00	3,57	128,388
S38		1.00	5.00	4,07	114,114	1.00	5.00	4,07	114,114	
Rapid prototyping		S39	1.00	5.00	3,36	133,631	1.00	5.00	3,36	115,073
		S2	1.00	5.00	3,93	120,667	1.00	5.00	3,93	120,667
S27		2.00	5.00	3,79	0.97496	2.00	5.00	3,79	0.97496	
Strategic agility		S40	1.00	3.00	1,86	0.86444	1.00	2.00	1,57	0.51355
		S18	1.00	5.00	3,64	121,574	3.00	5.00	3,93	0.73005
		S20	3.00	5.00	4,21	0.57893	3.00	5.00	4,21	0.57893
	S21	1.00	5.00	3,50	109,193	2.00	5.00	3,71	0.91387	
	S26	1.00	5.00	3,21	167,233	3.00	5.00	3,93	0.73005	
	S28	2.00	5.00	3,36	115,073	1.00	5.00	3,43	108,941	
	S29	1.00	5.00	4,07	126,881	1.00	5.00	4,07	126,881	
	S30	1.00	5.00	4,29	132,599	1.00	5.00	4,29	132,599	
	S42	1.00	5.00	4,14	109,945	1.00	5.00	4,14	109,945	
	Improving digital maturity	S43	2.00	5.00	4,07	0.99725	2.00	5.00	3,86	0.86444
S5		1.00	5.00	3,71	143,734	3.00	5.00	4,00	0.55470	
S6		1.00	5.00	3,14	140,642	1.00	5.00	3,21	125,137	
S11		1.00	5.00	3,64	108,182	1.00	5.00	3,79	105,090	
S13		3.00	5.00	4,50	0.85485	3.00	5.00	4,50	0.85485	
S14		1.00	5.00	4,29	113,873	1.00	5.00	4,29	113,873	
S15		1.00	5.00	4,43	108,941	1.00	5.00	4,43	108,941	
S16	1.00	5.00	4,21	118,831	1.00	5.00	4,21	118,831		
S19	1.00	5.00	3,50	145,444	2.00	5.00	3,79	0.80178		
Digital transforming	Redesigning internal structures	S31	2.00	5.00	4,50	0.94054	2.00	5.00	4,50	0.94054

This second round lasted 8 days (from March 22 to 30, 2021), with a response rate of 100%. The mean and SD of the agreement ratings for each response to each of the 16 statements were calculated (see Table 4). From the 16 statements evaluated in the second round, only one of them reached a consensus of agreement (S5) (see Appendix 2). Therefore, consensus was finally reached on 28 statements (see Appendix 5). On the opposite side, one of them (S40) reached a consensus of disagreement (see Appendix 3).

Regarding the rates obtained from the 43 statements, although they reached a Kendall's W greater than that obtained in the first round, they were very similar ($W = 0.28, X^2 = 165.62, p < 0.00$). Even though the level of consensus (W) obtained was also weak, consensus was considered to be stabilized in these two successive rounds. As recommended by Schmidt (1997), the rounds of the Delphi method should be repeated until either sufficient consensus is indicated by Kendall's (W) value or

Table 4
Digital dynamic capability priority based on the CDO key functions consensus of agreement.

CDO key functions fostering digital...	Means	Rank order based on mean
...Sensing	4.23	1
...Transforming	4.06	2
...Seizing	3.91	3

the level of consensus levels-off in two successive rounds. Moreover, as the potential improvement from another round was further judged to be low balanced to risking either drop-outs or making artificial consensus, we decided to stop our study after the second round.

In this context, statements S24, S12 and S23 belonging to digital sensing capability and digital scenario planning subcapability are expected to have the highest impact on DT process success, with an average ranging between 4.93 and 4.64, followed by statement S35, with an average of 4.64 (belonging to digital sensing/digital mindset crafting). Only one statement (S40 - CDO focuses on maintaining and advancing the current IT infrastructure and architecture, with a strong emphasis on reliability, performance and security), which was rated with a mean impact below 3.0, is not considered at all a CDO function.

3.6. Dissent analysis

In the absence of a consensus on mean statement scores, a dissent analysis can reveal valuable insights for discussion (Warth et al., 2013; Beiderbeck et al., 2021b). For this purpose, we checked for bimodal distributions and visually inspected histograms of 14 statements without consensus on our Delphi study. The bimodal distribution indicates that there are two separate and independent groups of experts with respective intragroup consensus.

