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The digitalization of search and recombination mechanisms

Tensions and implications
in the cultural heritage sector

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Summary

Over the last decades we have witnessed a profound digitalization of tangible products. While this shift offers new possibilities and great opportunities, it also exposes firms to significant challenges and constraints for innovation management in the digital age. Specifically, rather than centering on the corporate R&D department, firms acknowledge that innovation is an increasingly distributed activity, taking place in **networks and ecosystems** rather than within **hierarchies**. In turn, this calls for new forms of governance of information, new business models, new organizational architectures and generative technologies, encouraging new “uncoordinated” forms of innovation.

The thesis is rooted in the observation that firms need to combine different **innovation regimes** to tackle digital transformation. On one hand, physical products will remain physical goods delivering tangible value. On the other, this tangible value is increasingly enhanced by digital technologies, calling for new perspective on innovation. In addressing this challenge of searching and recombining different innovation regimes, the thesis draws on the **innovation management literature**. Among the various digital enabling technologies being considered in the digital transformation of companies, in the innovation management literature, **digitization** and **connectivity** have been associated with new possibilities and opportunities for innovation in general and for search and recombination mechanisms in particular. What has often been missing from innovation management research is the systematic consideration of digitization and connectivity as forces that not only creates **opportunities** but also changes the **organizational variables** that might affect some of the built-in assumptions in the extant innovation management literature.

This thesis addresses this gap in the literature by investigating how firms can make the search and recombination mechanisms enabled by digitization and connectivity **work for them and not against them** in the innovation process. In doing so, it introduces a a systematic integrative framework – grounded in the systematic analysis of the literature on digitization and connectivity – that predicts the likely scope of search and recombination mechanisms vis-à-vis digitization of the innovation function. Overall, the thesis shows that the potential "inertial" effects of digitization and connectivity (i.e., activities set into motion) on the scope of search and recombination are far from being unidirectional and ambiguous because digitization and connectivity engender changes in the micro-mechanisms of **absorptive capacity** and **innovation governance** that are at the core of search and recombination's scope.

Sensitizing the theoretical framework through two empirical studies of digital transformation this thesis derives several implications for theory and practice. Across two different, yet interlinked, embedded case studies in the cultural heritage sector it demonstrates the theoretical framework by leveraging differences on how digitization and connectivity affect search and recombination mechanisms in **network-centric** and **hierarchy-centric** innovation contexts.

On the question on how firms can make the search and recombination mechanisms enabled by digitization and connectivity work for them and not against them, the thesis shows that this depends on which forces unleashed by digital technology dominate over the other ones. These forces may affect a company's innovation governance and absorptive capacity – and, in turn, the scope for search and recombination – in three ways. First, digitization and connectivity might increase formal control and centralization in the governance of the innovation process, but they might also enable informal and distributed governance of the innovation process. Second, organization's absorptive capacity – via digitization and connectivity – might enable more formalized knowledge, better understanding of the linkages among pieces of knowledge and better communication flows. Finally, digitization and connectivity may change the distribution of skills in the innovation functions and – depending on the resulting balance between digital and legacy skills – the organization might embark in path-dependent innovation (legacy skills prevail), path-creating innovation (digital skills prevail) or more balanced innovation.

To a grandfather,
a second father,
and… a friend.

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Chapter 1

Introduction

1.1 Background

Marie Antoinette's young daughter is crying. Either that or she has conjunctivitis. A small yellowish daub of paint in the corner of her right eye glistens as she limpidly, lovingly gazes up at her mother, in Louise Eiisabeth Vigée-Lebrun's 1787 portrait of the queen and her children, seen in the extreme close-up that ***only seven billion pixels*** *can provide (Figure 1).*

Figure 1 - Marie-Antoinette de Lorraine-Habsbourg, queen of France, and her children. Élisabeth Vigée Le Brun (1787). Palace de Versailles (Paris, France). Source: Google Arts & Culture

February 1, 2011, Google launched the "Art Project" with contributions from seventeen museums distributed across nine countries. From the early days, the Art Project impressed the world with a feature with revolutionary potential: the "gigapixel" images of the works singled out by each participating institution. These seven billion pixels images of works offer more detail than the naked eye and allow users to take a microscopic view of the works from their home. Making that intense viewing accessible to virtually is exactly the point of the Art Project – says Amit Sood – the Director of Google's Cultural Institute *"These works of art are part of our shared culture. Anyone should be able to see and study them, regardless of where they live [...] Not only individuals get to interact with art, they also will be able to manipulate it. The Internet makes this possible."*

Although the launch of Google Art Project – now Google Arts & Culture – attracted enormous attention at the level of users thanks to the new functionality, the quote indicates that Google looks upon search and recombination enabled by digitization and connectivity as an important part of the Google service ecosystem, feeding multiplicity and heterogeneity. Second, the statement denotes a new organizing logic, where functionality is expected to emerge from the more or less independent work of third parties (e.g., art lovers, researchers, multimedia specialists, technology vendors, and specialized suppliers). In this vein, the "gigapixel" images were described as potentially revealing to conservators and generative of new scientific knowledge around the art works (Berwick 2011, 23). This opens up for unconstrained creativity and alternative modes of value generation. Third, it recognizes a new market dynamic, breaking with traditional ways to do business.

Over the last decades we have witnessed a profound digitization of tangible products (Yoo et al., 2010). Google's Arts & Culture initiative is nothing but a specific example of a general trend in technological change that has far-reaching impacts on firms across multiple sectors, a topic central to the field of innovation management for several decades (e.g., Abernathy and Clark 1985; Tushman and Anderson 1986; Henderson and Clark 1990; Afuah and Tucci 2003). However, the Google initiative is not just opening up access to artworks for everyone around the world – as popular discourse seems to indicate – nor is merely reinforcing the legacy museum function. Rather, it is "digitally transforming" the physical materiality of artworks in something new. Digitization and connectivity are at the core of the so-called "digital transformation" and their impact is widely predicted to be transformational for institutions, societies, and organizations. Digitization has been defined in several ways including the encoding of analog information into a digital format (Yoo, Henfridsson, and Lyytinen 2010) or the rendering of things into information, and in particular, as digitally represented information (Dhar and Sundararajan 2007). The complementary side of digitization is connectivity. Nonaka and Konno (1998, 40) and Trantopoulos et al. (2017) argue that connectivity entails a shared space for emerging relationships (that) "can be physical, virtual, or mental" and enables the assimilation of external knowledge by disseminating new process ideas, best practices, and solutions widely and rapidly among personnel.

Turning to the automotive industry, as an example, a modern car embeds more than 10 million lines of code and is increasingly connected to mobile devices and telematics services (Henfridsson and Lindgren 2005). It is argued that as much as 80% of all car innovations can be traced to digitization and connectivity (Leen and Heffernan 2002). Given this wide adoption of digital technologies, firms – from museums to carmakers – are triggered to rethink established models of innovation. Specifically, depending on whether related innovative solutions are closely related to the firm's pre-existing knowledge base – or they are instead distant from the firm's current routines and R&D trajectories – digitization and connectivity can be of exploitative (i.e., based on knowledge recombination mechanisms) or exploratory (i.e., based on knowledge search mechanisms) nature (Katila and Ahuja, 2002).

Over the last ten years, there has been a considerable escalation of interest in research around digitization and connectivity in innovation management literature. The topic is so significant that just in 2018 more than ten Special Issues on aspects related to digitization and connectivity were announced in some of the leading organization and management journals including *Strategic Management Journal, Organization Studies, Journal of Product Innovation Management, California Management Review,* and *Academy of Management Discovery*.

One aspect of digitization and connectivity that has perennially surfaced since the Internet boom of the early 2000s is the question of **whether existing innovation theories are up to the task of explaining and predicting performance in the digital age?** Even though there are several dimensions in which digitization and connectivity transform industries and organizations in ways that replicate previous transformations (e.g., the first industrial revolution), there is no consensus in the innovation management literature on whether digitization and connectivity require **new conceptual frameworks** or, more simply, **an adaptation of the existing ones**.

Specifically, in the innovation management literature, digital technologies have been associated with ***new possibilities and opportunities*** for innovation management in general, and for **search and recombination mechanisms** in particular. However, digital technologies might also shape some ***new challenges*** and ***constraints*** for innovation management in the Digital Age. The consolidated body of knowledge offers the opportunity to start systematically integrating digitization and connectivity with the extant innovation management literature to develop a comprehensive framework on the consequences of digital transformation and their implications for innovation management.

Overall, by delivering on this literature integration, the goal of the thesis is to provide a systematic integrative framework to shed more light on questions such as: How the changes initiated by the digital transformation may have an impact on the kinds of innovation that firm may produce? How digitization and connectivity may have an impact on the likely scope of search and recombination mechanisms for firms? Which established organizational trade-offs do digitization and connectivity make more – or less – prevailing? Do digitization and connectivity create new trade-offs in innovation capability (e.g., **legacy vs. digital**), innovation focus (e.g., **product vs. process**), innovation collaboration (e.g., **internal vs. external**), and innovation governance (**control vs. flexibility**)? Where do these trade-offs come from?

More fundamentally**, how can firms make the search and recombination mechanisms enabled by digitization and connectivity work for them and not against them in the innovation process?**

The answers to these questions will directly inform the debate on whether digital technologies are simply "**old wine in new bottles**" when it comes to innovation management and organization theories. My stance, based on an extensive literature review on digitization and connectivity (with specific focus on the innovation function) and two empirical studies of platform-based and firm-based innovation in the cultural heritage sector, is that it might be time to rethink some of these building blocks.

1.2 Digital transformation in the Innovation Management literature

Digital technologies – e.g., Artificial Intelligence, Internet of Things – are widely predicted to be pervasive within institutions, societies and organizations, and it is not uncommon to see them linked to concepts such as "transformation," "paradigm shift," and the "4th Industrial Revolution."

Among the various digital technologies (e.g., cloud computing, 3D printing, augmented reality, etc.) being considered in the digital transformation of companies – digitizing physical objects and connecting them to the Internet – has been considered as the pivotal innovation paradigm (Kim, Lee, and Kwak, 2017). In fact, it is ascribed to the potential to fundamentally change the nature of products, processes, and supply chains, alter industry structures and boundaries, and transform the nature of competition (Porter and Heppelmann, 2014). So, to be able to benefit from these opportunities, **firms are triggered to rethink established models of innovation**.

Specifically, rather than centering on the corporate R&D department, firms acknowledge that innovation is an increasingly **distributed activity** (Yoo, Henfridsson, and Lyytinen, 2010), taking place in **networks** and **ecosystems** (Bharadwaj et al. 2013; Yoo et al. 2012; Yoo et al. 2010) rather than within **hierarchies**. In turn, this calls for new forms of **governance of information** (Lazer and Friedman 2007; Gong, Nault, and Rahman 2016), new **business models** (Amit and Zott, 2001; Baden-Fuller and Haefliger, 2013), new **organizational architectures** (Nambisan et al., 2017) and **generative** technologies (Zittrain, 2006), encouraging new "**uncoordinated**" forms of innovation.

The thesis is rooted in the observation that **firms need to combine different innovation regimes to tackle digital transformation** (Svahn and Henfridsson 2012; Yoo et al. 2012). On one hand, physical products – for example cars – will remain physical goods delivering tangible value – transportation in the case of cars. On the other, this tangible value is increasingly enhanced by digitization and connectivity, calling for new perspective on innovation – for example, smart-connected cars.

In addressing this challenge of searching and recombining different innovation regimes, the thesis draws on the innovation management literature. This is a large body of literature, ranging from economics to entrepreneurship, via technology management and organizational science. However, for the particular purpose of this dissertation I have concentrated my efforts on the **potential effects of digitization and connectivity on the scope of search and recombination mechanisms**.

In the innovation management literature, digitization and connectivity have been associated with new possibilities and opportunities for innovation (Lyytinen, Yoo, and Boland 2016) in general and for **search and recombination mechanisms** in particular (Villarroel 2013; Tucci, Chesbrough, Piller and West 2016). For instance, Dougherty and Dunne (2012) analyze the generation of new scientific knowledge that would not be possible without digital technologies, such as bioinformatics, metabolomics, or genomics. One common recurring theme in the recent innovation management literature is that digital technologies enable a **broader search** through the solution space via a broader **reach of more "agents" whose expertise the focal agent potentially lacks** (e.g., Poetz and Schreier 2012). In that vein, several scholars have highlighted that digital technologies may enable new innovation management practices including boundary-spanning approaches (e.g., Levina and Vaast 2005; Lindgren, Andersson, and Henfridsson 2008) consisting in **innovation from networks** (e.g., Powell 1990; Tuomi 2002; Van de Ven and Poole 2005; Boland, Lyytinen, and Yoo 2007; Von Hippel 2007) **or ecosystems** (Basole 2009; Selander, Henfridsson, and Svahn 2013). However, digital technologies might also shape some **new challenges** and constraints for innovation management in the Digital Age.

What has often been missing from innovation management research is the **systematic consideration of digital technology as a force that not only creates opportunities but also changes the organizational variables that might affect some of the built-in assumptions in the extant innovation management literature.**

This thesis addresses this gap in the literature by investigating **how can firms make the search and recombination mechanisms enabled by digitization and connectivity work for them and not against them in the innovation process?**

In doing so, the thesis introduces a a systematic integrative framework – grounded in the systematic analysis of the literature on digitization and connectivity – that predicts the likely scope of search and recombination mechanisms vis-à-vis digitization of the innovation function.

1.3 Research aim and Research Questions

The motivation behind this investigation is related to the **unexplored consequences of digital technology adoption.** As Dougherty and Dunne (2012, 1467) state, the changes triggered by digitalization *"cannot simply be dumped into the innovation process"*. Specifically, the consequences of digital technology adoption go way beyond the technical process of encoding information in digital format and involve, for instance, organizing new sociotechnical structures (e.g., Yoo, Henfridsson, and Lyytinen 2010; Yoo 2012), bringing in new organizational skills (e.g., Troilo, De Luca, and Guenzi 2017) and establishing new organizational structures (Viscusi, Tucci, and Afuah 2018). In this sense, the body of knowledge accumulated to date is utterly fragmented, and this significantly hinders the possibility to develop a systematic understanding of the impact of digitization and connectivity in innovation management research.

Therefore, the thesis is centered on the systematic consideration of digitization and connectivity as "**digital transformation forces**" that create new value creation opportunities but also change the organizational variables. Whether firms will be able to transform innovation practices and leverage the opportunities of digitization and connectivity relies on their capability to **search** the transformation forces of a digital innovation regime and **recombine** them with the architectural perspective of product / service innovation. Thus, the dissertation is based on two main research questions:

RQ1: How do digitization and connectivity shape ***search*** *and* ***recombination*** *mechanisms and technological complementarities?*

In this first Building Block (BB1), the thesis looks at the built-in assumptions in the innovation management literature to generate predictions on the likely scope of search and recombination mechanisms vis-à-vis digitalization. In this vein, a synthesis of the key mechanisms and contingencies that are more (or less) likely to enable effective search and recombination mechanisms is conducted.

RQ2: How do digitization and connectivity sustain ***search*** *and* ***recombination*** *mechanisms and how do they change the foundations of organizational learning, absorptive capacity and combinative capabilities by which organizations adapt and innovate?*

In this second Building Block (BB2), the thesis looks at the digitization of organizations with specific focus on the innovation functions. In this vein, a systematic review of the literature on digitization and connectivity, and organizational transformation is performed, from which the multi-level properties of digitization and connectivity are captured and some emerging regularities are distilled.

Figure 2 synthetizes the heart of the literature review design. As a lens to be applied in my study of digital transformation of search and recombination mechanisms, I have developed a **theoretical framework** by comparing and contrasting the aforementioned building blocks. On a general level, the analysis of the literature review emerged from the two building blocks shows **surprising convergence** in terms of the overall implications of digitization and connectivity on the likely scope of search and recombination mechanisms. However, the two building blocks are relatively **sharp in their contours**.

Researchers essentially refer to the same knowledge base when using the notion of search and recombination mechanisms (BB1). Turning to digitization and connectivity (BB2), there is not yet such a clear body of innovation literature, despite the fact the wide adoption of digitization and connectivity has been translated into several research fields and has been recognized as the core of the so-called “digital transformation”.

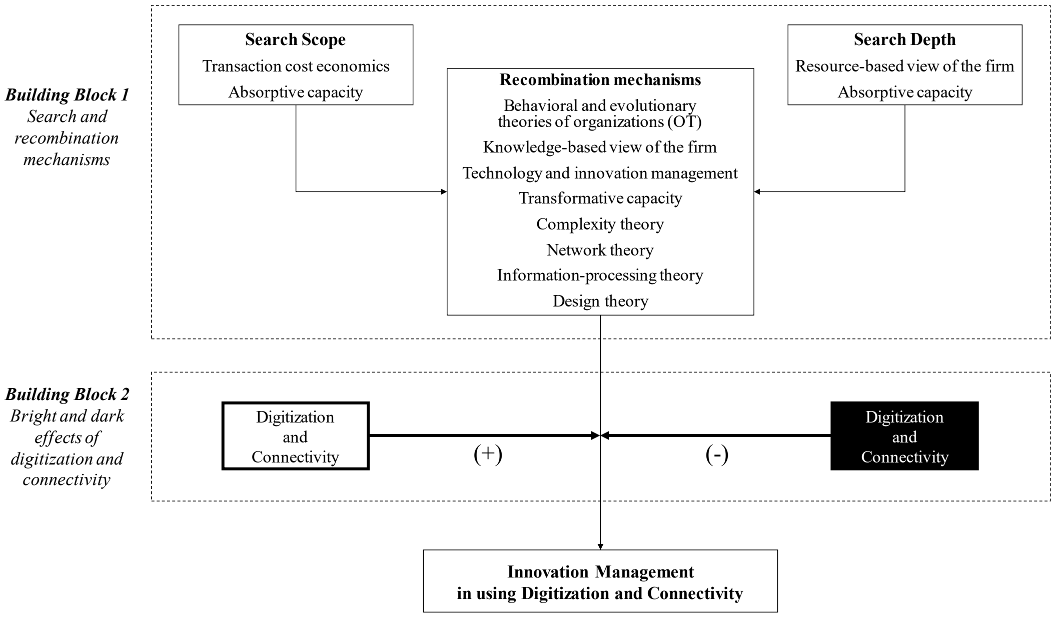


Figure 2 – The two building blocks at the heart of the literature review design

As a consequence, there may be reasonable consensus that innovation processes, centered on digitization and connectivity, follow a **different logic**. The thesis discusses this logic in the notion of **digital transformation of search and recombination mechanisms**. By comparing and contrasting the two building blocks, the review suggests that these two streams of research approach innovation with inherently different perspectives based on a fundamental dichotomy:

1. **network-centric (or platform-based) innovation**, where innovation is shaped by horizontal structures where independent actors together shape value in a non-linear way;

2. **firm-centric (or hierarchy-based) innovation**, where innovation is shaped in vertical structures where value is created in linear processes governed by behavioral control mechanisms.

In the first case, digitization and connectivity have been related to the emergence of platforms, infrastructures and ecosystems as new forms of organizing inter-firm relationships (Bharadwaj et al. 2013; Yoo et al. 2012; Yoo et al. 2010). This shift has been made possible by the connectedness infused into innovation outcomes and processes (Nambisan et al., 2017). On one hand, digital platforms and open standards enable different stakeholders to pursue innovation collaboratively (e.g., Gawer and Cusumano, 2014; Tiwana et al., 2010). On the other, collaboration among different stakeholders is enabled by the digital twinning of physical objects and the related digital-enabled capabilities, such as knowledge sharing, crowdsourcing, crowdfunding, virtuality, and dedicated social media.

In this vein, **digitization and connectivity fundamentally shape the scope, content, and direction of search and recombination mechanisms**. This highlights the growing importance of incorporating the microfoundations of digitization and connectivity into theories about innovation management that make network-centric innovation possible. Specifically, this shift creates the need for innovation management theories to address the following sub-research questions – derived from RQ1:

RQ1.1: How do platforms shape search and recombination mechanisms when its partners and their contributions are different, unknown or ill defined?

RQ1.2: How do digitization and connectivity enable, constrain or shape the nature of innovation as a collective action?

In the second case, digitization and connectivity have been linked to the search and scope mechanisms of organizational innovation. On one hand, digitization is likely to enable higher experimentation (increasing the scope and the level of recombinant innovation) and connectivity enables diffusion of knowledge and organizational learning (favoring the orchestration of the innovation process). On the other, the simultaneous introduction of a series of digital-connected technologies such as **efficiency technologies** (e.g., cloud computing), **automation technologies** (e.g., big data and artificial intelligence), and **virtual technologies** (e.g., augmented and virtual reality) challenges existing capabilities and skills into the organization (Dougherty and Dunne, 2012). This raises fundamental questions on the underlaying "process, capabilities and structures by which organizations adapt and innovate" (George and Lin, 2017, 17). In a related fashion, these phenomena challenge existing assumptions on the optimal organizational design and the optimal configuration of legacy and digital skills. Overall, these shifts create the need for innovation management theories to address the following sub-research question – derived from RQ2:

RQ2.1: How do digitization and connectivity enable new organizational forms and new ways of thinking about internal organizational boundaries when there is an increasing level of digital connectivity among products and services?

1.4 Empirical research setting

As previously described, the thesis is rooted in the observation that **firms need to combine different innovation regimes to tackle digital transformation** (Svahn and Henfridsson 2012; Yoo et al. 2012). On one hand, we have physical products that deliver tangible value (e.g., cars that delivers value in transportation). However, digitization and connectivity are inherently different from physical products (Yoo, 2010). As physical products (cars in our case) are increasingly enabled by digital technologies, the established innovation regime will be disrupted and a new innovation regime will emerge as physical products become increasingly digitized and connected (e.g., smart connected cars). Such a regime unfolds from a different set of microfoundations defining the elements and friction constituting the interplay between physical and digital.

Seeking a better understanding on how **firms need to combine different innovation regimes to tackle digital transformation** I have applied the theoretical framework to digital transformation of search and recombination mechanisms at the cultural heritage sector. Differently from the digital counterparts of most physical products – where digitization amplifies the capabilities and value of the physical components, while connectivity enables some of them to exist outside the physical product itself – for cultural artifacts digitization and connectivity were described as potentially revealing and generative of new scientific knowledge. In this vein, the cultural heritage sector can be considered a favorable empirical setting to analyze the scope of search and recombination mechanisms vis-à-vis digitization of the innovation function.

Also, the cultural heritage sector is about real things and tangible record of human achievement and – at first glance – its digital counterpart seems to be a very different and unrelated place. However, three basic human needs bring the digital and the physical cultural worlds together: **storage**, **communication** and **use**. On one hand, the storage conservation and use of cultural artifacts in cultural organizations, anticipate the storage, conservation, and use of data in the digital world. On the other, the digital world has created new power dynamics, new forms of governance and authority, and new communities with shifting expectations, motivations, and behavior (Hossini and Blankenberg, 2017) that enhances, accelerates, and shares the legacy capabilities of museums to store, analyze, and disseminate their knowledge and wisdom. In doing this, digitization and connectivity are bringing fundamental change in the way cultural organizations relate to their "firm-centric" knowledge resources and to their "network-based" communities.

The empirical section is based on two different, yet interlinked, embedded case studies. On one hand, the effects of digitization and connectivity on search and recombination mechanisms in **network-centric (or platform-based) innovation**. On the other, the effects of digitization and connectivity on search and recombination mechanisms in **firm-centric (or hierarchy-based) innovation**.

Specifically, the first empirical study is a **comparative case study** between the two leading digital platforms in the cultural industry: **Google Arts & Culture** and **Europeana**. It investigates how digitization and connectivity affect the scope of search and recombination mechanisms in a platform-based context. The results complete the perspective on RQ1 by discussing how digital platforms shape the scope of search and recombination mechanisms (RQ 1.1) and how they shape the nature of innovation as a collective action (RQ 1.2).

The second empirical study is longitudinal in its character and spans a period of approximately two decades. It investigates the link between the scope of search and recombination mechanisms vis-à-vis digitization of the innovation function through an **in-depth longitudinal case study** of one of the world-leading cultural organization: the Van Gogh Museum in Amsterdam. The results complete the perspective on RQ2 by discussing how digitization and connectivity sustain the scope of search and recombination mechanisms and how they change organizational structures (RQ 2.1).

Together, the two embedded cases leverage differences on how digitization and connectivity affect search and recombination mechanisms in network-centric and hierarchy-centric innovation contexts.

1.5 Research findings and research contribution

By comparing and contrasting the two aforementioned building blocks, the thesis develops an integrative framework – grounded in the systematic analysis of the literature on digitization and connectivity – that predicts the likely scope of search and recombination mechanisms vis-à-vis digitization of the innovation function. Sensitizing the theoretical framework through two empirical studies of digital transformation this thesis derives several implications for theory and practice. Across two different, yet interlinked, embedded case studies in the cultural heritage sector it demonstrates the theoretical framework by leveraging differences on how digitization and connectivity affect search and recombination mechanisms in **network-centric** and **hierarchy-centric** innovation contexts.

Overall, the thesis shows that the potential "inertial" effects of digitization and connectivity (i.e., activities set into motion) on the scope of search and recombination are far from being unidirectional and ambiguous because digitization and connectivity engender changes in the micro-mechanisms of **absorptive capacity** and **innovation governance** that are at the core of search and recombination's scope.

On the question on how firms can make the search and recombination mechanisms enabled by digitization and connectivity work for them and not against them, the thesis shows that this depends on which forces unleashed by digital technology dominate over the other ones. Managers might intentionally let some forces prevail to orient the output of the search and recombination processes in a way that fits their strategic innovation goals. However, this thesis shows that the digital transformation forces may affect a company's innovation governance and absorptive capacity – and, in turn, the scope for search and recombination – in three different ways:

1. Digitization and connectivity, on one hand, increase formal control and centralization in the governance of the innovation function process but that they might also enable informal and distributed governance of the innovation process;

2. Via digitization and connectivity, an organization's absorptive capacity might enable more formalized knowledge, better understanding of the linkages among pieces of knowledge and better communication flows;

3. Digitization and connectivity may change the distribution of skills in the innovation functions and – depending on the resulting balance between digital and legacy skills – the organization might embark in path-dependent innovation (legacy skills prevail), path-creating innovation (digital skills prevail) or more balanced innovation.

Taken together, these results suggest how, without further intervention, the changes initiated by the digital transformation may lead to a self-reinforcing loop that may have an impact on the kinds of innovation that the firm may produce. In general, therefore, the thesis suggests that the changes initiate by the digital transformation evolve in networks and ecosystems where digitization and connectivity make a tool to orchestrate a variety of heterogeneous pieces of knowledge for the reconfiguration and reuse of existing knowledge, thus acting as catalyzer for open-ended innovation.

The overall contribution of the thesis is fourfold. First, the dissertation complements the positive spin on digital technologies with a more holistic view to offer the first systematic analysis of the role of digitization and connectivity in the scope of search and recombination mechanisms. Second, the dissertation shows how digitization and connectivity "inertially" changes the micro-foundations for technology innovation management. Third, the dissertation provides an integrative framework that can move a step closer to gauge the likely output of different open innovation strategies in the digital age. These three contributions provide insights not only to the open innovation literature but also to the technology innovation management literature. Finally – despite the framework was primarily tested and investigated in the cultural heritage sector, laying bare the broader implications of digitization and connectivity for cultural organizations – by clearly spelling out antecedents and outcomes, the framework can be used as a guideline in other sectors.

The dissertation is concluded with a few notes on challenges for future research. In particular, it identifies some extensions of the proposed framework that might include the identification of the optimal balance between digital and legacy skills (it is not obvious that an imbalance toward digital is necessarily a good thing, despite popular press "hype" in that direction); the identification of incentives and structures to support digital transformation; and the practices and the capabilities that allow digital and physical product development processes to be coordinated effectively and efficiently.

1.6 Research structure

Following the theoretical sequencing of the two above mentioned building blocks – related to RQ1 and RQ2 respectively – and in light of the research's aim, objectives and sub-research questions, the thesis is organized as follows.

Chapter 2 and Chapter 3 aim to explore the two building blocks in a related fashion. In Chapter 2, the research problem is introduced at the outset and the Building Block 1 – related to the RQ1 – is discussed by means of the key mechanisms and contingencies that are more (or less) likely to enable effective search and recombination mechanisms. Chapter 2 summarizes the built-in assumptions in the innovation management literature to generate predictions on the likely scope of search and recombination mechanisms vis-à-vis digitalization with the view to provide the background for the subsequent integration with the literature on digitalization and connectivity (Building Block 2 in Chapter 3).

In Chapter 3, the Building Block 2 – related to RQ2 – is discussed my means of a systematic review of the literature on digitization, connectivity, and organizational transformation, from which the multi-level properties of digitization and connectivity are captured and some emerging regularities are distilled. Chapter 3 summarizes the findings for these two levels of analysis with the view to provide the background for the subsequent development of an integrative theoretical framework.

Chapter 4 defines the empirical context in which the previously discussed building blocks are investigated. By clearly spelling out the **antecedents** of digitization and connectivity on the search and recombination mechanisms, Chapter 4 introduces the context where the sub-research questions (i.e., RQ1.1, RQ1.2, RQ2.1) are empirically investigated: the cultural heritage sector.

In Chapter 5, the likely scope of search and recombination mechanisms for network-centric innovation is investigated through a **comparative case study** between the two leading digital platforms in the cultural heritage sector: Google Arts & Culture and Europeana. Chapter 5 builds on a published paper (Pesce, Neirotti and Paolucci, 2019) and completes the perspective on RQ1 by discussing how in platform-based context the innovation is shaped by horizontal structures where independent actors together shape value in a non-liner way, thus answering the sub research questions RQ1.1 and RQ1.2.

In Chapter 6, the likely scope of search and recombination mechanisms for firm-centric innovation is investigated through an **in-depth longitudinal case study** of one of the world-leading cultural organization: the Van Gogh Museum in Amsterdam. Chapter 6 builds on a working paper (Pesce, Lanzolla and Neirotti, 2019) and completes the perspective on RQ2 by discussing how in hierarchy-based context the innovation is shaped in vertical structures where value is created in linear processes governed by behavioral control mechanisms, thus answering the sub research question RQ2.1.

By comparing and contrasting the two building blocks, an integrative framework that predicts the likely scope of search and recombination mechanisms vis-à-vis digitization of the innovation function is developed in Chapter 7. The integrative framework presented in this chapter draws on a working paper (Lanzolla, Pesce and Tucci, 2019) developed during my PhD visiting period in the CASS Business School (London, UK) and co-authored with Gianvito Lanzolla (Professor of Strategy at the CASS Business School) and Christopher Tucci (Professor of Management of Technology at the Ecole Polytechnique Fédérale de Lausanne – EPFL). The developed framework is tested and discussed in the empirical context of the cultural heritage sector. The conclusions in Chapter 7 provide a critical summary of all the previous chapters and point out the theoretical and managerial implications as well as strengths and limitations of the dissertation. Finally, I discuss how this dissertation extends current view on innovation management literature and contributes to the emerging literature on digitization of organizations.

Chapter 2

Building Block 1: Search and Recombination mechanisms

2.1 Introduction

In the innovation management literature, digitization and connectivity have been associated with new possibilities and opportunities for innovation (Lyytinen, Yoo, and Boland 2016) in general and for **search and recombination mechanisms** in particular (Villarroel 2013; Tucci, Chesbrough, Piller and West 2016). For instance, Dougherty and Dunne (2012) analyze the generation of new scientific knowledge that would not be possible without digital technologies, such as bioinformatics, metabolomics, or genomics.

One common recurring theme in the recent innovation management literature is that digital technologies enable a **broader search** through the solution space via a broader **reach of more "agents" whose expertise the focal agent potentially lacks** (e.g., Poetz and Schreier 2012). In that vein, several scholars have highlighted that digital technologies may enable new innovation management practices including boundary-spanning approaches (e.g., Levina and Vaast 2005; Lindgren, Andersson, and Henfridsson 2008) consisting in **innovation from networks** (e.g., Powell 1990; Tuomi 2002; Van de Ven and Poole 2005; Boland, Lyytinen, and Yoo 2007; Von Hippel 2007) **or ecosystems** (Basole 2009; Selander, Henfridsson, and Svahn 2013). Also, a sizeable body of literature has focused on the role of digital technologies in Open Innovation and its more recent manifestation: crowdsourcing (Afuah and Tucci 2012; Poetz and Schreier 2012; Tucci et al. 2016; Acar (In Press); Pollok, Lüttgens, and Piller (In Press)). Open Innovation is a prevailing innovation mechanism in the innovation management literature, and one common recurring theme is that digital technologies enable a broader search through the solution space via a broader reach of more "agents" whose expertise the focal agent potentially lacks (e.g., Poetz and Schreier 2012).

However, digital technologies might also shape some new challenges and **constraints** for innovation management in the Digital Age.

What has often been missing from innovation management research is the systematic consideration of digital technology as a force that not only creates opportunities but also changes the organizational variables that might affect some of the built-in assumptions in the extant innovation management literature. In fact, the consequences of digital technology adoption goes way beyond the technical process of encoding information in digital format and involves, for instance, organizing new sociotechnical structures (e.g., Yoo, Henfridsson, and Lyytinen 2010; Yoo 2012), bringing in new organizational skills (e.g., Troilo, De Luca, and Guenzi 2017) and establishing new organizational structures (Viscusi, Tucci, and Afuah 2018). In this sense, the body of knowledge accumulated to date is utterly fragmented, and this significantly hinders the possibility to develop a systematic understanding of the impact of digitization and connectivity in innovation management research.

Therefore, this first building block is centered on the systematic consideration of digitization and connectivity as "**digital transformation forces**" that create new value creation opportunities but also change the organizational variables. A systematic analysis of mechanisms and implications for innovation and new product / service development has allowed to identify some key mechanisms and contingencies that are more (or less) likely to enable effective innovation. These can be grouped into two board categories related to:

1. **The type of search mechanisms** (Chapter 2, section 3)

2. **The type of knowledge recombination mechanisms** (Chapter 2, section 4)

Whether firms will be able to transform innovation practices and leverage the opportunities of digitization and connectivity relies on their capability to **search** the transformation forces of a digital innovation regime and **recombine** them with the architectural perspective of product / service innovation. In what follows, Chapter 2 summarizes the findings for these two broad categories of analysis with the view to provide the background where the ensuing Research Question 1 is investigated:

RQ1: How do digitization and connectivity shape ***search*** *and* ***recombination*** *mechanisms and technological complementarities?*

2.2 Type of search mechanisms

Firms attempt to solve problems in ambiguous and uncertain environments (cf. Huber 1991) in many cases by engaging in organizational learning through "search" process. In doing this, organization may undertake a wide variety of searches: for example, to develop **new innovations** (Von Hippel and Tyre 1995), to create **new methods** (Jaikumar and Bohn 1992), and to conceive of improved **organizational designs** (Bruderer and Singh 1996).

There is a well-established tradition of exploring search mechanisms using transaction cost economics (TCE; e.g., Williamson 2002). However, as pointed out by Afuah and Tucci (2012), the primary focus of TCE is on characteristics of isolated transactions – and these transactions might be irrelevant to solving the problem at hand (Ghoshal and Moran 1996). In addition, TCE often neglects firm-specific factors – such as absorptive capacity, knowledge, routines, cognitive frames, and prior commitments – in focusing on the attributes of transactions, and these firm-specific factors may often be considered critical for problem solving (Nelson and Winter 1982; Nelson 1991; Ghoshal and Moran 1996; Nelson and Winter 2002; Leiblein and Miller 2003).

