Digital transformation, for better or worse: a critical multilevel research agenda

R&D MANAGEMENT

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For better or worse, digital technologies are reshaping everything, from customer behaviors and expectations to organizational and manufacturing systems, business models, markets, and ultimately society. To understand this overarching transformation, this paper extends the previous literature which has focused mostly on the organizational level by developing a multi-level research agenda for digital transformation (DT). In this regard, we propose an extended definition of DT as "a socioeconomic change across individuals, organizations, ecosystems, and societies that are shaped by the adoption and utilization of digital technologies." We suggest four lenses to interpret the DT phenomenon: individuals (utilizing and adopting digital technologies), organizations (strategizing and coordinating both internal and external transformation), ecosystems (harnessing digital technologies in governance and co-producing value propositions), and geopolitical frameworks (regulating the environments in which individuals and organizations are embedded). Based on these lenses, we build a multi-level research agenda at the intersection between the bright and dark sides of DT and introduce the PIAI framework, which captures a process of *perception*, *interpretation*, and *action* that ultimately leads to possible *impact*. The PIAI framework identifies a critical research agenda consisting of a non-exhaustive list of topics that can assist researchers to deepen their understanding of the DT phenomenon and provide guidance to managers and policymakers when making strategic decisions that seek to shape and guide the DT.

1. Introduction

Digitalization – that is, the implementation of digital technologies (Setia et al., 2013) – has provided both major opportunities and significant challenges to individuals, organizations, ecosystems, and entire societies. At the core of such transformative trends are digital technologies, broadly defined as combinations of "information, computing, communication, and connectivity technologies" (Bharadwaj et al., 2013, p. 471) or so-called SMACIT technologies (social, mobile, analytics, cloud, Internet of Things; Sebastian et al., 2017). Despite major advances in digital technologies, the complexity of implementing those technologies and the implications they have for many aspects of social life are not yet fully understood. To better understand such complexity across different levels of analysis, the aim of this paper is to develop a framework and multi-level research agenda for digital transformation (DT) which can guide scholars and practitioners.

Digital technologies involve unique features for individuals and organizations: re-programmability, homogenization of data, and a self-referential nature (Yoo et al., 2010). In addition, they include new properties that make them generative, malleable, and combinatorial (Kallinikos et al., 2013; Hanelt et al., 2020; Kostis and Ritala, 2020), blurring the boundaries between the physical and digital worlds and enabling both flexibility and scalability. Most recently, the rapid development of digital technologies, coupled with the coronavirus disease 2019 (COVID-19) pandemic, has impacted all businesses and societies (Brem et al., 2020; Carnevale and Hatak, 2020; Kudyba, 2020; Soto-Acosta, 2020). Digital technologies are, for better or worse, reshaping the workplace (Marsh et al., 2021), organizational and manufacturing systems (Rauch et al., 2020), customer expectations and behaviors (Manyika et al., 2013; Coad et al., 2021), business models (Nambisan, 2017; Song, 2019), value creation and capture (Lanzolla et al., 2020), and markets (Diaz-Rainey et al., 2015; Autio et al., 2018).

The DT concept has been widely used to describe the adoption of digital technologies and the replacement of non-digital processes with digital ones, leading to organization-wide changes and the emergence of new business models (Radziwon et al., 2021; Verhoef et al., 2021) or the modification of existing ones (Dąbrowska et al., 2019). At its inception, DT was predominantly discussed in the information systems literature (Vial, 2019; Nadkarni and Prügl, 2020), with a focus on its technological aspects such as optimization of operational processes within organizations (Vial, 2019). More recently, increasing attention has been paid by management scholars (Hanelt et al., 2020) and multidisciplinary researchers (e.g., Verhoef et al., 2021), who emphasize DT's strategic, managerial, and organizational implications (Hanelt et al., 2020; Nadkarni and Prügl, 2020).[1]

In contrast to IT-enabled organizational transformation, DT transcends organizational boundaries (Nadkarni and Prügl, 2020), since it (re)defines an organization's value propositions and business models, and can even imply the development of new organizational identities (Wessel et al., 2020). Moreover,

DT is expected to have both positive and negative implications that go beyond the organization's immediate remit and affect individuals both within and outside companies, along with organizational business models, platforms and ecosystems, and whole industries (Autio et al., 2018; Vial, 2019). Still, the majority of studies in the management field (e.g., Hess et al., 2016; Singh et al., 2020) tend to focus on DT at the organizational level, which is reflected in DT definitions that specifically highlight "organizational change" (see, e.g., Hess et al., 2016; Hanelt et al., 2020; Nadkarni and Prügl, 2020). Crucially, such perspectives overlook other important levels of analysis: individual, ecosystem, and geopolitical, and their interplay.

We argue that, for better or worse, DT eventually leads to sociotechnical change (Geels and Schot, 2007) or, more broadly, socioeconomic change (Breslin, 2011; Ekbia et al., 2015). This change not only relates to organizations but also involves the individuals who use and adopt digital technologies, participants in the ecosystems who are co-creating their value propositions, and geopolitical frameworks that regulate the industries in which organizations and individuals are embedded. Hence, we define DT as *a socioeconomic change across individuals, organizations, ecosystems, and societies that is shaped by the adoption and utilization of digital technologies*. In this definition, the key elements are: "socioeconomic change" (expressing the multi-level nature of the phenomenon), "shaped" (referring to the overarching role of DT beyond the mere triggering role), and "digital technologies" (which can relate to the causes, contingencies, and outcomes of the sociotechnical change). We advocate four lenses through which DT can be viewed: individual, organizational, ecosystem, and geopolitical. Each level conditions and influences the other levels while providing a unique perspective on the processes and outcomes of DT. Importantly, regardless of the level, DT does not always lead to positive outcomes. It may also trigger conflicting interpretations, contradictions, and tensions, for which there is no single best solution but rather various solutions that may be good for some but worse for others (see, e.g., Selander and Jarvenpaa, 2020).

We conduct a design-oriented research synthesis focusing on the gaps and challenges of DT at the different levels of analysis and their relationships (see e.g., Bogers et al., 2017). Differently from positivist approaches (e.g., systematic literature reviews) aiming at summarizing literature by merging thematically similar studies, design-oriented approaches are suitable for exploratory conceptualization, as they serve to identify mechanisms within different studies and to assess the context in which such mechanisms produce their outcomes (Denyer et al., 2008). They have proven useful in management literature to understand and integrate different theories (Ferras-Hernandez and Nylund, 2019) or strands of research (Van Burg and Romme, 2014) into broader frameworks. In this study, we took a collaborative approach to the process of collection, selection, and interpretation of relevant literature (see, e.g., Bogers et al., 2017; Beck et al., 2020, 2021). For each of the four levels through which DT processes and outcomes can be analyzed, authors formed self-organizing teams collecting and interpreting salient contributions.