Regarding these statements, we found two cases with bimodal

distribution (S6- CDO complements marketing efforts and S32- CDO is less focused on operational reliability and more focused on experimenting with new capabilities in novel areas). Visual inspection of corresponding histograms also corroborated these results (see Fig. 2). One reason for the discrepancies observed in S6 statement could be because some organizations prefer the “digital marketer role”, as explained by Tumbas et al. (2017), considering that CDO leads organizations’ digital marketing tasks, emphasizing customer needs through social media and mobile computing technologies, and analysing customer data intensively. Others place the CDO role in a harmonizing position with the priority objective of elevating digital innovation activities to a more strategic level. Regarding S32, the disagreement could be because in some organizations, CDOs address digital innovation through existing executive positions, such as CIOs, usually also in charge of operational reliability.

In addition, to detect the statements with the greatest disagreement, we also conducted an analysis of the IQR (see Appendix 4). In the first round of our Delphi study, eleven statements indicated an IQR higher than 1.25, while in the second round, only three were observed (S6, S32 and S41), two of which confirmed the results of the previous bimodal analysis. Regarding S41- CDO is responsible for questioning existing business models, one dissent reason could be related to the sector to which their organization belongs. Although DT must lead to a radical change in business model, in some business sectors, changes are still associated with internal operational aspects related to products and/or specific processes that are outside our DT conceptual definition.

4. Study two: measurement instrument analysis

The internal consistency of 28 statements (27 statements with consensus of agreement from the first round and one statement with consensus of agreement from the second round) was verified with Cronbach’s alpha, assuming that high values indicate that statements measure the same construct. A reliability coefficient of 0.70 or higher is considered acceptable (Hakan and Seval, 2011).

Cronbach’s alpha result for the whole group of 28 statements reached 0.92, which indicates their validity in measuring “CDO key functions”. Specifically, the value for digital sensing capability was 0.78. Digital seizing capability statements obtained a value of 0.90, and for digital transforming capability statements, the value was 0.73. The findings suggest that the CDO functions rated by our experts had relatively high internal consistency. Thus, we calculated the mean scores obtained for each main capability and ranked them according to the mean (see Table 4).

To obtain a valid instrument for measuring the CDO functions, we decided to evaluate Cronbach’s alpha just for the statements that received a consensus of agreement of more than 90% (see Appendix 2) in Delphi study’s second round (with the result of top 9 statements). Given the acceptable value of 0.81 obtained, we suggest that these top 9 statements constitute a good instrument to measure CDO key functions.

Table 5 shows them ordered according to the mean scores.

The very good internal consistency of the functions that received the highest scores from the experts leads us to propose what is, to our knowledge, the first measurement instrument to assess whether there is a person in a company assuming the crucial functions of a CDO. This is important because we argue, in accordance with previous literature, that it is necessary for organizations to have a person who assumes these functions for a successful DT process. If no one is responsible for these functions, the organization should consider incorporating new talent with this profile. Additionally, the evidence that the best valued functions are in accordance with the three main digital capabilities from Warner and Wäger’s (2019) DDC framework provides theoretical support for the reliability of the instrument generated.

Thus, the final work consisted of grouping statements that were very similar and from which potential readers would not detect differences. This work consisted of transforming the first ranked nine functions with a consensus of agreement rate greater than 90% (see Table 5) into the final six functions, which make up the final instrument we summarize in Table 6.

5. Discussion

Previous literature has identified different roles of the CDO in business practice depending on both specific contextual factors and DT particular needs. Each CDO role has different focal domains in which they develop one or more digital capabilities (Haffke et al., 2016; Tumbas et al., 2017). Our work contributes to previous literature by compiling the most appropriate domains on which a CDO role should focus. As a result, a consensus of the key functions that a CDO should develop to ensure DT success was obtained. The consolidation of CDO roles is still emerging, and this paper provides evidence that this delimitation remains unfinished.

After organizing and classifying all the CDO functions found from the literature review on the basis of their relationship with the DDC framework, we obtained consensus of agreement for 28 functions and a consensus of disagreement in just one statement. Even considering the nine most rated functions (see Table 5), the three main DDCs were represented. Consequently, there seems to be general agreement that the CDO has an important role in fostering sensing, seizing and transforming digital capabilities. The fact that none of the three main digital capabilities has been unrepresented is consistent with our proposal to establish an integrated view of the CDO position using the DDC theoretical framework.

From a capability aggregated view, the functions linked to sensing are the most agreed upon by our experts, given the high consensus of agreement for the statements associated with digital scenario planning and digital mindset crafting subcapabilities.

