The Digital Transformation of the Innovation Process: Orchestration Mechanisms and Future Research Directions

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ABSTRACT

The importance of digital innovation is widely acknowledged among managers and scholars alike. However, the focus tends to be on digital innovation as an outcome, while we argue that management research should pay more attention to digital innovation as a process. Therefore, in this essay, we take stock of research on digital innovation as a process to explore the anatomy of digital transformation. Within the innovation process, we identify four orchestration mechanisms that are inherently processual, enabling the firm to effectively coordinate and leverage resources and people to create and capture value through the adoption and exploitation of digital technologies. Based on these orchestration mechanisms, we provide research directions that will inform future research on this topic.

Keywords: digital innovation, digital transformation, digital technologies, innovation process.

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Introduction

The concept of digital innovation has gained momentum in recent years among scholars (Appio et al., 2021) and practitioners (Kane et al., 2019). Many organizations currently face the challenge of engaging in digital innovation, regardless of their industry or competitive position (Christensen et al., 2018; Downes & Nunes, 2014; Ozalp et al., 2018). While digital innovation has become a new imperative, it also remains highly complex due to the often-implied radical transformation of the organization and the idiosyncratic challenges of adopting and using digital technologies in the innovation process. Therefore, many incumbent firms have now established specific organizational roles, such as Chief Digital Officer (CDO), as dedicated professionals who oversee the impact that digital technologies have on their innovation processes (Kunisch et al., 2020). These firms are expected to invest around $6.8 trillion globally between 2020 and 2023 in digital transformation projects (IDC, 2020). Similarly to incumbent firms, new ventures or start-ups with an innovative and digitally focused business model raised impressive amounts of equity capital in the second quarter of 2020 – about $61.6 billion – with an increase of 35% compared to the previous year (Forbes, 2020).

Even though the concept of digital innovation is pervasive and spans different communities of practice, its actual conceptual treatment in academic research is not necessarily clear or precise (Appio et al., 2021). Most research considers digital innovation as the *final result* of adopting digital technologies, such as new products, processes, services, or business models (Nambisan et al., 2017). In other words, this research advances the concept of digital innovation *as an outcome*. While this view is certainly useful, it provides a snapshot of the endpoint of complex, multi-party processes, sequences of actions and events triggered by digital affordances. Furthermore, it interprets digital innovation as a technical 'thing' that begins and ends within the walls of R&D laboratories, or flows linearly within the new product development (NPD) process. In parallel to this research on digital innovation as an outcome, the concept of digital innovation *as a process* has emerged, linking innovation capabilities, organizational structures, boundaries, and technology management in firms (Correani et al., 2020). Accordingly, research on digital innovation as a process explores the *anatomy of the digital transformation* of the innovation process (Urbinati et al., 2020).

Several aspects distinguish a digitally transformed innovation process from a non-digital one. First, the nature of the process itself differs. Traditional non-digital innovation usually assumes a strict articulation of the process in distinct phases, entailing a 'go-kill' decision where the products are conceptualized and developed linearly in the NPD process (Bianchi et al., 2020; Cooper, 1994, 2008). Conversely, digitally transformed innovation is more recursive over several phases of the process, enabling the more continuous engagement of customers and stakeholders for feedback throughout the process (Ghezzi & Cavallo, 2020). Second, the collaboration mechanisms differ. Compared to a non-digital process, in digitally transformed innovation, new ways of collaboration emerge, such as flash teams or virtual teams, which allow innovation professionals to experience geographically diffused ways of innovating (Mors & Waguespack, 2021; Retelny et al., 2014). Third, the capabilities and learning processes unfold differently. For example, the digital transformation of the innovation process allows organizations to implement new modes of sharing, creating, deploying, managing, and absorbing knowledge (Marion & Fixson, 2021), recombining legacy capabilities (or technologies) with digital capabilities (or technologies), and enhancing organizational learning across different firm levels.

Research on digital innovation as a process has paid attention to the mechanisms of sustained and punctuated interactions between the organization and other parties (e.g., suppliers, customers, technology providers) that contribute to making innovation happen (Garud et al., 2013). For instance, Autio (2021) focuses on orchestration in platforms and user communities as a strategic means of exploiting platform leadership with the group of organizations that cooperate within the platform. Building on Sirmon et al. (2011) and Hinings et al. (2018), we conceptualize the orchestration mechanisms for digital innovation as inherently processual, enabling the firm to effectively coordinate and leverage resources and people to create and capture value through adopting and exploiting digital technologies along the innovation process.