In the following section, we provide a brief overview of the gaps and challenges of DT based on the DTs' research synthesis at the individual, organizational, ecosystem, and geopolitical levels of analysis. Next, we develop a multi-level research agenda at the intersection between the bright and dark sides of DT, in which we view DT as a process of *perception, interpretation*, and *action* that eventually leads to a broader socioeconomic *impact* (PIAI framework). Our critical approach contributes to the DT literature by providing a holistic and pragmatic understanding of DT. By doing so, we embed practical and policy implications throughout the entire multi-level research agenda to guide companies and policymakers when making strategic decisions on the direction of DT.

2. Four levels of digital transformation

2.1. The individual-level digital transformation

Although digital technologies have a major impact on individuals, organizations implementing DT often lack an understanding of its human side (Davenport and Redman, 2020; Frankiewicz and Chamorro-Premuzic, 2020). The current emerging body of knowledge on the human side of DT can be divided into two groups. The first one focuses on employees or top management teams (TMTs) and point out that the determinants of success or failure in DT lie in an organization's ability to configure the right mix of talent (Karimi and Walter, 2015; Davenport and Redman, 2020) or in the skills, abilities, and orientations of employees and managers (e.g., Ritala et al., 2021). The second one offers a complementary view with an in-depth discussion of the co-existence and interdependence of humans and digital technologies (such as robots and artificial intelligence [AI]), along with considerations of their emotional, social, and moral implications (Pagani and Pardo,

2017; Amabile, 2019; Wang and Siau, 2019; Baptista et al., 2020; Solberg et al., 2020; Ulhøi and Nørskov, 2020).

2.1.1. Behaviors, perceptions, emotions, and their effect on digital transformation

Affect and emotions are central to change acceptance, resistance, and disengagement (Oreg et al., 2018). Employees' acceptance of or resistance to DT is influenced by their mindsets and cognitive processes, which reflect their self- and situation-oriented beliefs (Solberg et al., 2020). Many employees envisage digital technologies as a job destroyer, which amplify their resistance to change (Cortellazzo et al., 2019). These fears are justified when DT leads to replacing some workforce with AI, robotics, and virtual agents (Verhoef et al., 2021). Other documented resistance factors relate to employees' skeptical attitudes toward automation and efficiency promises and the loss of competence and autonomy associated with the fear of digital technologies' surveillance potential (Hirsch-Kreinsen, 2014), as well as a more general anxiety created by their use (Kummer et al., 2017). However, while uncertainty may inhibit the adoption of digital technologies, it may also motivate people to work harder to find solutions that are beneficial for them (Cacciotti et al., 2016).

2.1.2. Skills, capabilities, and the emergence of new jobs

DT is reshaping the labor market. This happens globally in a differentiated manner that depends heavily on the nature of the work, its predictability, and its complexity (Brynjolfsson and Mitchell, 2017), along with its routinization and transactional nature (Cortellazzo et al., 2019). New technologies simultaneously destroy and create jobs and induce significant and irreversible changes to the nature of work. Increasingly, job descriptions sit at the intersection of previously distinct disciplines: for example, smart healthcare specialists who master biomedical expertise with (big) data analysis, or accountants with knowledge of blockchains and smart contracts. In turn, demand is rising for skills related to data analytics, effective use, and interpretation of visualization and simulation systems, and interaction with objects and machines (Dougherty and Dunne, 2012; De Mauro et al., 2018).

This skills gap can be met by hiring new tech-savvy staff to complement in-house expertise. However, the skill gap may also create tension between existing employees with institutional memory and the new breed of workers, resulting in cultural conflict and suboptimal organizational outcomes (Kohli and Johnson, 2011). These conflicts can be mitigated if employee upskilling raises the aptitude of existing employees close to recent recruits (Cortellazzo et al., 2019). In addition, novel technical solutions, such as robot programming by gesture or demonstration (see, e.g., Kostis and Ritala, 2020), may allow workers to take care of machine reprogramming tasks without requiring them to have frontier educational backgrounds. Finally, digital know-how is increasingly required in top management positions, and new roles like chief digital officers are being created to facilitate the adoption of digital technologies (Hess et al., 2016).

2.1.3. TMTs and leadership

The complexity of DT requires TMTs to not only recognize the need for DT and coordinate its implementation but also to willingly take on the role of DT change agents (Cortellazzo et al., 2019). However, some DT processes fail because of a lack of malleable leadership skills within TMTs, such as DT awareness, acceleration, and harmonization (Hanelt et al., 2020). Solberg et al. (2020) found that TMT members responsible for DT can negatively impact employees' acceptance of DT based on their own attitudes, styles of communication, and understanding of the DT paradigm and the process through which it is achieved.

Proponents of a top-down approach to DT (e.g., Frankiewicz and Chamorro-Premuzic, 2020) consider it a prerequisite for the efficient adoption and acceptance of digital technologies. Likewise, several authors have argued that the successful adoption of digital technologies is contingent on the leadership support from TMTs (Karimi and Walter, 2015).

2.1.4. The co-existence and interdependence of human and digital: emotional, social, and moral implications

As organizations increasingly rely on digital technologies, managers need to balance the goals of efficiency and human wellbeing (Nørskov and Nørskov, 2020). One prominent example is AI's duality, as both a complementary enhancement to individual capabilities and a potential replacement for human cognition (Amabile, 2019; Wang and Siau, 2019). Similarly, the three-dimensional presence of social robots and their "human social" abilities imposes radically different types of perceptions of, reactions to, and interactions with these robots (Fong et al., 2003; Cross et al., 2012; Saygin et al., 2012; Dumouchel and Damiano, 2017). Likewise, with the recent work-from-home experiment due to COVID-19, the shift in workstyle intensified the utilization and adoption of digital technologies, yet it also uncovered unintended dark side effects in relation to employees' wellbeing (Marsh et al., 2021).

For technologies such as AI and social robotics, the crucial question is how organizations can leverage such technologies based on the principle of cooperation with rather than replacement of humans (Seibt et al., 2018). This is known as the "non-replacement maxim" (Seibt et al., 2018, p. 37), which argues that the process of research, development, and design of robotics should include value-sensitive social interactions (Friedman, 1996). These novel interactions will alter work processes, practices, occupations, and challenge the psycho-social contingencies in the workplace (Faraj et al., 2018; Beane, 2019; Ulhøi and Nørskov, 2020). For instance, new research is emerging on how AI-related algorithms are used in decision-making (Lindebaum et al., 2020), how it augments individual and team creativity (Amabile, 2019), or how DTs affect employees' well-being and performance in the digital workplace environment (Marsh et al., 2021). Yet, the consequences of augmenting individuals' capabilities via AI remain insufficiently explored (Longin and Deroy, 2022). Furthermore, scholars have begun to examine the positive effects of robots as facilitators of group processes (Sebo et al., 2020) and how human-robot dyads can boost human creativity (e.g., Kahn et al., 2016; Alves-Oliveira et al., 2020).