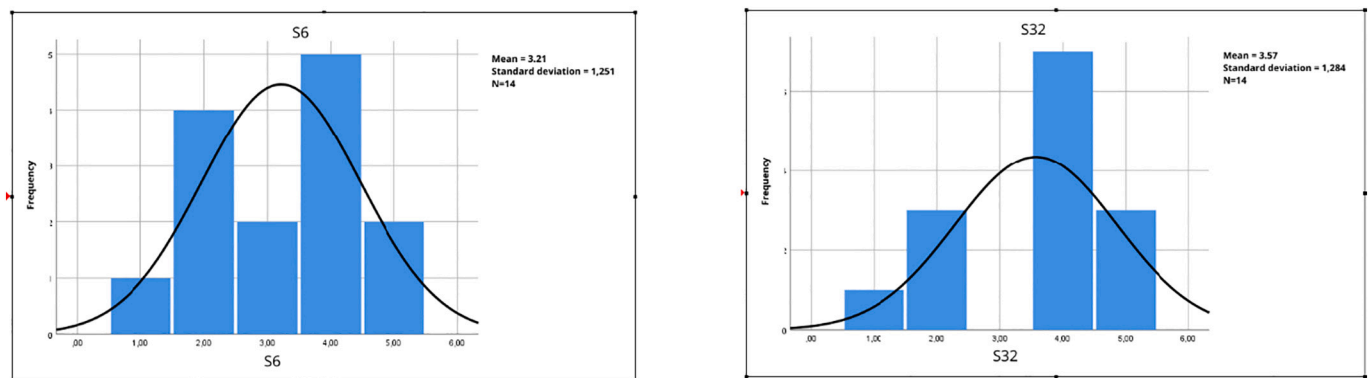


Fig. 2. Histograms of the S6 y S32 statements.

Table 5
Top 9 CDO functions resulting from the Delphi study and their correspondence to digital dynamic capability and subcapability.

Statements	Digital Subcapabilities	Digital capability	Round 2 (1)	Mean	Rank order (2)
S24. The CDO is brought in to take an aggregate and strategic view of all ongoing digital initiatives.	Digital scenario planning	Sensing	100%	4.9209	1
S12. The CDO manages digital initiatives across the organization with a long-term and strategic focus.	Digital scenario planning	Sensing	100%	4.7665	2
S35. The CDO is concerned with reconciling existing organizational values with digital innovations.	Digital mindset crafting	Sensing	100%	4.6170	3
S23. The CDO aligns the DT process with DT strategy.	Digital scenario planning	Sensing	93%	4.5958	4
S3. The CDO develops digital technologies that can enhance products, customer relationships and competitive position.	Balancing digital portfolios	Seizing	93%	4.2489	5
S8. The CDO needs a strong focus on strategic changes to organizational processes, products, services and business models.	Balancing digital portfolios	Seizing	93%	4.1817	6
S34. CDOs are generalists—focusing on a variety of digital opportunities.	Digital scouting	Sensing	93%	4.1817	7
S15. The CDO helps to successfully use various classes of digital technologies to generate value.	Redesigning internal structures.	Transforming	93%	4.1817	8
S20. The CDO understands data analytics techniques.	Improving digital maturity	Transforming	93%	4.1766	9

(1) % agreed with this statement; (2) Based on the mean.

Table 6
Instrument for measuring the CDO key functions.

Final questionnaire statement	Previous statements considered
In our organization, there is a person in charge of the digital transformation process who:	
1.- Continually works to make the most of new digital opportunities.	S34. CDOs are generalists—focusing on a variety of digital opportunities.
2.- Understands data analysis techniques.	S20. The CDO understands data analytics techniques.
3.- Strongly focuses on digital strategic changes over organizational processes, products, services and business models.	S3. The CDO develops digital technologies that can enhance products, customer relationships and competitive position. S8. The CDO needs a strong focus on strategic changes to organizational processes, products, services and business models.
4.- Manages and aligns digital initiatives with the DT strategy.	S24. The CDO is brought in to take an aggregate and strategic view of all ongoing digital initiatives. S12. The CDO manages digital initiatives across the organization with a long-term and strategic focus. S23. The CDO aligns the DT process with DT strategy.
5.- Reconciles the existing values in the organization with digital innovations.	S35. The CDO is concerned with reconciling existing organizational values with digital innovations.
6.- Supports using digital technologies to generate value in the organization.	S15. The CDO helps to successfully use various classes of digital technologies to generate value.

5.1. The role of the CDO in fostering digital sensing capability

Sensing capability is fostered through CDO functions that are linked to the following subcapabilities: *digital scenario planning* and *digital mindset crafting*. Both were highly rated, reaching almost 100% consensus of agreement in our Delphi study.