Therefore, in this essay, we take stock of research on digital innovation as a process to explore the anatomy of digital transformation and highlight the orchestration mechanisms occurring in the innovation process. Building on these orchestration mechanisms, we provide research directions that we hope will inspire future research on digital innovation.

Orchestration mechanisms in the digitally transformed innovation process

Research on digital innovation as a process has focused on the impact of the adoption and exploitation of digital technologies on the anatomy of the process itself (Lyytinen et al., 2016; Pigni et al., 2016). The adoption of digital technologies in innovation is important in contexts where the innovation process is increasingly open to the external environment (Urbinati et al., 2020; West & Bogers, 2014). Digital technologies can be used to effectively manage the increasing amount of knowledge and information flows gathered from outside the firm and the number of ideas exchanged within the organization's boundaries (Gilson & Litchfield, 2017). Furthermore, digital technologies have been shown to play a fundamental role in the co-creation of new products and services (Piller et al., 2015). Research has paid attention to the so-called 'digital-based toolkits' or design interfaces that through trial-and-error experimentation and simulated feedback on the outcome allow those involved in NPD and design processes to iteratively learn their preferences until achieving the optimal product or service design (Franke & Piller, 2004).

The intensive use of digital technologies in the innovation process leads to the digital transformation of the process itself, which requires a stronger theoretical effort to identify and analyse the orchestration mechanisms that allow managing and coordinating resources and people in this process. As Figure 1 shows, we propose four orchestration mechanisms that are inherently processual and enable the firm to effectively coordinate and leverage resources and people to capture and create value through adopting and exploiting digital technologies along the innovation process. Each of these mechanisms is dynamically related to the others over time. The first two orchestration mechanisms, (1) *adopting digital technologies* and (2) *leveraging digital technologies*, are sequential and represent the 'front-end' and 'back-end' of the innovation process respectively, the third and fourth, (3) *developing digital capabilities* and (4) *managing boundaries*, are transversal to the whole innovation process.

[Insert Figure 1 about here]

(1) *Adopting digital technologies.* We conceptualize the first orchestration mechanism as the situated set of actions and routines performed to search and adopt digital technologies in the innovation process. These actions and routines can flow in two alternative ways, i.e., top-down and bottom-up. The former implies a planning approach to the adoption of digital technologies in the innovation process where the

goals and decisions cascade linearly from the upper echelons to the lower levels of the firm. The latter instead conceives the emergence of digital technologies spontaneously, characterized by serendipitous, unintended, non-ergodic consequences (North, 1990; Seidel & Greve, 2017). While the top-down approach conceives the innovation process as plannable by rational and knowledgeable managers, the bottom-up approach stresses the absence of a predefined order and structure instead formed by the patterns of repeated interaction between the different actors (e.g., individuals, teams, functions, organizations) involved in the innovation process (Garud & Giuliani, 2013). Novelty can emerge through the search for different potential paths that digital affordances can generate, as in the case of social media (Leonardi & Vaast, 2017) and platforms. As Lyytinen et al. (2016) highlight, Google uses a bottom-up approach consisting in the '20% rule' whereby employees stimulate their own creativity to come up with novel solutions through the mediation of a digital platform.

In managing the adoption of digital technologies, the cognitive construal of technological features is pivotal. Indeed, the adoption of certain technologies might be rejected as inconsistent with the key organizing principles (or at least what they are believed to be). There might also be the case of bottom-up rejection, for example, due to a threatened professional identity (Nelson & Irwin, 2014) or organizational identity (Gawer & Phillips, 2013). The key assumption in these studies is that technologies are not neutral ready-to-use tools, but relational objects embedded in organizational routines, discourses, and practices whose actual use is mediated by the individual's cognitive framing, in turn influenced by the organization's official technological framing and how other members of the organization frame such technology (Leonardi, 2011a; Spieth et al., 2021). For example, Mishra and Agarwal (2010) highlight the interplay between the individual framing of technologies (as-a-benefit, as-a-threat, or as-an-adjustment) and the stock of technological capabilities spelled out by the organization to take advantage of them.

Accordingly, firms are called on to continuously evaluate the decisions associated with the different components and phases of the digitally transformed innovation process, which is 'powered by a self-contained system's generative capacity to produce something new without input from the system's originator' (Svahn et al., 2017, p. 248). Important decisions associated with the adoption of digital technologies in the innovation process might include the trade-off between customer data

retrieval/storage and its effective processing (Saldanha et al., 2017), product focus and process focus, internal collaboration and external collaboration, control and flexibility in process governance (Svahn et al., 2017).

In addition, since digital innovation and digital transformation might have cultural and institutional components associated with their adoption, managers might embark on digital technology adoption without a well-defined alignment of the strategic goals, negatively affecting the substantive rationale behind the adoption of digital technologies in the innovation process (Bromley & Powell, 2012; Zucker, 1977), or what Blank (2019) calls 'innovation theatre'.