2.2. *The organizational-level digital transformation*

At the organizational level, DT involves various changes such as changes to the company's strategy, legacy, governance, structure, resources, processes, competencies, culture, or leadership (Orlikowski, 1996; Cennamo et al., 2020; Hanelt et al., 2020). Successful DT involves the implementation and understanding of technology not only at an individual level but also at the organizational level and in the overarching strategy (Rogers, 2016; Mention, 2019; Nadkarni and Prügl, 2020).

2.2.1. Strategy and strategic responses to digital transformation

DT requires a significant departure from existing culture, work practices, and organizational routines, and a proactive exploration of new possibilities while generating organizational support for them (Garud and Karunakaran, 2018). As DT is triggered by the implementation of digital technologies and has the potential for pervasive use and impact on existing economic structures, DT cannot be conceived as a single process. DT simultaneously boosts organizational efficiency and increased responsiveness to the core legacy products and requires new ways of organizing value chains and interfirm relationships (Chesbrough, 2020). Indeed, as value creation shifts from single products to platform ecosystems (i.e., integrated offerings spanning multiple products and markets), the dynamics of the competition itself are profoundly altered (Cennamo et al., 2020). Relatedly, new ways of combining core competencies with digital innovations also require intensified inter-organizational collaboration (Chesbrough et al., 2018; Enkel et al., 2020).

2.2.2. Change and organizational design

Established organizational structures are often ill-suited to the uncertain outcomes of the DT process. This exacerbates the inherent ambiguity of innovation processes (Garud et al., 2013) with the additional complexity of digital innovation (Yoo et al., 2010). There are, however, at least two pathways that can alleviate such discontinuities: (a) enabling organizational support for the development of novel ideas (change from inside) and (b) introducing and adopting new organizational structures and forms (Lanzolla et al., 2020).

A positive perception of DT-related ambiguity can be recast as an enabler of interpretation of what DT means for the organization. The organization's employees may generate novel ideas that give meaning to the ambiguities by building narratives on their organizational experiences and expectations (March, 2010; Garud et al., 2011). This encourages individual-level behaviors that contribute to the contextual ambidexterity of DT (Gibson and Birkinshaw, 2004). Organizational design can be both a driver and a subject of change (see also Lanzolla et al., 2020). The new structures can embrace organizing logics and mechanisms that facilitate collaboration, interaction, and coordination for digital innovation. For instance, organizations might benefit from establishing cross-functional teams (Dremel et al., 2017) and DT offices or units (Singh et al., 2020). In addition, the introduction of new TMT functions like the chief digital officer, as discussed above, can promote a digital perspective inside the organization (Singh and Hess, 2017; Tumbas et al., 2018; Kunisch et al., 2020).

2.2.3. Building (digital) capabilities to support decision-making

DT also opens up discussion on new capabilities that could enhance (or constrain) the organization. These capabilities are often augmented by a variety of AI technologies that enable firms to improve their customer offerings by learning from the accumulated data and effectively generating "data network effects" that aim to constantly improve customer value (Gregory et al., 2020). These new capabilities build on new pools of structured and

unstructured data, integrating it with the data generated by machines while controlling for AI's own inbuilt flaws and biases (Hakala and Vuorinen, 2020). The implications are broad: in socially facilitated planning (e.g., road-mapping) contexts (e.g., Kerr et al., 2013), digital technologies could modify the dynamics by which managers analyze and make sense of current and future trends and plan around them. Enhancing sensemaking from complex datasets (An et al., 2018) may allow current processes to increase the innovation capability of firms (Mention et al., 2019) and generate a broader societal impact (Wang and Siau, 2019).

2.2.4. Changes in value creation and capture logics
Finally, as digital technologies are constantly evolving, DT can bring enormous long-term benefits to businesses able to recast their external relationships and interdependencies and embed them into new and more flexible business models. First, DT requires companies to establish and manage multiple modalities of value generation and delivery, to structure collective action at the field and ecosystem level (Alaimo, 2021). Second, it requires finding an optimal business model that leverages a company's skills and resources through data generated by digital technologies (Björkdahl, 2020). This effort should include (a) leveraging data-driven processes by focusing on monitoring, optimization, and organizational responsiveness, (b) approaching business model transformation that exploits the interconnection and interdependence between actors, and (c) taking advantage of platform marketplaces that render product-market boundaries irrelevant to define the type and intensity of competition (Cennamo et al., 2020). These insights show that the DT challenges at the organizational level cannot be assessed properly without considering the ecosystem perspective (Hanelt et al., 2020).

2.3. The ecosystem-level digital transformation

The management literature has recognized the importance of ecosystems in which numerous actors interact to collectively define and deliver an ecosystem-level output that aims at meeting both shared and individual goals (Radziwon et al., 2017; Dattée et al., 2018; Jacobides et al., 2018). Ecosystems offer unique access to diverse resources, including knowledge, expertise, and technologies (Aarikka-Stenroos and Ritala, 2017; Cobben et al., 2021). Increasingly, digital technologies and interfaces are used to bundle actors' inputs in ecosystems (Thomas et al., 2014; Cusumano et al., 2019; Gawer, 2020).

2.3.1. Digital affordances
Digital affordances refer to all types of activities made possible for ecosystem actors using digital technologies and infrastructures (Autio et al., 2018). Thus, diverse actors can co-create value across a particular field or domain, which can increasingly span different geographical regions by virtue of digital connectivity. Examples include open-source software development, which is (self-)organized into heterogeneous ecosystems that link together in digital forums and platforms (Fjeldstad et al., 2012; Mäenpää et al., 2018) and the global ecosystems operated by giant platform leaders like Amazon and Google Android.

Ecosystems evolve dynamically over time as their actors and relationships change (Rong et al., 2020). Their actors can utilize design artifacts that are constantly being made and remade (O'Shea et al., 2019). In turn, these artifacts and cues (digital forums, collaboration spaces, application programming interfaces, etc.) are needed to establish trustworthiness and standardization in the ecosystem. Members of an ecosystem collaboratively design that system by co-intuiting, co-interpreting, and co-integrating what they imagine it to be (O'Shea et al., 2019). However, we still have only a limited understanding of how ecosystems negotiate their legitimacy with the surrounding world and the various actors involved (Thomas and Ritala, 2021).

Digital technologies are not restricted by limitations of the physical location and thus they fundamentally change the ability of organizations to decide whether to be part of a specific ecosystem. Therefore, one of the key issues in the DT context is how organizations decide to form, join, remain in, or exit ecosystems and who manages those ecosystems. In this regard, we differentiate in the following subsection between two contrasting views on ecosystems: orchestrator-centric and system-community.