Our panel of experts considered that the key functions of a CDO to support *digital scenario planning* are S24, *establishing an aggregated and strategic view of all ongoing digital initiatives*; S12, *managing digital initiatives across the organization with a long-term and strategic focus*; and S23, *aligning the DT process with the DT strategy*. These results are consistent with recent research on organizations that have built strategic planning capabilities (Dong et al., 2016; Matt et al., 2015) to better equip themselves for the digital age. *Digital scenario planning* subcapability means dealing with digital and technological challenges and opportunities in line with the firm’s strategy (Singh et al., 2020). This subcapability focuses on developing, refining, and executing an overarching digital

strategy for the company (Haffke et al., 2016; Earley, 2017). This implies taking an aggregate and long-term view of DT (Tumbas et al., 2017). Continuous development and communication of the digital strategic plan across the firm are necessary to minimize internal conflict and to maximize complementarities and productive exchange within the enterprise.

The results also show a high level of consensus of agreement in the CDO function associated with *digital mindset crafting*, specifically S35, *reconciling existing organizational values with digital innovations*. DT processes must be supported by an organizational culture that emphasizes an innovative mindset as well as ambition for improvement (Kiron et al., 2016). However, altering culture is costly, so change will not be embraced instantaneously. Mindset crafting can be promoted and supported by CDO, reducing possible anxiety associated with cultural changes in organizations (Teece, 2007).

Finally, experts achieved 93% consensus of agreement for statement S34. *CDOs are generalists and focus on a variety of digital opportunities*, supporting the idea of their value in *digital scouting* activities and confirming their influence in all *digital sensing* subcapabilities.

The agreements regarding *sensing* capability statements support Tumbas et al.’s (2017) idea of CDO as an accelerator of technological innovation, supporting existing IT leaders in the organization.

5.2. The role of the CDO in fostering digital seizing capability

Additionally, once a CDO detects digital opportunities and evaluates the implications for the company, he or she must lead product or service innovation ideas, generating rapid prototyping and real options logic to effectively balance risk and reward, i.e., *seizing* them.

The most valued CDO functions to foster *seizing* capability are those associated with *balancing digital portfolios*. This subcapability is driven by the CDO balancing internal and external options and scaling up innovative business models with an appropriate speed of execution. To support these activities, CDO functions S3, *developing digital technologies that can enhance products, customer relationships and competitive position*, and S8, *focusing on strategic changes to organizational processes, products, services and business models*, were verified with a high level of consensus of agreement (93%).

Finally, regarding *seizing* capability, our experts considered that statement S40, *the CDO focuses on maintaining and advancing the current IT infrastructure and architecture, with a strong emphasis on reliability, performance and security*, is clearly not a function of CDO, reaching 100% disagreement consensus in the second round. This statement has a high level of agreement with statement S14, *CDOs should be freed from the responsibility of maintaining the existing IT infrastructure in their organizations*. This degree of consensus in both statements strengthens the idea of

distinguishing new CDO positions from traditional CIO functions and the evolution of the overall concept of the CDO role.

5.3. The role of the CDO in fostering digital transforming capability

In a fast-paced environment, digitalization increases the complexity of organizational activities, and the creation of learning, knowledge sharing, and knowledge integrating procedures is critical to business performance (Teece, 2007). While technologies can enable new and faster ways to innovate, without a CDO supporting *digital transforming* capability, the consolidation and maintenance of the DT process are not guaranteed.

We found that the CDO who assumes this task helps to *redesign internal structures* through function S15, *using various classes of digital technologies to generate value and improving digital maturity*, and through function S20, *helping to understand data analytics techniques*. In contrast, no functions related to the subcapability of *navigating innovation* ecosystems were identified from the literature review.

With these last two statements, our experts completed a basic profile of the CDO functions, all of them with a high percentage of at least 93%. However, other additional and important aspects were detected by Delphi consensus of agreement. Our experts considered, as previously mentioned, that *CDOs should be freed from the responsibility of maintaining the existing IT infrastructure in their organizations* (S14) and should have *the freedom and flexibility to experiment intensely with a variety of digital technologies* (S17). Regarding its hierarchical position within the company, and in accordance with the previous literature, our experts agreed that the CDO should be a *new member of the C-suite* (S13), thus *reducing the cycle time required* (S33). From this position, the CDO would complement existing IT leaders and *guide the organization's digital marketing efforts with an emphasis on customer intimacy* (S2), and the CDO would be in charge of linking together a wide variety of digital initiatives in many different areas of his or her organization. Concerning his or her skills, the CDO would *need extensive knowledge of digital technologies* (S36). This result emphasizes the importance of distinguishing the role of a CDO from that of the CIO. As shown by Hess et al. (2016), ideally, the CIO would focus on leading the IT function and take responsibility for the traditional IT strategy and its execution, while the CDO would be liberated from this responsibility. In this way, the CDO would assume with greater freedom the search and evaluation of emerging digital technologies in the market, which generally involves the company's products and services, as well as interface points with clients and partners (Hess et al., 2016).