(2) *Leveraging digital technologies.* We conceptualize the second orchestration mechanism as the set of actions and routines that enable the firm to configure and deploy digital technologies along the innovation process. A first key component that influences the effectiveness of this transformation is the commitment of top managers, but also middle management (Damanpour & Schneider, 2006), found to be beneficial to supporting the innovation process. Svahn et al. (2017) show that in the Volvo Connected Car Initiative, the top management team's commitment was crucial to addressing opposing pressures through the continuous balance between new opportunities and established practices along the innovation process. Here, important elements to be evaluated are the biases associated with boundedly rational managerial action (Gavetti et al., 2007).

A second key component is the coordination, control, and incentives at multiple levels that enable organizational actions (Lindenberg & Foss, 2011; Okhuysen & Bechky, 2009; Thompson, 1967). While a traditional perspective on organizing for the innovation process highlights the importance of 'formal organizational arrangements […] designed for exchanging and mobilizing resources in pursuit of collective goals' (McEvily et al., 2014, p. 306), the digitally transformed innovation process view highlights the casual ambiguity between the organizing practices and the exploitation of the technologies. In this direction, Marion and Fixson (2021) show that the use of enabling digital tools, such as collaborative information technology (CIT) and digital design, might spin into intended and unintended consequences on how R&D professionals collaborate within the same team and across different teams and functions, and how they create and share knowledge. Furthermore, collaboration *per*

se does not only bear the consequences of the aforementioned tools, but also how professionals relationally engage with machines and technologies (Leonardi, 2011a).

Research has shown the benefits of digital technologies in terms of team collaboration and prototyping (Marion et al., 2014), establishing the modular architecture of products (Marion et al., 2015), and implementing quick virtual changes in the design process (Marion et al., 2012). In the innovation process, digital technologies, such as augmented reality, are becoming even more relevant to integrate 3D virtual objects into a 3D real environment in real time (Ong et al., 2008), enabling the design and decomposition of potentially infinite simulations of process technologies. Furthermore, digital technologies also allow decentralizing innovation processes where operations are distributed and collaborations span different firms and sectors (Rindfleisch et al., 2017). Several contributions point out the importance of product lifecycle management (PLM) systems to support the development of products from their initial conception through design, engineering, production, launch, and use (Ming et al., 2007). In addition, rapid prototyping systems (such as 3D printing) help accelerate and reconfigure manufacturing production processes (e.g., Rayna & Striukova, 2016). There is also increasing interest in artificial intelligence (AI) as potentially supporting business intelligence and decision-making, linking sensor-related and human-based information to create more valuable applications from big data (O'Leary, 2013).

(3) *Developing digital capabilities.* We conceptualize the third orchestration mechanism as the set of processes aimed at developing and fostering digital capabilities, i.e., higher-level routines that occur systematically in firms and sustain the digital transformation of the innovation process. Imperative for firms is avoiding the path dependence of capabilities, which can turn core competencies into core rigidities (Leonard-Barton, 1992; Magistretti et al., 2021). However, the reproduction of digital capabilities that could sustain the digital transformation of innovation processes over time (Teece, 2007) might differ from non-digital processes. We highlight the interconnected and generative nature of such capabilities that need to be developed to respond not just to the firm's goals or strategies, but also to the changes in the ecosystem in which the firm is embedded. Implementing digital innovation requires firms to leverage new capabilities that can come from either within the organization or from a more or less distributed network of stakeholders (Nylén & Holmström, 2015). These capabilities enhance the

likelihood of creating specific roles in charge of digital tasks, activities, and functions. Such capabilities are not simply professional managerial skills, but also higher-level routines (Schilke et al., 2018), which are also enablers of, and enabled by, digital technologies. For example, Lyytinen et al. (2016) point out that the Google digital platform allows employees and company members to integrate and innovate with diverse stakeholder communities, but also enables the company to reduce its time-to-market with new services in its core offerings.

Digital capabilities are at the core of the organizational capacity to continuously enact and perform the firm's digital transformation through learning processes (Teece, 2007; Zahra & George, 2002). As the socio-materiality literature stresses, knowledge is embedded in artefacts, which in turn can be put to use by humans through relations and practices that link humans and artefacts (Leonardi, 2011b). As Teece (2007) and Helfat and Martin (2015) argue, capabilities have effects at the organizational level, yet their micro-foundations should be attributed to the series of actions and practices that individuals perform. The instrumental purpose of such underlying actions and practices is not simply to improve the efficiency of the use of existing assets, but also the more structured transformation and rearrangement of the organization itself to capture opportunities that digital technologies enable (Eisenhardt & Martin, 2000; Teece, 2016).