A consensus has developed in the literature that evolutionary and behavioral theories of organization, especially related to organizational search (e.g., Simon 1955; March and Simon 1958; Cyert and March 1963; Nelson and Winter 1982; Dosi and Marengo 2007) shed light on the TCE's limitation highlighted above. Winter (1984) defined real search activities as ones involved in the "manipulation and recombination of the actual technological and organizational ideas and skills associated with a particular economic context." In his seminal paper, Winter (1984) showed that the search model gives firms two main possibilities. First, that the searching firm draws knowledge from other firms engaged in the same sort of activity – what other works call **local search**. Local search also implies that organizations address problem with their pre-existing knowledge bases, or knowledge that is highly related to it (cf. Helfat 1994; Stuart and Podolny 1996; Martin and Mitchell 1998). In contrast, one major source of new knowledge might come from the firm's external environment, beyond other firms that are engaged in the same sort of activity – what other works call **distant search** – or what Heiner (1986) would characterize as knowledge beyond the normal experiences of the focal firm. Thus, distant or exploratory search behaviors may be the result of conscious or purposive efforts to expand one's knowledge base away from current knowledge and routines (March 1991).

Evolutionary theories of organizations suggest that **search with high scope** (broader search) positively affects innovation and specifically product innovation through two main mechanisms. First, broader search may enhance the pool of knowledge through variation and novelty of knowledge employed by the external source. This variety and novelty are necessary for problem-solving (March 1991).

Evolutionary theorists label this the "**selection effect of variation**" (Levinthal and March 1981; Nelson and Winter 1982; Katila and Ahuja 2002). Second, broader search may increase the number of new products via a mechanism of **search / recombination** (Nelson and Winter 1982; Fleming and Sorenson 2004). The argument goes that given a certain baseline of knowledge elements, there is a limit to the number of novel ideas that can spring from them. Thus, broader search adds new knowledge elements to the baseline, which then can be recombined with the existing baseline to invent new products or to create new knowledge.

On the other hand, evolutionary theories of organizations also suggest **two negative consequences** of extremely high levels of scope: the integration costs for the distant knowledge may be higher, and the "reliability" of such distant knowledge (Katila and Ahuja 2002). First, regarding the integration costs, as search scope broadens, the percentage of knowledge that needs to be integrated into the knowledge base of the organization also increases, and that might lead to challenges in both technological and organizational integration (Katila and Ahuja 2002). On the technological side, there would possibly need to be a new "language" or a new "interface" for the absorption, diffusion, and adoption. On the organizational side, there may need to be new networks, relationships, or communication patterns developed within and across firm boundaries (Henderson and Clark 1990). The broader the search or higher the scope, the more difficult and complex the integration problems are (Grant 1996). Taken to an extreme, at some point, **the benefits of broader search and opportunities of new knowledge will be dwarfed by the costs of knowledge integration**. Second, regarding the "reliability" of the distant knowledge, it might be the case that attempting to incorporate distant knowledge into the firm may lead to the decreasing reliability of the firm's products (cf. Martin and Mitchell 1998), or may make it more difficult for the firm to respond to new stimuli that require accurate decision-making (Heiner 1986).

Katila and Ahuja (2002) argue that although scope, or breadth of search for new knowledge is useful, it is, however, incomplete. They demonstrate that variation can occur not only in **breadth (local vs. distant)**, but also in **search depth**, which represents the degree to which the use, combination, and recombination of knowledge is possible. This has implications for problem-solving and product development (cf. Dougherty and Hardy 1996). One of the interesting contributions of the Katila and Ahuja (2002) study was that depth (**exploitation**) is not the opposite of breadth (**exploration**), but instead that they might be considered **orthogonal dimensions**. Exploitation could thus also be useful in new knowledge creation and not just in cost-cutting or efficiency (cf. Levinthal and March 1981). Exploitation may also be useful in the knowledge or solution recombination process (existing solutions), whereas exploration might be key in developing completely new solutions.

Katila and Ahuja (2002) therefore propose that increasing search depth may have a positive impact on product innovation, and by implication open innovation. These positive influences may be due to different kinds of "experience effects." First, regarding reliability, re-use and recombination of knowledge may help with searching itself, help with routines development, and help reduce errors (cf. Levinthal and March 1981). Second, as the knowledge to be searched is familiar, the requirements that should be met by the product are better understood. Further, as discussed in more detail below, innovation and product development tasks subject to deep searches might be modularized and decomposed, breaking them into more manageable chunks that can be solved or optimized (cf. Eisenhardt and Tabrizi 1995). Finally, reuse might lead to recombination itself. With constant reuse and deep searching, the firm might develop a more nuanced understanding of the (sub)problems and may be able to identify synergies and new combinations (Katila and Ahuja 2002). Search depth may not always have a positive influence on innovation, however. There could be diminishing returns to the technology's performance with cumulative effort (Foster 1986; Dosi 1988). In addition, routines and constant reuse may lead to rigidities as old solutions (that worked well in the past) might be applied inappropriately to new situations (Argyris and Schon 1978).

2.3 Type of knowledge recombination mechanisms

Closely intertwined with the search literature are the works of literature on knowledge characteristics and (re)combination mechanisms that seek to shed light on the **formal** and **informal** mechanisms through which effective knowledge integration may happen. Within this conceptualization, Petruzzelli and Savino (2014) describe innovation as a process of problem solving, where firms search across different landscapes (Fleming, 2001) to combine existing knowledge components in new and useful ways to innovate (Henderson and Clark, 1990; Kogut and Zander, 1992).

For instance, the "tacitness" of knowledge and complexity of a problem (Winter 1987; Reed and DeFillippi 1990; Kogut and Zander 1992) may limit the problem's delineation and transmission and can, therefore, decrease the scope of innovation, or the potential gain from innovation processes. Tacit knowledge cannot be described fully and cannot be codified (Polanyi 1967; Winter 1987), and is thought to be transferred from person to person in a labor-intensive fashion. The tacit nature of certain kinds of knowledge might also make it difficult to evaluate, transfer, and (re)combine that kind of knowledge, especially when it is the result of distant or broad search processes (Kogut and Zander 1992; Nonaka 1994; Von Hippel 2005; Afuah and Tucci 2012). Along the same lines, knowledge **complexity** (interdependencies between knowledge elements) makes evaluation, transfer, and (re)combination of distant knowledge quite challenging. High complexity of distant knowledge requires even more work for knowledge transfer, and higher tacitness of distant knowledge requires higher media richness for knowledge transfer (Teece 1981), thus hindering the delineation and transmission process. Complex problems might need to be simplified to ease communication with external parties, but the simplification might lead to misunderstandings or incorrect / irrelevant solutions. This could be exacerbated by the focal firm's usage of their traditional cognitive frames and routines in transmitting or translating the problem (cf. Henderson and Clark 1990; Afuah and Tucci 2012).

The "modularity" or decomposability of knowledge may also play an important role in problem-solving (Schilling 2000; Baldwin and Clark 2006; Hoetker 2006; Pil and Cohen 2006; Ethiraj, Levinthal, and Roy 2008; Tiwana 2008). Modularizable problems can be decomposed into smaller chunks or components, whose solutions can be "reassembled" or recombined into a new solution for the original problem. Modularity – although it can be applied in an ad hoc fashion to divide problems – is much more effective when there are no or few **interdependencies between the modules** (Von Hippel 1990) and when the problem is not a "systemic" one (Chesbrough and Kusunoki 2001; Staudenmayer, Tripsas, and Tucci 2005; Pil and Cohen 2006). Furthermore, even if it is relatively simple to define a problem, the solution to the problem may require tacit knowledge and/or complexity of knowledge. Explicit and modularized knowledge thus might help with knowledge absorption and recombination.

Garud and Nayyar (1994) proposed the notion of "**transformative capacity**," which they claimed helps understand how firms can use, combine, and recombine existing and past knowledge (technologies "on the shelf"), as well as save current technologies and knowledge for later use. The concept was intended to be complementary to the notion of absorptive capacity, building on the resource-based view and developing an analogy with "pollination" with innovation recombination: "Knowledge is like pollen; it creates new knowledge by interacting with other knowledge vectors acting as stamen" (Garud and Nayyar 1994, 372). As with the creation of hybrid plant varieties, creating new businesses is a probabilistic and path-dependent process. Therefore, consistent with the pollination analogy, time lags in knowledge and market development might open up opportunities for recombination based on the following tasks: Choice of knowledge vectors; Maintenance of knowledge vectors; and Reactivation and synthesis of knowledge vectors.

At a more macro-organizational level, further accepted insights in this literature are that the higher levels of **organizational slack**, the more **diverse** the organization and the more widely distributed the **skills** are to solve a certain problem, the higher the likelihood that someone will have the correct knowledge to solve the problem, or at least that someone will be able to engage in local search to solve the problem. In fact, in searching local and distant environments, the firm can obtain a collection of "fragments of knowledge of possible usefulness in the improvement of its routines" (Winter 1984, 293). As argued by Winter (1984), because such fragments may be quite limited relative to the firm's full routines, adoption, use, and recombination of the knowledge fragments also require efforts by the firm in problem-solving of a complementary nature. This is fully consistent with absorptive capacity arguments. In the same light, from the point of view of technology and knowledge, and as mentioned above, **technological recombination requires language and interface commonality to be able to be diffused within an organization and even to enter an organization** (e.g., Vaccaro, Veloso, and Brusoni 2009; Savino, Messeni Petruzzelli, and Albino 2017; Trantopoulos et al. 2017; Forman and van Zeebroeck (In Press)). The information processing needs of the different groups may require lateral information processing mechanisms (Galbraith 1973). On the other hand, in situations where the problem-solving knowledge is more sparsely distributed or less available, there may be an adverse selection or "market for lemons" Akerlof (1978) dynamic in the organization's Open Innovation activities, rendering it less useful with sub-optimal solutions.

Seshadri, Shapira and Tucci (2019) address a topic that has been somewhat neglected in recent research on knowledge management, and deals with the relation between **organizational form** and knowledge creation. They find that firms with **deeper hierarchies** tend to better deal with the process of evaluating and refining novel ideas through the sequential scrutinizing evaluation of supervisors as the embodiment of the ideas goes up the hierarchy. Thus, even though a unit manager may not have deeper scientific knowledge than the scientists who work for him or her, s/he may be able to seek advice from scientists and managers in different units who have not been consulted by her unit's scientists. Relatedly, Tushman and Katz (1980) emphasize the important role of *gatekeepers* in NPD organizations. These gatekeepers interact in an ongoing fashion with external parties and help span technological and organizational boundaries by "**translating**" and **contextualizing** the knowledge across boundaries, thus providing social capital and knowledge to improve product development and innovation outcomes. This relationship has been demonstrated in different sectors, including life sciences (e.g., Powell, Koput, and Smith-Doerr 1996) and manufacturing (Faems et al. 2010).

Finally, by focusing on the outsourcing of R&D as a mechanism for acquiring knowledge from outside the firm, Bianchi et al. (2016) explore the relation between the employment of external R&D consultants, the usage of a dedicated in-house R&D unit, and the "conversion" between inbound open innovation and product innovation performance. They propose an inverted U-shaped relation: external R&D consultants help initially with converting outsourced R&D into NPD outcomes, but this is subject to diminishing returns. Likewise, the internal unit is more useful in converting NPD outcomes when outsourcing R&D is relatively high. The study emphasizes the positive nature of the relation between inbound open innovation and NPD. Firms basing their competitive advantage on innovation and NPD can gain access to external knowledge of a technological nature and use it to raise the number of commercialized new products. However, the authors also caution against outsourcing too much R&D, as after a certain point, it becomes less useful and possibly detrimental for NPD. This line of reasoning is also consistent with absorptive capacity arguments.

2.4 Summary of the section

In this first Building Block (BB1), the thesis looks at the built-in assumptions in the innovation management literature to generate predictions on the likely scope of search and recombination mechanisms vis-à-vis digitalization. In this vein, a synthesis of the key mechanisms and contingencies that are more (or less) likely to enable effective search and recombination mechanisms is conducted. The synthesis of the literature on search and recombination mechanisms has shown that innovation governance and absorptive capacity have a pivotal role in search and recombination mechanisms which are at the core of innovation scope.

Chapter 3

Building Block 2: Digitization and Connectivity

3.1 Introduction

In the wider management and organization literature, the exploration of the effects of digital technology adoption in organizations is a relatively new topic and has been associated to several "constructs", among which digitization, digitalization and connectivity are often the most prevailing. As such, the systemic analysis of the literature conducted in Chapter 3 focused on such constructs as the keywords when searching in the leading management journal.

The initial screening of the literature returned **649 journal articles** – 12% on connectivity literature and 88% on digitization literature (please refer to Table 1 for the full list of journals and keywords. After carefully reviewing the abstracts, the 166 articles – which were more closely related to the innovation function of digitization and connectivity – were selected.

A systematic analysis of these articles, more than often rooted in disconnected literature streams, has allowed to identify some key consequences of the digital technology adoption. These can be grouped into two level of analysis:

1. **Micro** changes in the attributes of physical artifacts (Chapter 3, section 2)

2. **Macro** organizational changes (Chapter 3, section 3)

In what follows, Chapter 3 summarizes the findings for these two levels of analysis with the view to provide the background where the ensuing Research Question 2 is investigated:

*RQ2: How do digitization and connectivity sustain **search** and **recombination** mechanisms and how do they change the foundations of organizational learning, absorptive capacity and combinative capabilities by which organizations adapt and innovate?*

Table 1 - Summary of literature review scope and methodology

Reviewed Journals	*Academy of Management Annals, Academy of Management Journal, Academy of Management Perspectives, Academy of Management Review, Administrative Science Quarterly, California Management Review, Harvard Business Review, Human Relations, Information Systems Research, Journal of Consumer Research, Journal of International Business Studies, Journal of Management Information Systems, Journal of Management Studies, Journal of Management, Journal of Marketing, Journal of Product Innovation Management, Journal of Strategic Entrepreneurship, Journal of Strategic Information Systems, Journal of The Academy of Marketing Science, Leadership Quarterly, Management Science, MIS Quarterly Management Information Systems, Organization Science, Organization Studies, Research Policy, Strategic Management Journal.*
Database	*SCOPUS*
Connectivity literature	
Keywords for connectivity literature	*“connectivity”*
Output of the search on connectivity literature: 74 journal articles	
Digitization literature	
Keywords for digitization literature	*“digit*” OR “digiti?ation" OR "digitali?ation" OR "dat?fication" OR "digital transformation" OR "digital artifact" OR "digital twin" OR "digital copy" OR "digital materiality”*
Output of the search on digitization literature: 572 journal articles	

3.2 Micro-changes in the attributes of physical artifacts

To integrate digitization and connectivity into the literature on search and recombination mechanisms, a preliminary textual analysis using NVivo – which highlighted the existence of different themes and topics in digitization and connectivity literatures was conducted. Table 2 and Table 3 (in Annex A at the end of this chapter) show the first full list of micro properties emerged from the literature review for digitization and connectivity respectively. Content analysis (e.g., Krippendorff, 2013) was then used to distill these micro properties in order to provide a parsimonious set of characteristics that shows the non-linear, multi-faceted, impact of digitization and connectivity. Together, these micro properties provide new foundations for organizations, which are summarized in Figure 3 and discussed in what follows.

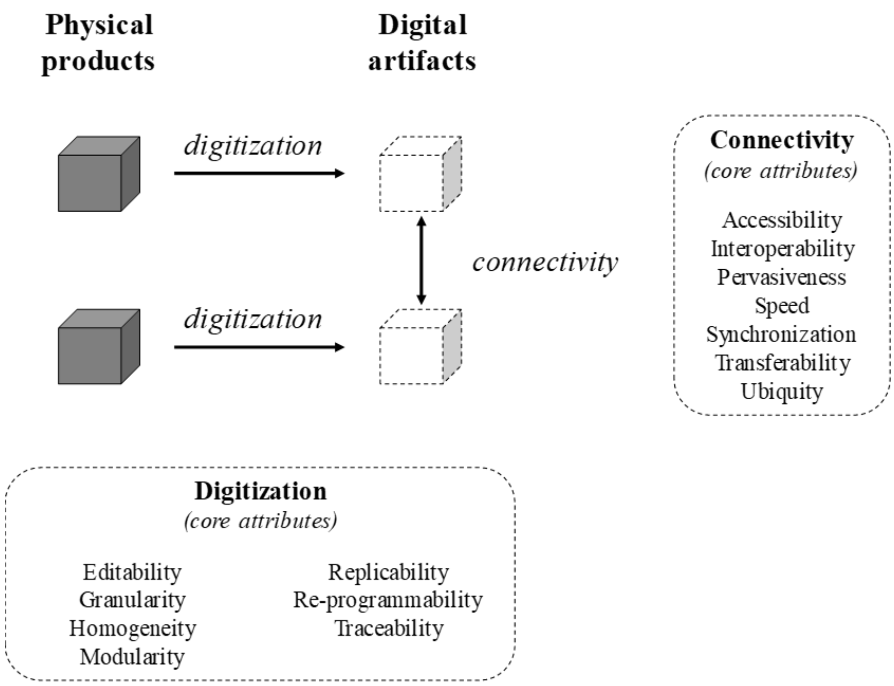


Figure 3 - Micro properties of digitized and connected artifacts

At the technical level, digitization incorporates the encoding of analog information into a digital format (Yoo, Henfridsson, and Lyytinen 2010) or the rendering of things into information, and in particular, as digitally represented information (Dhar and Sundararajan 2007). Yoo, Boland, Lyytinen, and Majchrzak (2012) show that at their core, digitized artefacts exhibit some specific attributes such as **re-programmable functionality** – enabled by its Von Neumann architecture – and **data homogenization** – enabled by discrete representation of data using strings of ones and zeros. Kallinikos, Aaltonen, and Marton (2013) argue that as digital artifacts become increasingly embedded in wider and malleable ecosystems, they become **editable**, **replicable** and **traceable**.

Other two aspects regard the **modularity** and **granularity** of digital artifacts (Bahrami and Evans 2011; Yoo et al. 2012; Kallinikos, Aaltonen, and Marton 2013; Barrett, Davidson, and Vargo 2015; Lusch and Nambisan 2015). While modularity concerns relationships between blocks of digital artifacts, granularity entails the stuff of which these blocks are made and reflects the depth of insights that the data hold (Kallinikos, Aaltonen, and Marton 2013).

The complementary side of digitization is connectivity. Nonaka and Konno (1998, 40) and Trantopoulos et al. (2017) argue that connectivity entails a shared space for emerging relationships (that) “can be physical, virtual, or mental” and enables the assimilation of external knowledge by disseminating new process ideas, best practices, and solutions widely and rapidly among personnel. Kolb (2008, 128) defines connectivity as “the mechanisms, processes, systems and relationships that link individuals and collectives (e.g. groups, organizations, cultures, societies) by facilitating material, informational and/or social exchange.” In Kolb’s view, connectivity includes such factors as technological (e.g., digital technologies and related infrastructure), geophysical (e.g., space, time, and location), as well as social interactions and artefacts, including “shared histories, travel, trade, migration, culture, politics, and other social activities” (Kolb 2008, 128). Overall, as a metaphor, connectivity is often equated to the concept of the enabler of intra- and inter- organizational interactions (Kolb 2008; Kolb, Caza, and Collins 2012).

Besides the metaphorical use, our review allows us to identify the core attributes of digital connectivity and these include: **interoperability** (Gosain, Malhotra, and El Sawy 2004; Bharadwaj et al. 2013; Porter and Heppelmann 2015), **pervasiveness** (Kolb 2008; Kolb, Caza, and Collins 2012), **speed** (Bharadwaj et al. 2013), **synchronization** (Chatterjee, Segars, and Watson 2006; Lazer and Friedman 2007; Porter and Heppelmann 2014), **accessibility** and **transferability** (Bankler 2006; Zittrain 2006; Lessig 2007; Matusik and Mickel 2011; Kallinikos, Aaltonen, and Marton 2013; Mazmanian, Orlikowski, and Yates 2013), and **ubiquity** (Agarwal et al. 2010; Wajcman and Rose 2011; Iansiti and Lakhani 2014; Symon and Pritchard 2015; Mardon and Belk 2018).

3.3 Macro organizational changes

Together, the micro properties identified in the previous section provide new foundations for organizations which, in what follows, are summarized in four macro organizational changes:

1. Knowledge decomposition / modularization
2. Information flows, knowledge "silos", and knowledge diversity
3. The balance between "digital" and "legacy" skills
4. Governance of information

3.3.1 The two faces of knowledge decomposition / modularization

On one hand, digitization enables modularization by allowing the decomposition/atomization of the elements by which digital artifacts are made, and by re-shuffling these elements to new configurations (Kallinikos, Aaltonen, and Marton 2010).

Nambisan et al. (2017) finds a relentless "deframing" and "reframing" of innovation outcomes and processes, influenced by a social process, which is highly similar to socio-cognitive innovation with fewer digital artifacts (Carlile 2004; Tsoukas 2009; Majchrzak, More, and Faraj 2012; Harvey 2014). Lessig (2002, 9) argues that digital technologies through modularization "could enable an extraordinary range of ordinary people to become part of a creative process" and von Hippel (2005, 13) emphasizes that "even individual hobbyists have access to sophisticated design tools […] With relatively little training and practice, they enable users to design new products and services." In some sense, this is modularization that might occur along lines that **minimize interdependencies** (e.g., digital "task partitioning", cf. Von Hippel 1990). This is called ***stable*** or ***predictable interdependencies*** further below.

On the other hand, modularization and pervasive connectivity might lead to **higher levels of complexity**. In this view, some researchers find that connectivity may create a new type of knowledge that is "more tacit and more difficult to convert into words" (Vaccaro, Veloso, and Brusoni 2009). This new form of digital knowledge provides essential complementary insights for complex innovation that cannot exist otherwise (Dougherty and Dunne 2012). Specifically, complexity generates a need for new knowledge, and so-called ***digitalization of science*** creates this new knowledge (Dougherty and Dunne 2012). By digitalization of science, Dougherty and Dunne, (2012) refer to the generation of scientific knowledge that would not be possible without digital technologies (in the specific case analyzed by Dougherty and Dunne, bioin<formatics, metabolomics, or genomics). Even though there is an increasing diffusion of knowledge technologies, knowledge can often remain "stubbornly localized around the comparatively small number of highly skilled knowledge workers engaged in high orientation networks…we still live and work in narrow social networks" (Howells 2012, 1014).

As digital technologies may increase knowledge exchange in the face of geographical distance, this will not necessarily be productive without careful examination of human resource management processes (Mabey and Zhao 2017). Mabey and Zhao (2017) show that the more pervasive the technologies for knowledge exchange, the more isolated knowledge specialists can become. Therefore, digitization may lead to ***dynamic*** or ***unpredictable interdependencies***, as discussed further below.

3.3.2 Information flows, knowledge "silos," and knowledge diversity

On one hand, digitization increases information flows, creating so-called "**boundaryless**" organization and **eliminating silos** (Cross et al. 2006). In doing so, digitization augments the efficiency of the knowledge generation process, increasing internal interfaces among the different organizational units (Garud and Nayyar 1994; Antonelli 2017). The improved quality of internal interactions favors the better use of internal information and capabilities that were dispersed, thus favoring a higher quality alignment of research activities with corporate strategies (Antonelli 2017). Therefore, internal governance costs, such as information processing costs, monitoring costs, and opportunity costs due to poor information, etc., might be reduced by digitization (Gong, Nault, and Rahman 2016, see further below for more information on governance). As long as internal governance costs are reduced, the efficiency of existing business processes are improved. In particular, in-house operations become more efficient, and firms prefer the internal provision of solutions (Gong, Nault, and Rahman 2016). This is called ***breaking silos*** further below.

On the other hand, Mabey and Zhao (2017), as mentioned above, find the paradoxical observation that mechanisms such as **digitization may inhibit knowledge exchange**. Newell et al. (2001, 97), studying a global bank, note that: "ironically, the outcome of intranet adoption was that, rather than integrate individuals across this particular organization, the intranet actually helped to reinforce the existing functional and national boundaries with 'electronic fences." As discussed further in Mabey and Zhao (2017), Howells (2012) – speaking in more general terms about the knowledge economy – proposes three explanations or enablers of these electronic fences. First, Howells observes that the knowledge economy may narrow the scope of peers with whom knowledge workers can interact, possibly further away geographically, as knowledge becomes more specialized. This may lead to "**relational isolation**" and is, therefore, a social explanation. Second, the different paths of knowledge evolution and the specialization of knowledge may make it difficult for experts in one certain area of knowledge to meaningfully interact with experts in different areas. This might be classified as a **technical explanation**. Third, cognitive limitations may make it difficult or undesirable to engage with people in many different knowledge domains. Below this theme is elaborated as ***new silos***.

Furthermore, Ferner et al. (2012) argue that digitization **reduces diversity** in knowledge exchange through codes of practice and standard operating procedures. Prabhu, Chandy, and Ellis (2005, 116) indicate, "With changes in market preferences and technological opportunities, knowledge that was once a source of competitive advantage may become irrelevant. Low diversity makes the firm especially vulnerable. ... Broader knowledge, however, gives the firm greater flexibility and adaptability in responding to environmental change ... the broader a firm's knowledge, the greater is its ability to create innovations." Lazer & Friedman, (2007) find that through digitization and connectivity, task processes and functions become **interconnected** and **inseparable** from one another (Luo et al. 2012) and this changes the structure of organizational diversity. According to information-processing theory, the higher the task connectivity, the stronger the demand for joint problem solving and information processing (Luo et al. 2012). In addition, the stickiness (i.e., tacit) nature of internal knowledge (Szulanski 1996) adds a unique feature to task interdependence. Digitization may decrease the diversity of programmable organizational functions through digitalized forms of standardized routines, leaving humans to handle the non-programmable tasks, especially those involving interpersonal communication and judgment (Bailey, Leonardi, and Barley 2012). Bailey, Leonardi, and Chong, (2010) further argue that the decision to tightly or loosely couple coordination and technology interdependence is influenced by a mix of work characteristics, organizational structures, social dynamics, and industry constraints. As an example, Bailey et al. (2010) discuss how ERP systems pose the greatest threat to the persistence of diversity in many knowledge occupations since they replace independent applications – unique to each function – with interrelated and standardized programs in functional modules. This phenomenon is labeled ***knowledge diversity*** below.

3.3.3 The balance between "digital" and "legacy" skills

Acemoglu and Autor (2011) show that the demand for skilled labor is closely correlated with advances in digital technologies, and therefore a question arises as to how the hiring of digital-skill employees affects the balance of those with digital skills against those with more traditional or "legacy" skills.

According to Troilo et al. (2017), one recent change in organizations following a digital transformation is hiring **data scientists**. They estimate that the demand for data scientists and advanced analysts will increase significantly over the next several years (cf. Markow et al. 2017). Many of these new jobs are in domains that did not exist a mere decade ago (Henke et al. 2016). For example, LinkedIn recently reported that the top emerging job of the past five years was Machine Learning Engineer, which saw a 9.8x growth rate. Coming in second, Data Science saw a 6.5x growth rate. Further, as digital 3D visualizations of complex designs became standard for large projects in the construction sector, one firm consolidated software engineers and "digital" construction engineers throughout and created a unit for internal consulting that provides capabilities in 3D visualization and simulation (Yoo et al. 2012). Troilo et al. (2017) demonstrate the **dual nature of data scientists**. On one hand, data scientists can be considered "socially skilled, analytical professionals" that combine analytics expertise with knowledge of the business; On the other, data scientists might be seen as "number crunchers," with "an old-fashioned siloed view of the organization." According to this second view, data scientists may act without sharing their competences. They may also be unwilling to help build a clearly understood common view of the business issues that analytics could resolve in an effective manner.

On the flipside, even though some companies have indeed begun to hire data scientists, Troilo et al. (2017) show that a large number of incumbent firms often find it difficult to reconfigure their innovation activities in the face of digitization and connectivity (e.g., D'Emidio, Dorton, and Duncan 2015). The rapid changes in digital technologies may indeed conflict with the legacy skills that characterize established organizations (Davenport 2014). Drawing on the literature on production and operation management, Bailey et al. (2010) discuss how with the introduction of digital technologies, many tasks in manufacturing systems today are performed – if not wholly replaced – by machines. Bresnahan et al. (2002) argue that this is essentially due to two distinct components of skill-biased technical change. On one hand, digital technologies like artificial intelligence, machine learning, and robotics have been substituting for routine tasks, displacing legacy skills. On the other, technologies like cloud computing, analytics, and rapid prototyping have augmented the contributions of more data-driven reasoning, increasing the value of digital skills compared to legacy ones.

Dougherty and Dunne (2012) argue that digitization has changed **how people work together**. Specifically, they show how the computational power of digital technologies coupled with scientific advances generates new patterns and new ways to explore existing knowledge. This reconfiguration of skills brought significant changes in the way firms manage and execute their contracts and internal diversity (Berente et al. 2007). Dougherty and Dunne (2012) explore how the use of digital technology in new drug discovery creates new types of "fault lines" between digital and legacy skills in three knowledge dimensions: **defining**

the product, **building the product**, and **projecting the future** (cf. Yoo et al. 2012). To address these "fault lines," there would need to be a transformation of both groups: those with digital skills and those with legacy skills. One of their innovation examples, drug discovery, could be considered a complex innovation process. Most digital technologies continue to evolve rapidly and are still immature. In the specific case of drug innovation, for example, genomics, although seemingly well developed for over 20 years, has led to few new cures so far because of the unimagined complexity, and some suggest it has been overhyped (Cohen 2011). Pisano (2006) suggests that many digital technologies were implemented simply as tools at first, not as new knowledge that needed to be integrated with other knowledge. These new tools were expected to replace, not complement, legacy skills, which would generate conflicts between digital and legacy skill groups. In the specific case of drug innovation, digitalization was proposed at several steps of the NPD process at the time to speed up development and commercialization because of the assumption that high-frequency screening of molecules and proteins would bring more drugs to market (Dougherty and Dunne 2012). However, this assumption appears (so far) to have been proven false based on the number of new drugs commercialized using high-frequency screening. Complexity must be addressed rather than avoided, meaning that the overall process of innovation may need to transform. The above tension is referred as ***balance between digital and legacy skills*** further below.

3.3.4 Governance of innovation: more distributed and more informal?

On one hand, digitization might move innovations toward the periphery of an organization (Jeppesen and Lakhani 2010; Yoo et al. 2012; Mauerhoefer, Strese, and Brettel 2017). Arquilla and Ronfeldt (2001) find that even the most hierarchical of organizations, the military, is arguably shifting to a more flexible, network-based system, with bottom-up, boundary-spanning, digital knowledge systems (Lazer and Friedman 2007). Antonelli (2017) proposes that digitization reduces the role of knowledge gatekeepers and increases the number of agents that can interact directly with each other agent in the system. The access to existing knowledge before the introduction of digital knowledge systems was characterized by **powerful hierarchies** that could provide gatekeepers with a pivotal role in centralizing the search for and processing of information. The representation of these systems in a network would be characterized by a **centered form** in which a central node interacts with a variety of unitary, disconnected agents who cannot form direct ties with the other agents. Thus, the introduction of digital-based procedures of knowledge search and screening has the possibility to significantly reduce the role of gatekeepers. This may reduce the costs of access to external knowledge and increase the possibility of information flows (Whelan 2007; Whelan et al. 2010). This effect is called the ***governance favoring distributed and informal forms*** of organizing.

On the other hand, digitalization and connectivity may make formal controls less expensive due to lowering of monitoring costs and communications costs (Brews and Tucci 2004; Lyytinen, Yoo, and Boland 2016). Falling communications costs can make hierarchy easier to maintain and reduce bureaucratic information losses, thus also making **deeper hierarchies** more viable (Malone, Yates, and Benjamin 1987; Brews and Tucci 2004). Digital technologies can make monitoring more effective and as such enable a much more formal control of the innovation processes (Lyytinen, Yoo, and Boland 2016). However, the outputs of this automated monitoring are not always fully transparent. Increasingly, even developers themselves admit that the outcomes of their "learning sets" are unpredictable (Bailey, Leonardi, and Chong 2010). As such, digital monitoring systems introduce a new degree of volatility in organizations. It follows that it might be challenging to build alignment between such (unpredictable) automated monitoring systems and the company's innovation goals. Finally, it is increasingly challenging to monitor and control innovation processes in inter-connected "organic" ecosystems. Despite these challenges, this effect is called the ***governance favoring more formal and centralized forms*** of organizing.

3.4 Summary of the section

In this second Building Block (BB2), the thesis looks at the digitization of organizations with specific focus on the innovation functions. In this vein, a systematic review of the literature on digitization and connectivity, and organizational transformation is performed, from which the multi-level properties of digitization and connectivity are captured and some emerging regularities are distilled. The analysis of the literature on digitization and organization has shown that the sheer adoption of digital technologies sets into motion some "inertial" organizational changes – i.e., organizational changes that come from the adoption of the technology itself and which manifest themselves unless other "forces" – managerial or non-managerial – change their inertia.