However, as our dissent analysis showed, there were two groups of experts with opposing views on whether a *CDO should focus less on operational realities and more on experimenting with new capabilities in novel areas* (S32). These opposing views can also be observed even in some statements where the experts reached a consensus, for example, in the statement that a *CDO is not different from IT executives in organizations* (S29), where one-fifth of the consulted experts did not give the maximum response values (see Appendix 5). The same is observed in the opinion on whether a CDO should be market-oriented or not. For example, in our dissent analysis, there were two groups of experts with conflicting views on whether a *CDO complements marketing efforts* (S6). Even in the statement that a *CDO guides the organization's digital marketing efforts by emphasizing customer intimacy through technologies such as social media, mobile computing and customer data analytics* (S2), about which agreement was achieved, one-fifth of the experts felt that a CDO should not guide an organization in this way (see Appendix 5). These results indicate, in our view, that some experts continue to anchor the role of the CDO to a more technical and functional role rather than a market and business role, i.e., they continue to overlap the role of the CDO with the role of other IT leaders, e.g., the CIO. We believe that this is because the term DT has been overused (and misused), especially in business practice, and experts still identify DT with minor digital adaptations or the mere digitisation of resources.

6. Conclusions, limitations and further research

The aim of this paper is to delineate the key functions of the newly emerging CDO position. To do so, Warner and Wäger's (2019) DDC framework was considered theoretical support to properly integrate the functions detected in previous literature. The Delphi study methodology was chosen to summarize and unify the criteria to finally obtain a measurement instrument.

Linking CDO functions to a proposed theoretical framework has revealed that this new position influences all three main DDCs relevant in the DT process, especially through *digital sensing* capability.

The prevalence of *sensing* could be caused by the organization's early stages in DT processes, requiring special attention to detect digital opportunities and threats and less focus on implementing or consolidating new ways of doing things. Regarding *digital seizing* and *transforming*, even though CDO functions reached a high score in Delphi consensus of agreement, there seem to be slight resistance in incorporating these functions into a new independent position, perhaps because there is still a tendency to prioritize technical aspects, which have usually been assumed by traditional positions such as CIO and CTO.

As organizations advance in DT, the complexity of the process entails traditional positions to address coordination, integration and strategic views to raise organizations' objectives. Thus, the new role must be consolidated as a managerial position with high-level responsibility, not merely a staff or consulting position (Earley, 2017) but integrated in the company structure (Singh et al., 2020) with a considerable business focus (Haffke et al., 2016) at the strategic level (Tumbas et al., 2017). As a new C-Suite member, the CDO with his or her business knowledge and technological strategic view will help the organization integrate, from the beginning of the DT process, all digital initiatives on the agendas in a planned, coordinated and efficient way. In line with Tumbas et al. (2017), CDOs' aggregated view of all ongoing digital initiatives may work as a "digital harmonizer" role that goes beyond IT infrastructure and architecture matters.

This research also has some practical implications. Despite its importance in the current digital era, as far as we know, there is no validated measurement instrument to use in the research that examines the existence of a CDO or to assess a CDO's performance. As a practical result, this paper preliminarily proposes a measuring instrument and encourages subsequent researchers to improve it in future works.¹ Additional practical implications can be extracted from this work. Organizations immersed in a DT process have a tool to better delimit the responsibilities and functions that should be assumed by a DT leader. The instrument can also be useful to detect if some functions are missed and for managers, to plan and prepare personnel requirements to face DT challenges.