Adopters and users of digital technologies can develop digital capabilities over time to sense, integrate, and exploit commercially new ideas by creating a dynamic fit between digital and non-digital resources (Svahn et al., 2017). Morabito (2015) underlines that the use of data and analytic tools facilitates the pursuit of several value creation and capture paths, such as (i) improving the characteristics of products, (ii) digitizing physical assets, (iii) combining data between and across industries, (iv) developing a variety of new offerings, and (v) automatizing business processes. In particular, interesting examples of such organizational transformation can be found in so-called digital ambidextrous organizations (Piccinini et al., 2015). This concept, stemming from the classic Marchian exploitation/exploration duality (March, 1991), stresses two important aspects associated with the strategic development of the digitally transformed innovation process. The first is the need to build capabilities (Lin et al., 2013) and the operational fit between digital technologies and business systems (Roberts et al., 2012) through integrating the new (digital) technology in the innovation process. The

second aspect is about making the new technology gain sustained legitimacy within the organization (Hinings et al., 2018), especially when it has the potential to disrupt the traditional ways of performing the innovation process.

To renew digital capabilities in the innovation process, firms can also engage in corporate entrepreneurial activities that involve the renewal of the current stock of technological knowledge, for example, through setting up new autonomous ventures for digital technology experimentation (Agarwal & Helfat, 2009; Nambisan, 2017).

(4) *Managing boundaries.* We conceptualize the fourth orchestration mechanism as the set of actions and processes aimed at managing different stakeholders and resources in the innovation process within and across the firm's boundaries, defined as 'the demarcation between an organization and its environment' (Santos & Eisenhardt, 2005, p. 491). Indeed, innovation processes do not occur in isolation, but in a maze of flows of resources, ideas, and technologies. Especially in digitally transformed innovation processes, the connectedness between different actors, enabled by digital technologies, such as platforms, requires firms to manage their boundaries strategically to sustain value creation and capture along the innovation process.

In a digitally transformed innovation process, organizational boundaries are more permeable than in a non-digital process, yet this also brings important challenges. For example, firms often adopt idea and knowledge management (IKM) systems (Chinneck & Bolton, 2013) to integrate and apply the specialized knowledge of firm members, suppliers, and other stakeholders to generate ideas to sustain the front-end of the innovation process (Pavlou & El Sawy, 2010). Worth mentioning here is the case of InnoCentive, the two-sided platform that matches the problems suggested by organizations and/or individuals with those of specialized problem solvers, part of what Nambisan et al. (2017) call 'problem solving organizations'. Another important case brings the apparent absence of inter-actor coordination in crowdsourcing to extreme consequences, i.e., the digitally transformed possibility to engage geographically dispersed and relatively uncoordinated individuals and organizations in the innovation process by leveraging the 'wisdom of the crowd' (Afuah & Tucci, 2012; Majchrzak & Malhotra, 2020).

In addition, in a digitally transformed innovation process, governance mechanisms change, especially in terms of coordinating and collaborating with stakeholders. For example, Pisano and

Verganti (2008) provide the example of innovation communities, also digitally transformed, characterized by flat governance and open participation, such as Linux and Android 4.0. Hilbolling et al. (2021) show that Philips, through mutual coordination between the different actors of its Hue connected lighting platform can sustain the innovation ecosystem created by users and complementors. In these types of (digital) innovation communities, participants are more involved in the innovation process than in a non-digital one. However, there is a trade-off between the cost of engaging many actors (the higher the number of actors involved, the higher the cost) and the development of new ideas or technologies. Firms need to deploy governance activities to properly manage this trade-off. Adopting and leveraging digital technologies at the interface of organizational boundaries calls for the different management of purposive inflows and outflows of knowledge and technologies.

Accordingly, another issue of the digital transformation of the innovation process is openness. For example, digital technologies can support the inbound dimension of open innovation by acquiring, storing, and analysing data to design novel products and services that are more responsive to customer needs and pains (Urbinati et al., 2020). For example, big data can be adopted to support product or service development and commercialization (Lobo & Whyte, 2017), or create new value propositions for customers, ultimately leading to value capture (Pagani, 2013). One approach is then to bundle big data with a well-functioning cloud infrastructure, thereby enabling the firm to collect, store, and analyse data to allow a magnifying effect of the adoption of big data (Urbinati et al., 2019). In addition, internet of things (IoT) technology can be adopted to integrate several technologies and communication solutions, allowing them to interact and cooperate to achieve the common goals of identification, tracking, and distributed intelligence (Mani & Chouk, 2018).