3.5 Annex A – Digitization and Connectivity: micro properties and implications

Table 2 Digitization micro properties and implications

Micro properties of digitization	Micro properties definition	Micro properties implications	Papers
1. Addressability – Associability	Digitization allows to individually respond to a message that was sent to many similar digital artifacts through standardized protocols such as IP address (Yoo, 2010). As they can be addressed, and therefore associated, with other objects to enable inferences about future states and conditions (Ng & Wakenshaw, 2017).	• Increase monitoring and control capability authenticating process participants, tracking activity and facilitating the virtualization of processes with high identification and control requirements.	(Agarwal et al., 2010; Angst & Agarwal, 2009; Dellarocas, 2003; Dhar & Sundararajan, 2007; Kallinikos et al., 2013; Kambil & Van Heck, 1998; Leonardi & Bailey, 2008; Ng & Wakenshaw, 2017; Overby, 2008; Yoo, 2010; Yoo, Henfridsson, et al., 2010)
2. Affordance	Digitization allow designer to expand existing physical materiality by "entangling" it with software-based digital capabilities (Yoo, 2010). Digital affordance refers to "an action potential, that is, to what an individual or organization with a particular purpose can do with a technology or information system" (Majchrzak & Markus, 2014). The affordances of pervasive digital technologies create innovations characterized by convergence and generativity (Yoo et al., 2012), thus, the focus is not on what features digital artifacts possess, but how actors' goals and capabilities can be related to the inherent potential offered by the features (Nambisan et al., 2017).	• Increase borderless and boundless allowing the combination of digital and physical components "to deliver diverse services, which dissolves product and industry boundaries" (Yoo, Henfridsson, et al., 2010).	(Barrett et al., 2015; Bogers, Chesbrough, & Moedas, 2018; Eaton, Elaluf-calderwood, Sørensen, & Eaton, 2015; Gaskin, Berente, Lyytinen, & Yoo, 2014; Kallinikos et al., 2010, 2013; Kalllinikos & Mariátegui, 2011; Majchrzak & Markus, 2014; Manovich, 2001b; Nambisan et al., 2017; W. J. Orlikowski & Scott, 2008; Yoo, 2010; Yoo et al., 2012; Yoo, Henfridsson, et al., 2010)
3. Computation	Digitization makes information amenable to a variety of forms of computation (Dhar & Sundararajan, 2007) enabling the creation of computer-based representations of physical phenomena (Bailey et al., 2012) providing the technical space upon which standards and interfaces as interconnecting modalities become possible (Kalllinikos & Mariátegui, 2011).	• Increase cheap and rapid experimentation allowing users to play with, share, and prototype complex ideas. • Decrease risks and mitigate uncertainty determining the value of novel ideas before significant investments and disruptions to existing technology and markets are made.	(Bailey et al., 2012; Dhar & Sundararajan, 2007; Dodgson, Gann, & Phillips, 2013; Dougherty & Dunne, 2012; Kallinikos et al., 2013)
4. Convergence	Digitization creates convergence by embedding technology into previously nondigital artifacts and creating so-called "smart"	• Increase products/services bundling creating new user experiences and bringing	(Barrett et al., 2015; Bogers et al., 2018; Kalllinikos & Mariátegui, 2011; Manovich, 2001; Tiwana,

	products and tools that can create new affordances (Yoo et al., 2012).	together previously separate ones. • Increase competition bringing together previously separate industries (e.g., Skype a software development firm, now competes directly with traditional telecommunication companies in international and long-distance markets. • Decrease the number of devices creating multiple new affordances, each of which previously required a separate product or tool (e.g., smartphone).	Konsynski, & Bush, 2010; Yoo, 2010; Yoo et al., 2012)
5. De-materialization	Digitization involves the creation of computer-based representations of physical phenomena enabling "liquification" (Normann, 2001) and facilitating separation between people and the represented phenomena (physical objects, physical processes, or other people) (Kallinikos et al., 2013).	• Increase efficiency and resource density facilitating easy access to appropriate resource bundles. • Increase analytics, "informated" work and workers equipped with digital capabilities for decision making. • Increase servitization though digital materiality (e.g. Rolls Royce has leveraged digital innovations around analytics and the IoT with the model of "power by the hour") a process in which companies re-categorize themselves from product companies to services groups. • Decrease costs of internal operation liquefying data and enabling the creation of effective decision-making systems.	(Agarwal et al., 2010; Anderson & Agarwal, 2011; Bailey et al., 2012; Bardhi & Eckhardt, 2017; Barrett et al., 2015; Belk, 2013; Chatterjee, Segars, & Watson, 2006; Chellappa, Sambamurthy, & Saraf, 2010; Dhaliwal & Benbasat, 1996; Dhar & Sundararajan, 2007; Faulkner & Runde, 2009, 2011; Galliers, Newell, Shanks, & Topi, 2017; Kallinikos et al., 2013; Lusch & Nambisan, 2015; Newell & Marabelli, 2015; Normann, 2001; W. J. Orlikowski & Scott, 2008; Tiefenbeck et al., 2018; Trantopoulos, von Krogh, Wallin, & Woerter, 2017; Xue, Zhang, Ling, & Zhao, 2013)
6. Editability	Digitization transforms conventional artifacts into playable and editable digital objects. Editability assumes many forms. It can be achieved by just rearranging the elements of which a digital object	• Increase openness and generativity, namely the capacity of a technology or a system to be malleable by diverse groups of actors in	(Alam & Campbell, 2017; Angst & Agarwal, 2009; Bailey et al., 2012; Barrett et al., 2015; Bogers et al., 2018; Dhar & Sundararajan, 2007; Eaton et al.,

	is composed, by deleting existing or adding new elements, or even by modifying some of the functions of individual elements. In other cases, editability is built into the object in the form of regular or continuous updating of content, items, or data fields, as is the case with digital repositories of various kinds whose utility is closely associated with constant updating (e.g., blogs or wiki pages, transaction or booking systems, currency exchange systems) (Kallinikos et al., 2013). Also, editability makes products and services intentionally incomplete throughout their lifetime and perpetually in the making (Garud et al., 2009; Zittrain, 2006) thus rendering the boundary of a product unknowable (Yoo, Henfridsson, et al., 2010).	unanticipated ways thus enabling new dynamic forms of digital innovation. • Decrease control in digital infrastructures (e.g., "jailbreaking" for iPhone).	2015; Ekbia, 2009; Garud et al., 2009; Ghazawneh & Henfridsson, 2013; Kallinikos et al., 2010, 2013; Kalllinikos & Mariátegui, 2011; Lusch & Nambisan, 2015; Manovich, 2001; Yoo et al., 2012; Yoo, Henfridsson, et al., 2010; Zittrain, 2006, 2008)
7. Expansibility	Digitization allows the infinite expansibility of a non-material object through which additional material bearers of that thing can be made available to potential users. Infinite expansibility denotes the limit case and refers to the property of a non-material object whereby the number of accessible material bearers can be made arbitrarily large arbitrarily quickly at no cost (Faulkner & Runde, 2011)	• Increase generativity and open innovation combining physical and digital, putting the users at the center, and creating new business models where new comers will enter and rapidly create entirely new markets.	(Barrett et al., 2015; Bogers et al., 2018; Faulkner & Runde, 2011; Trantopoulos et al., 2017; Zittrain, 2006, 2008)
8. Granularity	Digitization maps any analog signal – from the minute size and resilience of the elementary units or items by which are constituted – into a set of binary numbers (i.e., binary digits) allowing to any digital contents (audio, video, text and image) to be stored, transmitted, processed, and displayed using the same digital devices and networks (Yoo, Henfridsson, et al., 2010). Granularity refers to the minute size and resilience of the elementary units or items by which a digital object is constituted, an idea that is clearly conveyed by the difference between analog (non-granular) and digital systems. While modularity concerns relationships between blocks, granularity entails the stuff of which these blocks are made (Kallinikos et al., 2013). The granularity of digital objects derives from their ultimately numerical constitution and the ability this furnishes for tracing composite units deep down to the most minute elements and operations by which they are made (Manovich, 2001). Physical objects and, even more so, analog systems are	• Increase recombination from heterogeneous sources easily with other digital data to deliver diverse services, which dissolves product and industry boundaries. • Increase process technologies converting or replacing physical activities in a wide range of production processes where digitized value-adding activities are increasingly important compared to physical activities and aimed at lowering the cost of producing a good or service. • Increase collaboration among a large set of actors that eventually could lead to the	(Alam & Campbell, 2017; Andersen, 2006; Bahrami & Evans, 2011; Barrett et al., 2015; Kallinikos, 2009; Kallinikos et al., 2010, 2013; Kalllinikos & Mariátegui, 2011; Lusch & Nambisan, 2015; Marjanovic & Cecez-Kecmanovic, 2017; Nambisan et al., 2017; Trantopoulos et al., 2017; Yoo, 2012; Yoo, Henfridsson, et al., 2010)

	seldom granular. They are made of blocks or elements thus bundled as to be not readily decomposable and traceable down to elementary units (Kallinikos, 2009).	cocreation of value for the user. • Increase the generative matrix of the attributes of editability, interactivity, openness, and distributedness.	
9. Immersive	Digitization enables the creation of virtual worlds based on a shared, immersive environment where disparate contributors could operate with a sense of copresence or being there together (Dodgson et al., 2013).	• Increase self-extension in ways that provide new opportunities for effective learning and working and have significant implications for the collaboration mechanism. • Increase forms of playfulness absent in many large, bureaucratic organizations and that many organizations find difficult to manage enabling new ways of experimenting and exploring with the social interactions that underlie organizational learning. • Decrease the fidelity of face-to-face social interactions.	(Belk, 2013; Dodgson et al., 2013)
10. Interoperability	Digitization allows for the much deeper interpenetration of the items and operations by which they are constituted. Interoperability is an important condition of the digital ecosystem (Yoo, Henfridsson, et al., 2010).	• Increase and tend to construct a virtual object universe in which information sources and systems intersect are brought to bear upon another. • Increase platformization as the central focus of innovation processes and outcomes which act as foundations upon which other firms can develop complementary products, technologies or services. • Decrease control in digital infrastructures.	(Dhar & Sundararajan, 2007; Ekbia, 2009; Gawer, 2009; Kallinikos et al., 2013; Karimi & Walter, 2015; Yoo, 2010; Yoo et al., 2012; Yoo, Henfridsson, et al., 2010)

11. Interpretation	Digitization allows to interpret the types of information that were note readily available in physical products (Yoo, 2010). Through sensors, digitization allows to create alternative pathways along which human agents can activate functions embedded in the object, or explore the arrangement of underlying information items (Kallinikos et al., 2013).	• Increase interactive user experience enabling actions of contingent nature (depending upon user choice), a condition that sets digital objects apart from the non-contingent, and arrested responses of physical artifacts and the inert nature of paper and other non-digital records or artifacts. • Increase performativity, namely the creation of performative digital artifacts constructing social relationships and enactment involved in generating and experiencing service rather than simply representing something out there.	(Barrett et al., 2015; Ekbia, 2009; Kallinikos et al., 2013; Marjanovic & Cecez-Kecmanovic, 2017; W. J. W. J. Orlikowski & Scott, 2016; Yoo, 2010)
12. Layered	Digitization paves the way for layered and this is best exemplified by the Internet. The layers manifest two critical separations: that between device and service because of re-programmability and that between network and contents because of the homogenization of data (Yoo, Henfridsson, et al., 2010). Furthermore, these two separations led to the emergence of layered modular architecture that consists of four independents loosely coupled layers of physical devices, networks, services, and contents. A digital product with a layered modular architecture is a result of temporary binding of individual components in different layers (Yoo, 2012). Such dynamic and flexible architecture is also enabled by modularity, granularity, and standardized interfaces of digital artifacts (Kallinikos et al., 2013). As firms increasingly embed digital components into physical products, the layered modular architecture emerges (Yoo, Henfridsson, et al., 2010).	• Increase optimization since each layer is associated with a different design hierarchy, and thus the multiple components across the different layers are not bounded by a single product (i.e., product agnostic). • Increase the opportunity for innovative resource recombination expanding the potential for process innovation. As the tools used to support routines become digitalized and begin to follow layered modular architecture, processes can evolve through recombination of activities and components of tools of different layer. • Increase potential for product innovation and facilitate a combinatorial potential for service innovation enabling the mixing of inputs/outputs across the traditional and	(Alam & Campbell, 2017; Barrett et al., 2015; Kallinikos et al., 2013; Lusch & Nambisan, 2015; Marjanovic & Cecez-Kecmanovic, 2017; Trantopoulos et al., 2017; Yoo et al., 2012; Yoo, Henfridsson, et al., 2010)

		usually fixed industry borders associated with standard physical products and vertical integration.	
13. Memorability	Digitization allows to record and store information that digital artifacts generated, sensed or communicated (Yoo, 2010)	• Increase control by exploiting the ability to store information and historical logs of digital objects state and interactions. • Decrease privacy, security, and confidentiality of personal data, especially when combinations of personal data held by different firms could not merely identify them but reveal sensitive information as well. • Decrease attitudes about sharing information from a paper record versus a digitized version of the record. On the one hand this implies the potential significance of a range of IT capabilities - from information security and privacy protocols. On the other, highlights the need for re-examining the timing of consent since emotion plays a significant role in digital information disclosure decision.	(Andersen, 2006; Anderson & Agarwal, 2011; Angst & Agarwal, 2009; Dhar & Sundararajan, 2007; Miranda, Young, Yetgin, Kirchner, & Nabeth, 2016; Newell & Marabelli, 2015; Ng & Wakenshaw, 2017; Yoo, 2010)
14. Modularity	Digitization expands the notion of modularity adopted from the physical world (Yoo et al., 2012) and allows the decomposition of the elements by which digital artifacts are made and the re-shuffling and the reorganization of these elements to new configurations (Kallinikos et al., 2010). With combinatorial innovations of pervasive digital technologies, modules are most often designed without fully knowing the "whole" design of how each module will be integrated with another (Tiwana et al., 2010).	• Increase optimization since all the components are derived from a single functional design hierarchy and, as such, have a fixed product boundary (i.e., product specific). • Increase coordination of service exchange and creates more opportunities for value cocreation.	(Andersen, 2006; Bahrami & Evans, 2011; Baldwin, 2008; Baldwin & Woodard, 2009; Dhar & Sundararajan, 2007; Kallinikos et al., 2013; Nambisan et al., 2017; Ng & Wakenshaw, 2017; Tiwana et al., 2010; Xue et al., 2013; Yoo, Henfridsson, et al., 2010)

		• Increase control of the individual and contributes to innovation. Interfaces with suppliers are highly modularized and can thus be controlled over large distances thus affecting all activities involved in the design, production, and distribution. • Decrease the risk of adopting digital supply chain systems and therefore motivates firms to digitize more of their supply chain operations. • Decrease diversity in the digital ecosystem. • Decrease coordination costs and transaction costs across the module boundary and among constituents of a platform's ecosystem.	
15. Programmability - Re-programmability	Digitization sets new logic for digitized artifacts to modify their behaviors and functions by embedded software (Yoo, 2010). Also, it allows a procrastinated binding of form and function (Zittrain, 2006) meaning that new capabilities can be added after a product or a tool has been designed and produced (Yoo et al., 2012). Furthermore, even if a digital component is developed for a specific product, due to the re-programmability and the data homogenization, it can be easily repurposed for different products and services.	• Increase flexibility enabling separation of the semiotic functional logic of the device from the physical embodiment that executes it. • Increase openness since digital objects are open and reprogrammable in the sense of being accessible and modifiable by a program other than the one governing their own behavior. • Increase the separations between physical device (i.e., form embodied in particularly materials) and service (i.e., function), and that between contents and network. • Decrease slack of programmable organizational functions, leaving humans	(Bahrami & Evans, 2011; Barrett et al., 2015; Dhar & Sundararajan, 2007; Garud et al., 2009; Kallinikos et al., 2010, 2013; Kalllinikos & Mariátegui, 2011; Lusch & Nambisan, 2015; Manovich, 2001; Ng & Wakenshaw, 2017; Tiwana et al., 2010; Xue et al., 2013; Yoo, 2010; Yoo, Henfridsson, et al., 2010; Zittrain, 2006, 2008)

		to handle the nonprogrammable tasks, especially those involving interpersonal communication and judgment.	
16. Replicability	Digitization allows replicability since digital code can be reproduced and distributed at negligible cost, almost instantaneously. Due to digital code's non-rivalry in use and infinite replicability, digital consumption objects are often associated with abundance rather than rarity (Mardon & Belk, 2018).	• Increase long tail phenomena lowering the costs of production and distribution and increasing the variety of products available for consumption in many industries. • Decrease the "physical" experience of legacy firms changing competitive behavior and ushering in Schumpeterian creative destruction in many knowledge-based industries.	(Dhar & Sundararajan, 2007; Elberse, 2008; Faulkner & Runde, 2009; Mardon & Belk, 2018; Zhang, 2016)
17. Senseability	Digitization enables digital artifacts to sense and respond to changes in their environment, making the context aware. Using embedded sensors, digitalized information pertaining to the physical artifacts can be retrieved and used to mediate user experiences in interacting with the physical artifacts themselves (Yoo, Henfridsson, et al., 2010).	• Increase monitoring and control enabling new forms of relationship between actors and artifacts.	(Ng & Wakenshaw, 2017; Yoo, 2010; Yoo et al., 2012; Yoo, Henfridsson, et al., 2010)
18. Simulation	Digitization involves the creation of computer-based representations of physical phenomena and physical processes (Bailey et al., 2012) that offer exploration and experimentation in graphically rich, high-fidelity, interactive media (Dodgson et al., 2013).	• Increase experimentation and prototyping. • Increase changes in the work structure as well as in tasks and roles. • Increase (excessively) trust in models. • Increase a new type of tacit knowledge that is "more tacit and more difficult to convert into words" (Vaccaro, Veloso, & Brusoni, 2009). • Decrease workers' dependence on each other and on physical objects prompting a shift from symbolic to iconic simulation	(Bailey et al., 2012; Dodgson et al., 2013; Dougherty & Dunne, 2012; Manovich, 2001; Vaccaro et al., 2009)

		models and leading management to confound operating "within" representations with operating "with" or "on" representations.	
19. Standardization	Digitization allows for any type of data (audio, video, text and image) to be stored and transmitted using the same digital medium. Combined with the emergence of data and interface standards, the digital data allow different types of digital contents to be freely mixed and combined. Yoo and colleagues (2010) call it the homogenization of data where the creation of standardized interfaces so that other developers can combine them with their new products or services (Yoo, 2012).	• Increase process optimization monitoring and information sorting capabilities to reduce transaction costs and take advantages of production economies available in markets. • Decrease slack through digitalized forms of standardized routines. • Decrease search costs and avoid redundancy. • Decrease differentiation in terms of rigidity of pre-specifying customer requirements and individual customization. • Decrease the ability to adapt and respond to changes at the consumer usage end when contexts of use, even for the same person, could change. • Decrease adaptation to frequent changes and variation. • Decrease asset specificity of modules.	(Andersen, 2006; Barrett et al., 2015; Bogers et al., 2018; Chatterjee et al., 2006; Chellappa et al., 2010; Dhar & Sundararajan, 2007; Kallinikos et al., 2013; Kambil & Van Heck, 1998; Mauerhoefer, Strese, & Brettel, 2017; Ng & Wakenshaw, 2017; Schilling, 2000; Tiwana et al., 2010; Vaccaro et al., 2009; Yoo, 2012; Yoo, Henfridsson, et al., 2010)
20. Traceability	Digitization allows to chronologically interrelate events and entities over time (Yoo, 2010) leaving an unprecedent volume of digital traces as by-products that can lead to new innovations that were not anticipated by the original innovators or consumers (Yoo et al., 2012)	• Increase collaboration through the creation of a "digital loyalty network" that would allow to leverage supply and distribution chain partners and to serve customers better.	(Chatterjee et al., 2006; Kallinikos et al., 2013; Ng & Wakenshaw, 2017; Yoo, 2010; Yoo et al., 2012)

21. Transferability	Digitization enables transferability, namely how easily changes in the technology can be conveyed to others (Zittrain, 2008). With fully transferable technology, the fruits of skilled users' adaptations can be easily conveyed to less-skilled others. Digitization and connectivity together possess very strong transferability: a program written in one place can be shared with, and replicated by, tens of millions of other machines in a matter of moments (Zittrain, 2008)	• Increase distributedness creating digital objects that are seldom contained within a single source or institution. • Increase optimization since changes in one part of the system can be conveyed to other parts of the system or distributed to anther system instantiation	(Kallinikos et al., 2010, 2013; Kalllinikos & Mariátegui, 2011; Yoo et al., 2012; Yoo, Henfridsson, et al., 2010; Zittrain, 2008)
22. Transfigurability	Digitization makes possible various combinations out of a larger ecology of items, procedures, and programs, a condition that renders digital objects fluid and crucially transfigurable (Kallinikos et al., 2013).	• Increase borderless since, compared to physical objects, digital objects lack inherent borders that bound them as obvious entities. • Decrease the accountability of the workplace, namely the responsibility of employees to complete the tasks they are assigned, to perform the duties required by their job, and to be present for their proper shifts in order to fulfill or further the goals of the organization.	(Kallinikos et al., 2010, 2013)
23. Virtuality	Digitization facilitates separation between people and represented phenomena (physical objects, physical processes, or other people) and virtuality occurs when digital representations stand for, and in some cases completely substitute for, the physical objects, processes, or people they represent. In this sense, virtuality specifies what the interaction between the physical and virtual will be (Bailey et al., 2012).	• Increase organizational learning. • Increase virtual re-embodiment and self-extension moving activities that were once carried out by physical mechanisms to some form of electronic or other nonphysical means. • Increase changes in the work structure as well as in tasks and roles since virtuality typically working with a representation of the physical rather than with the physical itself.	(Bailey et al., 2012; Belk, 2013; Dodgson et al., 2013; Faraj & Sproull, 2000; Handy, 1995; Mardon & Belk, 2018; Overby, 2008; Overby, Slaughter, & Konsynski, 2010; Sieber & Griese, 1998)

		• Increase task interdependence across roles • Decrease task interdependence across teams since virtual teams often struggle with the mechanics of getting work done, especially when tasks are interdependent. • Decrease coordination since it is difficult for virtual teams gaining access to the individuals and information on which they depend. • Decrease access to individuals in other roles (e.g., workers placed on teams with members distributed geographically). • Decrease trust among team members since, as Handy (1995, p. 46) contended, “trust needs touch”.	

Table 3 - Connectivity micro properties and implications

Micro properties of connectivity	Micro properties definition	Micro properties implications	Papers
1. Amplification	Connectivity amplifies the capabilities and value of the smart components and enables some of them to exist outside the physical product itself (Porter & Heppelmann, 2014).	• Increase borderless and boundless spanning the organizational boundaries and operating across multiple levels of analysis in linking the macro with the micro.	(Angwin & Vaara, 2005; Bharadwaj et al., 2013; Porter & Heppelmann, 2014; Zhu & Kraemer, 2005)
2. Collaboration	Connectivity facilitates interpersonal communication (Jansen, Van Den Bosch, & Volberda, 2005), broadening collaboration via electronic platforms (Bloodgood & Salisbury, 2001; Scott, 1998) and enabling efficient sharing of different views, experiences, and insights (Trantopoulos et al., 2017).	• Increase knowledge absorption enabling the assimilation of external knowledge by disseminating new process ideas, best practices and solutions widely and rapidly. • Increase knowledge creation across activities and locations within and between organizational units. • Increase platformization facilitating interpersonal communication, broadening collaboration via electronic platforms and enabling efficient sharing of different views, experiences and insights. • Increase internal dynamism through a wider array of partnerships and access to a more diverse knowledge base. • Increase process innovation emerging as the dominant moderating technology, which could be interpreted as process innovation relying more extensively on new knowledge creation then on information processing per se.	(Alcácer et al., 2016; Björk & Magnusson, 2009; Bloodgood & Salisbury, 2001; Breschi & Catalini, 2010; Buckley & Prashantham, 2016; Cano-Kollmann et al., 2016; Caridi-Zahavi, Carmeli, & Arazy, 2016; Cattani, Ferriani, Negro, & Perretti, 2008; Cross, Laseter, Parker, & Velasquez, 2006; Gold, Malhotra, & Segars, 2001; Hansen, Nohria, & Tierney, 1999; Jansen et al., 2005; Kolb, 2008; Scott, 1998; Trantopoulos et al., 2017)

3. Communality	Connectivity enhances communality by favoring ease of accessing a common pool of information to perform generalized and productive exchanges (Phang, Kankanhalli, & Tan, 2015).	• Increase participation referring to the ease of reaching others who share similar interests or concerns. Connectivity influences participation intention for contributors and indirectly impacts participation intention via perceived communality. • Increase knowledge sharing creating a shared space for emerging relationships (that) "can be physical, virtual, or mental" (Nonaka & Konno, 1998, p. 40) and enabling the assimilation of external knowledge by disseminating new process ideas, best practices, and solutions widely and rapidly among personnel.	(Buckley & Prashantham, 2016; Cannella & McFadyen, 2013; Caridi-Zahavi et al., 2016; Cross et al., 2006; Fang, 2008; Fulk, Flanagin, Kalman, Monge, & Ryan, 1996; Gong et al., 2016; Gosain, Malhotra, & El Sawy, 2004; Kuk, 2006; Luo et al., 2012; Matusik & Mickel, 2011; Mazmanian, 2013; Mazmanian, Orlikowski, & Yates, 2013; Nonaka & Konno, 1998; Phang et al., 2015; Trantopoulos et al., 2017; Wajcman & Rose, 2011; Wonseok & Sangyong, 2007)
4. Continuity	Sociomateriality and digital technologies amplify practices and capacities of communication, reinforcing professional norms on the one hand and shifting them on the other hand, to engender a new dynamic of continuous - and compulsive – connectivity (Mazmanian et al., 2013).	• Increase exploration favoring information diffusion and the spread of effective strategies and reflecting the idea that the more connected we are, the better. • Increase (employee) identity, namely an intra-action of human and material agencies based on a sociomaterial assemblage that performs particular identities: being contactable and responsive; being involved and committed; and being in-demand and authoritative, indicating how connectivity is implicated in identity performances. • Increase collaboration allowing to "be in touch without really being in touch". • Decrease work performance. Although individual use of mobile email devices	(Barad, 2003; Buckley & Prashantham, 2016; Cannella & McFadyen, 2013; Kolb, Caza, & Collins, 2012; Kuk, 2006; Lazer & Friedman, 2007; Mazmanian, 2013; Mazmanian et al., 2013; Symon & Pritchard, 2015; Wajcman & Rose, 2011)

		offered professionals flexibility, peace of mind, and control over interactions in the short term, it also intensified collective expectations of their availability, escalating their engagement and thus reducing their ability to disconnect from work. • Decrease exploitation in terms of information diversity which is also related to performance. When agents are dealing with a complex problem, the more efficient the network at disseminating information, the better the short-run but the lower the long-run performance of the system. • Decrease personal autonomy and professional commitment.	
5. Coordination	Connectivity enables coordination and integration across individual activities with outside suppliers, channels and customers and across geography (Porter & Heppelmann, 2014).	• Increase orchestration participation and dialogue helping companies to orchestrate activities across several networks, to coordinate over geographical and technological space and to re-design the boundaries of those network. • Increase knowledge integration in an organization and process integration between the offshore service provider and its global client and between front-end functionalities and back-end activities.	(Alcácer et al., 2016; Angwin & Vaara, 2005; Bharadwaj et al., 2013; Buckley & Prashantham, 2016; Cano-Kollmann et al., 2016; Caridi-Zahavi et al., 2016; Carr et al., 2018; Fang, 2008; Gong et al., 2016; Gosain et al., 2004; Luo et al., 2012; Porter & Heppelmann, 2014; Zhu & Kraemer, 2005)
6. Density	Connectivity density refers to the level of access to unique resources, to redundant (nonunique) resources, the ease of interaction among the partners, and the extent to which the network constrains them (Cannella & McFadyen, 2013).	• Increase information flow and knowledge reuse creating boundaryless organization and eliminating silos.	(Cannella & McFadyen, 2013; Cattani et al., 2008; Cross et al., 2006; Lazer & Friedman, 2007)

7. Interconnection	Connectivity relies on rich information exchanges which includes not only an interconnection of things, but also an exploding digital network of people and data (Bharadwaj et al., 2013).	• Increase flexibility in responding, effectively, to multiple types of uncertainties including user requirements changes, technology changes, and system usage changes. • Increase partner relationships facilitating collaborative demand planning and fulfilment by offering a flexible range of electronic connectivity options.	(Alcácer et al., 2016; Bharadwaj et al., 2013; Cattani et al., 2008; Chatterjee et al., 2006; Gosain et al., 2004; Kolb, 2008; Kumar, 2004; Matusik & Mickel, 2011; Mazmanian et al., 2013; Wajcman & Rose, 2011)
8. Interdependence	(Task) connectivity is defined as the extent to which task's processes and functions are inseparable from one another, such that if one process or function fails, other processes or functions will fail (Luo et al., 2012).	• Increase modularity since to manage interdependencies, enterprises need to encapsulate their interconnected processes in modular chunks, and support these with IT platforms for information exchange in structured formats. • Decrease slacks requiring an appropriate alignment with task characteristics (task complexity and security) and task interdependence (task connectivity, stickiness, and dependence).	(Fang, 2008; Gosain et al., 2004; Luo et al., 2012; Mazmanian et al., 2013)
9. Interoperability	Connectivity allows to connect users within and outside the organization, support a large number of complex applications such as e-purchasing, customer relationship management (CRM), and electronic data interchange (EDI) (Kumar, 2004).	• Increase (design) optimization since products become components of broader systems. Through co design, companies can simultaneously develop and enhance hardware and software across a family of products, including those of other companies.	(Bharadwaj et al., 2013; Kumar, 2004; Porter & Heppelmann, 2015)
10. Multi-directional interactions	Connectivity is defined as the mechanisms, processes, systems and relationships that link individuals and collectives (e.g. groups, organizations, cultures, societies) by facilitating material,	• Increase generativity at the collective level, which is the capacity to produce unprompted change driven by large,	(Alcácer et al., 2016; Bharadwaj et al., 2013; Björk & Magnusson, 2009; Cannella & McFadyen, 2013; Cano-Kollmann et al., 2016;

	informational and/or social exchange. It includes geo-physical (e.g. space, time and location), technological (e.g. information technologies and their applications) as well as social interactions and artefacts (Kolb, 2008). Also, connectivity harnesses the bidirectional communication capabilities of the Internet to engineer large-scale, interactions (Dellarocas, 2003) as the extent to which everyone in the network knows, communicates and interacts with one another directly, instead of through a common third (Fang, 2008).	varied, and uncoordinated audiences. • Increase co-creation since connectivity between knowledge clusters may yield new relationship forms that enable knowledge co-creation, rather than mere transfer. • Increase openness as a manifestation of social context in which norms and identity are established and a context of openness and generativity is shaped to facilitate the process whereby knowledge that has been exchanged is applied and combined, a course of activities that are conducive for driving innovation. • Increase product/service innovation favoring new product development in terms of product/service quality, development speed and product/service innovation.	Caridi-Zahavi et al., 2016; Carr et al., 2018; Cattani et al., 2008; Dellarocas, 2003; Fang, 2008; Iansiti & Lakhani, 2014; Kolb, 2008; Kuk, 2006; Lusch & Nambisan, 2015; Matusik & Mickel, 2011; Mazmanian, 2013; Mazmanian et al., 2013; Phang et al., 2015; Trantopoulos et al., 2017; Wajcman & Rose, 2011; Zittrain, 2006, 2008)
11. Pervasiveness	Connectivity is unknowable pervasiveness which means that the extensiveness of networks now exceeds our ability to know who is connected to whom (Kolb, 2008).	• Increase accessibility in terms of the ease and intensity with which people, goods, capital, and knowledge flow across space that reduces the distance between physical and digital domains. • Decrease privacy and security both for companies and users requiring stepped-up network security, device and sensor security, and information encryption (e.g., new digital capabilities).	(Bharadwaj et al., 2013; Carr et al., 2018; Iansiti & Lakhani, 2014; Kolb, 2008; Luo et al., 2012; Matusik & Mickel, 2011; Mazmanian, 2013; Mazmanian et al., 2013; Phang et al., 2015; Porter & Heppelmann, 2015, 2014; Symon & Pritchard, 2015; Wajcman & Rose, 2011; Zhu & Kraemer, 2005)
12. Responsiveness	Connectivity allows the instantaneous transmission of real-time data across a wide range network of generating, transforming, and connected products and sensors (Porter & Heppelmann, 2014) thus	• Increase scope, scale, speed and source of value changing how value is created for customers and expanding the scope, the	(Bharadwaj et al., 2013; Cross et al., 2006; Iansiti & Lakhani, 2014; Luo et al., 2012; Matusik & Mickel, 2011; Mazmanian et al.,

	expanding rapidity and responsiveness (Mazmanian, 2013).	scale, the speed and the sources of value creation and capture when infrastructure becomes increasingly connected. • Increase monitoring capabilities enabling the comprehensive monitoring of a product's condition, operation, and external environment through sensors and external data sources. • Increase optimization allowing companies to optimize product performance in numerous ways, through the rich flow of monitoring data from smart, connected products, coupled with the capacity to control product operation.	2013; Porter & Heppelmann, 2014, 2015; Wonseok & Sangyong, 2007; Zhu & Kraemer, 2005)
13. Standardization	Connectivity facilitates the standardization of processes and interfaces by providing data in a form that can be easily processed by applications, by providing data quickly, and by identifying the data structure (Gosain et al., 2004).	• Decrease external operation costs (transaction costs) removing incompatibility of legacy information systems within and between firms and enhancing these systems' performance by allowing information sharing and coordination among trading partners.	(Gosain et al., 2004; Kumar, 2004; Luo et al., 2012; Porter & Heppelmann, 2014; Zhu & Kraemer, 2005)
14. Synchronization	Connectivity enables synchronous communications between different sources of data stored in different electronic memories (Wajcman & Rose, 2011) at different "clock speeds" (Porter & Heppelmann, 2014).	• Increase automation linking machines together in systems fully automating process and optimizing production. • Increase control enabling remote control of products functions and allows personalization of the user experience.	(Angwin & Vaara, 2005; Kolb, 2008; Mazmanian et al., 2013; Porter & Heppelmann, 2014, 2015; Wajcman & Rose, 2011)
15. Transferability	Connectivity enhance external knowledge absorption by supporting the storage and transfer of external knowledge (Trantopoulos et al.,	• Increase efficiency through the access and	(Bharadwaj et al., 2013; Breschi & Catalini, 2010; Cano-Kollmann et al., 2016; Caridi-

	2017) and the creation of new knowledge by transferring and combining internal and external knowledge more quickly (Fang, 2008).	utilization of knowledge assets and information that have been developed in different parts of the organization, such that time is not spent on developing knowledge that has already been accumulated. • Increase recombination enabling the paradigm of information/knowledge recombination instead of displacement and replacement. • Decrease internal operation costs (governance) such as information processing costs, monitoring costs, and opportunity costs due to poor, isolated and disconnected information.	Zahavi et al., 2016; Carr et al., 2018; Cross et al., 2006; Fang, 2008; Gong et al., 2016; Gosain et al., 2004; Iansiti & Lakhani, 2014; Kolb et al., 2012; Kuk, 2006; Kumar, 2004; Lazer & Friedman, 2007; Luo et al., 2012; Matusik & Mickel, 2011; Porter & Heppelmann, 2014, 2015; Trantopoulos et al., 2017; Wang, 2010; Zhu & Kraemer, 2005)
16. Ubiquity	Connectivity is made to appear anytime and everywhere with a ubiquitous, presenting simultaneous, multiple and ever-present nature (Wajcman & Rose, 2011) where everything and everyone is connected to each other on a global network level (Iansiti & Lakhani, 2014).	• Increase globality since connectivity is the lifeblood of the system between places, firms and individuals across geographical space that allows these complex networks to thrive, succeed and expand. • Increase user experience offering a much richer and personalized user experience. • Increase sharing economy enabling product-as-a-service business models that allow users to pay only for what they actually need. • Decrease privacy and security especially for users.	(Alcácer et al., 2016; Buckley & Prashantham, 2016; Cano-Kollmann et al., 2016; Carr et al., 2018; Gong et al., 2016; Iansiti & Lakhani, 2014; Kolb, 2008; Luo et al., 2012; Matusik & Mickel, 2011; Mazmanian, 2013; Porter & Heppelmann, 2014, 2015; Wajcman & Rose, 2011; Zhu & Kraemer, 2005)

Chapter 4

The empirical application case: The cultural heritage sector

4.1 Introduction

This chapter defines the empirical context in which the previously discussed building blocks are investigated. By clearly spelling out the **antecedents** of digitization and connectivity on the likely scope of search and recombination mechanisms in Chapter 2 and Chapter 3, this chapter introduces the context where the sub-research questions (i.e., RQ1.1, RQ1.2, RQ2.1) are empirically investigated: the cultural heritage sector.

As previously described, the thesis is rooted in the observation that **firms need to combine different innovation regimes to tackle digital transformation** (Svahn and Henfridsson 2012; Yoo et al. 2012). On one hand, we have physical products that deliver tangible value (e.g., cars that delivers value in transportation). However, digitization and connectivity are inherently different from physical products (Yoo, 2010). As physical products (cars in our case) are increasingly enabled by digital technologies, the established innovation regime will be disrupted and a new innovation regime will emerge as physical products become increasingly digitized and connected (e.g., smart connected cars). Such a regime unfolds from a different set of microfoundations defining the elements and friction constituting the interplay between physical and digital.

However, differently from the digital counterparts of the most physical products – where digitization amplifies the capabilities and value of the physical components, while connectivity enables some of them to exist outside the physical product itself – for cultural artifacts digitization and connectivity were described as potentially revealing and generative of new scientific knowledge.

For example, when Marc Chagall painted the dome of the Paris Opéra in 1964, he also portrayed an image of his infant son, David. As Chagall pained an area of 220 square meters with many tiny details, and since the ceiling is 60 meters from the floor, his son David was only able to recognize himself in the painting when the dome was digitized in ultra-high resolution by Google.

On that occasion, David took one hour to identify himself on the screen. The presence of a small yellow dot above his image helped the identification, since Marc Chagall was known to use this type of sign on his paintings to mark people who were real (Figure 4).

Figure 4 - The ceiling of the Opéra de Paris Garnier painted by Marc Chagall in 1964 and details of his son David. Source: Google Arts & Culture

The possibility of zooming into artworks can be particularly beneficial for large paintings that are not accessible for close inspection, like in the case of the Opera dome, or for those art streams, like the Flemish painters, where artists portrayed a plentitude of scenes, rich in small details, in a single painting.

For example, "The Harvesters" – Pieter Bruegel the Elder's world-famous 16th century painting, exhibited in the Metropolitan Museum in New York – depicts a wheat field where part of the wheat has been cut and stacked and where, in the foreground, a group of peasants, pausing in their work, are picnicking in the shade of a pear tree. Unlike what happens in the gallery, the zoom-in function allows users to discover a family enjoying a game of throwing sticks at a tied-up goose. By unveiling this hidden detail, curators have discovered that this game was a typical pastime of Shrove Tuesday (Figure 5).