As with any study, ours has limitations. First, we establish a conceptual basis for DT. However, we are aware that this is a limitation, since as Gong and Ribiere (2021) state, the concept of DT has been so widely used among firms that it is very difficult to consider it in its entirety. Consequently, our concept of DT may differ significantly from other related terms in the literature. Second, the CDO approach considered in this paper – that is, a CDO is responsible for driving organizations' DT process – is not the only approach that can be established, but it is the one that best fits our definition of DT. However, this is a limitation because there is a considerable variety of business circumstances and realities, and there may be companies where a CDO is somebody different entirely and even other companies that do not need a CDO. Third, we used DDC framework (Warner and Wäger, 2019) as, in our opinion, it best fits the key functions that a CDO should have according to our DT approach, but again, we are aware that this is not the only possibility and that other theories could certainly be incorporated

¹ This instrument is being used in a project (Reference FCAROLINA21-01) that is being carried out at the time of the preparation of this paper.

in future research. Fourth, although the sample for the Delphi methodology is not required to be statistically representative (Okoli and Pawlowski, 2004), caution is advised in generalizing our findings, which are based on only a limited number of experts (Keil et al., 2013). However, it is important to note that our panel experts' experience covers a broad range of industries and many digitalization initiatives. We can therefore be reasonably confident that the identified statements correspond to a fairly general representation of the CDO functions that support a successful DT.

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Author statement

The authors have contributed equally to this work. All authors read and approved the final manuscript.

Appendix 1. Questionnaire in our Delphi study: CDO functions and categorization based on the DDC framework proposed

Stat.	Statements description	Capability	Subcapability
S1	The CDO evaluates customer-centeredness using a variety of data to gain insights.	Digital sensing	Digital scouting
S2	The CDO guides the organization's digital marketing efforts with an emphasis on customer intimacy through technologies like social media, mobile computing and analysis of customer data.	Digital seizing	Strategic agility Balancing digital portfolios
S3	The CDO develops digital technologies that can enhance products, customer relationships and competitive position.	Digital seizing	Digital scouting
S4	The CDO actively senses the environment for emerging digital technologies.	Digital sensing	Redesigning internal structures
S5	The CDO drives digital innovation, typically complementing existing IT leaders.	Digital transforming	Redesigning internal structures
S6	The CDO complements marketing efforts.	Digital transforming	Balancing digital portfolios
S7	The CDO develops or acquires capabilities for data analysis so he or she can gain insights from both internal and external data sources.	Digital seizing	Balancing digital portfolios
S8	The CDO needs a strong focus on strategic changes to organizational processes, products, services and business models.	Digital seizing	Digital scouting
S9	The CDO establishes capabilities for providing intense focus on relationships with the organization's customers.	Digital sensing	Balancing digital portfolios
S10	The CDO requires a "we don't need to build and create everything" mindset and seeks out available options, including social media, crowd sourcing and other platforms.	Digital seizing	Redesigning internal structures
S11	The CDO role is integral to the role of customer-facing units and is thus concerned with establishing digital channels to the customer and mobile solutions.	Digital transforming	Digital scenario planning
S12	The CDO manages digital initiatives across the organization with a long-term and strategic focus.	Digital sensing	Redesigning internal structures
S13	The CDO is a new C-suite member.	Digital transforming	Redesigning internal structures
S14	The CDO function should be freed from responsibilities of maintaining the existing IT infrastructure.	Digital transforming	Redesigning internal structures
S15	The CDO helps to successfully use various classes of digital technologies to generate value.	Digital transforming	Redesigning internal structures
S16	The CDO is engaged with developing digital capabilities in relevant domains of the organization.	Digital transforming	Improving digital maturity
S17	The CDO has the freedom and flexibility to experiment intensely with a variety of digital technologies.	Digital seizing	Rapid prototyping
S18	The CDO emphasizes the need for transparency in digital projects.	Digital transforming	Improving digital maturity
S19	The CDO complements the IT functions in the organization.	Digital transforming	Redesigning internal structures
S20	The CDO understands data analytics techniques.	Digital transforming	Improving digital maturity
S21	The CDO acquires data analytics capabilities.	Digital transforming	Improving digital maturity
S22	The CDO leads the organization-wide DT.	Digital sensing	Digital mindset crafting
S23	The CDO aligns the DT process with DT strategy.	Digital sensing	Digital scenario planning
S24	The CDO is brought in to take an aggregate and strategic view of all ongoing digital initiatives.	Digital sensing	Digital scenario planning
S25	The CDO leads the efforts to analyse data for new insights.	Digital sensing	Digital scenario planning
S26	It is not necessary for CDOs to fully understand data analytics.	Digital transforming	Improving digital maturity
S27	The CDO adapts data policies to the digital evolution in the organization.	Digital seizing	Strategic agility
S28	The CDO focuses on data quality issues.	Digital transforming	Improving digital maturity
S29	The CDO is different from IT executives in organizations.	Digital transforming	Improving digital maturity
S30	Not all CDOs need to be technical experts—they do not need to be able to analyse data directly.	Digital transforming	Improving digital maturity
S31	The CDO coordinates between employees who work on DT activities in different units and at different hierarchical levels.	Digital transforming	Redesigning internal structures