2.3.2. Orchestrator-centric view vs. systems-community view
The first view on ecosystems focuses on a powerful hub actor (i.e., an orchestrator) that organizes the ecosystem around a joint value proposition (Jacobides et al., 2018; Shipilov and Gawer, 2020; Thomas and Autio, 2020; Thomas and Ritala, 2021) – oftentimes delivered over a digital platform. An example of an orchestrated digital ecosystem is the Amazon Marketplace (Ritala et al., 2014), where the platform orchestrator (Amazon.com) bundles complementary inputs into continuously renewing

offerings for wide customer bases. Another example of DT that follows an orchestrator-centric view is AirAsia, a low-cost airline based in south-east Asia that designed a completely new business model for its ecosystem, which served as a growth infrastructure for its post-pandemic future (Radziwon et al., 2021).

As much as success stories like Amazon.com and AirAsia demonstrate the potential of DT, similar changes and ecosystem initiatives are much more difficult to undertake in regulation-driven industries like finance and healthcare. This may explain why in recent years we have been witnessing a rapid development of fintech start-ups that benefit extensively from open data regulations and regulatory sandboxes (Alaassar et al., 2020) and have been disrupting larger and extremely rigid organizations. This happens because those more established organizations failed to develop interfaces between the legacy systems and multiple bureaucratic structures that have become part of their organizational culture. Hence, ecosystem orchestrators face challenges that are not only of a technical but also of an organizational and institutional nature (Dattée et al., 2018; Järvi et al., 2018). We still know very little about the complex nature of those challenges, how they interrelate or reinforce one another, or the mechanisms that could enable their resolution.

Whereas the orchestrator-centric view perceives ecosystems as something coordinated by a powerful focal or hub actor and directed toward particular goals (often set by the focal actor), the systems-community view is much more open-ended and incorporates an important but different role for other actors (Haarla et al., 2018; Hakala et al., 2020). According to this view, value creation, innovation, and entrepreneurial growth are both processes and outcomes of communities of actors concentrated around either a specific geographical region or joint knowledge, technology, or innovation challenges (e.g., van der Borgh et al., 2012; Autio et al., 2018; Järvi et al., 2018). Without a central governing organization, what is perceived as an ecosystem in terms of resource dependencies is negotiated by its members and determined collectively. This is in sharp contrast to the traditional purchasing and distribution arrangements – or platform interfaces and standards – of a powerful ecosystem orchestrator that determines who is part of an ecosystem and who is not. In the digital context, by contrast, even loosely coupled communities can form their own artifacts, institutions, and outputs, thus creating a digitally enabled organization. Furthermore, digital technologies increasingly allow also decentralized governance on platforms, as opposed to the classic orchestrator-led platform models (Chen et al., 2021).

2.4. The geopolitical-level digital transformation

The geopolitical level is reflected in the sociotechnical systems view of management research as part of sociotechnical regimes and landscapes (Geels, 2002). Sociotechnical landscapes can be perceived as broad business environments, while the sociotechnical regime consists of the set of institutions and rules that establish an ecosystem's boundaries (Geels and Schot, 2007; Brem and Radziwon, 2017). In the past, it was primarily cultural differences (Nonaka and Takeuchi, 1995; Asheim and Coenen, 2005) that distinguished landscapes and regimes. Today, the perception of data (Lee, 2018), intellectual property rights (IPRs), appropriation regimes (Petricevic and Teece, 2019), and geopolitical strategies have all become conditions the use of digital technologies and data (Brem and Nylund, 2021).

2.4.1. Data as the "new oil"

Data has become nowadays a key productive resource for companies, yet there are major differences in how it is used globally. In the United States, for example, data are regarded as the property of the company that collects it. That firm has the right to aggregate, process, and sell data as it sees fit, with the notable exception of personal health data. In China, by contrast, data are in the service of the state; it must be shared with the government on request and stored inside China's national boundaries.[2] In the European Union, the rules governing data are different still: it is the right of the citizen to control and limit the use of her or his data, and companies that compile data must adhere to a number of legislative restrictions, including the General Data Protection Regulation (GDPR). Moreover, individuals in the European Union have the right to be "forgotten" (i.e., to have their data removed from a commercial database), but no such rights exist in the United States or China. Indeed, China has been developing a sophisticated Social Credit System based on extensive observation of citizen behavior in the digital domain (Liang et al., 2018).

2.4.2. The geopolitical transformation

The geopolitical landscape has shifted markedly in the past 20 years. The hegemony of the United States and Europe is giving way to an Asian innovation resurgence led by China (Collinson and Liu, 2019), which is no longer a passive receiver of Western technologies but an important developer of innovation in its own right (Xu et al., 2018). It is also increasingly clear that China's rise will not simply fold into the existing institutional arrangements of global trade or conform to Western notions of data privacy. There is

a digital divide emerging in the quality of information systems and data between China and the West (Lee, 2018) that is generating a "splinternet." The Chinese innovation ecosystem relies heavily on governmental support and investment and porous boundaries between enterprises and policymakers (Zhang and Merchant, 2020). There is an emerging environment of "open innovation with Chinese characteristics" (Chesbrough et al., 2020), and the increasingly politicized nature of innovation has brought digital innovation to the forefront of the geopolitical agenda.

2.4.3. The protection of IPRs

IPRs have become a flashpoint for competition (Petricevic and Teece, 2019) in the reshaped global economic order. High-fidelity replication and transfer of innovations at little or no cost across firms and national boundaries are unique features of digital technologies, which are reshaping the protections that IPRs seek to enable. While global technology transfer, along with its appropriability regimes and transaction costs, has been discussed since 1980 (see Pisano and Teece, 1989), academics and organizations alike still face significant challenges in governing and measuring the technology flow in global systems of innovation. In addition, harmonizing DT policies through regulations, standards, procedures, and antitrust measures is a major challenge for policymakers across the globe. The large-scale production and accumulation of highly portable data will require better data infrastructures, interfaces, and storage (Otto and Jarke, 2019), along with more robust governance structures, which will allow its regulation-compliant commercialization. Since data is by nature "nonrival", it could generate a lot of value when shared widely; however, in practice data is often not shared due to competitive or legal concerns (Jones and Tonetti, 2020).

2.4.4. Digital competitive strategies

While most governments have embraced DT as imperative, their policies toward data have been extremely heterogeneous, at times even contradictory. As a result of different strategies, countries must, therefore, advance DT in distinctive ways, as exemplified by different indexes of digital competitiveness (Chakravorti et al., 2017). Innovative collaborations often require large amounts of data, which they also generate (Del Vecchio et al., 2018). However, the rights and abilities of organizations to use, manage, and control data are conditioned by the underlying institutional requirements of each country or region (Balachandran and Hernandez, 2019). Excluding foreign companies like Google and Facebook from the Chinese market (or Huawei from the US market), a requirement for Chinese and American companies to be GDPR-compliant to operate within the EU, and the recent threat to shut down the Chinese-owned video-sharing social media platform TikTok in the United States (Zhai et al., 2020) are all examples of these geopolitical differences, which influence the ways companies can manage their data internationally.