An agenda for future research

Research on the digital transformation of the innovation process is still scarce and calls for a great deal of theoretical and empirical effort. This suggests that much remains to be systematically addressed about how firms transform their innovation process with digital technologies, and how they orchestrate this process through a set of actions and routines. This section therefore outlines the research themes and

questions that we believe are relevant for each of the previously discussed orchestration mechanisms. Table 1 organizes and summarizes the proposed research themes and future research directions.

[Insert Table 1 about here]

(1) Adopting digital technologies. Coherently with the conceptualization of the first orchestration mechanism, we call for further research on how firms can manage the adoption of digital technologies in the innovation process. One area that we believe is fruitful is technological experimentation through digital technologies. In this case, it would be interesting to understand whether the fit between digital technologies and competences, whether 'competence-enhancing' or 'competence-destroying' (Tushman & Anderson, 1986), can be shaped and modulated within the innovation process. Indeed, according to the emergence perspective (Garud et al., 2010; Seidel & Greve, 2017), the potential outcomes of digital technology affordances in and around the innovation process might be infinite and differential in line with the innovation process architecture. Even social media, usually not considered a technology directly linked to the innovation process, can have important consequences on how individuals, within and outside the company, frame an innovation (Marion et al., 2014). In this sense, experimentation through digital technologies can enable a wider range of innovation paths that can be constructed and eventually followed. At the same time, the adoption of digital technologies might have a recursive effect on the design of the innovation process and on how the process unfolds in firms. Future research could explore the impact and the process of adopting digital technologies on the goals that inform the innovation strategy or the innovation process itself. As firms are called on to experiment new solutions through digital technologies, we need theoretically sound and empirically robust research that has an impact on innovation management and strategy practice. For example, longitudinal, small N studies could provide the richness of data needed to investigate these themes through the careful selection of the unit of analysis and research perspective.

A second research stream that we think will advance inquiry into the adoption of digital technologies in the innovation process is the impact that these technologies have on the (re)organization of the firm's structure. Indeed, firms might consider organizational restructuring when technology is more important than maintaining the current system of control and coordination mechanisms. Existing management

research still struggles to analyse how firms can reorganize themselves in a world that is ever more digital technology driven (Kim et al., 2004). More than sixty years ago, Chandler (1962) studied the transformation of American capitalism into professionally-managed, diversified big corporations, paving the way for more efficient forms of organizing. A famous mantra from his book is that 'strategy follows structure'. Has anything changed? Does strategy follow structure in a digital age? What is the interplay between a digitally transformed innovation process and a specific organizational structure? What are the new and emerging digitally transformed organizational structures?

Another topic of interest is digital transformation in the innovation process of small and medium enterprises (SMEs) given their resource constraints and the consequent need for flexibility and bricolage. Due to the pervasive strategic importance of digital innovation, we call for further research on how SMEs search and adopt digital technologies, how they manage the novelty stemming from digital technologies and the associated change processes and contingencies that influence the outcome.

(2) Leveraging digital technologies. In accordance with the second orchestration mechanism, conceived as the set of actions and routines that enable the firm to configure and deploy digital technologies along the innovation process, we call for further research to investigate the socio-technical processes affected by the exploitation of digital technologies. A promising research stream is the use of digital tools to start, sustain, and shape collaboration between individuals and teams in a digitally transformed innovation process. Indeed, although recent studies have highlighted how digital tools can shape the innovation process and affect the way project teams might benefit from their adoption (Marion & Fixson, 2021), most of these contributions are sector-specific, and future studies are needed to broaden the analysis to more firms and industries.

Digital tools for collaboration are increasing in terms of number, heterogeneity, and traction. This has strong implications for the design and unfolding of the innovation process, such as how NPD professionals innovate and collaborate for innovation. There is a need to extend current research on the synergies between the exploitation of digital tools and collaboration practices (Brunswicker et al., 2017; Nambisan et al., 2017; Schildt, 2017), which may deepen the mechanisms that allow collaborating remotely and new forms of collaboration outside the day-to-day routine of the innovation process. Reflections on how the use of digital tools affects collaborations in and around the digital innovation

process also extend to the design thinking field. Indeed, design thinking – also recognized as a collaborative-based approach to manage creativity and bias in innovation projects (Liedtka, 2015) – has a role in capitalizing on the market opportunities that digital technologies and tools provide (Pham et al., 2021). We invite future research to unpack the role of design thinking in the digitally transformed innovation process, investigating the design thinking practices that enable making the best use of digital technologies in the innovation process and support the material activity and cognitive framing of NPD professionals.