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Stat.	Statements description	Capability	Subcapability
S32	The CDO is less focused on operational reliability and more focused on experimenting with new capabilities in novel areas.	Digital seizing	Rapid prototyping
S33	A key principle for digital accelerator CDOs is that they reduce the cycle time required for different areas to consider and incorporate digital innovations.	Digital seizing	Balancing digital portfolios
S34	The CDOs are generalists—focusing on a variety of digital opportunities.	Digital sensing	Digital scouting
S35	The CDO is concerned with reconciling existing organizational values with digital innovations.	Digital sensing	Digital mindset crafting
S36	The CDO needs extensive knowledge of digital technologies.	Digital sensing	Digital scenario planning
S37	The CDO is charged with linking together a wide variety of digital initiatives in many different areas of their organizations.	Digital sensing	Digital scenario planning
S38	The CDO takes an agile approach to innovation and continually drives experimentation and iteration.	Digital seizing	Rapid prototyping
S39	The CDO facilitates continual experimentation with minimal viable products of digital innovations.	Digital seizing	Rapid prototyping
S40	The CDO focuses on maintaining and advancing the current IT infrastructure and architecture, with a strong emphasis on reliability, performance and security.	Digital seizing	Strategic agility
S41	The CDO is responsible for questioning existing business models.	Digital seizing	Balancing digital portfolios
S42	The CDO emphasizes visibility, prioritization and coordination of digital efforts.	Digital transforming	Improving digital maturity
S43	The CDO helps managers to understand how the quality of data impacts their business objectives.	Digital transforming	Improving digital maturity

Appendix 2. Results of consensus of agreement for the first and second Delphi rounds (N = 14)

Statements	Round 1% agreed	Round 1 - Consensus of agreement	Round 2% agreed	Round 2 - Consensus of agreement
S1	86%	Yes	86%	Yes
S2	79%	Yes	79%	Yes
S3	93%	Yes	93%	Yes
S4	79%	Yes	79%	Yes
S5	64%	No	86%	Yes
S6	43%	No	50%	No
S7	86%	Yes	86%	Yes
S8	93%	Yes	93%	Yes
S9	57%	No	64%	No
S10	86%	Yes	86%	Yes
S11	57%	No	71%	No
S12	100%	Yes	100%	Yes
S13	79%	Yes	79%	Yes
S14	86%	Yes	86%	Yes
S15	93%	Yes	93%	Yes
S16	79%	Yes	79%	Yes
S17	79%	Yes	79%	Yes
S18	57%	No	71%	No
S19	64%	No	71%	No
S20	93%	Yes	93%	Yes
S21	57%	No	71%	No
S22	79%	Yes	79%	Yes
S23	93%	Yes	93%	Yes
S24	100%	Yes	100%	Yes
S25	71%	No	71%	No
S26	50%	No	71%	No
S27	71%	No	71%	No
S28	43%	No	64%	No
S29	79%	Yes	79%	Yes
S30	79%	Yes	79%	Yes
S31	86%	Yes	86%	Yes
S32	50%	No	71%	No
S33	79%	Yes	79%	Yes
S34	93%	Yes	93%	Yes
S35	100%	Yes	100%	Yes
S36	86%	Yes	86%	Yes
S37	86%	Yes	86%	Yes
S38	79%	Yes	79%	Yes
S39	50%	No	50%	No
S40	0%	No	0%	No
S41	50%	No	64%	No
S42	86%	Yes	86%	Yes
S43	71%	No	71%	No

Appendix 3. Results of consensus of disagreement the first and second Delphi rounds (N = 14)

Statements	Round 1% disagreed	Round 1 - Consensus of disagreement	Round 2% disagreed	Round 2 - Consensus of disagreement
S1	0%	No	0%	No
S2	14%	No	14%	No
S3	7%	No	7%	No
S4	14%	No	14%	No
S5	29%	No	0%	No
S6	36%	No	36%	No
S7	0%	No	0%	No
S8	7%	No	7%	No
S9	14%	No	7%	No
S10	7%	No	7%	No
S11	7%	No	7%	No
S12	0%	No	0%	No
S13	0%	No	0%	No
S14	7%	No	7%	No
S15	7%	No	7%	No
S16	7%	No	7%	No
S17	7%	No	7%	No
S18	14%	No	0%	No
S19	29%	No	7%	No
S20	0%	No	0%	No
S21	14%	No	14%	No
S22	14%	No	14%	No
S23	0%	No	0%	No
S24	0%	No	0%	No
S25	14%	No	7%	No
S26	43%	No	0%	No
S27	14%	No	14%	No
S28	29%	No	21%	No
S29	14%	No	14%	No
S30	14%	No	14%	No
S31	7%	No	7%	No
S32	29%	No	29%	No
S33	14%	No	14%	No
S34	7%	No	7%	No
S35	0%	No	0%	No
S36	14%	No	14%	No
S37	7%	No	7%	No
S38	7%	No	7%	No
S39	21%	No	21%	No
S40	71%	No	100%	Yes
S41	29%	No	14%	No
S42	7%	No	7%	No
S43	7%	No	7%	No