3. The multi-level research agenda

Based on the interpretive approach to reviewing DT literature, we now build a multi-level research agenda i.e., how it might lead to positive impact whilst acknowledging the less comfortable aspects of change it could bring. The PIAI framework (see Figure 1) encourages the reader to evaluate *perception, interpretation*, and *action* in DT and ultimately their *impact* across various levels. The PIAI framework allows academics to move away from a single lens of analysis to leverage different (and adjacent) fields. While this might make the analysis more complex, we believe it better captures the broad nature of the phenomenon. Our critical assessment of the DT literature reveals a highly fragmented understanding of this topic that leads to a disjointed discussion on the consequences and efficacy of DT. A broader and multi-level view is needed to map the landscape of the processes and outcomes of DT as a managerial and socioeconomic phenomenon.

The PIAI framework is partly built on the psychological science literature. Psychologists have suggested that people perceive their environments in terms of their ability to act on them (Witt, 2011). Human behavior and personal and environmental factors are all intertwined, and learning – as a means to adapt to change – is affected as much by external as by internal reinforcement (Bandura, 1985). Since organizations, ecosystems, and countries are also made up of individual human beings, we extend the logic of perceiving, interpreting, and acting to inducing change and generating impact, both individually and collectively. In doing so, we argue that decisions on how to act on, adopt, and utilize DT will be determined based on perceptions and interpretations that are judgments resulting from the cognitive processing of what is perceived (Bitektine, 2011). DT would then bring change and have an impact at the different levels at which individuals, organizations, ecosystems, politicians, and governments deal with the phenomenon.

Our PIAI framework provides a non-exhaustive list of themes that are relevant to explore in further research; in the sub-sections below, we discuss the most critical research questions and directions across the four levels of analysis, thereby

Figure 1. The PIAI framework: tensions and paradoxes of digital transformation across multiple levels.

embedding their practical and policy implications. Furthermore, the PIAI framework highlights a set of opposing, paradoxical tensions (Schad et al., 2016) that characterize the scope of the emerging managerial challenges that DT poses at multiple levels. Given the overarching nature of DT, we expect such tensions to arise as different actors have both positive as well as negative perceptions, interpretations, and actions DT. Together, the proposed framework and accompanying questions can assist companies and policymakers in their strategic decision-making on the direction of DT, especially in turbulent environments, where the emergence of conflicting demands requires more rapid actions. We conclude with a summary table of exemplary research questions (Table 1).

3.1. The individual-level research agenda

For individuals, DT can be *perceived* as an opportunity to improve those aspects of work that are typically considered desirable: for instance, using digital technologies such as AI, robotics, or virtual collaboration environments to facilitate individual creativity (Kahn et al., 2016), creative collaborations between humans (Amabile, 2019; Kostis and Ritala, 2020), or by relying on AI, automation, and robots in personnel selection to increase fairness (Konradt et al., 2013; Nørskov and Ulhøi, 2020). However, DT can also be perceived as a threat to employees' current jobs (by replacing their skills) and to their social and emotional wellbeing. If work tasks are largely based on interactions with digital technologies, this is likely to limit the opportunity for employees to engage in and benefit from the socioemotional aspects of work, which are known to positively affect employee performance. To understand the effects of DT at the individual level, future research needs to differentiate between various digital technologies and examine how each unique technology type may influence the perceived meaningfulness of work and the different aspects of employee well-being.

Interpretation refers to the way in which technology is appropriated by users, or as "the sense-making activity of taking up technologies" (Kudina, 2019, p. 88). Because technologies act as "moral mediators" (Verbeek, 2015), they can shape and even fundamentally change the way people interact. As a result, a more granular understanding of human-technology encounters is needed, particularly regarding how digital technologies are appropriated by organizational members and how this process alters human social norms and value spaces within organizations. Crucially, developing such an understanding will inform and support the design and implementation of digital technologies in more culturally sustainable ways and with empowerment rather than forced adoption in mind.

Acting upon DT will necessarily entail the development of new practices, the changing of roles, and cognitive and social challenges for individuals. We offer some examples below.

First, physically embodied robots may have very different effects on human performance or creativity than virtual ones. Similarly, human-like robots that interact and behave according to human social norms and values (e.g., social robots) are likely to have different effects on human behavior and performance than tool-like industrial robots. Current research has yet to identify and understand such practices and distinguish between those that lead to digital immersion and those that lead to resistance or avoidance. Second, "prediction machines" based on AI could increasingly generate insights to help decision-makers reduce uncertainty and develop strategic plans (Agarwal et al., 2018). Researchers need to understand how socially driven (e.g., scouting methods) and digitally driven insights are merged by individuals and explore the consequence that automated insight development will have on the people involved (Kellogg et al., 2020). There is still limited research on how managers perceive the support of these AI agents and integrate their outcomes with those of human intelligence in the course of their decision-making. A critical question concerns how credible AI agents are in the eyes of humans. While it is widely acknowledged that digital tools could help identify hidden trends and make sense of both structured (e.g., patents or academic papers) (An et al., 2018) and, increasingly, unstructured data (Lindebaum et al., 2020), the interface between human and digital intelligence is still largely unexplored (Amabile, 2019). Third, virtual and augmented reality tools might create more persuasive ways to translate insights into more tangible alternative and future economic realities (Kostis and Ritala, 2020), as they could reduce some of the cognitive issues found in previous research (Kerr et al., 2012; Mortara, 2015). More work is needed to understand which configurations of AR and VR could help communicate insights.

The *impact* of designing and using digital technologies to stimulate certain desired human behaviors – with expectations of enhanced human creativity, engagement, problem-solving, and other performance goals – puts humans at risk of being treated merely as instruments that can be "tweaked" and "tuned" according to the needs of organizations (Kellogg et al., 2020; Nørskov, 2021). A substantial managerial (and research) task