Figure 5 The Harvesters (Pieter Bruegel the Elder, 1565): how a section of the painting appears at MoMA and as seen through Google's "Arts and Culture" zoom-in feature. Source: Google Arts & Culture

Digitization, through the zoom-in function, supports users – both visitors and researchers – to study brushwork in more detail, and thus to recognize an artist's "signature strokes". In this vein, the Museum of Modern Art (MoMA) selected van Gogh's "Starry Night" to be put on GAP, and scholars can see the individual colors in each stroke and details such as the bare patches of canvas, which are only visible through high magnification (Figure 6). Thus, while seeing images in a textbook lets users understand the overall structure of a painting, gigapixel technology allows them to see how the artwork was made. Before high-resolution digital imaging, only researchers were able to analyze these traits through such means as microscopes available in laboratories that required a physical inspection of the artworks. Today, the Internet has been made accessible these features to the general public. This contributes to "democratize" access to specialized knowledge about art and to break down the distinction between visitors and scholars.

Figure 6 The Starry Night (Vincent van Gogh, 1889) and how its details can be enlarged on Google's "Arts and Culture" platform. Source: Google Arts & Culture

Also, digital technologies offer the opportunity to unveil hidden content that stems from research activities. For example, the Museo Egizio in Turin (Italy) has recently introduced an interactive touchscreen to allow users to look deep inside an Egyptian sarcophagus (Figure 7). The visualized data had been generated, through computed topography (CT), laser scanning and photogrammetry, on eight Egyptian sarcophagi. The result is that visitors can now see inside the coffins and retrieve information about the surface, textures and colors of the mummy. This "virtual autopsy" table allows visitors to "digitally unwrap" an Egyptian mummy. With each layer of the scan, visitors can use their hands to rotate and zoom in and out of the 3D models. In this way, knowledge generated using advanced technologies for research purposes has been made accessible to the museum's visitors giving them new lenses and breaking their set of beliefs.

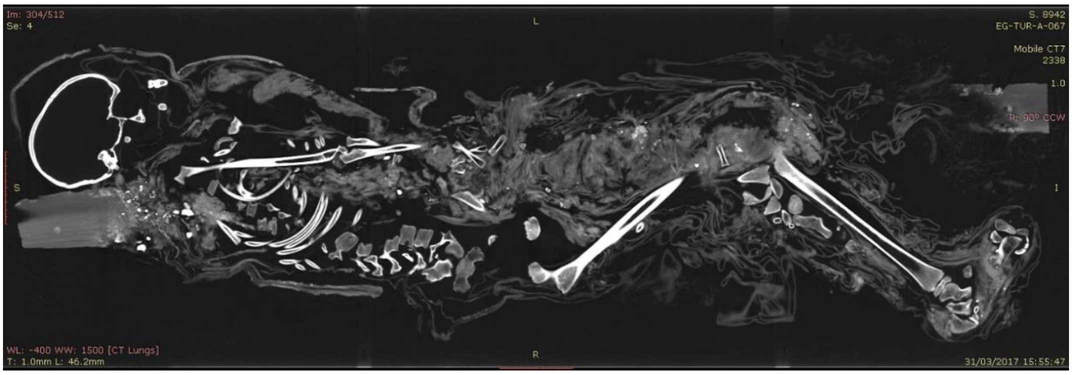


Figure 7 - An example of computed tomography of an ancient Egyptian mummy. Source: Museo Egizio (Turin, Italy)

In this vein, the cultural heritage sector can be considered a favorable empirical setting to analyze the scope of search and recombination mechanisms vis-à-vis digitization of the innovation function. Also, the cultural heritage is about real things and tangible record of human achievement and – at first glance – its digital counterpart seems to be a very different and unrelated place. However, three basic human needs bring the digital and the physical cultural worlds together: **storage**, **communication** and **use**. On one hand, the storage conservation and use of cultural artifacts in cultural organizations, anticipate the storage, conservation, and use of data in the digital world. On the other, the digital world has created new power dynamics, new forms of governance and authority, and new communities with shifting expectations, motivations, and behavior (Hossini and Blankenberg, 2017) that enhances, accelerates, and shares the legacy capabilities of museums to store, analyze, and disseminate their knowledge and wisdom.

In doing this, digitization and connectivity are bringing fundamental change in the way cultural organizations relate to their "firm-centric" knowledge resources and to their "network-based" communities.

The empirical section is based on two different, yet interlinked, embedded case studies. On one hand, the effects of digitization and connectivity on search and recombination mechanisms in **network-centric (or platform-based) innovation**. On the other, the effects of digitization and connectivity on search and recombination mechanisms in **firm-centric (or hierarchy-based) innovation**.

Specifically, the first empirical study is a **comparative case study** between the two leading digital platforms in the cultural industry: **Google Arts & Culture** and **Europeana**. It investigates how digitization and connectivity affect the scope of search and recombination mechanisms in a platform-based context. The results complete the perspective on RQ1 by discussing how digital platforms shape the scope of search and recombination mechanisms (RQ 1.1) and how they shape the nature of innovation as a collective action (RQ 1.2).

The second empirical study is longitudinal in its character and spans a period of approximately two decades. It investigates the link between the scope of search and recombination mechanisms vis-à-vis digitization of the innovation function through an **in-depth longitudinal case study** of one of the world-leading cultural organization: the Van Gogh Museum in Amsterdam. The results complete the perspective on RQ2 by discussing how digitization and connectivity sustain the scope of search and recombination mechanisms and how they change organizational structures (RQ 2.1).

Together, the two embedded cases leverage differences on how digitization and connectivity affect search and recombination mechanisms in network-centric and hierarchy-centric innovation contexts.

4.2 The cultural heritage sector

The cultural heritage is undergoing a process of digitization and "datification" that opens to endless possibilities of disentangling "property" and "proximity" from the physical materiality of cultural artifacts, thus offering new ways of creating social and economic value that go far beyond the traditional boundaries of the cultural sector (Avery, 2014). Museums produce knowledge on the historical and artistic heritage and have a significant educational function, but at the same time, they operate as economic actors that contribute to the tourist attraction of the territory as well as supply chain activators for other creative sectors (e.g., advertising and marketing, crafts, graphic and fashion design, film, TV, photography and visual arts, games, software and computer services, and publishing). Both functions generate relevant positive localized externalities, i.e. benefits that are freely exploited by private individuals and by the community as a whole.

At the same time, museums are undertaking their own digital transformation, rethinking what customers value most, and creating operating business models that take advantage of what is newly possible for competitive differentiation. On one hand, the challenge for museums is how fast and how far to go on the path of digital transformation and how to create culture and value in new forms. On the other, the challenge for the society is to find the instruments for channeling human and financial capital so that this transformation process will be powered with no relevant resource constraints.

In addressing this new "digital" paradigm, the lack of a holistic framework has taken center stage as one of the pivotal policy issues facing the cultural heritage sector where the strategies for expanding the range of cultural revenues have not been formalized, and the mechanisms of cross-elasticities and cross-interdependencies by which these strategies are related, have not been estimated. Specifically, digital technologies are changing the way cultural resources are created, disseminated, preserved and (re)used. They empower multiple types of stakeholders in the cultural heritage ecosystem to engage with culture, by enabling the use, (re)use and (re)purposing of cultural content "customized" to the specific stakeholders' needs and interests. On one hand, this increases the level of organizational complexity in managing the new forms of task and technological interdependencies generated by the digitization process. On the other, this higher level of organizational complexity needs to be managed effectively and efficiently without alienating cultural stakeholders and without jeopardizing the "aura" of the physical artifacts with their digital counterparts.

Because all these forms of "digital disruption", the cultural industry has been the subject of increasing attention in innovation management literature as a "laboratory" in which the transformations in the mechanisms of value creation that digital technologies can ignite in several other industries can be studied. Also, part of this attention is due to the competition that cultural sector is seeing between well-established organizations and digital players that enter this sector and take advantage of specialization patterns that are new to the industry. In the ongoing debate on the digital transformation of industries, museums have so far been the subject of limited attention. However, museums offer some unique points of interest in the debate on how digital technologies, and specifically digitization and connectivity, are reshaping the cultural industry structure.

The way through which cultural content can be digitized and connected into certain digital tools (e.g., smartphones, tablets, platforms, websites, kiosks, and interactive devices) has not yet become established, as it has in the case of other creative goods, such as news, music and advertising. Furthermore, compared to other creative sectors, the digital dissemination of art can take advantage of multiple enabling digital technologies, such as augmented reality (AR), virtual reality (VR), and artificial intelligence (AI), which are the subject of increasing explorative applications in the industry. Museums therefore face increasing technological complexity and uncertainty concerning how to exploit digitization and connectivity in order to create value for the cultural ecosystem.

From the innovation management perspective, this represents a promising avenue, but is still not completely clear to practitioners and scholars. In this vein, the more ambiguous the process through which art content can be disseminated through digital tools, the more external actors with specialization in digital technologies can enter the cultural heritage sector, finding new valuable ways to disseminate art. This implies that the new specialization patterns introduced by digitization and connectivity in the cultural sector may put traditional museums in a situation where they lose part of their market in the content distribution stage. In other words, once artworks have been digitized – and the related information has been synthetized, connected and distributed in new digital ways over the Internet, museums may lose their role in the cultural industry of "least replaceable players" (Jacobides, 2005). A similar case is currently happening in the newspaper industry were well-established firms are suffering from the advent of Google and Facebook. Compared to the legacy firms, the new digital entrants are taking advantage of digital technologies to recombine the core components of the service (i.e., news, advertising, classified ads) in new ways based on value creation mechanisms, such as customization and co-creation that are new to the industry.

What makes museums central in analyzing the likely scope of search and recombination mechanisms vis-à-vis digitization of the innovation function is that they are the best locus to provide a memorable experience to a visitor and are difficult to be substituted with a digital counterpart of the physical gallery. However, digitization and connectivity can lead museums to face types of service innovation that are hard to manage, and which require new capabilities and new forms of collaboration with actors specialized in such technologies. Also, using digital technologies in disseminating content may entail innovation in the service architectures (i.e., the way through which the functional components of a physical or a virtual visit should be arranged). These challenges are analogues to the innovation in the architecture of services and business models which legacy firms have managed to deal with their transition to e-commerce, e-books, movie streaming, music, online education, and online newspapers.

In a similar way to what has happened in the above-mentioned industries, new entrants in the distribution of cultural content can be more specialized than incumbents in enacting value creation mechanisms, such as co-creation (Lusch and Nambisam, 2015) and mass customization (Evans and Wurster, 1999). In the cultural sector, web platforms like Google, Instagram and TripAdvisor, can play a role in supporting museums and in reducing the cultural distance between producers and consumers. Duguid's (2005) discussion on wine trading in the 18^{th} to 20^{th} centuries provides a good illustration of this point. He observed that it was Port wine shippers (prosperous merchants, such as Sandeman) and not small growers who gained the trust of the public and who built up their role as the most important firms in the value chain. Similar dynamics can currently be observed in the cultural industry where digital platforms – such as Google and Europeana – and social media are gradually becoming specialized in delivering and "repackaging" cultural content to satisfy the idiosyncratic interests of a global array of multiple stakeholders. Compared to museums, these platforms might become more specialized in applying digital imaging or experiential computing in order to find new ways of managing their relationships with the public.

Also, the digital twinning of cultural objects can create a discontinuity related to the opportunity of creating innovations in meanings that users attribute to the product/service. What makes innovations in meanings complex to be managed is that they imply a new value proposition that change the sociocultural regimes of both users and producers (Verganti, 2008). Over the last two decades, all the innovations in meanings that museums have undertaken were based on the curators' capabilities of providing "emotional, physical, intellectual, and spiritual sensations" in the entertainment, aesthetic contemplation, and engagement of physical artworks. Although digital technologies could help museums to improve the visitors' experience, what makes the response of incumbents ineffective in leveraging digital solutions is their legacy set of rules and beliefs on how the economic value has been historically created in the cultural sector. This recalls the concept of technology affordance (Hutchby, 2001) – i.e., what a technology affords to do to an actor – and purely depends on the systems of values, managerial beliefs, rules (e.g., intellectual property rights), and professional norms of legacy organizations. This implies that the same technology, such as augmented reality or image digitization, can be used with different objectives according to who is in control of the creation of the new digital artefact (e.g., a company specialized in digital imaging, a digital platform, or a museum with a novel mindset).

4.3 The research setting and its "institutional" characterization

The cultural heritage sector can be considered a favorable empirical setting to analyze the scope of search and recombination mechanisms vis-à-vis digitization of the innovation function for a variety of reasons.

First, since the 1970s, thus before the rise of the Internet and other digital technologies, this industry has been undergoing a process of profound institutional change. In 1971, in his article "The Museum, a Temple or the Forum", Cameron, the director of the Brooklyn Museum, proposed that museums should evolve from "temples", devoted to the storage and the preservation of artworks, to a "forum" devoted to: **i) experimentation and innovation in the way artworks are exhibited and their meanings disseminated, and ii) a more open approach to**

the public. The vision of museums as temples was rooted in the fact that the way collections were structured for exhibitions reflected logics that were only meaningful to an elite group of curators and reflected the value system of the upper-middle-class. Over the years, the idea of the transition of museums from temples to forums has inspired a vision of the museum as a place of greater responsiveness to the audience, and of greater attention to the engagement of visitors and its educational function. In this vein, many authors and practitioners in the industry have agreed that museums have made a paradigm shift from 'collection-driven institutions' to 'visitor-centred museums' (Anderson, 2004). The manifestation of the "new museology" paradigm has become evident since the early 20th century, especially in North America and some European countries, such as France and the Netherlands, where many museums have tried to redesign their galleries as experiential realms aimed at infusing engagement, entertainment, emotions and aesthetic gratification in their visitors (Pine and Gilmore, 1998; Pallud and Straub, 2014).

Second, the industry has become more capital intensive. The availability of the new enabling technologies that are required for the research, preservation and dissemination of artworks has increased the level of capital expenditure that is needed. In many countries, especially in Europe, museums have had to cope with increasing capital intensity while relying on decreasing resources from public funding, due to the growth in the national public debt. In such a context, public museums have matured greater interest and more experience in partnerships with private firms and this has led to the introduction of financial resources to invest, managerial expertise, and/or specialization in the functional activities that have become more important.

Third, at the global level, the industry has traditionally offered a broad variety of situations related to ownership structure, governance mechanisms and managerial attitudes in which each museum is positioned. This variety of situations is reflected in the way museums differ in resource endowment, in their fundraising capabilities, in their emphasis on the new mission of being "forums", in their intellectual property protection, and in their capability of starting innovation activities vis-à-vis digitization of the innovation function.

4.4 The research setting and its "technological" characterization

Since the 2010s, digital technologies have offered several mechanisms to create economic value in the cultural heritage sector. Some of these technologies offer opportunities for **incremental innovations**, as the degree of novelty in their technological affordances is limited. Some examples of these opportunities are: e-commerce features to sell tickets or merchandising (e.g., mugs, posters, t-shirts) online, Near Field Communication (NFC) and proximity sensors (iBeacon), which are used to develop new interaction patterns between museums and their visitors (in their physical gallery). All these features do not revolutionize the service architecture of a visit to a museum, even though they can add new and valuable experiences or can remove inefficiencies, such as long queue lines. In this vein, online ticketing allows visitors to follow a fast lane to enter those museums whose indoor logistics is complicated and where preservation may not allow a high number of visitors to enter the same place at the same time.

In a different way, social media platforms offer different affordances to museums, depending on their mindsets. In fact, a well-rooted use of the social media, even among museums with no aptitude for experimentation, is to use it to promote permanent and temporary exhibitions. However, social media offers museums the possibility of improving the visitors' engagement too. For example, through gamification approaches based on Instagram' stories aimed at fostering the sharing of pictures and feelings associated with artworks. Such possibilities depend on the museum's capability to embrace the paradigm change – from "temple" to "forum" – more than to acquire new digital skills.

The affordances of digital image archiving technologies follow a similar principle, since it has been an established practice since the 2000s. Therefore, even the most conservative museums adopt some digital archiving practices for their collections. However, digital archiving can be also used to sustain the sharing and re-use of cultural content and to make research between cultural institutions more open and collaborative.

In a nutshell, the skills required to bring digital-based practices, such as e-commerce, NFC, iBeacon, social media interaction, and digital archiving, inside museums can easily be acquired in arm's length transactions with local service providers (e.g., experts on social media, e-commerce specialists, photographers). These skills do not require any significant changes related to work practices, competencies, capabilities or to the roles available in the legacy museums' workforces.

A second cluster of digital technologies includes artificial intelligence, augmented and virtual reality, high-resolution digital imaging, and the 3D scanning and printing of physical objects. These technologies introduce new islands of specialization to the cultural industry and oblige museums to: i) start collaboration with digital players – such as Google – that are new to the industry; ii) purse ongoing collaboration with research organizations, such as universities or preservation centers; iii) hire digital specialists, such as data scientists or machine learning engineers.

Therefore, this bundle of new enabling technologies can offer new digital affordances, thus paving the way toward a discontinuous change in the available opportunities through which museums can build engagement and provide memorable experiences. The discontinuities for museums are related to the fact that these digital technologies put museums at risk of developing new relational dependencies on specialized firms – such as Google – and require a profound change in their competence base and in the systems of values, beliefs, professional norms of museums' directors, their middle managers, and their specialists (e.g., curators).

4.5 Summary of the section

The cultural heritage is undergoing a process of digitization and "datification" that opens to endless possibilities of disentangling "property" and "proximity" from the physical materiality of cultural artifacts, thus offering new ways of creating social and economic value that go far beyond the legacy and traditional boundaries of the cultural heritage. Specifically, differently from the digital counterparts of the most physical products – where digitization amplifies the capabilities and value of the physical components, while connectivity enables some of them to exist outside the physical product itself – for cultural artifacts digitization and connectivity were described as potentially revealing and generative of new scientific knowledge. In this vein, the cultural heritage sector can be considered a favorable empirical setting to analyze the scope of search and recombination mechanisms vis-à-vis digitization of the innovation function.

Chapter 5

When cultural heritage meets digital platforms

This chapter builds on a published paper (Pesce, Neirotti and Paolucci, 2019) and completes the perspective on RQ1 by discussing how in platform-based context the innovation is shaped by horizontal structures where independent actors together shape value in a non-liner way, thus answering the sub research questions RQ1.1 and RQ1.2.

5.1 Introduction

In the last decade, the Internet and digital imaging technologies have offered new ways to disseminate cultural content that have important implications for the way cultural heritage contributes to the creation of social and economic value (Glaeser, Kolko, & Saiz 2001). The implications of these new dynamics go beyond the traditional cultural heritage boundaries and extend their impact across adjacent cultural sectors such as tourism (Del Vecchio, Mele, Ndou, & Secundo 2018). Specifically, digitization and connectivity have created new opportunities for people to enjoy exclusive cultural content that used to only be accessed by a physical visit to an exhibition. Where once there were a limited number of trustable knowledge providers – with museums being the most accessible – digitization and connectivity throw open an expanding universe of content, relationships and experiences that create new avenues for creation, distribution and exhibition of cultural content.

The literature review shows that digitization and connectivity have been related to the emergence of platforms, infrastructures and ecosystems as new forms of organizing inter-firm relationships (Bharadwaj et al. 2013; Yoo et al. 2012; Yoo et al. 2010). This shift has been made possible by the connectedness infused into innovation outcomes and processes (Nambisan et al., 2017). On one hand, digital platforms and open standards enable different stakeholders to pursue innovation collaboratively (e.g., Gawer and Cusumano 2014; Tiwana et al. 2010). On the other, collaboration among different stakeholders is enabled by the digital twinning of physical objects and the related digital-enabled capabilities, such as knowledge sharing, crowdsourcing, crowdfunding, virtuality, and dedicated social media. In this vein, digitization and connectivity fundamentally shape the scope, content, and direction of search and recombination mechanisms.

Then, how do platforms shape search and recombination mechanisms when its partners and their contributions are different, unknown or ill defined (RQ1.1)? How do digitization and connectivity enable, constrain or shape the nature of innovation as a collective action (RQ1.2)?

Approaching these questions, let us first note that – as theorized in Chapter 2 (Building Block 1) – digital innovation evolves in networks, centered on a shared platform that makes a tool to orchestrate a variety of heterogeneous knowledge in a non-linear way. Such a realignment can consist of a radical departure from the existing ways of doing business, and from the logics, values and beliefs that drive work practices and behaviors in an organization (Rezazade Mehrizi & Lashkarbolouki 2016). Museums and cultural organizations are required to develop new ways of disseminating heritage (related to art, science, archaeology, history) through an array of new digital channels, technologies and media (Avery 2014). Such ways require big data capabilities that are beyond the specialization of museums and they put such organizations in a position in which they have to deal with new partners, thus allowing them to create new value that none of them could achieve by itself (Adner 2006).

As cultural heritage is a piece of a wider ecosystem that determines the overall attractiveness of tourism in the geographical area in which they are located, cultural organizations, in their choice of “going online” have to deal with large volumes of varied data generated by different actors. There are approximately 55,000 museums throughout the world (Museums of the World 2017) – ideally each maintaining its own website – each with its own artworks. The digitization of artworks can thus enable a better organization of the cultural heritage, with benefits for their dissemination. In this perspective, platform logics can support the organization of the world's cultural information in such a way that it is universally accessible through only one gateway to the digital world. This explains the contemporary initiatives of Europeana – the European Commission’s digital platform for cultural heritage from the public sector – and the Google Arts & Culture – the non-profit project from the private sector, launched by Google, which is aimed at giving visibility and access to the heritage owned by thousands of museums over the world. Both initiatives aggregate the contents of museums and make them available through the Internet in a single online space. At least for the time being, the content volume and the geographical scope of Europeana and Arts & Culture outreach any other online aggregator that works, at most, at the local level.

While we have a solid theoretical understanding of how platforms orchestrate and coordinate value network among members to a common innovative effort (Giudici, Reinmoeller, & Ravasi 2018), we know far less as regard to the process through which platforms shape the nature of innovation as a collective action where the convergence of interests is realized among the actors (for example, museums and tourism institutions) which contribute to the platform with their own contents. This point assumes interest at the moment the platform initiatives launched by Google and by the Europeana project on cultural heritage seem to follow different strategies and to perform differently in terms of coverage of museums and in the ways through which cultural heritage is made accessible in the digital world.

In order to illuminate this issue, this section presents a multiple case study on the vis-à-vis positioning between the two leading platforms on the online dissemination of cultural heritage: “Google Arts & Culture” and “Europeana”. Specifically, the case study focusses on how the two platforms – an industry-specific digital incumbent (i.e. Europeana) and a new digital entrant (i.e. Google Arts & Culture) – have leveraged digitization and connectivity to create value from the heritage owned by museums.

The case study combines multiple data sources (interviews, observations, archival data) and was informed by the value-driver model on the sources of value creation in e-business developed by Amit & Zott in 2001, who identified four distinct drivers of value creations on markets mediated by the Internet: transaction efficiency, complementarity, novelty and lock-in. In general, the creation of value for each participant in a platform occurs through positive network effects. Network effects tend to create winner-take-it all markets and increase the possibility of lock-ins, which reduce the switching costs that prevent producers from leaving the platform. Along with generating lock-in through network effects, platforms can create value by ensuring vertical and horizontal complementarities between the activities and the outputs delivered by producers participating in a platform. Transaction efficiency refers to the reduction in transaction costs realized because of the reduction in information asymmetries between buyers (users in our case) and sellers (i.e., cultural institutions), users’ search costs, and delivery time. Novelty refers to the creation of new markets that involve previously unconnected parties (e.g. eBay in the late 1990s) or that are characterized by new value propositions or new logics of market exchange or of participation in a supply chain (e.g. sharing economy in the 2010s).

A platform can deploy digitization and connectivity to activate the novelty and complementarity drivers of value creation when it is able to involve different stakeholders with different interests that are potentially complementary in the network it orchestrates (Gunter et al., 2017). However, evidence about this process of convergence is lacking.

The cultural heritage sector offers an interesting industry setting, since multiple stakeholders – with different interests – interact with a network-based logic rather than a firm-centric one (Minghetti, Moretti, & Micelli 2001). Also, the interest is motivated by the inherent complexity of the value network around cultural institutions and by the fact that the digitization process of artworks entails strong economies of scale and scope that may lead to a rise in firms using platform strategies. These networks involve institutions and firms in such sectors as tourism, education, research, technology development and retail. Within this ecosystem, the specialization on digitization processes can be limited, and this explains why many actors in the network opt for being supported and mediated by a platform operating as a network orchestrator.

Starting from the identification of the value of arts, culture and heritage for the different industry stakeholders, the market logics and the implications of how Europeana and Google Arts & Culture create value for the network have been analyzed. The main difference is that the two platforms leverage on different technological capabilities that were either available within (in the case of Europeana) or outside the cultural heritage industry (in the case of Google Arts & Culture). As polar cases in which the process of interest is "transparently observable" (Pettigrew 1990), this variety in the theoretical sample allows the effects on value creation due to different drivers and mechanisms, and to different processes of alignment in the interests of the stakeholders involved in the two platforms to be explored.

The analysis reveals that a platform can overtake a rival one when it is able to offer multiple drivers of value creation that attract members from different industry contexts and that have different objectives in joining the platform. The platform orchestrator's capability of organizing data and making part of them available to members is the key condition through which their different interests are aligned. This capability is independent of the level of industry-specific knowledge that the platform orchestrator has.

The study provides empirical evidence and elaborates on the implications that these dynamics have for adjacent cultural sectors (e.g., tourism) and points out the role Google is assuming as a system integrator in the cultural heritage ecosystem by aligning stakeholders' interests and the perceived value of participating in its platform. By doing so, the findings encourage a rethinking of the investments in digital technologies as being developed relationally by the ongoing interaction of multiple stakeholders' interests. In this vein, the study provides a base to continue the investigation of value creation and convergence of stakeholders' interests in other industries.

5.2 Methodology

The study is based on a multiple case study on the competition between the two leading digital platforms in the cultural heritage sector: Europeana and Google Arts & Culture. The contemporary initiatives of Europeana (launched in 2008 as a public initiative of the European Commission) and Arts & Culture (launched in 2011 as a private initiative of the Google Cultural Institute) constitute an **adequate theoretical sample** in consideration of their similar purpose of aggregating content in a single online space and the substantial differences in the strategic approaches and the in their implementation modes of a digital dissemination strategy. These two **polar cases** are differentiated in three ways: (1) from the technological perspective, a digital platform – in the case of Google Arts & Culture – through which the public can access high-resolution images of artworks vs. a digital repository of artworks in low-resolution in the case of Europeana; (2) from the institutional perspective, a non-profit branch of a private company – in the case of Google Arts & Culture – vs. a public initiative of the European Commission; (3) from a geographical coverage perspective, a platform that operates worldwide – in the case of Google Arts & Culture – vs. a platform restricted to just European cultural institutions; (4) in terms of standard, a platform that requires standardized metadata from participants – in the case of Google Arts & Culture – vs. a platform with a low-level of standardized requirements; (5) a platform that can leverage on a strong brand and can count on complementarities with the other resources of the Google ecosystem (e.g., Google Maps) vs. a platform started in 2011 as an initiative promoted by the European Commission. Thus, as polar cases in which the process of interest is "transparently observable" (Pettigrew 1990), this variety in our theoretical sample allows the effects of digitization and connectivity on the scope of search and recombination mechanisms, and the different processes of alignment in the interests of the stakeholders involved in the two platforms to be explored.

Drawing on previous studies (e.g. N.G. Kotler, P. Kotler, & W.I. Kotler 2008), the primary stakeholders of the cultural heritage sector were grouped into six categories:

a) **users**: general public, visitors and art lovers who are interested in arts and culture and can use the digital services of Europeana and Google Arts & Culture;
b) **researchers**: curators, professionals and academics that may benefit from high-quality content and searchable metadata on cultural heritage;
c) **cultural institutions**: museums, galleries, libraries, archives which provide content to the digital platforms;
d) **tourism institutions**: local, national and international tourism bodies interested in improving the attractiveness of cities and local areas for tourists;

e) **specialized suppliers**: technology vendors and multimedia specialists interested in developing new digital products and services about arts and culture (e.g. games or apps);
f) **policy-makers**: government departments and other organizations that regulate, protect, encourage and financially (or otherwise) support activities related to arts and cultural heritage.

From a review of the literature on the economic effects of arts and culture, three primary sources of value in digital cultural heritage were distinguished. First, the **usage value** that users derive from visiting cultural heritage. Second, the **social value** which derives from the contribution of cultural heritage to education and the overall wellbeing resulting from the way by which digital technologies enable art museums to make their cultural heritage more accessible to society. Third, the **economic value** which follows from the way digital technologies allow museums to reduce the costs or envisage new sources of benefits for their visitors (both online and onsite in their galleries) of making their cultural heritage more accessible online (through smartphones, tablets, computers). In evaluating the value created by digitization and connectivity in the broad cultural ecosystem, "value" was considered as the combination of the three above-mentioned categories of effects.

5.2.1 Data Collection

Following prescriptions for case-based research (Yin 1984), the study relied on multiple source of data.

Archival research. Archival documents, mostly produced by Europeana and the Google Cultural Institute (strategic plans, corporate directories, business plans), archival research in the business press, and other secondary sources, such as websites and other publicly available documents and videos were used. These data helped to draw up profiles of the platforms, trace their recent history from 2008 to 2018 for Europeana and from 2011 to 2018 for Google Arts & Culture, and identify the mechanisms through which the platforms create value for stakeholders.

Moreover, many high-quality data about tourism institutions and policy-makers were obtained from government archives, cultural policies, tourism policies, tourism institution documents, regulation policies, and national and international press. These data were collected to gather information on the broad cultural ecosystem, in order to triangulate and deepen the analysis on the different stakeholders' interests and document the value created by Europeana and Arts & Culture for tourism institutions and policy-makers when this did not come directly from the primary data sources.

Semi-structured interviews. Archival research helped to design semi-structured interviews, which were aimed at collecting detailed information on the two platforms. At least one members of the board for each platform was interviewed. The selection of the informants was aimed at collecting data from directors or project managers who were in a good position to be informed about (a) the mechanisms of value creation for the different groups of stakeholders, and (b) the strategic plans around the enhancement of these mechanisms.

The interviews generally lasted about one hour and a half. In order to ensure reliability, two researchers were present at all the interviews. Given the content of the interviews, the researchers were not always allowed to use a recorder. However, detailed notes were taken, and after each interview, they were compared, integrated and transcribed. Following Miles & Huberman's prescription (1984), transcriptions were supplemented with contact summary sheets in which the essential data and insightful quotations that could help future theorizing were reported.

Following Eisenhardt (1989) and Burgelman (1983), semi-structured interviews with three international cultural organizations present in both Europeana and Arts & Culture – whose importance became clear during the data collection – were also conducted. These data were used to triangulate and deepen our analysis of repertoire enrichment and to document the use of the two digital platforms from the perspective of their direct strategic partners: museums. Specifically, 13 industry experts from art museums in Italy (the Uffizi Gallery in Florence), Spain (the Museum Nacional d'Art de Catalunya in Barcelona) and the Netherlands (the Van Gogh Museum in Amsterdam) were interviewed. The selection of three specific museums from different countries allowed us to control for any extraneous variation, while the focus on international museums constrained variation due to size differences among them. The average length of each interview was about one hour and a half. The interviewed experts were directors, heads of digital strategy, heads of marketing and art curators. In order to corroborate and triangulate data with the core dataset on Europeana and Google Arts & Culture, the interviews with the selected cultural institutions took into consideration:

a) how museums participate in the two platforms;
b) the motivations, the value seen and concerns about joining the platforms;
c) what types of data were shared with the platforms and under what restrictions;
d) what the differences were in using Europeana, Arts & Culture and the museum's own website for different groups of stakeholders as well as what the main pros and cons were for these stakeholders.

Other sources. Other sources, such as the two digital platforms' websites and the Arts & Culture official app were used to familiarize ourselves with the setting and to integrate and corroborate evidence from primary data and archival reports.

Moreover, one of the researchers participated in several conferences and workshops in industries where he interacted both formally and informally with different stakeholders in the industries, including (a) the "Museum Computer Network" conference on advancing digital transformation in museums (Pittsburgh, 2017); (b) the "Innovation and Cultural Heritage" conference (Brussels, 2018); (c) the "Museum: Vison 2026" workshop (Turin, 2016).

5.2.2 Data Analysis

The analysis combined coding techniques from grounded theory building (Locke 2001) with multiple case study analysis (e.g. Eisenhardt 1989; Pettigrew 1990; Yin 1984). The former helped to systematically track the value creation mechanisms concerning how Europeana and Arts & Culture made sense of the different stakeholders' interests. The latter helped to capture the approach and strategy that each platform has implemented to deal with the different stakeholders of the cultural ecosystem.

As is typical of case-based research (Yin 1984), the study started from a within-case analysis in order to become intimately familiar with each case as a stand-alone entity. The first step was the creation of a detailed chronological description of Europeana and Arts & Culture. Through this process, the unique patterns of each case started to emerge, and we began to observe the key junctions between the two cases.

In the next step, we moved to a cross-case search in order to establish patterns. Following Eisenhardt (1989), two dimensions to look for within-group similarities coupled with intergroup differences were selected: value creation and stakeholders' interests. In the first-order analysis, which tried to adhere faithfully to informant terms, in-vivo codes were used to distil the categories through which Europeana and Arts & Culture create value for the different groups of stakeholders. We started to look for similarities and differences between the main categories. Two researchers conducted this first step independently and generated the first-order codes while resolving occasional differences through discussion.

We then gave those categories labels, considering the two levels of value creation and the stakeholders' interests simultaneously, and we coded them at the more abstract second-order theoretical level of themes (Gioia, Corley, & Hamilton 2013). During this process, some of the interview data suggested that some concepts were viewed by cultural institutions as having contradictory implications for stakeholders. We, therefore, went back to the field to corroborate our data with cultural institutions and, through another round of coding, we were able to track all the oppositions we encountered in our database.

Once the concept development process had led to theoretical saturation (Glaser & Strauss 1967), we distilled the emergent second-order themes even further into second-order “aggregate dimensions” of: efficiency, complementarities, lock-in and novelty. We built two data structure representations (Table 4 for Europeana and Table 5 for Arts & Culture) of how we progressed from raw data to concepts and themes while conducting the analysis.

In the final round of the analysis, we examined how the drivers of value creation can attract all the different stakeholders’ interests over the entire ecosystem (Table 6), and a model that captures the informants’ experience in theoretical terms was developed (Figure 8).

5.3 Findings

5.3.1 The digitization of the museum content

Digitization and connectivity are essential ways of highlighting cultural and scientific heritage, of inspiring the creation of new content and of encouraging new digital services to emerge. Through online accessibility, the digitization process of cultural heritage helps to democratize access and to develop the information society and the knowledge-based economy (European Council of Ministers on the launching of the Europeana prototype, Brussels, 20 November 2008).

The digitization of cultural objects from physical to digital artifacts is a functional prerequisite that is necessary to enact the innovation pipeline. The digitization process essentially includes the digital photography of cultural objects, accompanied by the relevant information (metadata) and narrative content of the resulting file. The process can be conducted autonomously by museums (as in the case of Europeana) or in collaboration with the digital platform (as in the case of Google Arts & Culture). In both cases, the metadata and the narrative content are provided exclusively by museums.

Once digital shooting has been completed, and the metadata created, the object is “ingested” into the platform’s digital system. The ingestion entails uploading the digital copy of the physical object (i.e. the digital image) and its specific metadata (i.e. the content) by means of standardized interfaces made available by the same platform. In the ingestion stage, the object starts its transformation into what could be defined as a digital artifact, that is, a “digital twin” of the physical object made of bits that incorporate the museum-specific knowledge about the piece of art translated into metadata.