Appendix 4. Interquartile range (IQR) as an indicator for dissent

Stat.	Round 1 - IQR	Round 1 - Dissent	Round 2 - IQR	Round 2 - Dissent
S1	1,00	No	1,00	No
S2	1,00	No	1,00	No
S3	0,75	No	0,75	No
S4	1,00	No	1,00	No
S5	2,75	Yes	0,00	No
S6	2,00	Yes	2,00	Yes
S7	1,00	No	1,00	No
S8	1,00	No	1,00	No
S9	1,00	No	1,00	No
S10	1,00	No	1,00	No
S11	1,00	No	0,75	No
S12	0,00	No	0,00	No
S13	0,75	No	0,75	No
S14	1,00	No	1,00	No
S15	1,00	No	1,00	No
S16	1,00	No	1,00	No
S17	1,00	No	1,00	No
S18	1,75	Yes	0,75	No
S19	2,50	Yes	0,75	No
S20	0,75	No	0,75	No
S21	1,00	No	0,75	No
S22	1,00	No	1,00	No
S23	0,75	No	0,75	No
S24	0,00	No	0,00	No

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Stat.	Round 1 - IQR	Round 1 - Dissent	Round 2 - IQR	Round 2 - Dissent
S25	1,50	Yes	0,75	No
S26	3,00	Yes	0,75	No
S27	0,75	No	0,75	No
S28	1,75	Yes	1,00	No
S29	1,00	No	1,00	No
S30	0,75	No	0,75	No
S31	0,75	No	0,75	No
S32	1,75	Yes	1,50	Yes
S33	0,75	No	0,75	No
S34	1,00	No	1,00	No
S35	1,00	No	1,00	No
S36	1,00	No	1,00	No
S37	1,00	No	1,00	No
S38	1,00	No	1,00	No
S39	1,00	No	1,00	No
S40	1,75	Yes	1,00	No
S41	2,75	Yes	2,00	Yes
S42	1,00	No	1,00	No
S43	1,75	Yes	0,75	No

Level of dissent: IQR > 1.25.

Appendix 5. 28 statements with consensus of agreement from the Delphi study: percentage of responses from a panel of experts and categorization aggregated by capability and subcapability following the DCC framework (N = 14)

Capability	Subcapability	Stat.	Percentage of responses in each Likert category from 5 for full agreement to 1 for full disagreement.					
			5	4	3	2	1	
Digital sensing	Digital scouting	S4	43%	36%	7%	7%	7%	
		S1	50%	36%	14%	0%	0%	
		S34	64%	29%	0%	0%	7%	
		S12	79%	21%	0%	0%	0%	
		S23	71%	21%	7%	0%	0%	
		S24	93%	7%	0%	0%	0%	
	Digital scenario planning	S36	36%	50%	0%	7%	7%	
		S22	57%	21%	7%	7%	7%	
		Digital mindset crafting	S35	64%	36%	0%	0%	0%
			S3	71%	21%	0%	0%	7%
	Balancing digital portfolios	S33	29%	50%	7%	7%	7%	
		S8	64%	29%	0%	0%	7%	
		S10	36%	50%	7%	0%	7%	
		S37	43%	43%	7%	0%	7%	
S7		36%	50%	14%	0%	0%		
S17		43%	36%	14%	0%	7%		
Digital seizing	Rapid prototyping	S38	43%	36%	14%	0%	7%	
		S2	36%	43%	7%	7%	7%	
		S14	57%	29%	7%	0%	7%	
		S13	71%	7%	21%	0%	0%	
		S5	14%	71%	14%	0%	0%	
	Redesigning internal structures	S31	71%	14%	7%	7%	0%	
		S15	64%	29%	0%	0%	7%	
		S16	57%	21%	14%	0%	7%	
		S29	50%	29%	7%	7%	7%	
		S30	71%	7%	7%	7%	7%	
Digital transforming	Improving digital maturity	S42	43%	43%	7%	0%	7%	
		S20	29%	64%	7%	0%	0%	

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