Table 1. Research agenda – sample questions

Perception	Interpretation	Action	Impact
What are the boundaries of DT?	How could we better understand what is already happening and what will potentially happen at these different levels?	How do individuals, organizations, ecosystems, and governments act to support or prevent DT?	What are the (unintended) consequences of DT within and across the different levels of analysis?
What should remain unchanged at the individual, organizational, ecosystem, and societal levels?	Will DT exacerbate inequality in societies (at individual, organizational and geo-political level), and if so, how?		
Individual level questions to explore the PIAI framework perspective: • How can humans leverage digital technologies to augment their cognitive abilities, creativity, and learning? • How is DT changing the nature of human interactions? How is interpersonal communication affected by the rapid uptake of digital technologies? • How do employees' emotional factors, perceptions, and behaviors affect the acceptance and success of DT? • How do digital technologies influence the perceived meaningfulness of work, and how do they affect the different aspects of employee well-being? • What role can responsible research and innovation (RRI) play in fostering individuals' acceptance of DT? • How can managers make responsible decisions about which digital technologies their organizations will adopt to ensure the wellbeing of employees, and on what criteria should such decisions be based? • How is AI (and other digital technologies) used in decision-making? How does it contribute to biases reduction or reinforcement? • How can alternative and virtual reality tools be used to improve social decision-making processes? • How can robotics and AI be used to augment and facilitate individual and team creativity? • How can robots be designed (and perceived) in culturally sustainable ways? • How will labor markets be (further) impacted by DT?			
Organizational level questions to explore the PIAI framework perspective: • What are the new mechanisms enacted by digital technologies that affect companies? • What are the different antecedents, consequences, performance implications, and nuances of DT and digital technologies on incumbents, SMEs, and start-ups? • What are the factors accelerating or slowing down DT in mature industries? How can incumbents that are lagging in terms of digital technology adoption renew themselves? What is the role in this process for digital start-ups? • How can the emergence of a new organizational identity be encouraged through DT? • What are the organizational capabilities, processes, and structures, both formal and informal, of intelligence provision and decision-making to support DT? • How do decision-makers solve problems created by algorithmic biases and outsourced tasks? • How credible are AI agents in delivering insight, and how is their level of credibility measured? • What kind of decision-making can be left to algorithms and AI, and which decisions will still require human intervention or control? • What are the ethical implications of AI- and data-driven organizations?			

(Continues)

Table 1. (Continued)

Perception	Interpretation	Action	Impact
Ecosystem level questions to explore the PIAI framework perspective: • How do organizations decide to form, join, stay in, or exit digital ecosystems, and who manages them? • How can existing or new ecosystems implement and deploy digital technologies to improve and expand their value propositions and mobilize users and complementors around those value propositions? • How do digital technologies affect competition and cooperation dynamics, along with bargaining power over value creation and capture, in ecosystems? • How do ecosystem orchestrators construct legitimacy and the related collective identity, and how can digital technologies help in these tasks? • What are the (digital) organizing mechanisms and digital artifacts that facilitate innovation within and around the ecosystem? • How can new ecosystems be created and scaled up using platform governance and digital interfaces? • How can the openness and flexibility in digital ecosystems be balanced with the necessary level of control and oversight? What are the organizing elements needed to achieve this balance? • What happens to the knowledge brokers of the traditional ecosystems when and if data becomes digitally and openly available for ecosystem actors? • What are the key governance principles of self-organizing digital ecosystems? • How can ecosystems harness data from users and other actors in a way that is beneficial to both the core value proposition and the various ecosystem actors? Geopolitical level questions to explore the PIAI framework perspective: • How do countries and governments deal with the increasing power of major digital platforms and e-commerce giants? • What are the short- and long-term implications of DT for different industries and in different cultural contexts? • How do governments act upon the development of new technologies? • How are open data sharing practices affected, shaped, and enacted by DT? • How can openness (of data), transparency (of governmental intentions), and fairness (of AI) be handled effectively? • What are the risks, costs, and benefits of openness in sharing data (or access to data) as part of DT? • What legal ramifications could arise from the misuse of digital technologies and open data? • How do different data ownership frameworks affect open and collaborative digital innovation? • How can IPRs and their protection be reconceived in light of the different approaches to DT around the globe? • How can DT enable greater levels of civic engagement, participation, and deliberation, such as through RRI?			

thus awaits not only in determining how to design facilitative digital technologies but also in how to use them in culturally sustainable ways by ensuring that those technologies transform or disrupt work practices, values, and norms "in a way that leads to moral, social, and emotional upskilling or reskilling rather than deskilling" of employees (Ulhøi and Nørskov, 2020, p. 96). How such a responsible approach can be designed, what criteria it should be built upon, and how it should enable socially and ethically robust organizational decision-making are all issues that require much more investigation. For this, tools that foster responsibility and the integration of external stakeholders – such as the Responsible Research and Innovation (RRI) approach – should be included more widely and at an earlier stage (Jirotka et al., 2017).

Furthermore, the introduction of digital technologies can lead to individuals feeling included, while others are excluded due to a lack of opportunities or competencies. This progression can be detrimental to innovation and diversity. Likewise, DT might lead to the dispersion of individuals to geographically distant locations, with interaction both facilitated and constrained by digital technologies. Changes triggered by technologies encompass not only skills but also workers' jurisdictions since they alter the task domains of specialists and the division of labor (Barrett et al., 2012). For instance, whereas digital technologies may be able to promote learning (Belpaeme et al., 2018), engagement (Traeger et al., 2020), and problem-solving (Tennent et al., 2019), they may also change the status and visibility of workers in the workplace and lead to the marginalization of certain workers and occupations in favor of others. The open question is whether DT will lead to a more inclusive model of working in which individuals have rich access to knowledge and to each other or to a model from which only certain individuals derive benefit. Furthermore, the predictability of a task determines its "robotification" and automatization potential (Ford, 2015). While removing mundane, repetitive tasks is typically viewed as desirable, not all unpredictable work is meaningful; nor is all predictable work dull.

3.2. The organizational-level research agenda

At the organizational level, DT is *perceived* as either an enabler of organizational renewal that offers ample opportunities to recast how firms can best capture and create value (Bradley and O'Toole, 2016) or as an externally enforced driver that threatens a company's survival (Vial, 2019). In addition, given new challenges with IPRs and appropriability brought by DT (Ilvonen et al., 2018), DT demands the construction of an appropriation advantage (Di Minin and Faems, 2013) to create and capture value considering the interdependencies enabled by digital technologies and data, both within and between organizations. In fact, since data are by nature a "nonrival good," it can be used and reused with a near-zero marginal cost, highlighting both the value creation potential of data within and across organizations and the importance of capturing value from it (Jones and Tonetti, 2020, Alaimo, 2021).

DT can be *interpreted* as an opportunity to innovate and transform organizational legacies, capabilities, structures, processes, and business models (Cennamo et al., 2020; Lanzolla et al., 2020) or as a set of drastic changes that could disrupt and even cannibalize the core competencies of incumbent firms (O'Reilly and Tushman, 2016) or even entire industries. As with other technology-driven transformations in organizations, DT initiatives are known to be difficult to implement (Saldanha, 2019). As firms are confronted with discontinuous changes in their environment, they experience increasing ambiguity and issues of organizational identity (Tripsas, 2009), especially compared to "born-digital" players like Amazon, Netflix, and Airbnb. Interestingly, the internal structure of established companies becomes a subject of change itself, with the blurring of boundaries between units allowing for broader and continuous adaptation without inertia (Hanelt et al., 2020). This reflects an apparent paradox between the organizational intent of engaging in DT (and creating specific structures to support this change) and the inherent transformative properties of digital technologies that transcend existing structures and boundaries.