Once digitized and ingested, the digital artifact is ready to be indexed. The indexing process makes the digital artifact available on the platform and renders it searchable within the system, thus enabling the browsing of the object and its content, or metadata. However, the creation of a digital artifact is not enough to reap the benefits of leveraging on large volumes of varied data. **The *conditio sine qua non* to exploit this opportunity is the presence of an integrated infrastructure that spreads the scope of search and recombination mechanisms enabled by digitization and connectivity.**

5.3.2 The rise of "Europeana" form the cultural heritage sector

> *"Europeana is the EU's most visible expression of our digital heritage and reflects the ambition of Europe's cultural institutions to make our common and diverse cultural heritage more widely accessible to all". (Neelie Kroes, Vice President of the European Commission, 2010).*

Europeana is Europe's digital platform for cultural heritage, and it has promoted the richness and the diversity of over 54 million digitized objects from more than 3,700 cultural organizations since 2008. Launched in 2008 as a prototype, and operating as a full service since 2010, it is the organization that has been tasked and financed by the European Commission with developing its digital platform. The Europeana Foundation is a team that is made up of around 60 people who work with over 1,500 cultural heritage professionals, researchers and policy-makers to mobilize the cultural community across Europe. As pointed out by a Senior Data Specialist of Europeana:

> *"Europeana is a platform that connects users directly to authentic and curated material. [...] Our strategy is to democratize access to cultural heritage, through an open platform, so it can be used and enjoyed across national borders for work, learning or pleasure". (Nuno Freire; Senior Data Specialist Europeana)*

Europeana has framed its strategic plan around four strategic pillars to create value for its most important stakeholders: users, cultural organizations, policy-makers, specialized suppliers (e.g. technology vendors and multimedia specialists) and tourism institutions.

The first pillar of value creation for Europeana is **aggregate content**. The platform intends to assemble the most trustworthy collections of Europe's cultural heritage. Europeana controls descriptive metadata and not the creation of digitized artifacts. Given the breadth and width of its content – museum artifacts, books, photography, audio and video files – and the different cultural organizations on board – from museums and libraries to public and private foundations – **the platform operates more as a dedicated search engine than as an aggregation platform per se**. Content providers only upload thumbnail images and metadata of their digitized collections onto Europeana. This means that the users, once they have identified the items that interest them, through the platform's filtering tools, can only navigate through low-quality resolution and a limited number of the relevant metadata on each artifact, and are subsequently directed, through hyperlinks, to the museum's own website. However, by opening up access to online cultural heritage, increasing the social and economic benefits and removing the barriers to access, Europeana plays an important advocacy role with European policy-makers.

The second block of value creation is **accessibility** to facilitating knowledge access and knowledge transfer in the cultural heritage sector. Since the requirements of professional figures and education research communities are overlapping but distinct, Europeana aims at developing collaborations between the elements of this complex ecosystem.

> *"We will promote dialogue and collaboration between librarians, curators, archivists and creative industries, to work together in common interest areas [in the digital ecosystem]". (Europeana Strategic Plan 2011-2015)*

The searching and filtering options are the easiest ways to use and understand the platform, as tools are provided to search for metadata records and media in the Europeana repository and to interact with cultural data in much the same way as Wikipedia does.

The third pillar of value creation is the **dissemination** of cultural heritage to users "wherever they are and whenever they want it" (Europeana Strategic Plan 2011-2015), while making the cultural content as findable and understandable as possible. The platform offers teachers and students the possibility of sourcing learning objects that have the potential to enhance teaching and learning (e.g. a teacher can use Europeana results on smartboards). Moreover, promoting distribution through partnerships, for example in the tourism sector, allows one to interpret and re-purpose content for a specific audience and to create services for cultural explorers and travellers. For example, Europeana and Google's Niantic Labs have successfully completed a pilot project to integrate curated cultural content in Google's Field Trip app. The project was started in 2014 and was aimed to promote the dissemination of cultural content in the tourism sector. The app – developed by a Google internal startup – recognizes where people are and allows them to explore and discover more about their surroundings.

Finally, the last pillar of value creation pertains to **engaging** users in new ways of participating in their cultural heritage. Application program interfaces (APIs) and widgets make Europeana's content available on cultural (e.g. Wikipedia), social networks and blogs. The platform also encourages user-generated content. For example, in the "1914-1918" collection on the First World War, Europeana called for contributions in order to share digitized images of family memorabilia from the war period (e.g. a scanned copy of a picture, postcard, diary, uniform) together with a short story. In this case, this co-creation was aimed at creating and sharing a common identity about how the war touched the local populations in European countries.

Table 4 represents the data structure of our analysis and shows the means by which Europeana is delivering value to different stakeholder groups. Table 4 also provides a graphic representation of how we progressed from raw data to concepts (first-order codes in column 1) and themes (second-order codes in column 2) in conducting the analyses. Column 3 shows the aggregate theoretical dimensions derived from capturing the in-vivo code of our data in theoretical terms (informed by the value-driver model proposed by Amit & Zott). Column 3 is dealt with in more detail in the discussion section.

Table 4 - Europeana in-vivo code (data table): value creation for different stakeholder groups

First-order concepts Value creating activities and beneficiaries in parentheses *(stakeholders)*	Second-order themes	Aggregate dimensions Drivers of value creation
• Online visibility *(cultural institutions)* • Promoting European cultural heritage in the online world *(cultural institutions)* • Facilitating online aggregation of artworks while maintaining close control of IPRs *(cultural institutions)*	**Aggregate** *"Building the open trusted source of European heritage"*	Efficiency
• Searching for cost reductions (e.g. through filtering tools) *(users, researchers)*	**Access** *"Facilitating knowledge access in the cultural heritage sector"*	
• Facilitating content and knowledge sharing *(users, researchers)* • Creating an online retrieval system to make artworks widely available to instructors and schools *(policy-makers)* • Encouraging partnerships to deliver content in new ways *(tourism institutions, specialized suppliers)*	**Disseminate** *"Making heritage available to users wherever they are, whenever they want it"*	Complementarities
• Engaging users in content co-creation (e.g. providing family memorabilia on a First World War collection "1914-1918") *(users)*	**Engage** *"Cultivating new ways for users to participate in their cultural heritage"*	

5.3.3 The entry of a digital platform from outside: the rise of Google Arts & Culture

On February 2011, the Google Cultural Institute – a non-profit branch of Google – launched its Art Project (now known as Arts & Culture) as a cooperative research initiative with 17 museums in the US and Europe. With this project, Google launched its own web and mobile platform about artworks, where users can access high-resolution images of artworks housed in the initiative's partner museums. The Arts & Culture platform comes from the application of Google competencies in digital imaging and indexing. By curating a vast collection of worldwide digital artworks, the value proposition is consistent with Google's mission of "*organizing the world's information and making it universally acceptable and useful*" on the Internet. In this vein, digitizing artworks would have introduced two types of benefits for Google: (1) increasing the time users spend in a day on Google's platform and generating more data for their individual profiling; (2) enhancing the role and the reputation of Google in creating value at the societal level by inventing a way of accessing art that is free and which removes geographical barriers. As the Director of the Google Cultural Institute mentioned:

> *"Experiencing art should no longer be reserved just for "regular" museum-goers or those fortunate enough to have important galleries on their doorsteps but should be made available to a whole new set of people who might otherwise never get to see the real thing up close". (Amit Sood, Director of the Google Cultural Institute, 2011)*

Google Arts & Culture develops its value proposition around five main building blocks in order to create value for its most important stakeholders: users, cultural organizations, policy-makers, specialized suppliers (e.g., technology vendors and multimedia specialists) and tourism institutions.

The first value creation block is related to **organizing information** by leveraging on its previous capabilities of digitization and indexing. Arts & Culture offers an unlimited content hosting space, an advanced image processing technology, and searching and indexing tools through which cultural institutions can control, manage and access their digital assets and metadata with Google collection management support. Moreover, through this collaboration, museums are able to deploy Google's Street View technology to offer online navigation of their interior rooms and corridors, and include a digitized copy of some of their artworks in a repository of hundreds of ultra-high-resolution digitized images of paintings and sculptures from the partner collections.

In fact, users can zoom in to a brushstroke level of image details through the platform. In 2011, digitizing artworks in ultra-high-resolution was a complex technical challenge that required time, specialized and expensive equipment, and experts in digital imaging. To do this, Google deployed a robotic camera that was capable of capturing gigapixel images composed of one billion (10^9) pixels (picture elements) with approximately 1,000 times more detail than the average digital camera. Furthermore, Google was rapid in improving the cost performance of the technology, which was achieved by adding more automation to the digitalization process. The increased efficiency of digital image capturing and the fact that the digitization costs were handled by Google allowed Arts & Culture to move from 17 cultural institutions in 2011 to over 1,400 in 2018, including the top and less important museums in the world, but also to achieve a rich tier of local excellence.

This is particularly valuable for policy-makers and tourism institutions since Google Arts and Culture is bringing traditional and local heritage, food, festivity, spirituality and adventure to users in the form of online exhibitions in collaboration with national institutional bodies. For example, in partnership with the Ministry of Tourism, as part of its international tourism campaign "Incredible India", the exhibition takes viewers on a journey to some of the most iconic destinations in India. Talking about India as a destination of diverse experiences, Union Tourism Minister K. J. Alphons said:

> *"India is an iconic destination that offers unique experiences of climate, geography, culture, art, literature, and food. [...] Through our partnership with Google, we want to engage new and global audiences and offer them immersive content in a never-before-seen manner". (K J Alphons, Union Minister of State for Electronics and Information Technology, Culture, and Tourism in India, 2018)*

The same is happening in many other countries, where Google is developing partnerships with institutions whose mission is to promote tourism and the local heritage at the international level (e.g. the Grand Tour of Italy realized in partnership with the Youth Committee of the Italian National Commission for UNESCO). In this vein, the non-profit nature of the Google Arts & Culture initiative, and the fact that cultural institutions continue to maintain the copyrights of the uploaded content was decisive in persuading museums (and organizations as a whole) to develop their Internet visibility on the Google platform. As Google's initiative has a non-profit purpose, cultural institutions are generally willing to give Google a non-exclusive, royalty-free, worldwide license to use, reproduce and distribute such content. Google has the exclusive right to use the thus obtained gigapixel images for the first five years, and after that period, museums would have full control of them.

The second pillar of value creation refers to **accessibility in terms of "digital twinning"** – here intended as the capability of reaching a global audience by mimicking the experience they could have in a physical gallery, but without the constraints imposed by the physical context. In providing global access to culture, Arts & Culture enables users to virtually tour museums and galleries and to explore physical and contextual information about artworks, thus giving them exclusive access to hard-to-reach places. The “walk-through” feature (enhanced by the possibility of having immersive virtual reality experiences) is based on Google's Street View technology, and it allows visitors to enjoy a sharper layout and ambience of museums and galleries than when consulting a guidebook. Also, through filtering tools, users can search and access digitized copies of artworks hosted in a variety of physical collections in museums all over the world. Moreover, these tools can support researchers (and curators in particular) in the content retrieval and selection needed to curate temporary exhibitions, and scholars in conducting their research. As one of our informants observed:

> *“Indexing competences were deployed to provide advanced filtering tools, based on the ability to specify tags and descriptive metadata about an artwork. Through metadata, users can browse the content and the collections of the different cultural institutions involved. They can also search by artist and popularity, filter to search for artworks according to the used material, country, date, colours and typology”. (Giorgia Abeltino, Global Director Public Policy Google Cultural Institute, 2016)*

In this vein, the zero-marginal-cost for the distribution of digital goods makes it possible for visitors to access an abundance of digitized artifacts whose access can be offered to multiple devices at no price (e.g. on the mobile app, on the website, on users’ wrists with Android Wear, on TV screens with Chromecast Backdrop, etc.). Also, in order to attract visitors, the Arts & Culture platform can count on complementarities with other existing technologies in the Google set of application (e.g. Google Maps and Google Now) and the related real-time information that is of interest to tourists. As one of our informants explained:

> *“When travelling near a cultural institution, Google Now users see a card showing the museums’ opening hours, a highlight of the museum’s collection, the directions, popular times, live visit information, waiting times, typical visit durations, and nearby points of interest, such as restaurants and shops”. (Giorgia Abeltino, Global Director Public Policy Google Cultural Institute, 2016)*

Linking together people and their online practices in order to enact a form of algorithmic cultural recommendation has allowed latent and tacit consumer needs from different markets to be captured, and specific services to be created for cultural explorers and travelers fully-integrated in Google Maps.

The third block of value creation is related to the **dissemination** of digital artifacts and the curating of online exhibitions with partner museums and other stakeholders, such as national and international institutions. High-resolution digital imaging allows museums to share their collections and to easily start new collaborations for the virtual re-bundling of artworks that are stored in different museums and galleries. For example, in 2016, the Royal Museum of Fine Arts in Brussels, together with eight museums from around the world, launched the Bruegel Unseen Masterpiece project on the Arts & Culture platform. This initiative offers online visitors the chance to immerse themselves in Bruegel's work by honing into different paintings exhibited in different museums throughout the world. Cultural institutions can also curate online exhibitions with platform-integrated storytelling tools, such as a high-res zoom viewer, expertly narrated videos, viewing notes and maps. At the same time, users can join a community of like-minded people and "stay in the know on all things cultural", and they can share their thoughts on social media channels. Users can also join live-streamed conversations with experts that are broadcast on Google+ and ask questions in real time.

The fourth pillar of value creation for Arts & Culture is related to **engaging** users in using the platform in order to learn about arts and culture in new ways that enhance the entertainment dimension. The high-resolution digital imaging of artworks increases the engagement of users by strengthening the educational dimension of the online experience on the platform. Users of Arts & Culture can zoom into details that would not be captured by the naked eye during an inspection of the real copy. Before high-resolution digital imaging, only researchers were able to analyze these traits through such means as microscopes available in laboratories that required a physical inspection of the artworks. Today, these features have been made accessible to the general public. This contributes to "democratizing" access to specialized knowledge about art and to breaking down the distinction between users, art lovers and professional figures. As one of our informants retrospectively observed:

> *"While images in a text book let users understand the overall structure of a painting, gigapixel technology allows them to see how the artwork was made and to recognize an artist's signature strokes". (James Davis, Programme Manager Google Cultural Institute, 2017).*

Users can also create their own personal list of favorite cultural items in the same way as music playlists are created on Spotify or iTunes, share it on social media, write reviews, share photos, answer questions, add or edit places, thus acting as local guides in the digital world. To do this, they need to log in using their Google account. In this way, their preferences can be used to predict their interests and behavior, thus contributing to the enrichment of the amount of data and analytics that partner museums receive in exchange for their collaboration.

The final dimension refers to the new digital-based opportunities offered by Arts & Culture through which participants can **experiment** with cutting edge logics and approaches in creating and disseminating knowledge about arts and culture. Such experimentation can involve museums, technology and multimedia specialists, users and policy-makers, thereby enlarging the number and type of stakeholders involved in the platform. In doing this, over the years, Arts & Culture has also been able to embody new technological features in the fields of **artificial intelligence, machine learning, and virtual and augmented reality**. For example, the platform applies a series of image recognition algorithms, based on machine learning, to understand the artwork content independently from the descriptive metadata supplied by museums. Using over 4,000 tags and keywords (e.g. sun, moon, stars) generated by artificial intelligence, users can browse artworks in a similar way to how they "Google" words on the web. Moreover, professionals can explore an interactive 3D landscape created by machine learning algorithms that have organized thousands of artworks on the basis of visual similarity to find new pathways. All these forms of participation allow the "experiments" on other digital platforms (e.g. social media) to be shared, thus creating a community where new meaning can be formed.

Google Arts & Culture is also integrated with virtual and augmented reality features. With Google Expeditions and Google Cardboard, a teacher can guide students through collections of 360° scenes and 3D objects and point out interesting sites and artifacts along the way. Apart from the educational purposes, Arts & Culture has recently refreshed the app with all-new augmented reality features through which users can see real-size artworks in front of them and explore paintings in their own rooms.

The Google platform also favors gamification, namely the practice of providing game experiences in non-game contexts with the aim of generating learning along with entertainment. In these games, smartphones become the media that substitute video guides to access content. Google has recently developed an experiment that matches users' "selfies" with art from the collections of museums on Arts & Culture through a "visual similarity" index, which is calculated by machine learning algorithms. Since, in just a few days, people took more than 30 million selfies (Luo 2018), this possibility seems particularly attractive to museums in order to engage with new, young audiences. From the technology vendor and artist perspective, Google developed "Tilt Brush", a 3D virtual reality painting application, where movement in a 3D space creates brush strokes that are repeated in the virtual environment.

Table 5 represents the data structure of our analysis and shows the means by which Europeana is delivering value to different stakeholder groups. Table 5 also provides a graphic representation of how we progressed from raw data to concepts (first-order codes in column 1) and themes (second-order codes in column 2) in order to conduct the analyses. For the sake of completeness, column 3 shows the aggregate theoretical dimensions derived from capturing the in-vivo code of our data in theoretical terms (as described in the model proposed by Amit & Zott). Column 3 is dealt with in more detail in the discussion section.

Table 5 - Google Arts & Culture in-vivo code (data table): value creation for different stakeholder groups

First-order concepts Value creating activities and beneficiaries in parentheses *(stakeholders)*	Second-order themes	Aggregate dimensions Drivers of value creation
• Providing online visibility to museums and other cultural institutions *(cultural institutions)* • Sustaining the museums' digitization process of their cultural heritage *(cultural institutions)* • Promoting excellence and local traditions *(policy-makers, tourism institutions)*	**Aggregate** *"Leveraging on our digitization technologies and indexing capabilities"*	Efficiency
• Providing access to artworks in high resolution and with 360° virtual tours *(users, researchers)* • Searching for cost reductions (e.g. through filtering tools) *(users, researchers)* • Accessing a platform through multiple digital channels/devices *(users, tourism institutions, specialized suppliers)* • Providing real-time updated information about a physical gallery (e.g. opening hours, directions, popular and waiting times) *(users)* • Integrating a museum's content in the local touristic ecosystem of the city *(tourism institutions)* • Providing cultural institutions with analytics on their online attractiveness *(cultural providers)*	**Access** *"Reaching a global audience by publishing content on multiple platforms anytime, anywhere"*	
• Facilitating the sharing of knowledge and digitized copies of artworks *(users, researchers, museums)* • Providing storytelling tools *(cultural institutions)* • Co-creating exhibitions by involving different museums *(cultural institutions)* • Making an online retrieval system available to schools and instructors by providing specific educational tools (e.g. Augmented Reality) *(policy-makers)* • Creating partnerships to deliver content in new ways *(tourism institutions, specialized suppliers)*	**Disseminate** *"Bringing artworks and artifacts to life and creating beautiful stories"*	Complementarities
• Powerful zooming with images in ultra-high resolution *(users, researchers)* • Google set of services and ease of use *(users)*	**Engage** *"Getting involved in the global community by curating,*	Lock-in

• Curation and sharing of a museum's own art collections *(users)* • Loyalty programs based on user-generated recommendations and information about museums and other points of interest on Google Maps *(users, tourism institutions)*	*connecting and sharing"*	
• Providing access to Google's proprietary virtual and augmented reality apps for cultural heritage *(users)* • Exploring Artificial Intelligence tools for pattern recognition and matching related to artworks in an open source fashion, in order to encourage innovation from specialized suppliers and museums *(cultural institutions, specialized suppliers, policy-makers)* • Providing tools to create art digitally (e.g. Tilt Brush) *(users, specialized suppliers)*	**Experiment** *"Magic happens when technology meets culture"*	Novelty

5.4 Discussion

Table 6 offers a comparative analysis on the value creation mechanisms enacted by Europeana (Table 4) and Google Arts & Culture (Table 5) in function of the different stakeholders' interests in the online dissemination of cultural heritage. In comparing and contrasting columns 3 and 4 of Table 6, two main facts emerge. First, Google has been able to enact multiple and more powerful drivers of value creation than Europeana. Second, Google has been more able to meet the multiple interests expressed by different categories of stakeholders and to realign them in various domains that are related to research, technology development, promotion of the local tourism industry and the local cultural heritage. The following paragraphs discuss these points in detail.

5.4.1 Efficiency-related drivers of innovation

The comparative analysis of the third and fourth column in Table 6 points to transaction efficiency as one of the primary value creation drivers enabled by digital platforms when leveraging on digitization and connectivity. Such efficiency enhancements are achieved in two ways. The first is by **reducing search costs** that users and researchers bear to access digitized copies of artworks. Moreover, the reduction in the search costs is made possible by the active involvement of museums and other experts in the platform as content providers. In this vein, the two digital platforms offer a broad aggregation of artworks from different collections and from different museums in a single virtual place.

The second way of achieving efficiency enhancements is related to the reduction in the costs necessary to **acquire real visitors** and to accompany them to physical galleries. In this regard, Arts & Culture offers museums more value as it allows users to easily access and navigate the collection of any cultural institution by providing links and hyperlinks to the official museums' websites.

5.4.2 Complementary-related drivers of innovation

By hosting a bundle of goods together, the two digital platforms can convey more value than the total value of having each of the goods separately on every single museum's website. This feature draws on the concept of **complementarities among strategic assets** as a source of value creation (Amit & Zott 2001), which in turn can act as a driver of **network externalities** (Gulati 1999). By comparing and contrasting columns 3 and 4 in Table 6, it is possible to see that both platforms have the potential to offer **vertical complementarities** related to combining and integrating digitization capabilities with the capabilities of a museum of generating narrative content around artworks. However, we found limited evidence of **vertical complementarities** being generated by Europeana, since the platform operates more like an online repository of digitized artworks (in low resolution) and metadata on such artworks. This reduces the interest of museums in contributing to Europeana, since the platform cannot allow them to express their core capabilities of developing narrative content around artworks.

Furthermore, Table 6 shows that only Arts & Culture is able to offer **stronger horizontal complementarities** (i.e. offering a “one-stop-shop” logic in tourism) about which users can access a plenitude of content and information related to culture, arts, restaurants, hotels and other points of interest that are not available on Europeana. In doing so, Google offers museums the possibility of leveraging on the portability that narrative content and digitized artworks can have on the multiple loci available in its digital ecosystem, which integrates different domains like maps (Google Maps, Street View), search engines (Chrome), social networks (Google+), operating system (Android), and is accessible from a variety of devices (computers, smartphones, watches). For example, through the Android and the Chrome systems, Arts & Culture offers its users information about the opening hours of museums, popular times, live visit information, the expected waiting times, the duration of the visits, directions, traffic information and nearby points of interest, including restaurants, hotels and shops. This encourages museums to join the platform in order to facilitate visitors to retrieve the information useful to plan a visit to their physical galleries, thereby reducing their costs for acquiring customers.

This type of horizontal complementarity also increases the interest of local tourism institutions in advocating and promoting the use of the platform with the local museums, hotels, restaurants and any other actor involved in cultural heritage and tourism. In doing so, these actors can increase the attractiveness of a local area, thus allowing for end-to-end integration (Karmarkar 2010) in the provision of a touristic experience. As such, Arts and Culture wins over Europeana as it is part of a broader platform (e.g. Google) that acts as a **system integrator** for tourism and cultural heritage.

5.4.3 Lock-in drivers of innovation

The analysis reveals different **lock-in effects** generated by the studied platforms. Columns 3 and 4 in Table 6 reveal that the relative benefits offered to users by Arts & Culture are higher than the incentives to stick with the network established by Europeana. Specifically, the integration of Arts & Culture with the set of services offered by Google (e.g. Google Maps, Google Chrome, Google Now, Google Street View, Google +, YouTube and Google Mail) enhance lock-in by enabling users to customize information to their individual needs in a variety of ways. For example, Arts & Culture allows users to create their personalized list of favourite artworks, whereas Europeana does not offer this kind of customization feature. This feature is only possible if Arts & Culture’s users decide to log onto the platform with their Google account. In doing so, Arts & Culture can leverage on the knowledge Google has on each user (concerning demographics, interests and behaviours) and propose artworks that better match their socio-demographic profiles (applying the same mechanism already used by Google on YouTube). Thus, Arts & Culture can use the portability of its data to lock-in users to its platform, a mechanism that Europeana – at the time of this study – could not deploy. Arts and Culture also creates lock-in through the loyalty programs built on Google Maps based on the orchestration of a community of local guides that are engaged, by means of a gamification system, in providing knowledge about given points of interest (including museums) in a local area.

Even museums are locked-in on the Arts & Culture platform since they give Google a non-exclusive, royalty-free, worldwide license to use, reproduce and distribute high-resolution copies of their artworks for five years. In the first years of the Arts and Culture initiative, this significantly reduced the interest museums had in contributing to the platform since their fear was that they would be in a situation of **relational dependence** and **lock-in** in the use of their digitized collections. Many museums also feared that a digital player with no specialization on cultural heritage could disseminate their collections in a way that would be very divergent from the one made by the museum in the offline world (galleries, traditional and printed publications). However, our data suggest that the risk of developing relational dependencies was mitigated by those museums that had more resources to invest in online dissemination. Such museums have eventually developed an online dissemination strategy that is based on putting their digital content and data on their proprietary website and using their presence on Arts & Culture just to exploit the platform in order to attract visitors to their own websites.

The **Van Gogh Museum** is an excellent example of this strategy: although most of the digital content and data are located on the official website of the Van Gogh Museums, the museum has a good presence on Arts & Culture that is motivated by its willingness to reach a global audience. Moreover, despite the risk of developing relational dependencies, the interest of museums in being involved on the platform may be motivated by the opportunity of "**learning new things**" about how digital technologies can be applied to disseminate art and culture in novel ways. This point is related to the value creation mechanisms connected to novelty, which are explained below.

In general, museums overcome the fear of somebody from outside the industry (Google) disseminating content in ways that could be very different and non-appropriate in reference to the principles that are well-established in the museum and in the community of art experts. What was decisive to this end was the intention of Google to explore novel ways of disseminating art and of enlarging its audience, which is a strategic objective that is well-rooted in the mission of every museum.

5.4.4 Novelty-related drivers of innovation

Digital platforms support cultural organizations in providing new dimensions of value creation that are related to the introduction of **new products or services** (e.g. digital images in ultra-high resolution), **new methods of dissemination** (e.g. customization, experimentation, co-creation and gamification) and **new ways of doing business**. For example, the possibility offered by digital platforms to experience the global cultural heritage 24/7 and for free represents a discontinuity in the traditional structure of transactions between cultural organizations and users. This represents a fundamental pillar for the creation of "equality of cultural opportunity", which Cameron (1971) suggested for his vision of museums as forums. This pillar espouses the interest of policy-makers in making art dissemination more democratic and knowledge more accessible, thus breaking down the distinction between users and researchers.

Unlike Europeana, Arts & Culture has a dedicated section for experiments which encourages users to "**try experiments at the crossroads of art and technology**". By combining cultural data with machine learning and artificial intelligence techniques, Arts & Culture takes users on the scenic route by showing hidden paths, surprising connections, masterful works by unknown artists or the hidden beauty of mundane objects. Our data analysis shows that by using digital technologies to experiment with art, Google Arts & Culture realigns the interest of multiple stakeholders by enhancing new dimensions of value creation. For users, experimenting with art, science and history content creates "a feeling of fullness which can be taken as reality" (Bolter & Grusin 1999). For cultural institutions and policy-makers, the forms of experimentation made available by Google create new entertainment opportunities of providing game experiences in non-game contexts with the aim of generating learning along with entertainment. Also, artificial intelligence tools for pattern recognition and machine learning algorithms for pattern matching enhance the research opportunities for researchers and academics, while augmented and virtual reality encourage the development of new products and services by specialized suppliers.

5.4.5 Value creation and convergence in stakeholders' interests

Google Arts & Culture achieved an advantage over Europeana in realigning the multiple stakeholder's interests and in engaging them in sharing content and data with the platform. This is due to Google's capacity to enact all four mechanisms of value creation defined by Amit & Zott (2001) when combining digitization and connectivity.

Figure 8, which qualitatively emerged from the analysis of our data, illustrates this process of convergence and alignment of interests between the platform's owner and the multitude of stakeholders participating in the platform, and extends the value-driver model proposed by Amit & Zott in e-business. In other words, Figure 8 shows that each single value driver enacted by the platform contributes to creating value for a specific group of stakeholders. Only by enacting all four value drivers together can the platform attract all the different stakeholders' interests, thus creating higher value over the entire ecosystem. Therefore, the higher the platform's capability is to enact multiple value drivers on the online world through digitization and connectivity, the higher the convergence in the interests expressed by different stakeholders in joining the platform, and the higher the value created in the platform ecosystem.

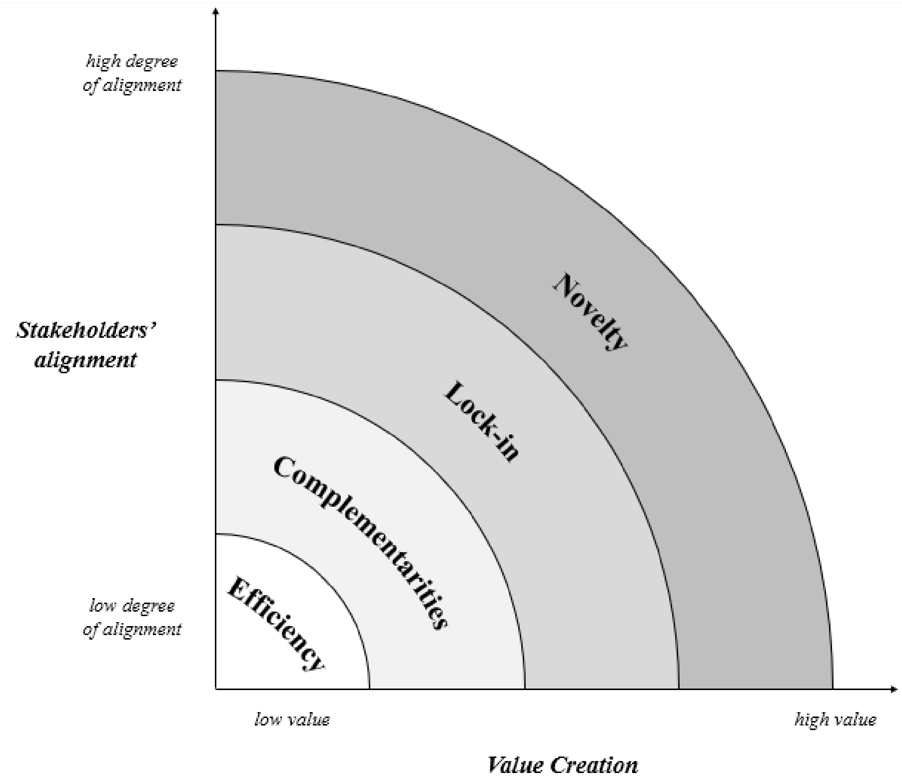


Figure 8 - Value creation and stakeholders' alignment

Table 6 - Comparative analysis of the value creation mechanisms enacted by Europeana and Arts & Culture for different stakeholders' groups

Stakeholder category	Stakeholders' perspective on the value of digital platforms in sustaining the online dissemination of cultural heritage	Value created by Europeana for the stakeholder category	Value created by Google Arts & Culture for the stakeholder category
Users	Accessing the cultural heritage through meaningful and inspiring online experiences	• **Efficiency** *(search costs reduction)*	• **Efficiency** *(search costs reduction)* • **Novelty** *(experimentation through digital technologies)* • **Lock-in** *(higher switching costs for users)*
Researchers	Reducing costs for searching and exploiting primary resource materials for research purposes	• **Efficiency** *(search costs reduction)*	• **Efficiency** *(search costs reduction)* • **Novelty** *(new inspection tools)*
Museums and other cultural institutions	Extending the collection's visibility to a wider community	• **Efficiency** *(costs for promoting brand awareness)*	• **Efficiency** *(in visitors acquisition costs)* • **Complementarities** *(horizontal and vertical)* • **Novelty** *(experimentation through digital technologies)* • **Lock-in** *(higher switching costs for museums)*
Specialized suppliers	Developing innovative digital products and services around arts and culture	• **Complementarities** *(limited evidence of vertical complementarities)*	• **Complementarities** *(horizontal and vertical)* • **Novelty** *(gamification through digital technologies)*
Tourism institutions	Promoting tourism in a region and attracting touristic inflows		• **Complementarities** *(horizontal and vertical)*
Policy-makers	Multiple interests: 1. Preserving cultural heritage 2. Building awareness about local cultural heritage 3. Promoting local tourism by giving online visibility to local cultural heritage	• **Efficiency** *(in building online visibility for cultural institutions)*	• **Efficiency** *(in aggregating online local cultural institutions from different fields)* • **Complementarities** *(vertical)* • **Novelty** *(new ways to disseminate art)*

5.5 Conclusion

The study has taken steps toward extending the analysis on the evolution of the cultural heritage sector by means of digital platforms and has discussed how digitization and connectivity are shaping this process by enabling new ways of creating value and of espousing the different types of interest expressed by the different types of stakeholders.

The results document how Google Arts & Culture has been more effective than its main rival platform – Europeana – in competing on the variety, customization and experimentation of artworks accessible online and in offering a one-stop-shop logic for all the relevant content and information. Specifically, the empirical evidence shows how Google Arts & Culture has enhanced the four drivers of value creation, namely efficiency, complementarities, lock-in and novelty, as defined by Amit & Zott (2001), more than Europeana. The fact that Google's platform has been able to enact these drivers jointly is at the same time both the reason for and the consequence of having favored a process of convergence in the interests expressed by different stakeholders through digitization and connectivity.

In raising this issue, the contribution is twofold. First, the study document how a process of convergence and alignment of interests between platform owners and participants can enable network-based innovation from digitization and connectivity. **The study shows that search and recombination mechanisms enabled by digitization and connectivity assume a central role in this process as they allow to leverage on large volumes of varied data generated by different actors (museums, specialized suppliers, users, scholars, the platform orchestrator and others) and to reuse them in valuable ways in other industry contexts, such as education, tourism and content generation in the multimedia sector.** This confirms the socio-technical nature of the network-based innovation enabled by digitization and connectivity. **The stakeholders that have joined and that exchange services on Google Arts and Culture represent a more heterogeneous network of actors than the actors in the ecosystem developed by Europeana.** The needs, strategic beliefs and interests of many of the actors in this network were divergent at the beginning, and the Arts and Culture initiative has realigned them toward a convergent direction. Search and recombination mechanisms emerge from the research as being more important than industry-specific knowledge in favoring such a process of alignment of interests expressed by different stakeholders.

The second contribution is related to the role of digitization and connectivity in changing the structure of industries – such as tourism – which are dominated by well-established business logics. **In this vein, by means of the search and recombination mechanisms documented in the study, Google is assuming the role of system integrator in the cultural heritage ecosystem**. This raises important managerial and policy-making implications in the cultural heritage industry and in its supporting and related industries, such as tourism.

The most evident implication is that cultural organizations are required to experiment with digital platforms in multiple and novel ways to create economic and cultural value in order to make their collection visible online. Second, new managerial tensions and trade-offs are emerging for museums since digital platforms put them in a more complex networks of stakeholders. Among such tensions, the most evident one is between "**open**" and "**closed**" approaches in the museums' online dissemination strategy. On the one hand, reasons related to maintaining brand identity and controlling the content disseminated online push museums toward **vertically integrated strategies** based on reducing the amount of collaboration and content given to digital platforms such as Google. On the other, since Google Arts & Culture is emerging as a platform in which a city, a region or a country is in competition with other areas to attract real (and not virtual!) international flows of tourism, policy-makers and local tourism institutions are pushing museums toward more **collaborative approaches** with digital platforms. Institutions and policy-makers in the educational context can apply the same logic.

This reasoning and the conflicting objectives museums have to face in the way they decide on how to "go-online" paves the way to future studies that could apply: (a) the institutional theory, to understand how digitization and connectivity are shaping the industry structure and the institutional forces at work in the industry; (b) theoretical approaches based on the concept of ambidexterity to understand how to balance a museum's digital presence on different media in order to align the different logics and interests expressed by a composite array of multiple stakeholders.

5.6 Summary of the section

A crucial element to create value form network-based (or platform-based) innovation enabled by digitization and connectivity is the capability of aligning different stakeholders' interests. However, it has not yet been investigated empirically how this process of alignment can be realized by means of search and recombination mechanisms. In Chapter 5 a multiple case study on the two leading digital platforms involved in the online dissemination of cultural heritage – Europeana and Google Arts & Culture – is conducted. The results reveal that a platform overtakes a rival one when it turns on multiple drivers of value creation in such a way that the drivers contribute to realign the interests expressed by stakeholders whose strategic objectives and beliefs were formerly divergent – or simply unrelated – to each other. This capability of realigning different stakeholders' interests is independent of the level of industry-specific knowledge that the platform orchestrator has. The dynamics document in the study imply that

Google has assumed a system integrator role in the cultural ecosystem. This generates new trade-offs for museums and cultural organizations in the way they generate value for the cultural sector. Overall, the study enriches our understanding of what strategies digital platforms adopt to create value by means of search and recombination mechanisms enabled by digitization and connectivity and provides a base to continue the investigation on other ecosystems shaped by digital transformation.