A second research avenue that merits further investigation is the exploitation of digital technologies for knowledge management. Digital technologies are important for firms to increase the effectiveness of information flows in and around their innovation process and the related organizational structure. Interesting examples of knowledge management tools and processes are online communities or digital networks (Dahl et al., 2011; Scuotto et al., 2016). Accordingly, worth underlining is the creation and transfer of knowledge through online communities (or digital networks) established for innovation projects (Baba & Nobeoka, 1998; Mahr & Lievens, 2012; Sammut-Bonnici & Paroutis, 2013). Members of online communities co-create knowledge by sharing their skills and capabilities in innovation projects. Research in this domain has started to explore how the variety and complexity of innovation projects influence the way firms establish online communities for innovation projects according to the needs of different knowledge sources. In addition, Ma and Agarwal (2007) provide an explanation of how and why individuals in online communities are more likely to contribute to knowledge co-creation. We encourage management scholars to deepen the role of online communities, digital networks, and ecosystems (Dahlander & Magnusson, 2008; West & Lakhani, 2008). In this regard, the way in which members contribute in these digital entities to co-creating knowledge has been neglected. The lack of generalizable findings calls for future research to investigate a broader spectrum of online communities, networks, and ecosystems for innovation projects to capture the drivers of individuals' behaviour towards knowledge contribution.

(3) Developing digital capabilities. The digital capabilities research domain is particularly interesting to analyse in terms of adopting and leveraging digital technologies, especially the alignment between existing capabilities and digital capabilities (Karimi & Walter, 2015; Setia et al., 2013). The actual

content and consequences of digital capabilities can differ according to the turbulence of the environment in which firms are embedded (Granados & Gupta, 2013; Lobo & Whyte, 2017). A promising avenue for future research on digital capabilities is investigating the dynamics and contingencies of digital capabilities affecting the innovation process, the firm, and the environment (e.g., industry, strategic groups, dominant designs). Here worth examining are the longitudinal dynamics of digital capabilities, such as their distinctive trajectories and patterns, the elements that contribute to modifying the path of these capabilities, as well as their outcomes, the impact on firm and innovation performance, and the speed of the NPD process. Furthermore, we call for multi-level studies that explore the interdependencies between managerial capabilities and organizational capabilities in the innovation process, or the patterns of adjustment of the innovation process design of a group of firms, either loosely linked or tightly coupled within an ecosystem, in response to an environmental jolt. In addition, digital capabilities might clash with the nature of existing non-digital capabilities due to the lack of legitimacy or the negative framing of the technology. Future research could investigate the contextual conditions that create a favourable environment for their development.

A second research avenue is the interplay between digital capabilities, value creation and capture mechanisms, and the innovation process (Kapoor & Teece, 2021; Teece & Linden, 2017). Digital capabilities play an important role given their direct link with the implementation of the value creation and capture mechanisms (Hsieh et al., 2011; Urbinati et al., 2019) that sustain the firm's competitive advantage. For example, future research might investigate the role of developing digital capabilities on resource endowment, the firm's activity system, and inter-organizational relationships. Existing research in this domain has just started studying the relationships between the value creation and capture mechanisms through digital technologies. Also worth noting is that research in the strategic management field examining the business model concept as a means of how firms create and capture value has called for a system-level holistic approach to explain how firms 'do business' (Zott et al., 2011), and how they change the way they do business (Foss & Saebi, 2016; Landoni et al., 2019). As such, future studies could embrace the systemic attributes of the business model concept and more explicitly leverage digital technologies as a mechanism that allows creating, sharing, and capturing value in an organizational or in a value network context.

(4) Managing boundaries. The ability to manage and govern organizational boundaries in and around the digitally transformed innovation process is crucial to understand how innovation unfolds in organizations today. A future research area that we highlight is the relationship between openness in innovation and digital technologies. While different scholars have addressed the former (Laursen & Salter, 2006; West & Bogers, 2014), the role of the latter in facilitating or constraining the permeability of organizational boundaries needs further investigation. Research at the intersection of open innovation and digital innovation has started to consider the 'open' nature of NPD processes (West & Bogers, 2017) to analyse the application and adoption of digital technologies that enable such 'open' processes (Urbinati et al., 2020). Hence, the role of digital technologies deserves further investigation, for example, by investigating the different impact of digital technologies in several phases of the 'digital' open innovation process (Enkel et al., 2020). For example, crowdsourcing is becoming an important tool for sourcing knowledge from outside the organization, altering organizational search mechanisms and the governance structure of the innovation process (Afuah & Tucci, 2012), as well as the goals of the innovation itself, which can be more focused on sustainable and social outcomes to respond to grand challenges. We also recognise the need for further theoretical and empirical research on the role of digital technologies for open innovation. For instance, future research might focus on the antecedents, processes, and outcomes of using digital technologies in NPD processes conducted in an 'open' perspective.