How companies *act* in response to DT will be determined by their perception and interpretation of disruptive events. A given company's actions may be offensive (first mover, market leader) or defensive. Companies can, for example, exploit digital technologies to enter previously unconnected markets by reinventing their legacy value chains (Lanzolla et al., 2020), to enter new markets created by technology diffusion, or to leverage digital technologies across various organizational units, whether to reduce costs, to optimize processes and production, or to make "smart" business decisions (Vial, 2019; Cennamo et al., 2020; Lanzolla et al., 2020). In the worst case, DT can result in inefficiencies in organizations, including dysfunctional information systems and interfaces and increasing coordination costs. Indeed,

a key question is whether digital technology serves the needs of the organization or whether the organization finds itself shaped to serve the features of the technology. Organizations thus face an ambiguous challenge in the need to balance the new structures, business models, and ecosystems developed as part of DT and the ability to harness the potential of their existing structures and capabilities (Maijanen and Virta, 2017). The implementation of DT also profoundly questions the soundness of existing growth strategies (Verhoef et al., 2021) and business models (De Marco et al., 2019).

The *impact* of organizational actions can affect not only companies' success in terms of financial performance, innovation performance, or even survival but will also have positive or negative implications on the broader economic and social structure by differentiating DT champions and beneficiaries from digital laggards. This opens the door for multidisciplinary research on the different antecedents, consequences, performance implications, and nuances of DT and digital technologies on incumbents, SMEs, and start-ups, as well as on the wider society.

Clearly, there are many research opportunities to investigate DT at the organizational level. For example, we still know little about the new organizational principles, designs, and processes that are triggered by digital technologies (Lanzolla et al., 2020). Moreover, we are not yet fully aware of the different ways in which incumbents lagging in digital technology adoption can renew themselves. For instance, technological collaborations with born-digital start-ups or more dominant born-digital players are likely avenues for renewal, but the effectiveness of these initiatives remains an open question. Furthermore, the consequences of new digital technologies on organizational decision-making or innovation performance (Usai et al., 2021) are not well known. Likewise, the accelerated adoption of digital workplace technologies (Marsh et al., 2021) and the recently promoted future-of-work in a "Metaverse" have short- and long-term consequences yet to be explored.

3.3. The ecosystem-level research agenda

At the ecosystem level, DT is *perceived* as either being embedded within the ecosystem itself (as in the case of digital platforms) or as a driver of transformation in existing ecosystems. We suspect that this difference in perception leads to significant differences in terms of organizational- and individual-level strategies that warrant research. For ecosystems, an interesting question is whether DT is perceived as serving the ecosystem members' individual interests or promoting shared ideas and collective action to compete against other ecosystems that may be less digitally capable. Furthermore, easy-access membership in many platform ecosystems invites more generativity, but might also spur opportunistic behavior (Karhu and Ritala, 2020). These challenges evoke the importance of the legitimacy of both the ecosystem and the legitimacy of its constituent organizations (Thomas and Ritala, 2021). The reality is that many (digital) ecosystems fail to attract enough valuable contributions and eventually die out. The role of digital technologies in securing and maintaining ecosystem health, renewal, and generativity (Kallinikos et al., 2013) is thus essential.

The *interpretation* of DT is similarly divided into fully digital organizing principles or introducing and implementing digital aspects in existing ecosystem governance. From the orchestrator-centric perspective, interesting aspects relate to how the orchestrator can mobilize ecosystem actors around a shared value proposition (Dattée et al., 2018) and the role played by digital technologies in this process. Further research could be devoted to the organizing principles that orchestrators can use to facilitate innovation within the ecosystem. Ecosystem orchestrators need to balance between several tensions, such as generativity as opposed to control (Cennamo and Santalo, 2019) and openness and flexibility in value creation as opposed to tightly enforced value capture principles (Karhu and Ritala, 2020). From the community-system perspective, DT scholars could examine how digital artifacts and interfaces change the interaction dynamics between ecosystem actors and which actors are influential in such ecosystems. The wealth of digitally available information amplifies misinformation and causes tensions on all levels, from the individual (e.g., cyberbullying, identity theft, or addictive use) to the political (Baccarella et al., 2018), on which the perceived fairness of the value appropriation within the ecosystem may vary and have implications at the individual (emotions), organizational (strategies), and geopolitical levels (regulations). These and other themes emerge as we try to understand the new possibilities of heterogeneous actors joining together to create value in distinctive types of ecosystems around various themes (Nylund et al., 2021).

The *action* that results is driven by the role of the digital ecosystem: it either ought to seek generativity and innovation through digital organizing (Cennamo and Santalo, 2019) or to facilitate interaction among ecosystem participants through digital tools and connectivity. While ecosystem relationships can be diverse and not always directly and immediately beneficial, they ought to provide meaningful affordances for ecosystem members if they are to be sustained over time (Nambisan, 2017). Interorganizational

relationships within ecosystems are both enabled and constrained by digital technologies. For example, digital technologies (such as platform interfaces) enable easier maintenance and augment interorganizational relationships, but they may also compromise the quality of relationships.

In addition, more research is needed to understand what the (intentional and unintentional) *impacts* of digital technology-driven changes could have on ecosystems. All ecosystems are naturally heterogeneous in their actors, technologies, and institutional environments (Aarikka-Stenroos and Ritala, 2017, Cobben et al., 2021); the impact of DT will therefore differ for each ecosystem. Some ecosystems, such as Facebook, are fundamentally born digital; they were built on the organizing principles of platform markets (Cennamo et al., 2020). On the contrary, some ecosystems, such as those in sectors like energy and health, are organized around a value proposition that may not be delivered in a (fully) digital format. Ultimately, ecosystems that can harness digital technologies are seeing significant growth advantages compared to those that cannot. However, there is also a risk of some established ecosystems becoming too powerful, and with their strengths in proprietary data and information systems, those companies may be less vulnerable to disruption than previously (Bessen et al., 2020). This might suppress competition and concentrate markets among even fewer companies and platforms. The resulting impact might differ for participants to digital ecosystems. As such, DT may lead to a "beautiful" virtuous cycle of value co-creation and co-evolution in which different actors join, innovate, and collaborate, contributing to the renewal and ongoing competitiveness of the entire ecosystem. Indeed, such generativity is seen as an ideal feature of digital technologies and digital ecosystems (Yoo et al., 2010; Cennamo and Santalo, 2019). Conversely, DT could lead to an "ugly" long tail of ecosystem actors that fail to profit or benefit from the ecosystem, if value only migrates to the rare superstar complementors or actors.

3.4. The geopolitical-level research agenda

At the geopolitical level, DT is *perceived* as a tool for market and even socio-political dominance. Only states and international organizations comprised of states have the resources and authority to balance the rights of individuals, organizations, the state, and society. Therefore, in assessing the potential of data and more broadly of DT, national and geopolitical contexts are of major relevance, even if they are typically overlooked in the literature. Thus, we should consider the geopolitical dimension as an independent unit of observation. We also need to acknowledge that geopolitical dynamics significantly influence the individual, organizational, and ecosystem levels, along with the regional and national units of analysis.