Chapter 6

Digital connectivity and organizational change: The co-evolutionary dynamics in the Van Gogh Museum

This chapter builds on a working paper (Pesce, Lanzolla and Neirotti, 2019) and completes the perspective on RQ2 by discussing how in hierarchy-based context the innovation is shaped in vertical structures where value is created in linear processes governed by behavioral control mechanisms, thus answering the sub research question RQ2.1.

6.1 Introduction

Digital connectivity has become a fundamental contemporary element of how organizations operate (Kolb, Caza, & Collins, 2012). Kolb (2008) defines connectivity as "**the mechanisms, processes, systems and relationships that link individuals and collectives (e.g., groups, organizations, cultures, societies) by facilitating material, informational and/or social exchange**." Such mechanisms can be related to several dimensions of interactions: geophysical (e.g., space, time, location), technological (related to the role played by the Internet and other information and communication technologies), social, and related to the type and the level of materiality involved in the interaction. Overall, as a metaphor, connectivity is often equated to the concept of enabler of intra- and inter- organizational interactions (Kolb, 2008).

The literature review (Building Block 1 in Chapter 2 and Building Block 2 in Chapter 3) shows that digitization and connectivity have been linked to the search and scope mechanisms of organizational innovation. On one hand, digitization is likely to enable higher experimentation (increasing the scope and the level of recombinant innovation) and connectivity enables diffusion of knowledge and organizational learning (favoring the orchestration of the innovation process). On the other, the simultaneous introduction of a series of digital-connected technologies challenges existing capabilities and skills into the organization (Dougherty and Dunne, 2012). This raises fundamental questions on the underlaying "process, capabilities and structures by which organizations adapt and innovate" (George and Lin 2017, 17). In a related fashion, these phenomena challenge existing assumptions on the optimal organizational design and the optimal configuration of legacy and digital skills.

Then, how do digitization and connectivity enable new organizational forms and new ways of thinking about internal organizational boundaries when there is an increasing level of digital connectivity among products and services (RQ2.1)?

Approaching this question, let us first note that extant research is not conclusive on the effects of (digital) connectivity in and around organizations (Kolb, 2008; Kolb et al., 2012). For instance, on the one hand, some research studies have highlighted that digital connectivity may contribute to **removing organizational silos** (Bahrami & Evans, 2011; Bogers, Chesbrough, & Moedas, 2018; Cross, Laseter, Parker, & Velasquez, 2006); may **improve information processing** (Galbraith, 1978; Luo, 2012; Gosain, 2004); and may enable **better coordination across organizations**. On the other hand, increased connectivity may make organizations more **structurally rigid** (Carr, Loucks, & Blöschl, 2018; Fang, 2008) and may make organizational actors more "similar" in their functional, cultural and interest background hence **reducing responsiveness to unexpected changes** (Van Alstyne & Brynjolfsson, 2005). A salient characteristic of digital connectivity is that it enables "**connectivity within organizations**" contextually with "**connectivity around organizations**." The dual aspect of digital connectivity has been only partially systematically explored in its organizational implications. Seeking to document such implications, in this section, the relationship between the increasing level of adoption of digital connectivity and the related transformations in organizational structures, roles, and work practices is analyzed.

The context of the study is the digital transformation of the Van Gogh Museum (VGM). We hand-collected detailed data from several primary and secondary sources, and we were able to draw a detailed and nuanced picture of how the VGM's digital connectivity and organizational structures, roles and work practices evolved over time. **The study shows that in response to the dual external/internal nature of digital connectivity, the VGM re-organized itself in functions grouped by knowledge output** – i.e., knowledge creation ("Museum Affairs"); knowledge communication ("Public Affairs") and knowledge commercialization ("Van Gogh Museum Enterprise"). Second, the study highlights that the **liaison digital roles** created in the organization are temporary and mostly geared towards enabling the transition of the organization into a "**new normal**" based on new dynamic connections among organizational "functions." Finally, the study illustrates the **tension between increased customer reach and decreased organizational diversity** which seems to be a key organization implication of digital connectivity.

6.2 Methodology

The study draws on an in-depth, longitudinal analysis the Amsterdam's Van Gogh Museum (VGM) digital transformation. VGM was opened in 1973. Drawing on its unique collection, the VGM has the mission of making the life and work of Vincent van Gogh and the art of his time accessible to as many people as possible in order to enrich and inspire them. In 1995, the VGM changed its legal entity and assumed the status of a private foundation that includes the Dutch state among the shareholders. This gave the VGM increased autonomy and flexibility for investments and organizational changes compared to other public museums in the Netherlands.

There are at least three reasons why the VGM is particularly well-suited for addressing our research question (Pettigrew 1990; Eisenhardt 1989). First, VGM was one of the first in the Netherlands and Europe to begin using Internet channels in a systematic way to reach its audience and change its *modus operandi* (Annual Report, 2007; Anderson, 2004; Parry, 2007). Second, in 2017 the VGM has achieved a leading international position in terms of digital connectivity adoption. For instance, according to industry statistics (Reputation Institute, 2017), the VGM positions itself as a "leading adopter" – alongside the Museum of Modern Art (New York), the Tate Modern (London) and the Metropolitan Museum of Art (New York) – firmly in the international top-five of museums. Furthermore, when it comes to digital engagement metrics, the VGM came first worldwide. Finally, the VGM's status as a foundation reporting to the Dutch government implies that it is obliged to make its records publicly available. Specifically, the VGM produced accessible, rich and varied data in its annual reports and strategic plans. We had, therefore, an exceptional level of access to secondary data that document the key technology adoption initiatives related to connectivity, and the organizational changes made by the museum. We then complemented this data with three rounds of semi-structured interviews. Overall, these factors make the process of interest transparently observable (Eisenhardt, 1989), and the VGM an ideal context to observe the co-evolution between digital connectivity and organizational transformation.

6.2.1 Data Collection

Following prescriptions for case-based research (Yin, 1984), the study relied on multiple source of data to build a detailed "narrative" of the VGM's digital transformation in the 1995 to 2018 period. Table 7 summarizes the main data sources and their use in the analysis.

Table 7 - Main data sources and use

Data Sources	Type of data	Use in the analysis
Archival data	**Internal documentation** 23 Annual Reports from 1995 to 2017 3 Strategic Plans: - 2009-2014 (1 page); - 2014-2017 (24 pages); - 2018-2020 (60 pages) 13 internal presentations	-Identifying the most relevant key digital initiatives, the changes in practices, the outcomes achieved, and the challenges encountered. -Identifying changes in the organizational structure by observing how departments were grouped in the organizational charts. -Identifying the introduction of new roles and new departments in charge of new activities, work practices, and lateral communication mechanisms.
	Press coverage 19 articles **Videos downloaded from the Internet** 5 videos of interviews with VGM management and VGM staff	-Triangulating facts and observations to overcome the limitation of the VGM's corporate rhetoric. -Enriching the database of evidence with third-party data.
Semi-structured interviews	**First round** **(November 2016 – March 2017)** 6 interviews with the Digital Communication, Education and Marketing departments. Informants included both the head of department and senior and junior team's members.	-Gaining an in-depth understanding of the VGM functions. Questions in the first round inquired about VGM's history, its functions, structures, and practices.
	Second round **(May 2016 – October 2017)** 8 interviews with the Research and Exhibition departments and with the Van Gogh Museum Enterprise. Informants included both the head of department and senior and junior team's members.	-Expanding the sample (departments and functions) to verify the presence of cross-department collaborations. -Triangulating facts and observations provided by VGM informants. -Gaining a better understanding of the co-evolutionary dynamics. Questions in the second round inquired about the timing of specific changes and the organizational guiding principles associated with them
	Third round **(March 2018 – June 2018)** 7 interviews with the Digital Communication, Curation and Education departments. Informants included both the head of department and senior and junior team's members.	-Composing a diverse sample reflecting the cross-department collaborations emerged in the second round of interviews. -Capturing the organizational changes related to the new Strategic Plan (2018-2020) and the appointment of a new Head in the Digital Communication department. -Triangulating facts and observations provided VGM informants.

Archival research. Archival data from the VGM's annual reports, and the three strategic plans released over the 1995 – 2018 period were hand-collected. These data helped to systematically reconstruct the history and the timeline of the VGM organizational functions. Also, the archival data allowed to identify changes in the organizational structure (by observing how departments were grouped in the organizational charts), identify the introduction of new roles and new departments in charge of new activities, work practices, and lateral communication mechanisms, and identify the most relevant key digital initiatives, the changes in practices, the outcomes achieved, and the challenges encountered between 1995 and 2018.

Semi-structured interviews. The archival data analysis helped to design semi-structured interviews. Interviews were conducted in three rounds, between 2014 and 2018. We interviewed a diverse sample of people, capturing different levels of seniority, organizational tenures, and functions. In total, we conducted 21 interviews representative of the following departments: **Digital Communication**, **Research**, **Curation**, **Education**, **Exhibition**, **Marketing**, and **Commercial** functions. The selection of our interviewees was aimed at collecting data from **directors** or **project managers** which were in a good position to be informed about the relationship between digital technologies adoption and organizational changes. Typically interviews lasted around one hour. In order to ensure reliability, two researchers were present at all the interviews. All interviews were tape-recorded (excluding four due to lack of authorization). However, detailed notes were collected, and after each interview, they were compared, integrated and transcribed. Following Miles and Huberman's prescription (1984), transcriptions were supplemented by contact summary sheets reporting essential data and insightful quotations that could help future theorizing.

6.2.2 Data Analysis

As is typical of case-based research (Yin, 1984), the analysis started by systematically reconstructing the history and the timeline of the VGM organizational functions. For each annual report, we engaged in an intensive, fine-grained reading of the data (Strauss and Corbin, 1990), generating a large dataset of in-vivo codes. Redundancies were iteratively consolidated, and the evolution of the VGM's organizational structure was gradually reconstructed. Specifically, we followed the strategy of "**analytically structured history**" that involves the identification and use of analytic constructs (e.g., digital connectivity in our specific case) "to search archival sources, enabling the construction of a narrative of structures and events that may not even have been perceived as such by actors at the time" (Rowlinson, Hassard, & Decker, 2014, p. 264). The upper rows in Table 8 (presented in the findings section) show our measures of digital connectivity adoption at VGM.

In the second analytical step, we carried out multiple rounds of coding of primary data to identify the most relevant key digital initiatives, the changes in practices, the outcomes achieved, and the challenges encountered. Two researchers conducted this step independently and generated the first-order codes resolving occasional differences through discussion.

In the third analytical step, we focused on disentangling the linkages between our primary and secondary data to build a coherent understanding of the VGM's adoption of digital technologies and the VGM's organizational transformation. In doing this, we triangulated primary and secondary data to delve into the relationship between digital connectivity and organizational changes in terms of new digital-native roles, new departments in charge of new digital-native activities, and new resulting work practices and lateral communications mechanisms. Once the concept development process led to theoretical saturation (Glaser and Strauss, 1967), we distilled the emergent organizational changes even further into the VGM's co-evolutionary dimension of digital connectivity and organizational changes.

The findings of the study are presented in the next section.

6.3 Findings

Table 8 shows the findings of the study with the reference of the key technology initiatives and the changes in the organizational structures observed between 1995 and 2018 in the Van Gogh Museum.

6.3.1 Period 1 (1995-2001): two core-line functions

In 1994, the museum changed its legal entity and assumed the status of a private foundation that included the Dutch state among its shareholders. The status of private foundation gave the museum more autonomy and flexibility compared to public museums in investments and hiring plans for new personnel (Annual Report, 1995). In 1995, after becoming a private foundation, the museum's organization structure consisted of **two-line functions**, namely the "**Collection**" and "**Exhibition and Display**" and counted 135 employees (Figure 9). Within these functions, the grouping of departments was based on the work process and function. The "**Collection**" included four departments, *Curation*, *Research*, *Preservation,* and *Library*, and was responsible for the preservation, the ongoing research and the organization related to the Van Gogh's artworks and the knowledge related to such artifacts. The "**Exhibition and Display**" function was a front-end function and was accountable for art dissemination. It included the departments of *Exhibition*, *Education*, *Register* and other functions responsible for relationship management with visitors and external stakeholders (e.g., public relations, press, visitor assistance in the museum). **Commercial Affairs** was responsible for sales of merchandise (e.g., posters, books, T-shirts, cups) and was partially outsourced to an external supplier given the marginal weight in the museum's revenue structure.

In 1999 the word "Internet" appeared for the first time in the corporate Annual Report to report the creation of the first corporate website. Initially, the website was intended as a channel where information and digital images about artworks. The size of the collection exhibited online was limited, and the digitized copies of artworks were shared in low resolution. The digitization of artwork was carried out by an external photography studio. Moreover, captions and narrative comments were limited and available only in Dutch.

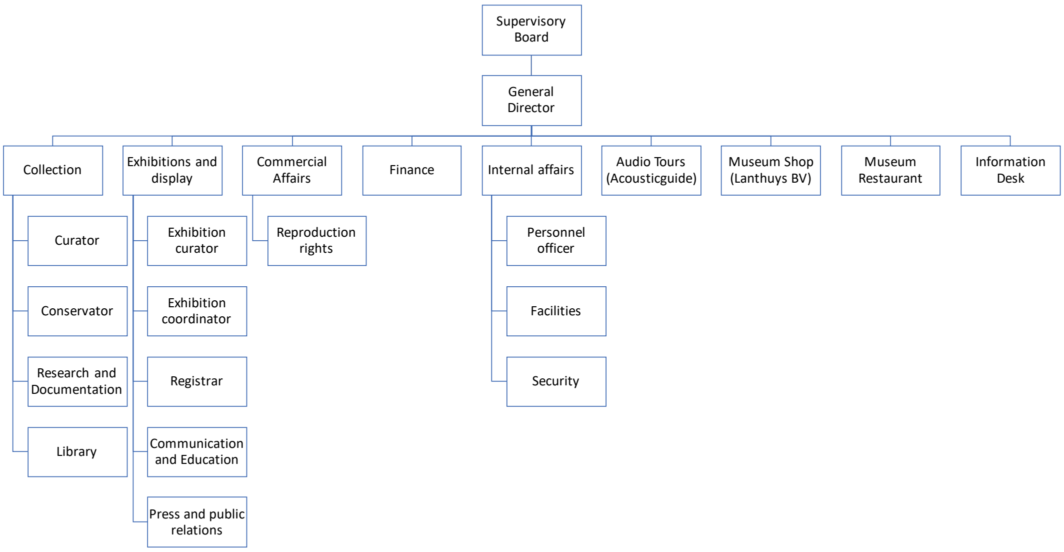


Figure 9 - The organizational structure of the Van Gogh Museum in 1995

6.3.2 Period 2 (2001-2005): the commercial function

The years between 2001 and 2005 were subject to incremental changes in both the digital technology infrastructure and in the organizational structure.

The collection available on the website was further expanded in 2001, and a virtual tour – linking some of the artworks digitized – was added. The expansion of the collection accessible online prompted the need of creating a second educational department specialized on contents made accessible on the Internet. The "*Education and the Internet*" department was thus separated from the traditional *Educational Department*, which kept its specialization on developing contents for school programs (Figure 10).

Also, the "**Van Gogh Museum Enterprises BV**" (henceforth VGME) was founded with the mission of being the commercial and for-profit arm of the Van Gogh Museum. This enterprise was responsible for commercializing products and services to be offered under the Van Gogh Museum brand name.

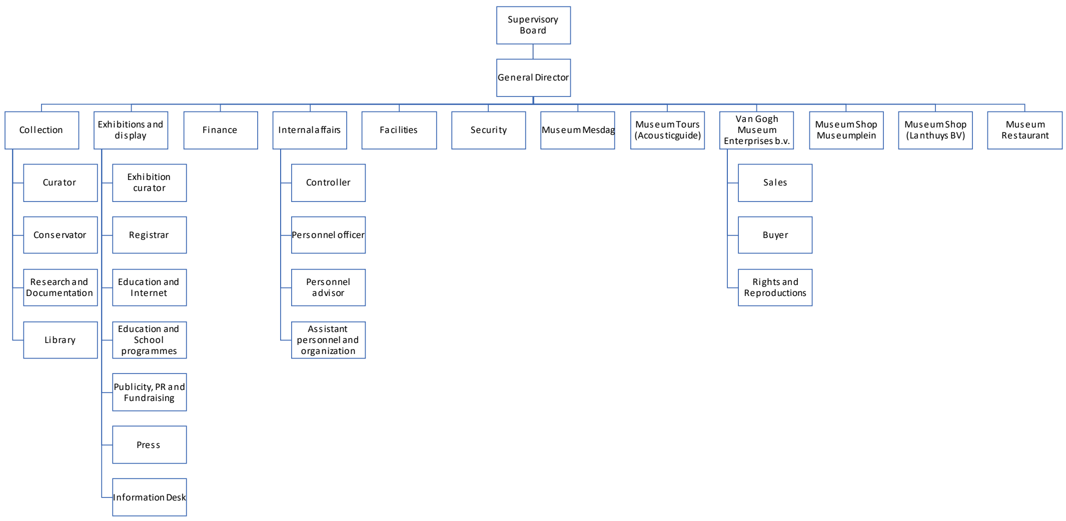


Figure 10- The organizational structure of the Van Gogh Museum in 2001

6.3.3 Period 3 (2005-2010): functional specialization and Web 2.0

The year 2005 represented a first turning point, with the appointment of a new General Director, Axel Rüger. After the appointment of the new General Director, the **organizational structure was changed with line functions shifting from two to four** (Figure 11). In the same period, the number of visitors increased (from 1,338,105 in 2004 to 1,417,096 in 2005) and contextually the size of the workforce employed in the museum (from 140 to 166 employees). As reported in the 2005 Annual Report:

> *"The total number of visitors to the museum in 2005 – 1,417,096 – is one of the highest in our history. As a consequence of the rise in visitor numbers and further expansion of service and commercial activities, the number of staffs at the museum has risen considerably in recent years. It is no longer possible to accommodate the entire staff in the museum building, so various departments have in the past been moved to another location." (Axel Rüger, GD)*

The new grouping mechanism in the operating line resulted in an increasing level of functional specialization for the **Research** department. Furthermore, the upward shift in the hierarchy of the Research department translated into an increasing power as the head of this unit reported directly to the General Director and no longer to the head of the Collection department. Thus, the head of Research became part of the executive team. The same change happened to the **Exhibition** department, which shifted from being reported to the "Exhibition and Display" function to becoming an autonomous line function. It is worth noting that the **Publications** department shifted from a support staff activity to the line, becoming a unit of the **Communication** function. The fact that Research, Exhibition, and Communication were now moved under the direct supervision of the General Director enhanced the level of **inter-department coordination**, as stated by the General Director, Axel Rüger, in his Foreword of the 2005 Annual Report:

> *"The decision to re-organize was prompted by the desire to improve internal communication and promote interdepartmental collaboration. All parties concerned are extremely enthusiastic about the new structure." (Axel Rüger, GD)*

Lastly, an additional change occurred with the transformation made in 2005, when the "**Marketing and Business Development**" group was created in the staff function.

The years between 2005 and 2008 were subject to incremental changes in the organizational structure, too. In 2007, a **temporary liaison role** was created on a project basis to facilitate **coordination** among departments, and an Intranet initiative was taken. In 2008, the museum acquired a private for-profit company – Lanthuys BV – running part of the sales of the official museum's merchandise. From a technological adoption standpoint, changes were more substantial and consisted in the creation of the Web 2.0 channels. The museum created official profiles on various social media channels including Facebook and Flickr, a YouTube channel, and a blog where the content about Van Gogh's letters where periodically realized in a simple and visitor-friendly way. The importance of Web 2.0 technologies to sustain the museum's accessibility and enlarge its reach was communicated in the museum's vision presented in 2009-14 Strategic Plan:

> *"The Van Gogh Museum reaches as many people as possible worldwide, including non-visitors, and forges a strong bond with its audience by offering a stimulating, enriching and visitor-friendly experience." (Strategic Plan 2009-2014)*

The Strategic Plan set the field for the period between 2008 and 2010 with no substantial changes in the organizational structure and the grouping mechanisms. The main remarkable change was the increased specialization and professionalization of the **Marketing** function, which had the role to understand visitors' behavior and to segment them accordingly, as expressed in the 2009 Annual Report:

> *"In 2009 the Marketing Department was set up to respond more effectively to the expectations of Dutch and foreign visitors. The*

department was sub-divided into three areas: Visitor Research & e-Marketing, Trade Marketing & Sales and Operational Marketing. The activities of the marketing department were set out in the 2010-2013 marketing strategy. Visitor research provides information about visitor behavior, make up, motivation and satisfaction." (Annual Report, 2009)

Between 2008 and 2010, the **digital technology adoption** registered substantial investments. In 2008 the e-commerce store was launched. Specialists in digitization were hired, and a photography studio was created within the **Research** department in order to start the digitization process in high-resolution of the entire collection. As stated in the 2010 Annual Report, the intended ultimate beneficiaries of such digitization process were researchers as well as the wider public:

"We are now working on an image archive which contains, in addition to a standard high-resolution master file, photographs taken in raking light and shots of details in very high-resolution, making it possible to zoom in to show a single brushstroke. These images offer new opportunities for research and for the development of applications for the public." (Annual Report, 2009)

Between 2009 and 2010, 60% of the entire collection was digitized in high-resolution. Contextually to the effort spent in digitization, in 2010 the museum started investing in indexing technologies, with the purpose of better organizing the digitized artworks, connecting them with the information available in the library and enriching them with narrative contents. As stated in the 2010 Annual Report:

"Rapid technological developments are also offering the Van Gogh Museum new ways of providing products and services better, faster and more simply to an even broader group of interested people. In 2010 much work was done to make information about the collection from the many existing sources accessible through a single new Collection Information System (CIS). The new Adlib Library application was also used for the first time. It establishes connections between library items and collection items and provides better functionality for the scholarly user. Once the implementation of a Data Asset Management (DAM) system has been completed, the museum will have a state-of-the-art management system available for digital images and files about the objects in the collection." (Annual Report, 2010)

In the same years, the museum spent an increasing effort on Web 2.0 technologies to increase its accessibility coherently with the Strategic Plan 2009-2014. As reported in the following statement of the 2009 Annual Report:

"In 2009 there was more work on the expansion and strengthening of national and international networks through the use of social media like Twitter and Facebook. These activities support the museum's strategic objective – to cover a broad range accessible to as large a group of people as possible. As part of the campaign to make the public aware of Van Gogh in an accessible way, we launched the Van Gogh blog www.vangoghsblog.com*, in which Vincent van Gogh talks about the places he visited, the art he saw and the things that inspired him. By linking an RSS feed to Twitter and Facebook, the blog updates were automatically distributed to thousands of national and international followers." (Annual Report, 2009)*

A further step in the direction of increasing external reach through digital technologies and exploring new features given digital imaging technologies was taken in 2011, with the museum participating in a pilot project of collaboration with the **Google Art Project**, a web-based platform aimed at hosting digitized artworks and related contents from 17 leading museums in the world.

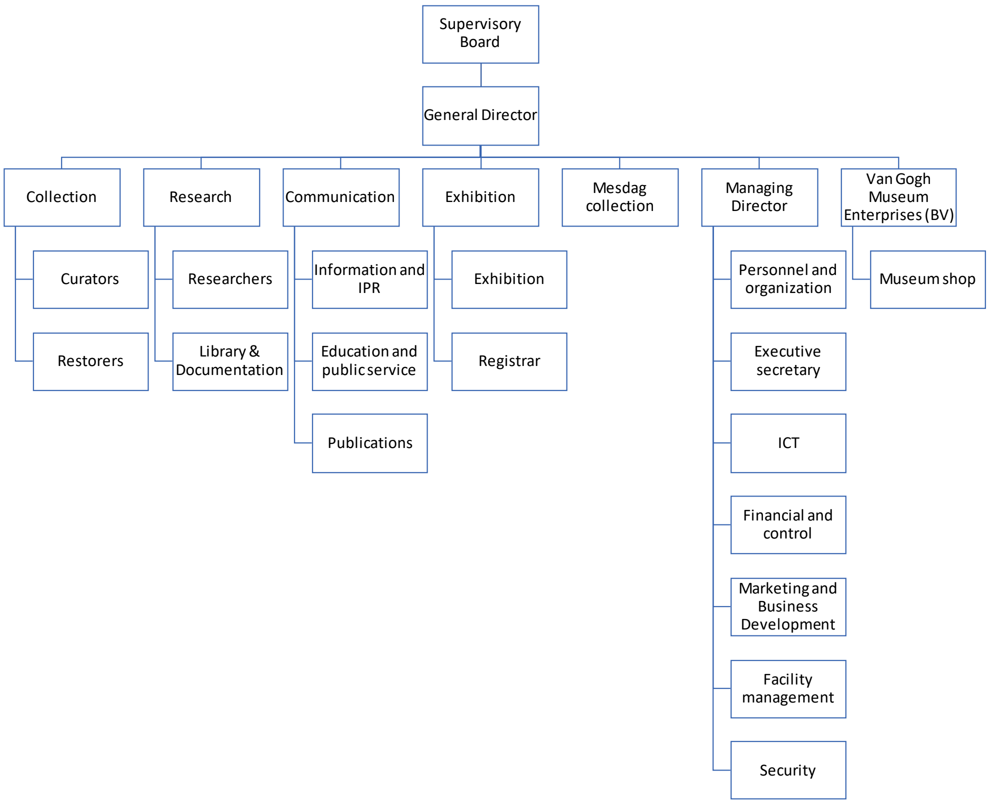


Figure 11 - The organizational structure of the Van Gogh Museum in 2005

6.3.4 Period 4 (2011-2016): research-driven and externally-oriented

After six years of relative stability in the museum's organizational structure, substantial changes occurred in 2011. **Line functions were reported from four to two** (Figure 12). Departments of Curation, Research, and Education were grouped into a back-end unit, the "**Museum Affairs**." A front-end, externally-oriented, unit, the "**Public Affairs**", was created and included among the others the *Communication*, the *Education*, the *VGME*, *Marketing* department. In the new structure four main changes were observable:

- Curation and Research were grouped together in a brand-new "*Art Department*";
- Education shifted from being part of the Communication function to be in the back-end, grouped closely to "*Curation and Research*";
- A "*Collection Management*" department was created, being accountable for the conservation and restoration of the collection
- *Marketing* shifted from a staff to a line function, being grouped under the **Public Affairs** function.

The change in the organizational structure of the museum around two poles/units took place in a context in which the organization was required to become more **research-driven** and more **externally-oriented** at the same time. Specifically, in the 2010 Annual Report the General Director reported what follows:

> *"The Museum Affair is tasked with expanding and deepening our knowledge of Van Gogh, his time and his contemporaries, and with making the collections and our knowledge accessible to a worldwide public." (Axel Rüger, GD)*

The creation of a department in which *Curation* and *Research* were grouped and the shift of *Education* close to this department **increased the level of integration** between research, curation and education activities, which were grouped closely.

> *"Close collaboration between the exhibition's creators and the educational staff and developments in digital technology enabled us to experiment and so to reach new audiences. Targeted external marketing and communication initiatives helped keep the public informed about the museum's program and encouraged them to take a virtual tour of the Van Gogh Museum." (Annual Report, 2010)*

Also, the *Education* department played a prominent role in increasing the outreach of the museum dissemination about its permanent collection:

> *"The collection is being made accessible to people who may not be able to visit the museum in person via an increasing number of projects. For example, a start was made on the development of interactive digital teaching materials, following requests from teachers for lessons on Van Gogh that can be conducted in the classroom." (Annual Report, 2010)*

In the early 2010 communication via Twitter grew faster. To reinforce the engagement on the Twitter channel, the museum started the "**Ask the Curator**" initiative, a once a day per year special twitter session in which six curators and researchers of the museum interacted via Twitter with the general public answering questions. For such event, curators were "virtually overwhelmed with questions" as reported by Axel Rüger in the 2010 Director's Foreword.

In the period between 2012 and 2014, there were no changes in the linking and the grouping mechanisms of the museum's organizational structure. By contrast, digital adoption initiatives kept on growing. In 2012 the **Education** department created the first online game on Van Gogh designed for kids (and awarded from the European Design Institute). The official museum' Instagram channel was launched in 2013. Also, in 2013 through a partnership with Fujifilm, the museum could create 3D printed reproductions of some artworks. Such reproductions had essentially two goals. The first was related to increasing the reach of the museum. Visitors were allowed to touch parts of the 3D reproductions so that they could feel and experience the structure of the canvas. This was particularly valuable for using 3D replicas in education (e.g., within schools) and to help blind and visually impaired people experience Van Gogh's works. The second goal was related to monetization. Certified reproductions could be printed and sold on-demand for prices about 22,000 euros.

In 2014 a new Strategic Plan covering the 2014-17 horizon was released. Compared to the previous plan, the new document was more complex (24 pages compared to the one-page plan of 2004-2009), confirmed the importance of accessibility and reach, and added a third objective, related to growth in income. As reported in the Strategic Plan mentioned above, the General Director stated:

> *"Besides the core assignment of the museum, the focus for the coming years will lie with three strategic pillars: accessibility (including the building of the new entrance and the new layout of the physical gallery), reach (including web strategy and social media) and income (including new business models)." (Strategic Plan, 2014-2017)*

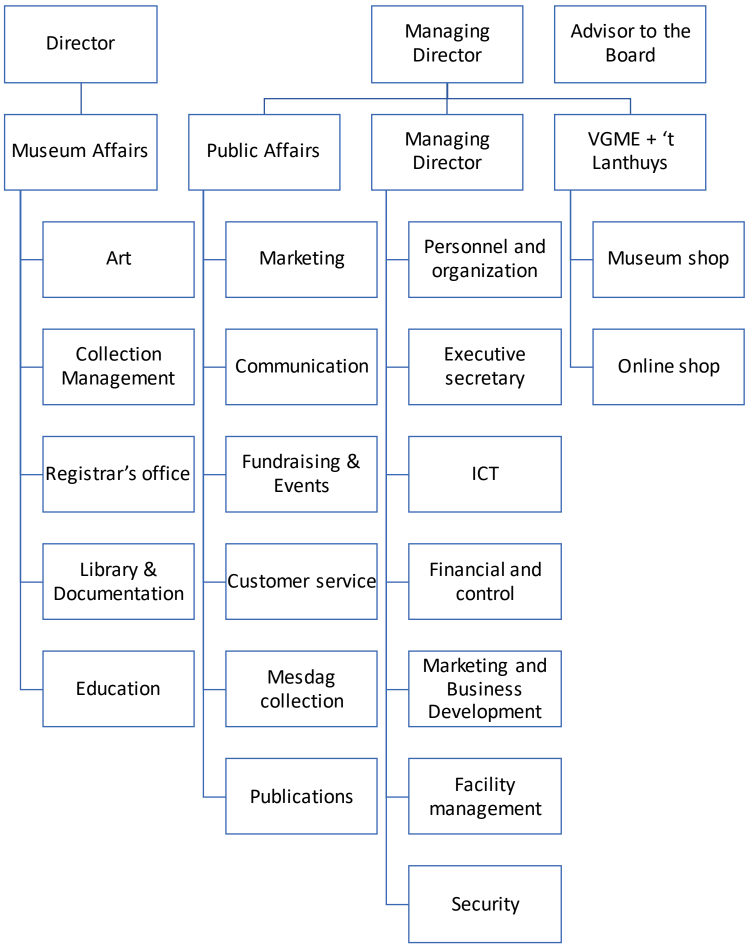


Figure 12 - The organizational structure of the Van Gogh Museum in 2011

6.3.5 Period 5 (2016-2018): new skill profiles and new digital roles

In 2016, the Van Gogh Museum announced a radical overhaul of its organizational structure (Figure 13). **Line functions from two (Museum and Public Affairs) became three**. Specifically, the Van Gogh Museum Enterprise, which was previously controlling the physical and the online stores, became a separate function that along with the museum's stores grouped together brand-new departments specialized in commercialization. Such departments included *e-Commerce*, *Retail*, *Buying and Merchandise*, *Business-to-Business activities*, *Logistics and Planning*, and *New Businesses*. The creation of these new departments led the museum to invest in **new skill profiles and roles**. As stated out by the Director of the Van Gogh Museum Enterprises Ricardo van Dam in the 2016 Annual Report:

> *"2016 was a very important year for the organization. Significant investments were made in knowledge and skills, notably in the field of retailing and e-commerce, with the recruitment of new specialists from both within and beyond the museum sector." (Ricardo van Dam, VGME)*

As a direct consequence, a fourth member - the Director of the Van Gogh Museum Enterprises BV (VGME) – was added to the management team.

Along with new departments focused in commercialization, a new ***Digital Communication*** department was created within the Public Affairs unit. The digital communication team was accountable for creating, managing and monitoring social media campaigns addressing the interest of special interest groups and stimulating the interaction with the public on social media. The other main activity of the digital communication team regarded the museum's website. As explained by the Head of the Digital Department, Martijn Pronk:

> *"The fans of Vincent van Gogh are spread all over the world. We stay in touch with them via social media: past and future museum visitors as well as all those not able to travel. We connect millions of people to Vincent's art, his letters and his incredible life story." (Martijn Pronk, Head of the Digital Communication)*

A primary specialization of the Digital Communication department was to differentiate content by type of social media. As stated by the Head of the Digital Communication department in the 2018 International Symposium on "Digital Innovation in Museums":

> *"You need to have the right content on the right platform for the right people, and you must look at the features of each platform. For instance, when you want to provide "touch" content in a very user-friendly way you can use an Instagram story. You could also think of email newsletters if you have things to say about new workshops. LinkedIn is very nice for all kinds of corporate information." (Martijn Pronk, Head of the Digital Communication)*

The organizational structure was adjusted in 2017, in what was the ultimate result of the Organizational Development Program. The Public Affairs and Museum Affairs sectors were both now put under the responsibility of the General Director (Public Affairs was previously the responsibility of the Managing Director). The Operations sector and Van Gogh Museum Enterprises BV were now the responsibility of the Managing Director.

In 2017 a department related to "*Business-to-Business*" relationship was added to the Van Gogh Museum Enterprise and was made accountable of managing the relationships with external partners specialized in the creation of digital content that were developed starting from the digitized images made available by the museum through an **open data regime**. The B2B department runs the task of selecting and promoting (by giving visibility in the online museum channels) multimedia contents developed by a specialized company. The *Digital Communication* department had the task of finding the right way to make this content visible on the various web channels. For example, computer graphics experts of Motion Magic made a virtual, animated, 3-D version of the Van Gogh's

Starry Night, making it possible for viewers to explore the world of Van Gogh. The animated video was shared on the museum's Facebook page. As reported in the 2017 Annual Report, the Van Gogh Museum was the first museum in the world to sign a licensing agreement with **Alibaba**, the leading online retail platform for the Asian world.