The second research area that merits further inquiry is the governance of the boundaries in the innovation process. In this research domain, at least two main trajectories are worth studying, particularly by management scholars. The first relates to the management of coordination issues. In a digitally transformed innovation process, purposive inflows and outflows of knowledge generation occur mostly outside the organization's boundaries, amplified when knowledge is tacit and difficult to codify in a reasonable amount of time. This issue can lead to high transaction costs associated with gathering, elaborating, and aligning the acquired information with the firm's innovation strategy. This research stream might investigate how digital technology affordances affect or are affected by the nature, type, and heterogeneity of inter-organizational ties in a 'digital' open innovation process. For example, trust is recognized as pivotal in studies on innovation process governance, but there is a lack of research

on developing trust in the relationship between the firm and ad-hoc innovation service companies (Nambisan et al., 2017), or stakeholders embedded in a distributed innovation ecosystem. Another relevant research area is how knowledge-specific features, such as tacitness or sharedness, affect the way R&D professionals and other stakeholders collaborate in the different phases of the innovation process. We call for future phenomenon-driven research on boundary openness in the digitally transformed innovation process by inductively studying novel ways of organizing for innovation, as in the case of flash teams, Amazon Mechanical Turk (MTurk), or blockchain organizations.

Conclusion

In conclusion, based on our review of research on digital innovation as a process and identifying the relevant orchestration mechanisms within the innovation process, we find ample opportunity for future research on this topic. A better understanding of digital innovation as a process will help scholars and managers deal with the multiple orchestration themes and mechanisms that characterize the digitally transformed innovation process. However, given the many contingencies that might affect a digitally transformed innovation process, we do not claim exhaustiveness, as we have only started to scratch the surface of this issue. We therefore encourage management scholars from different fields (e.g., innovation management, information systems, strategy, organization studies) to delve deeper into theorizing the digital transformation of the innovation process.

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Table 1. Proposed research themes and questions.

Orchestration mechanism	Research themes	Exemplary questions for future research
Adopting digital technologies	Technological experimentation	• What is the impact of technological experimentation on goal formation? Is this relationship linear or recursive? • Does technological experimentation affect the emergence of an innovation strategy within the firm? • What are the practices and applications associated with successful technological experimentation through digital technologies? • How does technological experimentation through digital technologies unfold differently in the phases of the innovation funnel? • How is technological experimentation through digital technologies performed in the different phases of the innovation process? What are the associated key and distinctive phase-specific processes?
	Organizational structure and design	• What are the internal and external conditions that firms should evaluate for reorganizing their organizational structure in light of digital technologies? • Do firms take advantage of reorganizing the organizational structure for the digital transformation of the innovation process? Does strategy always follow structure in the digital age? • What are the distinctive consequences of a digitally transformed innovation process in SMEs compared to larger firms or start-ups? • How do SMEs overcome their resource constraints to start and implement a digital transformation of the innovation process?
Leveraging digital technologies	Collaboration	• What role can design thinking play in a digitally transformed innovation process? In which phases of the innovation process are design thinking practices the most (or least) effective? • How does digitally driven gamification influence collaboration between teams in the innovation process? • How can we design digital tools for collaboration to increase innovation performance? • How can digital tools mitigate the presence of structural holes in the innovation process? And how does technological distance, cognitive distance, or degree of knowledge specialization between teams moderate this relationship?
	Knowledge management	• How does the variety and complexity of innovation projects influence the way firms establish online communities? • What knowledge sources do members of online communities require to co-create knowledge? • Which are the drivers and knowledge sources that significantly influence the development of online communities engaged in a digitally transformed innovation process? • How does embeddedness in a geographically dispersed network of innovators engaged in a digitally transformed innovation process influence the effective accrual and management of knowledge?
Developing digital capabilities	Dynamics and contingencies of digital capabilities	• How do inter-organizational relationships (i.e., alliances, acquisitions, etc.) influence the development of digital capabilities? • To what extent do firms benefit from the development and institutionalization of digital capabilities compared to non-digital capabilities? • Which contingencies or contextual conditions affect the development of digital capabilities over time? • Do digital capabilities in digital-born firms follow the same lifecycle pattern of those developed in analogue-born companies? And does the position of the firm in the industry (incumbent vs. new entrant) affect this trajectory? • What is the role of imitation (Winter & Szulanski, 2001) on the development of digital capabilities? • What is the role of knowledge or technological spillovers on the development of digital capabilities? • How do digital capabilities affect the innovation performance of firms? • Can digital capabilities be distributed across several actors?