The *interpretation* of DT does, however, vary greatly across states depending on whether personal data is viewed as an asset, a right, or a public good. Due to varying geopolitical perceptions of data, the consequences of non-transparent data handling differ around the world. For example, the StudiVZ platform started in Germany in 2005 as an online social network for students and young people; it achieved a user base of over six million in German-speaking countries by 2009. This number fell to around 600,000 in 2016 before the company declared bankruptcy in 2017. A significant contributor to this collapse was the criticisms the company received for data exploitation, which resulted in bad press and a loss of public trust (Fuchs, 2010). At the same time, Facebook continues to grow, with over 2.2 billion users (more than the population of any single nation), and still leads the market, despite even more concerning allegations around personal data misuse. Combined, these examples show how questions of data, regulation, and market competition are often unevenly distributed and may cause unintended and sometimes harmful consequences.

The transformation is *acted* on because of these considerations. In the United States, where data is seen as an asset, the government promotes the economic utilization of these assets by organizations. Platforms are thus encouraged to profit from data through business model innovation (Cusumano et al., 2019). In China, where data are a public good, platforms are asked to collect data that serves the state, and information sometimes triumphs over profit. In Europe, where data is an individual right whose protection is paramount, innovation becomes more defensive and reactive to regulation at every step. These approaches are all consistent with the prominent values of their respective regions. Future research should investigate when and how different approaches to data and geopolitical tensions influence innovation ecosystems and open innovation. Furthermore, ecosystems and platforms that grow too large or powerful may also be perceived as a threat to the power of governments, both democratic and autocratic, hence causing geopolitical responses aimed at their control. At the same time, DT – especially regarding data ownership issues – has also fueled the re-emergence of geopolitical blocs. While geopolitics is currently more concerned with the race for the ownership of as-yet unexploited natural resources, the discussions on data may further accentuate this trend.

However, DT means that actions transcend borders to a far larger extent, and the *impact* of DT on innovation is not only influenced by the approach of each nation but by the clashes between these approaches. As digital platforms change the sociotechnical landscape across the globe (Martin, 2016), they are becoming geopolitical tools (Andersson Schwarz, 2017), allowing multinationals and governments access to user data and the possibility of managing user interactions to such an extent that other nations may be excluded from market access. Another regulatory issue that emerges from DT is the "Uberization" of societies (Hill, 2015), which refers to the freedom of choice in capitalizing on one's tangible assets (cars in the case of Uber, real estate in the case of Airbnb) as sources of short-term income. However, the regulatory aspect of this freedom is often a grey area, so the long-term picture for technology-enabled access to services is not fully clear. If nothing changes, there may be negative consequences related to a lack of pension contributions for gig workers and issues with access to healthcare benefits, which are not a public good in many countries. Moreover, the apparent autonomy associated with embracing a sharing economy model (largely enhanced by digital businesses) may have serious implications both for individuals who are forced to accept precarious employment structures and for organizations tainted by a hyper-distrust of technological surveillance (Fleming, 2017; Zuboff, 2020). Similar challenges relate to the so-called "platform work" where individuals act as entrepreneurs in digital platforms, such as those focusing on food delivery.

In addition, large platforms in Europe may also face a series of non-regulatory issues, such as the need to offer access and service in local or minority languages. Platforms like Facebook and Twitter from the United States or TikTok and WeChat from China initially tap into far larger local markets broadly united by one language, which provides an edge over their multilingual European counterparts. However, network effects and other ecosystem-specific advantages of digital platforms are often not bound to a location (Nambisan et al., 2019), meaning that platforms can take advantage of their network effects even when they are late entrants into a particular geographical market. Moreover, as English-, Chinese-, or Korean-speaking communities are relatively well represented across the globe, their various diasporas could play an instrumental role in introducing locally popular products into completely different markets. Entrepreneurs on these platforms become dependent on the type of business dynamics that dominate such platforms (Cutolo and Kenney, 2019). These dynamics are in turn shaped by infrastructures, norms, and policies that shape the platform economy (Kenney and Zysman, 2016).

Recent technological developments in AI, cloud computing, 5G, and Web3 all call for either more regulatory actions, which may involve laws, regulations, and antitrust initiatives, or more international data standards, better data architecture, and greater interoperability of data through better interfaces. Some still unanswered research questions focus on the ways in which open data sharing practices are affected and shaped by DT, and how DT and new digital technologies can enact open data sharing practices. More broadly, we need to learn more about different ways of handling openness, transparency, and fairness (see, e.g., European Commission, 2018). Researchers could also look further into questions such as what are the risks and costs of openness in sharing data (or access to data) as part of DT, and what are the short- and long-term implications for different industries and in different cultural contexts?

4. Conclusion

This paper makes two key contributions. First, we propose an extended definition of DT that goes beyond capturing change at the organizational level. Second, given the broader socioeconomic and sociotechnical transformation (Geels and Schot, 2007) related to DT, we provide a foundation for advancing our understanding of DT across multiple levels of analysis by developing a critical, multi-level research agenda at the intersection between the bright and dark sides of DT. In doing so, we aim to answer the call of Urbinati et al. (2020) and Yoo et al. (2010), which invite us to provide strategic and innovation frameworks in a digital technology context. More concretely, we approach DT from the tensions and paradoxes perspective (Schad et al., 2016), and through the prism of our proposed PIAI framework (perception, interpretation, action, and impact). This framework provides a balanced way to approach the overarching transformation brought along by DT in multiple levels, inviting scholars and practitioners to embrace not only the best practices or benefits but different challenges and downsides as well.

Our contributions provide insights to R&D and innovation management, calling managers to make balanced decisions on the overarching, and sometimes the disruptive effect of digital technology. The multi-level framework allows managers to consider how actions at individual, organizational, ecosystem, and geopolitical levels are contributing (or not) to accelerate DT. Similarly, by connecting perceptions,

interpretation, and specific actions we draw a path they can follow to decipher what impact means in this context, and its consequences. DT is inevitable, but it is not deterministic, since individuals, organizations, ecosystems, and governments affect – whether intentionally or not – how it evolves and shapes the world.

In this study, we pursued not to simplify, but to embrace the complexity of DT, which provides a lot of future research opportunities. As the DT phenomenon evolves and permeates across and beyond the analysis dimensions of our framework, we encourage future research to further unpack and look inside the transformed or new processes, taking a closer look at different aspects of this phenomenon. We hope our work will be helpful in stimulating fruitful discussions, debates, and future research.

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Notes

[1]A Scopus search (December 17, 2021) reveals that over 40% of scientific papers that refer to "digital transformation" in the title, abstract, or keywords were published in the computer science and engineering fields, followed by business and management, social sciences, and decision sciences.

[2]The second draft of China's first comprehensive law on the protection of personal data, known as the Personal Data Protection Law, was released on 29 April 2021.

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