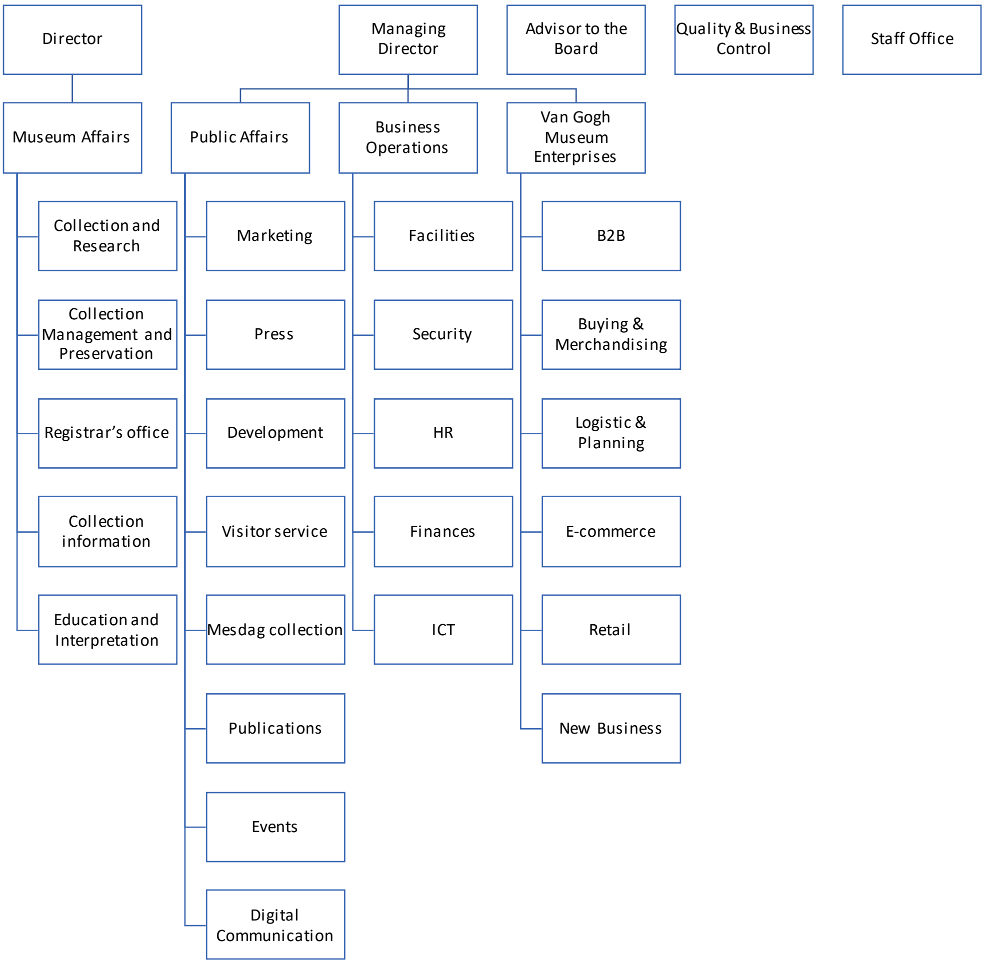
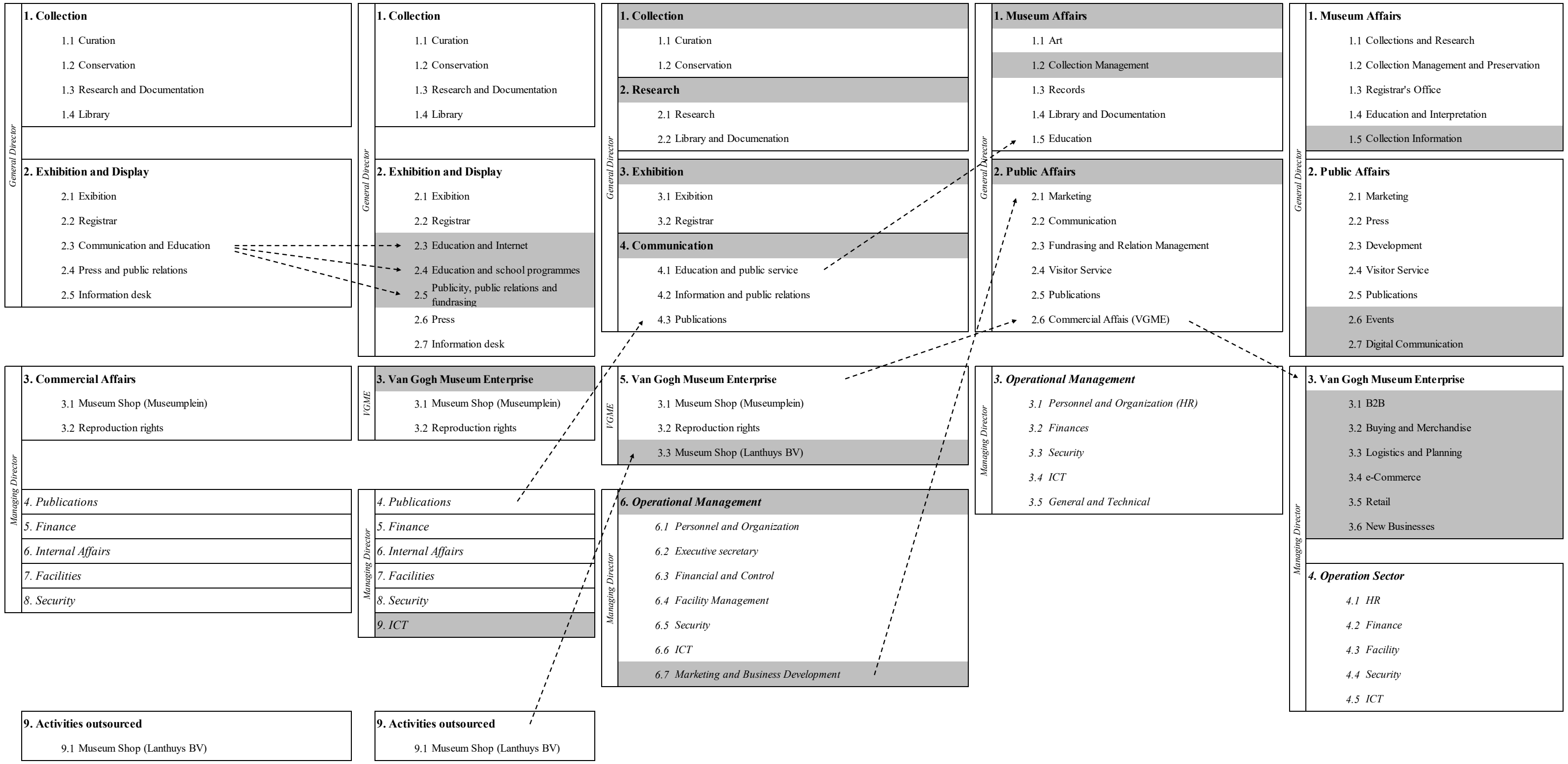


Figure 13 - The organizational structure of the Van Gogh Museum in 2016

Table 8 - Co-evolution between digital connectivity and organizational changes of the Van Gogh Museum from 1995 to 2018

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Technology adoption		audio tours			website					e-ticket			multimedia tours	e-commerce	social media	digitization	indexing	games	3D Instagram	app		Osiris camera		
Connectivity (Annual Report)	-	-	-	-	5	4	7	3	11	11	8	2	27	23	10	29	24	19	14	45	30	32	41	-
Connectivity (Strategic Plan)															-					11				36
Digitization (Annual Report)	1	-	-	-	-	-	1	-	-	1	1	1	7	8	5	9	9	11	10	11	9	11	22	-
Digitization (Strategic Plan)															-					17				55



6.4 Discussion

The analysis of the findings allows to identify some patterns in the VGM's digital transformation. Traditionally the VGM has been organized into departments that each reflects a unique role within the museum. Curators responsible for the collection and research were in one department and were defined with the language used by our informants "**people who love objects.**" Those who interact with the members of the public are in another and were defined with the language used by our informants "**people who love people.**" Visitor services such as retail and the shop are in yet another and were defined with the language used by our informants "**people who love money.**" Table 8 shows that over time in parallel with the growth of the level of digital connectivity, the VGM increasingly groups its organizational units into **knowledge output-oriented functions** (Figure 14): i.e., **knowledge creation** ("Museum Affairs"); **knowledge communication** ("Public Affairs"); and **knowledge commercialization** ("Van Gogh Museum Enterprise"). **These new functions connect once disconnected organizational units and roles** in order to create decision-making and departmental structures that are more relevant, more networked and more efficient. For instance, Research, Curation, and Education are now grouped together in Museum Affairs while in the past they belonged to different departments. Furthermore, the newly defined functions became also more **tightly coupled** both internally, and with other departments.

> *"In 2010/2011 we implemented a new organizational structure in which each sector has equal status. Each sector has its own specific role, but all work together to create maximum synergy. [...] Connection and balance are sought in every sphere and at every level." Adriaan Dönzelmann, MD (2016)*

> *"The content is defined by research, made available by the collection information staff, reinterpreted by the education department and co-developed with the digital communication team." Jacqueline Duerinck, Head of the Digital Department (2016)*

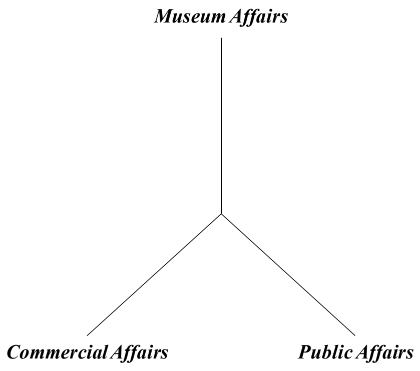


Figure 14 - Knowledge output-oriented functions at the Van Gogh Museum after 2016

The need for tight integration is often motivated by the need for addressing **more quickly** the rich spectrum of customer needs and preferences enabled by external digital connectivity, often in the form of social media campaigns. In this vein, digital connectivity become a thread that runs through the entirety and all departments become responsible for engaging with the visitors. For example, collection and research departments (i.e., people who love objects) were responsible for researching and documenting the collection, but through digitization and connectivity they become also responsible for making that collection accessible online and tracking by whom and why this content are accessed.

> *"The curators at the Van Gogh Museum are encouraged to carry out research and make their findings accessible to our visitors. Close collaboration between the exhibition's creators and the educational staff and developments in digital technology enabled us to experiment and so to reach new audiences". (Annual Report, 2010)*

In this output-oriented configuration, digitization and connectivity become the threads that run through the entire organization, and all departments become responsible for engaging with visitors in new ways. However, as digital technologies become quickly embedded in the entirety, they have also introduced new roles and responsibilities associated with digital throughout the organization. Among these, the **Head of IT** (responsible for the planning, staffing, and operations of the VGM's IT infrastructure), the **Digital Content Manager** (responsible for developing, maintaining and promoting information architecture for digital content throughout the VGM), the **Collection Information Manager** (responsible for administering, expanding, and integrating collection information systems to meet the VGM's digital strategy goals), the **Social Media Manager** (responsible for overseeing the VGM's conversation with visitors on all social networks that may be relevant for the museum), the **Digital Archivist** (responsible for the process of digitizing written, visual, and physical content held by the VGM), the **Web and Digital Media Developer** (responsible for the website and browser-based utilities), the digital content producer (skilled in multimedia authoring), the **Data Scientist** (responsible for collecting qualitative or quantitative information that can support the ability of the strategy and individual projects to meet KPIs), and the **eCommerce Manager** (responsible for planning new initiatives to increase revenue with a clear focus on customer experience).

To further foster communication across these new digital roles and the new **knowledge output-oriented functions**, a new organizational role – i.e., **Digital Communication** – acts as "**dotted line**" coordination mechanism to liaise internal functions among themselves and with external "stakeholders" (Figure 15).

"As Digital Communication department we want to surprise people and to inspire them. However, we do not produce digital products ourselves, but in close cooperation with our internal and external partners. There are always colleagues involved, like curators, educators and researchers with knowledge of our collection and the person Vincent van Gogh, together with members of our online team. ***We are the new kids on the block****." (Martijn Pronk, Head of the Digital Communication department, 2018)*

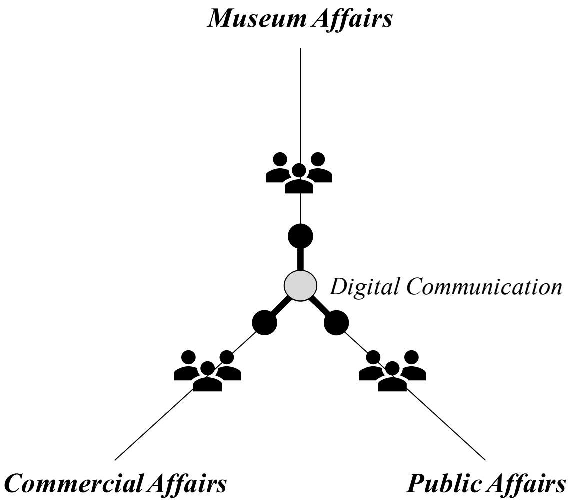


Figure 15 - The liaison role of the Digital Communication department at the Van Gogh Museum

The scope of these digital roles tends to be eroded since **digital work practices** become quickly embedded in the job specifications of the legacy roles. For example, those in charge of the VGME (i.e., people who love money) may still primarily be focused on revenue generation, but they need to do this by cleverer forms of engagement such as crowdsourcing and ecommerce. In the same way, crowdsourcing can be used to expand knowledge, to develop new products and services, and to raise money (crowdfunding), while ecommerce offers a great opportunity of collecting visitor data that can be fed back into all departments.

"With digital technologies impacting a growing range of verticals within the organization, departments across the organization are required to adapt to digital, and not just a single department. The end goal is not to have a digital department, but for an institution to use digital effectively to achieve its mission." (Martijn Pronk, Head of the Digital Communication department, 2018)

In other word, as digital become the "**new organizational baseline**", it is likely that specific digital jobs will fade away, and technical skills and scientific literacy will be expected form everyone. In this vein, the detailed analysis of our rich dataset, allows us to observe that **digital connectivity augments an (already) existing tension in the organization**. On the one hand, the new organizational structure improves organizational **effectiveness** and **efficiency**. However, increased teamwork has also the side effect to **decrease organizational diversity**.

> *"[...]That being said, an element of modesty should be retained: the Van Gogh Museum workforce still insufficiently reflects the cultural diversity of our society. There are still great gains to be made in this regard." (Martijn Pronk, Head of the Digital Communication department, 2018)*

> *"The world around us is changing rapidly. Cultural diversity is increasing, society is aging, and digitization of our world marches forth. How do we ensure that the museum reaches all sections of society and remains relevant to society as a whole? How can we utilize the ever-increasing digitization to reach and inspire more people all over the world? [...] One of the objectives of personnel policy is focused on* ***increasing employee diversity*** *throughout the organization" (Strategic Plan 2018-2020)*

The external dimension of digital connectivity – i.e., its enabling wider external reach – implies the need to address an ever-increasing distribution of customer preferences and interests of anywhere and anytime. This requires more collaboration, and thus, more cross-fertilization among the different competences of the organization.

> *"Being aware of Robin, Ryan, Pauline and Zhang's preferences, interests, tastes, attitude to life and motivation [should] allow[s] us to better cater to their needs and anticipate their behavior. The requirements of visitors from all over the world – with regard to a variety of aspects including the cloakroom, café menu, educational programmes and the design of the exhibition spaces – can all be traced back to these four main profiles." (Annual Report, 2017)*

As such, organizations now face the new challenge of tapping into **increased outreach** while experiencing **decreasing internal diversity**. On one hand, digital connectivity augments the efficiency of the knowledge generation process, increasing internal interfaces among the different organizational units (Garud and Nayyar 1994; Antonelli 2017). On the other, digital connectivity reduces diversity in knowledge exchange through codes of practice and standard operating procedures (Ferner et al., 2012) that make processes and functions interconnected and inseparable from one another, thus changing the structure of organizational diversity (Luo et al. 2012). The consequences of this new tension can also be observed in other companies. For example, a case in point here is **Facebook** whose well documented internal "monoculture" (Conger & Frenkel, 2018) is perhaps one the key reasons underpinning some of the recent scandals and the decreasing grip with the new emerging market categories – e.g., millennials.

6.5 Conclusion

By analyzing a rich dataset of hand-collected primary and secondary data around the digital transformation of the Van Gogh Museum, the study shows that the dual (internal/external) nature of digital connectivity triggers some novel organizational dynamics. First, to increase responsiveness vis-à-vis the augmented spectrum of customer needs, the VGM re-organized its functions by **knowledge output**. Second, the liaison digital roles created in the organization seem to be **temporary** and mostly geared towards enabling the transition of the organization into a "**new organizational baseline**." Third, and perhaps more fundamentally, the VGM is now facing an **augmented tension between the need to address a broader spectrum of customer needs while experiencing decreasing organizational diversity**.

Taken together, the results of the study contribute to the emergent literature on connectivity (Kolb, 2008; Kolb et al., 2012), digital materiality (Bailey, Leonardi, & Barley, 2012; Leonardi & Bailey, 2008; Orlikowski & Scott, 2008) and organizational trade-offs (Lewis, 2000; Schad, Lewis, Raisch, & Smith, 2016; Smith & Lewis, 2011; Wilson, O'Leary, Metiu, & Jett, 2008). As for all single case studies, generalization should be made with a note of caution. Nevertheless, the VGM seems to be representative of a wider set of organizations in **knowledge-intensive sectors**. Future research in other organizational contexts, however, is needed to produce more fine-grained insights.

6.6 Summary of the section

By hand-collecting data from several primary and secondary sources, with reference to the 1995 – 2018 period, the study presented in Chapter 6 documents the relationship between adoption of digital technologies that enable connectivity in and across organizations and the organizational transformation of the Amsterdam's Van Gogh Museum (VGM). Overall, the results show that the VGM's organization evolved to incorporate and leverage the capabilities that digital connectivity offers – e.g., **increased out-reach**; **increased real-time organizational interdependencies**. Specifically, the study highlights that in response to the dual **external/internal** nature of digital connectivity, the VGM re-organized itself in functions grouped by **knowledge output** – i.e., knowledge creation ("Museum Affairs"); knowledge communication ("Public Affairs") and knowledge commercialization ("Van Gogh Museum Enterprise"). Furthermore, the study shows that digital technology adoption triggered the creation of several new organizational "**liaison**" roles, which however have been quickly incorporated into "**new organizational baseline**." Finally, and fundamentally, the results show that digital connectivity triggers a **new organizational tension** between the need to address a broad spectrum of customer needs while experiencing decreasing organizational diversity.

Chapter 7

Towards an integrative framework

The integrative framework presented in this chapter draws on a working paper (Lanzolla, Pesce and Tucci, 2019) and predicts the likely scope of search and recombination mechanisms vis-à-vis digitization of the innovation function. The developed framework is then tested and discussed in the empirical context of the cultural heritage sector.

7.1 Introduction

The analysis of the literature on search and recombination mechanisms – Building Block 1 in Chapter 2 – has shown that innovation governance and absorptive capacity have a pivotal role in search and recombination mechanisms which are at the core of innovation scope.

The analysis of the literature on digitization and connectivity – Building Block 2 in Chapter 3 – has shown that the sheer adoption of digital technologies sets into motion some "inertial" organizational changes – i.e., organizational changes that come from the adoption of the technology itself and which manifest themselves unless other forces (managerial or non-managerial) change their inertia.

How these "inertial" organizational changes may affect the likely scope of search and recombination mechanisms is investigated in the empirical context of cultural heritage in Chapter 5 and Chapter 6. On one hand, in Chapter 5, the comparative case study between the two leading digital platforms in the cultural heritage industry – **Google Arts & Culture** and **Europeana** – has shown the effects of digitization and connectivity on the likely scope of search and recombination mechanisms for network-centric (or platform-based innovation). The results highlight how in such context the innovation is shaped by horizontal structures where independent actors together shape value in a non-liner way, thus answering the sub research questions RQ1.1 and RQ1.2. Specifically, the study points out that a crucial element to create value form network-based innovation enabled by digitization and connectivity is the capability of aligning different stakeholders' interests and reveals the system integrator role that Google has assumed in the cultural ecosystem. Overall, the study strengths the idea that digitization and connectivity generate new tensions for cultural organizations in the way they create value for the cultural sector by means of search and recombination mechanisms and provides a base to continue the investigation on other ecosystems shaped by digital transformation.

One the other, in Chapter 6 the in-depth longitudinal case study of one of the world-leading cultural organization – the **Van Gogh Museum** (VGM) in Amsterdam – has shown the effects of digitization and connectivity on the likely scope of search and recombination mechanisms for firm-centric (or hierarchy-based) innovation. The results highlight how in such context the innovation is shaped in vertical structures where value is created in linear processes governed by behavioral control mechanisms, thus answering the sub research question RQ2.1. Specifically, the study documents the relationship between digitization, connectivity, and the organizational transformation of the VGM. Overall, the results show that the VGM re-organized itself in functions grouped by **knowledge output** – i.e., knowledge creation, knowledge communication, and knowledge commercialization – to incorporate and leverage the capabilities that digitization and connectivity offers. Also, the study shows that digital technology adoption triggered the creation of several new organizational "**liaison**" roles, which however have been quickly incorporated into "**new organizational baseline**." Finally, the results show that the digital transformation of the VGM, by means of digitization and connectivity, triggers a **new organizational tension** between the need to address a broad spectrum of customer needs while experiencing decreasing organizational diversity. In this vein, the VGM seems to be representative of a wider set of organizations in **knowledge-intensive sectors** (e.g., journalism, music, banking, etc.).

Below, the two building blocks are integrated into a systematic framework that predicts the likely scope of search and recombination mechanisms vis-à-vis digitization of the innovation function and proposes how the "inertial" organizational changes, all else being equal, may affect a company's innovation governance and absorptive capacity and, in turn, the scope for open innovation. The theoretical framework is discussed on the theoretical and managerial implications for the cultural heritage sector.

7.2 The digital transformation of search and recombination mechanisms

First, as discussed above, on one hand, digitization and connectivity might increase **formal control** and **centralization** in the governance of the innovation process. On the other, digitization and connectivity might enable **informal and distributed governance** of the innovation process. These opposite potential outcomes on the governance processes are represented on the **vertical axis** of Figure 16.

Second, the analysis of the literature on digitization and connectivity in organizations points to **three** inertial effects which may have contradictory impacts on an organization's absorptive capacity. On one hand, digitization and connectivity might **enable more formalized knowledge**, **better understanding of the linkages among pieces of knowledge,** and **better communication flows**. These effects are often associated with an **increase in the scope of an organization's absorptive capacity**. On the other hand, the net effect of digitization and connectivity might be an **increase in complexity**, **new tacit knowledge**, and **new communication silos**. These effects are often associated with an **absorptive capacity that decreases in scope**. These opposite potential outcomes are represented on the horizontal axis of Figure 16.

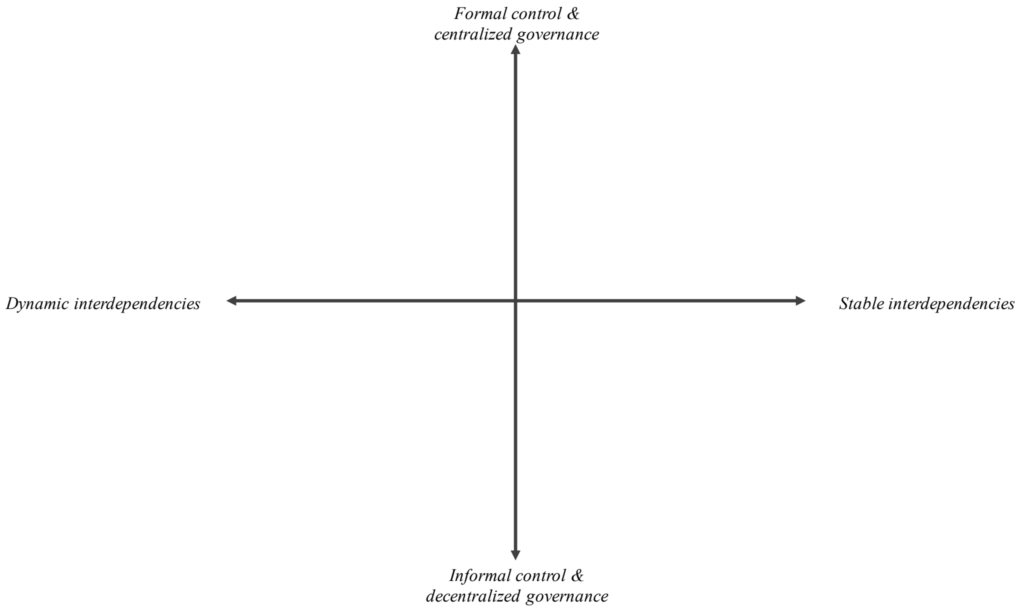


Figure 16 - Towards an integrative framework of the digitalization of search and recombination mechanisms

Third, digitization and connectivity **change the distribution of skills in the innovation function**. The empirical analysis in the cultural heritage sector (and casual reading of the news, e.g., Gadri 2017; Evans 2018) shows that organizations equip themselves with more and more digital skills. On one hand, the addition of digital skills to the organization adds to the **diversity** of the organization, which in turn may **increase absorptive capacity**. The combination of digital skills with existing knowledge bases to form new approaches to innovation – such as the digitalization of the cultural heritage but also the digitalization of the biology sector (i.e., biotech), of the medicine sector (i.e., medtech), and the finance sector (i.e., fintech) – witness the extent to which this increased diversity might bear fruit. On the other hand, if digital skills and legacy skills do not complement one another, a company's **absorptive capacity might be hindered or even reduced** by the conflicts arising between digital and legacy skills. For instance, Boland et al. (2007) find that at Volvo Cars, there were tensions evident between employees who sought to bring about change and those whose legacy capabilities were challenged by such changes. Bailey et al. (2010) show that efforts to substitute legacy capabilities with digital ones without considering organizational goals disrupt beneficial – albeit time-consuming – strategies that contribute to the development of products or organizational knowledge.

Overall, the net effect on innovation of digital/legacy skills distribution depends on the relative balance/imbalance between such skills. As observed in the Van Gogh Museum case study, the right balance between digital/legacy skills follows a gradualist approach that can become embedded within organizations only if embraced by all staff through incremental actions rather than a radical transformation. In Figure 17, this further dimension related to the balance/imbalance of digital and legacy skills is represented with the visual metaphor of a "scale."

Figure 17 shows four quadrants, labelled from A to D in a clockwise fashion, plus a third contingency in each quadrant related to the balance/imbalance of digital and legacy skills. As Figure 17 shows, t**he inertial organizational effects of digitization and connectivity are far from being unidirectional and ambiguous**. Depending on the specific type of the adopted digital technology and on its implementation, companies might find themselves drifting towards one of these quadrants without even realizing with important consequences on organizational dynamics. In what follows how the inertial forces enabled by digitization and connectivity might influence search and recombination dynamics (hence affecting the innovation scope) is discussed.

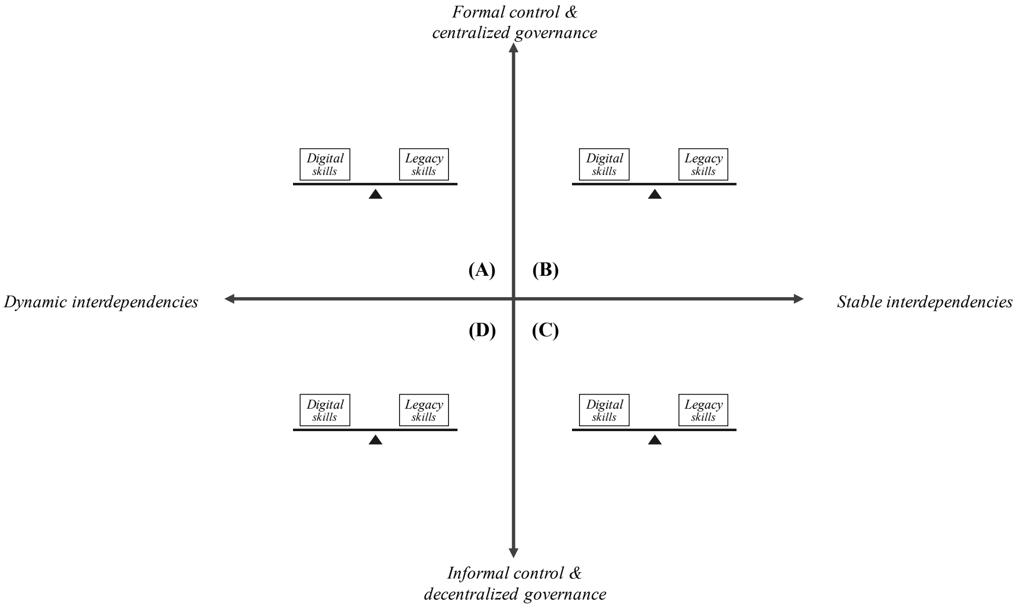


Figure 17 - Towards an integrative framework of the digitalization of search and recombination mechanisms

7.2.1 Quadrant A: incremental innovation in core components

At the top of Figure 17, digitization and connectivity may set into motion more **formal** and **centralized governance mechanisms**. The implication of this hierarchy-based innovation is that one might consider the role of an "architect" (or architects) who can make strategic decision about the organization and who should have a view over the knowledge components and the linkages between them. **This is likely to enable system-level search and recombination mechanisms**. However, at the same time, in Quadrant A, digitization and connectivity has also triggered increased **knowledge complexity**, **new tacit knowledge**, and **new communication silos**. This is likely to hinder the scope for wider search and recombination.

Therefore, the forces that are in action in Quadrant A are likely to lead to incremental innovation in core knowledge components which the architect may focus on due to the centralized organization. In other words, in Quadrant A it would be difficult to introduce both "radical" changes in knowledge components or architectural changes in interfaces/linkages given the fact that complexity may lead to unanticipated consequences, and new knowledge silos might make it more difficult to work on the linkages between knowledge components. Thus, incremental innovation in core knowledge components is predicted in Quadrant A (Figure 18).

This situation was found in the cultural heritage sector. The cultural heritage sector is undergoing a pervasive digital transformation where the majority of museums are not organized for the digital age, the departments tended to be siloed and hierarchies entrenched. Differently from what happened in the Van Gogh

Museum, which maintains the world's largest collection of the works of **one artist** – Vincent van Gogh – the majority of museums host different collections of different artists from different periods with different mediums. For example, the collection hosted by the Louvre Museum in Paris is divided among eight curatorial departments: Egyptian Antiquities; Near Eastern Antiquities; Greek, Etruscan and Roman Antiquities; Islamic Art; Sculpture; Decorative Arts; Paintings; Prints and Drawings. In this vein, evolutionary theories of organizations suggest two negative consequences of such extremely high levels of scope: the integration costs for the distant knowledge may be higher, and the "reliability" of such distant knowledge may be lower (Katila and Ahuja 2002). First, regarding the integration costs, as the museum scope broadens, the percentage of digital knowledge that needs to be integrated into the legacy knowledge base of the museum also increases, and that might lead to challenges in both technological and organizational integration. On the technological side, there would possibly need to be a new "language" or a new "interface" for the absorption, diffusion, and adoption of digital technologies. On the organizational side, there may need to be new networks, relationships, or communication patterns developed within and across museum boundaries (e.g., the outsourcing of the digitalization process for collections that range from flat prints and paintings, to sculpture with 3D renderings, to ancient and extremely fragile archeological artifacts). **In other words, the broader the search or higher the scope of the organization, the more difficult and complex the integration problems are.** Second, regarding the "reliability" of the distant knowledge, it might be the case that attempting to incorporate digital knowledge into the museum may lead to the decreasing reliability of the museum's core products – the physical collection – or may make it more difficult for the museum to respond to new stimuli that require accurate decision-making. Overall, the resulting uncoupling of legacy links among physical and digital pieces of knowledge and product components trigger high/new complexity and interdependencies that are difficult to be managed. Although someone in a leadership position – an "architect" as defined above – may set about implementing widespread transformation to make a legacy cultural institution more user-centric, collaborative, data-driven, and iterative (as occurred for the Louvre that in the 2000s spent more than €7 million on its new website) these changes happen in incremental innovation in core knowledge components rather than as an architectural one.

A similar example might be found in the auto industry (Staudenmayer, Tripsas, and Tucci 2005), which is now undergoing a pervasive digital and electric transformation. The resulting uncoupling of legacy links among components can trigger high/new complexity and interdependencies with the rest of the car (Magnusson and Berggren 2011). In such a context, many legacy manufacturers are using open innovation for incremental innovation in core components while a strict centralized governance on the overall architecture, e.g., Mercedes and AUDI.

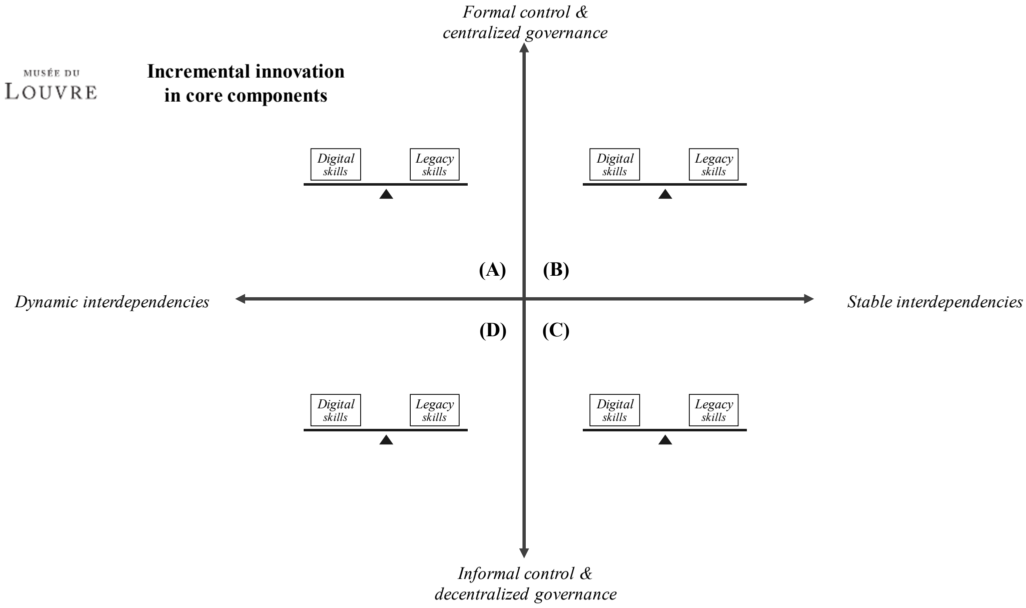


Figure 18 - Quadrant A: incremental innovation in core components

7.2.2 Quadrant B: architectural innovation in core components

Organizations that find themselves in Quadrant B are more likely to spur architectural innovation (Figure 19). As already said for Quadrat A, formal and centralized governance mechanisms enable system-wide search and recombination mechanisms. Furthermore, in Quadrant B, the interdependencies among pieces of knowledge and product components are more predictable or manageable, and the knowledge more formalized and easier to share and coordinate. Overall, in this case, the inertial effects of digitization and connectivity might give the organization and edge for search of distant knowledge that might be effectively applied to change the architectural interdependencies among pieces of knowledge and product components. Thus, new architectures – or linkages between knowledge and components – are predicted to be the most likely output of the innovation process form and manage (cf. Henderson and Clark 1990). Therefore, architectural innovation in knowledge components is predicted in Quadrant B (Figure 19).