		• Is there a co-evolutionary process between digital capabilities and innovation process design? • How do companies balance exploration and exploitation in a digitally transformed innovation process? • How do digital capabilities emerge?
	Value creation and capture in the innovation process	• How does the development of digital capabilities support the firm in creating and capturing value along the innovation process? • What are the managerial and organizational enablers of the development of these capabilities for value creation and capture along the innovation process? • Do firms always have a competitive advantage that originates from digital capabilities along the innovation process? • How do digital technologies affect the firm's ability and the willingness to sense and seize opportunities?
Managing boundaries	Openness of boundaries	• How and why do firms use digital technologies in open innovation processes as opposed to closed innovation processes? • Through which key dimensions is open innovation enabled and performed through digital technologies? • What is the 'dark side' of openness in a digitally transformed innovation process? • How are digital technologies used in the different phases of the open innovation process? And what are the associated strategic imperatives? • What are the benefits and challenges associated with the adoption of digital technologies along the open innovation process? • How can firms design and perform a digitally transformed open innovation process to successfully tackle grand societal challenges?
	Governance of boundaries	• How do firms manage coordination issues along the open innovation process? To what extent are these issues amplified when the exchanged knowledge and expertise are tacit? • How can firms manage distributed interactions in the innovation process? And which structural features enable it? • Does geographic distance between collaborating organizations affect the effectiveness of knowledge integration? • How does trust between collaborating actors engaged in digitally transformed innovation processes affect the motivational aspects associated with the pursuit of the innovation strategy objectives? • How does trust between collaborating actors engaged in digitally transformed innovation processes affect the search mechanisms of focal firms?

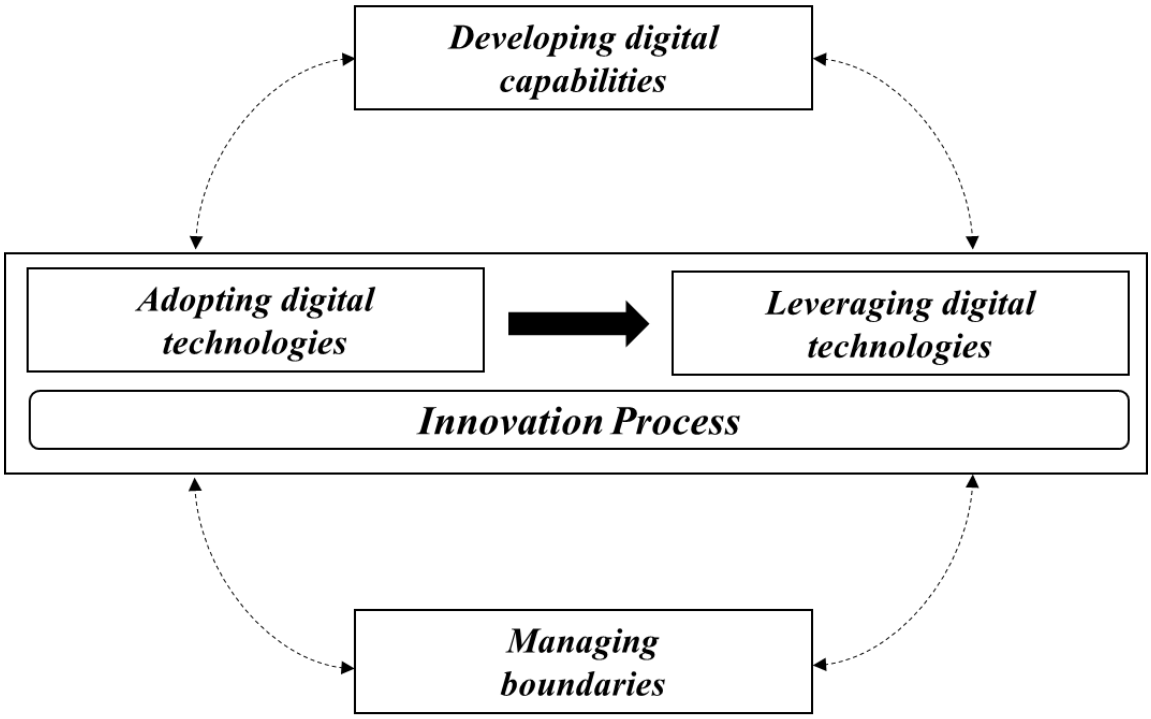

Figure 1. Orchestration mechanisms in a digitally transformed innovation process