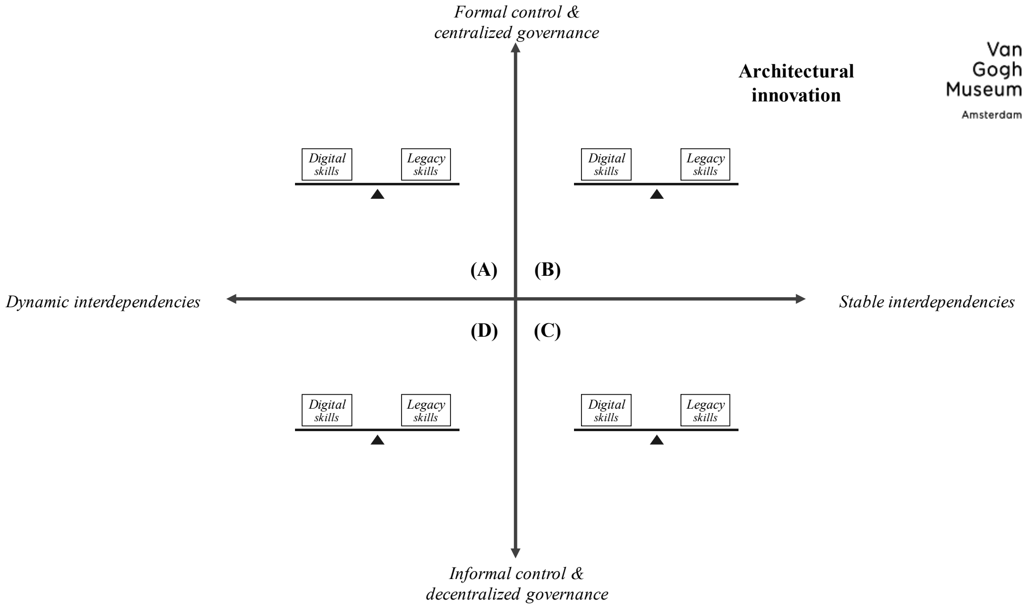


Figure 19 - Quadrant B: architectural innovation in core components

This situation is well documented by the case study on the organizational transformation of the Van Gogh Museum (Chapter 6) that evolved to incorporate and leverage the capabilities that digitization and connectivity offer, such as increased out-reach; increased real-time organizational interdependencies; experimentation at the crossroads of art and technology. Specifically, in the Van Gogh Museum (VGM) digital technologies have enabled the generation of scientific knowledge that would not be possible without digital technologies (e.g., "see the unseen"). Also, digitization has enabled knowledge modularization by allowing the decomposition/atomization of the elements by which digital artifacts are made, and by re-shuffling these elements to new configurations. In response to these new reconfigurations enabled by digitization and connectivity the VGM re-organized itself in functions grouped by knowledge output by means of new organizational "liaison" roles that become the new organizational baseline. The Digital Communication department become the new "gatekeeper" and acts as "**dotted line**" coordination mechanism to liaise internal functions among themselves and with external "stakeholders." The representation of these systems in a network would be characterized by a **centered form** in which a central node interacts with a variety of unitary, disconnected agents who cannot form direct ties with the other agents (Figure 20)

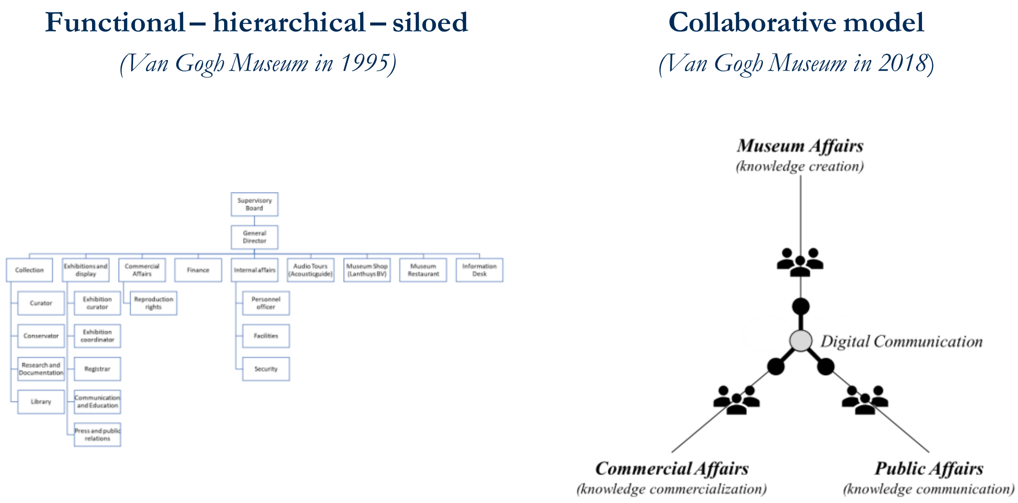


Figure 20 - The organizational transformation of the Van Gogh Museum: from 1995 to 2018

On one hand, the Digital Communication department interacts in an ongoing fashion with external parties and helps span technological and organizational boundaries by "**translating**" and **contextualizing** the knowledge across boundaries, thus providing social capital and knowledge to create new patterns and new ways to explore existing knowledge. This relationship has been demonstrated in different sectors, including life sciences (e.g., Powell, Koput, and Smith-Doerr 1996) and manufacturing (Faems et al. 2010). On the other, the Digital Communication department increases information flows, creating so-called "**boundaryless**" organization (Cross et al. 2006) and **eliminating silos.** In doing so, the Digital Communication department augments the efficiency of the knowledge generation process, increasing internal interfaces among the different organizational units (Garud and Nayyar 1994; Antonelli 2017). In particular, in-house operations become more efficient, and the VGM prefers the internal provision of solutions.

A similar example might be the platform approach that Apple adopted and tightly controlled, leading to product / service development breakthroughs (Teece 2018).

7.2.3 Quadrant C: localized architectural innovation

In this case, on the one hand, digitization and connectivity enable governance forces that are more informal/horizontal. Furthermore, digitization and connectivity also enable distributed innovation, as in the case of the network-based innovation generated by the Arts & Culture platform developed by Google and discussed in Chapter 5. At the same time, as in Quadrant B, digitization and connectivity leads to increased absorptive capacity by favoring the emergence of clear links among pieces of knowledge and product components.

At the intersection of the resulting search and recombination forces enabled by digitization and connectivity, organizations might be more likely to spur network-based innovation at the periphery of the legacy product, in the form of changed linkages among peripheral components but in the absence of an architect to control it. This is because the distributed organizing enabled by the digital transformation in this quadrant implies that various parties and stakeholders negotiate amongst themselves, whereas the more predictable interdependencies mean that they can work on the interfaces (linkages) between the components. Furthermore, the absence of a formal model in the governance of the innovation process might lead to a situation of crowding whereby organizations whose attention is limited, can pay attention to only a subset of local suggestions (Piezunka and Dahlander 2014; Piezunka and Dahlander (In Press)). Therefore, in these circumstances, digitization and connectivity are more likely to enable search and recombination mechanisms conducive to localized architectural innovation (Quadrant C in Figure 21).

In the cultural heritage sector, this situation is well documented by the case study on the Google's Arts & Culture platform (Chapter 5). On one hand, the platform allows to leverage on large volumes of varied data generated by different actors (museums, art lovers, researchers, multimedia specialists, technology vendors, and specialized suppliers) and to reuse them in valuable ways in other industry contexts, such as education, tourism and content generation in the multimedia sector. In doing so, Google offers museums the possibility of leveraging on the portability that narrative content and digitized artworks can have on the multiple loci available in its digital ecosystem, which integrates different domains like maps (Google Maps, Street View), search engines (Chrome), social networks (Google+), operating system (Android), and is accessible from a variety of devices (computers, smartphones, watches). For example, through the Android and the Chrome systems, Arts & Culture offers its users information about the opening hours of museums, popular times, live visit information, the expected waiting times, the duration of the visits, directions, traffic information and nearby points of interest, including restaurants, hotels and shops. This encourages museums to join the platform in order to facilitate visitors to retrieve the information useful to plan a visit to their physical galleries, thereby reducing their costs for acquiring customers. This type of horizontal complementarity also increases the interest of local tourism institutions in advocating and promoting the use of the platform with the local museums, hotels, restaurants and any other actor involved in cultural heritage and tourism. In doing so, these actors can increase the attractiveness of a local area, thus allowing for end-to-end integration (Karmarkar, 2010) in the provision of a touristic experience.

On the other, the platform supports cultural organizations in providing localized architectural innovation related to the introduction of **new products or services** (e.g. digital images in ultra-high resolution), **new methods of**

dissemination (e.g. customization, experimentation, co-creation and gamification) and **new ways of doing business**. For example, the forms of experimentation made available by Google create new entertainment opportunities of providing game experiences in non-game contexts with the aim of generating learning along with entertainment. Also, artificial intelligence tools for pattern recognition and machine learning algorithms for pattern matching enhance the research opportunities for researchers and academics, while augmented and virtual reality encourage the development of new products and services by specialized suppliers.

Other examples could be the product development of "Development Webs" such as digital cameras, open source software, and digital media (Staudenmayer, Tripsas, and Tucci 2005).

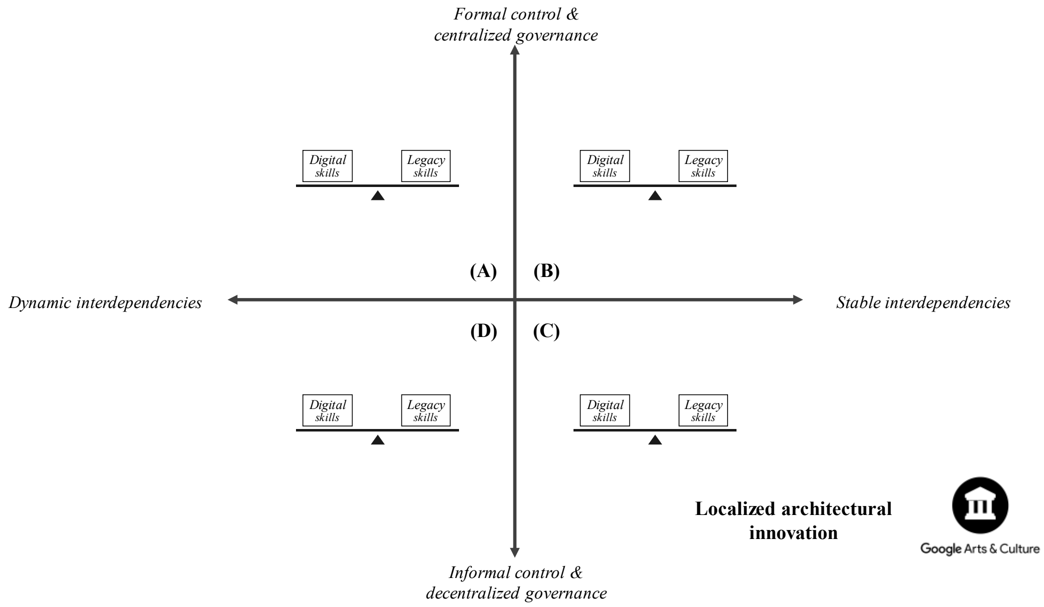


Figure 21 - Quadrant C: localized architectural innovation

7.2.4 Quadrant D: incremental innovation in peripheral components

In Quadrant D, the combined effect of decreased absorptive capacity and informal/distributed innovation governance makes it more likely that innovation might happen at the periphery in the form of incremental innovation. Here again, there is no central architect, and at the same time, digitization and connectivity are associated with more complexity and knowledge silos. This could lead to distributed negotiations but probably not to develop new linkages due to the unpredictable interdependencies and siloing of knowledge. Instead, the different parties could work on optimizing pieces of knowledge and product components, but the range of the components could be greater without centralized control. In such a situation the diversity of knowledge sources may be diminished. Thus, incremental innovation in peripheral knowledge components is predicted in Quadrant D (Figure 22).

In the cultural heritage sector, this situation is well documented by the case study on Europeana (Chapter 5). The platform intends to assemble the most trustworthy collections of Europe's cultural heritage. On one hand, by opening up access to online cultural heritage, increasing the social and economic benefits and removing the barriers to access, Europeana plays an important advocacy role with European policy-makers. Also, application program interfaces (APIs) and widgets make Europeana's content available on cultural (e.g. Wikipedia), social networks and blogs. On the other, Europeana controls descriptive metadata and not the creation of digitized artifacts. Given the breadth and width of its components – museum artifacts, books, photography, audio and video files – and the different cultural organizations on board – from museums and libraries to public and private foundations – **the platform operates more as a dedicated search engine than as an aggregation platform per se**. Content providers only upload thumbnail images and metadata of their digitized collections onto Europeana without centralized control. This means that the users, once they have identified the items that interest them, through the platform's filtering tools, can only navigate through non-standardized digital reproduction of physical artifacts and a limited number of the relevant metadata on each artifact. This reduces the interest of museums in contributing to Europeana, since the platform cannot allow them to express their core capabilities of developing narrative content around artworks. Other examples of this could be the Android ecosystem (Teece 2018), or the organization of CERN physics experiments (Mabey and Zhao 2017).

Thus, the framework predicts that incremental innovation will also occur in Quadrant D, mainly around a broader range of components, including the periphery. This also accords with Mabey and Zhao (2017), which showed that the more self-selecting and less centrally choreographed innovation processes, the more discriminatory such filters can become. Mabey and Zhao (2017) showed that in these circumstances digital technologies can reinforce social boundaries, homogenize collective behavior and perpetuate cultural conformity, all inimical to the innovation-seeking enterprise. Overall, this reflects the fact that the stakeholders that have joined and that exchange services on Google Arts & Culture represent a more heterogeneous network of actors than the actors in the ecosystem developed by Europeana.

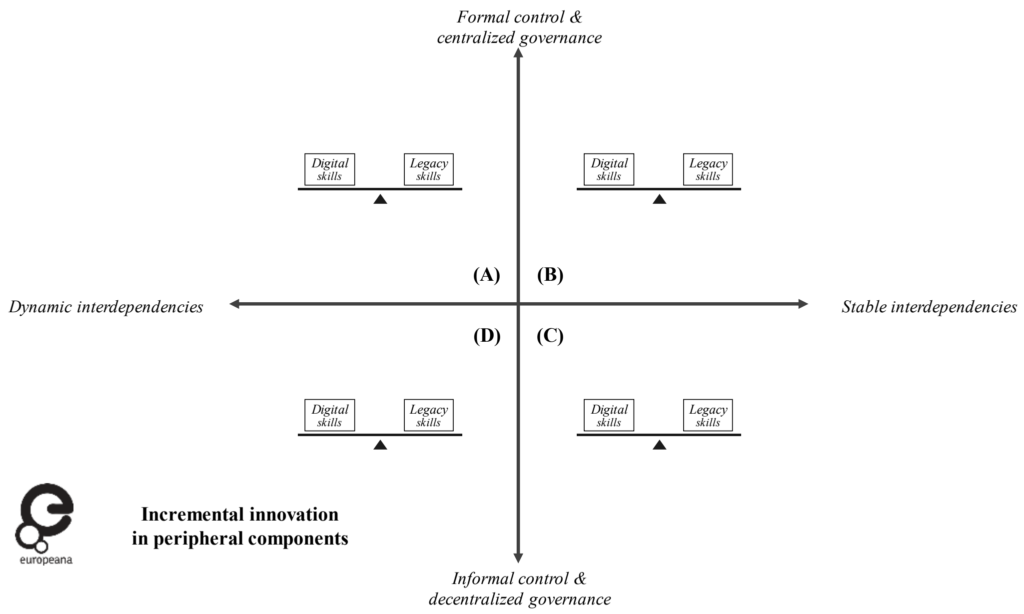


Figure 22 - Quadrant D: incremental innovation in peripheral components

7.2.5 The role of digital / legacy skills distribution

Figure 23 shows the full systemic integrative framework with the four predictions discussed above for each quadrant.

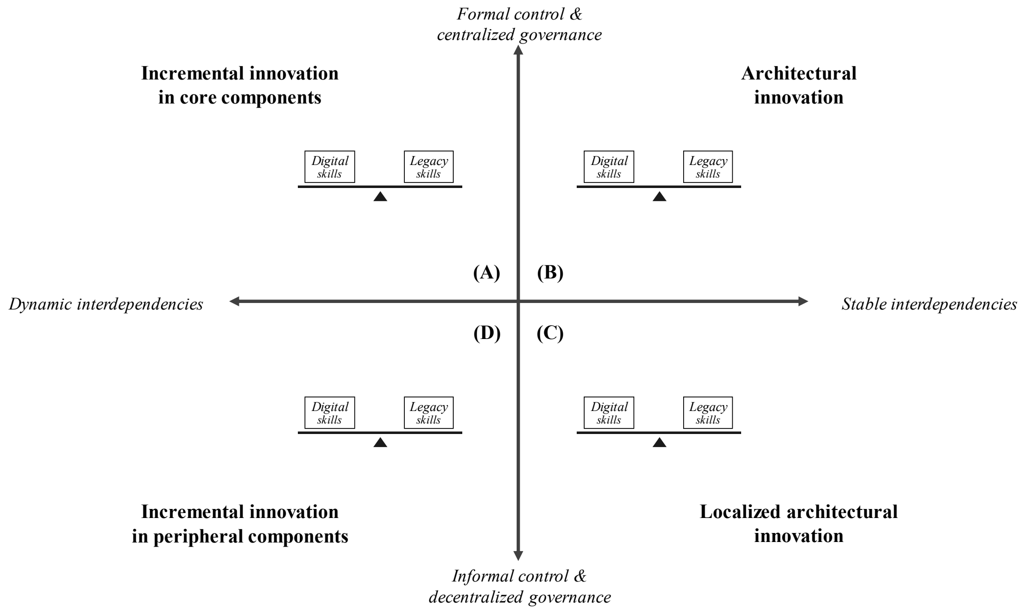


Figure 23 - The systemic integrative framework of the digitalization of search and recombination mechanisms

The predictions highlighted in Figure 23 assume that digital skills and legacy skills are balanced and complement each other. However, this might not always be the case. For cases of imbalances, emergent literature has shown that the prevalence of digital skills might enable **path-creating innovation** (Boland, Lyytinen, and Yoo 2007). Conversely, a prevalence of legacy skills might enable **path-dependent innovation**.

As such, the baseline predictions highlighted above will be moderated by the relative distribution of digital/legacy skills with innovation being more path-dependent or path-creating depending on whether legacy skills or digital skills prevail.

In the cultural heritage sector, curators have traditionally been at the top of the museum hierarchy, most directors came through the curatorial ranks, and the legacy knowledge of curators – primarily driven by the collection – dictated the direction of cultural organizations. Now directors are likely to have digital skills (e.g., crowdfunding, collection management, digitization processes), and some cultural organizations have hired digital officers as change agents (i.e., gatekeepers) whose aim is to introduce digital practices throughout the organization. Every museum nowadays need staff who can manage digital artifacts, social media, IT, website, and digital production and reproduction. However, the VGM case study highlights an incremental approach to change, in which new ways of working evolve as people with digital skills are hired and practices change on a smaller scale by working on a project basis. In other words, the drive for digital transformation grows up into an expectation that innovation happens in measured increments moderated by the relative distribution of digital/legacy skills with innovation being more path-dependent or path-creating depending on whether legacy skills or digital skills prevail. As digital becomes the norm, it is likely that specific digital jobs will fade away (e.g., the social media manager) and digital skills will be expected for everyone (e.g., curators that use Instagram to directly share their curatorial work).

7.3 Managerial implications

There are several implications of this thesis that help address the question: **How can a company make digital technologies work for them and not against them when using search and recombination mechanisms enabled by digitization and connectivity?** This depends on which forces unleashed by digitization and connectivity dominate over the other ones.

Managers might intentionally let some forces prevail to orient the output of the search and recombination processes in a way that fits their strategic innovation goals. For instance, for many years the Van Gogh Museum (VGM) was operating under “inertial” forces that would be described as the ones operating in Quadrants A. Curators was at the top of the VGM hierarchy and their knowledge and concerns, primarily driven by the collection, dictated the direction of the museum. The output of the innovation efforts during those times was in line with what predicted by the framework as they were mostly local architectural innovation and/or incremental innovation in peripheral components (Teece 2018). Yet, in 2016 a new ***Digital Communication*** department was created within the Public Affairs unit as a change agent whose goal is to introduce digital practices more organically throughout the organization.

As digital becomes the norm, the VGM effort was to reorganize and refocus the innovation process to a more corporate framework of hierarchy-based innovation. As explained by the Head of the Digital Department, Martijn Pronk during an interview: *“As Digital Communication department we want to surprise people and to inspire them. However, we do not produce digital products ourselves, but in close cooperation with our internal and external partners. There are always colleagues involved, like curators, educators and researchers with knowledge of our collection and the person Vincent van Gogh, together with members of our online team.* ***We are the new kids on the block****.”*

Thus, to foster communication across new digital roles and the new **knowledge output-oriented functions**, the Digital Communication department acted as “**dotted line**” coordination mechanism to liaise internal functions among themselves and with external “stakeholders.” Through **centralization** in the governance of the digital innovation process, the VGM moved from Quadrant A to Quadrant B (Figure 24).

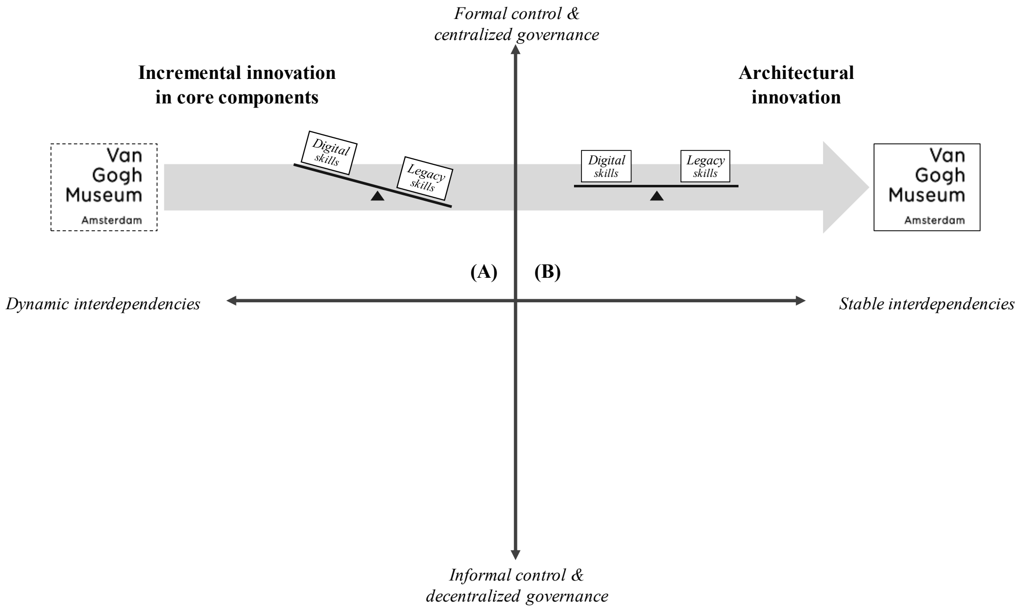


Figure 24 - Through centralization in the governance of the digital innovation process, the VGM moved from Quadrant A to Quadrant B

Another example come from the Google Labs project. For many years Google’s organization was operating under “inertial” forces that we would describe as the ones operating in Quadrants D. In 2011, Google decided to close down its Labs project in an effort to reorganize and refocus their innovation processes to a more corporate framework of planned, budgeted and hierarchically approved. *“[W]e're prioritizing our product efforts”,* Bill Coughran, senior vice president for research and systems infrastructure, wrote on the Official Google Blog. *“As part of that process, we've decided to wind down Google Labs. While we've learned a huge amount by launching very early prototypes in Labs, we believe that greater focus is crucial if we're to make the most of the extraordinary opportunities ahead”* (Coughran 2011). Through **formal control** and **centralization** in the governance of the innovation process, the Google repositioned itself from Quadrant D to Quadrant B.

The two examples are in line with what the developed framework suggests: It would pay to be extra vigilant in the R&D/NPD processes to ensure that the digital transformation is in line with the strategic goals.

Jointly, as well highlighted by the empirical case studies conducted in the cultural heritage sector, the balance between digital and legacy skills is particularly important in the context of the changing relationship between digital and physical product components. In fact, the micro properties of digitized and connected artifacts identified and discussed in Chapter 3 also influence the relationship between the physical and digital world by creating three potential types of relationships: **convergence**, "**smartification**," and **virtualization**. Together, these relationships provide new foundations for organizations, which are summarized in Figure 25 and discussed in what follows.

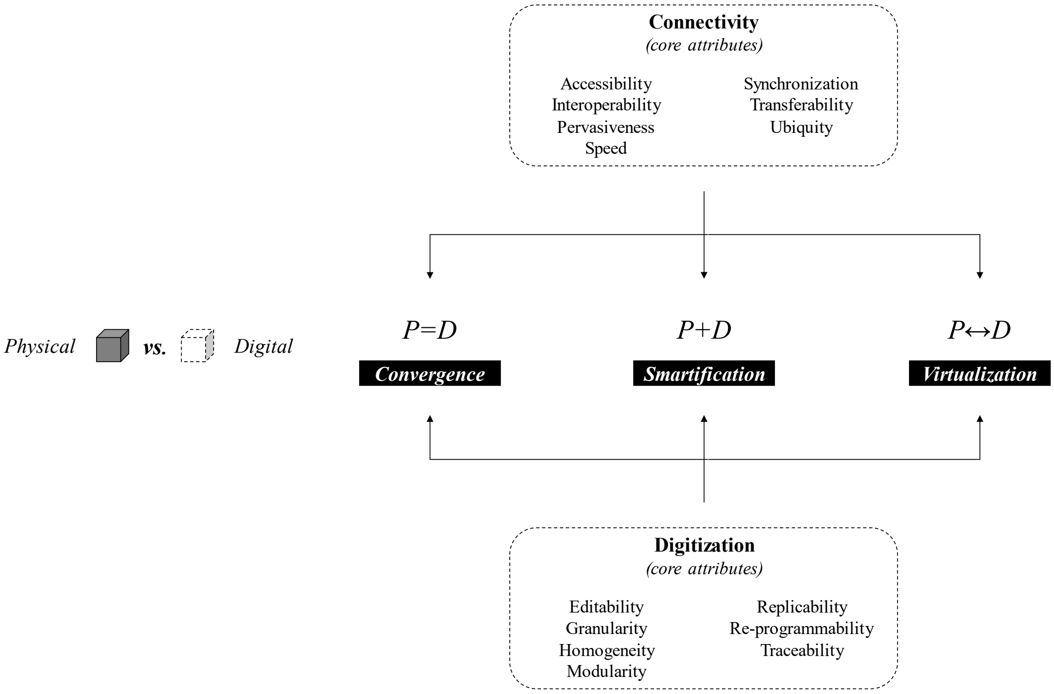


Figure 25 - Micro properties of digitized and connected artifacts and the relationship between the physical and digital world

Convergence implies that physical products – e.g., a painting, a letter, a book, etc. – become fully digitized (Kallinikos et al., 2013). In this vein, digitized physical artefacts lose their legacy materiality even though they still need physical interfaces to be played or used (Bailey et al., 2012; Bardhi and Eckhardt, 2017; Norman, 2001; Orlikovsky and Scott, 2008, 2016). Strategist coined the term omnichannel to describe the new approach enabled by digital convergence: **give customers what they want, when they want it, and how they want it, through every possible channel**. However, differently from the digital convergence of the most physical products – where digitization amplifies the capabilities and value of the physical components, while connectivity enables some of them to exist outside the physical product itself – for cultural artifacts digital convergence were described as potentially revealing and generative of new scientific knowledge (e.g., ultra-high resolution images). Also, digital convergence gives users the freedom to access museum content anywhere, and omnichannel planning strives to include every possible avenue of engagement, including ones that have not been invented (Hossaini & Blankenberg, 2017). In this vein, form R&D to sales, digitization and connectivity address people as individual but this require open content managed by standards the let it be scaled, served, and repurposed across any digital platform.

A second type of relationship is **smartification**, i.e., the incorporation of digital sensors into objects that previously had a purely physical materiality. Sensors allow objects to provide information about their environment, context and location (Alemdar & Ersoy, 2010). Using embedded sensors, digitized information pertaining to the physical artifacts can be retrieved and used to mediate user experiences in interacting with the physical artifacts themselves (Yoo, 2010). This second type of physical/digital relationship - often also referred to as digital materiality - highlights what the software incorporated into an artifact can do by manipulating digital representations (e.g., a running shoe with a microchip that can record representations of movement in a digital format). In this case, connectivity mediates the relations with objects rather than users and the level of separation enabled by digitization refers to the interaction between data collected by a physical system, the digital representation of the system's functioning, and how this interdependence changes the system's behavior (Bailey et al., 2012). In the cultural heritage context, the smartification of art is vastly simplifying **online** and **onsite** access to collection. Finding cultural objects becomes a simple online search. Online, cultural artifacts can be quickly retrieved and like any other digital artifact, items can easily accrue communities of interest where expertise is accessed, shared or recombined. Onsite, every item in the collection could be tagged for location awareness or in order to broadcast description, links, and other relevant content. Using smartification, artifacts in the gallery can "tell their own stories" by transmitting information directly to visitors using embedded chips, sensors, or processors such as iBeacon, Near-field communication (NFC), and Radio-Frequency Identification (RFID). Sensors and connected devices can also be used to analyze and optimize flows within the gallery and to help, preserve, and safeguard the physical cultural artifacts.

Finally, a third type of relationship between physical and digital is **virtualization**, which occurs when digital representations stand for, and in some cases completely substitute for, the physical objects, processes, or people they represent. In this sense, virtuality specifies what the interaction between the physical and virtual will be (Bailey et al., 2012). Augmented Reality (AR) and Virtual Reality (VR) are two of the most talked-about digital technologies at this time, particularly with the rapid rise in popularity of gamification (e.g., Pokémon GO) and excitement around new virtual reality headsets. On one hand, AR layers digital content onto the real world. On the other, VR transports users to a completely different digital world that can completely substitute for, the physical world it represents. Both the technologies have particular relevance in the cultural heritage sector. AR can provide visitors with more information on what they are seeing in the real world (e.g., reveal information about the painting normally not accessible, like x-ray, infrared and ultraviolet images, or even the back of the painting). VR can allow visitors to experience a completely different time or place that may be the focus of a museum exhibition (e.g., step inside the Van Gogh's bedroom and walk around).

One implication of the systematic integrative framework developed in this thesis (Figure 23) is that imbalances between digital and legacy skill might influence the effectiveness of product / service innovation strategies, especially when they entail convergence, smartification or virtualization. For example, in the early 2000s, museums matured a conservative attitude toward the "digital convergence" of cultural heritage on the web, as they feared that the web channel could have popularized art to an excessive extent. Museums in particular feared that art could have become a commodity on Google and the social media, with museums losing their control on the quality of the related art content. This fear was based on what had been happening in the newspaper industry, where online news had progressively been jeopardizing the customers' willingness to pay for news and for their quality (Rothmann and Koch, 2014). This fear was also the result of previous beliefs on the role that technological reproduction plays in shaping aesthetic experience. In his 1936 essay "The Work of Art in the Age of Mechanical Reproduction", Benjamin described the process by which technological reproduction, through photography and firms, stripped museums and their iconic artworks of their aesthetic authority. In this vein, Benjamin claimed the reproduction in mass of art pieces jeopardized their "holiness" (Benjamin, 1936).

Also, in "smartification" – or adding sensors to physical products – there could be a tendency to focus on the sensors, data analysis of the sensors, and software at the expense of improving the physical product, which may increase the "disconnect" between the digital and physical realms in the firm. This might not be an optimal outcome, however, as in many cases, competitive advantage may be gained from the blurring between digital and physical assets of the firm (McDonald 2013), and there is a real danger that an overemphasis on digital will leave the parts of the organization delivering the physical dimensions in a disadvantaged, isolated, or lower status state. **Overall, imbalances between digital and legacy skill may have the effect of increasing resistance to digital transformation and thus making it less effective.** Or, if the firm prioritizes the physical, since it happens at a slower clock speed, there is a chance that while the firm improves or replaces the physical product, the digital aspect of the service or product might become obsolete during that time. Therefore, innovation managers may want to develop strategies for timing the digital and physical assets.

Finally, digitization and connectivity allow project teams – that pull from multiple departments – to quickly form into "flash matrix organizations" (the case depicted in Quadrant B and C) that have the possibility to cohere and form more permanent bonds bringing together people who may not be used to collaborating toward a common goal. This sounds like a positive development, but quick team formation should also be managed purposefully since the teams might become siloed or isolated, or there might be so many of them that membership becomes distracting for the team members. Thus, there is a practical question of how does one keep the flash matrix organization aligned with the rest of the organization? It is difficult enough to align one permanent matrix structure (Katz and Allen 1985), but when multiple matrix structures can be created digitally, how can one align their innovation work with corporate strategy? Thus, the more negative consequences of flash matrixes need to be actively monitored and teams managed in such a way as to take full advantage of the positive consequences.

7.4 Conclusions, limitations and future research

The thesis has developed an integrative framework – grounded in the systematic analysis of the literature on digitization and connectivity – that predicts the likely scope of search and recombination mechanisms vis-à-vis digitization of the innovation function. Sensitizing the theoretical framework through two empirical studies of digital transformation this thesis has derived several implications for theory and practice. Across two different, yet interlinked, embedded case studies in the cultural heritage sector it has demonstrated the theoretical framework by leveraging differences on how digitization and connectivity affect search and recombination mechanisms in **network-centric** and **hierarchy-centric** innovation contexts.

Overall, the thesis has shown that the potential "inertial" effects of digitization and connectivity (i.e., activities set into motion) on the scope of search and recombination are far from being unidirectional and ambiguous because digitization and connectivity engender changes in the micro-mechanisms of **absorptive capacity** and **innovation governance** that are at the core of search and recombination's scope.

On the question on how firms can make the search and recombination mechanisms enabled by digitization and connectivity work for them and not against them, the thesis has shown that this depends on which forces unleashed by digital technology dominate over the other ones. Managers might intentionally let some forces prevail to orient the output of the search and recombination processes in a way that fits their strategic innovation goals. However, this thesis has illustrated that the digital transformation forces may affect a company's innovation governance and absorptive capacity – and, in turn, the scope for search and recombination – in three different ways:

1. Digitization and connectivity, on one hand, increase formal control and centralization in the governance of the innovation function process but that they might also enable informal and distributed governance of the innovation process;

2. Via digitization and connectivity, an organization's absorptive capacity might enable more formalized knowledge, better understanding of the linkages among pieces of knowledge and better communication flows;

3. Digitization and connectivity may change the distribution of skills in the innovation functions and – depending on the resulting balance between digital and legacy skills – the organization might embark in path-dependent innovation (legacy skills prevail), path-creating innovation (digital skills prevail) or more balanced innovation.

The thesis has intentionally focused on what has been found in the literature to be the main effects of digitization and connectivity (Building Block 1) and related those to the scope of search and recombination mechanisms (Building Block 2). As there could be other contingencies as well, it would be important to continue this line of theorizing and develop implications on how other "inertial" effects complement / substitute for one another in the context of innovation and new product development. Some extensions of the proposed framework might include:

a) The identification of the optimal balance between digital and legacy skills (it is not obvious that an imbalance toward digital is necessarily a good thing, despite popular press "hype" in that direction);

b) The identification of the practices and the capabilities that allow digital and physical innovation processes to be coordinated effectively and efficiently.

Also, the thesis has been conducted by analyzing several literature streams in an inductive fashion and using the cultural heritage setting to empirically link them. The developed framework and the proposed predictions would thus benefit from future empirical work in measurement, hypothesis development and testing, and understanding of the contingencies and nuances of these new concepts.

Finally, the thesis analyzed the impact of digitization and connectivity on search and recombination mechanisms in a single empirical setting. To extend the validity and generalizability of the findings, other cases from different sectors should be examined, and an empirical methodology to test the emerging propositions should be developed.

The overall contribution of the thesis is fourfold. First, the dissertation complements the positive spin on digital technologies with a more holistic view to offer the first systematic analysis of the role of digitization and connectivity in the scope of search and recombination mechanisms. Second, the dissertation shows how digitization and connectivity "inertially" changes the micro-foundations for technology innovation management. Third, the dissertation provides an integrative framework that can move a step closer to gauge the likely output of different open innovation strategies in the digital age. These three contributions provide insights not only to the open innovation literature but also to the technology innovation management literature. Finally, despite the framework was primarily tested and investigated in the cultural heritage sector (laying bare the broader implications of digitization and connectivity for cultural organizations), by clearly spelling out antecedents and outcomes, the framework can be used as a guideline in other sectors.

In conclusion, the thesis and the resulting framework predicts that – depending on the relative balance of the forces enacted by digitization and connectivity – the actual scope of search and recombination mechanisms vis-à-vis digital transformation might lead firms to more incremental innovation in core or peripheral components, or new linkages between components via self-organization or top-down direction. Taken together, the results show that if not intentionally managed, digital technologies may lead inertially to some innovation outputs that might (or might not be) aligned with the overarching organization's goals. The systemic integrative framework developed in the thesis, besides contributing directly to the literature on innovation management – and specifically on search and recombination – the thesis has contributed to the emergent literature on digitization of organizations. Thus, coming back to the first question on whether digital technologies are simply "**old wine in new bottles**" when it comes to innovation management and organization theories, the thesis shows that digitization and connectivity may directly influence some of the core assumptions of absorptive capacity and governance. As such, digitization and connectivity not only shape a new context but also might require new theories.

My stance, based on this doctoral dissertation, is that it might be time to rethink some of these building blocks.

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